

TIMEPAC

Academy

Session 3

Comparison of the modelled and real consumption data

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Politecnico di Torino



Cyprus Energy Agency

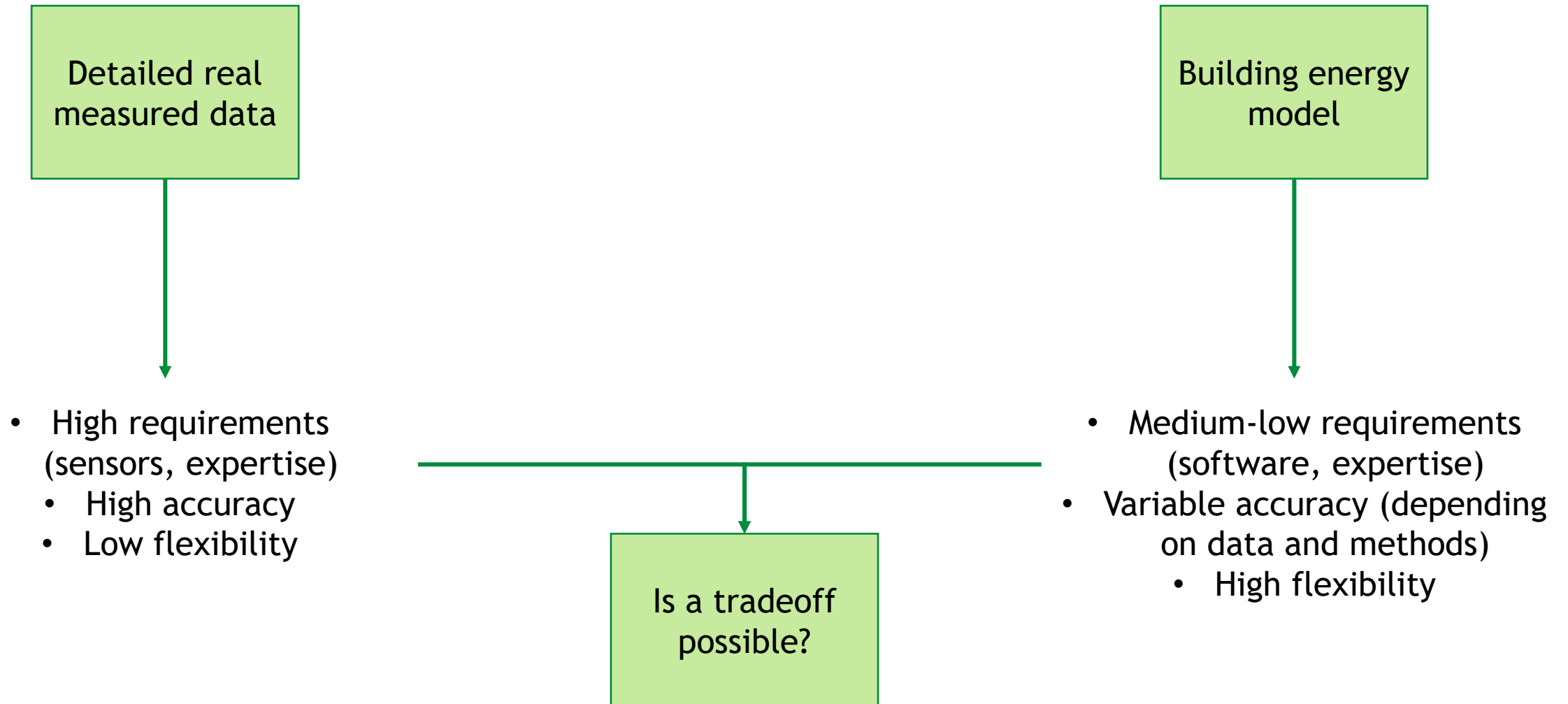
SERA

Institute for Sustainable Energy and Resources Availability

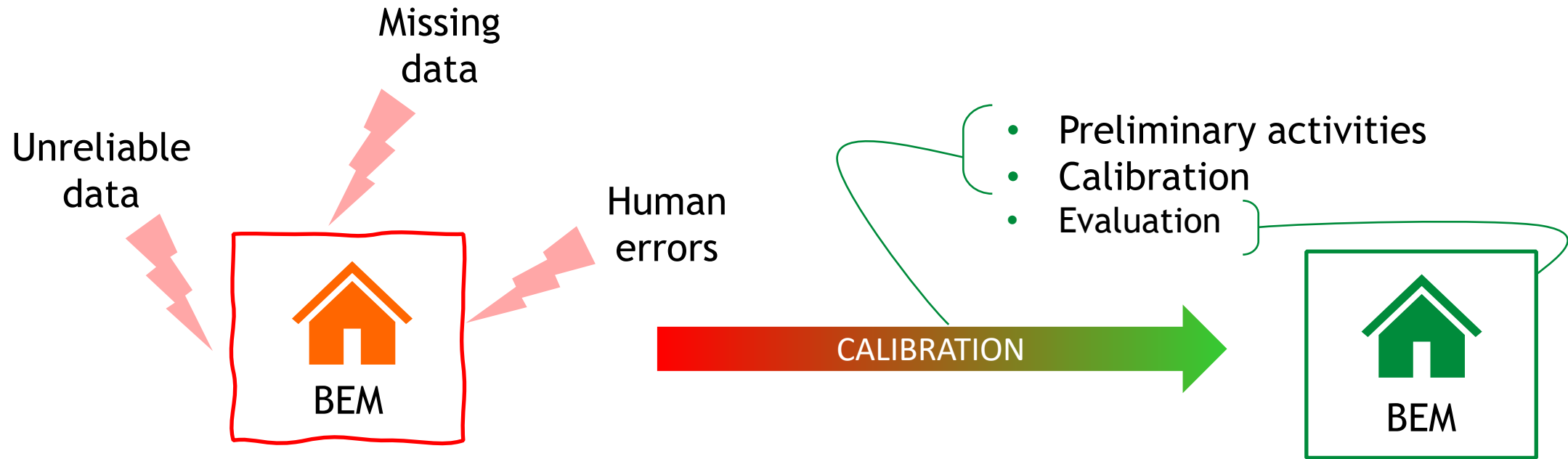


Jožef Stefan Institute

The building energy behaviour



The calibration



“The calibration is the process of reducing the uncertainty of a model by comparing the predicted output of the model under a specific set of conditions to the actual measured data for the same set of conditions”¹

