# EnergyPlus Exercise HVAC 2

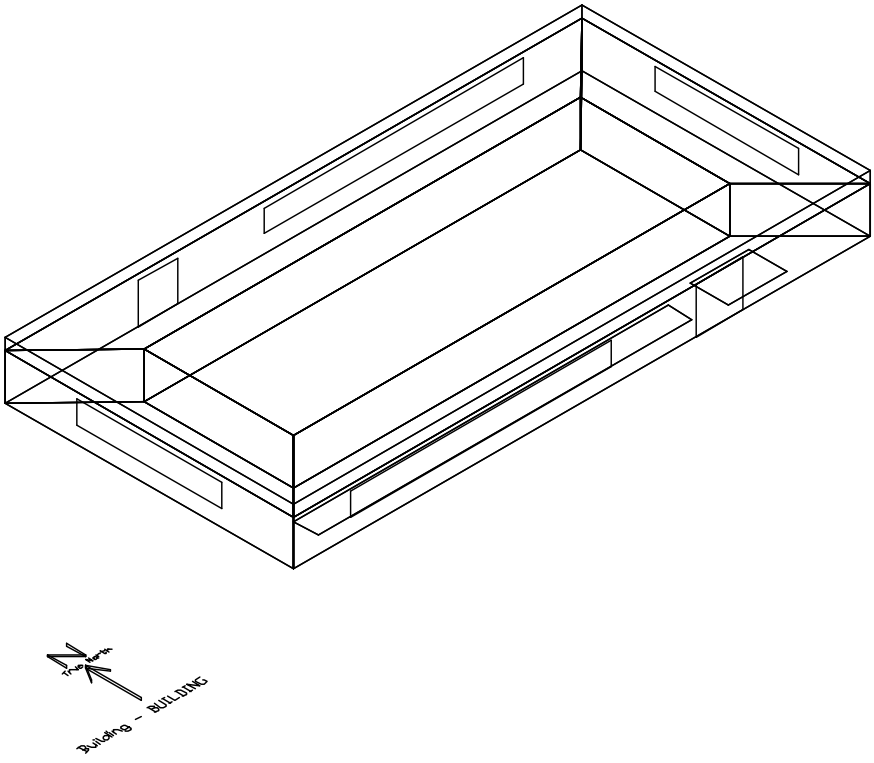
## *HVAC System Controls and Plant Equipment Sequencing*

*Last revised November 2012 for EnergyPlus v7.2.0.006*

## General Description

### Overview

- Rectangular single story building with 5 occupied zones and a ceiling plenum
- VAV with reheat serving the 5 occupied zones
- All equipment autosized using summer and winter design days



## Details

*Building Description*

- Single floor rectangular building 30.5 m (100 ft) by 15.2 m (50 ft) by 3m (10 ft) high.
- Building is oriented with the long axis running east-west.
- Floor Area 463.6 m2 (5000 ft2).
- 5 occupied zones - 4 exterior, 1 interior, zone height 2.4 m (8 ft). Exterior zone depth is 3.7 m (12 ft).
- 1 plenum zone 0.6 m (2 ft) high.
- Windows on all 4 facades
- South and north facades have glass doors.
- South facing glass is shaded by overhangs.
- Walls are wood shingle over plywood, insulation, and gypsum board.
- Roof is gravel built up roof with mineral board insulation and plywood sheathing.
- Floor slab is 0.1 m (4 in) heavy concrete.
- Windows and glass doors are double pane Low-e clear glass with argon gap.
- Window to wall ratio is approximately 0.3.
- Lighting is 16 W/m2 (1.5 W/ft2).
- Office electric equipment is 10.8 W/m2 (1.0 W/ft2).
- 1 occupant per 9.3 m2 (100 ft2) of floor area.
- Infiltration is 0.25 air changes per hour (always on, proportional to wind speed).

