Innovative Approach of Integrated Building Enclosure and HVAC Systems Modeling to Improve Building Energy Efficient Design

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Concept and Process

- Define data modeling, information exchange and simulation Engine
- Integrate and differential between building envelope and HVAC
- Reduce energy consumption through standardisation, which is recognised as a key element in design time, cutting construction costs and ensuring efficient building solutions
- Demonstrate indoor environmental quality (ventilation, lighting, thermal gain/loss).
- Interoperability
- Meet criteria Codes Compliance is the minimum standard to
- Evaluate options for a net zero energy building
Model Definition

- A model is a pattern, plan, representation (especially in miniature), or description designed to show the main object or workings of an object, system, or concept. (From-Venkatesan Sw/Engineer).
Building Information Library

- Building Information Library includes a library of building product information designed for the needs of the AEC community -- allowing to seamlessly insert specs, technical data sheets, CAD documents and Smart-BIM objects into the drawings and building models, search and find formatted building product information which includes:
  - Company profiles
  - 3-Part specifications
  - Technical data sheets
  - Manufacturer's catalogs
  - CAD documents
  - SmartBIM objects
The complexity of a building enclosure can be represented as an object oriented, where the building model parameters, and design variables are defined as classes, subclasses, and events.

Data in building’s objects (Both graphics and Attributes) are stored as the instance of class (integer, double, float, string, Boolean or they can refer to objects in other class) which defines type of the object, as well as the kind of the operations that it performs.
Data Exchange Model

- There is a framework called VME Application Program Interface (API) and a set of tools acquire information through accessing the model both graphical and parametric data and extract information from building model that has been created, and store in the database.

- VMS use iterative and recursive algorithms to sort, link, map, query, bind and store data in the database in both instance and building type parameters, and design variables, thus create energy input parameters for pre-processing and input data model and simulation engine parameters for energy simulation.
Data Exchange Model

- The operation that data can act on and objects can respond to are called method. VME and VMS use the abstract data type (ADT) class and generic algorithms in providing data exchange between building and energy performance simulation.

- The main class contains building enclosure and system’s data that applies and links to energy, environment in the building of the class, and which can show class hierarchy where classes are derived from each other, and that determine which properties and function are inherited.

- Subclasses contain data that is specific to each subclass and inherit the properties and method of the classes which they belong to.

- Building enclosure systems can be represented in the real world and tracked as operating and even driven object models.
The purpose is to improve energy modeling and simulation of building enclosure system for heating, cooling, and ventilation. This is done while maintaining the integrity, quality, and standard of building’s model, and increases the level of accuracy of the results, thus mitigates energy consumption and minimizes impacts on outdoor surroundings, and allows for the detailed thermal performance simulation of building envelope and HVAC systems.

The case study is the newly designed laboratory that is intended to be energy efficient, and sustainable, with healthy construction. The building model was created using Autodesk Revit Architecture 2008 and Revit Building System 2008. After a set of energy input parameters were created, all the data will be send to DOE 2.1E engine for energy simulation.
Model Phenomenon consists of building site, climate location and weather data. The site location is determined by the project site, location, climate location and weather data to match with energy simulation weather data. Chicago climate is in Latitude of 41.98, Longitude of -87.9, and Altitude of 658.136 feet above sea level, time zone (6) and provide necessary weather data, with very fluctuated in day and night temperature. Building orientation is the direction of the Plan to North or South.
# Envelope Massing Orientation Optimization

<table>
<thead>
<tr>
<th>Solar</th>
<th>M-btuh/ft² for 8,760 Hours</th>
<th>10% of M-btuh / ft² / Yr</th>
<th>M-btuh / kwh/Yr</th>
<th>KW / Total</th>
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Envelop Massing Orientation Optimization

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Envelope Massing Orientation Optimization
Project

Building Location
- Operating Schedule
- Internal Heat Gain
- Daylight
- Thermostatic Control
- Thermal Zones
- Thermal Surfaces
- Properties of Materials
- Lights Specification
- Equipments Specification
- HVAC Systems
- Plants
- Thermal Design Parameters

