INTERNAL GAINS MODULE—ENERGYPLUS EXERCISE INSTRUCTIONS

Exercise Introduction and Objectives

The exercise provides a base file for a two-story building, measuring 104′ x 48′. The building is modeled with core and perimeter zoning for each floor.

The objective of this exercise is to study the effect of internal gains from people, lighting and equipment on a building's energy use. The same structure is modeled as a hotel, an office and a retail building with different space-use characteristics, lighting plans and equipment data to study the difference in energy consumption.

Note:
These exercise instructions and associated input files have been written to conform with EnergyPlus v5.0.0 format. Use of these instructions and input files with later versions of EnergyPlus may require changes or updates to input objects and location of data sets and weather files.

Exercise Procedure

Schedules are a usage study, and the values are usually obtained from the architect's office or from previous simulations of similar buildings. Schedules are created for activity, work efficiency, air velocity and clothing. Schedules for people occupancy and lighting are imported from Eplus datasets for the three models.

Data for internal gains from people, lighting and equipment is entered in the respective spaces, the data being pulled from the ASHRAE Handbook or from the plethora of predefined material and schedule data that comes with EnergyPlus.

Simulations are run and energy usage data obtained for analysis.

Note: About IDF Editor
Users who want a simple way to create or edit EnergyPlus input data files (IDF) can use the IDF Editor. They can view and edit any EnergyPlus object using a spreadsheet-like grid. A list is provided for inputs with several options. The IDF Editor outputs an EnergyPlus input file with proper syntax and comments to help the user understand the input values. In addition, the IDF Editor converts standard inch-pound units into SI units that are compatible with EnergyPlus. The IDF Editor does not check inputs for validity, although it highlights some numeric fields that are out of range. For the purpose of this exercise, the IDF editor is a useful input interface.

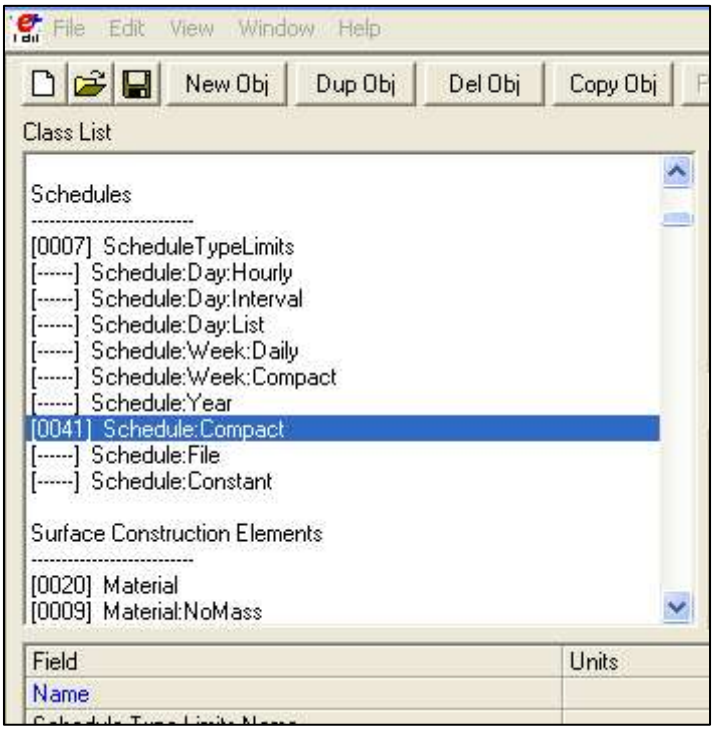
Hotel Building Data

A hotel hopes to have a fairly constant activity load. Although there is lower activity at night than during the day, the variation is not as great as in residential or other commercial locations.

For this exercise assume that the activity level of people within the space is uniform for the day and for all days of the year at 120 W/person. All building zones will have the same activity level.

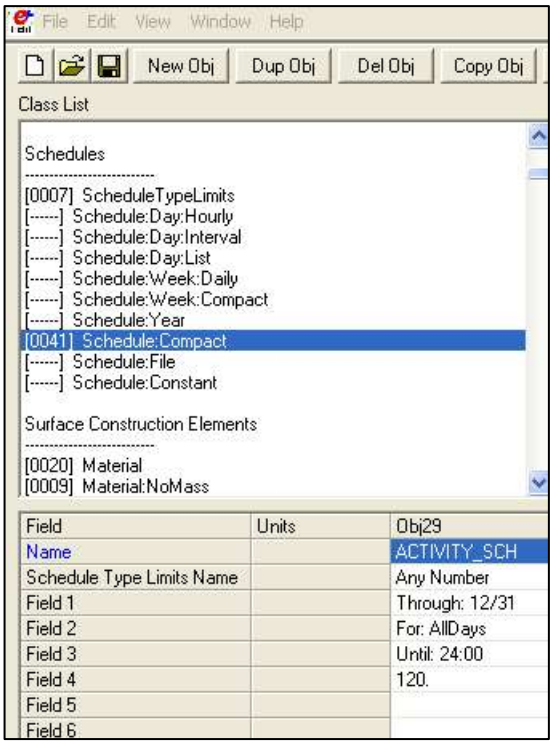
Instructions

1. Start IDF Editor > File > Open > 1.Base File.idf
2. Save as > 2.HotelBldg.idf in the destination folder.
3. Under Class List, select Schedules > Schedule: Compact > New Object



4. Create a schedule for Activity with the following data:

Name	ACTIVITY_SCH
Schedule Type Limits Name	Any number
Field 1	Through: 12/31
Field 2	For: AllDays
Field 3	Until: 24:00
Field 4	120.

