Modelling Guide for Unmet Load Hours

DesignBuilder v2025.1

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DesignBuilder

Table of Contents:

1 Introduction

Unmet Load Hours in DesignBuilder and EnergyPlus simulations indicate periods when HVAC systems are unable to maintain desired indoor conditions. This guide helps DesignBuilder users diagnose and resolve these issues through systematic analysis of common causes, from sizing discrepancies to airflow distribution problems.

Energy modellers of all experience levels will learn how unmet loads arise, how to interpret simulation results, and implement targeted solutions. Through practical examples and best-practice troubleshooting strategies, users will develop the skills to optimise HVAC systems, achieve compliance requirements, desired thermal comfort and ensure their models accurately represent real building performance.

2 Understanding Unmet Load Hours

2.1 Definition

Unmet Load Hours refer to the total number of hours during a simulation period (typically a year) when the HVAC system is unable to maintain the air temperature of the conditioned zones within the specified tolerance ranges for heating or cooling temperature setpoints. In simpler terms, these are the hours when the modelled heating or cooling systems are unable to keep the building at the desired temperature or comfort level.

Unmet Load Hours, indicating periods when an HVAC system fails to maintain desired indoor conditions, are a key diagnostic metric for general purpose building simulation and energy performance assessments like LEED and ASHRAE 90.1. These energy standards typically specify maximum thresholds for unmet load hours that building designs must meet to demonstrate adequate HVAC system performance.

2.2 Counting Unmet Load Hours

Most energy codes and green building rating systems, such as ASHRAE 90.1, LEED, and section 179D tax deduction, count Unmet Load Hours solely during the occupied hours of building operation when HVAC systems are operating. A common threshold is around 300 hours per year, meaning that Unmet Load Hours must not exceed 300 hours during occupied hours to meet compliance standards. Focusing on occupied hours ensures that the building is comfortable when it is in use, while allowing temperature flexibility during unoccupied periods to save energy.

In other cases, Unmet Load Hours can be counted during all HVAC operational periods, including unoccupied hours, to ensure consistent thermal comfort performance.

2.3 Monitoring Unmet Load Hours

EnergyPlus provides several ways to identify and monitor Unmet Load Hours, including:

1. The data is provided in the EnergyPlus Annual Building Utility Performance Summary (ABUPS) Report under the "Comfort and Setpoint Not Met Summary" section as:

    - Time Setpoint Not Met During Occupied Heating
    - Time Setpoint Not Met During Occupied Cooling

Comfort and Setpoint Not Met Summary

	Facility [Hours]
Time Setpoint Not Met During Occupied Heating	0.00
Time Setpoint Not Met During Occupied Cooling	65.00

2. The data is provided in the EnergyPlus LEED Summary Report under the "EAp2-2. Advisory Messages" section as:

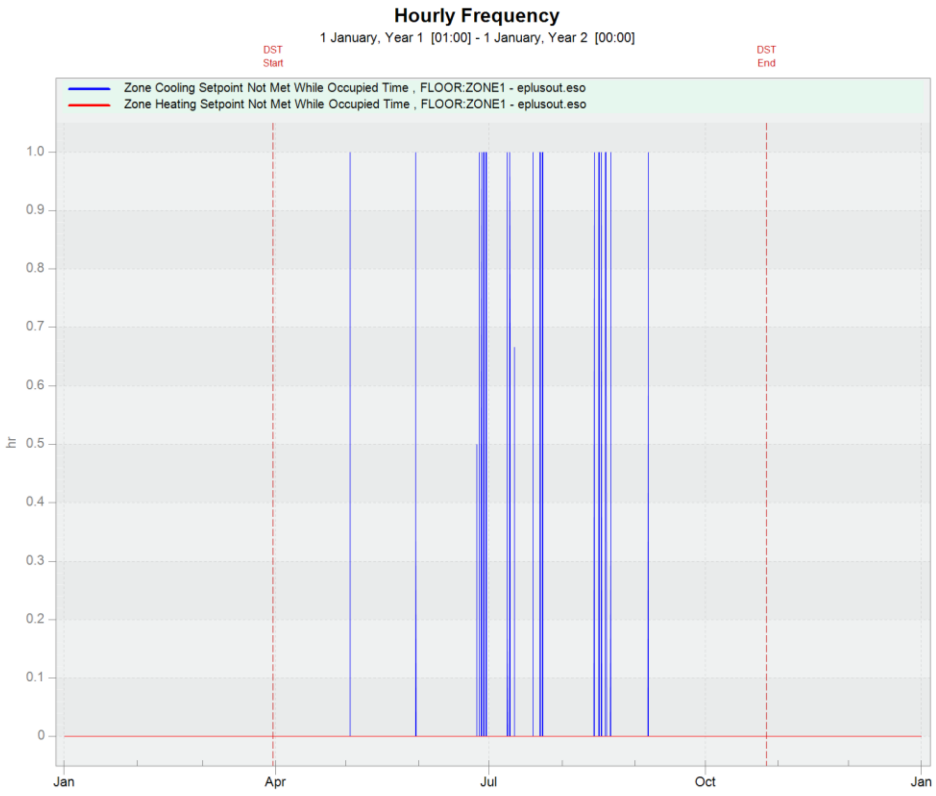
    - Number of hours heating loads not met
    - Number of hours cooling loads not met

EAp2-2. Advisory Messages

	Data
Number of hours heating loads not met	0.00
Number of hours cooling loads not met	65.00
Number of hours not met	65.00

3. Zone Wise - Using the DesignBuilder Results Viewer display the EnergyPlus ESO outputs:

- Zone Cooling Setpoint Not Met While Occupied Time
- Zone Heating Setpoint Not Met While Occupied Time
- Zone Cooling Setpoint Not Met Time
- Zone Heating Setpoint Not Met Time



The Results Viewer's ESO outputs provide detailed insights into HVAC system performance throughout the simulation period. Visualising zone setpoint data reveals specific periods of unmet heating or cooling loads, helping identify issues such as undersized equipment or incorrect thermostat schedules. This targeted analysis helps ensure zones remain within thermal comfort thresholds while optimising system design and performance.

2.4 Calculation of the Number of Unmet Load Hours

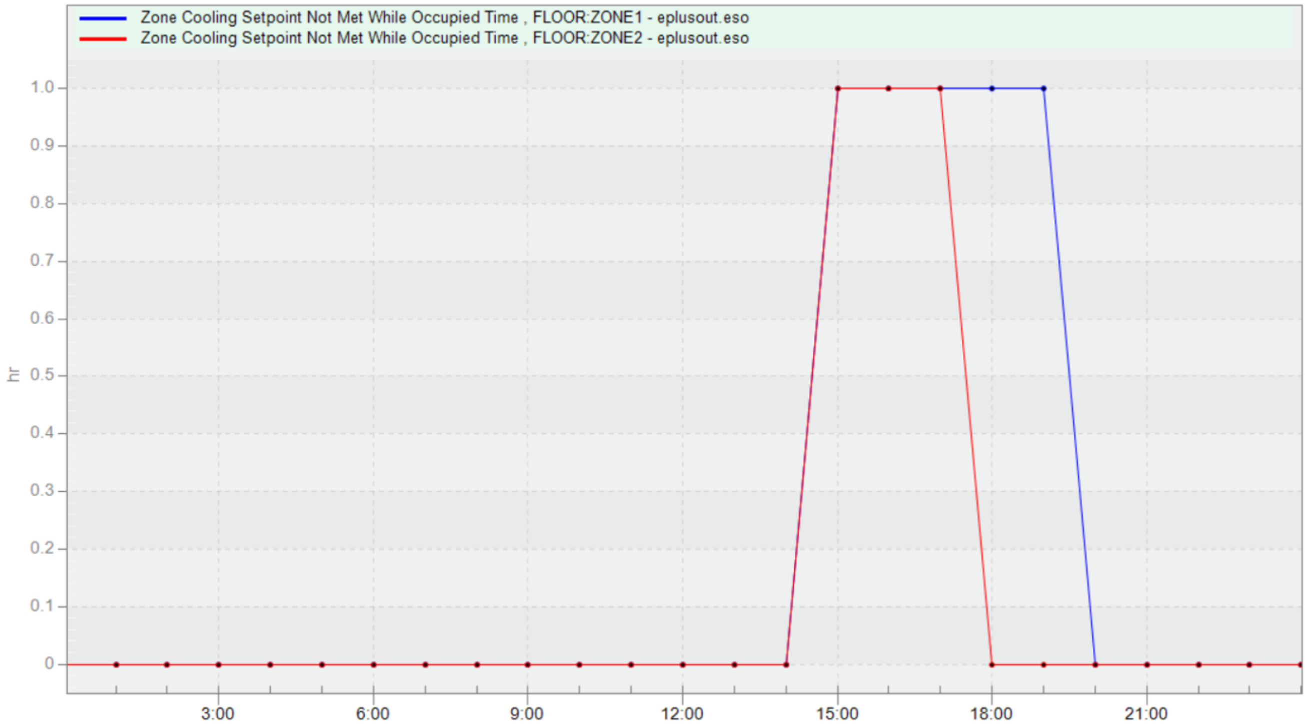
When multiple zones have unmet loads during the same hour, this counts as one Unmet Load Hour for the building.

When zones have unmet loads during different non-overlapping periods, the daily total is the sum of unmet load hours across all zones. The annual sum of these daily totals represents the building's total Unmet Load Hours.

