ASHRAE 90.1 Section 11 and Appendix G Submittal Review Manual

May 2021

Summary

The 90.1 Section 11 and Appendix G Submittal Review Manual (the Manual) is a comprehensive reference for reviewing modeling-based submittals. The Manual is a companion to the DOE/PNNL 90.1 Section 11 and Appendix G Compliance Form and supports 2016 and 2019 editions of ANSI/ASHRAE Standard 90.1. The forms can be downloaded here. The Manual includes the following:

a. The review checks to verify that the proposed design reported in the Compliance Form reflects design documents; that the configuration of the baseline/budget model is established correctly, that the baseline/budget and proposed design is modeled as reported, that the simulation is error-free, and that the compliance outcome is established correctly;

b. The review checks to verify compliance with the mandatory requirements of 90.1 relevant to the simulation inputs;

c. Examples and common mistakes;

d. The methodology for prioritizing the review;

e. Simulation reports for common BEM tools annotated with tips on performing specific checks.

In addition, the Manual provides recommendations to jurisdictions and rating authorities for establishing effective and efficient submittal review process including but not limited to the adoption of the DOE/PNNL 90.1 Section 11 and Appendix G Compliance Form and establishing the minimum qualification requirements for energy modelers and submittal reviewers.

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Abbreviations and Acronyms

AFUE - annual fuel utilization efficiency
AHJ – authority having jurisdiction
AHRI – American Heating and Refrigeration Institute
AHVAC – air-side HVAC
ANSI – American National Standards Institute
ASHP – air-source heat pump
ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers
BBREC – baseline building regulated energy cost
BBUEC – baseline building unregulated energy cost
BHP – brake horsepower
CF – compliance form
CFM – cubic feet per minute
CHP – combined heat and power
CV – constant volume
DCV – demand control ventilation
Ec - combustion efficiency
ECB – Energy Cost Budget Method described in ASHRAE Standard 90.1 Section 11
EFLH – effective full load hours
Et - thermal efficiency
ERV – energy recovery ventilator
DOAS – dedicated outdoor air system
HVAC – Heating, Ventilation and Air Conditioning
IECC – International Energy Conservation Code
IESNA – Illuminating Engineering Society of North America
LE – lighting, exterior

LI – lighting, interior
ML – miscellaneous loads
OA – outdoor air
PA – permit applicant
PCI – performance cost index
PCIt – performance cost index target
PRM – Performance Rating Method described in ASHRAE Standard 90.1 Appendix G
PRM RM – Performance Rating Method Reference Manual
PV – photovoltaic panels
SG – Simulation, General
SWH – service water heating
UMLH – unmet load hour
VAV – variable air volume
WBP – whole building performance
WHVAC – water-side HVAC
WWR – window to wall ratio

1. Background

The 90.1 Section 11 and Appendix G Submittal Review Manual (the Manual) is a comprehensive reference for reviewing modeling-based submittals. The Manual supports 2016 and 2019 editions of ANSI/ASHRAE Standard 90.1 focusing on the aspects unique to whole building performance-based compliance, as illustrated in Figure 1. Some of the enforcement steps that are the same for prescriptive and performance projects, such as site inspections and commissioning, are not addressed.

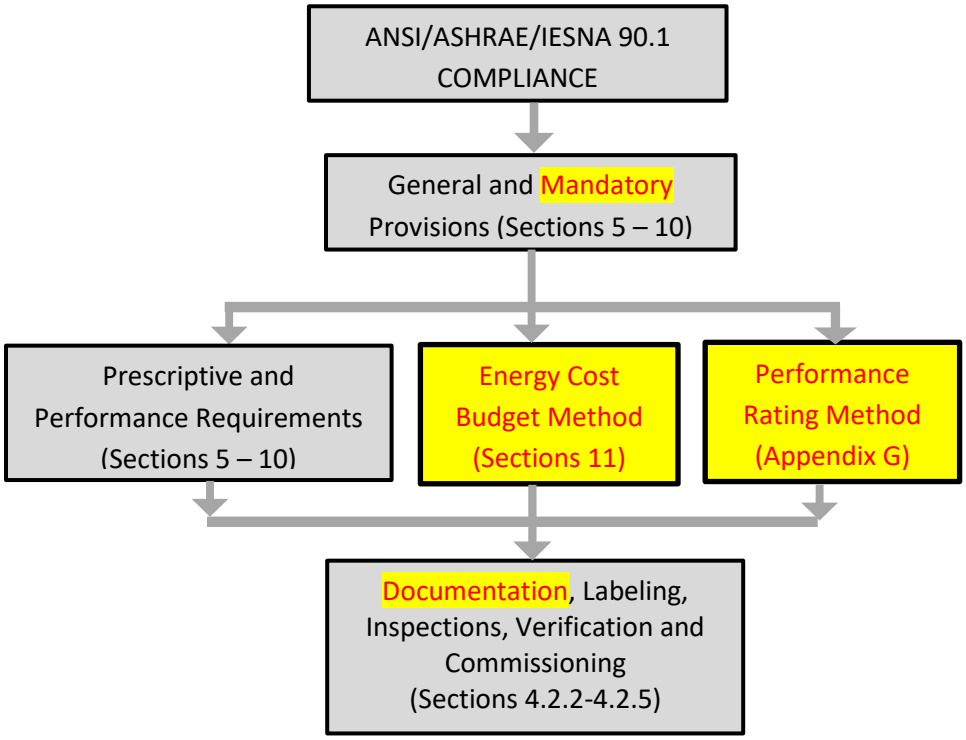


Figure 1: Scope of the Manual

The Manual is a companion to the DOE/PNNL 90.1 Section 11 and Appendix G Compliance Form (the Compliance Form) which meets 90.1 Section 11 and Appendix G documentation requirements. The Compliance Form is a spreadsheet-based tool that is filled out by the energy modeler and design team and submitted, along with the required supporting documentation, to the Authority Having Jurisdiction (AHJ) or the Rating Authority (RA) for review. The review checks described in this Manual are incorporated into the Quality Control Checks tab (QC Tab) of the Compliance Form. The compliance documentation process is illustrated in Figure 2.

The QC tab allows reviewer to identify the checks to be performed for the project based on the established high impact areas and the available review budget, and record pass/fail outcome and comments for each completed check. This Manual includes description of each check listed in the QC tab including references to the applicable 90.1 requirements, simulation reports, and common mistakes.

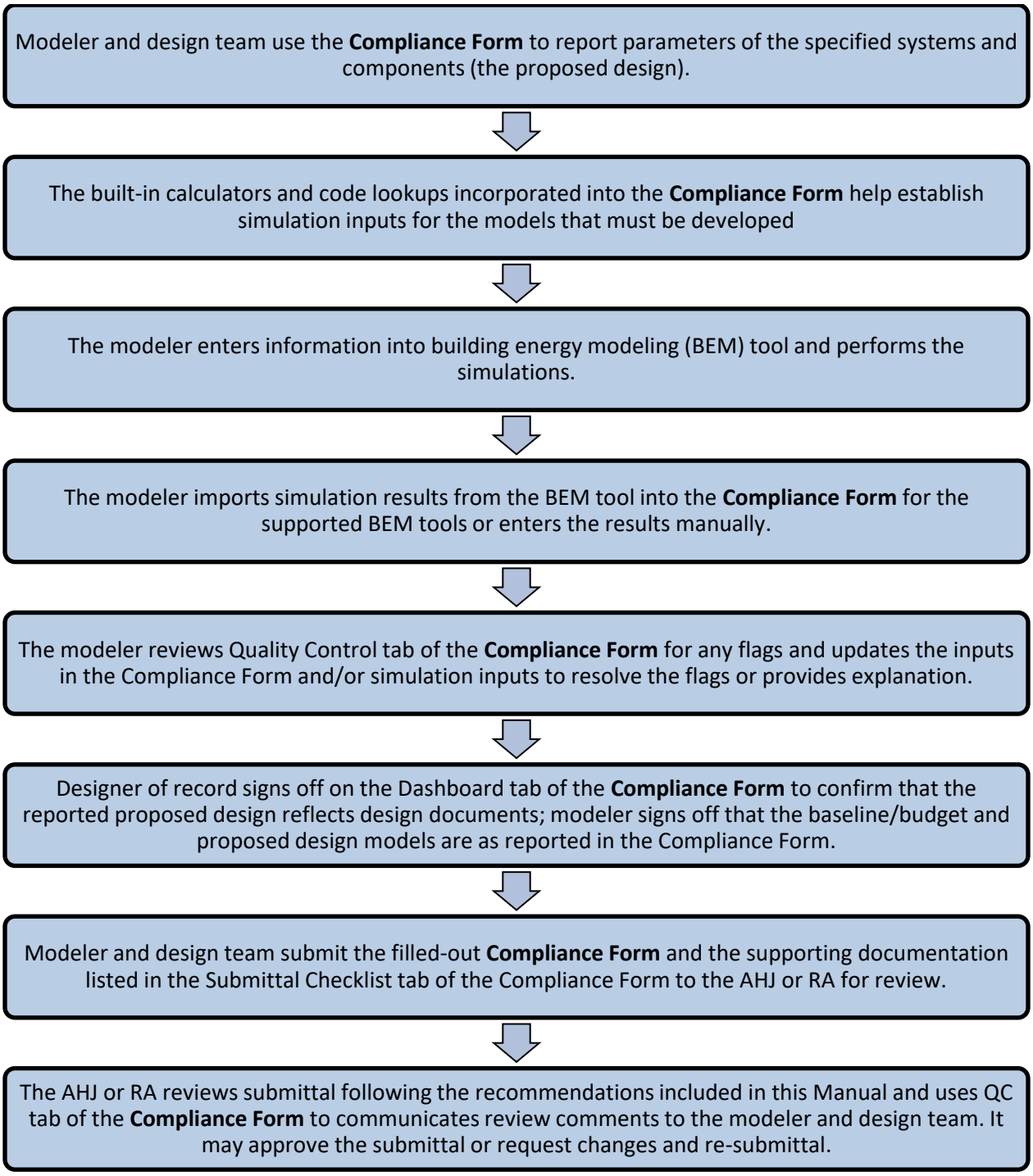


Figure 2: Compliance Documentation Process

This Manual includes the following:

a) The review checks to verify that the proposed design reported in the Compliance Form reflects design documents; that the configuration of the baseline/budget model is established correctly, that the baseline/budget and proposed design is modeled as reported, that the simulation is error-free, and that the compliance outcome is established correctly;

b) Examples and common mistakes;
c) The methodology for prioritizing the review to focus on the most impactful areas;
d) Simulation reports for common BEM tools annotated with tips on performing specific checks.
e) Checks to verify compliance with the mandatory requirements of 90.1 relevant to the simulation inputs.

In addition, the Manual provides recommendations to jurisdictions and rating authorities for establishing effective and efficient submittal review process including but not limited to the adoption of the DOE/PNNL 90.1 Section 11 and Appendix G Compliance Form and establishing the minimum qualification requirements for energy modelers and submittal reviewers.

2. Organization of the Manual

The Submittal Review Quick Start (Section 3) describes how this Manual may be used by different user groups including the following

- AHJ and RA administrators charged with establishing submittal review framework for their organizations
- building code officials and other professionals tasked with reviews of modeling-based submittals
- energy modelers who may use procedures outlined in the Manual for internal quality control before submitting to AHJ/RA.

The Review Process (Section 4) of this Manual provides step-by-step overview of the submittal review process including references to the tabs of the Compliance Form and sections of the Manual relevant to each step.

The Submittal Review Methodology (Section 5) of this Manual summarizes the general concept of Standard 90.1 Section 11 and Appendix G compliance, describes the types of review checks included in the Manual, and includes recommendations for identifying impactful aspect of the submittal to help prioritize review effort. The section also discusses how to use the QC Checks tab of the Compliance Form to establish scope of the review.

The Review Checks (Section 6) of this of this Manual is a comprehensive library of checks that may be performed. The checks are organized in subsections baseline on the type of building systems and components, such as interior lighting, building envelope, etc. Description of each check includes references to the relevant sections of 90.1, review tips including where the relevant information may be found in the Compliance Form, common mistakes, and references to the applicable simulation reports for the supported tools.

Simulation Reports (Section 7) of this Manual contain the annotated BEM tool reports that are referenced in the review checks, to help locate the necessary information.

The following additional Standard 90.1 resources are available and may include requirements applicable to special situations and exceptions that are beyond the scope of this Manual.

1. ANSI/ASHRAE/IES Standard 90.1-2016 and 90.1 2019 available from ASHRAE Bookstore[1]. Read-only version may also be available from the ASHRAE website.[2]
2. 90.1-2016 User's Manual (available from ASHRAE Bookstore). The User's Manual provides examples and explains requirements of the standard, including Section 11 and Appendix G.
3. ANSI/ASHRAE/IES Performance Rating Method Reference Manual[3]. The document expands on requirements of 90.1-2016 Appendix G and can be used as the source for the simulation assumptions and methodologies that are not addressed in 90.1.
4. ASHRAE Interpretation Requests
5. Questions on applying code requirements to the specific projects may be sent to ASHRAE as an official or unofficial interpretation request[4]. The official interpretations are posted on ASHRAE website for 90.1-2013[5] and 90.1-2016[6] and are a useful resource.
6. DOE Help Desk[7]
7. Additional software-specific resources are included in the Simulation Reports section.

3. Submittal Review Quick Start

For AHJ and RA Administrators

The recommendations below cover the organizational prerequisites for effective and efficient submittal reviews on project that follow 90.1 Section 11 and Appendix G utilizing the existing tools and resources.

1. To standardize submittal documentation, require use of the DOE/PNNL ASHRAE Standard 90.1 Performance Based Compliance Form available from DOE Energy Codes Program website[8]. The form meets documentation requirements of ASHRAE Standard 90.1 Section 11 and Appendix G and ensures that the information necessary for the meaningful submittal reviews is provided to the building official. The Compliance Form is the basis of the review procedures described in this manual.
2. To minimize modeler mistakes and overhead associated with review of poor submittals, establish the minimum qualification requirements for the modelers authorized to sign off on the submittal. The recommended minimum modeler qualifications are included in Appendix A of this Manual.
3. Set the minimum qualification requirements for model reviewers to ensure that they understand requirements of 90.1 Section 11 and Appendix G and have sufficient knowledge of building energy simulation to perform review checks described in this manual. The recommended minimum model reviewer qualifications are included in Appendix B of this Manual.

[1] https://www.ashrae.org/technical-resources/standards-and-guidelines
[2] https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards
[3] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26917.pdf
[4] https://www.ashrae.org/technical-resources/standards-and-guidelines/pcs-toolkit/standards-forms-procedures#interpretationrequest
[5] https://www.ashrae.org/standards-research--technology/standards-interpretations/interpretations-for-standard-90-1-2013
[6] https://www.ashrae.org/technical-resources/standards-and-guidelines/standards-interpretations/interpretations-for-standard-90-1-2016
[7] https://www.energycodes.gov/HelpDesk
[8] https://www.energycodes.gov/software/ashrae-standard-901-performance-based-compliance-form

4. To ensure consistency of review rigor between different reviewers, determine the desired scope of the reviews utilizing recommendations in the Review Methodology section of this manual. This may include identifying a subset of checks included in the Review Check section of this manual, using their CheckID, that must be performed on all projects, the additional checks that must be performed on projects based on certain criteria (e.g. building type, size, modeler or building systems), and any custom checks. The Quality Control Checks tab of the Compliance Form has built-in functionality to automatically select some of the checks for inclusion in the review. AHJ and RA may choose to follow this default logic is lieu of defining the custom scope. With this approach, all review checks automatically selected in the Quality Control Checks tab of the Compliance Form would be required to be performed.
5. To help improve initial quality of submittals, streamline reviews and reduce the number of review iterations, consider requiring that modelers perform the specified set of checks before submitting the documentation to the building official, and document the outcome of each completed check in the QC Checks tab of the compliance form
6. Decide whether external reviewers may be engaged
    a. Engaging third party reviewers may be desirable for jurisdictions that receive low volume of performance-based submittals and do not have reviewers with the necessary qualification requirements on staff. It may also be helpful for jurisdictions and rating authorities that lack financial resources for performing such reviews in-house.
    b. If external reviews are allowed, identify companies or professionals authorized to perform such reviews. The pre-approve third-party reviewers should at minimum meet the established qualification requirements for submittal reviewers.
    c. Decide on how third-party reviews will be funded. For example, permit applicants may bare the review cost.
8. Decide whether reviews completed by other programs may be accepted. For example, when project uses 90.1 Appendix G for both code compliance and incentive program participation, review performed by the incentive program may be deemed sufficient. The decision depends on whether the submittal requirements, modeler and reviewer qualification requirements and review rigor adopted by the candidate program are equivalent to the policies set in #1-4 above.

For Submittal Reviewers

1. Before performing the first review:
    a. Review the submittal review policy documents published by AHJ/RA to understand the documentation requirements, review scope, target turnaround time and budget.
    b. Read the Review Process section to understand the review steps.
    c. Read Review Methodology section to learn about the different types of checks included in the Manual and understand methodology for identifying impactful aspect of the submittal, and the tools available in the Compliance Form to help facilitate the reviews.
2. Follow the steps outlined in the Review Process section of this Manual to perform a review.

For Energy Modelers

Modelers and design teams should use the same process as described above for the Submittal Reviewers to perform quality control before submitting the package for review. This helps minimize review iterations and ensures a speedy approval. The following is recommended:

a. At minimum, review the QC Checks tab of the Compliance Form to verify that no automated checks result in "Fail" outcome. Investigate all failed checks and correct the inputs in the appropriate tabs of the Compliance Form and/or in the simulation to resolve the check. If check is not resolved, provide an explanation for reviewer.
b. To improve submittal quality, consider completing all checks for which "Include in Review" is automatically set to "Yes" in the QC Checks tab of the Compliance Form are completed. Some jurisdictions and rating authorities may require this step.
c. When replying to review comments, refer to the Review Checks section of this manual to understand the 90.1 requirements and common mistakes relevant to the particular checks.

4. Review Process

The section describes the submittal review process utilizing the QC Checks tab of the Compliance Form.

Step 1: Check submittal for completeness

Use Submittal Checklist tab of the **Compliance Form** to verify that all required materials are provided. Request additional information if submittal is incomplete.

- Review the Dashboard tab of the **Compliance Form** to verify compliance outcome and confirm that modeler and design professional signed off on the submittal as required

Step 2: Get general understanding of the project

- Review the General Information tab of the **Compliance Form** to understand building type, size, location, whether it's a new construction or renovation and the compliance path followed
- Review the Energy Performance Summary tab of the **Compliance Form** to understand which end uses have significant impact on the modeled energy use. (See Identifying Impactful Aspects of the Submittal section.)