Building Area
- Zone

Rooms or Space
- Floor
  - Materials
  - Size & Dimensions
  - Perimeter
- Roof
  - Materials
  - Size & Dimensions
- Ceiling
  - Materials
  - Size & Dimensions
- Interior Walls
  - Size & Dimensions
  - Materials
- Walls
  - Window
    - Overhangs
    - Pans
  - Doors
    - Types & Size
  - Types & Size
SmartBIM Objects

- Rules and parameters required to define standard of its elements representation and relationship which return the parameters. The rules define a set of standard solutions which can bring up to:
  - Naming Convention:
  - Building Product Information
  - Manufacturer:
  - Name of Equipment:
  - Type: Model #
  - Shared Parameter File Location:
  - Library\Shared txt
  - Parameters to Fill In:
  - All Identity Data
  - URL.
  - Link all Information
  - Equations for example
  - Lumens = Lumens Per Lamp * Lamp Quantity

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Building Enclosure

- Geometrical 3D model which served as the basis for establishing an energy input model consists of relevant geometrical, coordinate and topological data.

- It is equipped
Building Enclosure

- The building floor plan which has 59 rooms, 25,198 ft², one story 15'-0” high. To perform an effective energy analysis and simulation can only be done if the entire volume of the building model is included in a set of parameters information that sending to and from DOE$ 2.1E. The model is identified as a triangulation area, zone and space component graph, a graph of room faces, a room graph and a relational object graph, which explain algorithms to derive these relations.
Ideally the plug-in should incorporate a generic algorithm to automatically identify spaces. Thus, the designer-user will not have to spend time to specify the surfaces a space consists of.

The algorithm to support this feature should be based on geometric facts.

If two surfaces are adjacent to each other, then they share an edge, etc.). Also, while spaces are created, there is a need to ensure that the particular space is contiguous.

Algorithms to perform these tasks have been incorporated into Demeter..
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<tr>
<th>Space Zone</th>
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<th>Area</th>
<th>Zone Origin</th>
<th>Perimeter</th>
<th>Azimuth</th>
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<td>430' - 4 5/32&quot;</td>
</tr>
<tr>
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<td>175' 10&quot;</td>
<td>157' - 1 5/8&quot;</td>
</tr>
<tr>
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<td>829</td>
<td>65' 6&quot;</td>
<td>175' 10&quot;</td>
<td>128' - 8 19/32&quot;</td>
</tr>
<tr>
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<td>D</td>
<td>3183</td>
<td>129' 8&quot;</td>
<td>99' 10&quot;</td>
<td>301' - 0 13/16&quot;</td>
</tr>
<tr>
<td>Warehouse</td>
<td>E</td>
<td>2207</td>
<td>41 2&quot;</td>
<td>45 5&quot;</td>
<td>212' - 8 3/16&quot;</td>
</tr>
<tr>
<td>Kitchen Dining</td>
<td>F</td>
<td>2385</td>
<td>0' 0&quot;</td>
<td>0' 0&quot;</td>
<td>225' - 4 7/8&quot;</td>
</tr>
<tr>
<td>Conference</td>
<td>G</td>
<td>1689</td>
<td>99' 8&quot;</td>
<td>65' 8&quot;</td>
<td>234' - 9&quot;</td>
</tr>
<tr>
<td>Toilet</td>
<td>H</td>
<td>490</td>
<td>70' 3&quot;</td>
<td>153' 11&quot;</td>
<td>91' - 3 13/32&quot;</td>
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<tr>
<td>Regulatory</td>
<td>I</td>
<td>422</td>
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<td>153' 11&quot;</td>
<td>95' - 2 3/16&quot;</td>
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<td>216' - 9 7/16&quot;</td>
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<td>Corridor</td>
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<td>Grand total: 11</td>
<td></td>
<td>25198</td>
<td>Grand total: 11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Building Enclosure

