BOPTEST Reference Test Case Peer Review Document

This document serves a peer review template for a reference test case emulation model.

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Section I is to be completed by the Model Developer. The remaining sections are to be completed by the designated Model Reviewer, and returned to the Model Developer so that they may make the appropriate edits. This process should be repeated until all concerns of the reviewer are addressed. Each review should be documented using a separate version of this document, specified by the Review # in Section 1 below.

# I. General Information

|  |  |
| --- | --- |
| **Reference Case** | Multizone Office Simple Hydronic |
| **Current Location** | Test Case Directory: <https://github.com/icupeiro/project1-boptest/tree/issue465_multizone_office_simple_hydronic>  Modelica Model Package:  <https://github.com/icupeiro/project1-boptest/tree/issue465_multizone_office_simple_hydronic/testcases/multizone_office_simple_hydronic/models/BuildingEmulators>   Model Path: BuildingEmulators.BuildingSystem  Buildings, IDEAS, and IBPSA Library Versions:  See <https://github.com/icupeiro/project1-boptest/blob/issue465_multizone_office_simple_hydronic/testcases/multizone_office_simple_hydronic/models/library_versions.json> |
| **Model Developer** (Name, Institution, Email) | Iago Cupeiro, iago.cupeiro@deltaq.io |
| **Model Reviewer**  (Name, Institution, Email) | Javier Arroyo, KU Leuven, javier.arroyo@kuleuven.be  Reviewing with OpenModelica v1.20.0-dev-235-g9e89a156ea in MacOS |
| **Review #** | 1 |

# II. General Comments

List each comment in separate row with number. Additional rows may be added as needed. They should be supported by the responses in Sections III and IV.

|  |  |
| --- | --- |
| **#** | **Comment** |
| 1 | The emulator needs to merge latest BOPTEST master |
| 2 | There is a temporary “days.json~” file that has been wrongly committed: see [here](https://github.com/icupeiro/project1-boptest/blob/issue465_multizone_office_simple_hydronic/testcases/multizone_office_simple_hydronic/models/days.json~). I suggest removing since it may create confusion. |
| 3 | Some symbols are not rendered properly in doc/index.html. See:        There may be others. |
| 4 | Normally, the index.html should show in the documentation pane of the model to allow inspecting and editing the model documentation directly from whatever Modelica tool is being used. |
| 5 | Unit tests are implemented. It is just missing to add the list of relevant variables to [compare\_references.py](https://github.com/icupeiro/project1-boptest/blob/issue465_multizone_office_simple_hydronic/testing/compare_references.py). This is just for analyzing the critical model variables when references change, so it is best that the selection is decided by the modeler. |
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# III. Model Checks