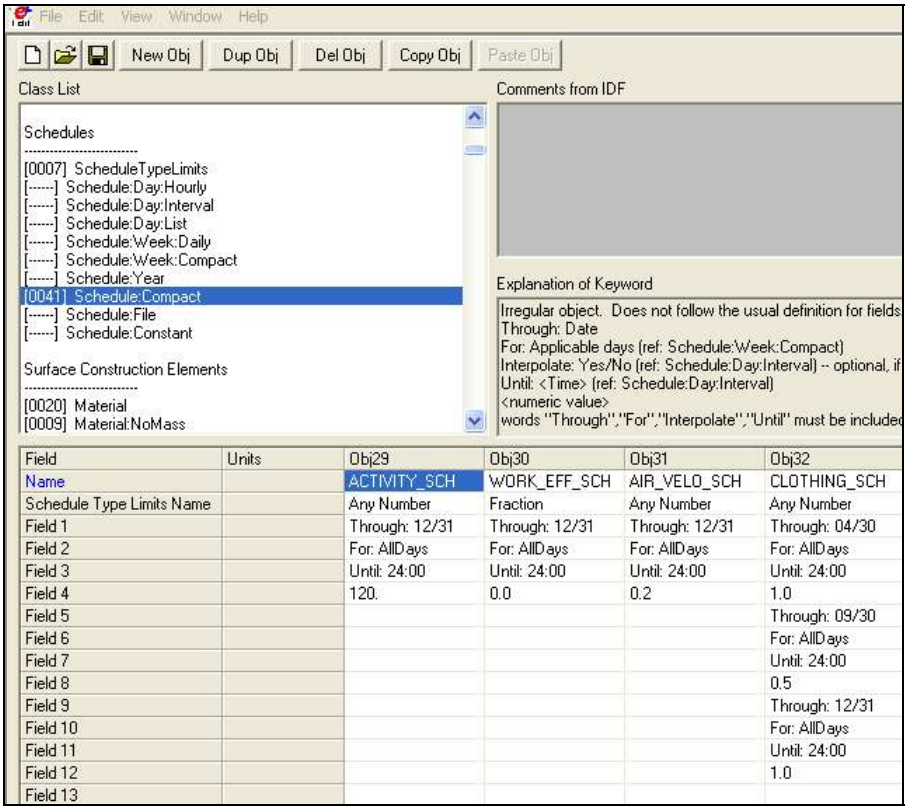


5. Similarly create schedules for work efficiency, air velocity, clothing with the following data:

Name	WORK_EFF_SCH
Schedule Type Limits Name	Fraction
Field 1	Through: 12/31
Field 2	For: AllDays
Field 3	Until: 24:00
Field 4	0.0

Name	AIR_VELO_SCH
Schedule Type Limits Name	Any Number
Field 1	Through: 12/31
Field 2	For: AllDays
Field 3	Until: 24:00
Field 4	0.2

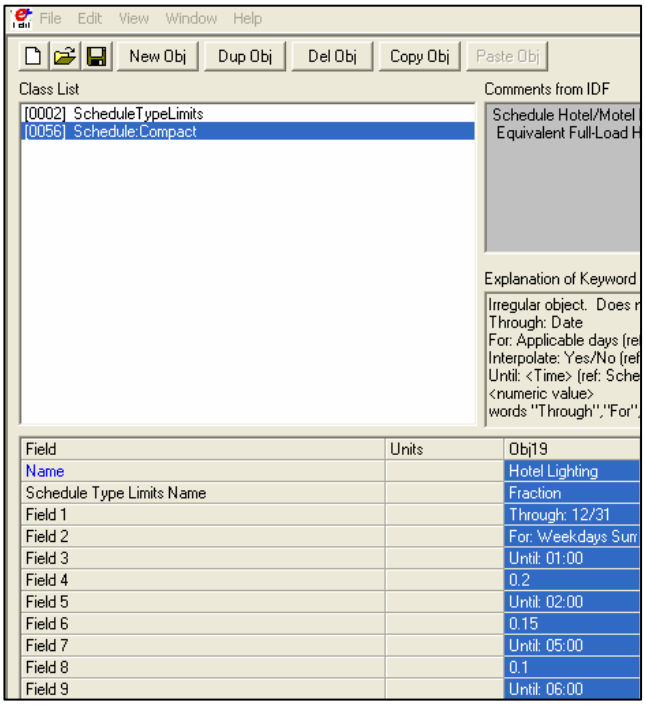
Name	CLOTHING_SCH
Schedule Type Limits Name	Any Number
Field 1	Through: 04/30
Field 2	For: AllDays
Field 3	Until: 24:00
Field 4	1.0
Field 5	Through: 09/30
Field 6	For: AllDays
Field 7	Until: 24:00
Field 8	0.5
Field 9	Through: 12/31
Field 10	For: AllDays
Field 11	Until: 24:00
Field 12	1.0