¹American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE Guidelines 14-2014: Measurement of energy, demand, and water savings. Atlanta (USA): ASHRAE, 2014.

Preliminary phases – Monitored data

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1. Identification of the **type** and **temporal discretisation of monitored data** against which perform the model calibration

Types of monitored data (examples):

- Energy consumption
- Indoor temperatures
- ...

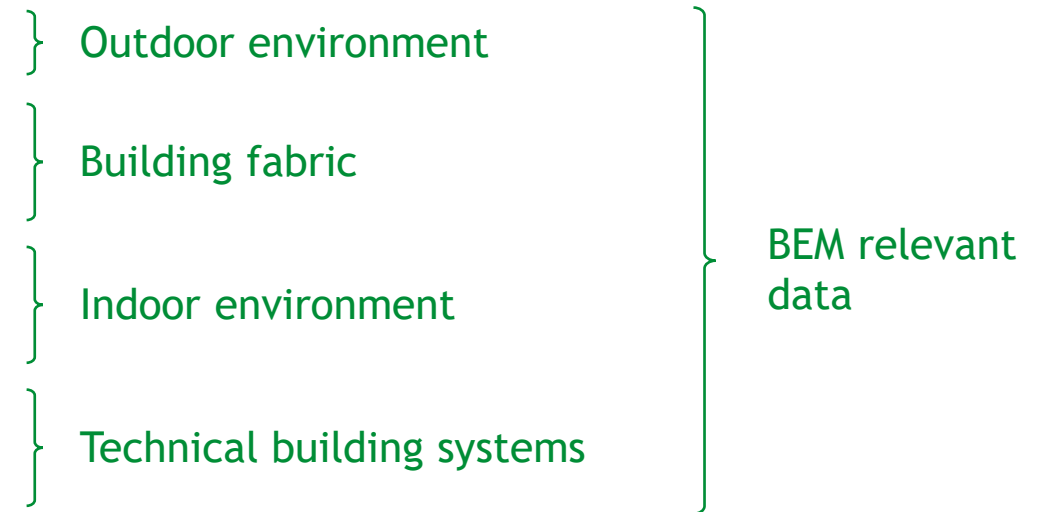
Temporal discretisation of monitored data:

