TIMEPAC Academy

Session

Analysis of the context of energy and water consumption – proper benchmarking

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Objective of the presentation

The aim of this lecture is to propose for a real building, through a case study approach, the baseline definition for the energy and water consumption as a chronological sequence of steps according to EN 16247-1 and EN 16247-2 from the data collection phase to the report elaboration, and the comparison against the proper benchmarks.

This exercise will also focus on the quality check of input data, calculation assumptions for simulating the building performance, visualization and communication of the analysis output

European context

40%

of the final energy consumption in the Union is related to buildings

75%

of Union buildings are still energy-inefficient

36%

Of the energy-related greenhouse gas emission is related to buildings

39%

of the energy consumption used for space heating is covered by natural gas

⇩

The 2024/1275 directive (EPBD) has the fundamental objective of triggering and driving the ***Renovation Wave***, promoting intervention in the existing building stock

Data source:
- Proposal for the EPBD (recast) - Analysis of the final compromise text with a view to agreement (2024-01-15)
- https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

European context

What does the EPBD mean by intervening in the existing building stock?

Non residential buildings

Art. 9, par. 1

- All non-residential buildings must be below the 16% threshold starting from 2030
- All non-residential buildings must be below the 26% threshold starting from 2033

Residential buildings

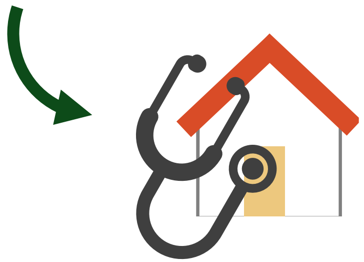
Art. 9, par. 2

- The average primary energy consumption must decrease by at least 16% compared to 2020 by 2030
- The average primary energy consumption must decrease by at least 20-22% compared to 2020 by 2035
- The 55% reduction in average primary energy consumption must be achieved through the renovation of the 43% of the worst-performing residential buildings.

European context

Intervening in the existing building stock…

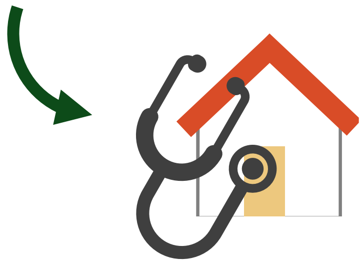
…proposing retrofit strategies that address the deficiencies of the building in its current state



European context

Intervening in the existing building stock…

We need to define a robust baseline of the building to plan and implement the proper retrofit strategies…



European context

Not only considering the energy consumption

In the context of the global energy transition towards a **low-carbon economy**, it is necessary to build a robust baseline to plan actions aimed at **reducing greenhouse gas emissions**, effectively **respond to climate change**, and **promote the use of renewable energy sources** in both the civil and industrial sectors.

What is a baseline?

According to EN 16247-1 and to ISO 50001, a baseline is a quantitative reference providing a basis for comparison of *energy performance*

- An energy baseline reflects a specified period of time.
- An energy baseline can be normalized using variables which affect energy use and/or consumption, e.g. production level, degree days (outdoor temperature), etc.
- The energy baseline is also used for calculation of energy savings, as a reference before and after implementation of energy performance improvement actions.

What is a baseline?

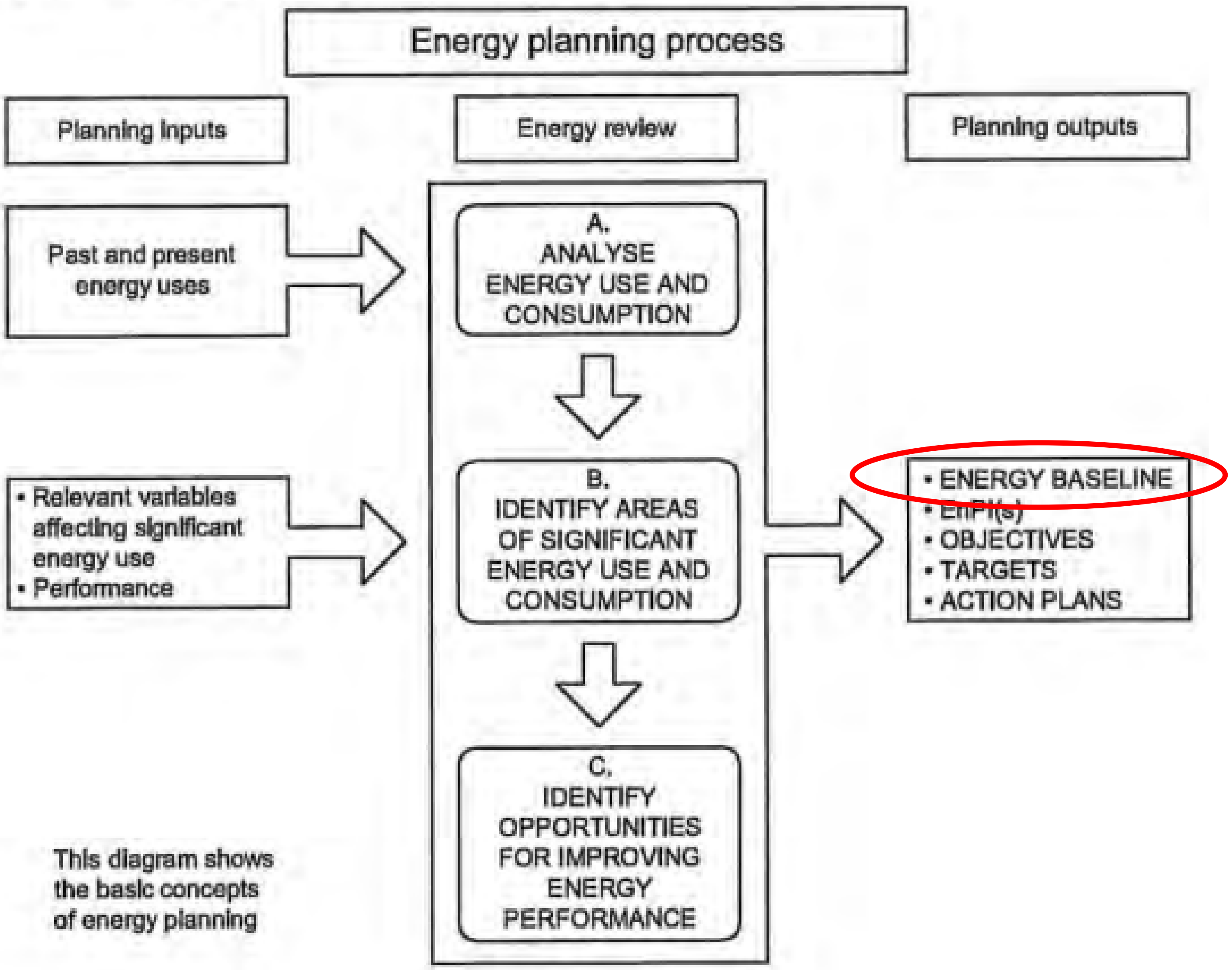
The organization shall establish an energy baseline(s) using the information in the initial energy review, considering a data period suitable to the organization's energy use and consumption.

Changes in energy performance shall be measured against the energy basel ine(s). Adjustments to the baseline(s) shall be made in the case of one or more of the following: - EnPls no longer reflect organizational energy use and consumption, or - there have been major changes to the process, operational patterns, or energy systems, or - according to a predetermined method.

The energy baseline(s) shall be maintained and recorded.

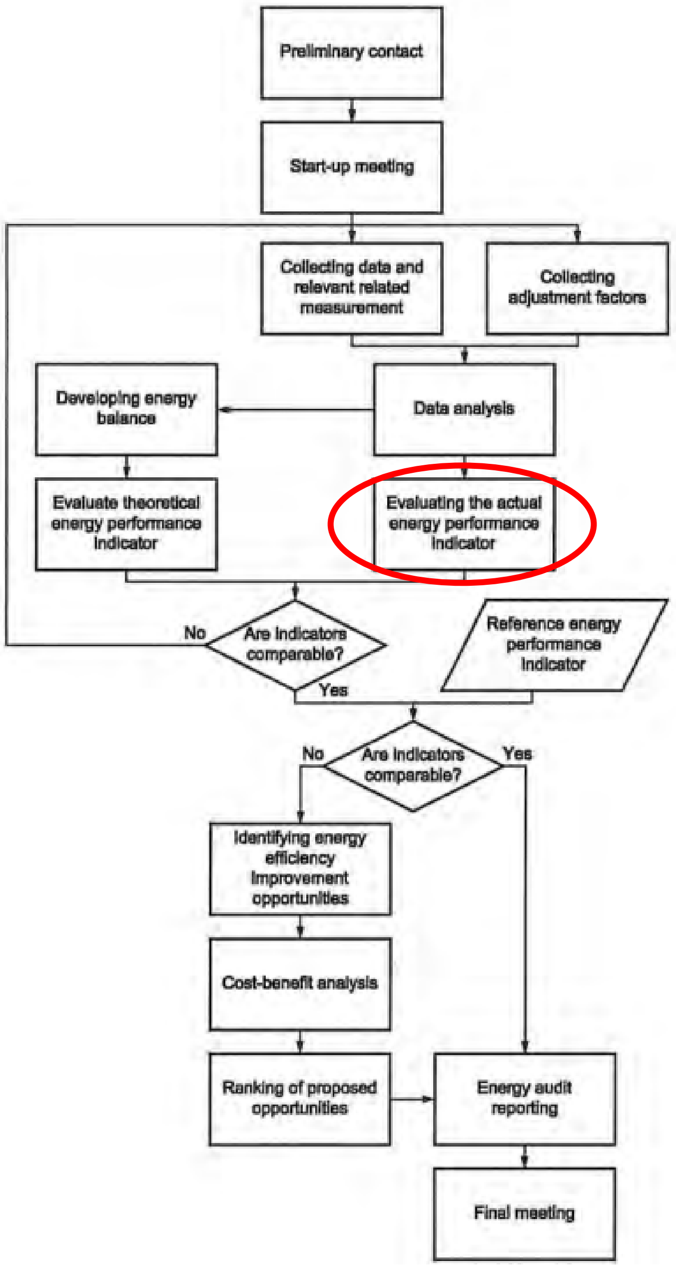
What are the uses of a baseline?

In the ISO 50001 context



What are the uses of a baseline?

In the EN 16247 context



What are the methods for determine a robust baseline?

According to International Performance Measurement and Verification Protocol (M&V protocol), there are different ways to determine a baseline:

Option A

Option A involves isolation of the energy use of the equipment affected by an ECM from the energy use of the rest of the facility. Measurement equipment is used to isolate all relevant energy flows in the pre-retrofit and post-retrofit periods. Only partial measurement is used under Option A, with some parameter(s) being stipulated rather than measured. However such stipulation can only be made where it can be shown that the combined impact of the plausible errors from all such stipulations will not significantly affect overall reported savings.

What are the methods for determine a robust baseline?

