

EnergyPlus 8.9.0 User Guide

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1 EnergyPlus Packages

The installation of EnergyPlus will create a whole folder in the assigned directory. The following items describe some of the important files necessary for building a model. Notice that all documentations mentioned are available in the folder *Documentation* and in this site: <https://energyplus.net/documentation>.

1.1 EP-Launch

EP-Launch is the program that is used to run simulation. It is not available for Mac. Similar program on Mac is called EP-Launch-Lite, with less functions available. This section explains the functions of EP-Launch 8.9.0 on Windows system. Detailed description of input and output file will be provided in the next section. Figure 1 shows the interface of EP-Launch.

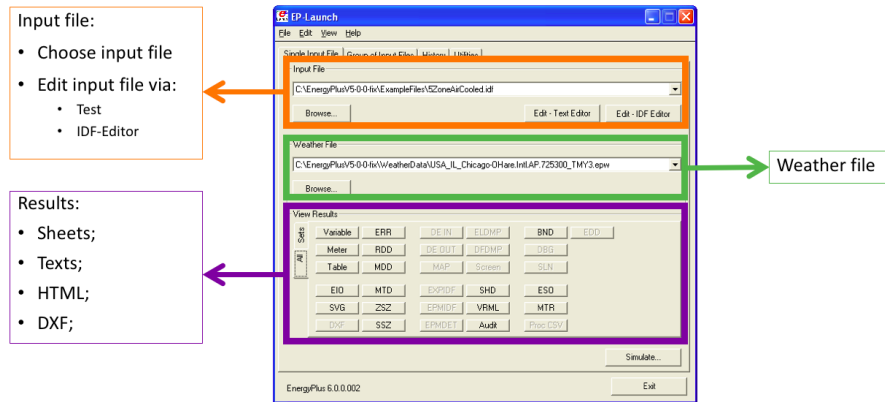


Figure 1: EP-Launch Interface

In EP-Launch, the following tasks can be performed:

- Choose input idf file via **Browse...** button in Input File section.
- Edit input idf file via **Edit-Text Editor** or **Edit-IDF Editor** button. Editing by text editor would require user to be very meticulous with syntax and input. IDF-Editor provides the interface where user can edit input and output variables more easily. Later in this section, IDF-Editor will be explained.

- Choose input epw weather file via **Browse...** button in Weather File section. Weather file can be downloaded in EnergyPlus website: <https://energyplus.net/weather>.
- Open and View output files in **View Results** section. There are two tabs on the left side: **Sets** and **All**. Choosing the **Sets** tab and clicking the button will open all the output files of the selected type. E.g. if selected the **Spreadsheets** button in this tab, all excel sheets will be opened.
- Customize default editor and viewers in **View-Options...**. Select the default program to open an output file. In this way, user can conveniently edit or open the file via View Results section with the selected program. For more detail, please read the *Documentation/Getting Started* manual.

1.2 IDF-Editor

IDF-Editor is installed along with Windows installation. It is a convenient tool for editing input variables in the idf file. Figure 2 shows the interface of IDF-Editor.

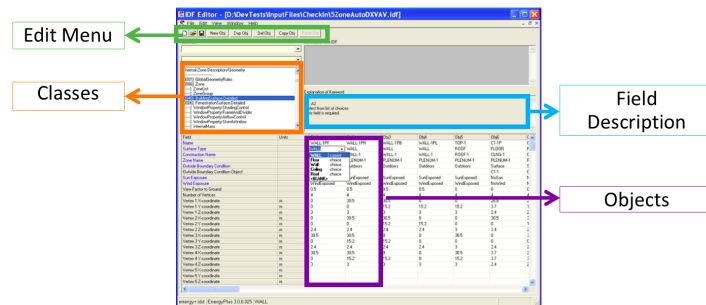


Figure 2: IDF-Editor Interface

Four fields in the interface are important to know after user opens one idf file:

- Edit menu. The edit menu contain buttons to duplicate and copy and object. An object is defined as a complete column of information.