6. Obtain the occupancy and lighting use schedules for typical hotels from the EnergyPlus database.

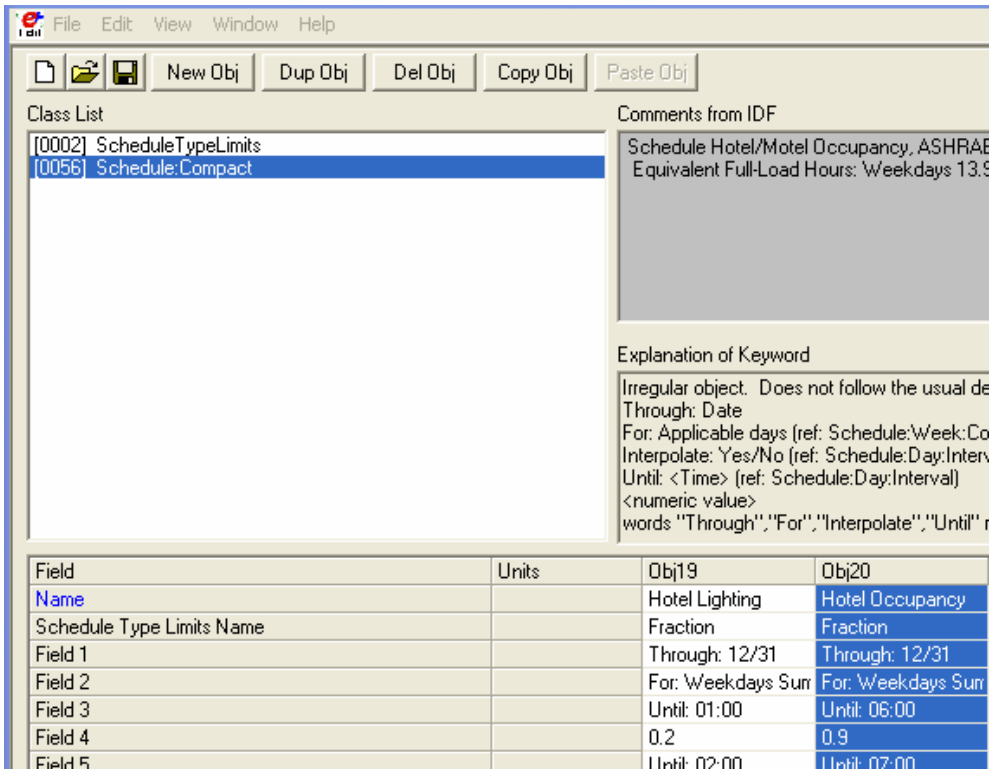
   To import people, lighting schedules from the database:

   a) File > Open Dataset > Schedules.idf
   b) Open Class List > Schedules > Schedule:Compact
   c) Look for Hotel Lighting Schedule > Copy Object



d) Paste Object into 2.HotelBldg.idf

e) Repeat the same process with Hotel Occupancy Schedule.

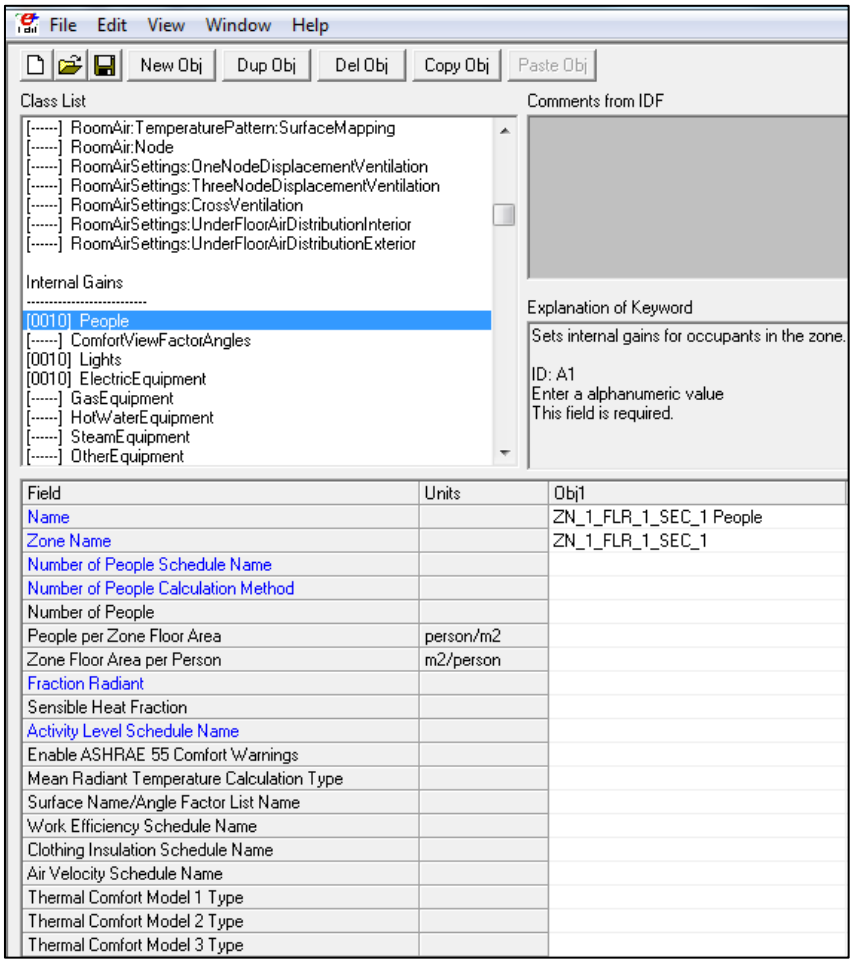


f) For the HVAC Operation Schedule (Obj12), for Weekdays SummerDesignDays, Until: 24:00, change Field 8 from 0.0 to 1.0.

g) The schedules are complete. We now need to enter the data needed for internal gains input.

7. The next step is to add the actual internal gains. One good source of data is the Lawrence Berkeley National Laboratory (LBNL) report, Commercial Heating and Cooling Loads Component Analysis, June 1998, http://gundog.lbl.gov/dirpubs/37208.pdf.