According to International Performance Measurement and Verification Protocol (M&V protocol), there are different ways to determine a baseline:

Option B

Short term or continuous metering may be used under Option B. Continuous metering provides greater certainty in reported savings and more data about equipment operation. These data can be used to improve or optimize the operation of the equipment on a real-time basis, thereby improving the benefit of the retrofit itself.

What are the methods for determine a robust baseline?

According to International Performance Measurement and Verification Protocol (M&V protocol), there are different ways to determine a baseline:

Option C

Option C involves use of utility meters or whole building sub-meters to assess the energy performance of a total building. Option C assesses the impact of any type of ECM, but not individually if more than one is applied to an energy meter. This Option determines the collective savings of all ECMs applied to the part of the facility monitored by the energy meter. Also, since whole building meters are used, savings reported under Option C include the impact of any other changes made in facility energy use (positive or negative).

What are the methods for determine a robust baseline?

According to International Performance Measurement and Verification Protocol (M&V protocol), there are different ways to determine a baseline:

Option D

Option D involves the use of computer simulation software to predict facility energy use. Such simulation model must be "calibrated" so that it predicts an energy use and demand pattern that reasonably matches actual utility consumption and demand data from either the baseyear or a post-retrofit year

What are the methods for determine a robust baseline?

In this lecture, the **calibrated simulation approach** is used!

What calculation method?

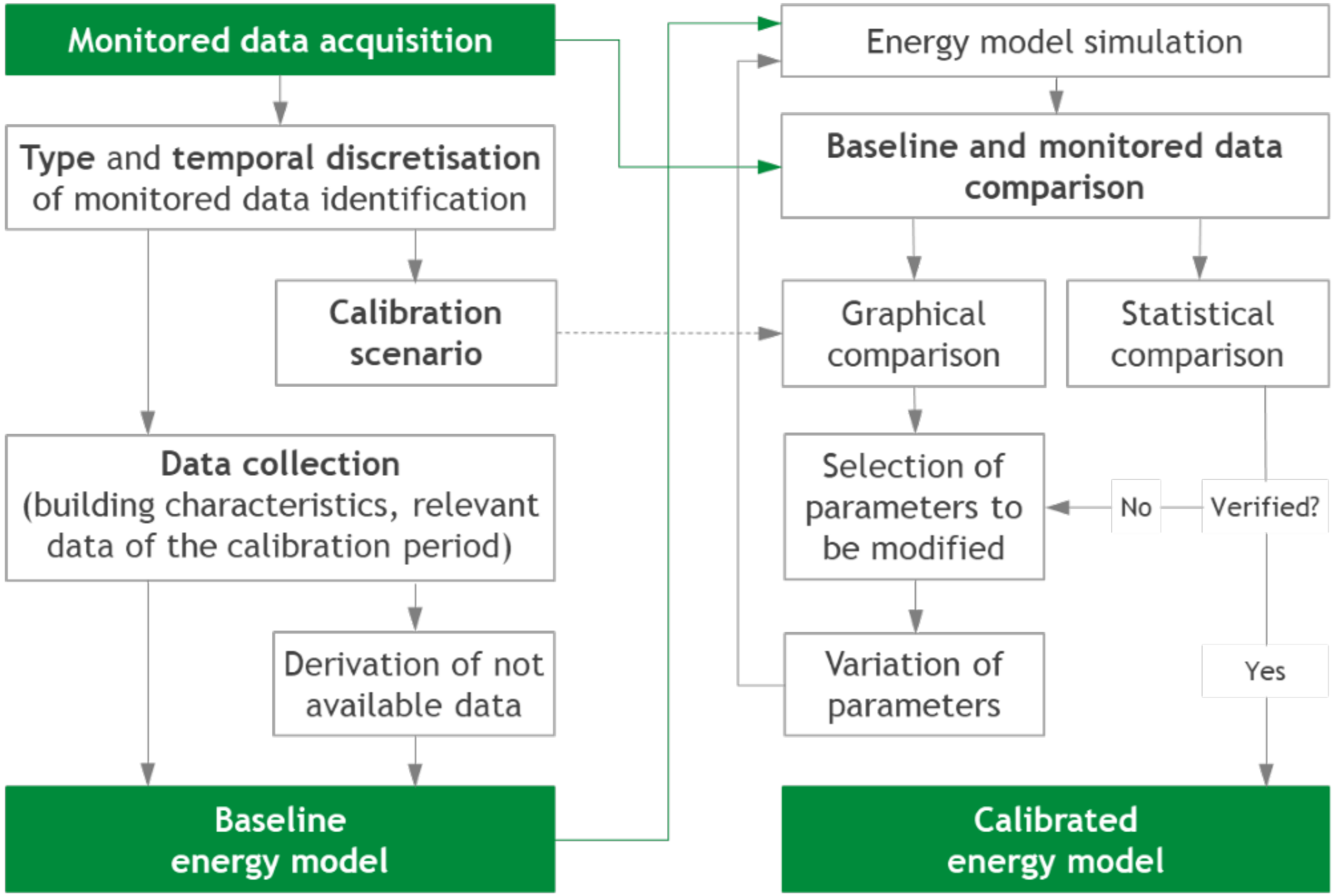
The methodology should represent the actual operating conditions, allowing the use of measured energy for correctness and comparability purposes [...].

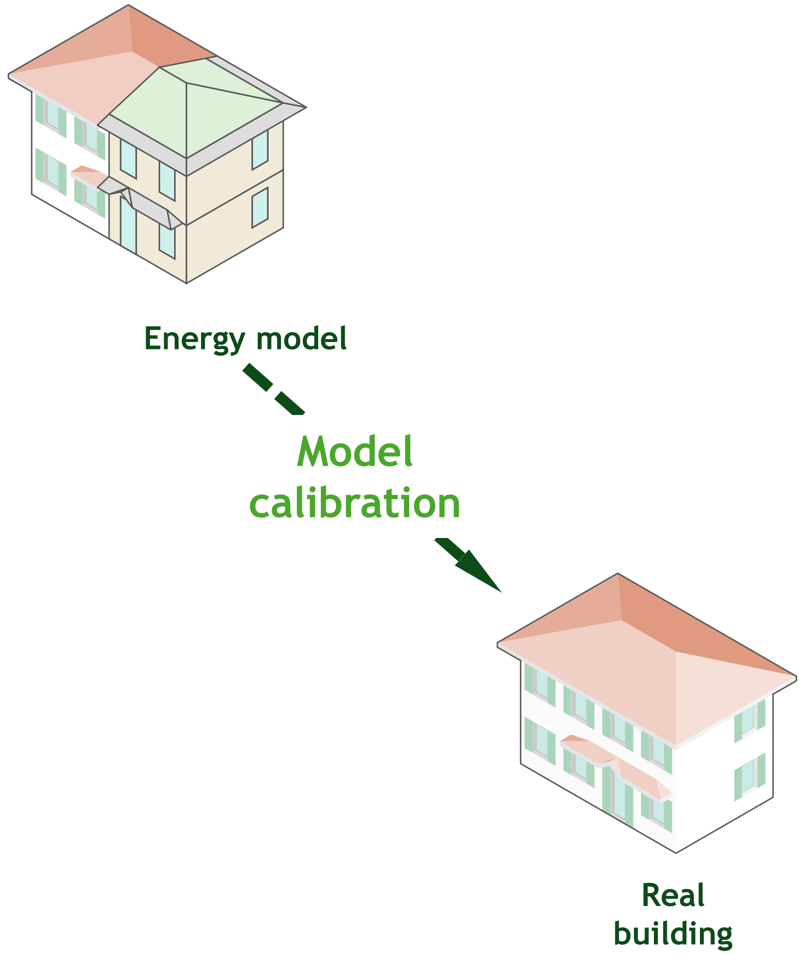
Section 12 of the introduction of **EPBD** (text approved the 12° of March 2024)

What calculation method?

In this analysis we used the hourly method according to EN ISO 52016-1

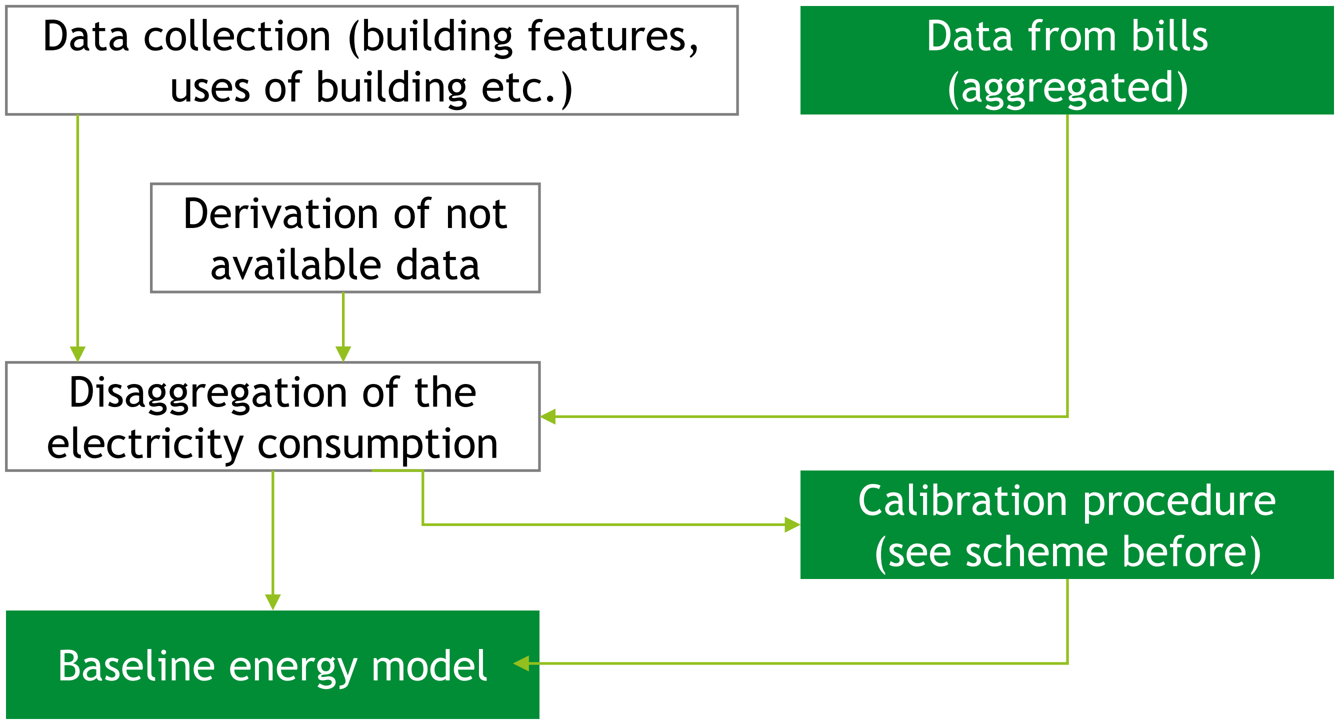
Methodology for the creation of a baseline for analysing the energy and water consumption (natural gas)





TIMEPAC Project Deliverable D2.2 Enhancing EPC schemas through operational data integrationhttps://timepac.eu/reports/3168/

Methodology for the creation of a baseline for analysing the electricity consumption



Calibration process

"Calibration is the process of reducing uncertainties of a model by comparing the model outputs for a specific set of conditions with the measured data for the same specific set of conditions"

American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE). **ASHRAE Guidelines 14-2014**: Measurement of energy, demand, and water savings. Atlanta (USA): ASHRAE, 2014.

