

ENERGYPLUS™ VERSION 8.5 DOCUMENTATION

Using EnergyPlus for Compliance

U.S. Department of Energy



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Chapter 1

Introduction

1.1 Background

Energy Standards abound throughout the world. This document provides guidance on using EnergyPlus and its reports for compliance with energy standards.

The tabular reports from EnergyPlus were designed to help collate information into a form usually required for reporting on designs for energy use. The tabular reports are fully described in the Output Details document and will be judiciously reproduced here for clarity and reference. In addition, by using the `Output:Table:Style` object, one can obtain the reports in a variety of formats – ready for incorporating into your own style for submission or presentation.

First, we describe the features available in the tabular report that might be used for energy compliance reporting or presentation of energy designs to clients.

1.2 Compliance Objects

To facilitate using EnergyPlus for compliance reporting, a group of Compliance Objects is described in the Input Output Reference document. Currently, there is only one object in this group: **Compliance:Building** which, when fully populated, will describe various aspects that are needed specific to buildings. Other compliance objects will be added to this group when appropriate.

1.3 Tabular Summary Reports

Several predefined reports are available from the `Output:Table:Predefined` object including the following.

- Annual Building Utility Performance Summary
- Input Verification and Results Summary
- Demand End Use Components Summary

- Source Energy End Use Components Summary
- Climatic Data Summary
- Equipment Summary
- Envelope Summary
- Surface Shadowing Summary
- Shading Summary
- Lighting Summary
- HVAC Sizing Summary
- System Summary
- Component Sizing Summary
- Outside Air Summary
- Object Count Summary

In addition, specifying “All Summary” will enable all the reports in this category (more than are shown here).

1.3.1 Annual Building Utility Performance Summary

First and foremost, the Annual Building Utility Performance Summary gives a good overview of the energy use by category:

Report: **AnnualBuildingUtilityPerformanceSummary**

For: **Entire Facility**

Timestamp: **2009-09-17 17:30:22**

Values gathered over 8760.00 hours

Site and Source Energy

Type	Storage Volume [m ³]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Fac- tor
None					

Source to Site Energy Conversion Factors

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Building Area

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

End Uses

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Note: Natural gas appears to be the principal heating source based on energy usage.

End Uses By Subcategory

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Normalized Metrics

Utility Use Per Conditioned Floor Area

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Utility Use Per Total Floor Area

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					
Electric Loads Satisfied					
Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					
On-Site Thermal Sources					
Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					
Water Source Summary					
Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					
Comfort and Setpoint Not Met Summary					
Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Note 1: An asterisk (*) indicates that the feature is not yet implemented.

1.3.2 Input Verification Summary

The input verification summary gives a good overview of the facility being simulated:

Report: **InputVerificationandResultsSummary**
 For: **Entire Facility**

Timestamp: 2009-09-17 17:30:22

General

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

ENVELOPE

Window-Wall Ratio

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Skylight-Roof Ratio

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

PERFORMANCE

Zone Summary

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

1.3.3 Source Energy End Use Components Summary

The source energy end use components summary gives a good overview of the source energy consumption broken down by end uses for the facility being simulated:

Report: **SourceEnergyEndUseComponentsSummary**

For: **Entire Facility**

Timestamp: **2011-10-07 20:53:43**

Values gathered over 8760.00 hours

Source Energy End Use Components Summary

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Normalized Metrics

Source Energy End Use Components Per Conditioned Floor Area

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Source Energy End Use Components Per Total Floor Area

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

1.3.4 Other Summary Reports

The Climatic Data Summary, Envelope Summary and Equipment Summary reports might be quite important to some reporting or presentation.

Report: **ClimaticDataSummary**

For: **Entire Facility**

Timestamp: **2009-09-17 17:30:22**

SizingPeriod:DesignDay

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Weather Statistics File

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Report: **EnvelopeSummary**
 For: **Entire Facility**
Timestamp: 2009-09-17 17:30:22
 Opaque Exterior

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Fenestration

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Report: **ShadingSummary**
 For: **Entire Facility**
Timestamp: 2009-09-17 17:30:22
 Sunlit Fraction

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Window Control

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

Report: **LightingSummary**
 For: **Entire Facility**
Timestamp: 2009-09-17 17:30:22
 Interior Lighting

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Daylighting

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Exterior Lighting

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Report: **EquipmentSummary**
 For: **Entire Facility**
Timestamp: 2009-09-17 17:30:22
 Central Plant

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Cooling Coils

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
------	---------------------	-----------	--------------------------	---------------------------	---------------

None

Heating Coils

Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					
Fans					
Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					
Pumps					
Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					
Service Water Heating					
Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
None					

1.4 Features Related to Appendix G and LEED

EnergyPlus has several built-in features to make demonstrating compliance with ASHRAE Standard 90.1 Appendix G easier. Appendix G is used in Energy and Atmosphere Credit 1 Optimize Energy Performance of the U.S. Green Building Council (USGBC) building certification system called Leadership in Energy and Environmental Design (LEED) Green Building Rating System™. The following sections describe the features.