Step 3: Establish Review Scope

- Open Quality Control Checks tab of the **Compliance Form** (Figure 3). The tab includes all review checks listed in the manual. For some checks, "Include in Review" box will be set to "Yes" by default based on the logic described in the Establishing Review Scope section of this Manual. I it recommended that review at minimum includes these checks.

CheckID	QC Check	Include in Review?	Review Outcome	Rev 0 Review Comments
Ref SG01	The same approved weather file was used in the baseline and proposed design simulations	Yes		
Ref SG02	At least 8760 hours per year were explicitly modeled.	No	n/a	
Ref SG03	The number of unmet load hours (UMLH) for baseline and proposed design is below 300.	Yes	Pass	
Ref SG04	Confirm that the modeled floor area of the proposed design reflects design documents.	Yes		

Figure 3: Quality Control Checks tab of the Compliance Form

- For some of the pre-selected checks, the review outcome is automatically set to "Pass" or "Fail" based on the information provided on other tabs of the **Compliance Form**. For checks with "Fail outcome, a default review comment is displayed and may be edited by the reviewer.
- Follow recommendations in the Identifying Impactful Aspects of the Submittal and Establishing Review Scope sections of the Manual ot identify additional checks to be performed on the project. For these checks, set "Include in Review" box to "Yes" in the Quality Control Checks tab of the Compliance Form (Figure 4).

Step 4: Perform the Review

- Perform the selected review checks in the order listed in the QC Checks tab of the **Compliance Form**. Record "Pass" or "Fail" outcome for each check and provide actionable review comments for each check with the "Fail" outcome.
    - A "Pass" outcome means that no changes are required in the given area and any provided comments can be treated as informative.
    - A "Fail" outcome means that changes must be made to the submittal before it is approved. In this case, the issues and required changes should be described in the review comment.
- Confirm the outcome on the checks that are automatically set to "Pass" and update the outcome if necessary.
- Use CheckID provided in the QC Checks Tab to locate the 90.1 references and tips for performing the check in the Review Checks section of the Manual as necessary.
- For checks that involve verifying simulation reports, use the names of the reports listed for each check to locate the annotated reports in the Simulation Reports section of the Manual.

Step 5: Communicate review outcome to the Permit Applicant

Provide written comments to the applicant if corrective actions are required or approve the submittal. The comments may be communicated by returning the **Compliance Form** with the filled-out Quality Control Checks tab to the applicant.

5. Review Methodology

General Concept of Standard 90.1 Section 11 and Appendix G Compliance

The performance path allows projects to not meet some of the prescriptive requirements and make up for the associated energy penalty by improving over mandatory and prescriptive provisions in other areas. For example, projects with high window to wall ratio may demonstrate compliance by showing that the energy penalty associated with the high thermal loads is offset by savings from an efficient

HVAC system and daylighting. The required analysis involves developing two whole building energy simulation models. The first model establishes the point of reference and is referred to as budget (90.1 Section 11) or baseline (90.1 Appendix G) building design. The second model represents the building design based on the design documents. The compliance outcome is established by comparing the simulated annual energy cost of the two models. This general concept is illustrated in Figure 4.

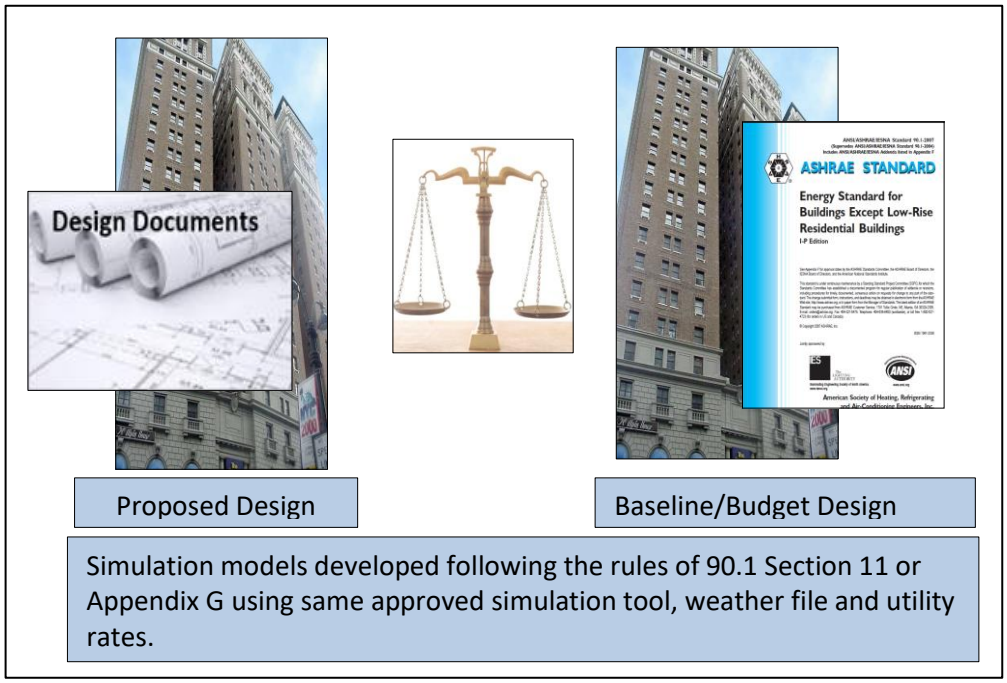


Figure 4: General Concept of 90.1 Section 11 and Appendix G

Types of the Review Checks

The review checks described in this manual have the following focus areas:

1. **General requirements of 90.1 Section 11 and Appendix G**
   - Examples include verifying that an approved simulation tool and weather file was used.
2. **Specified systems and components reported in the Compliance Form reflect design documents**
   - Examples include verifying that the rated wattage of lighting fixture and the number of lighting fixtures specified in various spaces reported in the Compliance Form are consistent with the lighting plans and schedules; that the reported HVAC system types, capacities and efficiencies reflects design documents, etc.
3. **Specified systems and components meet the mandatory requirements in 90.1 Sections 5 - 10.**
   - Examples include verifying that the specified lighting controls meet mandatory requirements in Section 9; that efficiency of the specified HVAC systems meet or exceed minimums provided in Section 6, etc.
   - The applicable mandatory requirements for many systems and components are listed in the Compliance Form. Compliance with these requirements is automatically verified by these QC checks

4. **Budget/baseline systems and components reported in the Compliance Form reflect requirements of 90.1 Section 11 or Appendix G**
    - Examples include verifying that the lighting power density, HVAC system types, thermal and solar properties of the envelope reported in the Compliance Form for the budget/baseline design are established correctly.
    - In many cases, the relevant parameters are automatically populated in the Compliance Form by applying the rules of Section 11 or Appendix G to the reported "triggers". For example, project climate zone is one of the triggers that determine the auto populated U-values of the baseline exterior walls. The key triggers are typically listed in the check description.
    - The auto-populated budget/baseline parameters may be accepted without further review once the triggers are verified and if the auto-populated values are not over-written.
    - Some defaults may be over-written, for example when 90.1 rules have exceptions that are not automated in the Compliance Form. The over-written defaults are shown in brown font in the Compliance Form and may require additional verification.
5. **Simulation inputs reflect systems and components reported in the Compliance Form**
    - Examples include verifying that lighting power density or mechanical system type, capacity and efficiency is modeled as reported in the Compliance Form. E.g., if the Compliance Form indicates that the baseline exterior lighting power is 1,700 W, the check would confirm that it matches the exterior lighting input in the simulation tool.
    - Such checks apply to both the baseline/budget and proposed design models.
6. **Simulation outputs are consistent with systems and components reported in the Compliance Form**
    - Baseline/budget and proposed design models include numerous inputs in addition to those reported in the Compliance Form. These undisclosed inputs, as well as modeling mistakes, may have a significant impact on the compliance outcome. Confirming a reasonable correlation between inputs and outputs is an effective way of identifying potential issues. For example, if air leakage through the envelope is reported to be the same in the baseline and proposed design, an output report may be used to verify that infiltration heating and cooling loads are the same in the baseline (budget) and proposed models.
    - Some of these checks are automated in the Compliance Form. For example, since both non-coincident interior lighting peak demand and the rated lighting fixture wattage are reported, projects with non-coincident peak demand exceeding the rated lighting wattage are clearly erroneous. Similarly, projects with no electric space heating systems reported in the Compliance Form but with electricity used for space heating based on the simulation reports are automatically flagged.
7. **Simulation outputs are consistent with the selected benchmarks**
    - The check may be applied at the whole building level, for example to confirm that the modeled energy use intensity (EUI) of the budget design is similar to typical EUI for buildings of similar type in the same climate zone minimally compliant with the given edition of 90.1. A similar approach may be used to verify EUI of individual end uses such as lighting or space heating.

- The benchmarks for the budget/baseline and proposed designs are selected in Table 4 of the Energy Performance Summary tab of the Compliance Form. The default benchmarks are set based on DOE/PNNL prototype models[9] (the prototype models) as described below.
  a. Proposed design documenting minimum code compliance: the prototype model of the appropriate building type and climate zone, compliant with the same edition of 90.1.
  b. Proposed design documenting performance above code: the prototype model of the appropriate building type and climate zone, compliant with 90.1 2019.
  c. Section 11 budget design: the prototype model of the appropriate building type and climate zone, compliant with the same edition of 90.1.
  d. Appendix G baseline: the prototype model of the appropriate building type and climate zone, compliant with 90.1 2004.
  e. For mixed use buildings, the benchmark energy use is calculated as an area-weighted average.

  The configuration and key operating assumptions of the prototype models are summarized in Appendix D of this Manual.

- The default limits by which the modeled EUIs can deviate from the benchmark EUIs before a flag is triggered for the corresponding review check on the Quality Control Checks tab are included in Table 6 of the Performance Summary tab from the proposed design, and in Table 7 for the baseline/budget design and may be customized.

Identifying the Impactful Aspects of the Submittal

This section provides tips for identifying systems and components, and the related modeling inputs, that have a significant impact on the compliance outcomes and that should be targeted in the reviews. The impactful building systems and components may be established using a three-step process described below.

Step 1: Identify the impactful end uses

End uses that fall into the top tier based on either of the following criteria should be considered impactful.

a. Contribution toward the difference in energy use between the baseline/budget and proposed design.
   For example, lighting end use should be considered impactful for both the baseline and proposed design if reduction in lighting energy use of the proposed design relative to the baseline is one of the top three contributors toward the total reported savings. (In this example, the top tier is defined as top three end uses.)

b. Contribution toward the total energy use of the proposed design, except when the trade-offs for the end use are not allowed.

c. The relative contribution toward the total energy use of the budget/baseline design, except when the trade-offs for the end use are not allowed.

[9] https://www.energycodes.gov/development/commercial/prototype_models

Criteria (b) and (c) are important because there are typically multiple differences between the systems and components of the budget/baseline versus proposed design that affecting a given end use. Some of the difference may result in energy savings while others in energy penalty. For example, proposed design may have less efficient envelope, but more efficient heating system compared to the budget/baseline, resulting in a similar heating energy use in the budget/baseline and proposed design. In such scenarios, criteria (a) may not be triggered by criteria (b) and (c) would apply if heating end use is a significant contributor toward energy use of the budget/baseline or proposed design. This will ensure that the trade-offs between envelope and heating are evaluated as part of the review.

Criteria (b) and (c) are not applicable to end uses for which no trade-offs are allowed, such as miscellaneous equipment for projects following 90.1 Section 11 or documenting the minimum compliance following 90.1 Appendix G, or exterior lighting for projects following Section 11.

Tables 2-4 of the Energy Performance Summary tab of the **Compliance Form** rank the end uses based on these criteria using simulation results reported in the Compliance Calculations tab (Figure 5). The ranking may be different depending on units used to express simulation results. Since 90.1 Section 11 and Appendix G compliance is based on energy cost, the impactful end uses should also be determined on the cost basis. Alternative units may be used when required by AHJ or rating authority.

Table 2: Enduses with the Highest Contribution Towards the Total Energy Use of the Proposed Design

Rank	Site Energy	Source Energy	Energy Cost	GHG Emissions
#1	Space heating (42%)	Misc equipment (27%)	Misc equipment (29%)	Space heating (34%)
#2	Service water heating (17%)	Space heating (25%)	Space heating (22%)	Misc equipment (22%)
#3	Misc equipment (17%)	Space cooling (12%)	Space cooling (13%)	Service water heating (14%)
#4	Space cooling (7%)	Fans - interior ventilation (11%)	Fans - interior ventilation (12%)	Space cooling (10%)
#5	Fans - interior ventilation (7%)	Interior lighting (11%)	Interior lighting (12%)	Fans - interior ventilation (9%)

Table 3: Enduses with the Highest Contribution Towards the Total Energy Use of the Baseline Design

Rank	Site Energy	Source Energy	Energy Cost	GHG Emissions
#1	Space heating (36%)	Interior lighting (21%)	Interior lighting (24%)	Space heating (29%)
#2	Service water heating (17%)	Space heating (20%)	Misc equipment (20%)	Interior lighting (18%)
#3	Interior lighting (14%)	Misc equipment (18%)	Space cooling (17%)	Misc equipment (15%)
#4	Misc equipment (12%)	Space cooling (16%)	Fans - interior ventilation (16%)	Service water heating (13%)
#5	Space cooling (10%)	Fans - interior ventilation (14%)	Space heating (15%)	Space cooling (13%)

Table 4: Enduses with the Highest Contribution Towards Savings of the Proposed Design vs. Baseline Design

Rank	Site Energy	Source Energy	Energy Cost	GHG Emissions
#1	Interior lighting (30%)	Interior lighting (40%)	Interior lighting (38%)	Interior lighting (35%)
#2	Space heating (25%)	Space cooling (22%)	Space cooling (23%)	Space cooling (19%)
#3	Space cooling (17%)	Fans - interior ventilation (20%)	Fans - interior ventilation (20%)	Space heating (18%)
#4	Service water heating (15%)	Space heating (12%)	Misc equipment (9%)	Fans - interior ventilation (17%)
#5	Fans - interior ventilation (15%)	Service water heating (8%)	Space heating (7%)	Service water heating (11%)

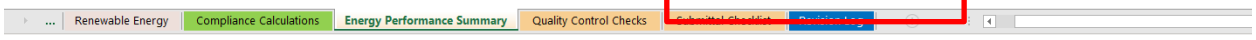


Figure 5: Ranking of the Impactful End Uses in the Energy Performance Summary tab of the Compliance Form.

Step 2: Identify the impactful systems and components

Systems and components associated with the impactful end uses are shown in Table 1 and should be considered impactful.

Step 3: Identify the performance characteristics and operating conditions that drive the modeled energy use of the impactful systems and components.

The performance characteristics and operating conditions that drive the modeled energy use of the impactful systems and components are shown in Table 1.

Table 1 Impactful Systems and Components to be Reviewed

Lighting End Use	
Performance Characteristics	**Operating Conditions**
i. Wattage of the lighting fixtures which account for at least 10% of the lighting power based on the fixture wattage and quantity. ii. Lighting controls in a representative sample of spaces.	i. Lighting runtime hours in a representative sample of spaces.
Service Water-heating End Use	
Performance Characteristics	**Operating Conditions**
i. Type, capacity and efficiency at full and part load of the service water heaters that account for 25% or more of the total specified or installed capacity.	i. Volume of hot water consumed. ii. Supply hot water temperature.
Space Heating End Use	
Performance Characteristics	**Operating Conditions**
i. Type, capacity and efficiency at full and part load of the space heating systems accounting for 25% or more of the total specified or installed capacity. Where there are multiple systems of the same type, the combined capacity of all systems of that type shall be compared to the 25% threshold. ii. In envelope-dominated building types including multifamily, hotels/motels, dormitories and schools: - For each opaque surface type[10]: U-factors and area of assemblies accounting for 25% or more of the total opaque surface area of this type - For fenestration: window to wall ratio; U-factor and area of assemblies accounting for 25% or more of the total fenestration area - Infiltration rate iii. Mechanical ventilation rate iv. Exhaust air energy recovery including recovery effectiveness and bypass control v. HVAC system controls	i. Hourly heating thermostat setpoints ii. HVAC control setting iii. Mechanical ventilation schedule
Space Cooling and Heat Rejection End Use	
Performance Characteristics	**Operating Conditions**
i. Type, capacity and efficiency at full and part load of the space cooling systems accounting for 25% or more of the total specified or installed capacity. Where there are multiple systems of the same type, the combined capacity of all systems of that type shall be compared to the 25% threshold. ii. Fenestration SHGC. iii. Infiltration rate in the envelope-dominated occupancies including multifamily, hotels/motels, dormitories and schools. iv. Mechanical ventilation rates.	i. Hourly cooling thermostat setpoints ii. HVAC control setting iii. Mechanical ventilation schedule

[10] Exterior wall, roof, exposed floor, interior surfaces adjacent to unconditioned spaces, etc.

v. Exhaust air energy recovery including recovery effectiveness and bypass control vi. Economizer operation. vii. HVAC system control.	
Fan End Use	
Performance Characteristics	**Operating Conditions**
i. Type, rated flow CFM, BHP, flow control method, minimum specified flow fraction, fan and motor efficiency at full and part load for fans serving air-side systems identified as impactful. ii. Mechanical ventilation rate and schedule relevant to the identified fans. iii. HVAC system controls relevant to the identified fans.	i. Fan full load hours ii. The hourly ratio of actual flow to design flow
Other HVAC Equipment (e.g. Pumps) End Use	
Performance Characteristics	**Operating Conditions**
i. Type, rated flow GPM, BHP, flow control method, minimum specified flow fraction, pump and motor efficiency at full and part load for pumps serving heating or cooling loops associated with the systems identified as impactful. ii. HVAC system controls relevant to the identified pumps	i. Pump full load hours ii. The hourly ratio of actual flow to design flow
Other End Uses	
Performance Characteristics	**Operating Conditions**
i. Peak and daily average kW load for systems and equipment that combined account for at least 75% of the rated design kW of all equipment associated with this end use. Examples include but not limited to refrigeration equipment and elevators.	i. Equipment full load hours

Establishing Review Scope

The goal of the review is to identify whether any specified systems or components must be changed in order for the design to comply with ASHRAE Standard 90.1 Section 11 or Appendix G. Both compliance options require designs to meet the applicable mandatory provisions of the Standard; thus, any identified issues with the mandatory requirements will necessitate changes to the design.

Since 90.1 Section 11 and Appendix G allow performance trade-offs between systems and components (with the exception of falling below the mandatory provisions), identifying issues pertaining to the impactful systems are likely to affect compliance outcome and necessitate changes to the design. On the other hand, uncovering issues with systems that have relatively low impact on the modeled energy cost of baseline/budget and proposed design may result in updates to the models and/or information reported in the Compliance Form without any changes to the design documents. (It is important to stress that some of the systems and components that fall into low impact category for the purpose of 90.1 compliance modeling may have high impact on building lifecycle cost and occupant comfort.) Table 2 illustrates the recommended review prioritization logic based on these considerations.