Calibration process

How?

Refining the model parameters (input data, standard parameters, etc.)

Calibration process

1. It is not a standard process, and a shared methodology to apply has never been reached."
2. "Due to the variability of the parameters, which can be influenced by uncertainties, and the breadth of their respective ranges of variation, applying a methodical process is very challenging."
3. "The process mainly depends on the experience and capabilities of the user (modeler)."
4. "Calibration lacks unique solutions – usually, multiple calibrated models are identified.

Data sources:

- Energy performance assessment of buildings: a novel approach for model validation / DE LUCA, Giovanna. - (2022 Oct 28), pp. 1-209.

Calibration process

1. Calibrated models may not be suitable for representing the actual behavior of the building under conditions different from those of calibration."
2. "Standardized calibration criteria are lacking."
3. "The process requires a lot of monitored data and of quality."
4. "Available data, and their temporal discretization, can vary greatly and lead to different levels of calibration

Data sources:
- Energy performance assessment of buildings: a novel approach for model validation / DE LUCA, Giovanna. - (2022 Oct 28), pp. 1-209.

Calibration process

What approaches exist?

Manual calibration

- The user iteratively varies the most uncertain parameters to achieve a match between simulated and monitored data.
- Generally, multiple calibrated models can be obtained.

Automatic calibration

- The user identifies the most uncertain parameters and defines ranges of variation.
- The parameters are automatically varied (within the ranges) using mathematical, statistical, or optimization methods.
- A single calibrated model is obtained

Data sources:

- Energy performance assessment of buildings: a novel approach for model validation / DE LUCA, Giovanna. - (2022 Oct 28), pp. 1-209.

Calibration process

Manual calibration approach

1. Identification of the type and temporal discretization of monitored data
2. Collection of input data for the creation of the energy model
3. Creation of the energy model of the building (base model)
4. Comparison of the model outputs with the monitored data
5. Modification of the energy model

Until the calibration indices fall within the established ranges

Calibration process

1 Identification of the type and temporal discretization of monitored data

Typologies:

Energy consumption

Thermal flows

Indoor air temperature

Surface temperature of the envelope components

…

Temporal discretization:

Seasonal

Monthly

Weekly / daily

Hourly / Sub-hourly

…

➡ Depending on the type and temporal discretization, the calibration indices to be calculated and their acceptable values vary

Calibration process

2 Collection of input data for the creation of the energy model

Real data (in field analysis, ecc.)

Geometrical data

Use of the building

Characteristics of the technical building systems

Climatic data

They can be derived from field monitoring or from meteorological stations

Calibration process

2 Collection of input data for the creation of the energy model

Data that can be derived from standards or other sources

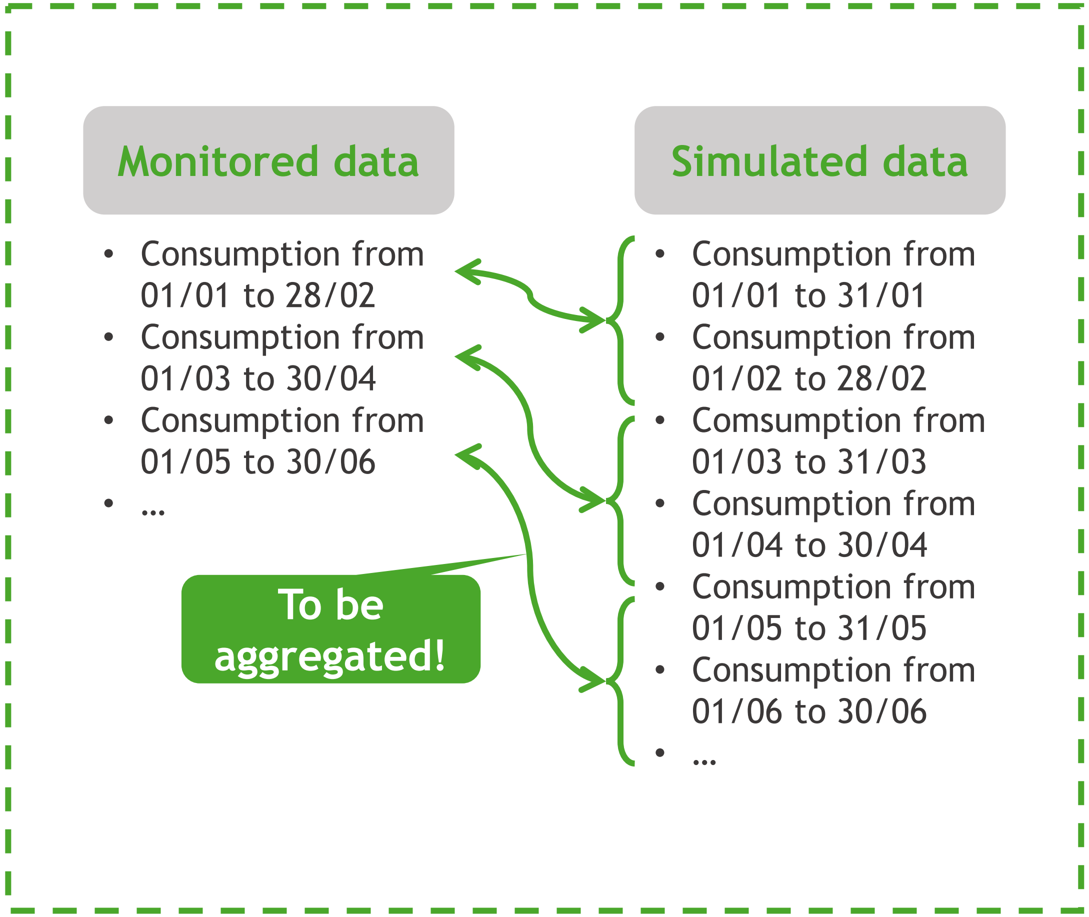
Building components' characteristics	**EN ISO 10456, similar buildings**
Users' information	**EN 16798-1**
Set-point temperature	**EN 16798-1**
Operation of the building technical ystems	**EN 16798-1**

If derived from regulations or other sources, these data may be subject to uncertainty and may therefore be considered as the first to vary in the calibration process

Calibration process

4 Comparison of the model outputs with the monitored data

- Reprocessing the simulated data in such a way that they are comparable with the monitoring data



Calibration process

4 Comparison of the model outputs with the monitored data

- Reprocessing the simulated data so that they are comparable with the monitoring data
- Statistical comparison **Compulsory**
- Graphical comparison **Usefull**

Calibration process

4 Comparison of the model outputs with the monitored data

- Reprocessing the simulated data so that they are comparable with the monitoring data

Statistical comparison

- Graphical comparison

Percentage variation (MBE)*

$$MBE = \frac{\text{simulated datum} - \text{monitored datum}}{\text{monitored datum}}$$

Threshold values:

- Monitored datum on houlry/daily basis **± 10%**
- Monitored datum on a monthly basis **± 5%**

* Index to be used for comparing energy consumption

Calibration process

4 Comparison of the model outputs with the monitored data

- Reprocessing the simulated data so that they are comparable with the monitoring data
- Statistical comparison

Graphical comparison

Energy signature

A very useful step because it allows identifying which parameters/input data to refine/modify in the calibration process ...how?

Calibration process

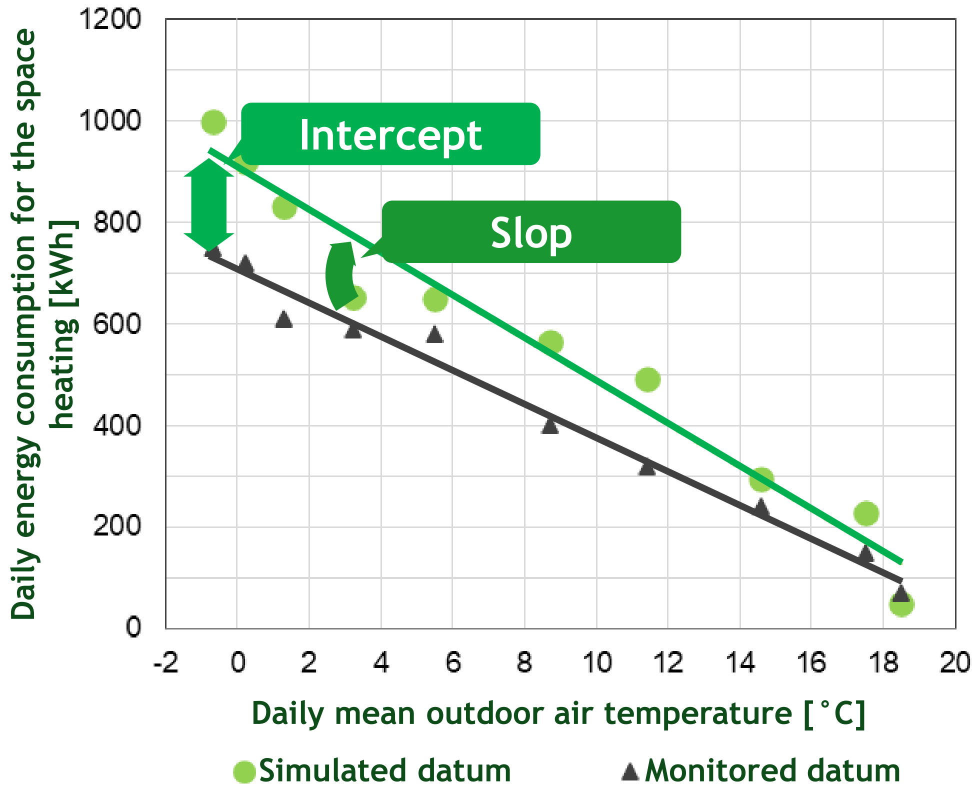
4 Comparison of the model outputs with the monitored data

- Reprocessing the simulated data so that they are comparable with the monitoring data
- Statistical comparison

Graphical comparison

To align the slope: Modify the parameters that depend on the temperature difference between the interior and the exterior.

e.g., Material properties, thermal transmittances, ventilation rates, system efficiencies, ...