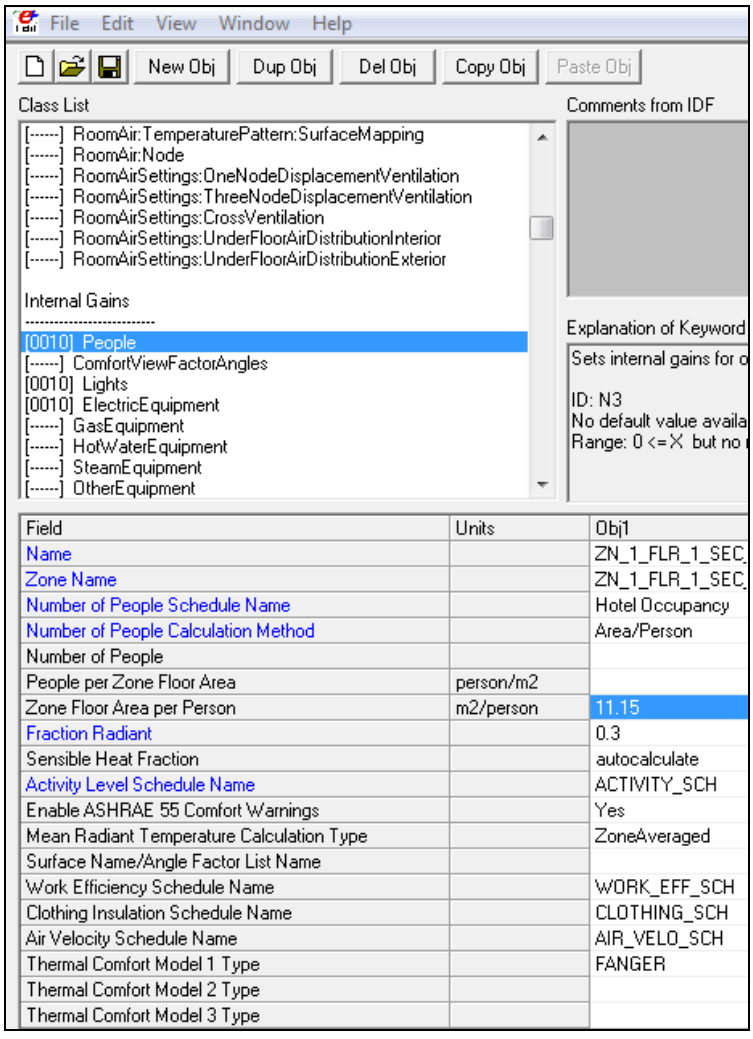
8. Add the internal gains for people.
   Input for Hotel building: Internal Gains: People
   Select Class List > Internal Gains > People
   The base file contains 10 objects with names for input fields and the zone names.



The choice selected for calculation method in this exercise is Zone Floor Area per person, and the values for Hotel building type are obtained from Table 12 on page 33 of the LBNL report mentioned above. For the small hotel, the suggested value of 120 ft^2/person = 11.15 m^2/person is taken. The schedules can be selected from a pull-down menu. This same data is entered for all 10 zones.

The full set of data for input is as follows:

Number of People Schedule Name	Hotel Occupancy
Number of People Calculation Method	Area/Person
Zone Floor Area per Person (m^2/person)	11.15
Fraction Radiant	0.3
Sensible Heat Fraction	Autocalculate
Activity Level Schedule Name	ACTIVITY_SCH
Enable ASHRAE 55 Comfort Warnings	Yes
Mean Radiant Temperature Calculation Type	ZoneAveraged
Work Efficiency Schedule Name	WORK_EFF_SCH
Clothing Insulation Schedule Name	CLOTHING_SCH
Air Velocity Schedule Name	AIR_VELO_SCH
Thermal Comfort Model 1Type	Fanger



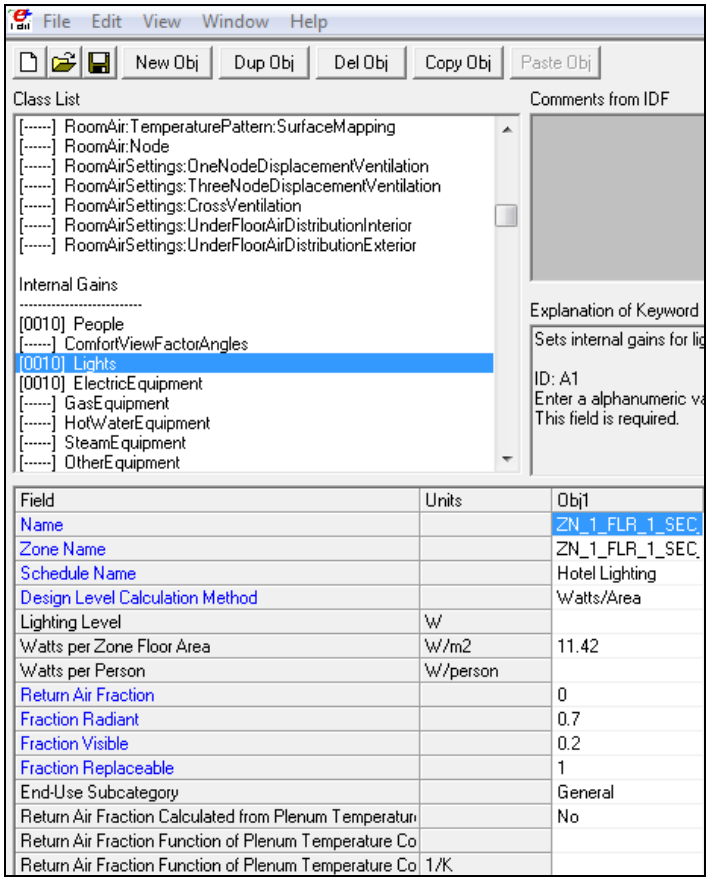
9. Input for Internal Gains: Lights

Similar to the People section, the base file contains 10 objects with names for input fields and the zone names. The choice selected for calculation method in this exercise is Watts per Zone Floor Area, and the values for each building type are obtained from the LBNL Heating and Cooling loads report. The data entered for all 10 zones is same.