Table 2: Review Check Prioritization Strategies

Type of Review Checks (see Types of Review Checks section)	PROPOSED DESIGN	BASELINE/BUDGET DESIGN
General requirements of 90.1 Section 11/App G	Always	
Specified systems reported in the Compliance Form reflect design document	Always, based on sampling	NA
Specified systems meet mandatory requirements	Always, based on sampling	NA
Budget/baseline systems reported in the Compliance Form meet 90.1 Section 11/Appendix G	NA	Only for impactful systems, based on sampling
Simulation inputs reflect systems and components reported in the Compliance Form	Only for impactful systems based on sampling IF passes #2	Only for impactful systems based on sampling IF passes #4
Simulation outputs are consistent with systems and components reported in the Compliance Form	Only for impactful systems, based on sampling IF passes #2	Only for impactful systems, based on sampling IF passes #4
Modeled end uses are consistent with benchmark	Always (Note 1)	Always (Note 1)

Note 1: Consistency with the benchmark is always checked for the total site energy use intensity (EUI) and the following end uses: interior lighting, miscellaneous and process equipment, space heating, space cooling, ventilation fans, heat rejections, service water heating and elevators.

The Review Checks section of the Manual includes sub-sections dedicated to the key building systems (e.g., interior lighting, building envelope, etc.). Each subsection starts with an introduction that includes a table listing the available checks based on their type, as defined in the first column of Table 2, and component being addressed (e.g., lighting wattage, lighting controls, etc.) These introductory sections also include the sampling recommendations. For example, verification that the specified lighting fixture wattage reported in the compliance form reflects design document should focus on fixtures that account for the largest share of the specified wattage and spot-checking other fixtures.

6. Review Checks

Nomenclature

The review checks included in this section are organized into the following groups:

Simulation General (SG) checks verify compliance with the general simulation requirements such as that an approved simulation program was used to model baseline/budget and proposed design, that project's climate zone was established correctly, that simulation results used to establish compliance outcome reflect submitted simulation reports, and that the number of unmet load hours does not exceed the specified limit. In addition, SG checks verify that the total simulated energy use intensity and energy intensities of individual end uses including lighting, miscellaneous loads, heating, cooling, fans, pumps, heat rejection and service water heating are consistent with the selected benchmarks.

Utility Rates (UR) checks verify that energy cost is established using utility rates from an approved source and are properly modeled.

Building Envelope (BE) checks verify that the envelope geometry, thermal and solar properties are established and modeled correctly.

Lighting, Interior (LI) and Lighting, Exterior (LE) checks verify that the interior and exterior lighting power and controls are properly established and modeled.

Plug, Process and Other Loads (PPO) checks verify that the miscellaneous unregulated loads, industrial process, elevators, regulated refrigeration, motors and combined heat and power systems are properly established and modeled.

Service Water Heating (SWH) checks verify that service water heating equipment type, efficiency and controls, that the related auxiliary equipment and hot water demand were established and modeled correctly.

Air-side HVAC Systems (AHVAC) and Water-side HVAC Systems (WHVAC) checks verify heating, cooling and ventilation system type, capacity, efficiency and controls, and parameters of the related auxiliary components such as fans, pumps and heat rejection equipment were established correctly and properly modeled.

Renewable Energy (RE) checks cover renewable electricity and thermal energy generation systems such as photovoltaic (PV) systems. Exceptional Calculations (EC) checks address calculations that were completed outside of the simulation tool. The checks are only relevant to projects involving renewable systems or exceptional calculations, respectively.

In addition, checks are designated as applying to the Baseline/Budget Design or Proposed Design.

> **Budget/Baseline Design (B)** checks confirm that the baseline (budget) design described in the submittal reflects the requirements of the selected compliance path and is modeled as reported.
>
> **Proposed Design (P)** checks verify that the parameters of the proposed design reported in the Compliance Form match design documents, comply with applicable 90.1 mandatory requirements, and are appropriately modeled.

Each check has CheckID expressed using this nomenclature. For example, BE08-P is check #8 related to building envelope (BE) for the proposed design (P).

Sections below list the checks included in each check group. The following information is provided for each check:

- Summary of the relevant 90.1 requirements
- Review tips including location of the relevant information in the Compliance Form, steps for completing the check, sampling recommendations for checks that apply to multiple similar systems and components (e.g. HVAC systems), and common mistakes.

- For review checks that involve verifying simulation inputs or outputs, list of the relevant simulation reports of commonly used BEM. The annotated reports are included in the Simulation Reports section of this Manual.

Simulation General (SG)

Overview of Simulation General Checks

Simulation General checks help gauge the general quality of the submittal, such as whether the approved simulation tool and weather file were used, modeled floor area reflects design documents, and simulation results reported in the compliance form reflect simulation output reports.

In addition, there are checks that compare modeled energy use of the baseline/budget and proposed design to the selected benchmarks to verify that the simulation results are reasonable. The relevant information is shown on the Energy Performance Summary tab of the Compliance Form in both the tabular and graphical format (Figure 6). Significant deviations between the modeled energy use intensities of the baseline/budget and proposed design and the benchmark should be flagged, as discussed in the specific checks described below.

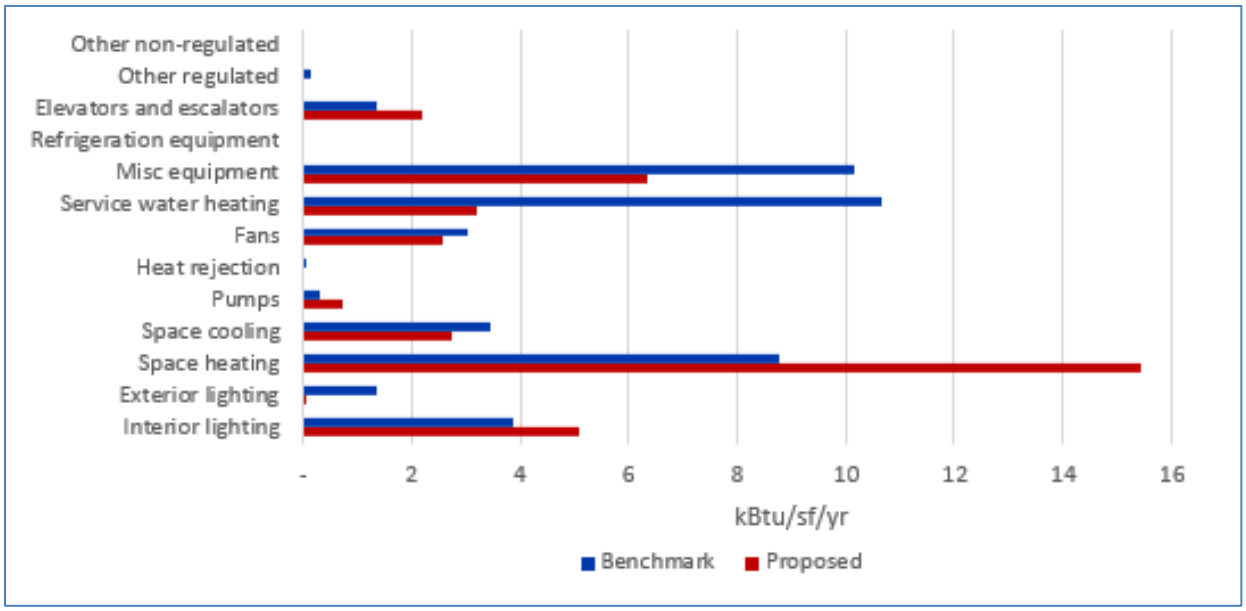


Figure 6: Energy Performance Summary tab of the Compliance Form, Benchmark Comparison

Of especial concern are the instances when the baseline/budget EUI is significantly higher than the benchmark or proposed EUI is significantly lower than the benchmark as it may result in overly optimistic compliance outcome.

However, the differences may be justified by different operating conditions (e.g. longer daily operating hours) between the project and the benchmark and the building use (e.g. school project that has a swimming pool versus school benchmark with no swimming pool). The configurations of the benchmarks are summarized in Appendix D of this Manual. In addition, high difference may be

acceptable for end uses that account for a small percentage of energy use in both benchmark and completed models, such as heating energy use in Miami or cooling energy use in Alaska.

Table 4 summarizes the checks included in the Simulation General section.

Table 4: Simulation General (SG) Checks Overview

Focus of the Check	Type of Check	Proposed Design	Baseline/ Budget Design
Simulation Tools	General requirements of 11/G	SG01	SG01
Climate Zone	General requirements of 11/G	SG02	SG02
Weather File	General requirements of 11/G	SG03	SG03
Floor area	CF inputs reflect design documents	SG04	NA
	Simulation inputs consistent with CF	SG05	SG05
Number of hours per year explicitly modeled	Simulation inputs consistent with CF	SG06	SG06
Unmet load hours	CF inputs reflect requirements of 11/G	SG07	SG07
	Simulation outputs consistent with CF	SG08	SG08
Energy Use	Simulation outputs consistent with CF	SG09-P	SG09-B
Total EUI	Simulation outputs consistent with benchmark	SG10-P	SG10-B
Interior Lighting EUI	Simulation outputs consistent with benchmark	SG11-P	SG11-B
Miscellaneous and Process EUI	Simulation outputs consistent with benchmark	SG12-P	SG12-B
Space Heating EUI	Simulation outputs consistent with benchmark	SG13-P	SG13-B
Space Cooling EUI	Simulation outputs consistent with benchmark	SG14-P	SG14-B
Ventilation Fans EUI	Simulation outputs consistent with benchmark	SG15-P	SG15-B
HVAC Pumps EUI	Simulation outputs consistent with benchmark	SG16-P	SG16-B
Heat Rejection EUI	Simulation outputs consistent with benchmark	SG17-P	SG17-B
Service Water Heating EUI	Simulation outputs consistent with benchmark	SG18-P	SG18-B
Elevator EUI	Simulation outputs consistent with benchmark	SG19-P	SG19-B
Compliance Calculations	CF inputs reflect requirements of 11/G	SG20	SG20
LEGEND			
PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form			

SG01 The same approved simulation program used for the baseline/budget and proposed design models

90.1 2016/2019 Section 11

Section 11.4.1 The *simulation program* must be approved by the *adopting authority* and have the following capabilities:

- explicitly support simulation method, systems and components listed in Section 11.4.1.1, such as hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays; thermal mass effects; ten or more thermal zones; part-load performance curves for mechanical

equipment; capacity and efficiency correction curves for mechanical heating and mechanical cooling equipment.; air-side economizer and fluid economizer with integrated control; and the budget building design characteristics specified in Section 11.4.5.

- either directly determine the design energy cost and energy cost budget or produce hourly reports of energy use by energy source suitable for determining the design energy cost and energy cost budget using a separate calculation engine (11.4.1.2)
- perform design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with Section 6.4.2 for both the proposed design and the budget building design.

In addition, the simulation program must be tested according to ASHRAE Standard 140, except for Sections 7 and 8, and the results must be furnished by the software provider (Section 11.4.1.4). In 90.1 2019, the relevant reporting requirements were expanded and clarified as follows:

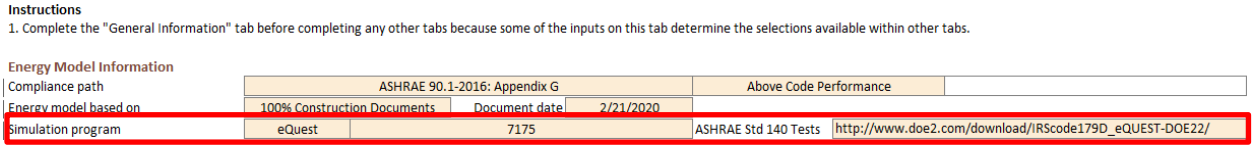
- The test results and modeler reports must be posted on a publicly available website and include the test results of the simulation program along with the results of the other simulation programs included in ASHRAE Standard 140, Annexes B8 and B16.
- The modeler report in Standard 140, Annex A2, Attachment A2.7 must be completed for results exceeding the maximum or falling below the minimum of the reference values or for missing results.

90.1 2016/2019 Appendix G

Section G2.2.1 has requirements similar to Section 11.4.1 summarized above.

Review Tips

1. Simulation tool name and version is reported in the Energy Model Information section on the General Information tab of the Compliance Form.



Instructions

1. Complete the "General Information" tab before completing any other tabs because some of the inputs on this tab determine the selections available within other tabs.

Energy Model Information

Compliance path	ASHRAE 90.1-2016: Appendix G			Above Code Performance	
Energy model based on	100% Construction Documents	Document date	2/21/2020		
Simulation program	eQuest	7175		ASHRAE Std 140 Tests	http://www.doe2.com/download/IRScode179D_eQUEST-DOE22/

2. If AHJ/RA has the list of simulation programs, verify that the simulation program used for the project is on the list.
3. If AHJ/RA does not have the list of simulation programs, verify that the simulation program meets the relevant requirements of 90.1 summarized above. While there is currently no national mechanism for certifying simulation programs as compliant with 90.1, the following tools (alphabetically) are often accepted: DesignBuilder, EnergyPlus, eQUEST, HAP, IESVE, OpenStudio, Trace3DPlus, Trace 700. Individual AHJ/RA may allow only some of these programs, a subset of versions for each program, or simulation programs not listed above.
4. If it is determined that simulation program used on the project is not approved, it is recommended that the issue is resolved before proceeding with other checks described in the manual. Alternatively, only the checks that do not involve verifying simulation inputs or outputs should be completed.

SG02 Project climate zone reported in the Compliance Form is established correctly

90.1 2016/2019 Section 11 and Appendix G

Section 5.1.4: Use ASHRAE Standard 169, Table B-1, "U.S. Climate Zones by State and County," Table A-5, "Canada Stations and Climate Zones," and Table A-6, "International Stations and Climate Zones," to determine the assigned climate zone and, where required, the assigned climate zone letter. If there are recorded historical climatic data available for a construction site, they may be used to determine compliance if approved by the building official. The information is also included in 90.1 Annex 1 contains the relevant abstracts from ASHRAE Standard 169.

Review Tips

1. Project address is listed in the Project Information section of the Contact Information tab of the Compliance Form. Use the reported zip code to determine the county. confir

Project Information			
Project # or ID	123456	Submission date	6/12/2020
Project name	The Woods on Main Street		
Project address	123 Main Street		
Project City	Bedford Falls	State	New York
Zip code	12345		

2. Refer to 90.1 Annex 1 to confirm that the climate zone listed on the General Information tab, Energy Model Information section is established correctly based on the state and county where project is located.

Energy Model Information			
Compliance path	ASHRAE 90.1-2016: Appendix G		
Energy model based on	100% Construction Documents	Document date	2/21/2020
Simulation program	eQuest	7175	
Simulation weather station	Central Park		
Type of weather data	TMY3		
Name of simulation weather file	NY_New_York_Central_Prk_O.bin		
Climate zone	4A		

SG03 The same approved weather file used in the baseline/budget and proposed simulation

90.1 2016/2019 Section 11

Section 11.4.2: The simulation must be performed using hourly values of climatic data, such as temperature and humidity from representative climatic data, for the city in which the proposed design is to be located. For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer must select available weather data that best represent the climate at the construction site.

Section 11.4.4: The same weather file must be used for the budget (baseline) and proposed design simulations.

90.1 2016/2019 Appendix G

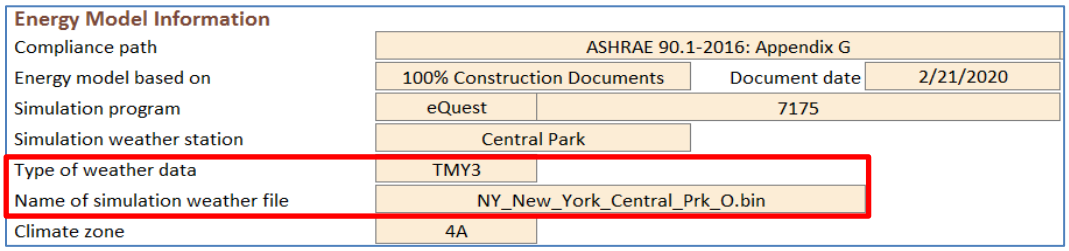
G2.2.1: The simulation must be performed using hourly values of climatic data, such as temperature and humidity from representative climatic data, for the city in which the proposed design is to be located.

For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer must select available weather data that best represent the climate at the construction site.

G2.1: The same weather file must be used for the budget (baseline) and proposed design simulations.

Review Tips

1. Weather file used in the simulation is reported in the General Information tab of the compliance Form.



Energy Model Information			
Compliance path	ASHRAE 90.1-2016: Appendix G		
Energy model based on	100% Construction Documents	Document date	2/21/2020
Simulation program	eQuest	7175	
Simulation weather station	Central Park		
Type of weather data	TMY3		
Name of simulation weather file	NY_New_York_Central_Prk_O.bin		
Climate zone	4A		

2. If AHJ/RA has pre-approved weather files that must be used for specific project locations, confirm that the approved weather files is listed in the Compliance Form and in the model
3. If AHJ/RA doesn't have pre-approved weather files, as a general rule projects should use weather file for the Typical Meteorological Year (TMY) station closest to the project site. In areas with large elevation changes or micro climates, the closest station may be at a significantly different elevation and therefore have different weather or psychrometric characteristics, or may be in a different microclimate. In such cases, a weather station at similar elevation and latitude or similar microclimate may be a better fit.
4. Once the weather station is determined, TMY2[11] and TMY3[12] data files for the selected station should be used (for projects located in the United States). TMY3 data reflects more recent weather patterns than TMY2 data. Alternative weather data sources, such as those accounting for expected climate change, may be allowed with sufficient supporting documentation.
5. The same weather file must be used for the budget/baseline and proposed design simulations.

eQUEST	BEPS and at the top of other reports
Trane TRACE 700	Title Page report (the same weather file will always be used for both alternatives)
Trane TRACE 3D Plus	Climatic Summary report
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'Top' sectionEnergyPlus HTML output file > Input Verification and Results Summary report > General table > "Weather File"
OpenStudio	eplustbl.html 'Top' section; EnergyPlus HTML output file > Input Verification and Results Summary report > General table > "Weather File"
Carrier HAP v5	Simulation Weather Summary Report *(The same simulation weather file will always be used for both Proposed and Baseline in the same project. It is not*

[11] http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/tmy2/State.html

[12] http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html

	possible to use different simulation weather data for Proposed and Baseline in a single project)
Design Builder	EnergyPlus Output Summary Document

SG04 The reported project floor area is consistent with the design documents.