Calibration process

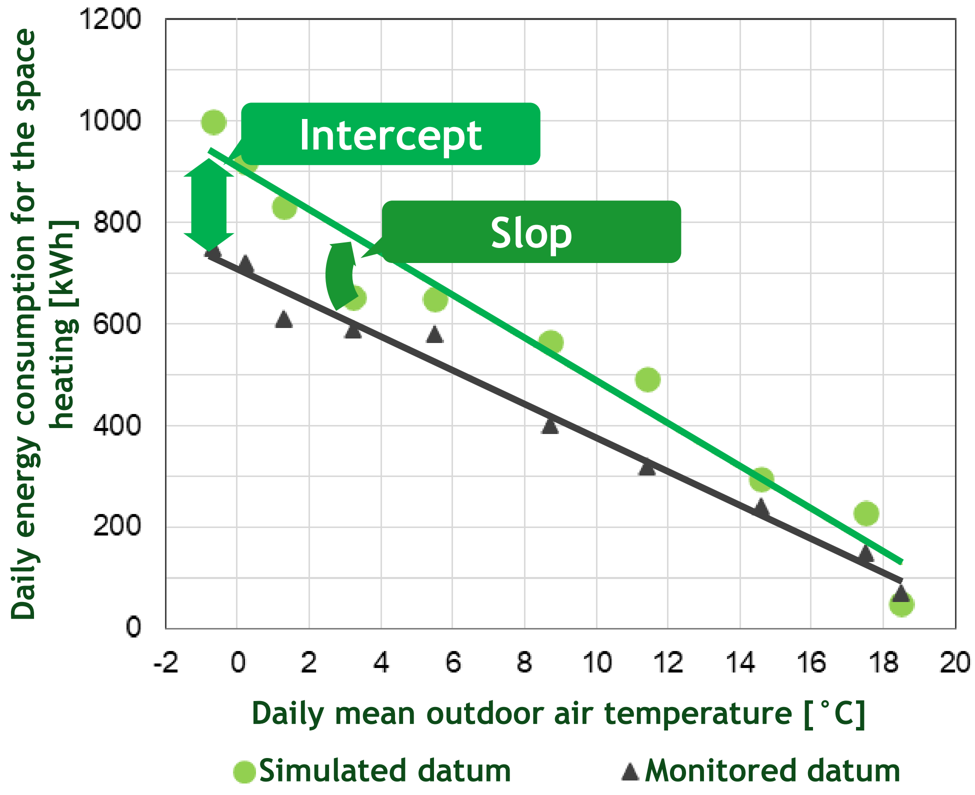
4 Comparison of the model outputs with the monitored data

- Reprocessing the simulated data so that they are comparable with the monitoring data
- Statistical comparison

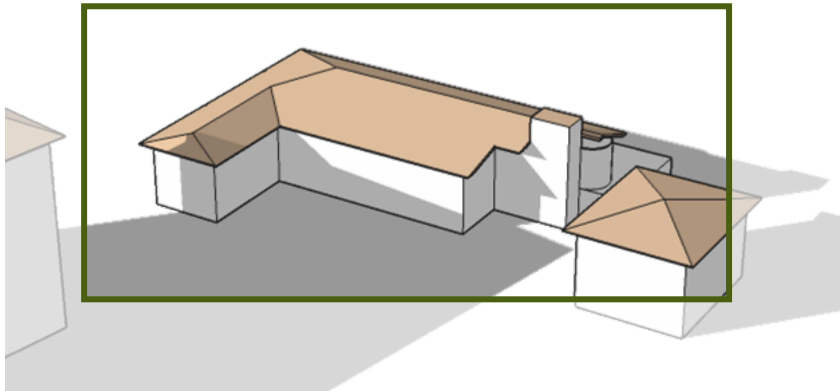
Graphical comparison

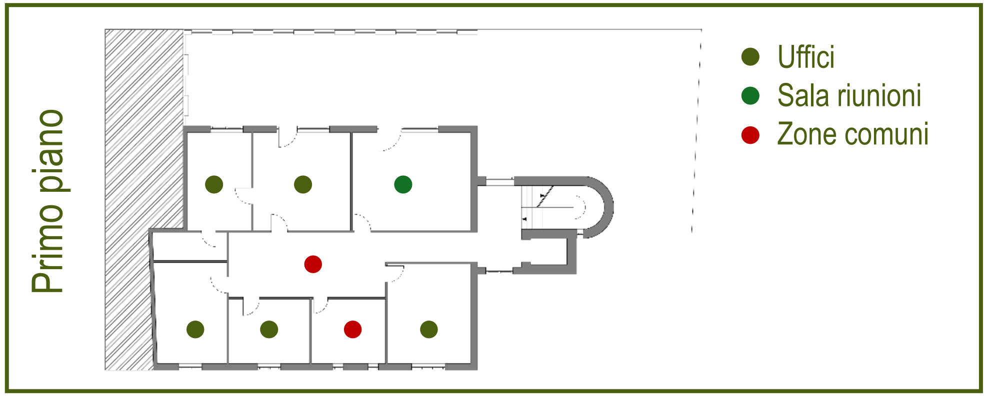
To align the intercept: Modify the parameters that do not depend on the temperature difference between the interior and the exterior.

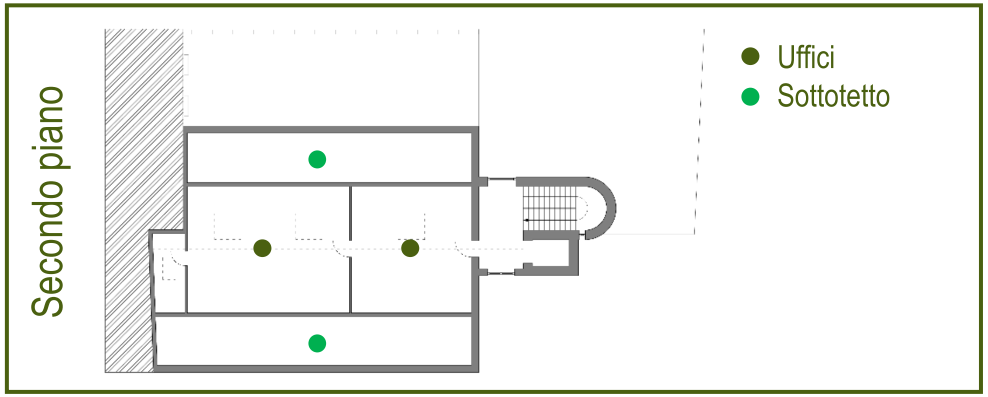
e.g., Internal gains, solar gains (solar properties of windows), set-point temperatures, system operation schedules, …



