IES Virtual Environment & Compliance with ASHRAE 90.1 2004, 2007, and 2010 Appendix G
Performance Rating Method

Supplied by: Integrated Environmental Solutions (IES) Ltd. Software Vendor
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Introduction

The purpose of this document is to provide an overview of the capabilities of the IES Virtual Environment (VE) software in relation to the requirements of ASHRAE 90.1 2004, ASHRAE 90.1 2007 and ASHRAE 90.1 2010, Appendix G, Performance Rating Method for application to projects pursuing LEED EAp2 & EA1c1 for new construction and core & shell.

Relevant excerpts have been taken directly from ASHRAE 90.1-2007, Appendix G, Section 2.2 “Simulation Program”, and used as headings underneath which a thorough explanation of VE capabilities has been provided.

G2.2 Simulation Program. The simulation program shall be a computer-based program for the analysis of energy consumption in buildings (a program such as, but not limited to, DOE-2, BLAST, or EnergyPlus). The simulation program shall include calculation methodologies for the building components being modeled. For components that cannot be modeled by the simulation program, the exceptional calculation methods requirements in Section G2.5 may be used.

The IES Virtual Environment (VE) is a suite of integrated building energy and environmental performance modeling software tools. The analysis engine, called ApacheSim, meets all of the requirements of this section as outlined in this document.

Please refer to the links provided below for detailed technical documentation.

The key simulation engine capabilities underlying the VE can be summarized as follows:

- 3-D Modelling of the Building, Site and Surroundings
- Solar Shading Simulation
- Daylight and Artificial Lighting Simulation
- Dynamic Thermal Simulation
- Building load calculations using ASHRAE Heat Balance Method
- Macroscopic Airflow (Bulk / Inter-zonal) Simulation
- Microscopic Airflow (CFD) Simulation
- HVAC Equipment and Controls System Simulation
- Renewable Energy Systems Simulation
- Water Systems Simulation

These tools can be applied from the earliest stages of the design process right through to the operation, and measurement and verification of the building to produce a wide variety of high quality performance information on sustainability and LEED issues such as:

- Sustainable Sites:
  - Exterior solar shading by site, surroundings and building self-shading
  - Right to light of building and surroundings

- Exterior wind effects, pedestrian comfort and pressure envelope
- Contaminant dispersal
- Outdoor thermal comfort
- Heat island effect
- Stormwater quantity and quality
- Exterior lighting levels and pollution

- Energy:
  - HVAC Equipment – Design load calculations for boilers, chillers, fans, pumps and heat recovery devices
  - Energy – Annual end use and peak demand, Running costs and Carbon Emissions. ASHRAE 90.1 Performance Rating Method.

- Indoor Environment Quality
  - Room ventilation rates and carbon dioxide levels (ASHRAE 62.1)
  - Thermal Comfort incl. air, mean radiant, dry-resultant and surface temperatures, relative humidity, PPD and PMV (using ASHRAE standard 55 calculation methodology)
  - Visual Comfort incl. daylight, views and glare. (LEED EQ 8.1)

This information is extremely valuable in determining better performing, more sustainable solutions for passive and active building systems and strategies in areas such as:

- Passive Design Components – Site, Orientation, Massing, Form, Layout, Glazed Areas, Glazing Types, Shading Devices, Thermal Mass, Insulation, Air tightness, Daylighting and Natural Ventilation
- Active Systems – Interior and exterior lighting, Process equipment, Heating, Cooling, Ventilation, Water and Controls
- Innovative Technologies – Mixed-mode Ventilation, Radiant Heating and Cooling, Displacement Ventilation, Daylight dimming, Green Roofs, Thermal storage etc.

The following resources can be used for a more complete understanding of the VE:

About the VE: [http://www.iesve.com/software/](http://www.iesve.com/software/)

ASHRAE 140 Test Results:

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<tr>
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<td>ASHRAE 140</td>
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Dynamic Thermal and Macroscopic Airflow Simulation Calculation Methods:
G2.2.1 The simulation program shall be approved by the rating authority and shall, at a minimum, have the ability to explicitly model all of the following:

(a) 8,670 Hours per year

Dynamic thermal simulation in the VE using the Apache engine facilitates fully flexible specification of pre-conditioning periods, time steps and simulation durations, up to one year or 8760 hours. The VE provides the capability to adjust the simulation time steps based on the analysis that is being conducted (shorter time steps allow for more explicit calculation of heat transfer time-lag effects). The maximum allowable time step is 30 minutes and the minimum is 1 minute however typically a 6 minute time step is used which results in 87,600 calculation time steps to represent one year.

(b) hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and HVAC system operation, defined separately for each day of the week and holidays;

The VE contains a sophisticated tool for the creation of variation profiles for individual days, weeks, months and years including holidays. These profiles can be assigned to a wide range of model components including but not limited to occupancy, lighting, equipment, set-points using percentage, absolute or formula driven values. Figure 1 below provides some examples of daily, weekly profiles and the advanced formula profile editor.
User Manuals

<table>
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<tr>
<td>Apache Weather &amp; Site</td>
<td>User Guide</td>
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(c) Thermal mass effects:

The thermal mass effects of a building are influenced and captured in the VE by dynamic thermal simulation using the Apache engine and a first principles finite difference mathematical model of heat transfer of:

- Thermal conduction and storage
- Exterior and interior convection
- Exterior and interior long wave radiation
- Internal heat gains radiant and convective split
- Air movement by wind pressures, buoyancy pressures, mechanical pressures
- Solar radiation by absorption, reflection, transmission, distribution and influenced by exterior and interior shading

Another important factor influencing how the building’s thermal mass is modeled is the accurate representation of the building’s geometry (see point ‘d’ below for further information) and the explicit dynamic thermal modeling of all discrete spaces comprising the building including conditioned zones and non-conditioned spaces such as ceiling voids, service shafts, elevator shafts etc.