Example: Each zone has “unmet hours” in the specified hours show below:

Hour	Zone 1 Unmet Load Hours (hr)	Zone 2 Unmet Load Hours (hr)
14:00	1	1
15:00	1	1
16:00	1	1
17:00	1	0
18:00	1	0

The total number of Unmet Load Hours is: 5 hrs (14:00, 15:00, 16:00, 17:00, 18:00) and not 8 hrs (14:00, 14:00, 15:00, 15:00, 16:00, 16:00, 17:00, 18:00).



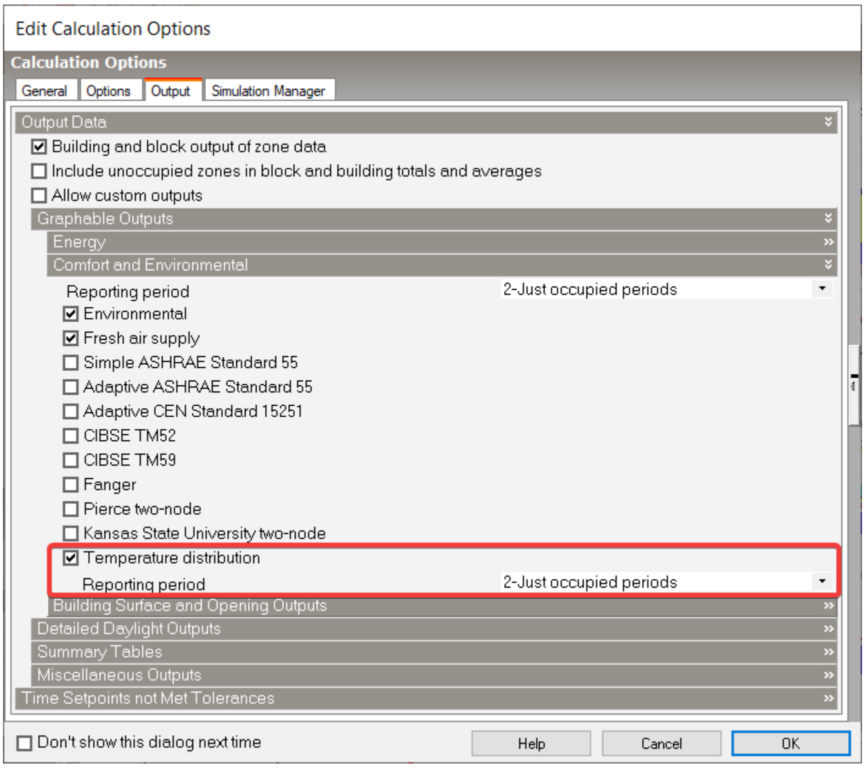
2.5 Temperature Distribution Plots

Temperature distribution provides a quick graphical overview of thermal conditions, helping identify comfort issues and unusual patterns. These plots often reveal insights that aren't immediately obvious from other data, saving time and improving design decisions.

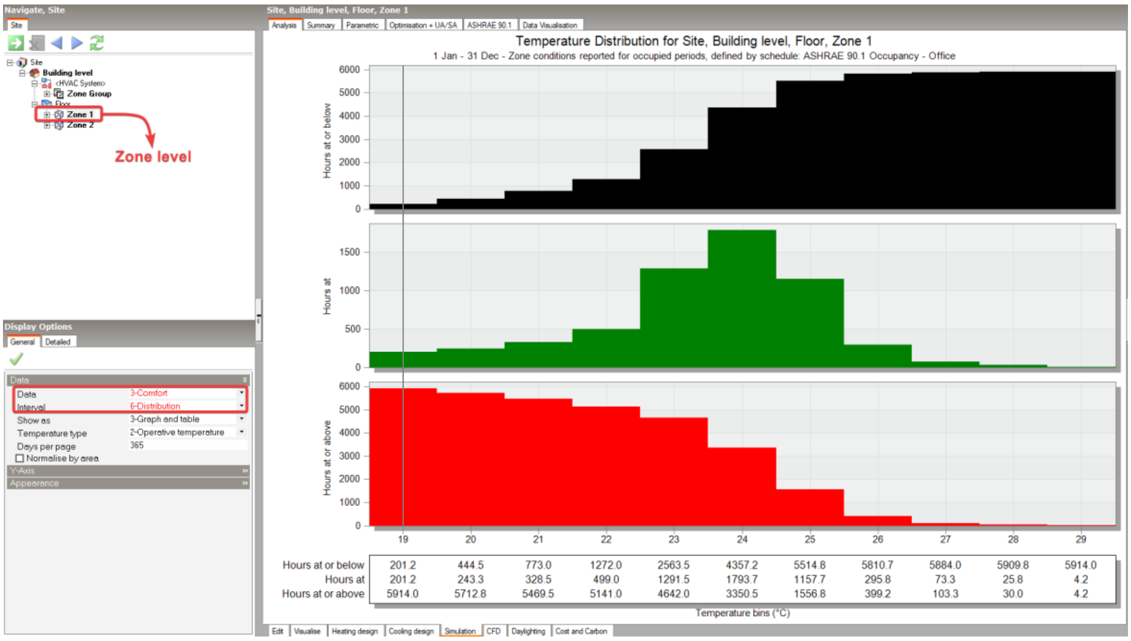
How it works:

- Analyses sub-hourly temperature data in 1°C intervals (or 'bins').
- Reporting period: occupied hours or provide a bespoke schedule.
- Generates three curve types: 'hours at', 'hours below' and 'hours above'.
- Each bin covers temperatures from its label up to next degree. Example: 12°C bin includes 12°C to 12.99°C.

To include this report: when running a simulation, from the Calculation Options dialog, on the Output tab, under the Comfort and Environmental header, check the "Temperature distribution" option and set the "Reporting period" to either "2-Just occupied periods", or to "3-User-defined schedule". In the latter case, select a specific schedule to define the reporting period.



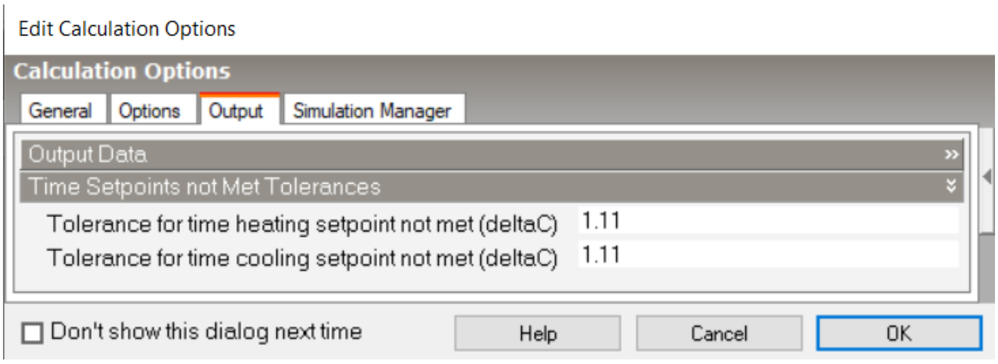
To view results: After the simulation is finished, go to a zone. In the Display Options set the “Data” option to “3-Comfort” and the “Interval” to “6-Distribution”.



2.6 Time Setpoints not Met Tolerances

The purpose of "Time Setpoints not Met Tolerances" is to avoid logging minor temperature fluctuations or short-lived deviations as Unmet Load Hours. This helps to make the results more realistic and meaningful for practical performance evaluations. By applying these tolerances, the simulation can ignore insignificant deviations from the setpoints, ensuring that only sustained or more extreme temperature variations are counted as Unmet Load Hours. This prevents an overestimation of system inadequacies or discomfort conditions.

The "Time Setpoints not Met Tolerances" can be adjusted on the Calculation options dialog on the Output tab under the “Time Setpoints not Met Tolerances” header. This is done by setting the desired ‘’Tolerance for time heating setpoint not met’’ and ‘’Tolerance for time cooling setpoint not met’’ values as shown in the image below.



2.6.1 Tolerance for Time Setpoints Not Met

These tolerance settings determine how far temperatures can deviate from setpoints before counting toward Time Setpoints Not Met, providing a practical buffer for normal HVAC operation.

For heating, if the zone temperature is below the heating setpoint by more than this value, the following report variables will increment as appropriate:

- Time Heating Setpoint Not Met
- Time Heating Setpoint Not Met While Occupied

For cooling, if the zone temperature is above the cooling setpoint by more than this value, the following report variables will increment as appropriate:

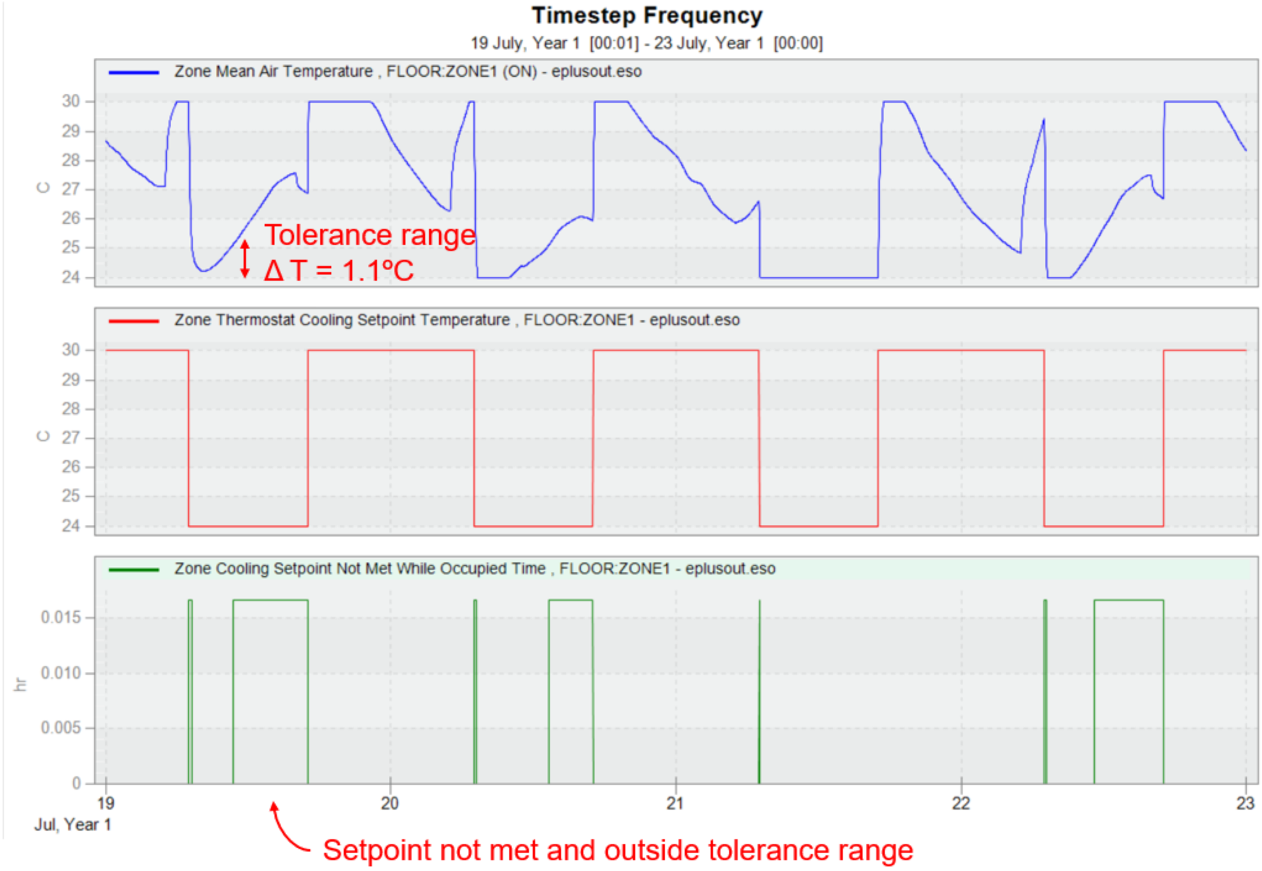
- Time Cooling Setpoint Not Met
- Time Cooling Setpoint Not Met While Occupied

These tolerances also impact table report "Annual Building Utility Performance Summary", sub-table "Comfort and Setpoint Not Met Summary".

The default tolerance used in DesignBuilder for both heating and cooling is 1.11°C (2°F). This tolerance is broad enough to prevent overreporting of minor or transient deviations but tight enough to capture genuine failures to maintain setpoints. It reflects a balance between maintaining occupant comfort (e.g. ASHRAE Standard 55) and accommodating the realistic performance of HVAC systems. This default tolerance is a widely accepted benchmark in industry, frequently used for compliance with rating systems and standards such as LEED and ASHRAE 90.1.

The example below illustrates how the default zone tolerance impacts Unmet Load Hours. A sub-hourly zone temperature plot during the summer with 3 series is shown with the following outputs:

a) Zone mean air temperature,
b) Zone thermostat cooling setpoint temperature and
c) Zone cooling setpoint not met while occupied time.



2.6.2 Impact of Time Setpoints not Met Tolerances on Temperature Deviations:

Cooling Setpoint Temperature: 24°C (75.2°F)

<u>Without Tolerance</u>
If the temperature deviates slightly from the cooling setpoint temperature, it will count toward Unmet Load Hours.

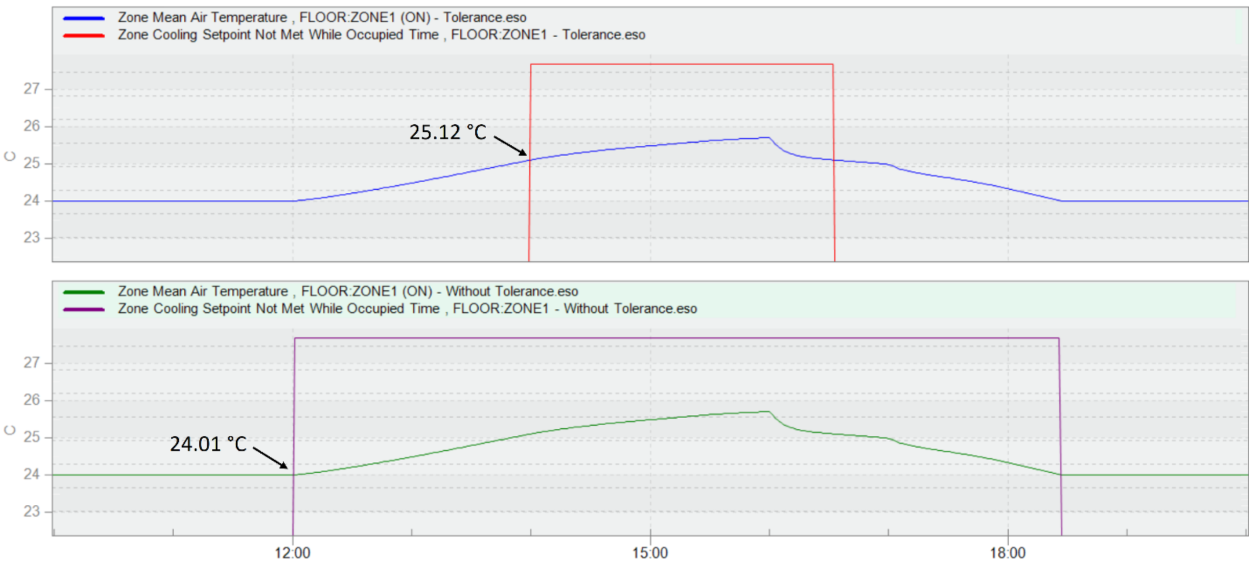
For example:

- Zone temperature increases to 24.01°C (75.22°F), which is 0.01°C above the cooling setpoint. Without any tolerance, this would be considered an Unmet Load Hour because the zone temperature is not exactly 24°C.

<u>With a 1.11°C (2°F) Tolerance</u>
Now, let's apply the 1.11°C (2°F) tolerance. This means deviations of up to 1.11°C (or 2°F) below or above the setpoint temperature will not be counted as Unmet Load Hours.

For example:

- Zone temperature is 24.01°C (75.22°F). Since the deviation is only 0.01°C, which is less than the 1.11°C tolerance, this would not count as an Unmet Load Hour.
- Zone temperature increases further to 25.12°C (77.2°F). This is 1.12°C above the cooling setpoint, exceeding the 1.11°C tolerance. Therefore, this hour will count as an Unmet Load Hour because the zone is not maintaining the setpoint within the allowed tolerance.



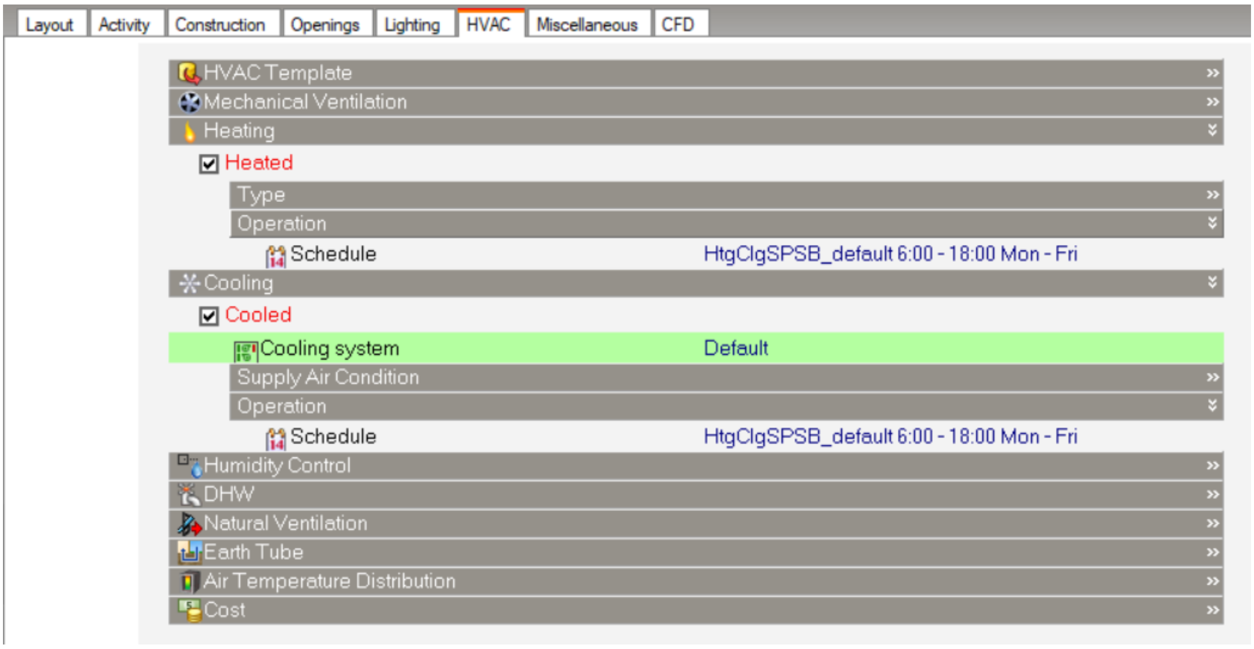
3 Diagnosing Excessive Unmet Load Hours

Possible causes of Unmet Load Hours are listed in the sections below.