Case study: office building in Novara province

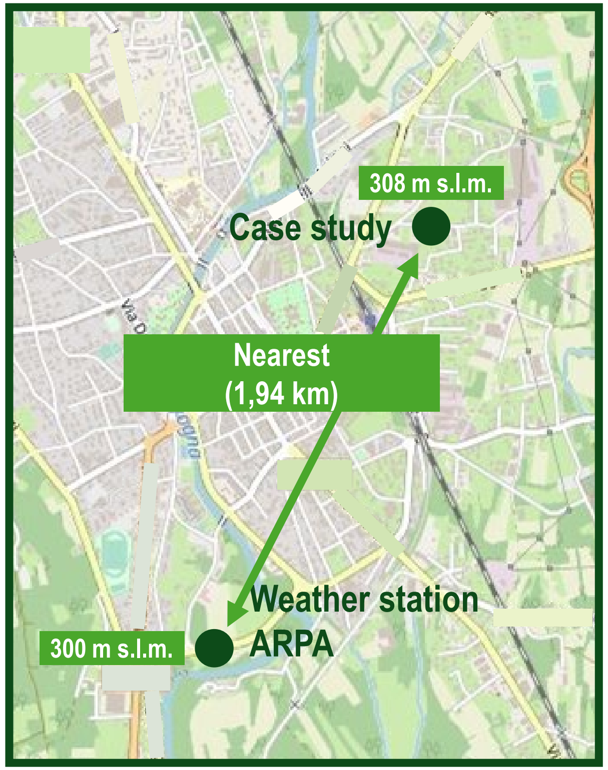




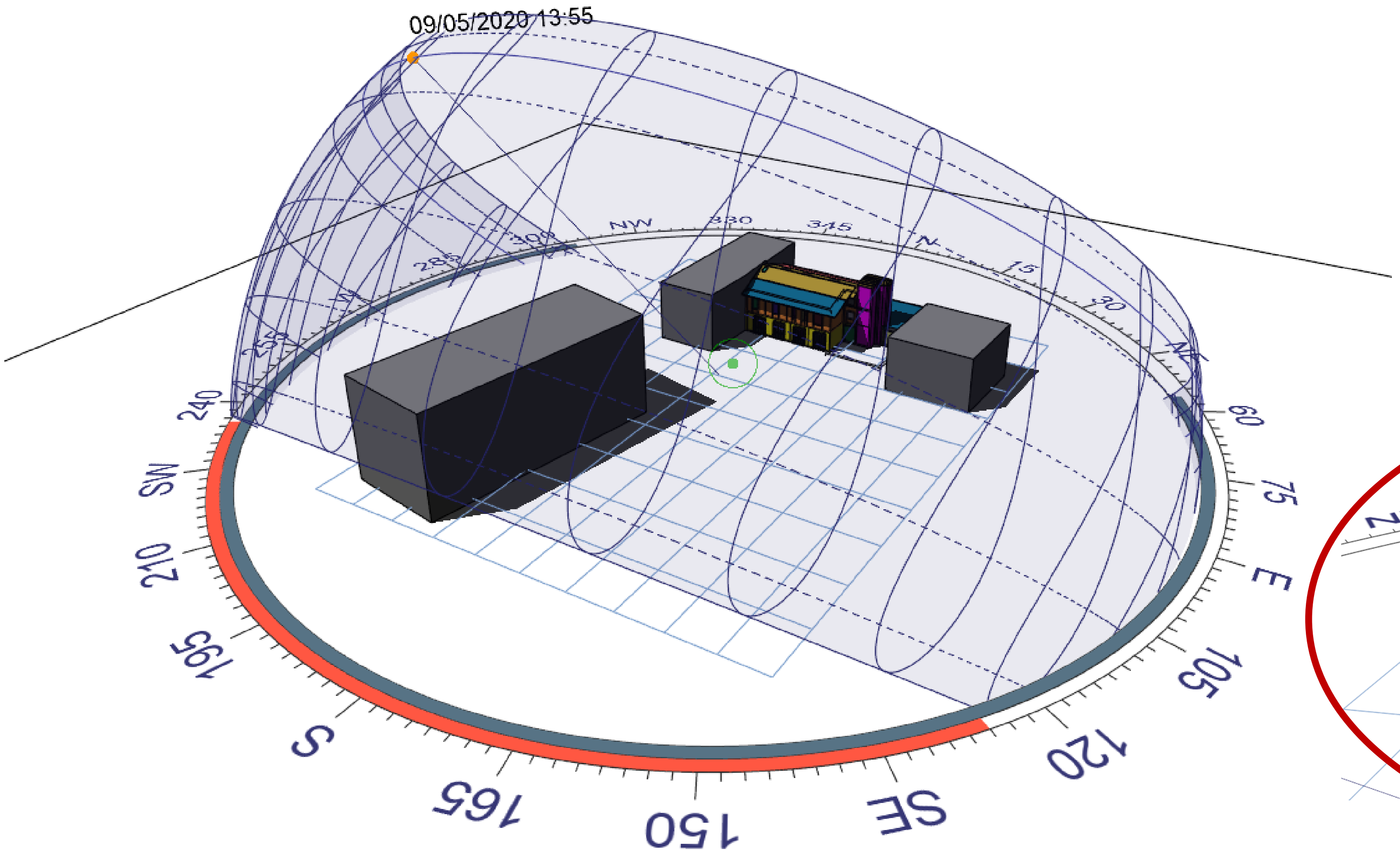


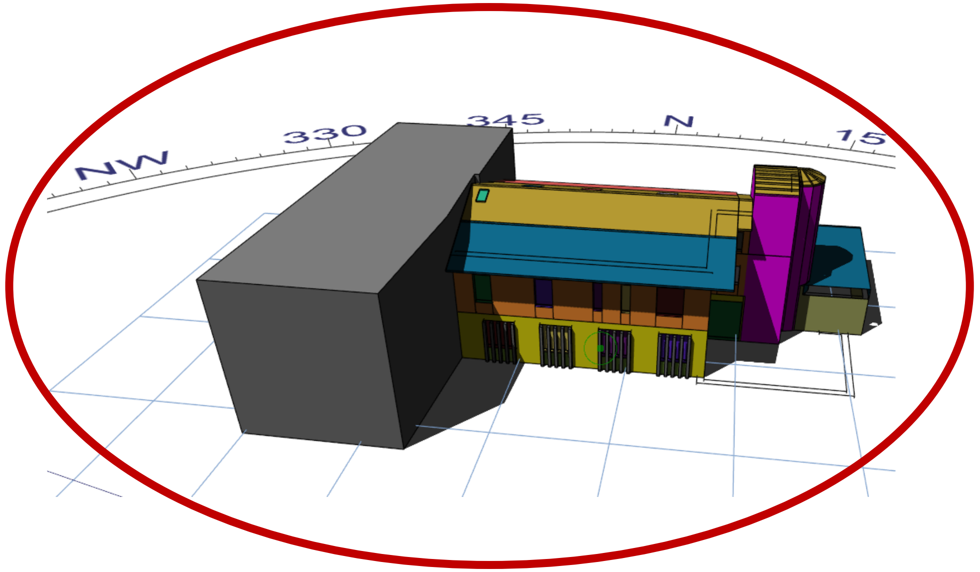
Data collection – climatic data

Data	Source	Objective
Solar radiation Wind speed Air temperature Dew point temperature Relative humidity	UNI 10349	Standard energy performance assessment Tailored energy performance assessment
Solar radiation Wind speed	ARPA Piemonte climatic station	Calibration
Air temperature Dew point temperature Relative humidity	In field measurement	Calibration



Data collection – geographical data





Geometrical characteristics

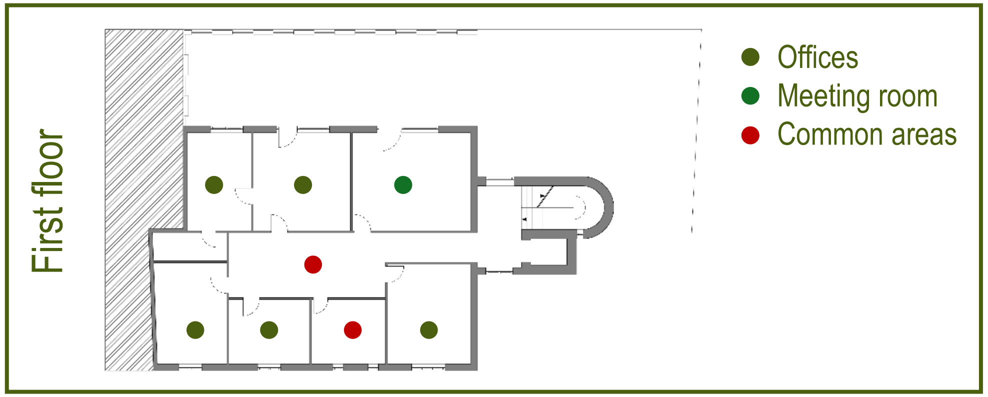
- Dimensions of spaces
- Interfloor heights

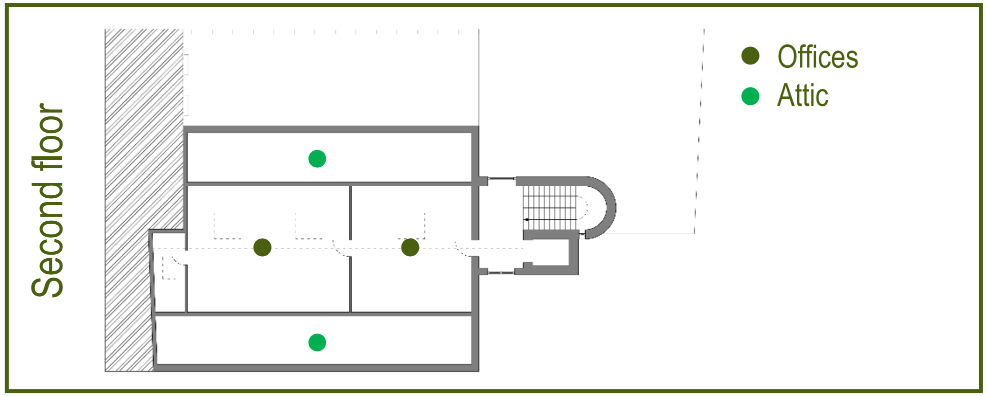
} Building documentation
In field measurement

- Windows
- Uses of spaces

} In field measurement

Window			Window dimensions									
ID.	Floor	Type	L	H	A	B	C	D	NO	E	NV	F
	[-]	[-]	[m]	[m]	[m]	[m]	[m]	[m]	[-]	[m]	[-]	[m]
FI01_DEP01	GF	Vertical	1.64	1.60	0.12	0.10	0.11	0.11			1	0.15
FI01_UFF01	GF	Vertical	1.90	1.60	0.12	0.10	0.11	0.11			1	0.15
FI01_UFF02	GF	Vertical	1.72	1.60	0.12	0.10	0.11	0.11			1	0.15
FI01_DEP02	GF	Vertical	2.14	1.60	0.12	0.10	0.11	0.11			1	0.15
FI01_UFF03	GF	Vertical	2.14	1.60	0.12	0.10	0.11	0.11			1	0.15
FI02_UFF03	GF	Vertical	2.14	1.60	0.12	0.10	0.11	0.11			1	0.15
PF01_COM01	GF	Vertical	2.18	2.59	0.01	0.15	0.07	0.07			1	1.23
FI01_UFF04	GF	Vertical	2.02	2.04	0.46	0.10	0.11	0.11			1	0.15
FI01_UFF05	GF	Vertical	2.06	2.03	0.44	0.10	0.11	0.11			1	0.15
FI01_UFF06	GF	Vertical	2.05	2.03	0.44	0.10	0.11	0.11			1	0.15
FI01_UFF07	GF	Vertical	2.02	2.04	0.45	0.10	0.11	0.11			1	0.15
FI01_COM02	FF	Vertical	0.30	8.20	0.07	0.07	0.07	0.07			1	0.48
FI02_COM02	FF	Vertical	1.37	1.17	0.11	0.10	0.10	0.10				
FI03_COM02	FF	Vertical	1.33	1.33	0.09	0.08	0.09	0.09	1	0.06	1	0.06





Users' information

- Internal gains profile
- Specific gains
  - Occupants: 53 W/per
  - PC: 46 W/app
  - Monitor: 13 W/app
  - Lighting: 60 W/app
- Mechanical ventilation
  - 0,58 vol/h

Internal gains profile → Weekly monitoring sheet

Specific gains → ASHRAE Fundamentals «re-adapted» from calibration of a single office

Mechanical ventilation → Real feature and profile

Monitoring sheets

For each room and each occupant

OCCUPANCY

P = in office | R = not in office | A = at home

User	Operator 1																					
	8:00-9:00		9:00-10:00		10:00-11:00		11:00-12:00		12:00-13:00		13:00-14:00		14:00-15:00		15:00-16:00		16:00-17:00		17:00-18:00		18:00-19:00	
Monday	A	A	P	P	P	P	P	P	P	P	R	R	P	P	P	P	P	R	P	P	A	A
Tuesday	A	A	P	P	P	P	P	P	P	P	P	R	P	P	R	R	R	P	P	P	A	A
Wednesday	A	A	P	P	P	P	P	P	P	P	P	P	P	P	R	P	P	P	P	P	A	A
Thursday	A	A	P	P	P	P	P	P	P	P	R	R	P	P	R	R	R	P	P	P	A	A
Friday	A	A	A	P	P	P	P	P	P	P	P	R	P	P	P	P	P	P	P	P	A	A
Saturday	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Sunday	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Energy modelling assumption

Creation of an internal gains profile for weekdays for:
- Occupants
- Device usage
- Artificial lighting usage

Building occupants

For each room:
- Total number of occupants (sub-hourly basis) for each day of the week
- Fraction of the number of occupants (number of occupants / total number of occupants)
- Average to obtain hourly value

	Occupancy profile																					
	8-9		9-10		10-11		11-12		12-13		13-14		14-15		15-16		16-17		17-18		18-19	
Lun	0	0.8	1	1	1	1	1	1	1	0.8	0	0.3	0.8	0.8	0.8	0.5	0.5	0.3	0.5	0.5	0.3	0
Mar	0	0.3	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.3	0	0.3	0.5	0.3	0.3	0.3	0.5	0.5	0.5	0.3	0
Mer	0	0.5	0.8	0.8	0.8	1	1	1	1	1	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5	0.5	0.3	0
Gio	0	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.3	0	0.8	0.8	0.5	0.5	0.5	0.8	0.8	0.8	0.3	0
Ven	0	0.3	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0	0
Sab	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Occupancy profile										
	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Lun	0.38	1.00	1.00	1.00	0.88	0.13	0.75	0.63	0.38	0.50	0.13
Mar	0.13	0.63	0.75	0.75	0.75	0.13	0.38	0.25	0.38	0.50	0.13
Mer	0.25	0.75	0.88	1.00	1.00	0.50	0.50	0.25	0.50	0.50	[illegible]
Gio	0.25	0.75	0.75	0.75	0.75	0.13	0.75	0.50	0.63	0.75	0.13
Ven	0.13	0.63	0.75	0.75	0.75	0.25	0.50	0.50	0.50	0.38	0.00
Sab	0	0	0	0	0	0	0	0	0	0	0
Dom	0	0	0	0	0	0	0	0	0	0	0

- Average for each hour of the fraction of occupants on each day of the week

	Occupancy profile										
	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Feriali	0.23	0.75	0.83	0.85	0.83	0.23	0.58	0.43	0.48	0.53	0.10
Festivi	0	0	0	0	0	0	0	0	0	0	0

Energy modelling assumption

Device usage

- Consider one PC and one monitor per occupant (total of 59 W per occupant)
- For each room: Analysis of occupancy: absent (A), in office (P), not in office (R)
- (just like for occupants)