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| **Criteria** | **Reviewer Response** |
| **Reference Case Representation** |  |
| Does the model represent overall intent of reference case?  Are the relevant thermal systems, heat loads, and control signals accounted for? | Yes |
| **Climate** |  |
| Complete weather data file, similar to TMY? | Yes, using BEL\_ULG\_Uccle.064470\_TMYx.2007-2021.mos |
| Sufficiently long period, e.g. one year? | Yes |
| **Internal Gains** |  |
| Occupancy schedule? | Yes. 1 person per 15m2, that is, daily schedule with a maximum occupancy of ~333 people for this building. |
| Occupancy gain values reasonable for building type? | Yes, and well documented |
| Lighting schedule/control? | Yes |
| Lighting gain values reasonable for building type? | Yes |
| Equipment schedule? | Yes |
| Equipment gain values reasonable for building type? | Yes |
| **Envelope Modeling** |  |
| Are IDEAS, Buildings, or AixLib component models used for building envelope and window modeling? | Yes, IDEAS and Buildings |
| If not IDEAS, Buildings, or AixLib component models, are dynamic wall heat transfer models used? | N/A |
| If not IDEAS, Buildings, or AixLib component models, are complex fenestration models used? | N/A |
| If not IDEAS, Buildings, or AixLib component models, is latitude and longitude consistent with intended region or weather file? | N/A |
| If not IDEAS, Buildings, or AixLib component models, are convection models for inside and outside nonlinear? | N/A |
| If not IDEAS, Buildings, or AixLib component models, are the inside and outside radiation models appropriate? | N/A |
| Are window surface areas reasonable? | Yes, window-to-wall ratio of 50% |
| Are insulation levels reasonable? | Yes, 10 cm of material with k=0.035 W/m2K. |
| Are all surfaces accounted for? (e.g. the roof is not forgotten) | Yes |
| Which of the following is used for modeling air infiltration?  *None*  *Constant*  *Pressure-driven flow*  *Buoyancy-driven flow*  *Mixed pressure and buoyancy-driven flow* | Constant, based on n50=5 |
| Inter-zone airflow and common wall heat transfer properly accounted for? | Yes, both zones share an internal wall. There is no air exchange between the zones. |
| **HVAC Modeling** |  |
| Are moisture and condensation effects properly accounted for? | Yes, a moist air model is used. Humidity is modeled but not controlled. |
| Are fluid components such as ducts, pipes, actuators, pumps, fans, and heat exchangers modeled with pressure-flow relationships? Are pressure drops reasonable? | Yes, all checked values are reasonable |
| Is the heat transfer performance of other equipment such as heat exchangers and plant equipment modeled reasonably? | Yes, each recuperator in the AHUs has a constant effectiveness of 84%. |
| Are equipment capacities reasonable? | Yes |
| Are equipment efficiencies such as COP, heating, hydraulic, and motor reasonable? | Yes. Gas boiler efficiency is dependent on supply and condensation temperatures. The chiller EER is dependent on supply and ambient temperatures. |
| Is reasonable baseline control provided in the model? Can the model be simulated without an external controller? | Yes. Simulated for 1 year with Dassl |
| **External Control Input Signals** |  |
| Are Modelica signal exchange blocks used? | Yes |
| Reasonable set of external control signals? | Yes |
| Units assigned?  In SignalExchange.Overwrite assign a unit to the input variable u. | Yes |
| Descriptions assigned?  In SignalExchange.Overwrite use the parameter description. | Yes |
| Min/max assigned?  In SignalExchange.Overwrite assign a min and max to the input variable u. | Yes |
| **Measurement Output Signals** |  |
| Are Modelica signal exchange blocks used? | Yes |
| Reasonable set of measurement output signals? | Yes |
| Is at least one, and more if necessary, of the following KPI labels used to account for equipment power/fuel consumptions for KPI calculation? Is power consumption from all relevant equipment tagged? {ElectricPower, DistrictHeatingPower, GasPower, BiomassPower, or SolarThermalPower}  In SignalExchange.Read, use the parameter KPIs. | Yes |
| Are all necessary zone temperatures tagged with one of the following KPI labels for KPI calculations and appropriate zone identifier(s) given? {AirZoneTemperature or OperativeZoneTemperature}  In SignalExchange.Read, use the parameters KPIs and zone. | Yes |
| Are all zone CO2 measurements tagged with the following KPI label for KPI calculations and appropriate zone identifier(s) given? {CO2Concentration}  In SignalExchange.Read, use the parameters KPIs and zone. | Yes |
| Units assigned?  In SignalExchange.Read assign a unit to the output variable y. | Yes |
| Descriptions assigned?  In SignalExchange.Read use the parameter description. | Yes |
| **Compilation and Simulation** |  |
| Uses official library release versions (with Modelica “Uses” statement)? | No. Not specified in model. |
| Can be compiled into model-exchange or co-simulation FMU that can be simulated without use of commercial licensing? | Yes, but can’t be done with current jm image. It can be compiled with OpenModelica though. |
| What is the intended solver, tolerance, and timestep (if constant timestep solver)? Are these reasonable to simulate the model dynamics? | Default solver was Dassl with 1e-06 tolerance in OpenModelica. |
| Simulates for full year? | Yes, in approximately 10 minutes. |