- **Field Description.** Contains explanation about the field. For more information about inputs and outputs, please refer to *Documentation/InputOutputReference*.
- **Objects.** All EnergyPlus variables are categorized by objects. Objects are categorized by classes. For each field in object, it could be either self-defined value or options. Depending on different situation, some field may be blank, may have default value, or must have an input.
- **Classes.** The following graph shows the list of all classes in EnergyPlus. Notice that the **HVAC Templates** class could directly be used as template to add HVAC system to the model, instead of self-defining the system in other classes.

- | | | | |
|---|--|---|----------------------|
| • Simulation parameters | • Zone HVAC forced air units | • Solar collectors | • Operational faults |
| • Compliance object | • Zone HVAC radiative/convective units | • Plant heating and cooling equipment | • General data entry |
| • Location and climate | • Zone HVAC air loop | • Condenser equipment and heat exchangers | • Hybrid model |
| • Schedules | • Zone HVAC equipment connections | • Water heaters and thermal storage | • Performance curves |
| • Surface construction element | • Fans | • Plant-condenser loops | • Performance tables |
| • Thermal zones and surfaces | • Coils | • Plant-condenser control | • Fluid properties |
| • Advanced construction, surface, zone concepts | • Evaporative coolers | • Energy management system | • Economics |
| • Detailed ground heat transfer | • Humidifiers and dehumidifiers | • External interface | • Parametrics |
| • Room air models | • Heat recovery | • User defined HVAC and plant component models | • Output reporting |
| • Internal gains | • Unitary equipment | • System availability managers | |
| • Daylighting | • Variable refrigerant flow equipment | • Setpoint managers | |
| • Zone airflow | • Controllers | • Refrigeration | |
| • Natural ventilation and duct leakage | • Air distribution | • Demand limiting controls | |
| • Exterior equipment | • Node-branch management | • Electric load center-generator specifications | |
| • HVAC templates | • Pumps | • Water system | |
| • HVAC design object | • Plant-condenser flow control | | |
| • Zone HVAC controls and thermostats | • Non-zone equipment | | |

Figure 3: EnergyPlus Input Classes

1.3 DataSets

DataSets folder contain values for commonly seen data. For example, **CompositeWallConstructios.idf** contains predefined values for some construction materials. Each object may be copied to targeted idf file and directly be used. **WindowGlassMaterials.idf** and **Schedules.idf** may also be useful.

1.4 Documentation

This folder contains the same set of files that are in the site: <https://energyplus.net/documentation>. Here're brief descriptions of three rel-

atively important documents:

- [EngineeringReference.pdf](#). This file explains the algorithm EnergyPlus's computation is based on. It explains computations in detail and shows the equations being used. Figure 4 shows the overall computation scheme of EnergyPlus.

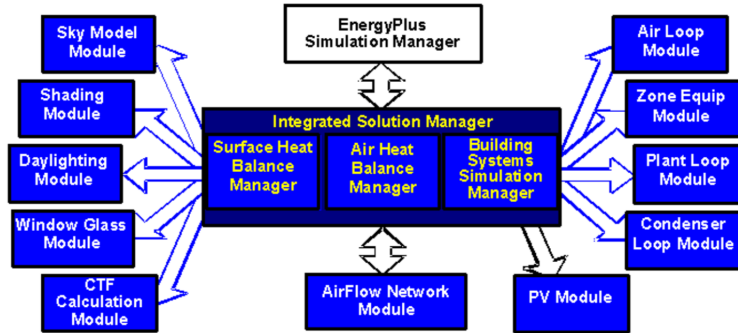


Figure 4: EnergyPlus Algorithm Overview

- [GettingStarted.pdf](#). This file can be served as a starting guide for using EnergyPlus. It is largely based on Windows version of EnergyPlus. Two examples are shown in this manual.
- [InputOutputReference.pdf](#). This file provides an detailed description of input and output variables. It should be referred to whenever user has any question about a particular field. It provides explanations for variables with default value, e.g. **autosize**.

1.5 WeatherData

This directory contains sample weather files. Weather files are necessary files to run simulation, if the built model require a weather file to run. Weather files can be found on EnergyPlus website: <https://energyplus.net/weather>.

1.6 ExampleFiles

This folder include examples of idf files. Inside the **BasicFiles** folder under this directory, there are two sets of starting files and solution files for two basic exercises to help user get started. Please follow the guide in *Getting*

Started manual to do this exercise.