	Occupancy profile																					
	8-9		9-10		10-11		11-12		12-13		13-14		14-15		15-16		16-17		17-18		18-19	
Lun	A	A	P	P	P	P	P	P	P	P	R	R	P	P	P	P	P	R	P	P	A	A
Mar	A	A	P	P	P	P	P	P	P	P	P	R	P	P	R	R	R	P	P	P	A	A
Mer	A	A	P	P	P	P	P	P	P	P	P	P	P	P	R	P	P	P	P	P	A	A
Gio	A	A	P	P	P	P	P	P	P	P	R	R	P	P	R	R	R	P	P	P	A	A
Ven	A	A	A	P	P	P	P	P	P	P	P	R	P	P	P	P	P	P	P	P	A	A
Sab	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Dom	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

A Devices switched off
P Devices switched on
R Devices switched on (stand-by)

- Fraction of the number of devices turned on (also considering stand-by with power reduced to 20% - ASHRAE value)
- Average to obtain hourly values
- Average for each hour of the fraction of devices on each day of the week

	Dispositivi										
	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Feriali	0.225	0.755	0.825	0.85	0.83	0.31	0.59	0.465	0.5	0.53	0.1
Festivi	0	0	0	0	0	0	0	0	0	0	0

Energy modelling assumption

Artificial lighting usage

Consider that, even if there is only one occupant, the system is on (100% power)
For each room: Analysis of occupancy: absent (A), in office (P), not in office (R)

	Occupancy profile																					
	8-9		9-10		10-11		11-12		12-13		13-14		14-15		15-16		16-17		17-18		18-19	
Lun	A	A	P	P	P	P	P	P	P	P	R	R	P	P	P	P	P	R	P	P	A	A
Mar	A	A	P	P	P	P	P	P	P	P	P	R	P	P	R	R	R	P	P	P	A	A
Mer	A	A	P	P	P	P	P	P	P	P	P	P	P	P	R	P	P	P	P	P	A	A
Gio	A	A	P	P	P	P	P	P	P	P	R	R	P	P	R	R	R	P	P	P	A	A
Ven	A	A	A	P	P	P	P	P	P	P	P	R	P	P	P	P	P	P	P	P	A	A
Sab	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Dom	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

A Lighting off
P Lighting on
R Lighting off

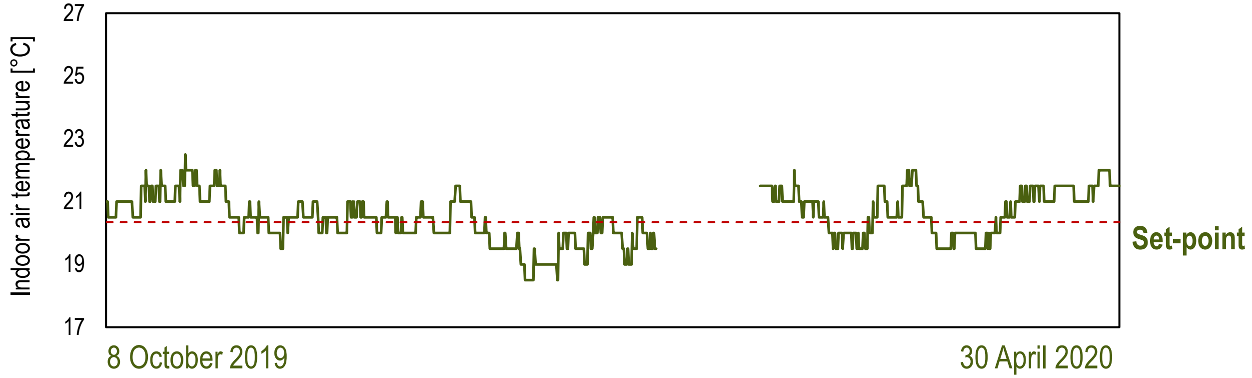
- Average to obtain hourly values
- Average for each hour of the fraction of devices on each day of the week

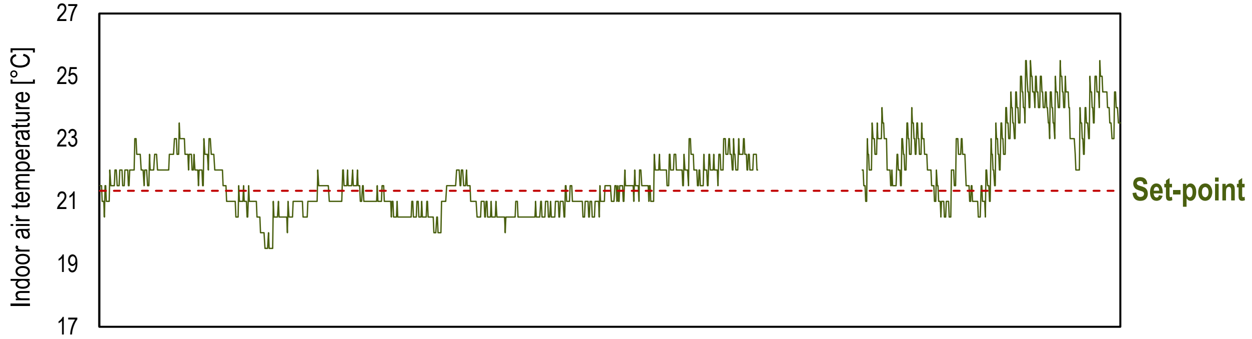
	Illuminazione										
	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Feriali	0.5	1	1	1	1	1	1	1	1	1	0.4
Festivi	0	0	0	0	0	0	0	0	0	0	0

Energy modelling assumption

Identification of internal set-point temperatures

Analysis of temperature trends during nighttime hours and on weekends for monitored spaces
Average value of temperatures during non-occupancy hours (nighttime and weekdays)





UFF01	20.3 °C
UFF02	21.1 °C
COM02	21.6 °C
UFF03	20.7 °C
UFF05	22.3 °C
UFF07	22.6 °C
UFF08	22.3 °C
UFF11	22.6 °C
UFF13	21.3 °C

Energy modelling assumption

Activation of mechanical ventilation system

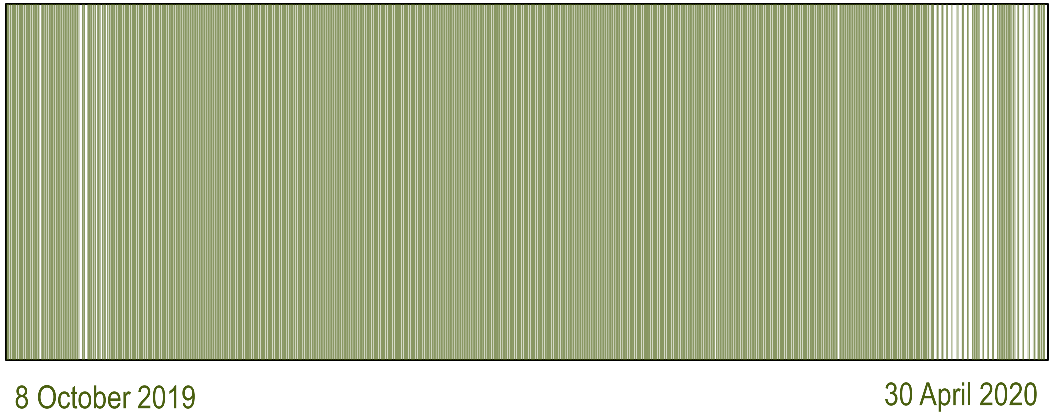
System on: Monday to Friday, from 7:30 to 19:30 Saturday, from 7:30 to 12:00

Supply air temperature: 19°C if the outdoor temperature is below 19°C or, equal to the outdoor temperature (unconditioned air)

Building documentation
In field analysis/interview

When?

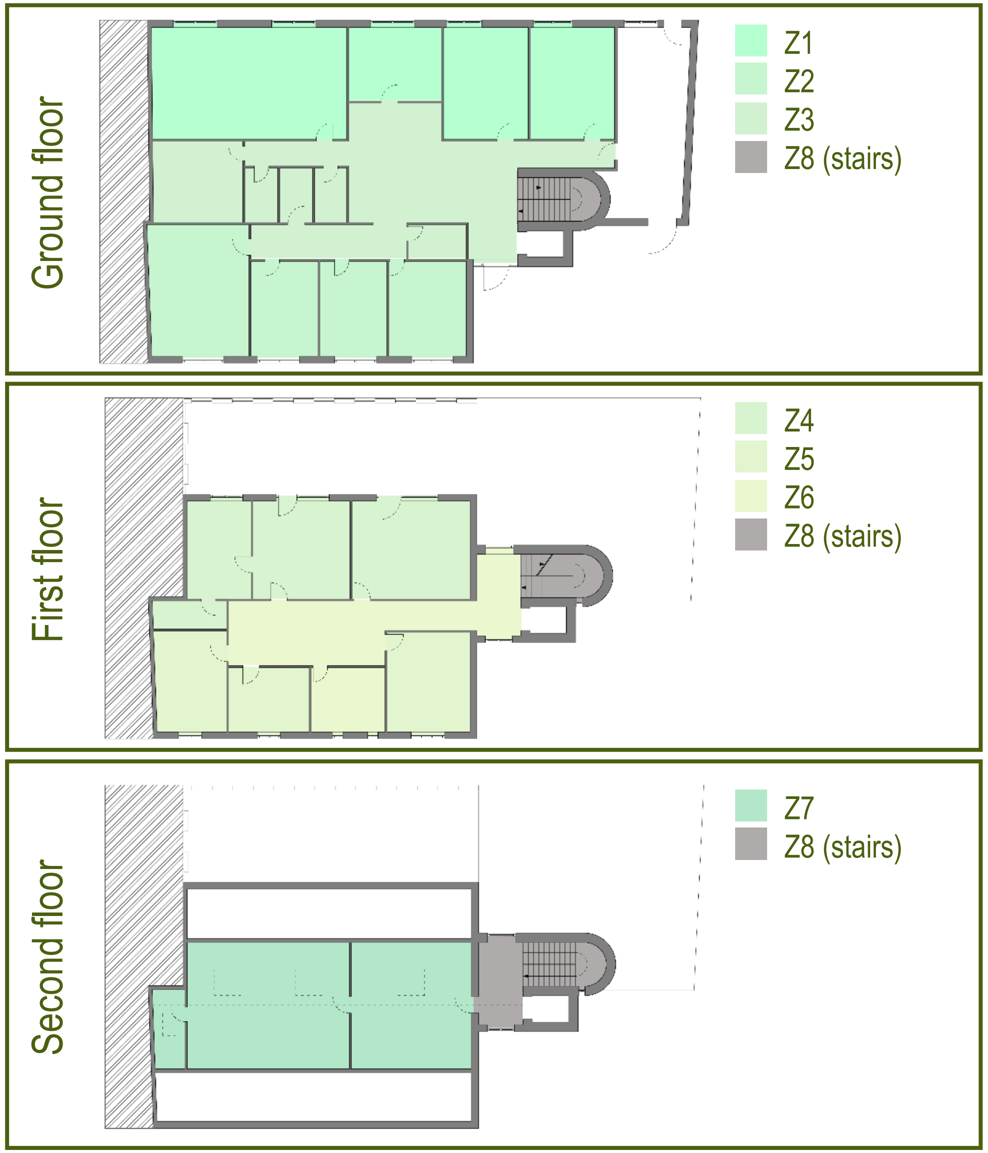
Analysis of outdoor temperatures during system activation periods