(d) ten or more thermal zones:

The VE itself has no built-in restrictions on the number of zones it can model (however limitations can be encountered due to computer hardware required for simulation processing time and output data storage). Models containing many hundreds or even thousands of zones are commonly modeled in the VE to analyze large, complex buildings and systems.

As a building’s massing, form, layout and architectural detailing is of fundamental importance to its energy and environmental performance the VE provides the necessary tools to capture all of these factors in a high level of detail which can evolve in parallel to design development. Some examples of whole building VE model geometry / zoning are shown below in Figure 2.
HVAC equipment and controls system simulation is implemented in such a way in the VE that offers great flexibility in defining HVAC equipment and controls systems. A user can either start with a predefined system configuration or create customized systems by assembling a series of components and specifying the control strategies. This approach allows users to model a wide range of common system types, or highly customized systems. Performance data, including part-load capacity and efficiency correction curves can then be applied to the equipment.

The HVAC equipment and controls simulation is fully integrated with the solar, daylight, dynamic thermal and macroscopic airflow simulation. All of this results in very effective representation of the complex interactions between the building, climate, internal loads, and the HVAC systems. This level of detail is needed for detailed engineering energy analysis, or comparing system options.

Some system components available in the system are (but not limited to):

- Boilers with or without heat pumps
- Heat pumps
- Chillers
- Unitary Cooling Systems (Types)
- DX Cooling (Types)
- Waterside Economizers (Types)
- Air Heating Coils
- Air Cooling Coils
- Spray humidifiers
- Steam injection humidifiers
- Ductwork heat pick up
- Heat Recovery Devices
- Fans
- Dampers / Airside economizers
- Direct acting heaters
- Radiators
- Chilled Ceilings
- Water to water heat pumps
- Heat transfer loop
- Fully auto sizable prototype systems
Figure 3 below contains examples of HVAC equipment and controls system simulation data in the VE.
(f) capacity and efficiency correction curves for mechanical heating and cooling equipment;

Yes. See point (e) above

(g) air-side economizers with integrated control;

Yes. See point (e) above

(h) baseline building design characteristics specified in G3;

See G3.3.1 below

G2.2.2 The simulation program shall have the ability to either (1) directly determine the proposed building performance and baseline building performance or (2) produce hourly reports of energy use by an energy source suitable for determining the proposed building performance and baseline building performance using a separate calculation engine.

The VE also contains a highly flexible and interactive results analysis and output tool which can be used to provide greater levels of detail, insight and understanding of any building or system component’s performance. The VE contains aspects of standard output reports developed specifically for conducting PRM that collates all energy end use and peak demand information for both proposed and baseline building design models.
G2.2.3 The *simulation program* shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with generally accepted engineering standards and handbooks (for example, *ASHRAE Handbook—Fundamentals*) for both the proposed design and baseline building design.

The VE contains design load calculations in accordance with the ASHRAE Heat Balance Method that can be used to determine HVAC equipment capacities for both the proposed and baseline building designs. The ASHRAE Fundamentals Handbook states that the Heat Balance Method is the most detailed load calculation procedure and tends to produce the most reliable results. The VE simulation engine performs all of the explicit HBM calculations. As required for the baseline building design calculations, the user may specify the oversizing factor of 1.15 for cooling and 1.25 for heating.

G2.3 Climate Data. The *simulation program* shall perform the simulation using hourly values of climate data, such as temperature and humidity from representative climate data, for the site in which the *proposed design* is to be located. For cities or urban regions with several climate data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site. The selected weather data shall be approved by the *rating authority*.

The VE contains a large database of widely accepted annual climate data files for locations all over the world. A large number of different climate data file formats can be used in the VE however the most common are TMY, TMY2, IWEC, TRY and DSY. Climate data from a wide variety of other sources can also be imported for use in the VE (including the US Dept. Of Energy’s .epw weather data format). At a minimum these data files must contain a complete year’s data at hourly intervals for the following variables (from which other climate variables can be derived):

- Dry-bulb temperature
- Wet-bulb temperature (or relative humidity)
- Direct solar radiation
- Diffuse solar radiation
- Wind speed
- Wind direction

![Graphs](https://example.com/graphs)

Figure 4: Examples of annual hourly climate data in the VE
G2.4 Energy Rates. Annual energy costs shall be determined using either actual rates for purchased energy or state average energy prices published by DOE’s Energy Information Administration (EIA) for commercial building customers, but rates from different sources may not be mixed in the same project.

Energy rates can be defined in the VE for different energy sources and used to calculate running costs.

G3.1.1 Baseline HVAC System Type and Description. HVAC systems in the baseline building design shall be based on usage, number of floors, conditioned floor area, and heating source as specified in Table G3.1.1A and shall conform to the system descriptions in Table G3.1.1B.

Using the HVAC equipment and controls system simulation in the VE it is possible to model all 8 baseline systems including all system specific baseline requirements specified in G3.1.3. See G2.2.1 (e) for more information.

ADDITIONAL NOTE

The VE has been tested in accordance with ASHRAE Standard 140 and meets or exceeds all requirements of this test. Results of the ASHRAE 140 test are available to download from our website:

http://www.iesve.com/software/software-validation

The VE has been tested in accordance as Acceptable Software for Calculating Commercial Tax Deductions as required by the US DOE for EPAct.

http://energy.gov/eere/buildings/qualified-software-calculating-commercial-building-tax-deductions