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# IV. Test Case Checks

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| --- | --- |
| **Criteria** | **Response** |
| **Documentation** |  |
| Building Design and Use (including architecture, constructions, occupancy schedules and comfort, internal loads and schedules, climate) | All is documented |
| HVAC System Design (including primary and secondary system designs, equipment specifications and performance maps, rule based and/or local loop controllers) | Yes |
| Additional System Design  (such as lighting, shading, onsite generation and storage) | Yes |
| Points List (including control inputs signals with descriptions, units, min/max, and default values, and measurement output signals with descriptions and units) | Yes |
| Important Model Assumptions  (such as infiltration models, moist/dry air assumptions, well-mixed assumptions, CO2 generation from occupants and concentration in outside air) | Yes |
| Scenario Information (including time periods, energy pricing, and emission factors) | Yes |
| HTML template followed (see Appendix A)? | Yes, but see comment 4. |
| **BOPTEST Data Requirements** |  |
| If model DOES NOT make use of signal exchange Modelica blocks, is a KPI JSON provided for matching output signals to KPI keywords (see Appendix B)? | N/A |
| Is a Days JSON provided for specifying scenario time periods (see Appendix B)? | Yes |
| Data for weather provided as csv with correct header names (see Appendix C)?  Does the data of this type used within the model match the data provided in the csv? | Yes |
| Data for zone comfort setpoint temperature(s) for each zone provided as csv with correct header names (see Appendix C)? Does the data of this type used within the model match the data provided in the csv? | Yes |
| Data for occupancy (number of occupants) schedule for each zone provided as csv with correct header names (see Appendix C)?  Does the data of this type used within the model match the data provided in the csv? | Yes |
| Data for internal gains for each zone provided as csv with correct header names (see Appendix C)? Does the data of this type used within the model match the data provided in the csv? | Yes |
| Data for GHG emission factors for each fuel source provided as csv with correct header names (see Appendix C)? | Yes |
| Data for energy pricing provided as csv with correct header names (see Appendix C)? | Yes |

# Appendix A: Documentation Template

<html>

General model description.

<h3>Building Design and Use</h3>

<h4>Architecture</h4>

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</p>

<h4>Constructions</h4>

<p>

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<h4>Occupancy schedules</h4>

<p>

…

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<h4>Internal loads and schedules</h4>

<p>

…

</p>

<h4>Climate data</h4>

<p>

…

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<h3>HVAC System Design</h3>

<h4>Primary and secondary system designs</h4>

<p>

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<h4>Equipment specifications and performance maps</h4>

<p>

…

</p>

<h4>Rule-based or local-loop controllers (if included)</h4>

<p>

…

</p>

<h3>Model IO's</h3>

<h4>Inputs</h4>

The model inputs are:

<ul>

<li>

<code>Input1</code> [UNIT1]: Description

</li>

</ul>

<h4>Outputs</h4>

The model outputs are:

<ul>

<li>

<code>Output1</code> [UNIT1]: Description

</li>

<li>

<code>Output2</code> [UNIT2]: Description

</li>

</ul>

<h3>Additional System Design</h3>

<h4>Lighting</h4>

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<h4>Shading</h4>

<p>

…

</p>

<h4>Onsite Generation and Storage</h4>

<p>

…

</p>

<h3>Model Implementation Details</h3>

<h4>Moist vs. dry air</h4>

<p>

…

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<h4>Pressure-flow models</h4>

<p>

…

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<h4>Infiltration models</h4>

<p>

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<h4>CO2 models</h4>

<p>

…

</p>

<h3>Scenario Information</h3>

<h4>Time Periods</h4>

<p>

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<h4>Energy Pricing</h4>

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<h4>Emission Factors</h4>

<p>

…

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</html>

# Appendix B: JSONs

KPI JSON

{<kpi\_ID> : // Unique identifier for KPI

[<output\_ID>] // List of FMU outputs to be included in calculation

}

Saved as “kpis.json”

For kpi\_IDs requiring zone designations, the zone designation can be appended to the end of the kpi\_ID as <kpi\_ID>[z], where z is the zone designation. These are AirZoneTemperature[z], OperativeZoneTemperature[z], and CO2Concentration[z].

Days JSON

{<time\_period\_ID> : // Unique identifier for specifying time period

<day #> // Integer value indicating day number to use for specifying time period

}

Saved as “days.json”

# Appendix C: Specifications for Data CSV Files

This information is taken from the BOPTEST Development Requirements and Guide Section IV. D.

The CSV data files should accomplish the following requirements:

1. The files can have any name.
2. The files should have a “*time*” column indicating the time since the beginning of the year in seconds.
3. The files should have column names using the key-words specified by the conventions below. Columns that do not apply to the test case may be omitted (e.g. *EmissionsGasPower* if the test case does not use gas power).
4. The files can have optional header rows for holding information about the data contained in the csv file. These header rows can be indicated by starting the row with the character "#".