For the small hotel, the suggested value of 1.06 W/ft^2 = 11.42 W/m^2 is taken from Table 12 on page 33 of the LBNL report. Since the value is within the allowed lighting power density of ASHRAE 90.1, we will use this value for the simulation. The lighting gain is a combination of many differing types, so a 70 percent radiant fraction is assumed.

Select Class List > Internal Gains > Lights and input the data as follows:

Schedule name	Hotel Lighting
Design Level Calculation Method	Watts/Area
Watts per Zone Floor area (W/m^2)	11.42
Return Air Fraction	0
Fraction Radiant	0.7
Fraction Visible	0.2
Fraction Replaceable	1
End-Use Subcategory	General
Return Air Fraction Calculated from Plenum Temperature	No

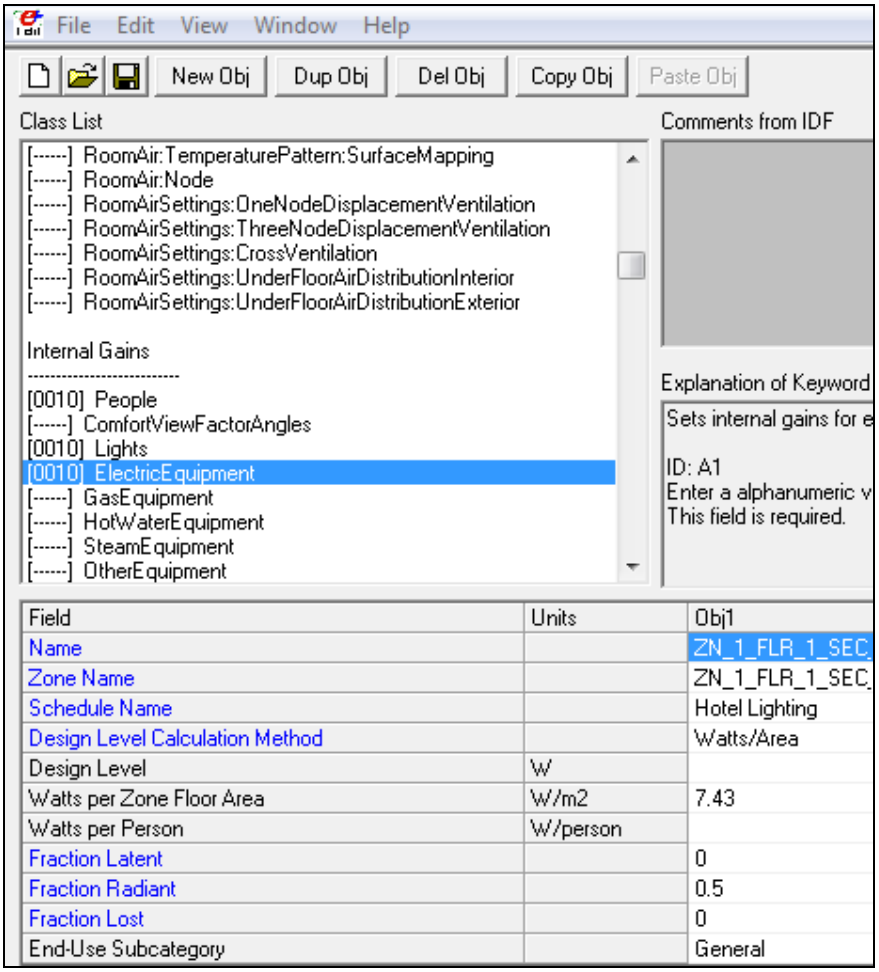


10. Now we have to input internal gains from electrical equipment. There are several ways to do so, but one of the easiest is to assume some level of power per unit area. The data used here are obtained from Table 12, p. 33 of the LBNL report.

    This report suggests using the value 0.69 W/ft^2 =7.43 W/m^2 for a small hotel. Since the electrical equipment load is a combination of small motor appliances and small electronics, a 50 percent radiant fraction should be used.

    The schedule for equipment is assumed to be the same as Hotel Lighting.
    The data for inputting in all 10 zones is as follows:

Schedule Name	Hotel Lighting
Design Level Calculation Method	Watts/Area
Watts per Zone Floor Area (W/m^2)	7.43
Fraction Latent	0
Fraction Radiant	0.5
Fraction Lost	0
End-Use Subcategory	General



11. All data required for Hotel-Building Internal Gains is entered into the idf file, which now needs to be set up for required output.

Output Data

The following objects allow standard reports to be defined and utilized in EnergyPlus:

- Output: Table: Time Bins
- Output: Table: Monthly
- Output: Table: Summary Reports
- Output Control: Table: Style

No Output: Meter or Output: Variable objects need to be specified to use the standard reports. A good set of sample reports is available in the StandardReports.idf file in the DataSets directory of EnergyPlus.

This exercise is limited to creating basic summary reports in html format and monthly Output Tables for Occupant Comfort Data.

Instructions (continued)

12. Select Class List > Output Reporting > Output: Table: Summary Reports > New Object
    Enter the following data:

Report 1 Name	AnnualBuildingUtilityPerformanceSummary
Report 2 Name	EnvelopeSummary
Report 3 Name	InputVerificationandResultsSummary
Report 4 Name	ClimateDataSummary
Report 5 Name	EquipmentSummary

    These are basic reports that allow for a quick analysis of the building's performance. More detailed reports can be selected from the pull-down menu for in-depth analysis.