$t_{est} < 19$ °C Treated air
$t_{est} > 19$ °C Untreated air

The air must be conditioned for 96% of the activation time, so a constant supply temperature of 19°C has been considered

Energy modelling assumption



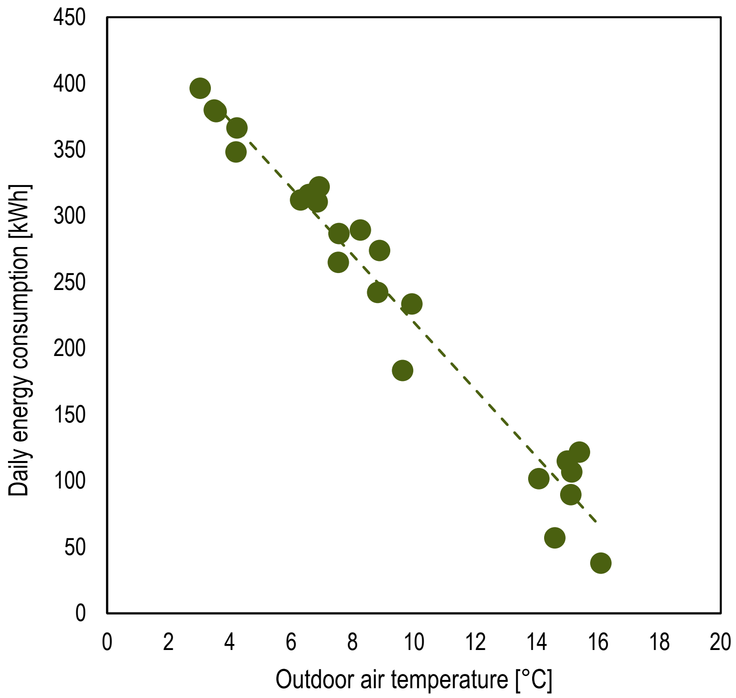
- Each room has been associated with corresponding profiles and values for internal gains.
- In the common areas (Z3, Z6, and Z8), only the thermal gain due to lighting has been considered.
- For each thermal zone, an internal set-point temperature value has been calculated by averaging the values of the rooms belonging to the thermal zone (for Z3, Z6, and Z8, a set-point of 20°C has been considered).
- White spaces have been considered as non-conditioned spaces (including the basement).

Calibration procedure

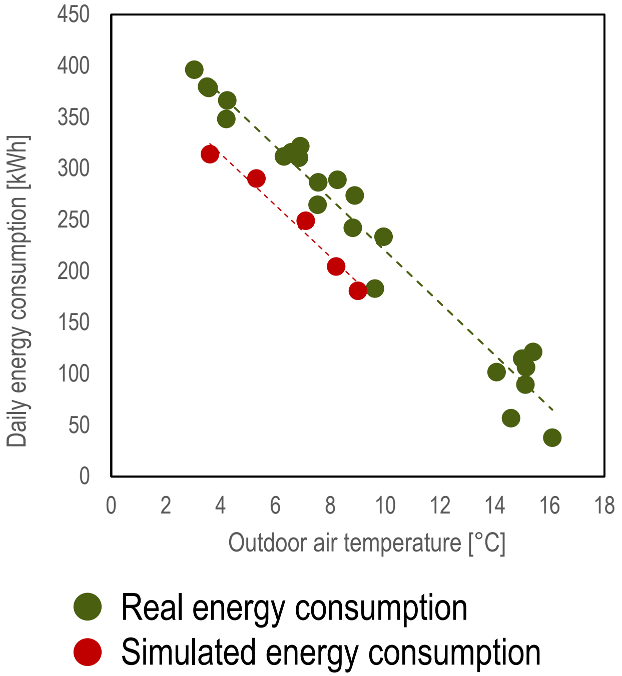
The calibration is carried out using a graphical method (ASHRAE Guidelines 14:2014) applying the energy signature.
Reduced errors in attributing consumption to one month or another for periods spanning across two months

For each reading period:

- Average daily consumption (total consumption of the period / number of days)
- Average outdoor temperature of the reading days



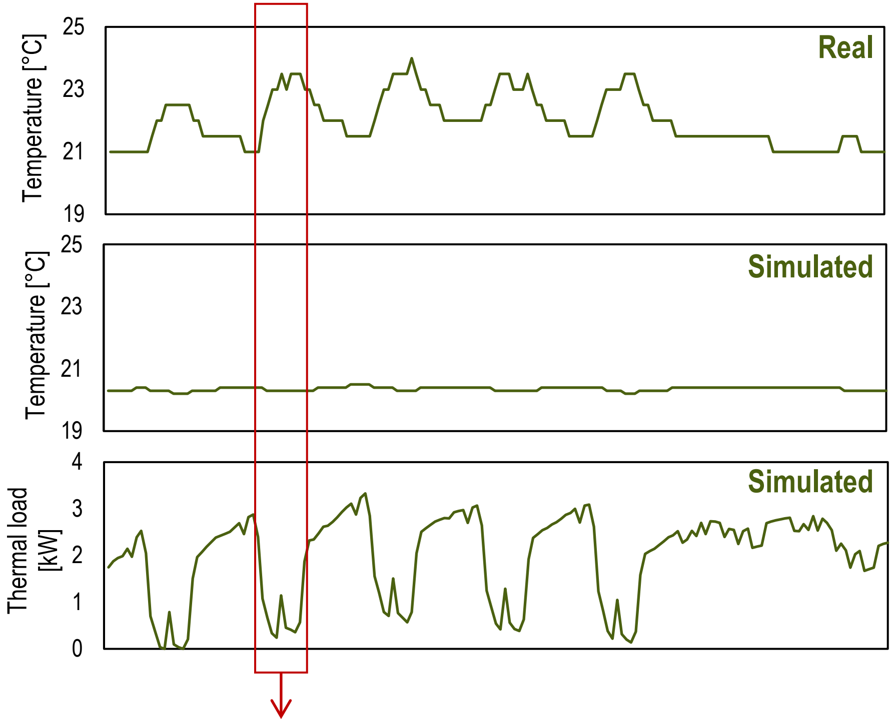
Calibration procedure



✓ Slop × Intercept

Variables independent of the temperature difference between the indoor and outdoor environment

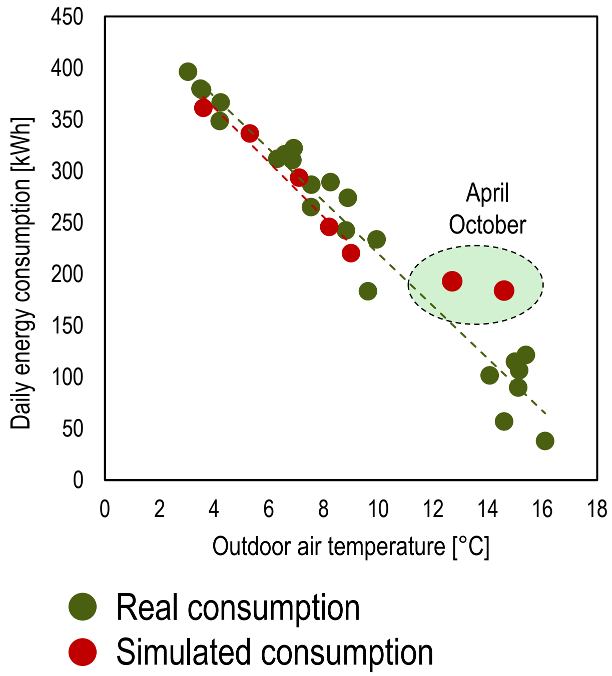
Why?



Ideal air temperature control

Lower demand than actual!

Calibration procedure



Modified variables:

Set-point temperatures
Thermal gains from lighting
Generation and distribution efficiencies