90.1 2016/2019 Section 11

Table 11.5.1 Column A, #1a: The simulation model of the proposed design must be consistent with the design documents thus the modeled project area is expected to be as designed.

90.1 2016/2019 Appendix G

Table G3.1 Proposed Building Performance column #1a: The simulation model of the proposed design must be consistent with the design documents thus the modeled project area is expected to be as designed.

Review Tips

1. Project floor area is reported in Table 1 of the General Information tab.

Building Area Type(s)	Conditioned Floor Area, ft²		Semi-Heated and Unconditioned Floor Area, ft²		Spaces not Enclosed, ft²		
	New Construction	Renovation	New Construction	Renovation	New Construction	Renovation	Total, ft²
Multifamily	84,365						84,365
Retail	24,750						24,750
Sub-total	109,115	-	-	-	-	-	-
Total	109,115		-		-		109,115

SG05 The modeled floor area is as reported in the Compliance Form and the same between budget/baseline and proposed design

90.1 2016/2019 Section 11

Table 11.5.1 Column B, #1a: The baseline building design shall be modeled with the same number of floors and floor area as the proposed design.

90.1 2016/2019 Appendix G

Table G3.1 Baseline Building Performance column #1: The baseline building design shall be modeled with the same number of floors and floor area as the proposed design.

Review Tips

1. Use simulation reports listed below to confirm that the modeled project floor area is as reported in the Compliance Form and the same in the baseline/budget and proposed design. Project floor area is reported in Table 1 of the General Information tab.
2. Small deviations between the modeled area and the area specified in the design documents are common and may be acceptable. Below are some common reasons for the mismatch.
   a. Gross floor area reported in the design documents is based on the definition in the 2015 IBC [6], which differs from the 90.1 – 2016 definition (both are quoted below). ECB and PRM do not specify how building area should be inputted into the model, e.g. whether it should be based on the inside perimeter of the exterior walls (based on the IBC definition), or the outside perimeter of the exterior walls (90.1 definition), so it may be modeled either way.

Floor Area, Gross (IBC). The floor area within the inside perimeter of the exterior walls of the building under consideration; exclusive of vent shafts and courts, without deductions for corridors, stairways, ramps, closets, the thickness of interior walls, columns or other features. The floor area of a building, or portion thereof, not provided with surrounding exterior walls shall be the usable area under the horizontal projection of the roof of floor above. The gross floor area shall not include shafts with no openings or interior courts.

Floor Area, Gross (90.1): the sum of the floor areas of the spaces within the building, including basements, mezzanine and intermediate-floored tiers and penthouses with a headroom height of 7.5 ft or greater. It is measured from the exterior faces of walls or from the centerline of walls separating buildings, but excludes covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features.

b. 90.1 distinguishes between the enclosed spaces, which include directly or indirectly conditioned, semi-heated, or unconditioned spaces and un-enclosed spaces, such as crawlspaces, attics and parking garages with natural or mechanical ventilation (see 90.1 definition of unconditioned space). Un-enclosed spaces may be modeled with ambient conditions, thus not contributing to the modeled floor area.

c. Multilevel spaces such as stairwells may be modeled as an open shaft (i.e. modeled area = area of the footprint), or as multiple floors (modeled area = area of the footprint times the number of floors the space spans).

d. To ensure a fair comparison between the floor areas shown in the simulation reports and the design documents, it's important to understand how the floor area is reported by the simulation tool. For example, certain simulation reports may show conditioned floor area, others the gross floor area including unconditioned spaces and plenums, etc.

+/- 5% difference between the modeled floor area of heated and cooled spaces and the area of the corresponding spaces listed in the design documents may be acceptable. Higher deviations may be permitted with an appropriate explanation.

eQUEST Reports	Conditioned area: LS-C, CSV Space Loads Report
Trane TRACE 700	LEED Summary Section 1.2
Trane TRACE 3D Plus	LEED Summary Section 1.2
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Annual Building Utility Performance Summary' report
OpenStudio	eplustbl.html 'Annual Building Utility Performance Summary' report
Carrier HAP v5	"LEED Summary" report, Section 1 "Report and Project Information", table titled "Space Summary"
Design Builder	LEED Summary Reports in EnergyPlus output summary document

SG06 The correct number of hours per year was explicitly modeled

90.1 2016 Section 11

11.4.1.1 At least 1,400 hours per year representing the full range of conditions must be explicitly simulated; the same number of hours must be explicitly simulated for the budget and proposed design.

90.1 2019 Section 11

11.4.1.1 8,760 hours (full year) must be explicitly simulated.

90.1 2016/2019 Appendix G

G2.2.1: 8,760 hours (full year) must be explicitly simulated.

Review Tips

1. Refer to the simulation reports listed below to confirm that the simulation timestep was as required and the same for both the baseline/budget and proposed design models.

eQUEST Reports	8,760 simulated by default; CSV Hourly Results, LS-F and other monthly reports
Trane TRACE 700	Project Information entered values report
Trane TRACE 3D Plus	The program always models 8,760 hours
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Annual Building Utility Performance Summary' report; EnergyPlus HTML output file > Input Verification and Results Summary report > General table > "Hours Simulated"
OpenStudio	eplustbl.html 'Annual Building Utility Performance Summary' report; EnergyPlus HTML output file > Input Verification and Results Summary report > General table > "Hours Simulated"
Carrier HAP v5	8760 hours simulated by default. There is no way to simulate fewer hours. To provide proof you can graph simulation results or export hourly simulation results to CSV and demonstrate in Excel.
Design Builder	Output Summary Document

SG07 The number of unmet load hours reported in the Compliance Form does not exceed the prescribed limits.

90.1 2016/2019 Section 11

Section 3: Unmet load hour is an hour in which one or more zones is outside of the thermostat set point plus or minus one half of the temperature control throttling range. Any hour with one or more zones with an unmet cooling load or unmet heating load is defined as an unmet load hour.

11.5.2 i: Unmet load hours for the proposed design or baseline designs shall not exceed 300 hours. In addition, the UMLHs for the proposed design shall not exceed the unmet load hours for the budget building design. Unmet load hours exceeding these limits may be accepted if sufficient justification is given that the accuracy of the simulation is not significantly compromised by these unmet loads. See Section 3 above for the definition of unmet load hour.

90.1 2016/2019 Appendix G

G3.1.2.3: Unmet load hours for the proposed design or baseline building design shall not exceed 300 out of the 8,760 hours simulated. Unmet load hours exceeding these limits may be accepted if sufficient justification is given that the accuracy of the simulation is not significantly compromised by these unmet loads. See Section 3 above for the definition of unmet load hour.

Review Tips

1. Unmet load hours (UMLH) are reported in Table 1 on the Compliance Calculations tab of the Compliance Form

Unmet Loads	Proposed Design	Baseline Design
Number of hours heating loads are not met	15	6
Number of hours cooling loads are not met	6	2
Total	21	8
Compliance	Yes	

2. The prescribed limits should be enforced for most projects, because high UMLHs is often due to simulation errors that may have a high impact on the compliance outcome. The higher the UMLHs in the proposed design compared to the baseline (budget) model effectively means that even though the two models have the same thermostat setpoints, the actual space temperatures in the proposed design were lower during the heating season and/or higher during the cooling season. This will reduce energy use of the proposed design, which is not an allowed trade-off. Below are several common reasons for a high UMLH [3].
   a) The thermostat schedules do not align with the schedules associated with HVAC system operation, occupant schedules, miscellaneous equipment schedules, outside air ventilation schedules and other schedules of operation that could affect the HVAC system's ability to meet loads in the thermal block.
   b) The inputs for internal gains, occupants and outside air ventilation are unreasonable and inconsistent with the intended operation of the building.
   c) The simulated operation of the controls associated with primary or secondary heating or cooling equipment (pumps, coils, boilers, etc.) is out of alignment with the heating and cooling requirements of the building.
   d) Inadequate equipment capacity in the proposed design.
   Example: The specified equipment may be intentionally under-sized to achieve higher part load performance, resulting in unmet loads during the extreme conditions. In this case, the modeled thermostat setpoints should be adjusted to ensure that the UMLH in the proposed design are within the required limits. Once such the thermostat schedule is established, it must be modeled the same in the baseline/budget and proposed designs.

3. Example of extenuating circumstances that may be considered include the following:
   a) Number of UMLHs beyond the allowed limit
   Reviewer may judge a submittal with 350 UMLHs (that exceed the 300 limit by 50 hours) to be acceptable, but reject a submittal with 800 UMLHs (that exceed the 300 limit by 500 hours).
   b) Floor area of the thermal blocks where the UMLHs occur
   Reviewer may choose to accept a submittal with high UMLHs in a 100 ft2 thermal block (e.g. a stairwell) but reject a submittal with high UMLHs in the zones that account for a notable fraction (e.g. over 5%) of the overall conditioned floor area.
   c) How far the indoor temperatures drop or rises outside of the acceptable range.

For example, the AHJ may accept a submittal if the actual zone temperatures during an UMLH is one or two degrees outside of the throttling range, but reject submittals with larger discrepancies, for example if during the UMLH the temperature in the thermal block is 60F compared to a 70F heating setpoint.

Reviewer may request additional simulation reports to substantiate the explanations provided by the modeler.

SG08 The number of unmet load hours reported in the Compliance Form reflects simulation results.

Review Tips

1. Review simulation reports listed below to confirm that the number of unmet load hours reported in the compliance form is aligned with the simulation reports.

eQUEST	BEPU, SS-R, SS-O, LS-C, CSV Space Loads Report
Trane TRACE 700	Energy Cost Budget/PRM Summary, LEED Summary Section 1.3
Trane TRACE 3D Plus	LEED Summary report Section 1.3
IESVE SOFTWARE	Unmet Hours Report, PRM Compliance Report, ECB Compliance Report
EnergyPlus	eplustbl.html 'LEED Summary' report, section EAp2-2 Advisory Messages
OpenStudio	eplustbl.html 'LEED Summary' report, section EAp2-2 Advisory Messages
Carrier HAP v5	"LEED Summary" report, Section 2 "Minimum Energy Performance Calculator", table titled "Unmet Loads")
Design Builder	LEED Minimum Energy Performance Calculator, LEED Summary report

SG09-B, SG09-P Energy use reported in the Compliance Form matches simulation reports

Review Tips

PRM and ECB compliance is established based on the simulation outputs for the baseline (budget) and proposed design. A Compliance Form allows modelers to copy results from the standard simulation output reports generated by the supported modeling tools into the designated areas to auto-populate the template with the simulation results, to avoid mistakes from manual data transfer. Performing this check should involve the following:

a) Confirm that electricity (kWh) and natural gas (Therm) use for the baseline/budget design reported in the Compliance Calculations tab of the compliance form matches the submitted simulation reports.
b) Confirm that the total baseline/budget design energy cost reported in the Compliance Calculations tab matches the submitted simulation reports.
c) Confirm that electricity (kWh) and natural gas (Therm) use for the proposed design reported in the Compliance Calculations tab matches the submitted simulation reports.
d) Confirm that the total proposed energy cost reported in the Compliance Calculations tab matches the submitted simulation reports.

e) Spot-check electricity and gas use for individual end uses reported in the compliance form versus simulation reports.

eQUEST Reports	ES-D, BEPS
Trane TRACE 700	LEED Summary Section 1.4
Trane TRACE 3D Plus	LEED Summary report
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'LEED Summary' report, section EAp2-7 Energy Cost Summary
OpenStudio	eplustbl.html 'LEED Summary' report, section EAp2-7 Energy Cost Summary
Carrier HAP v5	"LEED Summary" report, Section 2, "Energy Performance Calculator", table titled "Performance Rating Energy Consumption and Cost by Fuel Type – Performance Rating Method Compliance".
Design Builder	LEED Summary Reports in EnergyPlus Output Summary Document

SG10-P Site Energy Use Intensity (EUI) of the proposed design is generally consistent with the selected benchmark

Review Tips

1. The benchmarks are selected in Table 4 of the Energy Performance Summary tab in the Compliance Form. See #6 in the Types of Review Checks section for additional information. Table 6 of the Energy Performance Summary tab shows the modeled EUI versus the EUI of the selected benchmark.
2. Verify the following
    a. If the default benchmark in Table 4 of the Energy Performance Summary tab is overwritten, verify that an appropriate option is selected. (The over-written defaults are shown in brown font.)
    b. If the default values in columns Table 6 of the Energy Performance Summary tab, the "Acceptable Difference Before QC Flag" columns, the "Total" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.)
    c. Question results if the difference between the modeled EUI and the benchmark EUI is outside the acceptable limits. Proposed EUI that is below the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic modeled energy use of the proposed design.
    d. Higher deviations may be justified by project-specific circumstances, for example if project aims to significantly exceed code and participates in a utility incentive program or pursues LEED or passive house certification or have significantly longer operating hours that the benchmark.

SG10-B Site Energy Use Intensity (EUI) of the budget/baseline design is generally consistent with the selected benchmark

Review Tips

1. The benchmarks are selected in Table 4 of the Energy Performance Summary tab in the Compliance Form. See #6 in the Types of Review Checks section for additional information. Table 7 of the Energy Performance Summary tab shows the modeled EUI versus the EUI of the selected benchmark.
2. Verify the following:
    a. If the default benchmark in Table 4 of the Energy Performance Summary tab is overwritten, verify that an appropriate option is selected. (The over-written defaults are shown in brown font.)
    b. If the default values in columns Table 7 of the Energy Performance Summary tab, the "Acceptable Difference Before QC Flag" columns, the "Total" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.)
    c. Question results if the difference between the modeled EUI and the benchmark EUI is outside of the acceptable limits. Baseline/budget EUI that is above the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient baseline/budget energy use.
    d. Higher deviations may be justified by project-specific conditions – for example, if project involves a school building that is occupied year-round compared to a benchmark school occupied only during the school year.

SG11-P Modeled interior lighting energy use of the proposed design is generally consistent with the selected benchmark, with the difference less than set threshold.

Review Tips

1. If the default values in Table 5 of the Energy Performance Summary tab, the "Acceptable Difference Before QC Flag" columns, the "Interior Lighting" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.)
2. Question results if the difference between the modeled interior lighting EUI and the benchmark EUI is outside the limits set in the last two columns of Table 6. See #6 in the Types of Review Checks section for the default values. Proposed EUI that is significantly below the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in optimistic lighting energy use in the proposed design.
3. Common reasons and possible mistakes:
    a. Lighting wattage too high/low
    b. Lighting runtime hours are too high/low
    c. Savings from occupancy sensors and daylighting are too high/low

SG11-B Modeled interior lighting energy use in the baseline/budget design is generally consistent with the selected benchmark, with difference less than set threshold

Review Tips

1. If the default values in columns Table 6 of the Energy Performance Summary tab, the "Acceptable Difference Before QC Flag" columns, the "Interior Lighting" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.)
2. Question results if the difference between the modeled interior lighting EUI and the benchmark EUI is outside the limits set in the last two columns of Table 6. See #6 in the Types of Review Checks

section for the default values. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient baseline/budget design.

3. Common reasons and possible mistakes:
   a. Lighting wattage too high/low
   b. Lighting runtime hours are too high/low
   c. Savings from occupancy sensors and daylighting are too high/low

SG12-B Modeled energy use intensity of the miscellaneous and process loads in the baseline/budget design is generally consistent with the selected benchmark, with the difference less than the set threshold.

Review Tips

1. If the default values in columns Table 6 of the Energy Performance Summary tab, the "Acceptable Difference Before QC Flag" columns, the "Interior Lighting" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.

2. Question results if the difference between the modeled interior lighting EUI and the benchmark EUI is outside the limits set in the last two columns of Table 6. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient baseline/budget design. However, it may be justified by difference in operating conditions (e.g. longer than typical operating hours), or differences in building use. For example, hotels with dining facilities will have higher miscellaneous equipment EUI than hotels without restaurants.

3. Common reasons and possible mistakes:
   a. Unrealistic miscellaneous equipment loads impact HVAC end uses. For example, unrealistically low loads reduce internal heat gains, over-estimating heating energy use and magnifying the impact of any heating-related trade-offs (e.g. savings from high performance heating system in the proposed design). On the other hand, cooling energy use is lower than expected minimizing penalty from cooling-related deficiencies in the proposed design, such as when economizer is not specified.

SG13-P, SG13-B Modeled heating energy use in the proposed and baseline/budget design is generally consistent with the selected benchmark, with the difference less than the set threshold

Review Tips

1. If the default values in Table 6 of the Energy Performance Summary tab (Table 5 for the baseline/budget), the "Acceptable Difference Before QC Flag" columns, the "Space Heating" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.
2. Question results if the difference between the modeled heating EUI and the benchmark EUI is outside the limits set on the Energy Performance Summary tab, except when heating energy use is

low in both the benchmark and the model, such as for projects in the climate zones with the minimal heating. Focus on the following:

a. Proposed EUI that significantly lower than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic heating energy use in the proposed design.
b. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient heating in the baseline/budget design.

3. Common reasons or mistakes that may result in unrealistically high/low heating energy use intensity include the following:
    a. Thermal properties of the envelope are not established or modeled correctly
    b. Infiltration rate is too high/low
    c. Window to wall ratio (WWR) is higher (lower) than typical for the building type
    d. Internal heat gains from lighting, appliances, or plug loads are too low/high
    e. Excessive simultaneous heating/cooling (simulation outputs show high heating use during summer months, leading to high heating EUI)
    f. Modeled ventilation rate is too high/low
    g. Heating efficiency is too low/high
    h. Heating thermostat setpoints are too high/low

SG14-P, SG14-B Modeled cooling energy use in the proposed and baseline/budget design is generally consistent with the selected benchmark, with the difference less than the set threshold

Review Tips

1. If the default values in Table 6 of the Energy Performance Summary tab (Table 5 for the baseline/budget), the “Acceptable Difference Before QC Flag” columns, the “Space Cooling” row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.
4. Question results if the difference between the modeled cooling EUI and the benchmark EUI is outside the limits set on the Energy Performance Summary tab, except when the end use is low in both the benchmark and the model, such as for projects in the climate zones with the minimal heating. Focus on the following:
    a. Proposed EUI that significantly lower than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic cooling energy use in the proposed design.
    b. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient cooling energy use in the baseline/budget design.
2. Common reasons or mistakes that may result in unrealistically high/low cooling energy use intensity:
    a. Fenestration SHGC is too high/low
    b. WWR significantly higher (lower) than typical
    c. Internal heat gains from lighting, appliances, or plug loads are too high/low

d. Excessive simultaneous heating/cooling (simulation outputs show high cooling use during winter months, leading to high cooling EUI)
e. Modeled ventilation rate is too high/low
f. Baseline cooling efficiency is too low/high
g. Modeled heating thermostat setpoints are too low/high
h. Economizer not modeled or modeled incorrectly

SG15-P, SG16-B Modeled HVAC fans energy use in the in the proposed and baseline/budget design is generally consistent with the selected benchmark, with the difference less than the set threshold

Review Tips

1. If the default values in Table 6 of the Energy Performance Summary tab (Table 5 for the baseline/budget), the "Acceptable Difference Before QC Flag" columns, the "Fans" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.
2. Question results if the difference between the modeled fan EUI and the benchmark EUI is outside the limits set on the Energy Performance Summary tab. Focus on the following:
   a. Proposed EUI that significantly lower than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic fan energy use in the proposed design.
   b. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient fan energy use in the baseline/budget design.
3. Common reasons or mistakes that may result in unrealistically high/low fan energy use intensity:
   a. Fans are not modeled explicitly (low EUI)
   b. Fans modeled and reported as process or miscellaneous load (low EUI)
   c. Exhaust or DOAS fans are modeled in addition to the baseline allowance (high baseline EUI)
   d. Project includes parking garage with exhaust fans
   e. Flow controls are not properly modeled (e.g. high EUI if Constant Volume (CV) instead of Variable Air Volume (VAV) control was modeled)
   f. Minimum flow rates on VAV systems are set too high/low

SG16-P, SG17-B Modeled HVAC pumps energy use in the proposed and baseline/budget design is generally consistent with the selected benchmark, with the difference less than the set threshold

Review Tips

4. If the default values in Table 6 of the Energy Performance Summary tab (Table 5 for the baseline/budget), the "Acceptable Difference Before QC Flag" columns, the "Pumps" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.
1. Question results if the difference between the modeled pump EUI and the benchmark EUI exeeds the limits. Focus on the following:

a. Proposed EUI that significantly lower than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic pump energy use in the proposed design.
b. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient pump energy use in the baseline/budget design.