3.1 HVAC Setpoint Timing and Operation

The Heating and Cooling operation schedules must be set correctly to ensure that HVAC systems activate at the correct times, as required by building occupancy and load demands.

HVAC operation schedules should align with the building's actual occupancy hours. If HVAC systems operate outside of required times, or don't align with occupancy peaks, this may result in excess Unmet Load Hours.

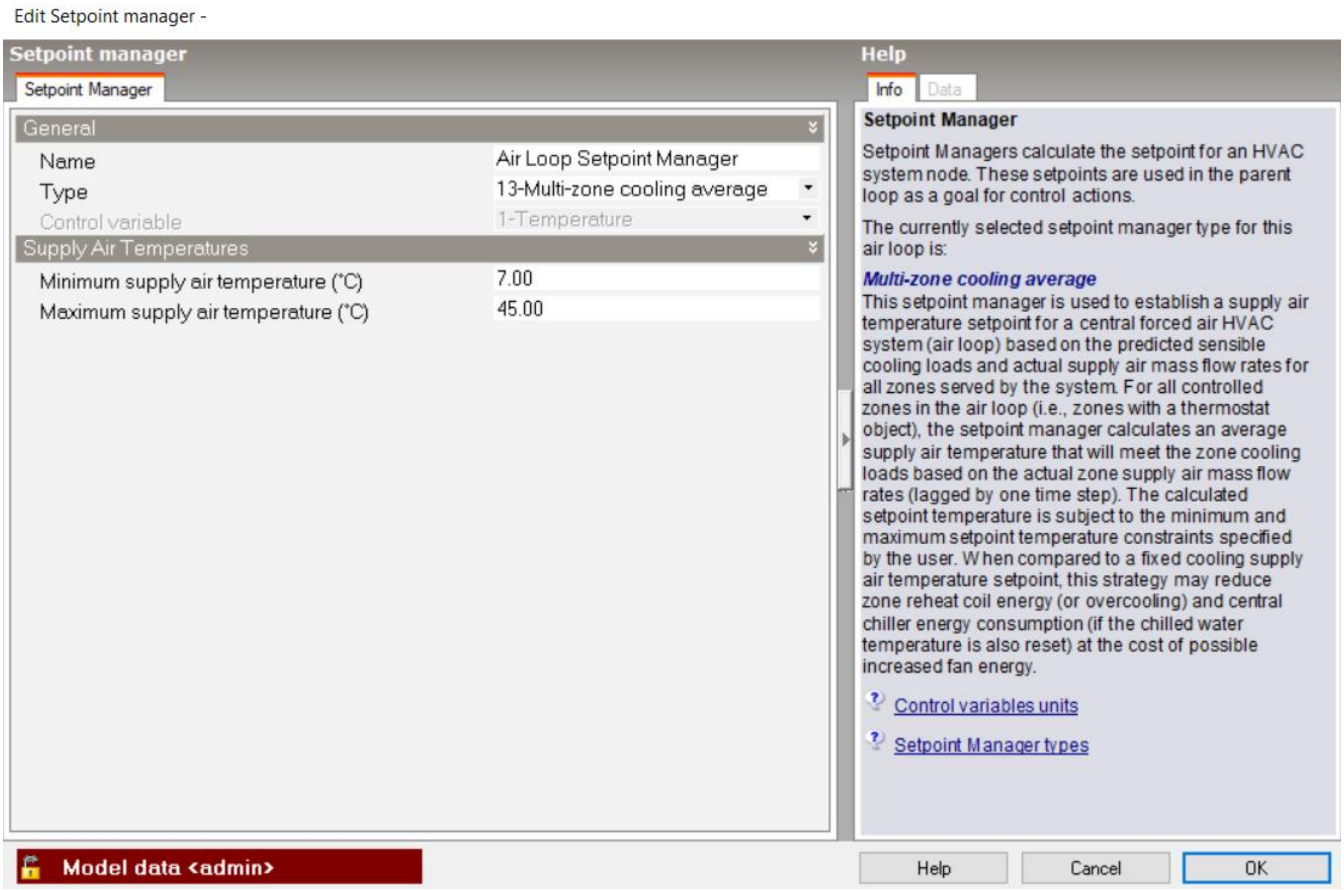


Refer to the Heating operation schedule and Cooling operation schedule Program help topics for more information.

3.2 Incorrect Setpoint Manager

In Detailed HVAC, the setpoint manager regulates temperature, pressure, mass flow rate, and humidity across the system. It is important to select the right type of setpoint manager (SPM) for your building's needs. For example, use a multi-zone SPM for offices with varying zone loads, single zone cooling SPM for uniform spaces like retail, or scheduled SPM for consistent occupancy patterns. Choose appropriate setpoints to avoid Unmet Load Hours.

For more information on the different types of setpoint mangers and how to configure them, you can read our help article.



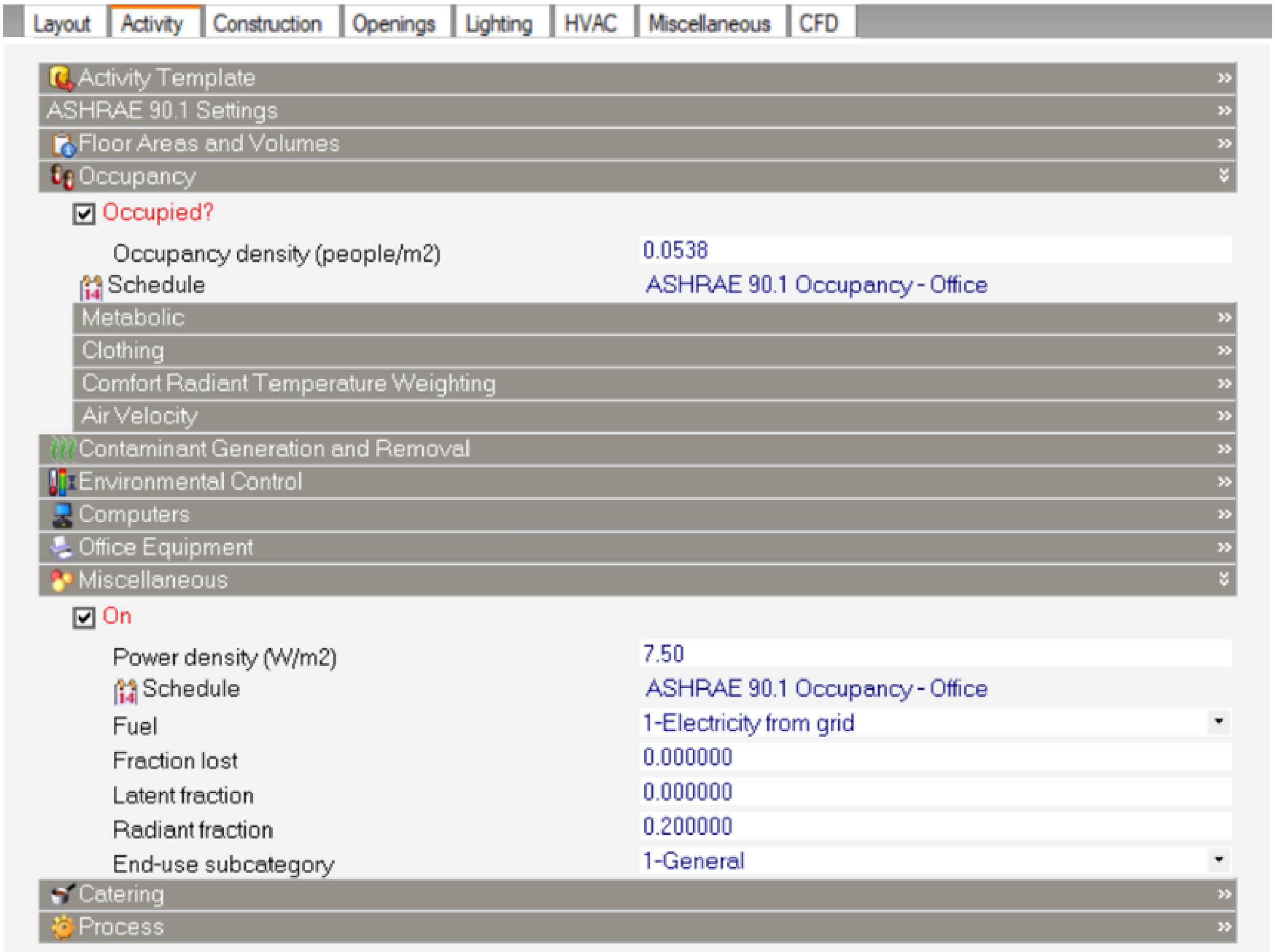
3.3 Inaccurate internal load calculations

Inaccurate internal load calculations can either undersize HVAC systems, leading to comfort issues and excessive Unmet Load Hours, or oversize them, resulting in higher installation costs and reduced operational efficiency. Both scenarios compromise building performance.

Internal heat gains are generated by the activity of occupants, equipment and lighting.