1.4.1 Baseline Building Rotations

Table G3.1 Section 5 Building Envelope of ASHRAE Standard 90.1 Appendix G requires that the baseline building be simulated facing four directions:

Orientation. The baseline building performance shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, and

270 degrees, then averaging the results.

This provision intends to provide a baseline that is neutral to building orientation so that buildings purposely oriented to minimize energy use can realize a percent savings.

Step 1. The first step of performing the building rotations is to include a Compliance:Building object which contains the Building Rotation for Appendix G field. The value of the field should be different for four simulations, 0, 90, 180 and 270 (see Step 2 below). This is further documented in the Input Output Reference.

```
Compliance:Building,
    90;                Building Rotation for Appendix G
```

Also make sure that the HTML summary reports will be generated by including the following:

```
OutputControl:Table:Style,
    HTML;                !- type

Output:Table:SummaryReports,
    AllSummary;          !- type
```

Step 2. The ParametricPreprocessor automates the creation of the four simulation input files so that only a single simulation file is needed to be created by the user. By setting the file name suffixes (which are appended to the existing file name for each simulation), setting a variable that varies for the four simulations, and setting the Building Rotation for Appendix G to this variable, the user can automatically create the four files when using EnergyPlus. The following example shows what should be included in the EnergyPlus file. The Parametric objects are described further in the Input Output Reference and the ParametricPreprocessor is described in the Auxiliary Programs documentation.

```
Parametric:FileNameSuffix,
    Names,
    G000,
    G090,
    G180,
    G270;
```

```
Parametric:SetValueForRun,
    $appGAngle,          !- Parameter Name
    0.0,                 !- Value 1
    90.0,                !- Value 2
    180.0,               !- Value 3
    270.0;               !- Value 4
```

```
Compliance:Building,
    = $appGAngle;        !- Building Rotation for Appendix G {deg}
```

```
OutputControl:Table:Style,
    HTML;                !- type
```

```
Output:Table:SummaryReports,
    AllSummary;          !- type
```

Step 3. Run the simulation using EP-Launch. Using the “Single Input File” tab of EP-Launch select the input that contains the Compliance:Building, Parametric:FileNameSuffix, Parametric:SetValueForRun objects as shown above in Step 2 as well as the weather file.

In EP-Launch, make sure under VIEW .. OPTIONS .. MISCELLANEOUS that the RUN PARAMETRICPREPROCESSOR option is checked.

Step 4. Review the results and revise the model inputs as needed. You can view the results of the simulation by using the EP-Launch and the History tab. At the bottom of the history list, four simulations that use the G000, G090, G180 and G270 file name suffixes should appear and the result files associated with each can be selected and opened.

Step 5. Use the AppGPostProcess to average results across the simulations. In EP-Launch under the UTILITIES tab, select AppGPostProcess utility and select one of the HTML files resulting from the multiple simulation runs (e.g., <filename>-G000.html). This will open all four files and generate a new output file with the file suffix GAVG for the HTML and other results files that can be opened on that tab.

1.4.2 Completing LEED Forms from Tabular Reports

The U.S. Green Building Council building certification system called Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ includes Energy and Atmosphere Credit 1 Optimize Energy Performance. Credit 1 includes an option that requires a series of building energy simulations that follow the procedures of ASHRAE Standard 90.1 Appendix G Performance Rating Method. The LEED Summary report provides many of the simulation results required for the forms. The report can be produced by specifying LEEDSummary in Output:Table:SummaryReports which is also part of the AllSummary option.

Report: **LEED Summary**

For: **Entire Facility**

Timestamp: **2013-03-01 15:24:37**

Sec1.1A-General Information

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-1. Space Usage Type

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11

	Percent [%]
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-2. Advisory Messages

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-3. Energy Type Summary

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-4/5. Performance Rating Method Compliance

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11

	Percent [%]
Miscellaneous	39.99

EAp2-6. Energy Use Summary

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-7. Energy Cost Summary

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

Process energy cost based on ratio of process to total energy.