2. This check is optional because the difference in pump energy use between the model and the benchmark is often due to difference in the HVAC system type. For example, the model may include geothermal or water-source heat pump or chilled/hot water system while the benchmark may have heating/cooling provided by DX systems with gas furnaces.
3. Common reasons or mistakes that may result in unrealistically high/low pump energy use intensity:
   a. Hot or chilled water loops are modeled with constant flow (three-way valves) instead of variable flow (two-way valves).
   b. Hot water loop is modeled as operating year-round instead of only during heating season, which is often the case for buildings such as multifamily.

SG17-P, SG18-B Modeled heat rejection energy use in the proposed and baseline/budget design is generally consistent with the selected benchmark, with the difference less than the set threshold

Review Tips

1. If the default values in Table 6 of the Energy Performance Summary tab (Table 5 for the baseline/budget), the "Acceptable Difference Before QC Flag" columns, the "Heat rejection" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.
2. Question results if the difference between the modeled heat rejection EUI and the benchmark EUI exceeds the set limits. Focus on the following:
   a. Proposed EUI that significantly lower than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic heat rejection energy use in the proposed design.
   b. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient heat rejection in the baseline/budget design.
3. This check is optional because the difference in heat rejection energy use between the model and the benchmark is often due to difference in the HVAC system type. For example, the model may include cooling towers while the benchmark may have heating/cooling provided by DX systems with energy associated with heat rejection reported under cooling end use.

SG18-B, SG18-P Modeled service water heating energy use in the baseline/budget and proposed design is generally consistent with the selected benchmark, with the difference less than the set threshold

Review Tips

1. If the default values in Table 6 of the Energy Performance Summary tab (Table 5 for the baseline/budget), the "Acceptable Difference Before QC Flag" columns, the "Service water heating" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.
2. Question results if the difference between the modeled service water heating EUI and the benchmark exceeds the set limits. Focus on the following:
    a. Proposed EUI that significantly lower than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic service water heating energy use in the proposed design.
    b. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient service water heating energy use in the baseline/budget design.
4. Common reasons and mistakes that may result in unrealistically high/low service water heating energy use:
    a. Hot water demand too high/low
    b. Water heater efficiency too low/high

SG19-P, SG19-B Modeled elevator energy use in the baseline/budget and proposed design is generally consistent with the selected benchmark, with the difference less than the set threshold.

Review Tips

1. If the default values in Table 6 of the Energy Performance Summary tab (Table 5 for the baseline/budget), the "Acceptable Difference Before QC Flag" columns, the "Elevators and Escalators" row are overwritten, confirm that the entered values are justified. (The over-written defaults are shown in brown font.) See #6 in the Types of Review Checks section for the default values.
2. Question results if the difference between the modeled elevator EUI and the benchmark EUI is outside the set limits. Focus on the following
    a. Proposed EUI that significantly lower than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly optimistic elevator energy use in the proposed design.
    b. Baseline/budget EUI that is significantly higher than the benchmark is of especial concern as it may indicate inappropriate simulation assumptions or modeling mistakes that result in overly inefficient/lenient elevator energy use in the baseline/budget design.

    Projects that have more stories or longer operating hours than the selected benchmark may justifiably have higher elevator energy use.

3. Common mistakes that may result in unrealistically high/low elevator energy use:
    a) Unrealistically high/low modeled elevator runtime hours

SG20 Compliance outcome is established correctly

90.1 2016/2019 Section 11

Section 11.2: The energy cost of the proposed design (design energy cost) must not exceed the energy cost budget. Both the design energy cost and the energy cost budget must be based on the completed simulations and may include adjustments based on exceptional calculation methods.

90.1 2016/2019 Appendix G

Section 4.2.1.1 c: The section includes the methodology for calculating the Performance Cost Index Target (PCIt). In order to demonstrate compliance, the project's Performance Cost Index (PCI) calculated as a ratio of the proposed energy cost to the baseline energy cost, must not exceed the PCIt. The PCIt calculation requires separating the baseline energy cost into the baseline building regulated energy cost (BBREC) and the baseline building unregulated energy cost (BBUEC) components. Regulated energy cost is calculated by multiplying the total baseline energy cost by the ratio of the regulated energy use to the total energy use for each fuel type. Unregulated energy cost is calculated by subtracting regulated energy cost from total energy cost.

Section 3: regulated energy use is defined as energy used by building systems and components with requirements prescribed in Sections 5 through 10. This includes energy used for HVAC, lighting, service water heating, motors, transformers, vertical transportation, refrigeration equipment, computer-room cooling equipment, and other building systems, components, and processes with requirements prescribed in Sections 5 through 10.

Review Tips

Section 11

1. The calculation is automated in the Compliance Calculations tab of the Compliance Form based on the simulation results for the budget and proposed design.

Appendix G

1. The PCI and PCIt calculations are automated in the Compliance Calculations tab of the Compliance form based on the simulation results for the baseline and proposed design. However, the compliance outcome is strongly influenced by whether the baseline energy cost is properly separated into regulated (BBREC) and unregulated (BBUEC) components, thus the review should focus on verifying that the regulated versus unregulated loads are identified correctly on the Compliance Calculations tab.
2. Reporting regulated load as unregulated makes Appendix G less stringent. Review Table 2 of the Compliance Tab to verify that regulated loads are not erroneously listed as unregulated. The table has default regulated/unregulated assignments for common end uses. Review any over-written defaults (these will be shown in brown font in the "Unregulated?" column of the table). Below are examples of loads unregulated loads.
    - Transformers except low-voltage dry-type transformers included in Section 8.4.4.

- Plug-in equipment including but not limited to residential kitchen appliances, consumer and office electronic systems.
- Industrial process equipment with no requirements in 90.1.
- Lighting subject to the exceptions 90.1 Section 9.1.1 including the emergency lighting that is automatically off during normal building operation, lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation and decorative gas lighting systems.

3. Common mistakes involving reporting regulated loads as unregulated include the following:
   a. Elevator energy is included in the unregulated "Misc. Equipment" category instead of being separately reported as a regulated load under "Elevators and escalators" end use.
   b. Parking garage fans are not reported as regulated load in the "Fans - parking garage" end use. (Such fans have requirements in Section 6.4.3.4.5 and must thus be treated as regulated.)
   c. Energy use of miscellaneous motors covered in 90.1 Section 10 is included under unregulated "Misc. Equipment" category instead of being treated as regulated. (Projects can get credit for exceeding the required efficiency in accordance with Table G3.1 #12.)

Utility Rate (UR)

Overview of the Utility Rate Checks

Utility Rate checks verify that utility rates from the approved source were used for all applicable fuels, that the required supporting information is included in the submittal, and that modeling inputs and outputs reflect the reported rate structure. Table 5 summarizes the checks included in the Utility Rates section. This group of checks may be skipped if project documents compliance using unit other than energy cost, such as site or source energy or emissions, which may be allowed by some rating authorities and jurisdictions.

Table 5: Utility Rates Checks Overview

	Type of Check	Proposed Design	Baseline/ Budget Design
Utility Rates	CF inputs reflect design documents	UR01	NA
	Simulation outputs consistent with CF	UR02	UR02
	Simulation inputs consistent with CF	UR03	UR03
LEGEND			
PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form			

UR01 The utility rate for electricity, natural gas and other applicable energy sources are based on the approved source

90.1 2016/2019 Section 11

11.4.3.2: The rates for purchased energy (such as electricity, gas, oil, propane, steam and chilled water) must be approved by the AHJ.

90.1 2016/2019 Appendix G

Section G2.4.2: Either the actual rates for purchased energy or state average energy prices published by U.S. Energy Information Administration (EIA) for commercial building customers may be used, but rates from different sources may not be mixed in the same project.

Review Tips

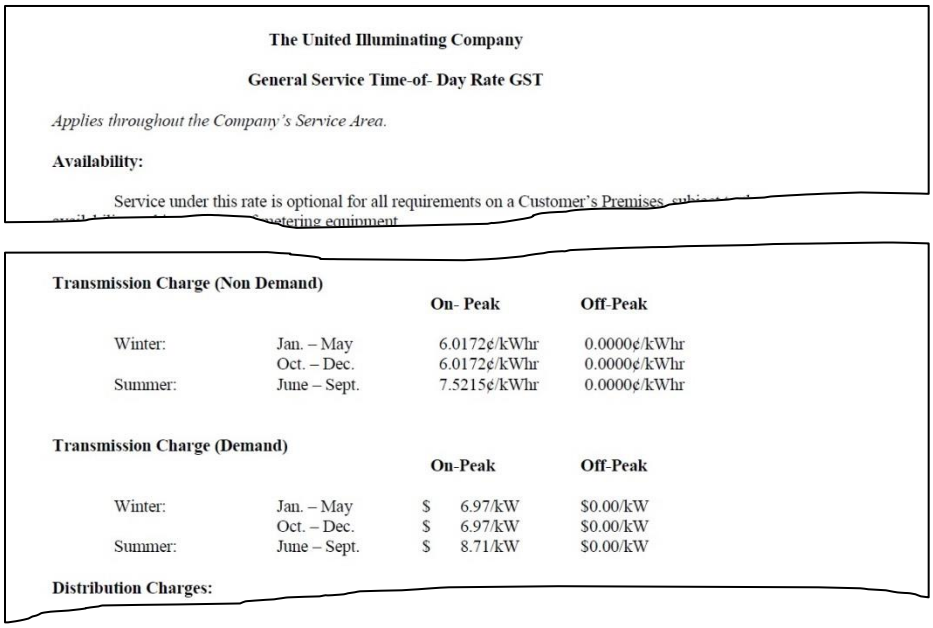
1. All fuels applicable to the baseline/budget or proposed design must be listed on the Energy Sources tab of the Compliance Form. Table 1 includes the list of fuels and description of utility rates for each.

Energy Type	Energy Consumption Units	Demand Units	Utility Rate Type
Electricity	kWh	kW	Fixed Rates per unit of consumption
Natural Gas	therm	kBtu/hr	Fixed Rates per unit of consumption

The fee structures for each fuel is further described in Tables 2-4 of the Energy Sources tab. Table 2 is used for reporting rates that have uniform charges, Table 3 for time of user charges, Table 4 for block charges. These tables also list Source of Data for each rate which may include Actual Rates, EIA Rates or Other.

Energy Type	Energy Consumption Units	Demand Units	Season 1					Source of Data
			Start Date	End Date	Monthly Meter Charge [$/Month]	$/Unit Demand	$/Unit Energy	
Electricity	kWh	kW	Jan-01	Dec-31	$25.0	n/a	$0.138	Actual Rates
Natural Gas	therm	kBtu/hr	Jan-01	Dec-31	$32.0	n/a	$1.131	Actual Rates

2. With the EIA option, the most recent annual average rates for electricity and natural gas published at the EIA website should be used. These rates are readily available and are simple usage charges such as $/kWh.
3. The actual rates may be more challenging to establish for a new construction project, as several different rate classes and choice of electricity suppliers may apply. The actual rates may also be harder to model as they often include block charges, time of use charges, demand charges, ratchet clauses, etc. However, using the actual rates makes models more representative of the post-occupancy energy costs and allows capturing impact of electricity demand and time of use on compliance. If actual utility rates are used on the project, the supporting information should be included in the submittal (Submittal Checklist #7), such as rate description from the utility company.



The United Illuminating Company

General Service Time-of- Day Rate GST

Applies throughout the Company's Service Area.

Availability:

Service under this rate is optional for all requirements on a Customer's Premises, subject to [illegible] metering equipment

Transmission Charge (Non Demand)

		On- Peak	Off-Peak
Winter:	Jan. – May	6.0172¢/kWhr	0.0000¢/kWhr
	Oct. – Dec.	6.0172¢/kWhr	0.0000¢/kWhr
Summer:	June – Sept.	7.5215¢/kWhr	0.0000¢/kWhr

Transmission Charge (Demand)

		On-Peak	Off-Peak
Winter:	Jan. – May	$ 6.97/kW	$0.00/kW
	Oct. – Dec.	$ 6.97/kW	$0.00/kW
Summer:	June – Sept.	$ 8.71/kW	$0.00/kW

Distribution Charges:

UR02 The difference between the average (virtual) modeled budget/baseline and proposed utility rates for electricity, natural gas and other applicable energy sources are as expected.

Review Tips

1. Background

   The average annual rate, often referred to as the virtual rate, is calculated for each fuel as the ratio of the annual fuel consumption to the annual fuel cost. For example, if the simulation output reports show that the baseline annual electricity use was 509,150 kWh and the annual electricity cost was $76,370, the virtual electricity rate is $76,370 / 509,150kWh = 0.15 $/kWh.

   For projects that used EIA rates or the actual rates with fixed usage charges (e.g. $/kWh, $/Therm) and no demand, time of use, or block charges, the virtual rate is expected to be the same for the budget/baseline and the proposed design and match the rate reported on the Energy Sources tab of the Compliance Form. For projects that use more complex utility rate structures, virtual rates may differ between the budget/baseline and proposed design. For example, the virtual electricity rate for

the proposed design may be lower than for the budget (baseline) design if the proposed design reduces the peak demand and the modeled electricity rates include demand charges.

2. Virtual utility rates for the budget/baseline and proposed design that are not equal for projects with simple utility rate structures or differ by more than 5% for projects with complex utility rate structures, should be flagged.

UR03 The modeled utility rates for electricity, natural gas and other fuels applicable to the project are as reported on the Compliance Form and are the same in the baseline/budget and proposed design model.

Review Tips

1. Review simulation input and output reports to confirm that the utility rate structure described in the submittal was properly modeled. This QC check should be performed if UR02 check fails or instead of UR02.

eQUEST Reports	ES-D, ES-E, ES-F
Trane TRACE 700	Library Members entered values report Utility rates section for utility rate input, Monthly Energy Consumption and Monthly Utility Cost reports for consumption and cost output
Trane TRACE 3D Plus	Site Consumption Summary report for energy consumption for each fuel and Economic and Life Cycle Costs Summary report for consumption costs for each fuel
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Tariff Report' report
OpenStudio	
Carrier HAP v5	"Electric Rate Inputs", "Fuel Rate Inputs" reports. Virtual rate found on "Billing Details" report, generated by energy or fuel source.
Design Builder	Utility:Tariffs sections in Input Data file (.idf)

Building Envelope (BE)

Overview of the Building Envelope Checks

Building Envelope group of checks addresses above and below grade walls and floors, roof, fenestration, infiltration, building orientation and exterior and interior shading. Table 6 summarizes the checks included in this group.

Table 6: Building Envelope Checks Overview

	Check Type	Proposed Design	Baseline/Budget Design
Above-grade wall	CF inputs reflect design documents	BE01-P	NA
	CF inputs reflect requirements of 11/G	NA	BE01-B
	Simulation inputs consistent with CF	BE06-P	BE06-B
	Simulation outputs consistent with CF	BE19	BE19
Below-grade Walls	CF inputs reflect design documents	BE02-P	NA
	CF inputs reflect requirements of 11/G	NA	BE02-B
	Simulation inputs consistent with CF	BE07-P	BE07-B
	Simulation outputs consistent with CF	BE19	BE19
Roof	CF inputs reflect design documents	BE03-P, BE11-P	NA
	CF inputs reflect requirements of 11/G	NA	BE03-B, BE11-B
	Simulation inputs consistent with CF	BE08-P, BE12-P	BE08-B, BE12-B
	Simulation outputs consistent with CF	BE19	BE19
Exterior Floor	CF inputs reflect design documents	BE04-P	NA
	CF inputs reflect requirements of 11/G	NA	BE04-B
	Simulation inputs consistent with CF	BE09-P	BE09-B
	Simulation outputs consistent with CF	BE19	BE19
Slab-on Grade	CF inputs reflect design documents	BE05-P	NA
	CF inputs reflect requirements of 11/G	NA	BE05-B
	Simulation inputs consistent with CF	BE10-P	BE10-B
	Simulation outputs consistent with CF	BE19-P	BE19
Fenestration	CF inputs reflect design documents	BE13-B, BE15-B	NA
	CF inputs reflect requirements of 11/G	NA	BE13-P, BE15-P
	Simulation inputs consistent with CF	BE14-P, BE16-P	BE14-B, BE16-B
	Simulation outputs consistent with CF	BE19	BE19
Infiltration	CF inputs reflect design documents	BE17-P	NA
	CF inputs reflect requirements of 11/G	NA	BE17-B
	Simulation inputs consistent with CF	BE18-P	BE18-B
	Simulation outputs consistent with CF	BE19	BE19
Orientation	CF inputs reflect design documents	BE20-P	NA
	CF inputs reflect requirements of 11/G	NA	BE20-B
	Simulation inputs consistent with CF	BE21-P	BE21-B
Interior/Exterior Shading	CF inputs reflect design documents	BE22-P	NA
	CF inputs reflect requirements of 11/G	NA	BE22-B
	Simulation inputs consistent with CF	BE23-P	BE23-B

LEGEND

PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form

The following strategies may be used to prioritize the review:

1. Checks related to slab on grade floors and below grade walls are more important for low-rise buildings (e.g. 5 floors or less) where HVAC energy use is envelope-dominated such as in multifamily, hotels, motels, dormitories and schools. For other types of projects it may be spot-checked or skipped.
2. Focus on verifying constructions that account for the largest surface area and spot-check the rest. For these selected constructions, perform all types of checks listed in Table 6. To facilitate prioritization based on surface area, the Quality Control Checks tab of the Compliance Form includes a table showing the three constructions accounting for the largest area within each surface type (exterior wall, roof, floor, etc.)
3. Review of fenestration should similarly focus on window products accounting for the largest area. Refer to the table on the Quality Control Checks tab, Building Envelope section for the fenestration types sorted by area.
4. Roof reflectance has higher impact in cooling-dominated climates such as Climate Zones 0-4 and may be spot-checked or skipped for projects in other climate zones.
5. Interior and exterior shading has higher impact in cooling-dominated climates such as Climate Zones 0-4 and may be spot-checked or skipped for projects in other climate zones.