- Seasonal data
- Monthly data
- Hourly data

Preliminary phases – Data gathering

2. Collection of relevant data for the creation of the building energy model and for the calibration period

- Climatic data
- Geometric data
- Building envelope data
- Occupant behaviour data
- Set-point temperatures
- HVAC technical specifications
- HVAC operation
- Monitored data



Mandatory data » Calibration cannot be performed without these data

Preliminary phases – BEM

- 1
- 2
3. Derivation of not available data from Standards (or other sources*) - only for not mandatory data!!
 - Building envelope data » Typical constructions, EN ISO 10456 (material properties)
 - Occupant behaviour data » EN 16798-1
 - Set-point temperatures » EN 16798-1
 - HVAC operation » EN 16798-1
4. Creation of the **base model**, based on the collected or derived input data

* E.g., national or international legislation, market analysis, historical records

Preliminary phases – Calibration scenario

5. Choose of the “calibration scenario” and proceed to calibration phases

	Energy consumption	Indoor temperature
Seasonal	Scenario 1	Not applicable
Monthly	Scenario 1	Not applicable
Hourly	Scenario 2	Scenario 2

Calibration phases – Energy consumption

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6. Simulation of the base model, extraction of the simulated energy consumptions, and comparison with the monitored data
 - a. Elaboration of simulated data to make them comparable with the monitoring periods
 - b. Calculation of the *MBE* and/or *CV(RMSE)* statistical indices
 - c. Performing an energy signature
 7. Check for statistical indexes compliance with the limit values

Statistical indices

Mean bias error (MBE)

Is an indication of overall bias in a regression model.

$$MBE = \frac{(\sum y_{\text{measured}} - y_{\text{simulated}})}{n}$$

Where:

y is the energy consumption

n is the number of considered time-steps

Data time-step	Limit value ¹ [%]
Hourly	±10
Monthly	±5

¹American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE Guidelines 14-2014: Measurement of energy, demand, and water savings. Atlanta (USA): ASHRAE, 2014.

Statistical indices

Coefficient of variation of the root-mean-square error [CV(RMSE)]

Is an indication of how much variation or randomness there is between the data and the model

$$CV(RMSE) = \left(\frac{\sum (y_{\text{measured}} - y_{\text{simulated}})^2}{n} \right)^{1/2} / \bar{y}$$

Where:

y is the energy consumption

n is the number of considered time-steps

Data time-step	Limit value ¹ [%]
Hourly	30
Monthly	15

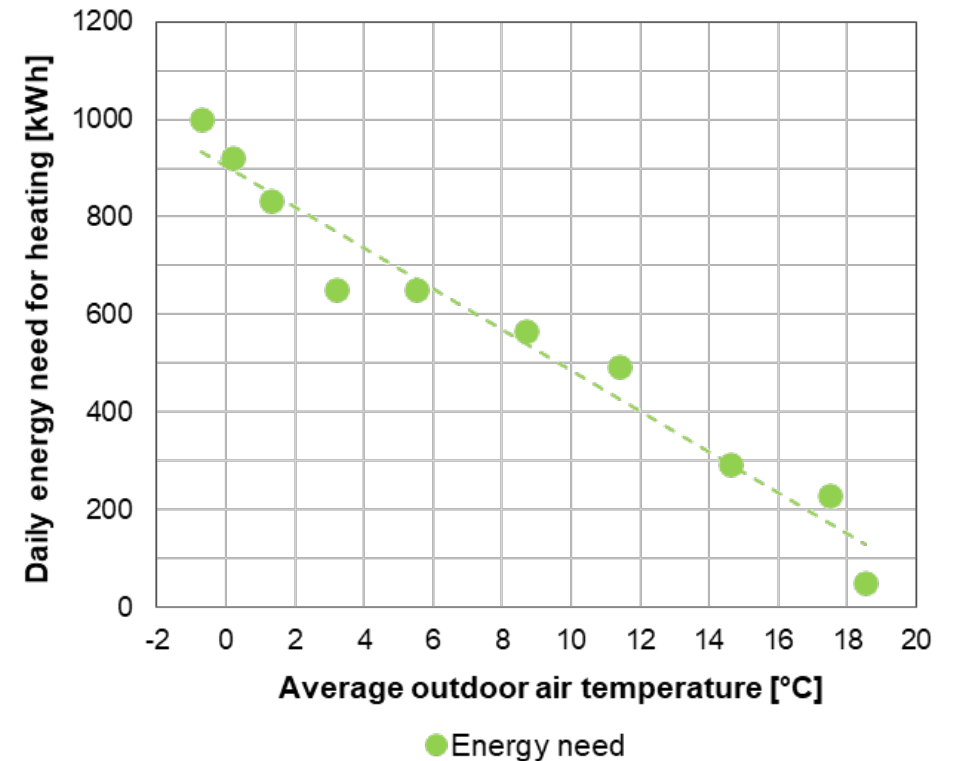
¹American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE Guidelines 14-2014: Measurement of energy, demand, and water savings. Atlanta (USA): ASHRAE, 2014.

Energy signature

“For a given energy-balance model, the energy signature (ES) of a building denotes a set of parameters that describe its energy performance. The number of parameters used depends on the energy-balance model and can vary from one to five”²

Linear regression

$$Q = Q_0 - LT_e$$
$$Q = Q_0 + L(T_i - T_e)$$



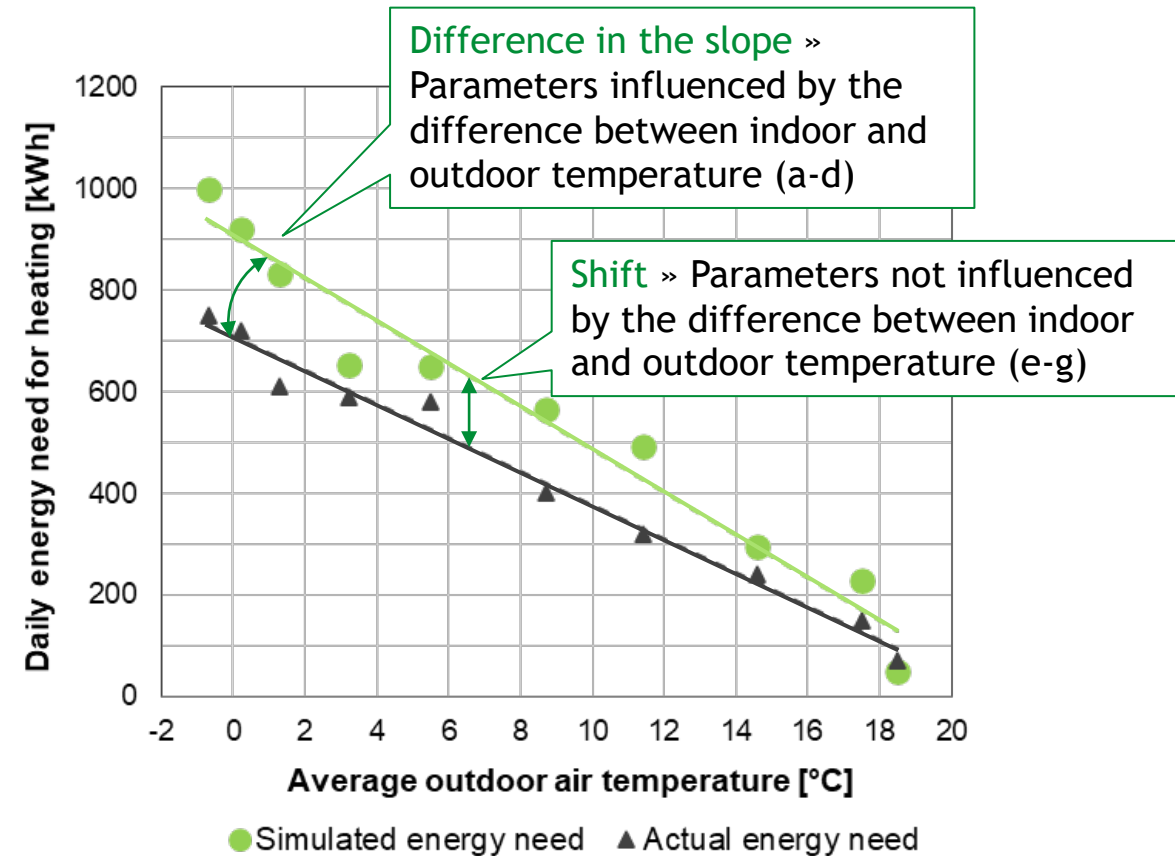
²S. Hammarsten. A critical appraisal of energy-signature models. Applied Energy, 26 (2) (1987), pp. 97-110