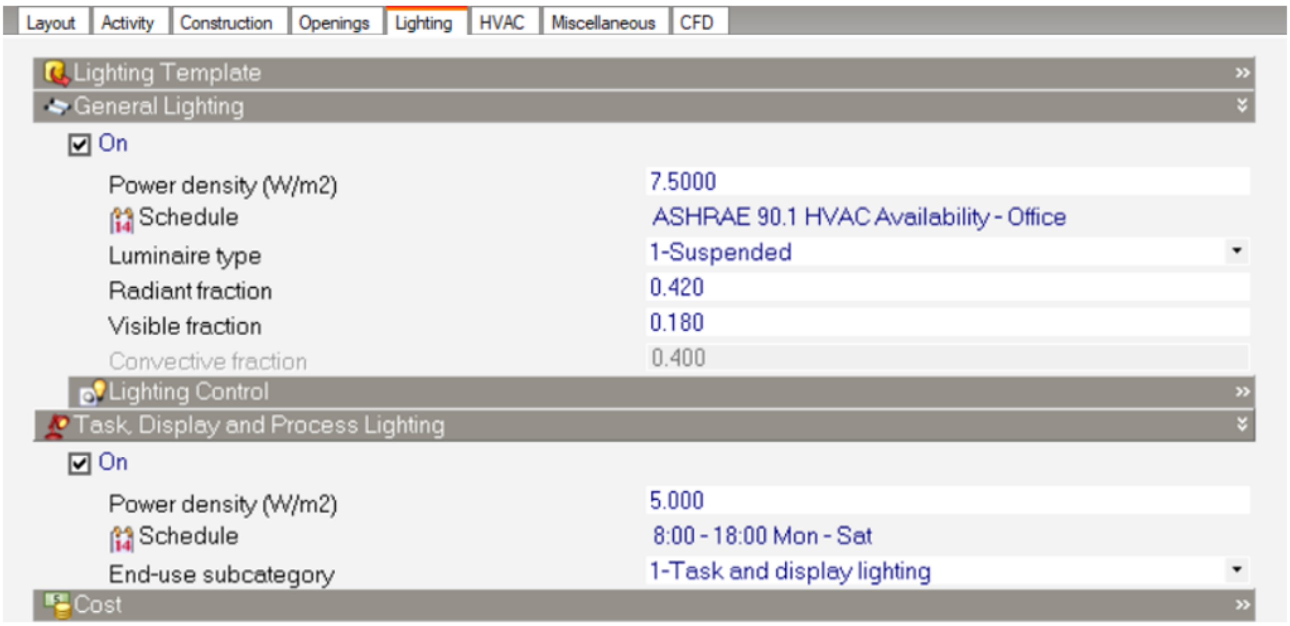
Data on the Activity tab allows you to define the occupancy and equipment heat gains:

- Occupancy
- Computer gains
- Office equipment gains
- Miscellaneous gains
- Catering gains
- Process gains



Data on the Lighting tab allows you to define the lighting heat gains:

- General lighting
- Task and Display lighting



Inaccurate internal load estimates can lead to either undersizing or oversizing HVAC systems, impacting their ability to maintain temperature setpoints or operate efficiently.

Internal gains should normally be excluded from Heating system sizing calculations to ensure that the HVAC system can produce the required heating on its own. This is achieved by using the winter design day tag in the schedule. Otherwise, your heating system may be undersized.

Lighting and Equipment load profiles should match load profiles to actual usage patterns. For example, in an office building, peak equipment and lighting loads occur during working hours, and any incorrect assumptions here can affect HVAC sizing and operation.

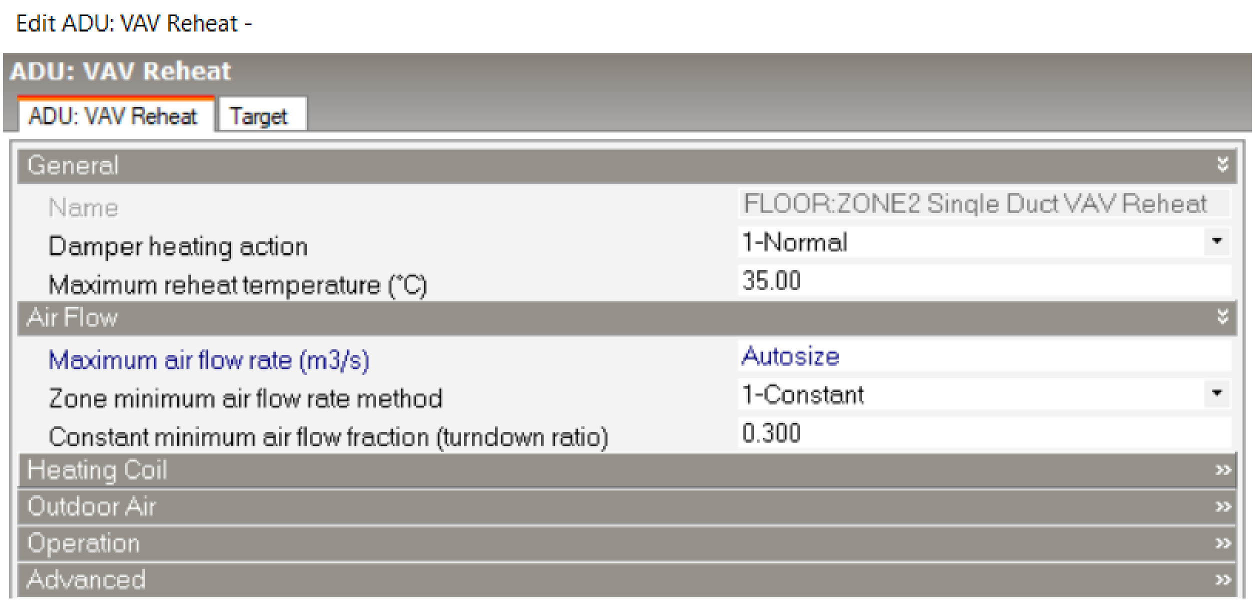
3.4 Incorrect modelling of Air Distribution Units (ADUs)

Inaccurate configuration of ADUs can lead to poor temperature control and increased Unmet Load Hours. The full list of ADU types available in DesignBuilder can be reviewed here.

Terminal unit selection impacts system performance and comfort. VAV units suit multi-zone spaces with varying loads, offering individual control. CAV units work better for single-zone or uniform spaces, where simplified control suffices.

In cases with reheat at the ADU supply, air temperature can be adjusted at the terminal to provide local control. This is especially useful in perimeter zones or areas with high cooling needs, as it allows localized temperature adjustments to meet demand, reducing Unmet Load Hours.

Airflow limits maintain comfort and system efficiency. The minimum rate prevents stagnation while the maximum prevents over-conditioning. VAV units modulate between these limits based on cooling load, with the damper closing as demand decreases. Setting appropriate limits based on zone characteristics is crucial for optimal performance.



3.5 Incorrect AHU and zone Outdoor / Supply airflow rates

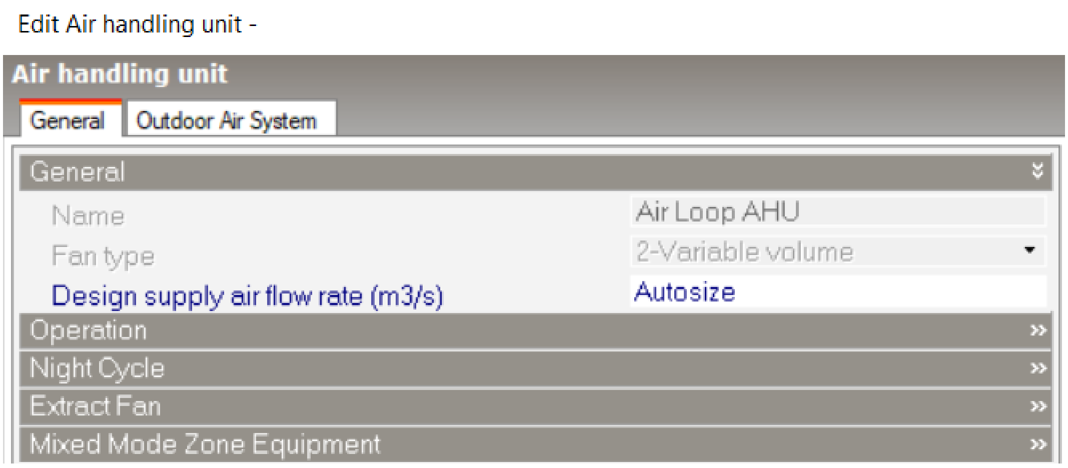
Incorrect outdoor and supply airflow rates defined at the Air Handling Unit (AHU) and Zone level, can cause insufficient ventilation or excessive conditioning, leading to discomfort and increased Unmet Load Hours.

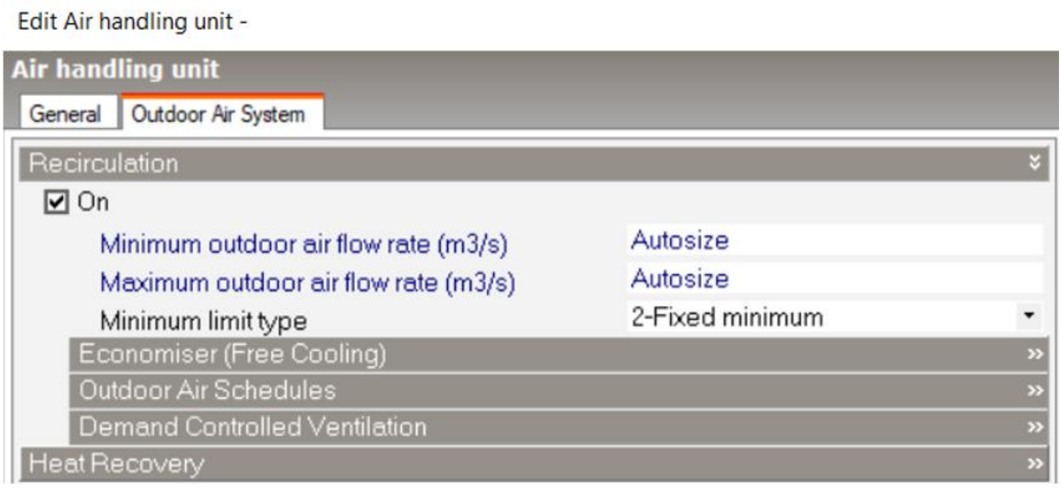
3.5.1 Air Handling Unit

It is important to ensure correct AHU airflow configuration for optimal HVAC performance. To do this:

1. Set outdoor airflow rates based on zone ventilation needs and, for example, ASHRAE 62.1 standard.
2. Configure supply airflow rates to meet peak loads, using DesignBuilder's automatic sizing based on building parameters and design conditions.

