## Correct HVAC Operations Schedules

### Description

It is well understood that operating HVAC equipment (fans/pumps/coils, chillers, etc) to serve unoccupied areas is a significant potential energy waste. This energy efficiency measure (EEM) aggressively modifies the availability schedules of HVAC Airloop and Zone Equipment objects to better reflect equipment availability when airside equipment is serving ‘occupied’ areas, and the shut off the equipment when the areas served by the equipment become ‘unoccupied’. The flag for determining whether areas served by a piece of equipment is determined by a threshold of 5% of peak occupancy. For example, if (for a given timestep) the zones serving a Multizone Air Handling Unit contain more than 5% of the peak occupancy of the combined zones, the unit will operate in ‘occupied’ (or available) mode for that timestep. Zone HVAC equipment objects, by definition, need only examine the occupancy of the spaces associated with the single thermal zone to determine the equipment availability (occupied or unoccupied). The danger in aggressively setting HVAC availability is that zone conditions are allowed to drift from setpoint during unoccupied status. An abrupt occupied condition can result in both uncomfortable space conditions and unmet load hours may occur during startup. This measure adds thermal comfort and space reporting variables so these conditions can be monitored.

### Modeler Description

The measure begins by looping through all airloops in the model. For each airloop, the people objects associated with the spacetypes associated with the spaces associated with the thermal zones are analyzed. A binary schedule representing a threshold value (5%) of the current/peak airloop occupancy is generated. This scheduled is then assigned to the airloop availability schedule. Next, the measure loops though each thermal zone. The people object(s) associated with the spacetype object associated with the space object(s) associated with the unique thermal zone are similarly analyzed, and a binary schedule representing a threshold value (5%) of the current/peak thermal zone occupancy is generated. This scheduled is then assigned to the availability schedule of all associated zone equipment. Finally, thermal comfort (the Fanger model and ASHRAE 55 warnings) are added to each thermal zone, and reporting values for thermal zone setpoint, thermal zone temperature and AirLoop Air System Simulation Cycle On Off Status are added to the model at the detailed timestep.

### Use Case Types

Retrofit EE

### Arguments

No arguments

### Initial Condition Message

The initial model contained {X} applicable airloop HVAC objects and {Y} applicable ZoneHVACEquipment objects which this measure is applicable.

### Final Condition Message

{X} airloop HVAC objects and {Y} applicable ZoneHVACEquipment objects were modified by this measure.

### Not Applicable Messages

N/A

### Warning Messages

The model contains no airloop objects for which this measure is applicable.

The model contains no ZoneHVACEquipment objects for which this measure is applicable.

### Information Messages

Any time an object’s properties are changed, an info message will be generated indicating the object name, old value and new value.

### Error Messages

### None

### Code Outline

1. Loop through each airloop
   1. Retrieve the thermal zones associated with the airloop and store in a hash
   2. Loop through each thermal zone
      1. Retrieve the spaces array associated with each thermal zone and store in a hash
      2. Retrieve the numberOfPeople associated with each thermal zone and store in a hash
      3. Loop through each Space object
         1. Retrieve the optional Spacetype object associated with each Space and store in a hash
         2. Retrieve the numberOfPeople associated with each space and store in a hash
         3. Loop through each spacetype object
            1. Retrieve the peoples array associated with each Spacetype object and store in a hash
            2. Loop through the peoples array to store the people definition object associated with the people object.

Retrieve the numberOfPeopleSchedule object associated with each people object and store in a hash.

SetEnable ASHRAE 55 comfort warnings to the people definition object

Set the Fanger thermal comfort model type to the people definition object

* + 1. Determine and calculate the arguments needed to pass to the method developed by NREL (AP) - #TODO. The threshold value argument shall be 5%.
    2. Call the method described in step 4 above. The method will return a schedule of an object of type fixed interval with a value of 0 or 1 based on the threshold.
  1. Assign the new fixed interval schedule to the air loop availability schedule attribute of the airloop.

1. Loop through each thermal zone in the model
   1. Loop through the ZoneHVACEquipment Objects
      1. If ZoneHVACEquipment.count > 0 then
         1. Retrieve the spaces array associated with each thermal zone and store in a hash
         2. Retrieve the numberOfPeople associated with each thermal zone and store in a hash
         3. Loop through each Space object in the spaces array
            1. Retrieve the optional Spacetype object associated with each Space and store in a hash
            2. Retrieve the numberOfPeople associated with each space and store in a hash
            3. Loop through each spacetype object

Retrieve the peoples array associated with each Spacetype object and store in a hash

Loop through the peoples array to store the people definition object associated with the people object.

SetEnable ASHRAE 55 comfort warnings to the people definition object

Set the Fanger thermal comfort model type to the people definition object

Retrieve the numberOfPeopleSchedule object associated with each people object and store in a hash.

* + - 1. Determine and calculate the arguments needed to pass to the method developed by NREL (AP) - #TODO. The threshold value argument shall be 5%.
      2. Call the method described in step 4 above. The method will return a schedule of an object of type fixed interval with a value of 0 or 1 based on the threshold.
      3. Assign the new fixed interval schedule to the availability schedule attribute of the ZoneHVACEquipment object.
      4. Add Fanger
    1. If ZoneHVACEquipment.count = 0 then skip this zone

1. Add reporting variables at the detailed time step.
   1. Air System Simulation Cycle On Off Status
   2. Zone Air Temperature
   3. Zone Thermostat Heating Setpoint Temperature
   4. Zone Thermostat Cooling Setpoint Temperature

### Tests

**This measure applies to:**

1. Secondary School
2. Primary School
3. Outpatient Healthcare
4. Large Office
5. Warehouse
6. Midrise Apartment
7. Small Office
8. Medium Office
9. Stand-Alone Retail
10. Strip Mall
11. Supermarket
12. Quick Service Restaurant
13. Full Service Restaurant
14. Small Hotel
15. Hospital
16. Large Hotel

**Test results:**

Run the simulation using prototype .osm files, examine the results, cut and paste some before/after screenshots/evidence that makes you think that the measure is working correctly, including generating messages.

**Engineering Notes:**