Calibration phases – Parameters to be modified

- 1
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8. Selection of parameters to be modified
 - a. Material properties
 - b. Thermal bridges
 - c. Ventilation/Infiltration rates
 - d. HVAC technical specifications
 - e. Internal heat gain load and/or profiles
 - f. Heating/cooling set-points
 - g. HVAC operation profile
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How to choose which parameters?

-> From the energy signature



Calibration phases – Energy consumptions

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9. Variation of the parameters, one-at-the-time or combined

10. Simulation of the modified model and comparison with the monitored data

a. Calculation of the *MBE* and/or *CV(RMSE)* statistical indexes

b. Performing an energy signature

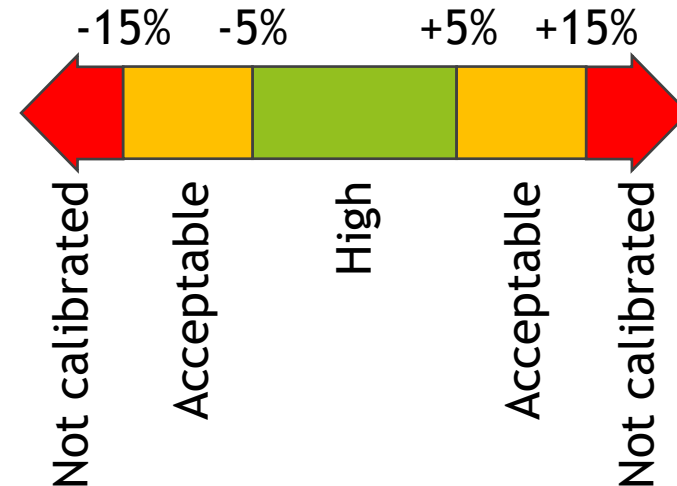
11. Check for statistical indexes compliance with the limit values

Repeat points 8-11 until the calibration target is reached!

Evaluation phases

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12. Calculation of the tailored energy performance (EP), using the calibrated energy model (calibrated building envelope parameters, users, etc.) with standard climatic data
13. Calculation of the standard energy performance, using the calibrated energy model (only with calibrated building envelope parameters) with standard users and climatic data
14. Definition of the “quality index” of the calibrated model

MBE for Scenario 1



**If you would like more information,
please visit www.timepac.eu or contact us at
franz.bianco@polito.it**

Thanks for your attention!