BE01-B Thermal properties of the baseline/budget above-grade walls are established correctly.

BE02-B Thermal properties of the baseline/budget below-grade walls are established correctly.

BE03-B Thermal properties of the baseline/budget roof are established correctly.

BE04-B Thermal properties of the baseline/budget exterior floors are established correctly.

BE05-B Thermal properties of the baseline/budget slab-on-grade floor are established correctly.

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Table 11.5.1 #5, Column B: The opaque assemblies, such as roof, floors, doors and walls must be modeled with the same heat capacity (the same construction) as the proposed building design and the U-factors in 90.1 Section 5.5 for new buildings or additions and 90.1 Section 5.1.3 for alterations. When trade-offs are made between an addition and an existing building as described in the exception to **Section 4.2.1.2**, the envelope in the budget building design must reflect existing conditions prior to any retrofits that are part of the permit. Unconditioned envelope components must be modeled with the same properties as specified in the proposed design.

90.1 2016/2019 Appendix G

Table G3.1 #5: Opaque assemblies of new buildings, existing buildings, or additions shall conform with assemblies detailed in 90.1 Appendix A and match the appropriate assembly maximum U-factors in 90.1 Tables G3.4-1 through G3.4-8:

• Roofs—Insulation entirely above deck (90.1 Section A2.2).
• Above-grade walls—Steel-framed (90.1 Section A3.3).
• Below-grade walls—Concrete block (90.1 Section A4).
• Floors—Steel-joist (90.1 Section A5.3).
• Slab-on-grade floors shall match the F-factor for unheated slabs from the same tables (90.1 Section A6).

Unconditioned envelope components must be modeled in the baseline with the same properties as specified in the proposed design.

Review Tips

1. Baseline/budget assembly U/F/C factors are auto populated in Table 1 of the Envelope Areas tab of the Compliance Form based on the space conditioning categories specified by the user. Thus, the review should focus on verifying that the building envelope conditioning categories are established correctly, with the focus on the above-grade exterior walls that account for the greatest area. (The ranking of exterior walls by area is shown in the Quality Controls Checks tab, Building Envelope (BE) area.

Modeled Construction Name	New, Existing to Remain, or Retrofitted	Building Area Type (for Appendix G Projects Only, 90.1 Section G3.1.1-1)	Orientation	Building Envelope Conditioning Category	Proposed Design: Net Area, ft²	Proposed Design: Plans / Specs	Proposed Design: Software Reports	Baseline Design: Assembly U/F/C-Factor	Baseline Design: Roof Solar Reflectance/ Thermal Emittance
SOGFL	New	Retail (stand alone)	Horizontal	Residential	8,436	A-301		F-0.73	n/a
AGW1	New	Other	North	Residential	3,606	A-301		U-0.064	n/a
AGW1	New	Other	East	Residential	9,881	A-301		U-0.064	n/a
AGW1	New	Other	South	Residential	3,606	A-301		U-0.064	n/a
AGW1	New	Other	West	Residential	9,881	A-301		U-0.064	n/a
AGW1	New	Retail (stand alone)	North	Nonresidential	2,498	A-302		U-0.124	n/a

The selection should be based on the following criteria:

- Residential surface bounds residential space and must be classified as exterior building envelope
- Nonresidential surface bounds nonresidential space and is classified as exterior building envelope
- Semiheated surface is classified as semiexterior building envelope
- All other surfaces are classified as unconditioned.

90.1 Section 3: Residential vs non-residential spaces

- Residential spaces are “spaces in buildings used primarily for living and sleeping. Residential spaces include, but are not limited to, dwelling units, hotel/motel guest rooms, dormitories, nursing homes, patient rooms in hospitals, lodging houses, fraternity/sorority houses, hostels, prisons, and fire stations.”
- All other enclosed spaces are classified as non-residential.
- Unenclosed spaces include crawlspaces, attics, and parking garages with natural or mechanical ventilation and are treated as exterior when determining applicable envelope requirements.

90.1 Section 3 and Figure 5.5.2: Exterior vs semi-exterior building envelope

- Exterior Building Envelope: the elements of a building that separate conditioned spaces from the exterior
- Semiexterior Building Envelope: the elements of a building that separate conditioned space from unconditioned space or that enclose semiheated spaces through which thermal energy may be transferred to or from the exterior, to or from unconditioned spaces, or to or from conditioned spaces.
- Spaces may be classified as conditioned (cooled, heating or indirectly conditioned), semiheated, unconditioned or unenclosed. See definition of the space in 90.1 Section 3 for more details.
- Common examples of conditioned spaces include offices, classrooms, hotel guestrooms, etc. Common examples of semiheated spaces include storage areas.

2. Common Mistakes
   a. Floors of conditioned spaces adjacent to garages must be treated as exterior surfaces when establishing the baseline floor U-value, as garages are considered un-enclosed spaces.
   b. Treating envelope of residential spaces in non-residential buildings as non-residential envelope. For example, even though hospital is considered non-residential building type, patient rooms are used primarily for living and sleeping, and are thus residential spaces.

BE01-P Thermal properties of the exterior walls in the proposed design are established correctly.

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Table G3.1 #5 (a), Proposed Building Performance column

All components of the building envelope in the proposed design must be modeled as shown on architectural drawings or as built for existing building envelopes.

All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate floor stabs, concrete floor beams over parking garages, roof parapet) must be separately modeled using either of the following techniques:

- Separate model of each of these assemblies within the energy simulation model.
- Separate calculation of the U-factor for each of these assemblies. The U-factors of these assemblies are then averaged with larger adjacent surfaces using an area-weighted average method. This average U-factor is modeled within the energy simulation model.

Any other building envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described, provided that it is similar to an assembly being modeled. If not separately described, the area of a building envelope assembly must be added to the area of an assembly of that same type with the same orientation and thermal properties.

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Table 11.5.1 #5 Column A

All components of the building envelope in the proposed design must be modeled as shown on architectural drawings or as installed for existing building envelopes. Any building envelope assembly

that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of a building envelope assembly must be added to the area of the adjacent assembly of that same type.

Review Tips

1. Locate constructions selected for the review in the design documents based on the reference provided for that construction in the Plans/Specs column of Table 1 in the Proposed Envelope Assemblies tab of the Compliance form. Focus the review on constructions that account for the highest wall area, as shown in the table in the Building Envelope (BE) section of the Quality Control Check tab.

Modeled Construction Name	Surface Type	Construction Type Legend: AGW = Above Grade Wall	Detailed Description	Rated R-Value of Cavity Insulation	Rated R-Value of Continuous Insulation	Effective U/F/C-Factor of Cont + Cav Insulation Based on 90.1 App A	Total R-value of Materials in Addition to Cont. and Cav. Insulation (If Any)	Modeled U/C/F-factor Including Int. and Ext. Air Film	Modeled U/C/F-factor Includes Uninsulated Assemblies?	Modeled U/C/F-factor Includes Similar Assemblies?
SOGFL	Slab-On-Grade Floor	Unheated	Unheated - Fully insulated slab	0	15	F-0.300, Table A6.3.1-1	n/a	0.300	No	No
Roof1	Roof	Insulation Entirely above Deck	Insulation Entirely above Deck	0	40	U-0.025, Table A2.2.3	n/a	0.025	No	No
AGW1	Above-Grade Exterior Wall	Steel-Framed	16 Inch on Center with a 6.0 Inch Depth (Steel-Frame)	19	10	U-0.052, Table A3.3.3.1	n/a	0.052	No	No

2. Verify that description of the construction provided in the table reflects design documents. The location in the design documents where construction is described is included in the last column of Table 1 in the Proposed Envelope Assemblies tab of the Compliance Form shown above.
3. Verify that the value reported in “Modeled U/C/F-factor Including Int. and Ext. Air Film” is established correctly. (See Common Mistakes section.)
4. Review architectural details drawing to identify if project includes any uninsulated assembles such as projecting balconies, perimeter edges of intermediate floor stabs, concrete floor beams over parking garages and roof parapets. If present, check “Modeled U/C/F-Factor Includes Uninsulated Assemblies?” column to confirm that such elements were included with the adjacent constructions with the appropriate adjustment to overall U-factor (based on area-weighted average) or reported as separate construction. If separately reported, refer to Envelope Areas tab Table 1 to confirm that the reported Net Area for such assemblies is appropriate.
5. Common Mistakes
   a. The overall assembly U-value is established without accounting for thermal bridging, as required by 90.1 Section 5.5.3. For example, a steel framed wall assembly with R-13 insulation in the 16” on center steel framing cavity and R-3 continuous insulation must be reported as U-0.091.

TABLE A3.3.3.1 Assembly U-Factors for Steel-Frame Walls

Framing Type and Spacing Width (Actual Depth)	Cavity Insulation R-Value: Rated (Effective Installed [see Table A9.2B])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing) — Rated R-Value of Continuous Insulation												
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00
Steel Framing at 16 in. on Center																
3.5 in. depth	None (0.0)	0.352	0.260	0.207	0.171	0.146	0.128	0.113	0.102	0.092	0.084	0.078	0.072	0.067	0.063	0.05
	R-11 (5.5)	0.132	0.117	0.105	0.095	0.087	0.080	0.074	0.069	0.064	0.060	0.057	0.054	0.051	0.049	0
	R-13 (6.0)	0.124	0.111	0.100	0.091	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.050	0.048	
	R-15 (6.4)	0.118	0.106	0.096	0.087	0.080	0.074	0.069	0.065	0.061	0.057	0				
		0.109	0.099	0.090			0.071	0.066	0.062	0.058						

Proposed Envelope Properties with 90.1 Appendix A

b. For tapered roof insulation, the U-value should be based on the area-weighted average R-Value for the varying insulation thickness (see Standard 90.1 2016 User's Manual Example FY1, Area Weighted Averages).

BE02-P Thermal properties of the proposed below-grade walls are established correctly.

Review Tips

1. The QC check may be skipped for projects with small below-grade wall area.
2. See BE01-P for additional tips.

BE03-P Thermal properties of the proposed roof are established correctly.

Review Tips

See BE01-P for additional tips.

BE04-P Thermal properties of the proposed exterior floors are established correctly.

Review Tips

1. Majority of projects that include garage on lower floors are expected to have this surface type as garages are typically classified as un-enclosed spaces (which is equivalent to ambient conditions for envelope compliance purposes) and the floor separating garage from conditions spaces above should be insulated appropriately.
2. See BE01-P for additional tips.

BE05-P Thermal properties of the proposed slab-on-grade floor are established correctly.

Review Tips

1. Unless project includes portion of the building over conditioned spaces (e.g. floors 3-10 of a building that has conditioned 2nd floor), it is expected to have exposed floors, slab-on-grade, or below-grade walls. (Slab below grade doesn't have to be reported). If neither of these surfaces are included in the compliance form, a comment should be made to request that missing surfaces are reported in the Compliance Form and modeled.
2. See BE01-P for additional tips.

BE06-B, BE06-P Modeled U-factors and areas of the baseline/budget and proposed above-grade walls are as reported in the Compliance Form.

Review Tips

1. Use simulation reports to verify that modeled U-factors and areas of the exterior walls reflect the values reported in the Compliance For. The reported values are located in the following tables within the Compliance Form:
    a. Baseline/budget design: Table 1 in the Envelope Areas tab.
    b. Proposed Design: Table 1 in the Proposed Envelope Assemblies tab.
2. Focus on constructions that account for the largest above grade wall area based on the table in the Building Envelope section of the Quality Control Checks tab.
3. Small deviations (e.g. up to 3%) between the value reported in the Compliance Form and simulation output reports may be accepted as it is often due to the contribution of the exterior air film. The

prescriptive U-factors included in 90.1 Section 5 are based on the exterior air film R-values listed in 90.1 Appendix A (e.g., R-0.17 for roof constructions), while simulation tools may determine it dynamically based on the hourly weather conditions.

eQUEST Reports	LV-D
Trane TRACE 700	Building U-Values, Building Areas
Trane TRACE 3D Plus	Envelope Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report
EnergyPlus	eplustbl.html 'Envelope Summary' report
OpenStudio	eplustbl.html 'Envelope Summary' report
Carrier HAP v5	Surface Areas: "LEED Summary Report", Section 2 "Minimum Energy Performance Calculator", table titled "Above Grade Wall & Vertical Glazing Areas" Wall Assembly U-Value: "Wall Constructions" report.
Design Builder	Opaque Exterior Table in Output Summary Document

BE07-B, BE07-P Modeled C-factors and areas of the baseline/budget and proposed below-grade walls are as reported in the Compliance Form.

1. Use simulation reports to verify that modeled C-factors and areas of the below-grade walls reflect the values reported in the Compliance For. The reported values are located in the following tables within the Compliance Form:
    c. Baseline/budget design: Table 1 in the Envelope Areas tab.
    d. Proposed Design: Table 1 in the Proposed Envelope Assemblies tab.
2. Focus on constructions that account for the largest below grade wall area based on the table in the Building Envelope section of the Quality Control Checks tab.
3. The QC check may be skipped for projects with relatively small area of below-grade walls.

eQUEST Reports	LV-D
Trane TRACE 700	Building U-Values, Building Areas
Trane TRACE 3D Plus	Envelope Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report
EnergyPlus	eplustbl.html 'Envelope Summary' report
OpenStudio	eplustbl.html 'Envelope Summary' report
Carrier HAP v5	Wall and Roof Surface Areas: "LEED Summary Report", Section 2 "Minimum Energy Performance Calculator", table titled "Above Grade Wall & Vertical Glazing Areas" Wall Assembly U-Value: "Wall Constructions" report.
Design Builder	Opaque Exterior Table in Output Summary Document

BE08-B, BE08-P Modeled U-factors and areas of the baseline/budget and proposed roof are as reported in the Compliance Form.

1. Use simulation reports to verify that modeled U-factors and areas of the roof reflect the values reported in the Compliance For. The reported values are located in the following tables within the Compliance Form:
    a. Baseline/budget design: Table 1 in the Envelope Areas tab.
    b. Proposed Design: Table 1 in the Proposed Envelope Assemblies tab.
2. Focus on constructions that account for the largest roof area based on the table in the Building Envelope section of the Quality Control Checks tab.

eQUEST Reports	LV-D
Trane TRACE 700	Building U-Values, Building Areas
Trane TRACE 3D Plus	Envelope Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report
EnergyPlus	eplustbl.html 'Envelope Summary' report
OpenStudio	eplustbl.html 'Envelope Summary' report
Carrier HAP v5	Wall and Roof Surface Areas: "LEED Summary Report", Section 2 "Minimum Energy Performance Calculator", table titled "Above Grade Wall & Vertical Glazing Areas" Roof Assembly U-Value: "Roof Constructions" report.
Design Builder	Opaque Exterior Table in Output Summary Document

BE09-B, BE09-P Modeled U-factors and areas of the baseline/budget floor is as reported in the Compliance Form.

1. Use simulation reports to verify that modeled U-factors and areas of the floor reflect the values reported in the Compliance For. The reported values are located in the following tables within the Compliance Form:
    a. Baseline/budget design: Table 1 in the Envelope Areas tab.
    b. Proposed Design: Table 1 in the Proposed Envelope Assemblies tab.
2. Focus on constructions that account for the largest floor area based on the table in the Building Envelope section of the Quality Control Checks tab.

eQUEST Reports	LV-D
Trane TRACE 700	Building U-Values, Building Areas
Trane TRACE 3D Plus	Envelope Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report
EnergyPlus	eplustbl.html 'Envelope Summary' report
OpenStudio	eplustbl.html 'Envelope Summary' report
Carrier HAP v5	Exposed Floor Area and U-Value: "Space Input Data" report.
Design Builder	Opaque Exterior Table in Output Summary Document

BE10-B, BE10-B P Modeled F-factors and areas of the baseline/budget slab-on-grade are as reported in the Compliance Form.

1. Use simulation reports to verify that modeled U-factors and areas of the floor reflect the values reported in the Compliance For. The reported values are located in the following tables within the Compliance Form:
    a. Baseline/budget design: Table 1 in the Envelope Areas tab.
    b. Proposed Design: Table 1 in the Proposed Envelope Assemblies tab.
2. Focus on constructions that account for the largest floor area based on the table in the Building Envelope section of the Quality Control Checks tab.
3. The QC check may be skipped for projects involving buildings over 5 floors.

eQUEST Reports	LV-D
Trane TRACE 700	Building U-Values, Building Areas
Trane TRACE 3D Plus	Envelope Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report
EnergyPlus	eplustbl.html 'Envelope Summary' report
OpenStudio	eplustbl.html 'Envelope Summary' report
Carrier HAP v5	Slab on Grade, Below Grade Area and U-value: "Space Input Data" report
Design Builder	Opaque Exterior Table in Output Summary Document

BE11-B Baseline/Budget roof reflectance is established correctly in the Compliance Form

90.1 2016/2019 Section 11

Table 11.5.1 Column A No 5 (b).

The exterior roof surfaces shall be modeled with a solar reflectance and thermal emittance as required in Section 5.5.3.1.1(a). All other roofs, including roofs exempted from the requirements in Section 5.5.3.1.1, shall be modeled the same as the proposed design.

90.1 2016/2019 Appendix G

Table G3.1 #5 Baseline Building Performance (f) and (g)

- The exterior roof surfaces shall be modeled using a solar reflectance of 0.30 and a thermal emittance of 0.90.
- All roof surfaces shall be modeled with a reflectivity of 0.30.

Review tips

1. The related properties of the roof surfaces in the baseline/budget design are reported on the Envelope Areas tab Table 1 and are set by default to 0.30/0.90 solar reflectance / thermal emittance. The over-written values are shown in bold brown.
2. This QC check is important for project located in cooling-dominated climates such as Climate Zones 0-4.

BE11-P Proposed design roof reflectance reported in the Compliance Form reflects design documents

90.1 2016/2019 Section 11

Table 11.5.1 Column A No 5 Exception 3.