- **Rooms or Space Geometrical Model**
- Building model was transferring and translated its geometrical, topological and coordinates data into floor area, rooms or space volume model, decomposing into a so-called connection model and then extracting volume bodies into elements and components. Air flow and thermal energy model are derived from rooms or space geometric model, and shows knowledge of linkage between model hierarchies where the coupling strategies are implemented. Figure 4 shows the technique is demonstrated within the scope of building energy simulation by dividing the space into zones for setting up a thermal multi-zone model and a geometrical model. The algorithm is basically applicable to any building energy simulation software tool. Room parameters are definable spatial relationships, which can show the relationship between any elements, properties and space in a floor plan.
Building Enclosure

- Surface and space attribution
- The model created in the sketching environment consists of many surfaces which form spaces. Each surface has its own identity (ID) so that it can be referenced whenever necessary. Surface attribution is also an essential part of building simulation modelling. By attributing surfaces the user can specify whether the specific surface is an external or an internal wall, underground or roof slab, etc. In terms of openings attribution, the tool should be able to identify whether a sub-surface is attached to another so that the opening (sub-surface) can be referenced with regards to the surface attached. Then the attribution of the openings could be established by specifying the opening type (fixed window, air, skylight, sliding door, etc.)
Building Enclosure

- HVAC Thermal Zone Model
- Thermal zone model in turn is a dimensionally reduced model. It can be described by an geometric representations of thermal zones, and for each thermal zone that enclosed heat transfer surfaces, which represents the building structure in a hierarchical manner, i.e. the model is organized in building level, rooms, building components, layers, materials, etc. The prerequisites for establishing a numerical coupling between both approaches are incidence matrices relating models and components. In other words, a CFD and HVAC simulation requires volume bodies of air volumes together with boundary conditions while a thermal multi-zone simulation.
Building Enclosure

- Thermal surfaces refer to heat transfer surfaces to describe the thermal representations of building surfaces, such as walls, roof, windows, doors, ceiling, and floor. Each surface has some attributes to determine its interaction between internal and external environment. The surfaces in Table 3 allows to fill information regarding surfaces to represent inter zone heat transfer. Thermal surfaces are the basic ingredients of the thermal simulation. A SIMULATION PROJECT AGGREGATES A NUMBER OF ZONES, WHERE THE LATTER AGGREGATE ONE OR MORE AIR VOLUMES. AIR volume objects are aware of the corresponding set of adjacent bodies and their semantics. Structural elements themselves are composed of a multilayered structure with respective individual materials. Although they form part of the geometric model, we also tore the surface geometry and vertex coordinates.
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</tbody>
</table>
Building Enclosure

Pongsak Chaisuparasmikul Building Enclosure Science and Technology Conference June 12, 2008
## Building Enclosure

<table>
<thead>
<tr>
<th>Exterior Envelope</th>
<th>0 = Baseline STD90.1</th>
<th>1 = Proposed</th>
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<td><strong>Parameter</strong></td>
<td><strong>Exterior Walls</strong></td>
<td><strong>Interior Walls</strong></td>
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<tr>
<td><strong>Exterior Walls</strong></td>
<td>8 In. Light Weight Concrete Block (U=0.084)</td>
<td>8 In. Light Weight Concrete Block (U=0.060)</td>
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<tr>
<td><strong>Interior Walls</strong></td>
<td>Frame Partition With 0.75 In. Gypsum Board (U=0.2589)</td>
<td>Frame Partition With 0.75 In. Gypsum Board (U=0.2589)</td>
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<tr>
<td><strong>Slabs</strong></td>
<td>Un-Insulated Solid-Ground Floor (U=0.125)</td>
<td>Un-Insulated Solid-Ground Floor (U=0.125)</td>
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<td><strong>Roofs</strong></td>
<td>4 In. Light Weight Concrete (U=0.2254)</td>
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<td>Large Double-Glazed Windows (Reflective Coating) - Industry (U=0.5636)</td>
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</table>
Specify Space and Zone Parameters for Energy Analysis and Simulation

Room instance parameters that were used for energy analysis and simulation and calculating heating and cooling loads are

Condition type or the type of conditioning for the room which consisting of the followings;
- Heated
- Cooled
- Heated and cooled
- Unconditioned
- Vented
- Naturally vented only