Data for the CSV files may optionally be generated using the functions that are available in the module *data/data\_generator.py* located in the software repository at https://github.com/ibpsa/project1-boptest. Default parameters for these functions may be used, or modified based on the test case. If default parameters are used, care should be taken to make sure the resulting data matches that which may be used in the test case model.

|  |  |  |
| --- | --- | --- |
| **CATEGORY: *weather*** | | |
| **NAME** | **UNIT** | **DESCRIPTION** |
| *HDifHor* | W/m2 | Horizontal diffuse solar radiation. |
| *HDifNor* | W/m2 | Direct normal radiation. |
| *HGloHor* | W/m2 | Horizontal global radiation. |
| *HHorIR* | W/m2 | Horizontal infrared irradiation. |
| *TBlaSky* | K | Output temperature. |
| *TDewPoi* | K | Dew point temperature. |
| *TDryBul* | K | Dry bulb temperature at ground level. |
| *TWetBul* | K | Wet bulb temperature. |
| *celHei* | m | Ceiling height. |
| *cloTim* | s | One-based day number in seconds. |
| *lat* | rad | Latitude of the location. |
| *lon* | rad | Longitude of the location. |
| *nOpa* | 1 | Opaque sky cover [0, 1]. |
| *nTot* | 1 | Total sky Cover [0, 1]. |
| *pAtm* | Pa | Atmospheric pressure. |
| *relHum* | 1 | Relative Humidity |
| *solAlt* | rad | Altitude angel. |
| *solDec* | rad | Declination angle. |
| *solHouAng* | rad | Solar hour angle. |
| *solTim* | s | Solar time. |
| *solZen* | rad | Zenith angle. |
| *winDir* | rad | Wind direction. |
| *winSpe* | m/s | Wind speed |

|  |  |  |
| --- | --- | --- |
| **CATEGORY: *prices*** | | |
| **NAME** | **UNIT** | **DESCRIPTION** |
| *PriceElectricPowerConstant* | ($/€)/kWh | Completely constant electricity price |
| *PriceElectricPowerDynamic* | ($/€)/kWh | Electricity price for a day/night tariff |
| *PriceElectricPowerHighlyDynamic* | ($/€)/kWh | Spot electricity price |
| *PriceGasPower* | ($/€)/kWh | Price to produce 1 kWh thermal from gas |
| *PriceDistrictHeatingPower* | ($/€)/kWh | Price of 1 kWh thermal from district heating |
| *PriceBiomassPower* | ($/€)/kWh | Price to produce 1 kWh thermal from biomass |
| *PriceSolarThermalPower* | ($/€)/kWh | Price to produce 1 kWh thermal from solar irradiation |

|  |  |  |
| --- | --- | --- |
| **CATEGORY: *emissions*** | | |
| **NAME** | **UNIT** | **DESCRIPTION** |
| *EmissionsElectricPower* | kgCO2-eq/kWh | Kilograms of carbon dioxide equivalent to produce 1 kWh of electricity |
| *EmissionsGasPower* | kgCO2-eq/kWh | Kilograms of carbon dioxide equivalent to produce 1 kWh thermal from gas |
| *EmissionsDistrictHeatingPower* | kgCO2-eq/kWh | Kilograms of carbon dioxide equivalent to produce 1 kWh thermal from district heating |
| *EmissionsBiomassPower* | kgCO2-eq/kWh | Kilograms of carbon dioxide equivalent to produce 1 kWh thermal from biomass |
| *EmissionsSolarThermalPower* | kgCO2-eq/kWh | Kilograms of carbon dioxide equivalent to produce 1 kWh thermal from solar irradiation |

|  |  |  |
| --- | --- | --- |
| **CATEGORY: *occupancy*** | | |
| **NAME** | **UNIT** | **DESCRIPTION** |
| *Occupancy[z]* | Number of occupants | Number of occupants at zone ‘z’ |

|  |  |  |
| --- | --- | --- |
| **CATEGORY: *internalGains*** | | |
| **NAME** | **UNIT** | **DESCRIPTION** |
| *InternalGainsRad[z]* | W | Radiative internal gains at zone ‘z’ |
| *InternalGainsCon[z]* | W | Convective internal gains at zone ‘z’ |
| *InternalGainsLat[z]* | W | Latent internal gains at zone ‘z’ |

|  |  |  |
| --- | --- | --- |
| **CATEGORY: *setpoints*** | | |
| **NAME** | **UNIT** | **DESCRIPTION** |
| *LowerSetp[z]* | K | Lower temperature set point of the comfort range at zone ‘z’ |
| *UpperSetp[z]* | K | Upper temperature set point of the comfort range at zone ‘z’ |
| *UpperCO2[z]* | ppm | Upper CO2 concentration limit for zone ‘z’ |