Exercise-1 provides instruction in adding construction information and pre-defining reports. Exercise-2 provides instruction in adding HVAC system and controlling simulation.

2 Basic File Types

2.1 Input Files

There are two kinds of input files:

- **idf file.** Editable by test editor or idf editor.
- **Weather epw file.** Accessible on EnergyPlus website.

2.2 Output Files

EnergyPlus generates many kinds of output files. The following list of files are important to know:

- **html.** Need to add a **OutputControl:Table:Style** object with HTML format in the idf file, if want to generate this file. An HTML form output file is a handy way of viewing summary of tables and results, as many other output files contain data that are rather messy and unorganized.
- **Error log.** Records error, warnings and other messages that appear when running the simulation. Notice that warnings won't stop the simulation process, only fatal and severe errors will.
- **.csv files.** These are excel spreadsheets that contain tables of the output values.
- **.dxf.** Images of the physical model. Since zone geometric information are recorded in EnergyPlus as materials' parameters, coordinates, dxf file provides a convenient way of checking the correctness of geometry. Can be opened using Autodesk applications.
- **.svg.** HVAC system diagram. Similar to dxf file, this diagram provides a handy method of checking the input HVAC system.

3 Building Scheme

Building a model simulating energy consumption of a room in EnergyPlus involve the consideration of many different aspects. The overall process can be broken down into the following parts.

3.1 Physical Model

The essential part of an EnergyPlus model for a room is a physical model with location, thermal zone geometry, materials and construction information:

- **Location.** Location information is added as a **Site:Location** type object. It includes the building name, latitude, longitude, time zone and elevation information.
- **Materials.** Materials information about wall/floor/ceiling/roof is added as **Material** type objects. Materials information about window is added as one of the **WindowMaterial** type objects. These two types of objects have different variables. Please refer to *Documentation/InputOutputReference* for detailed information. There are two ways of adding material information:
 - Builtin Library. EnergyPlus has a builtin library of material information that user can directly copy from. To open the builtin data sets, go to **File - Open DataSets** menu in IDF-Editor and open the targeted data sets. Window materials and construction materials are stored in different data sets.
 - Self Define. User can also self define materials. Notice that some of the variables have default values and some need users to look up by themselves.
- **Construction.** Here construction information is defined as the information of layers of materials. Construction type object uses material information defined in the previous point. Only those that have been added to the same idf file can be used. Choose with a drop-down menu.
- **Geometry.** A "zone" in EnergyPlus is a thermal, but not geometric, concept. However, for the purpose of only simulating a room, it is reasonable to assume that the thermal zone concept is equivalent to

the geometric concept. The following steps need to be followed to define a zone:

- Define the rules user will follow to put in zone geometric information as an **GlobalGeometryRules** object.
- Define the target zone as **Zone** object. Only define the name, coordinate origin, height and volume here.
- Define type, construction layer name, exposure condition, coordinates, belonging zone name of each flat surface in **BuildingSurface:Detailed**. All information except surface name and coordinates should be chosen in a drop-down menu.
- Windows may be added as **FenestrationSurface:Detailed** type object. Doors may be added as **Door** type object. Please define the surface before adding these two.

The model can be visualized after run one simulation and the 3D image will be stored in the dxf file, as mentioned in the previous section. This is a good way of checking whether coordinates are added in the right sequence, whether the shape is correct or not.

3.2 Occupancy

To add an occupancy schedule into the simulation, follow these steps described below:

- Define the occupancy schedule as a **Schedule:Compact** object. For the field "Schedule Type Limits Name", choose Fraction. To define a schedule, it would be helpful to follow the example schedule from data set file *Schedules.idf*. The schedule is defined here as the fraction of peak occupancy.
- Add occupancy schedule to the simulation by adding a **People** type object. The peak of number of people in the target zone is defined here.

3.3 HVAC System

User can self define HVAC system using objects from different classes, but it is recommended to use the objects in **HVAC Templates** class. This class contains many types of HVAC system template. E.g. user can define a valid Variable Air Volume (VAV) HVAC system by only using objects from HVAC

Templates class.

To simulate an HVAC system in EnergyPlus, user may break this process down into four parts: thermostat, zone, system, plant. Plant can be broken down into three components: chiller and chilled water loop, boiler and hot water loop, as well as tower. The figure shows this overall structure.