The exterior roof surface shall be modeled using the aged solar reflectance and thermal emittance determined in accordance with Section 5.5.3.1.1(a). Where aged test data are unavailable, the roof surface shall be modeled with a solar reflectance of 0.30 and a thermal emittance of 0.90.

90.1 2016/2019 Appendix G

Table G3.1 #5 Baseline Building Performance (a)3

The exterior roof surface shall be modeled using the aged solar reflectance and thermal emittance determined in accordance with Section 5.5.3.1.1(a). Where aged test data are unavailable, the roof surface may be modeled with a reflectance of 0.30 and a thermal emittance of 0.90.

Review tips

1. Reflectance of the roof surfaces in the proposed design is reported in the Proposed Envelope Assemblies tab, Table 1.
2. If reported reflectance/emittance differ from the default values of 0.3/0.9, refer to design documents to confirm the entered values or ask modeler for supporting documentation.
3. This QC check is important for project located in cooling-dominated climates such as Climate Zones 0-4.

BE12-B, BE12-P Baseline/Budget and proposed roof reflectance is modeled as reported in the Compliance Form

Review Tip

Review simulation reports to verify that roof reflectance was modeled as reported in the Compliance Form.

BE13-B Fenestration area in the baseline/budget design is established correctly

90.1 2016/2019 Section 11

90.1 Table 11.5.1 #5 c: The budget building design must have identical exterior dimensions as the proposed design, except when the fenestration area of the new buildings or additions exceeds 40% of the gross exterior wall area, the budget fenestration area is reduced proportionally along each exposure until the total fenestration area is equal to 40%. Fenestration must be distributed on each face of the building in the same proportion as in the proposed design.

> Exception: When trade-offs are made between an addition and an existing building, as described in the exception to Section 4.2.1.2, the budget building design shall reflect existing conditions, such as fenestration area, prior to any revisions that are part of the permit.

90.1 2016/2019 Appendix G

Table G3.1 #5 Baseline Building Performance column (c) and Table G3.1.1-1: The baseline fenestration area depends on the Building Area Type in Table G3.1.1-1. For example, a 40,000 ft^2 office building is modeled with the baseline vertical fenestration area equal to 31% of the gross above grade wall area.

For building types not specified in Table G3.1.1-1, such as multifamily, the baseline fenestration area shall be equal that in the proposed design or 40% of the gross above-grade wall area, whichever is smaller. Fenestration must be distributed on each face of the building in the same proportion as in the proposed design.

> Exception: The fenestration area for an existing building shall equal the existing fenestration area prior to the proposed work and shall be distributed on each face of the building in the same proportions as the existing building.

Review Tips

1. Baseline/budget fenestration area by exposure and building type is shown in the Envelope Areas tab Tables 3-5. The areas are automatically calculated by the Compliance Form by applying the appropriate rules of 90.1 to the project, but may be over-written by the modeler. If the default value was over-written, the input in the Fenestration Area, ft^2 column is shown in light brown font. Over-ride may be justified for projects involving existing buildings where the baseline/budget fenestration must reflect area prior to retrofit. The over-written values should be commented on, to request an explanation.
2. Based on the 90.1 Definition section, all areas (including frame) that let in lighting, such as windows, translucent plastic panels, doors that are more than one half glass and glass block walls are considered fenestration.

   Example: A multifamily project with 58,000ft^2 gross wall area including 8,000 ft^2 of operable windows, 5,000 ft^2 of transparent glass block walls and 7,000 ft^2 of spandrel, has fenestration area of 8,000 ft^2 + 5,000 ft^2 = 13,000 ft^2 or 13,000 ft^2/58,000 ft^2=22% of gross exterior wall

BE13-P Fenestration area in the proposed design reported in the Compliance Form reflects design documents

90.1 2016/2019 Section 11

Table 11.5.1 No5, Column A: Fenestration area must be as shown on architectural drawings, or as installed for existing building envelopes.

90.1 2016/2019 Appendix G

Table G3.1 #5, Proposed Building Performance column*:* Fenestration area must be as shown on architectural drawings, or as installed for existing building envelopes.

Review Tips

1. The proposed fenestration area and the design documents where it can be found is reported in Table 2 of the Envelope Areas tab. Cross-check fenestration areas reported in the Compliance Form for representative orientations to confirm the alignment with the design documents.

Modeled Fenestration Name	New, Existing to Remain, or Retrofitted	Building Area Type (for Appendix G Projects Only, 90.1 Section G3.1.1-1)	Orientation	? Building Envelope Conditioning Category	Proposed Design	
					? Fenestration Area, ft²	Plans / Specs
W1	New	Other	North	Residential	1,943	A-301
W1	New	Other	East	Residential	5,319	A-302
W1	New	Other	South	Residential	1,943	A-303
W1	New	Other	West	Residential	5,319	A-304
W2	New	Retail (stand alone)	East	Nonresidential	4,104	A-301

BE14-B, BE14-P Modeled fenestration areas for the baseline/budget and proposed design are as reported in the Compliance Form

Review Tips

1. Use simulation reports to confirm that the modeled fenestration area is as reported in the Compliance Form. The reported values are found as follows:
   Baseline/budget design: Envelope Areas tab Tables 3-5
   Proposed Design: Envelope Areas tab Table 2

eQUEST	LV-D
Trane TRACE 700	Building U-Values, Building Areas, Walls by Direction Entered Values report, Walls by Cardinal Direction entered values report
Trane TRACE 3D Plus	
IESVE SOFTWARE	
EnergyPlus	
OpenStudio	
Carrier HAP v5	"LEED Summary" report, Section 2, "Minimum Energy Performance Calculator", table titled "Above Grade Wall and Vertical Glazing Areas"
Design Builder	

BE15-B Baseline/budget fenestration U-factor, SHGC and VT reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.1 #5, Column B: Fenestration U-factor and SHGC must be based on the code requirements for the appropriate climate (90.1 Tables 5.5-1 to 5.5-8). The fenestration for envelope alterations must reflect the limitations on area, U-factor and SHGC as described in 90.1 Section 5.1.3. When trade-offs are made between an addition and an existing building based on 90.1 Section 4.2.1.2, properties of the existing envelope in the budget building design must reflect existing conditions prior to any revisions that are part of the permit. Fenestration in unconditioned spaces must be modeled as specified for the proposed design.

90.1 2016/2019 Appendix G

Table G3.1 #5, Baseline Building Performance column (c): Vertical Fenestration Assemblies for new buildings, existing buildings and additions must have U-factors and SHGC matching the requirements for the appropriate climate zone in 90.1 Tables G3.4-1 to 3.4-8. All vertical fenestration shall be assumed to

be flush with the exterior wall and no shading projections shall be modeled. Manual window shading devices such as blinds or shades are not required to be modeled. Fenestration in unconditioned spaces must be modeled in the baseline as specified for the proposed design.

Review Tips

1. Baseline/budget fenestration U-factor, SHGC and VT are determined automatically in the Compliance Form based on project climate zone and space conditioning category and are shown in the Envelope Areas tab Table 2.

BE15-P Proposed fenestration properties are established correctly

90.1 2016/2019 Section 11

Table 11.5.1#5 Column A: All components of the building envelope in the proposed building design must be modeled as shown on architectural drawings or as installed for existing building envelopes, except any building envelope assembly that covers less than 5% of the total area of that assembly type (e.g. vertical fenestration) need not be separately described. If not separately described, the area of that assembly must be added to the area of the adjacent assembly of that same type and the thermal and solar properties of the aggregated surface must reflect the area-weighted average

90.1 2016/2019 Appendix G

Table G3.1 #5 Proposed Design Column (a): All components of the building envelope in the proposed building design must be modeled as shown on architectural drawings or as installed for existing building envelopes, except any building envelope assembly that covers less than 5% of the total area of that assembly type (e.g. vertical fenestration) need not be separately described. If not separately described, the area of that assembly must be added to the area of the adjacent assembly of that same type and the thermal and solar properties of the aggregated surface must reflect the area-weighted average

Review Tips

1. Cross-check vertical fenestration products listed in Table 2 of the Proposed Envelope Assemblies tab with the design documents to confirm alignment. (The location of window schedules should be apparent from Plans/Specs reference included in this table.) Focus the review on fenestration products that account for the largest area.
2. Refer to design document referenced in Plans / Specs column for the fenestration units being reviewed to confirm that specified U-factor, SHGC and VT align with the values reported in Table 2 of the Proposed Envelope Assemblies tab.
3. Verify that the required supporting information specified to the right of Table 2 of the Proposed Envelope Assemblies tab is included in the submittal package.
4. Review supporting documentation to verify that U-factor, SHGC and VLT are established correctly using the approved method, as described below.
    - 90.1 Section 5.8.2.1 requires that the performance of the windows and other fenestration products including U-factor, SHGC, VT and air leakage rate be determined by a laboratory accredited by the National Fenestration Rating Council (NFRC) or another nationally recognized rating authority. Fenestration U-Factor must be determined in accordance with NFRC 100; SHGC

and VT must be determined in accordance with NFRC 200. Other approaches, such as AMCA, are not allowed.

- Default values from 90.1 Appendix A (e.g. 90.1 Table A8.2 for the vertical fenestration) must be used for the fenestration products for which NFRC 100 and NFRC 200 test results are not available.
- 90.1 Section 5.8.2.2 requires that all manufactured and site-built fenestration and door products state the rated performance factors either on a label or a signed and dated manufacturer's certificate provided with the product. If such information is not available, projects must use the defaults from 90.1 Table A8.1-1.
- The NFRC standards referenced in 90.1 Section 5.8.2.3 require that the rated U-value takes into account properties of the entire fenestration assembly including heat loss through center of glass, edge of glass, sash and frame elements. This requirement is often overlooked for custom fenestration, with center of glass properties used in lieu of the properties of the entire assembly, which typically under-estimates fenestration U-value.

5. Confirm that Visible Light Transmittance (VLT) is provided. VLT affects savings from daylighting controls. Fenestration with lower SHGC reduces space solar heat gains (with positive impact on cooling), but often have lower VLT which reduces daylighting.

BE16-B, BE16-P Modeled U-factor, SHGC and VLT of the baseline/budget and proposed fenestration are as reported in the Compliance Form

Review Tips

1. Use simulation reports to verify that the modeled U-factor, SHGC and VLT are as reported in the Compliance Form. The reported values are found at the following locations:
   Baseline/budget design: Table 1 in the Envelope Areas tab.
   Proposed Design: Table 2 in the Proposed Envelope Assemblies tab
2. Focus on fenestration types that account for the largest area.

eQUEST Reports	LV-D
Trane TRACE 700	Building U-Values, Building Areas, Walls by Direction entered values report, Walls by Cardinal Direction entered values report
Trane TRACE 3D Plus	Envelope Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Envelope Summary' report
OpenStudio	eplustbl.html 'Envelope Summary' report
Carrier HAP v5	"Window Constructions" Report
Design Builder	Exterior Fenestration Table in Output Summary Document

BE17-B Baseline/budget infiltration rate reported in the Compliance Form is established correctly

90.1 2016/2019 Section 11

Air-leakage is not prescribed. Thus, it must be modeled the same in the budget and proposed design Based on Table 11.5.1 No1.

90.1 2016 Appendix G

Table G3.1 No 5 b: The air leakage rate of the building envelope (I75Pa) at a fixed building pressure differential of 0.3 in. of water shall be 0.4 cfm/ft^2. Infiltration must be modeled using the same methodology, air leakage rate and adjustments for weather and building operation in both the proposed design and the baseline building design. The air leakage rate of the building envelope must be converted to appropriate units for the simulation program using one of the methods in 90.1 Section G3.1.1.4.

90.1 2019 Appendix G

Table G3.1 Baseline Building Performance No 5(h): The air leakage rate of the building envelope (I75Pa) at a fixed building pressure differential of 0.3 in. of water shall be 1.0 cfm/ft^2.The air leakage rate of the building envelope shall be converted to appropriate units for the simulation program using one of the methods in Section G3.1.1.4.

Review Tips – Section 11

1. Infiltration rate is not prescribed thus any reasonable rate may be modeled. Modeling unrealistically high air leakage will exaggerate contribution of heating energy use toward budget building performance and may skew the compliance outcome. Assumptions that are substantially different from the default values shown in Table 1 of the Infiltration tab may be questioned if heating is one of the impactful end uses.

Review Tips – Appendix G

1. The required infiltration rate at 75Pa pressure differential is automatically calculated in Table 1 of the Infiltration tab shows the applicable baseline/budget infiltration rate.

	Pressure Differential	Air Leakage Rate of the Building Envelope @ Specified Pressure Differential	Air Leakage Measurement Type	Total Building Envelope Area	Total Air Leakage at the Specified Pressure Differential
	-	I	-	S	Q
	Pa	cfm/ft^2	-	ft^2	cfm
Proposed Design:	75	0.4	Whole Building (ASTM e779)	77,046	30,818
Baseline Design:	75	0.4	n/a		30,818

BE17-P Proposed infiltration rate reported in the Compliance Form is established correctly.

90.1 2016/2019 Section 11

Air-leakage is not prescribed and thus must be modeled with the same rate as in the budget design.

90.1 2016 Appendix G

Table G3.1 No 5: The infiltration rate in the proposed design must be the same as in the baseline, except when whole-building air leakage testing in accordance with ASTM E779 is specified during design and completed after construction, the measured air leakage rate must be modeled in the proposed design.

90.1 2019 Appendix G

Table G3.1 Proposed Building Performance column No 5b: The air leakage rate of the building envelope (I75Pa) at a fixed building pressure differential of 0.3 in. of water shall be 0.6 cfm/ft2 for buildings providing verification in accordance with Section 5.9.1.2. The air leakage rate of the building envelope shall be converted to appropriate units for the simulation program using one of the methods in Section G3.1.1.4., except when whole-building air leakage testing in accordance with ASTM E779 is specified during design and completed after construction, the measured air leakage rate must be modeled in the proposed design.

Review Tips

1. Table 1 of the Infiltration tab shows the applicable infiltration rate at 75Pa pressure differential for the proposed design assuming no air leakage testing was performed. If the air leakage rate for the proposed design is over-written by modeler, the entered values is show in light brown font.
2. If the value is over-written, verify the following:
    a) Confirm that infiltration testing report is submitted – see Submittal Checklist check #13.
    b) Confirm that test results are based on the approved testing method (ASTM E779)
    c) Confirm that test results at 75Pa shown in the testing documentation are correctly transferred to Table 1 for the proposed design.

BE18-B, BE18-P *Baseline/budget and proposed modeled infiltration rate reflects the values reported in the Compliance Form*

Review Tips

1. Use the simulation reports to verify that the modeled baseline/budget infiltration rate is as reported in Table 2 of the Infiltration tab. Ensure that both the units (e.g. CFM/SF, ACH) and the value is correct.
2. Common Mistakes
    a. An infiltration rate from Table 1 of the Infiltration tab is entered into simulation tool without converting to normal wind conditions. This exaggerates infiltration related loads by about factor of ten, significantly increasing the heating load and any savings from air leakage reduction in the proposed design.

eQUEST Reports	LV-B
Trane TRACE 700	Room Information entered values report
Trane TRACE 3D Plus	System Cooling Checksums report and System Heating Checksums report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, BPRM Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'InitializationSummary' report, 'ZoneInfiltration Airflow Stats Nominal' section
OpenStudio	eplustbl.html 'InitializationSummary' report, 'ZoneInfiltration Airflow Stats Nominal' section
Carrier HAP v5	"Space Input Data" report.
Design Builder	Zone Infiltration Airflow Stats Nominal Table in EnergyPlus Output Summary Document

BE19 Change in the proposed versus baseline/budget total annual and design loads from envelope components is reasonable given the difference in the proposed versus baseline/budget envelope parameters reported in the Compliance Form

Review Tips

1. This check verifies that the simulation outputs are generally consistent with the baseline/budget and proposed envelope parameters. The check do not consider factors such as thermal mass, exposure and shading, so look for a general correlation and not an exact match.
   a. If a given envelope component has the same or very similar thermal properties in the baseline (budget) and proposed design, heating and cooling losses and gains from this component should be the same or very similar based on the simulation outputs. For example, all 90.1 Section 11 projects and most 90.1 2016 Appendix G projects (except for those that performed air leakage testing) must model the same infiltration rate in the baseline/budget and proposed design, thus the heating and cooling losses and gains from infiltration are expected to be the same or very close in the baseline/budget and proposed simulations.
   b. Conductive heat losses through surfaces (windows, exterior walls, roofs) should correlate to the surface U-value and area.
      Example 1: Based on the submittal, the proposed roof is U-0.032, compared to U-0.063 in the PRM baseline. The annual heat losses through the roof in the simulation output reports should be substantially lower in the proposed design. Assuming the skylight area is the same in the proposed and baseline building, the heat loss through the baseline roof should be about twice that of the proposed building roof (0.063/0.032=2).
      Example 2: Based on the submittal, the proposed design has 40,000 SF of vertical fenestration with U-0.5; the baseline has 30,000 SF of fenestration with U-0. 5. The heat loss through windows due to conduction should go up. ($(U_{prop} \times A_{prop})/(U_{base} \times A_{base})$ =(40,000*0.5)/(30,000*0.5)~1.3)
   c. Solar heat gains through windows should be approximately proportional to the product of the window area and SHGC.

The scope of this check depends on the reporting capabilities of the simulation tool.

eQUEST Reports	LS-C, LS-F
Trane TRACE 700	Building Envelope Cooling Loads at Coil Peak and Building Envelope Heating Loads at Coil Peak
Trane TRACE 3D Plus	Room and Zone Cooling and Heating Loads by Component Reports (keep in mind if the room/zones are peaking at the same time or not)
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Sensible Heat Gain Summary' report
OpenStudio	eplustbl.html 'Sensible Heat Gain Summary' report
Carrier HAP v5	"Air System Design Load Summary" report, generated for HVAC air side system, for same design cooling day hour for Baseline and Proposed.
Design Builder	simulated output result file (.eso)

BE20-B The baseline/budget building performance is an average of four orientations, if required

90.1 2016/2019 Section 11

Table 11.5.1 Column B #5 (c): If the vertical fenestration area facing west or east of the proposed building exceeds the area limit set in 90.1 Section 5.5.4.5, then the energy cost budget shall be generated by simulating the budget building design with its actual orientation and again after rotating the entire budget building design 90, 180 and 270 degrees and then averaging the results.

90.1 2016/2019 Appendix G

Table G3.1 Baseline Building Design column #5 a): The baseline building performance must be calculated by simulating the building with its actual orientation and again after rotating the entire building 90, 180 and 270 degrees, then averaging the results. The baseline building performance may be based on the actual building orientation (without averaging) if (a) the building vertical fenestration area on each orientation varies by less than 5%, or if (b) it is demonstrated to the satisfaction of the AHJ that the building orientation is dictated by site considerations, such as for major renovation projects, or building sharing party walls with the adjacent buildings on a city block.