  * Refers to specific glass type included in the EnergyPlus datasets directory (WindowGlassMaterials.idf)

*Space Conditioning*

Heating setpoints: 21.1C (70F) occupied, 12.8C (55F) unoccupied
Cooling setpoints: 23.9C (75F) occupied, 40.0C (104F, system off) unoccupied
Plenum zone not controlled

*Environment*

| | |
|---|---|
| Location: | Sterling, Virginia, USA (Dulles Airport, Washington, DC) |
| Design Days: | Summer 0.4% dry bulb |
| | Winter 99.6% (design days used for sizing only) |
| Annual Simulation Period: | Jan 1-31, Apr 1-30, Jul 1-31 |
| Ground Temperature: | 20-23 C from Slab preprocessor |

## Instructions

## Exercise HVAC 2A – Use "warmest" supply temperature reset controls

*Objective: See how various supply air temperature controls impact results.*

*HINT: Note that IDF Editor has no "undo' feature, save often while editing so that an unwanted change (such as deleting an object by mistake) can be easily recovered from.*

1. Open ExerciseHVAC2.idf, select the "USA_VA_Sterling-Washington.Dulles.Intl.AP.724030_TMY3.epw" weather file, run the simulation, and review results. Look especially at the bin reports on zone relative humidity in the Table (HTML) output file. In the Variables output file, note the hourly temperatures and setpoints at the supply air node (VAV WITH REHEAT SUPPLY FAN OUTLET) and the VAV damper positions.
2. Open ExerciseHVAC2.idf and save it as ExerciseHVAC2A.idf, using IDF Editor.
3. In the Building object, change the building name to "Exercise HVAC 2A".
   *Note: This helps in identifying HTML output files, because the building name is shown at the top and is also part of the window title.*
4. In the HVACTemplate:System:VAV object, change the "Cooling Coil Setpoint Reset Type" from "None" to "Warmest".
5. Save the idf and run the simulation.
6. Compare results with ExerciseHVAC2. In the Table (HTML) output file, "Annual Building Utility Performance Summary" report, compare total and end-use energy consumption, especially changes in cooling, heating and fan energy use. In the table and bin reports, see the impact on zone temperature and humidity. In the Variables output, compare the supply air node (VAV WITH REHEAT SUPPLY FAN OUTLET) temperatures and setpoints, and the VAV damper positions.

## Exercise HVAC 2B – Add dehumidification controls

*Objective: Learn how to activate dehumidification control for the SOUTH PERIMETER zone to 50% RH.*

1. Open ExerciseHVAC2A.idf in IDF Editor and save it as ExerciseHVAC2B.idf.
2. In the Building object, change the building name to "Exercise HVAC 2B".

3. In the HVACTemplate:SYSTEM:VAV object change the following fields:
    a. "Dehumidification Control Type" = "CoolReheat".
    b. "Dehumidification Control Zone Name" = "SOUTH PERIMETER"
    c. "Dehumidification Setpoint" = 50% RH.
4. Save the idf and run the simulation for ExerciseHVAC2B. (Remember to select ExerciseHVAC2B as the input in EP-Launch before pressing Simulate.)
5. Compare results with ExerciseHVAC2A. In the Annual Building Utility Performance Summary report compare total and end-use energy consumption, especially changes in cooling, heating and fan energy use. In the table and bin reports, see the impact on zone temperature and humidity. *Note that the supply air temperature setpoint is the non-humidity control setpoint at system node "VAV with Reheat Supply Fan Outlet". This setpoint is adjusted for fan heat and for humidity control and the cooling coil is controlled to the setpoint placed on "VAV with Reheat Cooling Coil Outlet". While the humidity in the SOUTH PERIMETER zone is lower, the control is not perfect, because the chiller chilled water temperature may not be low enough, and the minimum airflow rates in the zones may not be high enough to achieve the desired latent load removal.*

## Exercise HVAC 2C – Add a Small Air Cooled Chiller for Winter Operation

*Objective: Learn how to add a chiller and control chiller sequencing.*

1. Open ExerciseHVAC2B.idf and save it as ExerciseHVAC2C.idf (using IDF Editor).
2. In the Building object, change the building name to "Exercise HVAC 2C".
3. Locate the HVACTemplate:Plant:Chiller object named "Chiller 1", duplicate it, and name the new chiller "Chiller 2".
4. Make Chiller 2 field Condenser Type = AirCooled chiller with a nominal COP of 3.0.
5. Set Chiller 1 Sizing Factor to 0.75 and set Chiller 2 Sizing Factor to 0.25.
6. Create a PlantEquipmentList object named "Chilled Water Plant Big Chiller First". Put Chiller 1 first on the list and Chiller 2 second.
   *Note: The Equipment 1 Object Type and Equipment 2 Object Type are "CHILLER:ELECTRIC:EIR"*
7. Duplicate this PlantEquipmentList object and name the new one "Chilled Water Plant Small Chiller First". Reverse the order of the chillers so that Chiller 2 is first and Chiller 1 is last.