Accurately configuring outdoor and supply airflow rates for the AHU is essential for modelling an efficient HVAC system that meets both ventilation and comfort needs. The outdoor airflow rates should be set according to the ventilation needs of the zones served by the system. Ensure these rates meet standards like ASHRAE Standard 62.1 if applicable. Supply airflow rates should be based on the system's ability to meet the building's peak heating and cooling demands. These rates can be automatically sized based on user-specified building configuration and design outside conditions.

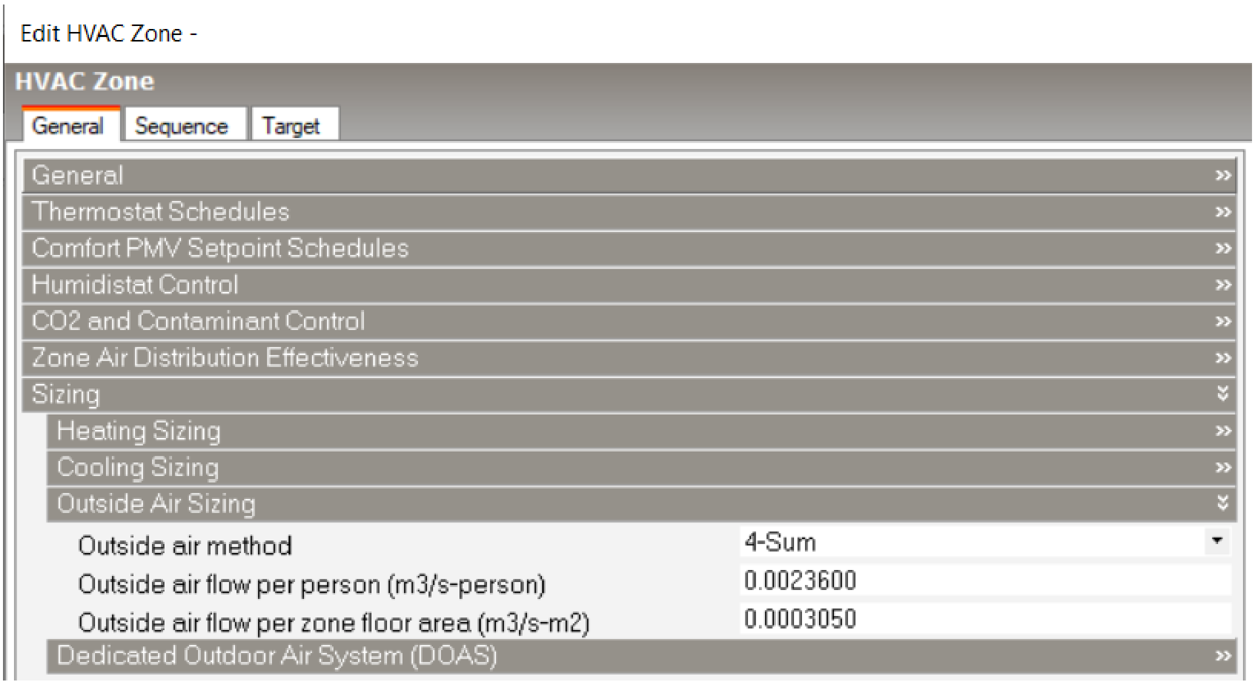




Refer to the Generic Air Handling Unit (AHU) for more information.

3.5.2 HVAC Zone

Minimum outdoor airflow rates defined at the Zone level specify the required amount of fresh air for each zone to maintain indoor air quality and meet ventilation standards. These rates must be set correctly to ensure that adequate ventilation is delivered to each zone based on the occupancy category and any regulatory requirements, like ASHRAE Standard 62.1.



Refer to the Editing HVAC Zone Data for more information.

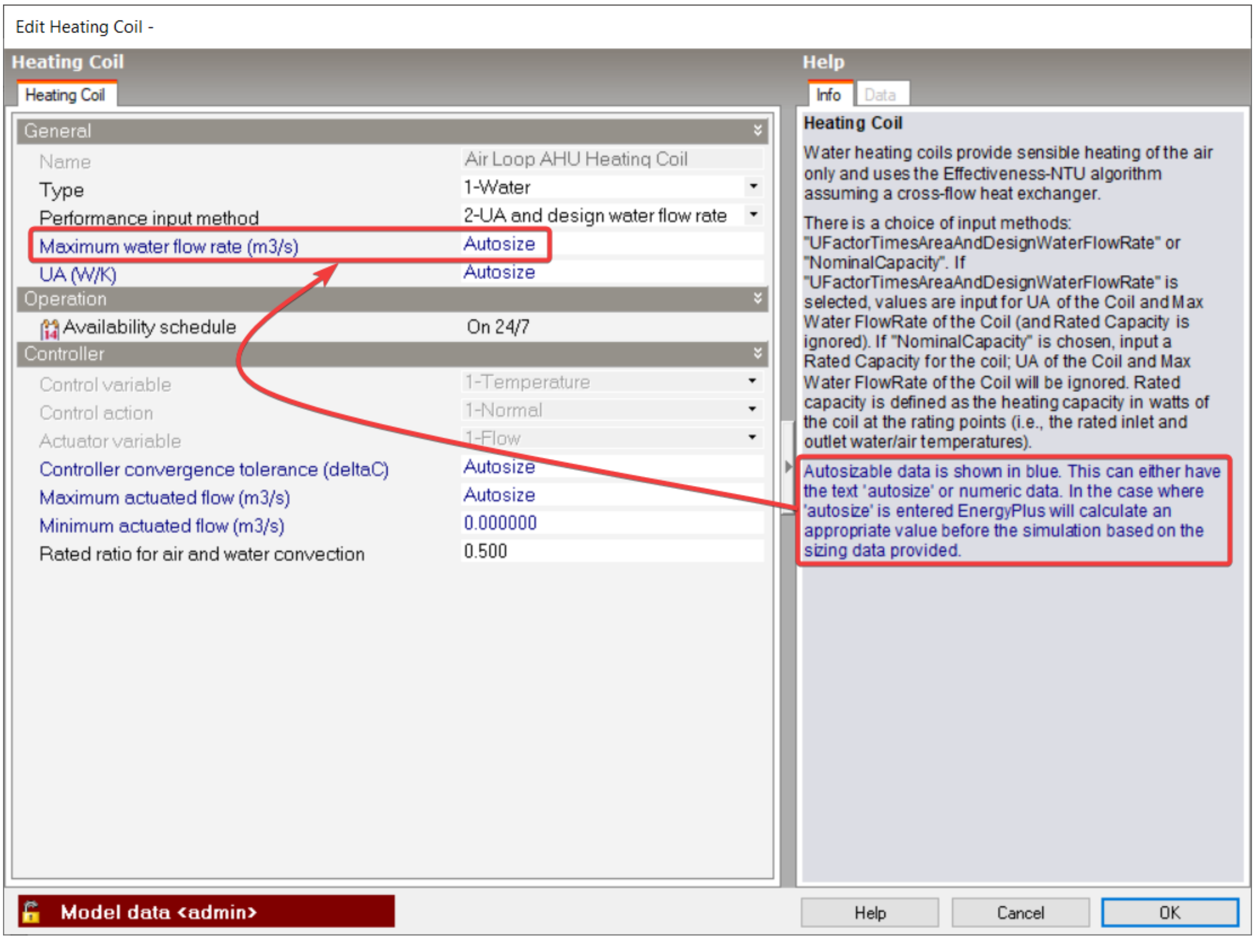
Overestimating minimum outdoor airflow rates can introduce too much unconditioned outdoor air, increasing heating or cooling loads beyond the system's fixed capacity, particularly in extreme weather conditions. In such cases, the HVAC system may not condition the excess outdoor air sufficiently, leading to increased Unmet Load Hours. This is only likely to happen if equipment capacities were specified by the user instead of using DesignBuilder's autosize function.

When the minimum outdoor airflow rates are underestimated, the fresh air supplied to the zone may not receive sufficient airflow and not meet ventilation requirements, potentially causing Unmet Load Hours.

3.6 HVAC sizing

Many HVAC components can be autosized in DesignBuilder based on building configuration and design conditions. Autosizable settings appear in dark blue on component dialogs. Enter "Autosize" in the edit control to enable autosizing for a setting.