Airflow consists of supply, return, and exhaust airflow.
- Supply airflow is the sum of the supply airflow for all the supply air terminals in the room.
- Return airflow is the return airflow for all the return air terminals in the room.
- Exhaust airflow is the sum of the exhaust airflow for all the exhaust air terminals in the room.
People Loads is the people in the room occupying a space, which consist of

- Number of People to specify a value based on the number of people assumed to occupy the room for load calculations.
- Area per Person to specify a value based on the area allotted per person.
- Sensible Heat Gain per Person - the portion of the heat gain directly given off by people occupying the space.
- Latent Heat Gain per Person - the load is associated with the water vapors given off by people occupying the space.

Lighting load is the sum of the lighting load for all the lighting fixtures within the space. The value can be expressed as Watts or Watts per area or Lighting Power Per Area.
HVACR

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- Lighting load is the sum of the lighting load for all the lighting fixtures within the space. The value can be expressed as Watts or Watts per area or Lighting Power Per Area.
● Reusability of components as a library that can be called from multiple areas of the applications and application interface allowed the model to interact with the simulation data and match with the simulation parameters in DOE2, and predicts the hourly energy use and energy cost of a building given hourly weather information and a description of the building, and its HVAC equipment and utility rate structure. DOE2 will calculate the heating and cooling loads necessary to maintain thermal control set points, conditions throughout a secondary HVAC system and coil loads, and the energy consumption of primary plant equipment to verify that the simulation is performing as the actual building would. Designers can determine the choice of building parameters that improve energy efficiency while maintaining thermal comfort and cost-effectiveness. x
Interoperability capabilities include building code compliant, codes search, codes check, outlined specifications, linked model for internal data sharing, clash detection, and collaboration.
# Prescriptive Envelope Energy Code Compliance Data

<table>
<thead>
<tr>
<th>Space Zone</th>
<th>Block</th>
<th>Total Surface Area (ft²)</th>
<th>Wall-U</th>
<th>Glass-Area</th>
<th>Door-Area</th>
<th>Door+Glss</th>
<th>% Area of Activity</th>
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<td></td>
<td></td>
<td></td>
<td>6.70</td>
<td>Conference</td>
</tr>
</tbody>
</table>
### HVACR

- **Boiler Attributes**
  - Type
  - Example
  - Description
  - Manufacturer
  - Model
  - Ref Width (mm)
  - Depth (mm)
  - Height (mm)
  - Maintenance space left (mm)
  - Maintenance space right (mm)
  - Maintenance space front (mm)
  - Maintenance space back (mm)
  - Maintenance space above (mm)
  - Maintenance space below (mm)
  - Access width (mm)
  - Access height (mm)
  - Output (kW)
  - Gas input rate (m³/h)
  - Minimum gas inlet pressure (mbar)
  - Maximum gas inlet pressure (mbar)
  - Gas setting pressure (mbar)
  - Water content (l)
  - Water flow rate (l/s)
  - Minimum Water flow rate (l/s)
  - Pressure drop (kPa)
  - Maximum water pressure (bar)
  - Minimum water pressure (bar)
  - Flue gas volume (m³/h)
  - Flue gas temperature (°C)
  - Gas connection size (mm)
  - Gas connection location
  - xGas connection location
  - yGas connection location
  - zGas connection direction
  - xGas connection direction
  - yGas connection direction
  - zLPHW inlet connection size (mm)
  - LPHW inlet connection location
  - xLPHW inlet connection location
  - yLPHW inlet connection location
  - zLPHW inlet connection location
  - xLPHW outlet connection location
  - yLPHW outlet connection location
  - zLPHW outlet connection location
  - LPHW outlet connection location
  - xLPHW outlet connection location
  - yLPHW outlet connection location
  - zLPHW outlet connection location
  - Flue connection size (mm)
  - Flue connection location
  - xFlue connection location
  - yFlue connection location
  - zFlue connection location
  - xFlue connection direction
  - yFlue connection direction
  - zFlue connection direction
  - Electrical connection size (mm)
  - Electrical connection location
  - xElectrical connection location
  - yElectrical connection location
  - zElectrical connection location
  - Electrical connection direction
  - xElectrical connection direction
  - yElectrical connection direction
  - zRunning Current (Amps)
  - Starting Current (Amps)
  - Phases
  - Weight (kg)
  - STRING