8. Locate the Schedule:Compact object named “Constant”, duplicate it and create a new schedule named “Summer Operation”. The new schedule should be 1 from March 1 through November 30, and 0 (zero) from December 1 through February 28.
9. Duplicate the new “Summer Operation” schedule, name it “Winter Operation” and reverse the values so that this schedule is 1 for December thru February, and zero for all other times of the year.
10. Create a PlantEquipmentOperation:CoolingLoad object named “Chilled Water Plant Summer Chiller Operation”. Set the load range to be from 0 to 1.0E12 and select “Chilled Water Plant Big Chiller First” for the Priority Control 1 Equipment List Name.
    *Hint: EnergyPlus will accept E format numbers as input. 1.0E12=1x10$^{12}$.*
11. Duplicate the new PlantEquipmentOperation:CoolingLoad object, name the new one “Chilled Water Plant Winter Chiller Operation”, and select the “Chilled Water Plant Small Chiller First” equipment list.
12. Create a PlantEquipmentOperationSchemes object named “Chilled Water Plant Operation”. Edit this object to use PlantEquipmentOperation:CoolingLoad “Chilled Water Plant Summer Chiller Operation” with the “Summer Operation” schedule, and PlantEquipmentOperation:CoolingLoad “Chilled Water Plant Winter Chiller Operation” with the “Winter Operation” schedule. *Hint: All of these names should be available in the pulldown lists. This is why the new objects were made before this step.*
13. In the existing HVACTemplate:Plant:ChilledWaterLoop object, change the “Chiller Plant Operation Scheme Type” from “Default” to “UserDefined”, and set the “Chiller Plant Equipment Operation Schemes Name” to “Chilled Water Plant Operation”.
14. Save the idf and run the simulation for ExerciseHVAC2C. (Remember to select ExerciseHVAC2C as the input in EP-Launch before pressing Simulate.)
15. Review the results. Note in the Variables output file that Chiller 1 runs first in the April and July run periods, and Chiller 2 runs first in January. There are also several warm days Jan 3-6 where both chillers run.
    *Note: Not that one would necessarily want the chiller to run for a short time in January, but this is happening due to the humidity control settings. One might try adding an AvailabilityManager to shut off the chilled water system below a certain outdoor temperature, or other adjustments for a more realistic simulation.*

## List of New or Modified Objects

This is a listing of new objects added or modified in this Exercise.

## Exercise HVAC 2A

*Modified object:*

```
HVACTemplate:System:VAV,
  VAV with Reheat,         !- Name

. . .

    Warmest,                 !- Cooling Coil Setpoint Reset Type
    None,                    !- Heating Coil Setpoint Reset Type
    None,                    !- Dehumidification Control Type
    ,                        !- Dehumidification Control Zone Name
    60,                      !- Dehumidification Setpoint {percent}
    None,                    !- Humidifier Type
    ,                        !- Humidifier Availability Schedule Name
    0.000001,                !- Humidifier Rated Capacity {m3/s}
    2690,                    !- Humidifier Rated Electric Power {W}
    ,                        !- Humidifier Control Zone Name
    30,                      !- Humidifier Setpoint {percent}
    NonCoincident;           !- Sizing Option
```

## Exercise HVAC 2B

*Modified objects:*

```
HVACTemplate:System:VAV,
  VAV with Reheat,         !- Name

. . .

CoolReheat,              !- Dehumidification Control Type
SOUTH PERIMETER,         !- Dehumidification Control Zone Name
50,                      !- Dehumidification Setpoint {percent}
```