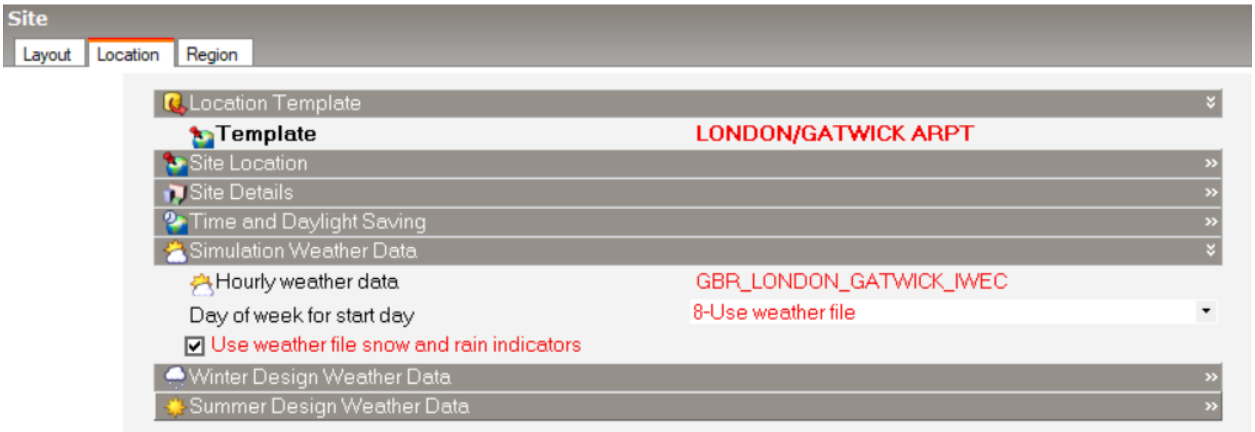
For example, for a hot water coil, the Maximum water flow rate can be autosized:



3.6.1 Weather Data

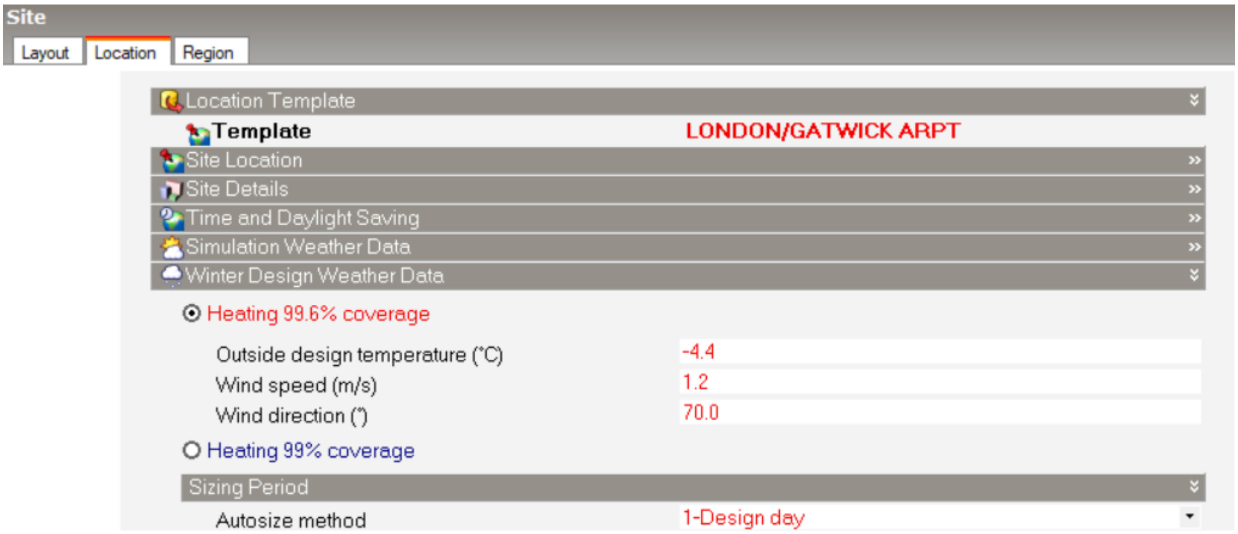
Using weather data that does not represent typical conditions or does not account for climate variations can lead to significant inaccuracies in performance predictions, affecting design decisions, operational strategies, and overall sustainability outcomes.

Different weather data is used for autosizing the HVAC system than is used for the dynamic simulation. DesignBuilder uses EnergyPlus format hourly weather data to define external conditions during simulations. Each location has a separate file describing the external temperature, solar radiation, atmospheric conditions etc. for every hour of the year at that location.

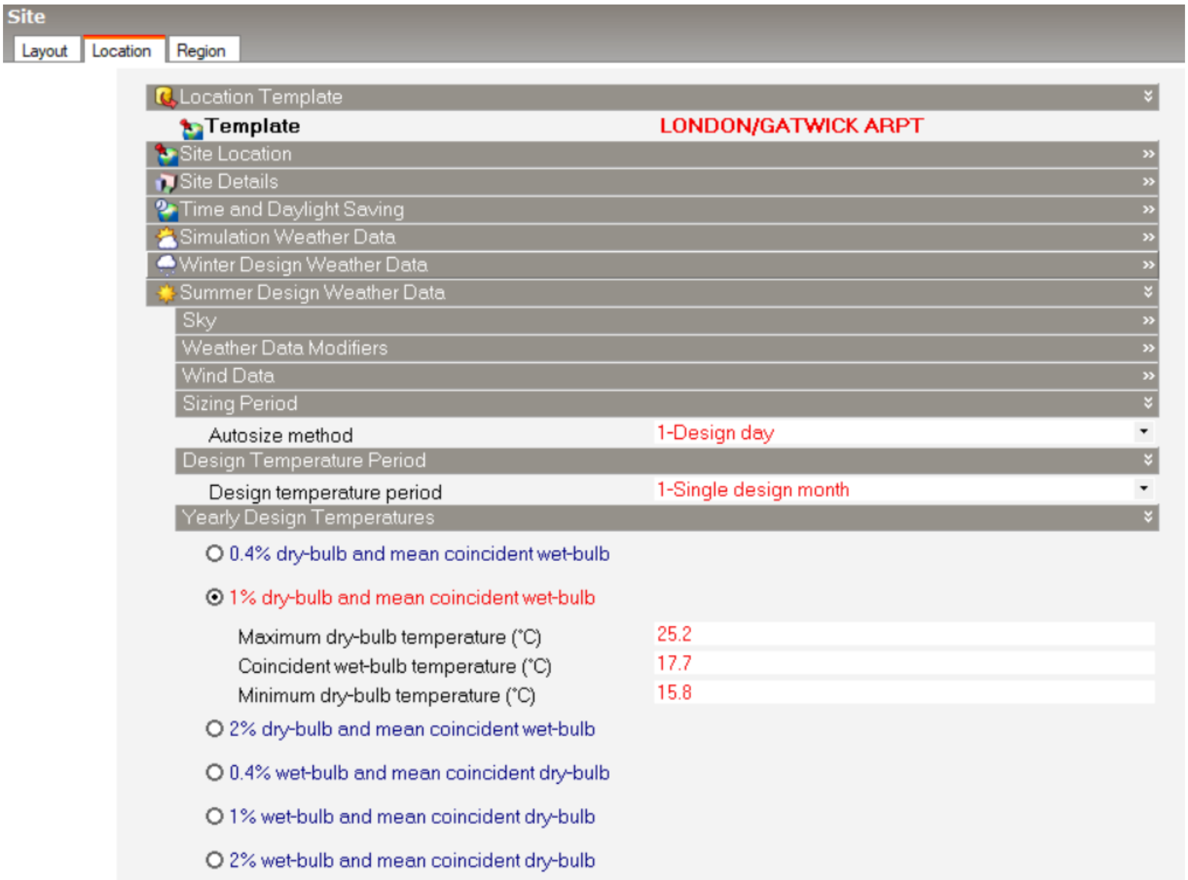


Refer to the [Simulation using Hourly weather data]() and [Simulation Weather Data]() for more information.

[Heating design]() and simulation autosizing simulations use simplified winter design weather based on a worst-case design day.



[Cooling design]() and simulation autosizing simulations use simplified summer design weather based on worst-case design days.



Refer to the Winter design weather data and Summer Design Weather Data for more information.

Confirm the correct weather data for the project location is being used in both cases in the Location Tab to avoid inappropriate HVAC sizing and Unmet Load Hours.

