# VALIDATION OF MODELS FOR PREDICTION OF BUILDING ENERGY PERFORMANCE:
## PROCEDURES AND RECOMMENDATIONS

**EU Directive 2010/31/EU** on energy performance of buildings

- Minimum requirements to the energy performance (e.g. Annual heating or cooling demand, mean U-value)
- Methodology for calculating the energy performance
- Requirement to apply European (CEN) standards

**ICNB WP4 Expected Outcomes:**

- Provide procedures and recommendations for using BIM for Building Energy Models
- Improve energy performance of buildings

**Plan:**

Review article in ”Renewable and Sustainable Energy Reviews”

Title given above; Present validation procedure; Recommend new CEN standards

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# ICNB WP4: Recommend new standards

**Problem:** **Existing Energy Performance Gap**

Building Energy Model (BEM) predictions do NOT EQUAL measured data

**Solution:** **Validation** of BEM by comparison of model predictions against measured data

- Standard for data exchange format (Industry Foundation Classes) exist
  => Common language (BIM vision)
- Standards for BEM (e.g. ISO 13790 and ISO 52016-1) exist. Validity?
- Standard for validation (using measured data) of BEM is missing!
  => Inaccurate BEM predictions
- Standard vocabulary on validation is missing! => No common language.
- Science citations are (almost always) missing! => No connection to science.



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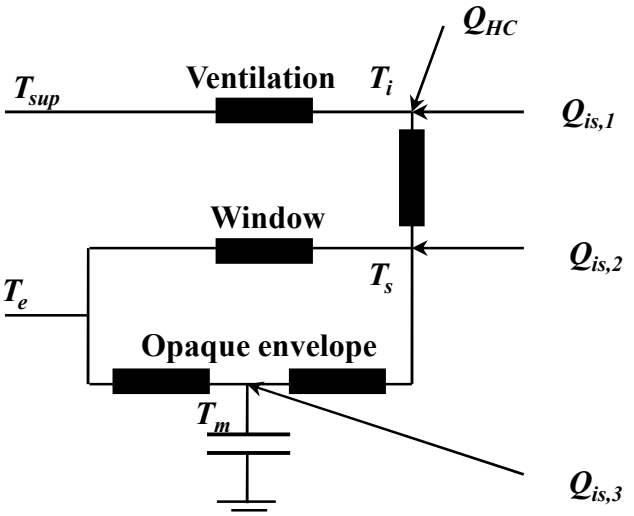
# Case study:
# Validation of “Simple hourly model” of CEN/ISO 13790: 2008




**5R1C Network model of whole building**

$T_i$ = interior temp., $T_e$ = exterior temp.

$T_s$ = surface temp., $T_m$ = opaque envelope temp.

$T_{sup}$ = temp. of supplied ventilation air

$Q_{HC}$ = power for heating/cooling

$Q_{is}$ = heat flux from internal sources and sun

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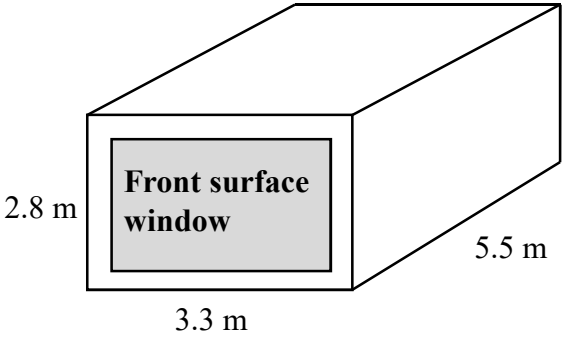
# Case study:
# Validation of hourly models of CEN/ISO 13790 and CEN/ISO 52016-1

**Table 4.** Verification and validation of CEN ISO standards for calculation of heating and cooling energy needs.

| ISO 13790: 2008<br>Simple hourly method | | ISO 52016-1: 2017<br>Hourly calculation procedure | |
|---|---|---|---|
| **Reference** | Comment | Reference | Comment |
| **Verification** | | | |
| **ISO 13790, Appendix H.4, [73]** | EN 15265 test cases; [33] | ISO 52016-1, section 7.2.2.1. verification test cases; [72] | Based on BESTEST 600 and 900 test case series, ANSI/ASHRAE 140, [77] |
| **Kokogiannakis et al., 2008, [78].** | Comparison to ESP-r and Energy-Plus. Building: 3 stories; 336 m². | Lundström, 2019, [79] | Comparison to IDA ICE. Modified RC-model, based on ISO 52016-1. |
| **Millet, 2007, [80]. Science citations missing.** | EN 15265 test cases; Comparison to 5 software. | Zakula, 2019, [81] | Comparison to TRNSYS. 10 reference buildings; Heating load differed 11% on average; main cause was window modelling |
| **Atmaca et al., 2011, [82]. Science citations missing.** | Comparison to Energy-Plus. Building: 65 m². | | |
| **Kristensen et al., 2016, [83]** | Sensitivity analysis | | |
| **Michalak, 2017, [84].** | Comparison to Energy-Plus. Building: 156 m²; 20 European locations. | | |
| **Validation** | | | |
| **Burhenne, 2008, [75]** | Building: 436 m²<br>Model modified by calibration using measured data. | [none] | |

# Standard EN 15265 Test Cases

- Front surface exposed to climate of Paris (Trappes)
- Annual Heating/Cooling loads are given
- ACH = 1 $h^{-1}$
- Heating to 20 °C, cooling to 26 °C
- Window/Wall = 7 $m^2$/3 $m^2$ (front)




| Test | HC | Glazing | Internal gain | External roof | Thermal mass | |
|---|---|---|---|---|---|---|
| | | | ($Wm^{-2}$) | | Ceiling | Floor |
| 1 | 0 | Sh DP | 20 | No | H | H |
| 2 | 0 | Sh DP | 20 | No | L | L |
| 3 | 0 | Sh DP | 0 | No | H | H |
| 4 | 0 | DP | 20 | No | H | H |
| 5 | HC | Sh DP | 20 | No | H | H |
| 6 | HC | Sh DP | 20 | No | L | L |
| 7 | HC | Sh DP | 0 | No | H | H |
| 8 | HC | DP | 20 | No | H | H |
| 9 | HC | Sh DP | 20 | Yes | R | H |
| 10 | HC | Sh DP | 20 | Yes | R | L |
| 11 | HC | Sh DP | 0 | Yes | R | H |
| 12 | HC | DP | 20 | Yes | R | H |

**Table 2.** EN 15265 test cases.
HC is heating and cooling with unlimited power. Sh is shading device and DP is double pane. H and L are high and low thermal mass, respectively. R is a non-adiabatic roof. Initial tests 1-4 are informative, while tests 5-12 are normative.

# Outcome from ICNB/WP4: Procedures and recommendations

**Procedure based on science for validation of BEM:**

- Apply the approach of Coleman & Stern (Aerospace engineering)

Presently, there is NO scientific consensus on validation of BEM

**Recommendations to industry on standards:**

- **Include Science citations** => Connect to science
- **Standard vocabulary on BEM validation** => Common language
- **Apply IFC standard to describe 3D geometry (and more) of existing validation experiments** => Improve data exchange in validation studies