## Exercise HVAC 2C

*Modified objects:*

```
HVACTemplate:Plant:ChilledWaterLoop,
  Chilled Water Plant,     !- Name
  ,                        !- Pump Schedule Name
  Intermittent,            !- Pump Control Type
  UserDefined,             !- Chiller Plant Operation Scheme Type
  Chilled Water Plant Operation,  !- Chiller Plant PlantEquipmentOperationSchemes
Name

. . .
```

```
   HVACTemplate:Plant:Chiller,
       Chiller 1,               !- Name
       ElectricReciprocatingChiller,  !- Chiller Type
       autosize,                !- Capacity {W}
       3.6,                     !- Nominal COP {W/W}
       WaterCooled,             !- Condenser Type
       ,                        !- Priority
       0.75;                    !- Sizing Factor
```

*New objects:*

```
HVACTemplate:Plant:Chiller,
    Chiller 2,               !- Name
    ElectricReciprocatingChiller,  !- Chiller Type
    autosize,                !- Capacity {W}
    3,                       !- Nominal COP {W/W}
    AirCooled,               !- Condenser Type
    ,                        !- Priority
    0.25;                    !- Sizing Factor

PlantEquipmentList,
  Chilled Water Plant Big Chiller First,  !- Name
  Chiller:Electric:EIR,    !- Equipment 1 Object Type
  Chiller 1,               !- Equipment 1 Name
  Chiller:Electric:EIR,    !- Equipment 2 Object Type
  Chiller 2;               !- Equipment 2 Name

PlantEquipmentList,
  Chilled Water Plant Small Chiller First,  !- Name
  Chiller:Electric:EIR,    !- Equipment 1 Object Type
  Chiller 2,               !- Equipment 1 Name
  Chiller:Electric:EIR,    !- Equipment 2 Object Type
  Chiller 1;               !- Equipment 2 Name

Schedule:Compact,
  Summer Operation,        !- Name
  on/off,                  !- Schedule Type Limits Name
  Through: 2/28,           !- Field 1
  For: AllDays,            !- Field 2
  Until: 24:00,            !- Field 3
  0,                       !- Field 4
  Through: 11/30,          !- Field 5
  For: AllDays,            !- Field 6
  Until: 24:00,            !- Field 7
  1,                       !- Field 8
  Through: 12/31,          !- Field 9
  For: AllDays,            !- Field 10
  Until: 24:00,            !- Field 11
  0;                       !- Field 12
```

```
Schedule:Compact,
  Winter Operation,        !- Name
  on/off,                  !- Schedule Type Limits Name
  Through: 2/28,           !- Field 1
  For: AllDays,            !- Field 2
  Until: 24:00,            !- Field 3
  1,                       !- Field 4
  Through: 11/30,          !- Field 5
  For: AllDays,            !- Field 6
  Until: 24:00,            !- Field 7
  0,                       !- Field 8
  Through: 12/31,          !- Field 9
  For: AllDays,            !- Field 10
  Until: 24:00,            !- Field 11
  1;                       !- Field 12

PlantEquipmentOperation:CoolingLoad,
  Chilled Water Plant Summer Chiller Operation,  !- Name
  0,                       !- Load Range 1 Lower Limit {W}
  1000000000000,           !- Load Range 1 Upper Limit {W}
  Chilled Water Plant Big Chiller First;  !- Priority Control 1 Equipment List Name

PlantEquipmentOperation:CoolingLoad,
  Chilled Water Plant Winter Chiller Operation,  !- Name
  0,                       !- Load Range 1 Lower Limit {W}
  1000000000000,           !- Load Range 1 Upper Limit {W}
  Chilled Water Plant Small Chiller First;  !- Priority Control 1 Equipment List Name

PlantEquipmentOperationSchemes,
  Chilled Water Plant Operation,  !- Name
  PlantEquipmentOperation:CoolingLoad,  !- Control Scheme 1 Object Type
  Chilled Water Plant Summer Chiller Operation,  !- Control Scheme 1 Name
  Summer Operation,        !- Control Scheme 1 Schedule Name
  PlantEquipmentOperation:CoolingLoad,  !- Control Scheme 2 Object Type
  Chilled Water Plant Winter Chiller Operation,  !- Control Scheme 2 Name
  Winter Operation;        !- Control Scheme 2 Schedule Name
```