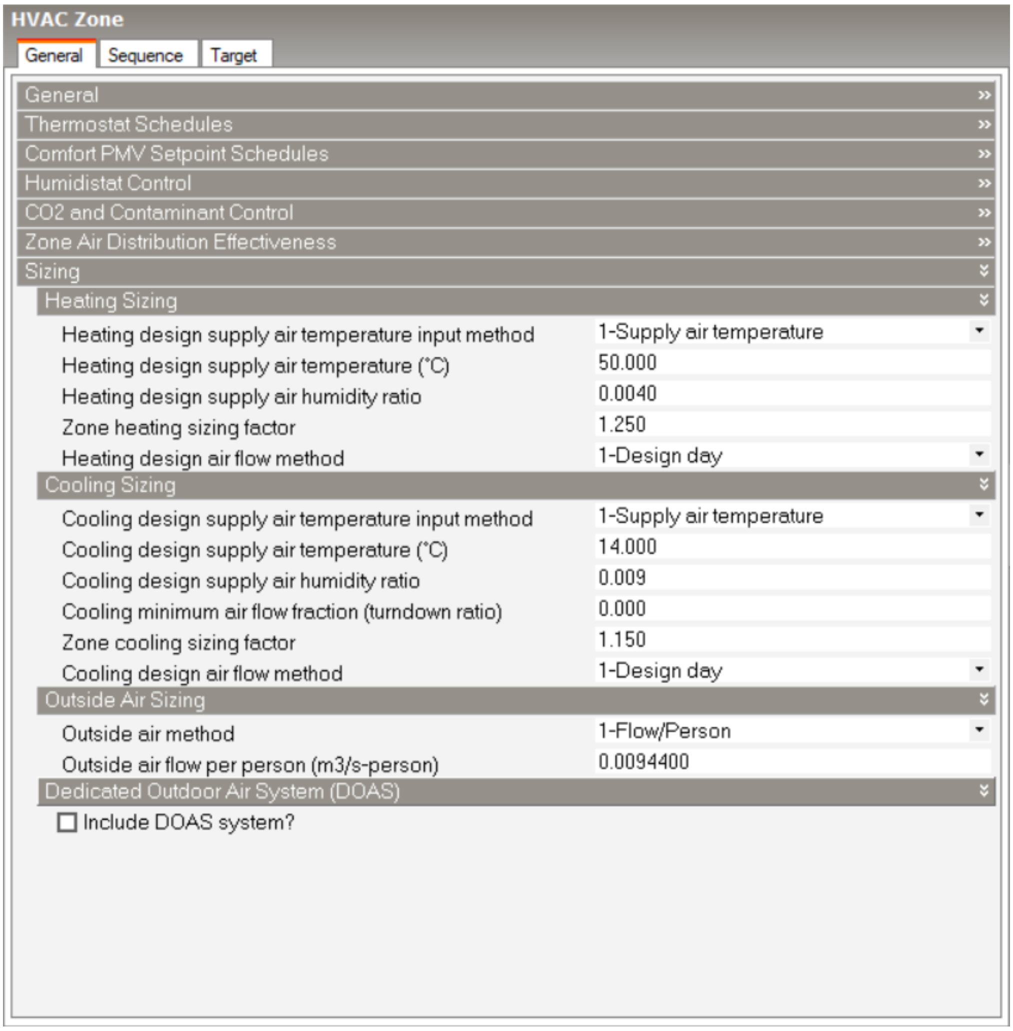
3.6.2 Undersized HVAC Equipment

Undersized HVAC equipment lacks the capacity to meet peak heating or cooling demands, leading to increased Unmet Load Hours. Possible causes are the use of outdated or overly conservative design assumptions, misinterpreting climatic data or ignoring microclimatic variations and neglecting the impact of internal loads, such as varying occupancy or equipment usage patterns.

3.6.3 Incorrect zone/system sizing

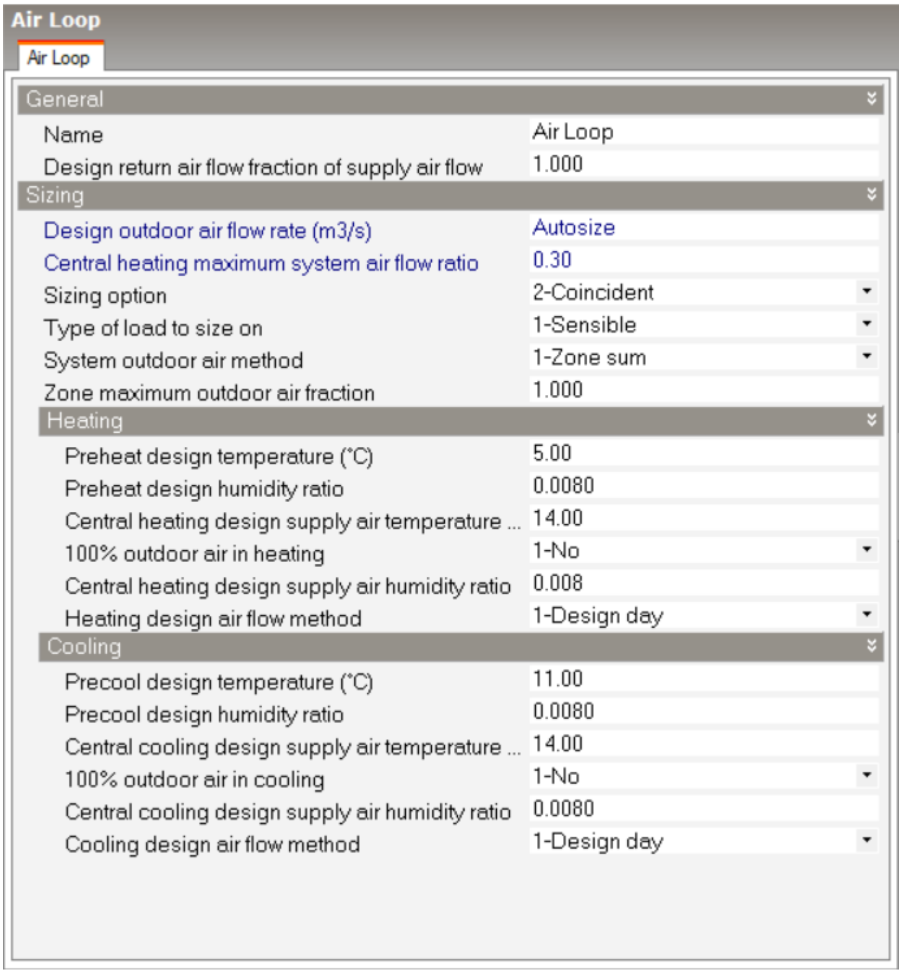
HVAC Zone

EnergyPlus autosizing begins with zone-by-zone design day simulations to calculate airflow rates. These rates inform subsequent HVAC and plant air/fluid flow sizing. Incorrect zone sizing can cause unmet loads through mismatched capacity allocation.



HVAC System

Using the calculated zone design airflow rates (including any modified or user-specified values), EnergyPlus determines central air system flow rates and calculates the corresponding cooling and heating loads.



For the best results, follow these guidelines during HVAC equipment autosizing:

1. Start with a fully autosized system for all HVAC components.
    - Confirm correct operation of the autosized system before manually specifying the any equipment sizes.
2. Align control settings with sizing inputs:
    - For example, if the Air Loop "Central cooling design supply air temperature" is set to 13°C, the user must make sure that the setpoint manager for the central cooling coil controls to 13°C as design conditions. EnergyPlus does not cross-check these inputs. The sizing calculations use the information in the Air Loop and HVAC Zone data. The simulation uses the information in controllers and setpoint managers.
3. Flow rate specifications only affect sizing calculations when entered in HVAC Zone or Air Loop objects.
    - Components cannot influence sizing calculations through their individual specifications, with one exception: plant loop sizing incorporates all component water flow rates, whether autosized or user-specified.
4. Zone thermostat schedules control the times at which design loads are calculated.
    - Zone-level schedules (lighting, equipment, infiltration) are active during sizing calculations using the specified sizing period day type.
    - System and plant schedules are not considered in sizing calculations.
    - To exclude specific periods from sizing calculations, adjust thermostat setpoint schedules for Summer/WinterDesignDay. Example: Setting cooling setpoint to 99°C during night hours in SummerDesignDay prevents cooling load calculation during those times.

Refer to the Autosizing HVAC Components, Autosizing Heating and Cooling Equipment, and Schedules and Design and Sizing Simulations for more information.

4 Troubleshooting Checklist for Unmet Load Hours

To help identify and fix issues related to Unmet Load Hours, the following checks can be made:

4.1 Schedule Options

We recommend using either:

1. 7/12 Schedules with the 2-Profiles option, defining heating and cooling operations explicitly using separate profiles.
2. Compact schedules, similarly, explicitly defining heating and cooling design operations.

4.2 Setting up Schedules

When setting up schedules for Detailed HVAC simulations, consider the following:

1. Determine whether the schedule will be active or inactive during the heating and cooling sizing simulations used for autosizing equipment.
2. Internal gains should generally be excluded from heating sizing. For example, if the 7/12 schedule applies to internal gains, occupancy, or lighting, select the "Off" schedule for the Heating Design Day Profile.

4.3 Plant and Condenser Loop Configuration

1. Verify the design temperatures for each Plant and Condenser Loop.
2. Check that it corresponds to the operational temperature in the Plant and Condenser Loop's Setpoint Manager.

4.4 System and Zone Configuration

1. Verify supply air temperatures and setpoint control strategies in the Air Loop to ensure alignment with design conditions for different zone types.
2. Ensure the configuration of AHU economizers is appropriate.
3. Review HVAC operation schedules to confirm that zone thermostat schedules align with HVAC system operation schedules.
4. Verify that the Zones are meeting their setpoint temperatures receiving the correct amount of supply airflow during cooling and heating.

4.5 Weather File

1. Review the Design Weather Data used. You can cross-check this with ASHRAE sources.
2. Check for extreme weather conditions in the weather file that exceed the design day conditions.
3. For custom weather data you can refer to DesignBuilder Climate Analytics.

4.6 Equipment Performance

Confirm that Performance Curves for equipment (e.g., Heat pumps, VRF systems, coils) are not reducing available capacity.

5 Using Optimisation and Sensitivity Analysis to Reduce Unmet Load Hours

Building systems are often oversized in an attempt to guarantee occupant comfort, but this leads to unnecessary costs and possible inefficiency. A better approach uses engineering design principles to achieve optimal comfort while minimising both system costs and environmental impact.

DesignBuilder's Optimisation and Sensitivity Analysis tools help engineers find this balance through automated simulation batches. These simulations identify the ideal equipment sizing and control settings that maintain comfort requirements while reducing installation and operating costs. These analyses can be set up to use Unmet Load Hours as a key performance metric.

Uncertainty and Sensitivity Analysis uses regression to determine which variables most strongly influence unmet hours. Optimisation runs multiple simulations testing different combinations of key design variables that you define. Both methods help designers find solutions that effectively balance comfort (measured by Unmet Load Hours) with other goals like energy efficiency.