- **Hamworthy Purewel P50**
  - P5053295087215050610460006002100505.9217.52512.5301.080.54160.4278.8200201311000056901050311185
  - 26901050328.51050573010206266648720015000000066150
- **Pump**
- **Attributes**
  - **Type**
- **Example**
- **Description**

| Manufacturer | Model | Ref Width (mm) | Depth (mm) | Height (mm) | Maintenance space left (mm) | Maintenance space right (mm) | Maintenance space front (mm) | Maintenance space back (mm) | Maintenance space above (mm) | Maintenance space below (mm) | Access width (mm) | Access height (mm) | Power (kW) | Water Flow Rate (l/s) | Pressure Drop (kPa) | LPHW inlet connection size (mm) | LPHW inlet connection location x | LPHW inlet connection location y | LPHW inlet connection location z | LPHW outlet connection size (mm) | LPHW outlet connection location x | LPHW outlet connection location y | LPHW outlet connection location z | LPHW outlet connection direction x | LPHW outlet connection direction y | LPHW outlet connection direction z | Electrical connection size (mm) | Electrical connection location x | Electrical connection location y | Electrical connection location z | Electrical connection direction x | Electrical connection direction y | Electrical connection direction z | Running Current (Amps) | Starting Current (Amps) | Phases | Weight (kg) |
|--------------|-------|---------------|-----------|-------------|----------------------------|-----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------|----------------|-----------|------------------|----------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|------------------|---------------|-------------|

Pongsak Chaisuparasmikul Building Enclosure Science and Technology Conference June 12, 2008
- **Pressurisation unit**

- **Attributes**

- **Example**

- **Description**

- Manufacturer
- Model
- Reference
- Width (mm)
- Depth (mm)
- Height (mm)
- Maintenance space left (mm)
- Maintenance space right (mm)
- Maintenance space front (mm)
- Maintenance space back (mm)
- Maintenance space above (mm)
- Maintenance space below (mm)
- Access width (mm)
- Access height (mm)
- System Volume (l)
- System Temperature (°C)
- Vessel Volume (l)
- Fill Pressure (bar)
- Static head (bar)
- Antifreeze percentage (%)
- Maximum Temperature (°C)
- Mains supply connection size (mm)
- Mains supply location x
- Mains supply location y
- Mains supply location z
- Mains supply direction x
- Mains supply direction y
- Mains supply direction z
- System fill connection size (mm)
- System fill connection location x
- System fill connection location y
- System fill connection location z
- System fill connection direction x
- System fill connection direction y
- System fill connection direction z
- Electrical connection size (mm)
- Electrical connection location x
- Electrical connection location y
- Electrical connection location z
- Electrical connection direction x
- Electrical connection direction y
- Electrical connection direction z
- Motor Size (kW)
- Running Current (Amps)
- Starting Current (Amps)
- Phases
- Weight (kg)

**STRING**

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### Panel board

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Type</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Manufacturer</td>
<td>Model</td>
<td>Ref. Width (mm) Depth (mm) Height (mm) Maintenance space left (mm) Maintenance space right (mm) Maintenance space front (mm) Maintenance space back (mm) Maintenance space above (mm) Maintenance space below (mm) Access width (mm) Access height (mm) Incomer size (No) Outgoing ways (No) Incoming cable tray connection location x Incoming cable tray connection location y Incoming cable tray connection location z Incoming cable tray connection location x Incoming cable tray connection location y Incoming cable tray connection location z Outgoing cable tray connection size (mm) Outgoing cable tray connection location x Outgoing cable tray connection location y Outgoing cable tray connection location z Outlet connection location x Outlet connection location y Outlet connection location z Outlet connection direction x Outlet connection direction y Outlet connection direction z Electrical connection size (mm) Electrical connection location x Electrical connection location y Electrical connection location z Electrical connection direction x Electrical connection direction y Electrical connection direction z Running Current (Amps) Starting Current (Amps) Phases Weight (kg)</td>
</tr>
<tr>
<td>STRING STRING Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer STRING</td>
<td>STRING STRING Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer Integer STRING</td>
<td>Panel board Bill BT20640015077040040001200110060021002006225200750010302007577001060</td>
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### Fan