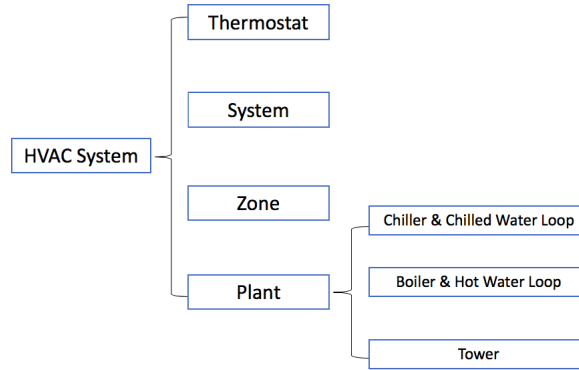


Figure 5: EnergyPlus Algorithm Overview

Here're the detailed description of all required classes, assuming user is using object types from only the **HVAC Templates** class:

- **Thermostat.** Information defined will be used when defining **Zone** type object. It requires input of the names of two valid Schedule type objects, one for heating setpoint schedule and one for cooling setpoint schedule. The schedule may be defined as a **Schedule:Compact** type object. However, being more understandable, building up the schedule from **Schedule:Hourly**, to **Schedule:Week:Compact**, to **Schedule:Year** would be the recommended method. Defining the schedule through this process allows user to define the schedule of individual days, assign day schedules throughout the week, and assign week schedules to different months throughout the year. Only the schedule defined as **Schedule:Year** type can be used as **Thermostat** input.
- **System.** Define an HVAC system as a **HVACTemplate:System:...** type object. Must define system first before defining zone. "System" type object simulates the air handling unit (AHU) and "Zone" type

object simulates the control at the terminal (inside the zone). E.g. **HVACTemplate:System:VAV** asks for information about heating and preheat coil type, which are components of VAV AHU. On the other hand, **HVACTemplate:Zone:VAV** asks for information about reheat coil type, which is a component of the VAV terminal that is installed inside the thermal zone.

- **Zone.** Define the control of zones as **HVACTemplate:Zone:...** type objects. As mentioned before, system must be defined before zone, since system name is one of the input values for zone type objects. This type of object defines the kind of HVAC system that is controlling a zone.
- **Plant: Chiller/Chilled Water Loop.** Define the chiller as a **HVACTemplate:Plant:Chiller** type object. Define the plant and condenser loop of chilled water as a **HVACTemplate:Plant:ChilledWaterLoop** type object. They are defined as independent object. In other words, neither of them need the other as input value.
- **Plant: Boiler/Hot Water Loop.** Define the boiler as a **HVACTemplate:Plant:Boiler** type object. Define the hot water loop as a **HVACTemplate:Plant:HotWaterLoop** type object. Similar to chiller and chilled water loop, they are defined as independent objects.
- **Plant: Tower.** Tower has to be added into the idf file, in order to run the simulation. It is added as a **HVACTemplate:Plant:Tower** type object.

In general, these several types of objects that simulate an HVAC system require many specific inputs. However, most of them have default values. For more information on example values, default values, short explanation of variables, please see the HVAC system directory inside this Github repository.

3.4 Simulation Control

Besides the above aspects, simulation control also needs to be taken into consideration. There're several parts that user might want to modify to run the desired simulation:

- **SimulationControl.** In this type of object, define all the sizing options and define simulation running period option.

- **Timestep.** For **Timestep** type object, there's only one field, which asks user to put in timestep option. This is a useful tool to use, especially when user want to generate data by small steps, e.g. 5 minutes. The reporting frequency is defined in the Output class.
- **RunPeriod.** Define the start and end day of the simulation as a **RunPeriod** type object.

4 User Tip

Here are some useful tips for using EnergyPlus.

- **ctrl + L.** Hide/Reveal all types without any input. This provides a clean way of examining components already added and those that have not.
- **start from a working idf file.** Would recommend start from a working idf file because EnergyPlus asks for many input values and user could easily get lost when starting from scratch and nothing works.

5 Further Reading

- *Documentation/EngineeringReference.*
- *Documentation/InputOutputReference.*
- *Documentation/GettingStarted.*
- [EnergyPlus University Course Teaching Material](#)