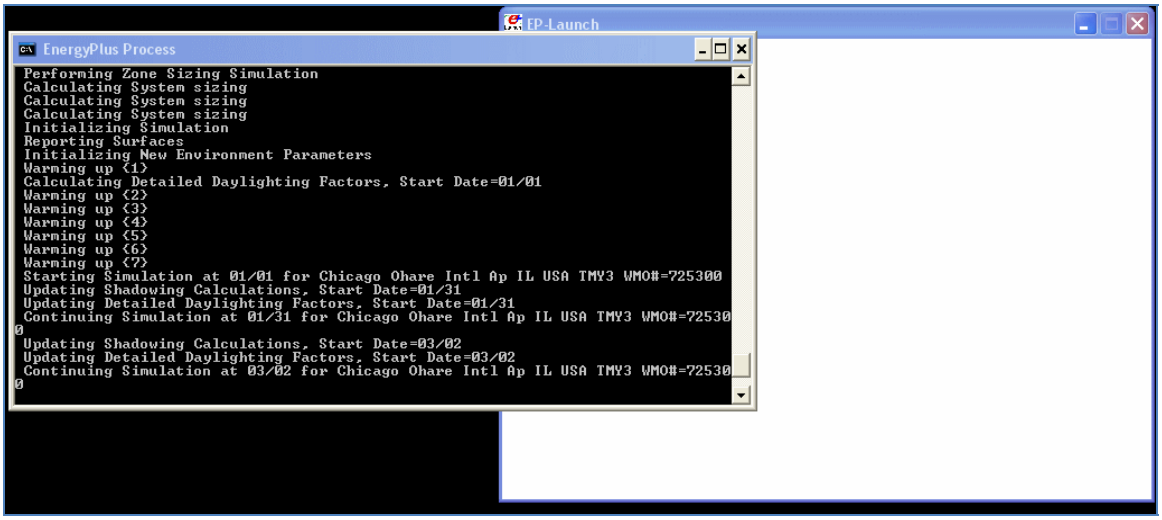
13. Select Class List > Output Reporting > Output: Table: Monthly > New Object
    Enter the following data:

Name	Occupant Comfort Data Summary
Digits After Decimal	3
Variable or Meter 1 Name	People Number of Occupants
Aggregation Type for Variable or Meter 1	HoursNonZero
Variable or Meter 2 Name	ThermalComfortMRT
Aggregation Type for Variable or Meter 2	SumOrAverageDuringHoursShown
Variable or Meter 3 Name	FANGERPMV
Aggregation Type for Variable or Meter 3	SumOrAverageDuringHoursShown

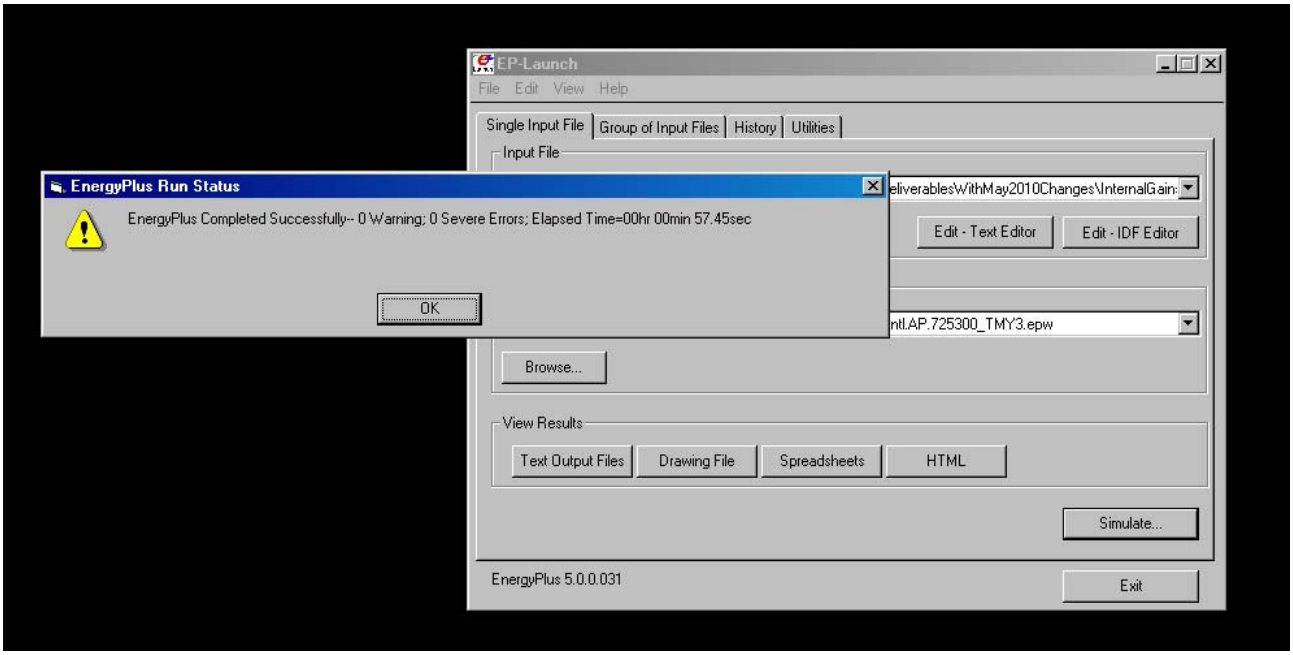
    This data gives the monthly Occupant Comfort Data in the entered variables for each zone.
14. Select > Class List > Output Reporting > Output Control: Table Style > New Object
    Enter the following data:

Column Separator	HTML

    Other default styles include comma (which works well for importing data into spreadsheet programs such as Microsoft® Excel®), tab (for word processing programs), fixed, etc.
    The idf file is now ready for simulation after saving changes as 2.HotelBldg.idf
15. Start > EP-Launch > Input file > Browse > Select 2.HotelBldg.idf from its destination folder.
16. Weather File > Browse > C:\EnergyPlusV5-0-0\WeatherData\USA_IL_Chicago-OHare.Intl.AP.725300_TMY3.epw
17. Simulate



Simulation in Process



Simulation Completed

Program Version:**EnergyPlus 5.0.0.031, 5/19/2010 11:44 AM**

Tabular Output Report in Format: **HTML**

Building: **2StoryHotelBuilding**

Environment: **Chicago Ohare Intl Ap IL USA TMY3 WMO#=725300**

Simulation Timestamp: **2010-05-19 11:44:32**

Report: **AnnualBuildingUtilityPerformanceSummary**

For: **Entire Facility**

Timestamp: **2010-05-19 11:44:32**

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	374.67	403.94	403.94
Net Site Energy	374.67	403.94	403.94
Total Source Energy	878.12	946.72	946.72
Net Source Energy	878.12	946.72	946.72

Sample Image of HTML Output

Office Building Data

1. The process above is to be repeated for an office building. Start with the Hotel and save as 3.OfficeBldg.idf
2. The activity, work efficiency, air velocity and clothing schedules remain the same for all modules.
3. Office occupancy and office lighting schedules are imported from the same dataset as earlier. For office occupancy schedule, for Sunday Holidays, Until: 18:00, change 0.05 to 0.0.
4. Input for Office Building: Internal Gains: People
   Occupancy data taken from Table 10 of Page 31 of the LBNL Report for a small office is 470 ft^2/person = 43.66 m^2/person
   The full data set to be input is:

Number of People Schedule Name	Office Occupancy
Number of People Calculation Method	Area/Person
Zone Floor Area per Person (m^2/person)	43.66
Fraction Radiant	0.3
Sensible Heat Fraction	Autocalculate
Activity Level Schedule Name	ACTIVITY_SCH
Enable ASHRAE 55 Comfort Warnings	Yes
Mean Radiant Temperature Calculation Type	ZoneAveraged
Work Efficiency Schedule Name	WORK_EFF_SCH
Clothing Insulation Schedule Name	CLOTHING_SCH
Air Velocity Schedule Name	AIR_VELO_SCH
Thermal Comfort Model 1Type	Fanger

5. Input for Office Building: Internal Gains: Lighting
   The suggested value from Table 10, p. 31 of the LBNL report is a lighting gain of 1.7 W/ft^2 which is in excess of the most current ASHRAE 90.1 allowance. Thus, we will assume that the building being simulated has only a lighting gain of only 1.1 W/ft^2 = 11.8 W/m^2.
   The full data set to be input is:

Schedule Name	Office Lighting
Design Level Calculation Method	Watts/Area
Watts per Zone Floor Area (W/m^2)	11.8
Return Air Fraction	0
Fraction Radiant	0.7
Fraction Visible	0.2
Fraction Replaceable	1
End-Use Subcategory	General
Return Air Fraction Calculated from Plenum Temperature	No

6. Input for Office Building: Internal Gains: Electric Equipment
   From the LBNL report the suggested equipment power density is 0.5 W/ft^2 = 5.385 W/m^2. The full data set for inputting into all 10 zones is:

Schedule Name	Office Lighting
Design Level Calculation Method	Watts/Area
Watts per Zone Floor Area (W/m^2)	5.385
Fraction Latent	0
Fraction Radiant	0.5
Fraction Lost	0
End-Use Subcategory	General

7. Repeat the output setup instructions for this file.
8. Simulations can be run for Office Building with entered data after saving changes.

Retail Building Data

1. The process above is to be repeated for a retail building. Start with the Office and save as 4.RetailBldg.idf
2. Import retail occupancy, retail lighting schedules from the same dataset as earlier.
3. Input for Retail Building: Internal Gains: People
   The people gain data comes from Table 11, p. 32 of the LBNL report and is an occupancy of 1635 ft^2/person = 151.89 m^2/person.
   The full data set is:

Number of People Schedule Name	Retail Occupancy
Number of People Calculation Method	Area/Person
Zone Floor Area per Person (m^2/person)	151.89
Fraction Radiant	0.3
Sensible Heat Fraction	Autocalculate
Activity Level Schedule Name	ACTIVITY_SCH
Enable ASHRAE 55 Comfort Warnings	Yes
Mean Radiant Temperature Calculation Type	ZoneAveraged
Work Efficiency Schedule Name	WORK_EFF_SCH
Clothing Insulation Schedule Name	CLOTHING_SCH
Air Velocity Schedule Name	AIR_VELO_SCH
Thermal Comfort Model 1Type	Fanger

4. Input for Retail Building: Internal Gains: Lighting
   The lighting gain data comes from Table 11, p. 32 of the LBNL report and is a lighting power density of 1.7 W/ft^2 = 18.31 W/m^2.
   The full data set is:

Schedule Name	Retail Lighting
Design Level Calculation Method	Watts/Area
Watts per Zone Floor area (W/m^2)	18.31
Return Air Fraction	0
Fraction Radiant	0.7
Fraction Visible	0.2
Fraction Replaceable	1
End-Use Subcategory	General
Return Air Fraction Calculated from Plenum Temperature	No

5. Input for Retail Building: Internal Gains: Electric Equipment
   The data from Table 11, p. 32 of the LBNL report is 0.5W/ft^2 = 5.385 W/m^2.
   The full data set is:

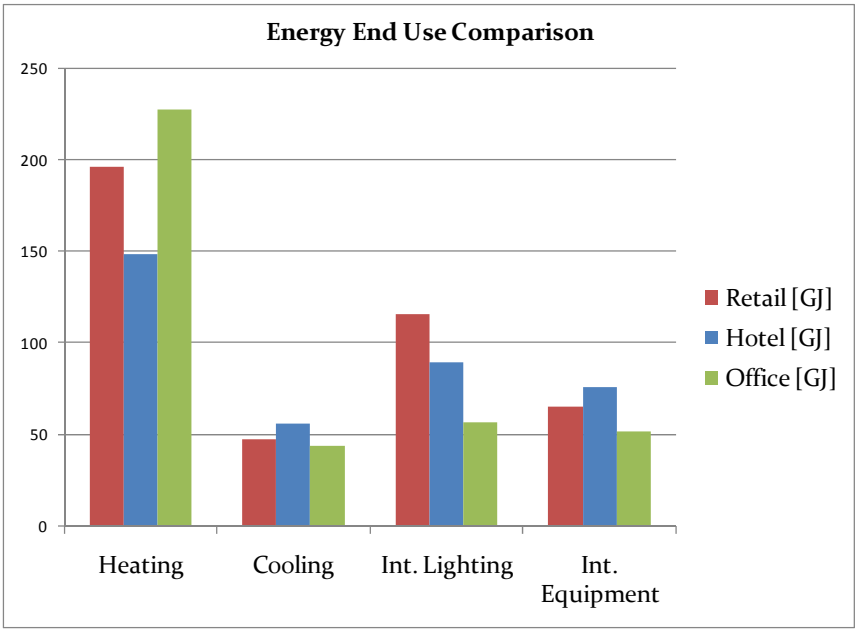
Schedule Name	Retail Lighting
Design Level Calculation Method	Watts/Area
Watts per Zone Floor Area (W/m^2)	5.385
Fraction Latent	0
Fraction Radiant	0.5
Fraction Lost	0
End-Use Subcategory	General

6. Repeat the output setup instructions for this file.
7. Run simulations after saving changes.

RESULTS

Energy End Use Comparison

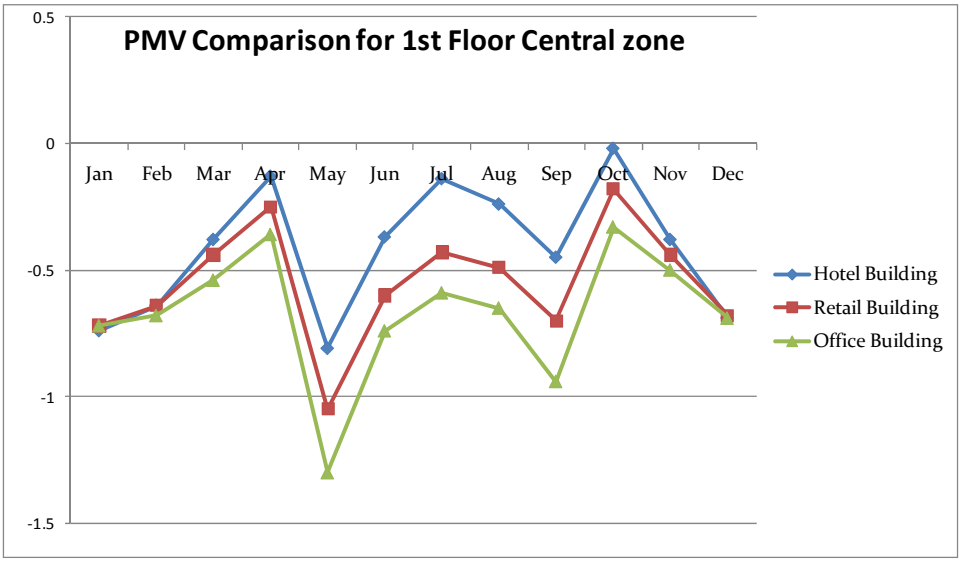
The output graphs are created from the data in END USE Table in the Annual Building Utility Performance Summary Report.



	Retail [GJ]	Hotel [GJ]	Office [GJ]
Heating (Nat. Gas)	196.24	148.08	227.03
Cooling (Elect.)	47.20	56.02	43.87
Int. Lighting (Elect.)	115.63	89.35	56.47
Int. Equipment (Elect)	65.41	75.85	51.48

Thermal Comfort Data: Fanger PMV Comparison

The output graphs (for core zone of ground floor) are created from the data in ZN_1_FLR_1_SEC_5 PEOPLE Table in the Occupant Comfort Data Summary Report.



For: ZN_1_FLR_1_SEC_5 PEOPLE	Hotel Building	Retail Building	Office Building
Jan	-0.74	-0.72	-0.72
Feb	-0.64	-0.64	-0.68
Mar	-0.38	-0.44	-0.54
Apr	-0.13	-0.25	-0.36
May	-0.81	-1.05	-1.30
Jun	-0.37	-0.60	-0.74
Jul	-0.14	-0.43	-0.59
Aug	-0.24	-0.49	-0.65
Sep	-0.45	-0.70	-0.94
Oct	0.02	-0.18	-0.33
Nov	-0.38	-0.44	-0.50
Dec	-0.69	-0.68	-0.69

Note:
An environment is considered acceptable for thermal comfort when -0.5 < PMV < 0.5.

This material is based upon work supported by the U.S. Department of Energy under Award Number DE-FG26-07NT43330 to the Alliance to Save Energy.