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Model</td>
<td>Ref. Width (mm) Depth (mm) Height (mm) Maintenance space left (mm) Maintenance space right (mm) Maintenance space front (mm) Maintenance space back (mm) Maintenance space above (mm) Maintenance space below (mm) Access width (mm) Access height (mm) Power (kW) Air Flow Rate (m³/s) Pressure drop (Pa) Sound power (dBA) Outlet connection size (mm) Outlet connection location x Outlet connection location y Outlet connection location z Outlet connection direction x Outlet connection direction y Outlet connection direction z Electrical connection size (mm) Electrical connection location x Electrical connection location y Electrical connection location z Electrical connection direction x Electrical connection direction y Electrical connection direction z Running Current (Amps) Starting Current (Amps) Phases Weight (kg)</td>
</tr>
</tbody>
</table>
HVACR

- **Fan coil unit**
  - **Attributes**
  - **Type**
  - **StringDescription**

  ManufacturerModel Ref.Width (mm)Depth (mm)Height (mm)Maintenance space left (mm)Maintenance space right (mm)Maintenance space front (mm)Maintenance space back (mm)Maintenance space above (mm)Maintenance space below (mm)Access width (mm)Access height (mm)Outlet duct connection size (mm)Outlet duct connection location xOutlet duct connection location yOutlet duct connection location zOutlet duct connection direction xOutlet duct connection direction yOutlet duct connection direction zOutlet duct spigot numberOutlet duct spigot pitchInlet duct connection location xInlet duct connection location yInlet duct connection location zInlet duct connection direction xInlet duct connection direction yInlet duct connection size (mm)Inlet duct spigot numberOutlet duct spigot pitchCooling coil water content (%)Cooling coil water flow rate (l/s)Cooling coil pressure drop (bar)Maximum CHW pressure (bar)CHW inlet connection size (mm)CHW inlet connection location xCHW inlet connection location yCHW inlet connection location zCHW inlet connection direction xCHW inlet connection direction yCHW inlet connection direction zCHW outlet connection size (mm)CHW outlet connection location xCHW outlet connection location yCHW outlet connection location zCHW outlet connection direction xCHW outlet connection direction yCHW outlet connection direction zCondensate connection size (mm)Condensate connection location xCondensate connection location yCondensate connection location zCondensate connection direction xCondensate connection direction yCondensate connection direction zHeating output (kW)Heating coil water content (%)Heating coil water flow rate (l/s)Heating coil pressure drop (kPa)Maximum LPHW pressure (bar)LPHW inlet connection size (mm)LPHW inlet connection location xLPHW inlet connection location yLPHW inlet connection size (mm)LPHW outlet connection location xLPHW outlet connection location yLPHW outlet connection location zLPHW outlet connection direction xLPHW outlet connection direction yLPHW outlet connection direction zFilter EU ratingFan power (kW)Air Flow Rate (m3/s)Fan pressure drop (Pa)Sound power (dBA)Electrical connection size (mm)Electrical connection location xElectrical connection location yElectrical connection location zElectrical connection direction xElectrical connection direction yElectrical connection direction zRunning Current (Amps)Starting Current (Amps)PhaseWeight (kg)STRING