Criticality

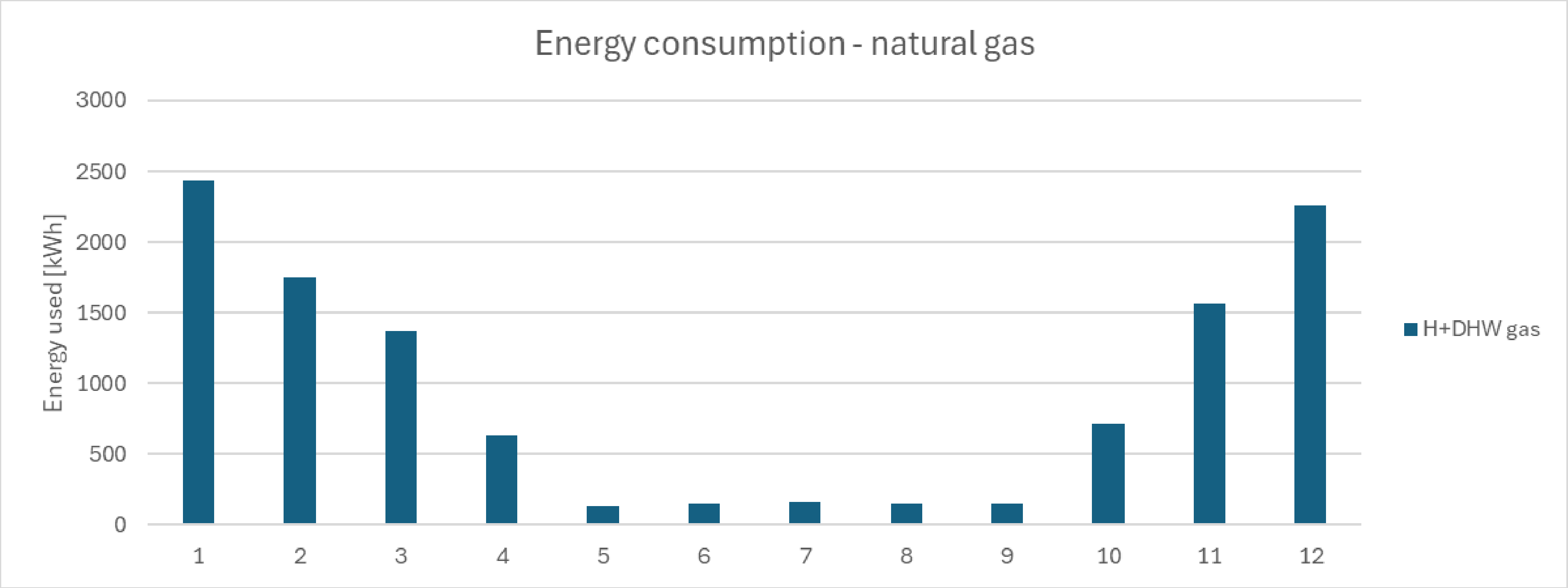
October and April months

Overestimation of consumption in the intermediate months

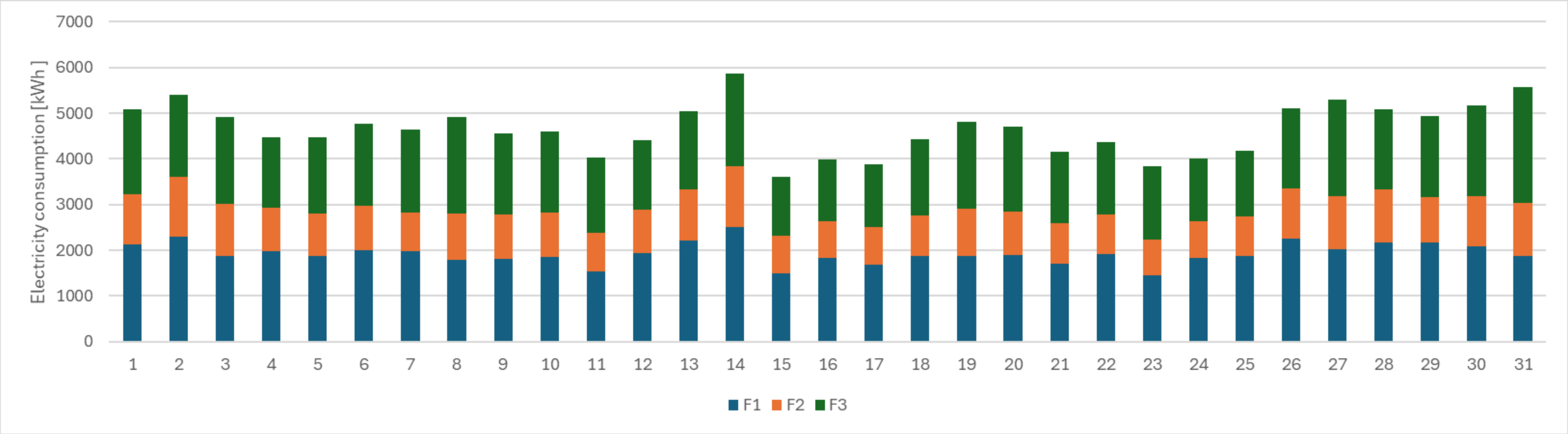
The same criticality was also found in a previous work, where the hourly model UNI EN ISO 52016-1 overestimates heating thermal demands in the intermediate months compared to a detailed dynamic model.

The reason for the discrepancy was attributed to different modeling approaches for thermal capacity and incoming solar radiation into the environment.

Energy baseline



Disaggregation of the electricity consumption



	F1	F2	F3
Min	34%	19%	33%
Ave	42%	21%	37%
Max	46%	24%	45%

F1: active from Monday to Friday, from 8.00 to 19.00, excluding national holidays.

F2: active from Monday to Friday, from 7.00 to 8.00 and from 19.00 to 23.00, excluding national holidays; Saturday, from 7.00 to 23.00, excluding national holidays.

F3: active from Monday to Saturday from 0.00 to 7.00 and from 23.00 to 24.00; Sunday and holidays all hours of the day

Disaggregation of the electricity consumption

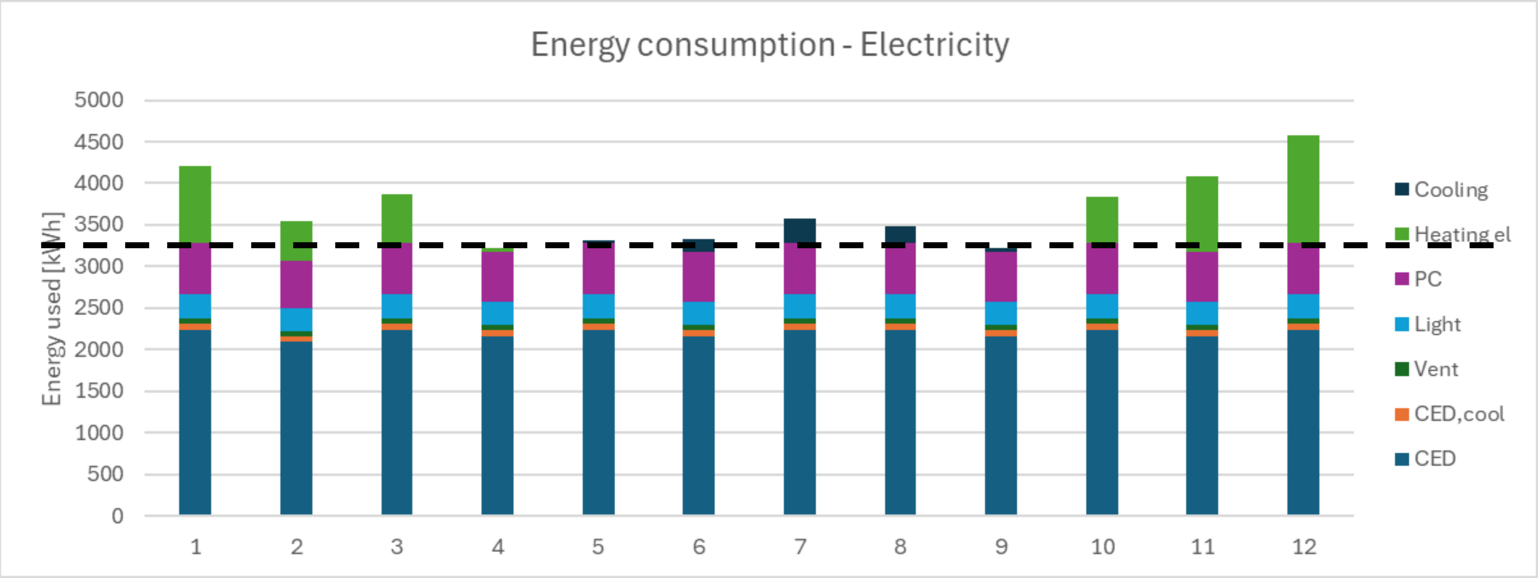
Consumption bands	Energy uses
F1 (working hours)	Heating (auxiliary + pre-heating) Cooling Ventilation Lightning PCs Data centers Data centers cooling
F2	Heating (auxiliary + pre-heating) Data centers Data centers cooling
F3	Heating (auxiliary + pre-heating) Data centers Data centers cooling

Active 24/24

Active during working hours

More consuming during the night-time due to back up

Disaggregation of the electricity consumption



energy uses that depend on the outdoor temperature

energy uses that are assumed to be nearly constant throughout the year

PC → calculated based on the number of PCs, their estimated power and the time of use
Lighting → calculated based on the number of lamps installed, their estimated power and the time of use
Ventilation and heating → from a rough simulation

Benchmarking

Benchmarking is the practice of comparing the measured performance of a device, process, facility, or organization to itself, its peers, or established norms, with the goal of informing and motivating performance improvement.

When applied to building energy use, benchmarking serves as a mechanism to measure energy performance of a single building over time, relative to other similar buildings, or to modeled simulations of a reference building built to a specific standard (such as an energy code).

https://www.energy.gov/scep/slsc/building-energy-use-benchmarking

Benchmarking

- Building envelope
  - U-Values of the opaque envelope components compared with the Italian reference building
  - U-values of the transparent envelope components compared with the Italian reference building
- Building technical systems
  - Energy efficiency of the sub-systems

https://www.energy.gov/scep/slsc/building-energy-use-benchmarking

Benchmarking

Cod.	Tipo	Descrizione	U media [W/m²K]
M2	T	Vs. vano scala	0,739
M4	T	Esterno (terra)	0,528
M6	U	Vs. Magazzino	1,875
M7	T	Esterno (primo/secondo)	1,146
M8	U	Vs. sottotetto (1)	0,585
M9	T	Esterno (secondo)	0,621
M13	U	Vs. vano scala (U)	0,707
M18	U	Vs. sottotetto (2)	0,585
P1	G	Vs. terreno	0,178
P2	U	Terra vs. interrato	1,963
S5	U	Secondo vs. primo corridoio (U)	0,281
S6	T	Soffitto a terrazzo	0,639
S10	T	Tetto a falda	0,497
S13	U	Secondo vs. primo corridoio (U-2)	0,281

Zona climatica	U (W/m²K)	
	2015[(1)]	2019/2021[(2)]
A e B	0,45	0,43
C	0,38	0,34
D	0,34	0,29
E	0,30	0,26
F	0,28	0,24

Zona climatica	U (W/m²K)	
	2015[(1)]	2019/2021[(2)]
A e B	0,38	0,35
C	0,36	0,33
D	0,30	0,26
E	0,25	0,22
F	0,23	0,20

Zona climatica	U (W/m²K)	
	2015[(1)]	2019/2021[(2)]
A e B	0,46	0,44
C	0,40	0,38
D	0,32	0,29
E	0,30	0,26
F	0,28	0,24

Benchmarking

Cod.	Tipo	Descrizione	U [W/m²K]
W2	T	FI01_UFF01	1,788
W3	T	FI01_UFF02	1,791
W4	T	FI01_DEP02	1,786
W5	T	FI01_UFF03	1,786
W6	T	FI02_UFF03	1,786
W7	T	PF01_COM01	1,829
W8	T	FI01_UFF04	1,802
W9	T	FI01_UFF05	1,801
W10	T	FI01_UFF06	1,801
W11	T	FI01_UFF07	1,801
W13	T	FI02_COM02	1,788
W14	T	FI03_COM02	1,791
W15	T	PF01_DEP03	1,707
W16	T	PF01_UFF08	1,693
W17	T	FI01_UFF08	1,702
W18	T	FI01_UFF09	1,694
W19	T	FI01_UFF10	1,683
W20	T	FI01_UFF11	1,683
W21	T	FI01_COM03	1,684
W22	T	FI02_COM03	1,684
W23	T	FI01_UFF12	1,686
W24	T	FI01_COM04	1,791
W25	T	FI02_COM04	1,792
W26	T	FI01_UFF13	1,715
W27	T	FI01_UFF14	1,715
W28	T	FI02_UFF14	1,715
W29	T	FI01_COM05	1,697

Zona climatica	U (W/m²K)	
	2015 (1)	2019/2021 (2)
A e B	3,20	3,00
C	2,40	2,20
D	2,00	1,80
E	1,80	1,40
F	1,50	1,10

Benchmarking

Heating system

Energy efficiency	Symbol	[%]
Energy efficiency of the emission sub-system	$\eta_{H,em}$	93,6
Energy efficiency of the regulation sub-system	$\eta_{H,rg}$	94,0
Energy efficiency of the distribution sub-system	$\eta_{H,d}$	96,0
Energy efficiency of the generation sub-system	$\eta_{H,gn}$	88,7
Global energy efficiency of the heating system	$\eta_{H,g,p,tot}$	70,9

Domestic Hot Water production

Energy efficiency	Symbol	[%]
Global energy efficiency of the DHW production system	$\eta_{H,g,p,tot}$	56,5

To conclude

- A robust baseline is necessary for all energy and environmental goals related to the decarbonization of the building stock.
- Different baselines could be used depending on the objectives of the analysis.
- There are several ways to achieve a robust baseline. In the absence of energy data from monitoring, calibrated simulation can be the right approach.
- The baseline is not static: it must be updated if there are changes that alter the building's energy demand.
- Updating the baseline is essential and should be archived along with the rest of the documentation within the building logbook

If you would like more information, please visit www.timepac.eu or contact us at

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Thanks for your attention!

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