L-1. Renewable Energy Source Summary

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-17a. Energy Use Intensity - Electricity

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-17b. Energy Use Intensity - Natural Gas

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-17c. Energy Use Intensity - Other

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

EAp2-18. End Use Percentage

	Percent [%]
Interior Lighting	18.93
Space Heating	24.22

	Percent [%]
Space Cooling	4.11
Fans-Interior	1.63
Service Water Heating	0.00
Receptacle Equipment	11.11
Miscellaneous	39.99

1.4.2.1 LEED Form Section 1.4 – Comparison of Proposed Design Versus Baseline Design

Unlike other portions of the LEED forms, Section 1.4 Comparison of Proposed Design Versus Baseline Design is less structured with many possible “Model Input Parameters” to match with the “Proposed Design Input” and “Baseline Design Input”.

1. *Exterior wall, underground wall, roof, floor, and slab assemblies including framing type, assembly R-values, assembly U-factors, and roof reflectivity when modeling cool roofs. (Refer to ASHRAE 90.1 Appendix A)*

Use the values from the Envelope Summary table, Opaque Exterior subtable for Construction, Reflectance, U-Factor with Film, and U-Factor no Film.

2. *Fenestration types, assembly U-factors (including the impact of the frame on the assembly, SHGCs, and visual light transmittances, overall window-to-gross wall ratio, fixed shading devices, and automated movable shading devices)*

Use the values from Input Verification and Results Summary table, Window-Wall Ratio table Window-Wall Ratio percentage as well as Skylight-Roof Ratio table. Also use the values from the Envelope Summary table, Fenestration subtable for Construction, Area of Openings, U-Factor, SHGC, Visible Transmittance, and Shade Control. For shading use the Shading Summary report including Sunlit Fraction and Window Control.

3. *Interior lighting power densities, exterior lighting power, process lighting power, and lighting controls modeled for credit.*

Use the values from the Lighting Summary report for Interior Lighting, Daylighting and Exterior Lighting including Lighting Power Density, Schedule Name, Average Hours/Week, Daylighting Type, Control Type, Fraction Controlled, Lighting Installed in Zone, Lighting Controlled.

4. *Receptacle equipment, elevators or escalators, refrigeration equipment and other process loads.*

Use the values from Input Verification and Results Summary table, Zone Summary subtable for Plug and Process.

5. *HVAC system information including types and efficiencies, exhaust heat recovery, pump power and controls, and other pertinent system information. (Include the ASHRAE 90.1-2004 Table G3.1.1B Baseline System Number)*

Use the Equipment Summary report, Central Plant subtable for Type, Nominal Capacity and Nominal Efficiency; Cooling Coils subtable for Nominal Total Capacity and Nominal Efficiency; Heating Coils subtable for Type, Nominal Total Capacity and Nominal Efficiency; Fans subtable for Type, Total Efficiency, Delta Pressure, Max Flow Rate, Rated

Power, Motor Heat in Air Fraction; Pumps subtable for Type, Control, Head, Power and Motor Efficiency. Use the System Summary report, Economizer subtable for High Limit Shutoff Control and Minimum Outdoor Air; the Demand Controlled Ventilation using Controller:MechanicalVentilation subtable.

6. Domestic hot water system type, efficiency and storage tank volume.

Use the Equipment Summary report, Service Water Heating subtable for Type, Storage Volume, Input, Thermal Efficiency, Recovery Efficiency, and Energy Factor.

7. General schedule information.

Use the Lighting Summary report, Interior Lighting subtable Schedule Name and Average Hours/Week; Exterior Lighting subtable Schedule Name and Average Hours/Week. Use the System Summary report, Demand Controlled Ventilation using Controller:MechanicalVentilation subtable for the Air Distribution Effectiveness Schedule.

1.5 Features Related to California Title 24 Compliance

EnergyPlus has a reporting feature that is useful for obtaining Time Dependant Valuation (TDV) of source energy use for the entire facility being simulated. Hourly variations of fuel factors can be specified through the ‘FuelFactors’ input object and will be used to calculate TDV based source energy consumption broken down by end uses. The Source Energy End Use Components Summary report above provides these TDV based values. The source energy consumption is also reported based on area normalized metrics. Refer to ‘Fuel Factors’ and ‘Output:Table:SummaryReports’ in the Input-Output Reference manual for more details.

Also included is the California_Title_24-2008.idf dataset (described briefly in the Output Details document).