<table>
<thead>
<tr>
<th>Diffuser</th>
<th>Attributes</th>
<th>Type</th>
<th>Example</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>ManufacturerModel</td>
<td>Ref.Width (mm)</td>
<td>Depth (mm)</td>
<td>Heigh (mm)</td>
<td>Maintenance space left (mm)</td>
</tr>
<tr>
<td></td>
<td>Maintenance space right (mm)</td>
<td>Maintenance space front (mm)</td>
<td>Maintenance space back (mm)</td>
<td>Maintenance space above (mm)</td>
</tr>
<tr>
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<td>Maintenance space below (mm)</td>
<td>Access width (mm)</td>
<td>Access height (mm)</td>
<td>Duct connection Type</td>
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<td>Duct Diameter</td>
<td>Duct connection location x</td>
<td>Duct connection location y</td>
<td>Duct connection location z</td>
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<tr>
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<td>Duct connection direction x</td>
<td>Duct connection direction y</td>
<td>Duct connection direction z</td>
<td>Duct connection TypeDuct Diameter</td>
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<tr>
<td></td>
<td>Effective Area (m²/s)</td>
<td>Air Flow Rate (m³/s)</td>
<td>Pressure Drop (kPa)</td>
<td>Noise Criteria (dB)</td>
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<td>Weight (kg)</td>
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SmartBIM Objects

- Rules and parameters required to define standard of its elements representation and relationship which return the parameters. The rules define a set of standard solutions which can bring up to;
  - Naming Convention:
  - Building Product Information
  - Manufacturer:
  - Name of Equipment:
  - Type: Model #
  - Shared Parameter File
    - Location:
    - Library\ Shared txt
  - Parameters to Fill In:
  - All Identity Data
  - URL.
  - Link all Information
  - Equations for example
    - Lumens = Lumens Per Lamp * Lamp Quantity
Optimum Tilt Angle for PV-Panel facing South

<table>
<thead>
<tr>
<th></th>
<th>M-btuh/ft² for 8,760 Hours</th>
<th>M-btuh/ft²/YR</th>
<th>KW/ft²/YR</th>
<th>kwh/yrMbtuh</th>
<th>kwh/yrMbtuh</th>
</tr>
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<tbody>
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<tr>
<td>Total</td>
<td>325.4</td>
<td>56.2</td>
<td>491,925</td>
<td>49,193</td>
<td>0.049</td>
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<tr>
<td>Direct</td>
<td>267.5</td>
<td>34.0</td>
<td>297,878</td>
<td>29,788</td>
<td>0.030</td>
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<tr>
<td>Total</td>
<td>333.6</td>
<td>58.9</td>
<td>516,044</td>
<td>51,604</td>
<td>0.052</td>
</tr>
<tr>
<td>Direct</td>
<td>276.9</td>
<td>36.1</td>
<td>315,875</td>
<td>31,587</td>
<td>0.032</td>
</tr>
<tr>
<td>Total</td>
<td>337.9</td>
<td>58.5</td>
<td>512,382</td>
<td>51,238</td>
<td>0.051</td>
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<tr>
<td>Direct</td>
<td>275.4</td>
<td>35.7</td>
<td>312,507</td>
<td>31,251</td>
<td>0.031</td>
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<td>Total</td>
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<td>54.9</td>
<td>481,217</td>
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<td>Direct</td>
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<td>32.9</td>
<td>287,940</td>
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<tr>
<td>Total</td>
<td>311.5</td>
<td>48.6</td>
<td>425,678</td>
<td>42,568</td>
<td>0.043</td>
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Building Envelope Compliance

- Mandatory Provisions Checklist
  - Insulation (§ 5.2.1)
    - Insulation Materials are installed in accordance with manufacturer's recommendations and in such a manner as to achieve rated R-value of insulation.
    - Exception: for metal building roofs or metal building walls.
    - Loose-fill insulation is not used in attic roof spaces when the slope of the ceiling is more than three in twelve.
    - Attic eave vents have baffling to deflect the incoming air above the surface of the insulation.
    - Insulation is installed in a permanent manner in substantial contact with the inside surface.
    - Batt insulation installed in floor cavities is supported in a permanent manner by supports no greater than 24 in. o.c.
    - Lighting fixtures; HVAC; and other equipment are not be recessed in ceilings in such a manner to affect the insulation thickness unless.
      - Exceptions:
        - The recessed area is less than one percent
        - The entire roof, wall, or floor is covered with insulation to the full depth required
        - The effects of reduced insulation are included in calculations using an area weighted averages.
        - Roof insulation is not installed over suspended ceiling with removable ceiling panels.
        - Exterior insulation is covered with a protective material to prevent damage.