Review Tips

1. The Envelope Areas tab, "Baseline Orientation and Rotation" indicates whether the baseline/budget design was "rotated". The default is auto-populated based on applying the appropriate 90.1 rules described above to the project. Modeler can over-write this default. If the default is over-written, confirm that an explanation is provided in the Note field and that it acceptable. For example, modeler may indicate that the project was not rotated because it is a major renovation.
2. If it is established that the baseline must be rotated, verify that simulation results are reported for the four baseline orientations in the Compliance Calculations tab Table 2 (Baseline 0 Rotation, Baseline 90 Rotation, Baseline 180 Rotation, Baseline 270 Rotation).

BE20-P Proposed building orientation reflected in the Compliance Form is as specified

Review Tips

1. Proposed building orientation must reflect the actual building exposure. Compare surface areas by orientation in Table 5 of the Envelope Areas tab to architectural drawings to ensure alignment in exposure.

BE21-B, BE21-P Baseline/budget and proposed building orientation is modeled as reported in the Compliance Form.

Review Tips

1. Use the simulation reports listed below to verify that the modeled exposure is as reported in the Compliance Form.

eQUEST Reports	LV-D, results for the four baseline orientations must be averaged externally
Trane TRACE 700	LEED Summary Section 1.6
Trane TRACE 3D Plus	Envelope Summary report Azimuth/Cardinal Direction columns

IESVE SOFTWARE	Model Orientation and Rotation Check Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Input Verification and Results Summary' report
OpenStudio	eplustbl.html 'Input Verification and Results Summary' report
Carrier HAP v5	"LEED Summary" report, Section 2, "Minimum Energy Performance Calculator", table titled "Above Grade Wall and Vertical Glazing Areas".
Design Builder	Output_Performance_1 sheet in LEED Minimum Energy Performance Calculator

BE22-P Proposed interior and exterior shading is established correctly in the Compliance Form

90.1 2016/2019 Section 11

Table 11.5.1 #5, Proposed Building Design column Exception 4

Manually operated fenestration shading devices, such as blinds or shades, must not be modeled. Permanent shading devices, such as fins, overhangs, and light shelves, must be modeled.

90.1 2016/2019 Appendix G

Table G3.1 Proposed Building Performance Column No 5 (a #4,5)

- Manual fenestration shading devices, such as blinds or shades, must be modeled or not modeled the same as in the baseline building design.
- Automatically controlled fenestration shades or blinds must be modeled.
- Permanent shading devices, such as fins, overhangs, and light shelves must be modeled.
- Automatically controlled dynamic glazing may be modeled. Manually controlled dynamic glazing must use the average of the minimum and maximum SHGC and VT.

Table G3.1 Proposed Building Performance column #14 (a)

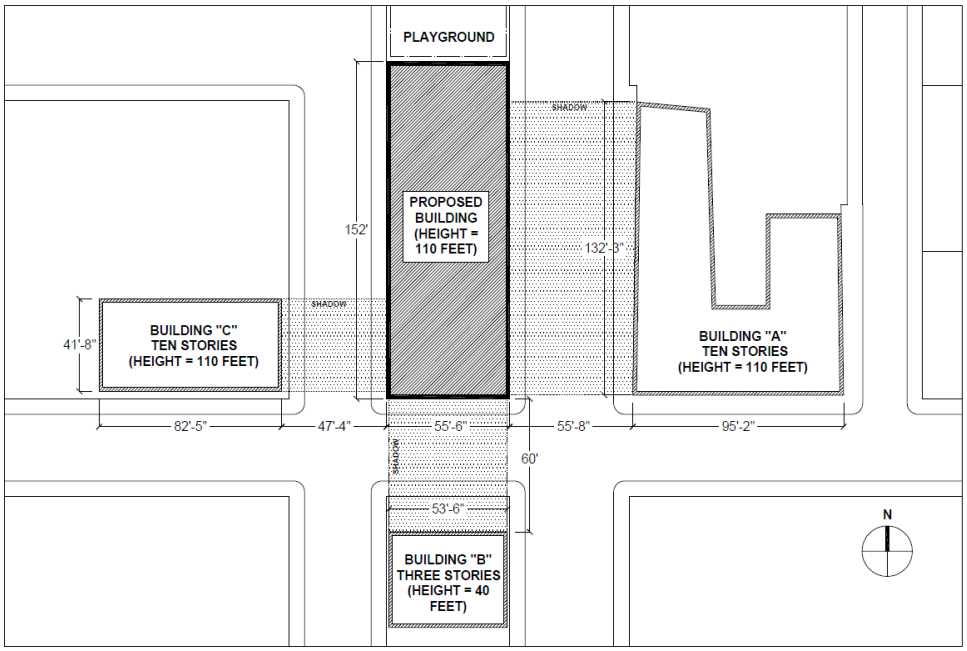
- All elements whose effective height is greater than their distance from a proposed building and whose width facing the proposed building is greater than one-third that of the proposed building shall be accounted for in the analysis.

G1.3 (g)

- A site plan showing all adjacent *buildings* and topography that may shade the proposed *building* (with estimated height or number of stories).

Review Tips

1. For Appendix G projects, review the site plan showing all adjacent *buildings* and topography that may shade the proposed building with the estimated height or number of stories (Submittal Checklist tab #8). An example of site shading documentation is provided below.



2. Exterior and interior shading of the proposed design is described in the Envelope Areas tab Table 6. The applicable 90.1 modeling rules are shown in the table and may be over-written by the modeler. The over-written values are shown in brown font. If any of the values are overwritten, the changes must be described in the notes below the table. Confirm that modeling approach aligns with 90.1 rules stated above.
3. The check should be performed on projects located in Climate Zones 0-5.

BE22-B Baseline/Budget interior and exterior shading is established correctly in the Compliance Form

90.1 2016/2019 Section 11

Table 11.5.1 Column B #5 (c)

No shading projections are to be modeled; fenestration is assumed to be flush with the wall or roof.

90.1 2016/2019 Appendix G

Table G3.1 Baseline Building Performance column #5 (d)

- All vertical fenestration shall be assumed to be flush with the exterior wall, and no shading projections shall be modeled.
- Manual window shading devices such as blinds or shades are not required to be modeled.

Table G3.1 Proposed Building Performance column #14

Shading by adjacent structures and terrain must be the same as in the proposed design.

Review Tips

1. Exterior and interior shading of the proposed design is described in the Envelope Areas tab Table 6. The applicable 90.1 modeling rules are shown in the table and may be over-written by the modeler. The over-written values are shown in brown font. If any of the values are overwritten, the changes must be described in the notes below the table. Confirm that modeling approach aligns with 90.1 rules stated above.

2. The shading is especially important in climate zones where cooling is significant, such as Climate Zones 0-5, and where fenestration area is relatively large

BE23-B, BE23-P Baseline/Budget and proposed interior shading is modeled as reported in the Compliance Form

Review Tips

1. Review simulation reports to confirm that interior and exterior shading is modeled as reported in the Compliance Form.
2. The check should be performed on projects located in Climate Zones 0-5.

Lighting, Interior (LI)

Overview

Lighting Interior check group addresses interior lighting power and controls. Table 7 summarizes the checks included in this group.

Table 7: Lighting Interior Quality Control Checks Overview

	Type of Check	Proposed Design	Baseline/Budget Design
General	CF inputs reflect design documents	LI01	NA
	Simulation outputs consistent with CF	LI11	NA
Lighting Power	CF inputs reflect design documents	LI02-P	NA
	CF inputs reflect requirements of 11/G	LI03	LI03
	Meet mandatory requirements	NA	NA
	Simulation inputs consistent with CF	LI07	LI07
	Simulation outputs consistent with CF	LI06	LI06
Lighting Controls	CF inputs reflect design documents	LI04-P	NA
	CF inputs reflect requirements of 11/G	NA	LI04-B
	Meet mandatory requirements	LI05	NA
	Simulation inputs consistent with CF	LI08, LI09	LI08, LI09
	Simulation outputs consistent with CF	LI10	LI10
LEGEND			
PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form			

The following strategies should be used to prioritize the review:

1. For checks that verify the specified fixture wattages, focus on fixtures that account for the largest total wattage on the project and spot-check the rest.
2. For checks that verify the specified fixture counts, focus on space types that account for the largest total wattage and spot-check the rest.
3. For checks that verify that the lighting wattage is modeled as reported, check the thermal blocks that account for the highest wattage.

4. 90.1 Section 9 requires occupancy sensors and daylighting controls in many types of spaces. These requirements are mandatory and must be met where applicable. Perform the checks to verify that mandatory requirements are met for a representative sample of spaces selected as described in #2 above.

Refer to the table included in the Quality Control Checks, Lighting Interior section that ranks lighting fixtures, space types and thermal blocks based on their total wattage to facilitate the prioritization described above.

Space Type, Thermal Block, and Fixture Type Rank by Total Wattage

Rank based Upon Total Wattage Associated with Each	Space Types	Thermal Blocks	Fixture Types
	Name, Total Wattage	Name, Total Wattage	Name, Total Wattage
1	Dwelling Unit, 45,600	Retfl1Sales, 5,904	E, 17,712
2	Sales Area, 17,712	Retfl2Sales, 5,904	D, 3,840
3	Corridor/All Other, 2,610	Retfl3Sales, 5,904	A, 2,610
4	Storage Room/≥50 ft^2, 2,400	MF1ESE Perim Spc (M.ESE15), 4,620	C, 1,426
5	Stairwell, 1,196	MF1WSW Perim Spc (M.WSW22), 4,620	
6	Lounge/Breakroom/All Other, 768	MF1ENE Perim Spc (M.ENE18), 4,578	
7	Office/Enclosed, 480	MF1WNW Perim Spc (M.WNW19), 4,578	
8	Storage Room/<50 ft^2, 230	MF1East Perim Spc (M.E17), 4,524	
9	Restroom/ All Other, 192	MF1West Perim Spc (M.W20), 4,524	
10		MF1East Perim Spc (M.E16), 4,518	

LI01 The floor area used in the lighting calculations is consistent with the reported project floor area.

Review Tips

1. In order to establish the baseline/budget lighting power allowance, the floor area of individual spaces (for projects using space-by-space method) or building area types (for Section 11 projects using building area method) are reported in Table 1 of the Interior Lighting Counts tab. The baseline/budget lighting power allowance will not be determined correctly if the total floor area reported on the Interior Lighting Counts tab does not match the actual floor area in Table 1 of the General Information tab. Misalignment should be flagged. This check is performed automatically in the Quality Control Checks tab with discrepancies over 1% flagged. See also SG05.

LI02-P Proposed lighting power reported in the Compliance Form reflects design documents for spaces where lighting is fully specified.

90.1 2016/2019 Section 11, 90.1 2016/2019 Appendix G

90.1 Table 11.5.1 #6, Table G3.1 #6

- Where a complete lighting system exists (e.g. in a renovation project where lighting is left as is), the actual lighting power must be modeled for each thermal block.
- Where a lighting system has been designed, lighting power must be determined in accordance with 90.1 Sections 9.1.3 and 9.1.4. Based on these sections, the wattage must include all power used by the fixtures including lamps, ballasts, transformers and control devices and be based on the manufacturers' labeled maximum wattage of the luminaire. Some exceptions may apply (90.1 Sections 9.1.1, 9.1.3, 9.1.4, 9.2.2.3, 9.4.2).

- Lighting system power shall include all lighting system components shown or provided for on plans (including lamps, ballasts, task fixtures and furniture mounted fixtures).

Review Tips

1. Refer to the table in the Interior Lighting section on the Quality Control Tab to identify lighting fixtures with the highest total wattage. Focus the review on these fixtures and spot-check others. data.

Space Type, Thermal Block, and Fixture Type Rank by Total Wattage

Rank based Upon Total Wattage Associated with Each	Space Types	Thermal Blocks	Fixture Types
	Name, Total Wattage	Name, Total Wattage	Name, Total Wattage
1	Dwelling Unit, 45,600	Retfl1Sales, 5,904	E, 17,712
2	Sales Area, 17,712	Retfl2Sales, 5,904	D, 3,840
3	Corridor/All Other, 2,610	Retfl3Sales, 5,904	A, 2,610
4	Storage Room/≥50 ft^2, 2,400	MF1ESE Perim Spc (M.ESE15), 4,620	C, 1,426
5	Stairwell, 1,196	MF1WSW Perim Spc (M.WSW22), 4,620	
6	Lounge/Breakroom/All Other, 768	MF1ENE Perim Spc (M.ENE18), 4,578	
7	Office/Enclosed, 480	MF1WNW Perim Spc (M.WNW19), 4,578	
8	Storage Room/<50 ft^2, 230	MF1East Perim Spc (M.E17), 4,524	
9	Restroom/ All Other, 192	MF1West Perim Spc (M.W20), 4,524	
10		MF1East Perim Spc (M.E16), 4,518	

For these selected fixtures, locate fixture make and model on the lighting schedule drawings and verify that the manufacturer maximum rated wattage reported for the fixtures in Table of the Interior Lighting Counts tab is aligned with the manufacturer's maximum rated fixture wattage shown on the cutsheets. Request cutsheets for selected fixtures if necessary.

How were Automatic Daylighting Controls Modeled?							
Lighting Schedule Dwg #		E-105					
Fixture Label from Lighting Schedules		A	B	C	D	E	
Maximum Rated Fixture Wattage		26.1	30.1	23.0	32.0	48.0	
Exempt Lighting Application?		No	No	No	No	No	N
Decorative Lighting		No	No	No	No	No	N
Sales Area Merchandise Highlighting		No	No	No	No	No	N
109,661	Total Fixture Counts:	100	-	62	120	369	
?	?						

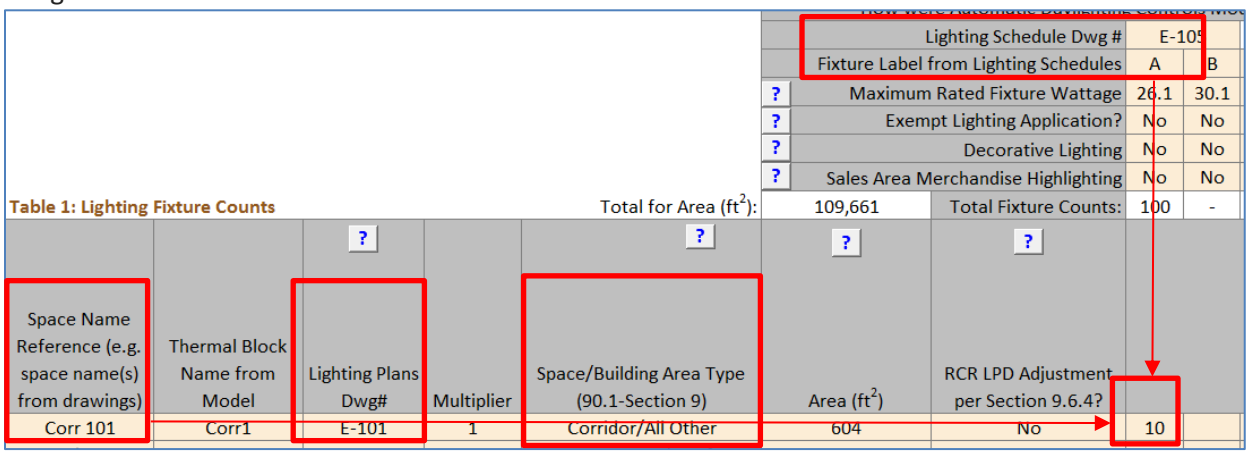
Example: Wall sconces installed in the corridors of a multifamily building are specified with two 18W CFL bulbs but have the manufacturers' rated wattage of 120 W based on incandescent bulbs. The 120W per fixture must be used in the LPD calculations for the proposed design, unless the installed fixtures are re-labeled by the manufacturer based on the CFL lamps. Thus, unless all of the specified fixtures reflect the maximum rated wattage, or the fixtures are re-labeled by the manufacturer, the total fixture wattages specified on the lighting drawings will typically be *lower* than the wattages that must be used in the lighting compliance calculations.

2. Refer to the table in the Interior Lighting section on the Quality Control Tab to identify space types that account for the greatest total lighting wattage.

Space Type, Thermal Block, and Fixture Type Rank by Total Wattage

Rank based Upon Total Wattage Associated with Each	Space Types	Thermal Blocks	Fixture Types
	Name, Total Wattage	Name, Total Wattage	Name, Total Wattage
1	Dwelling Unit, 45,600	Retfl1Sales, 5,904	E, 17,712
2	Sales Area, 17,712	Retfl2Sales, 5,904	D, 3,840
3	Corridor/All Other, 2,610	Retfl3Sales, 5,904	A, 2,610
4	Storage Room/≥50 ft^2, 2,400	MF1ESE Perim Spc (M.ESE15), 4,620	C, 1,426
5	Stairwell, 1,196	MF1WSW Perim Spc (M.WSW22), 4,620	
6	Lounge/Breakroom/All Other, 768	MF1ENE Perim Spc (M.ENE18), 4,578	
7	Office/Enclosed, 480	MF1WNW Perim Spc (M.WNW19), 4,578	
8	Storage Room/<50 ft^2, 230	MF1East Perim Spc (M.E17), 4,524	
9	Restroom/ All Other, 192	MF1West Perim Spc (M.W20), 4,524	
10		MF1East Perim Spc (M.E16), 4,518	

Locate several spaces of that type on the Interior Lighting Counts tab. Refer to the lighting plans to confirm that fixture types and counts for these spaces reported in the Compliance Form match design documents.



							Lighting Schedule Dwg #	E-105	
							Fixture Label from Lighting Schedules	A	B
						?	Maximum Rated Fixture Wattage	26.1	30.1
						?	Exempt Lighting Application?	No	No
						?	Decorative Lighting	No	No
						?	Sales Area Merchandise Highlighting	No	No
Table 1: Lighting Fixture Counts				Total for Area (ft²):	109,661		Total Fixture Counts:	100	-
Space Name Reference (e.g. space name(s) from drawings)	Thermal Block Name from Model	? Lighting Plans Dwg#	Multiplier	? Space/Building Area Type (90.1-Section 9)	? Area (ft²)	? RCR LPD Adjustment per Section 9.6.4?			
Corr 101	Corr1	E-101	1	Corridor/All Other	604	No		10	

3. Common Mistakes
   a. Fixture wattage is not based on a complete fixture including lamp and ballast and does not reflect manufacturer rated fixture wattage.
   b. Track lighting is not calculated according to the allowed methods as described in 90.1 Section 9.1.4.
   c. Proposed LPDs are based on partially specified or temporary lighting. For example, in hotel guest rooms the hardwired fixtures shown on drawings are typically supplemented by plug-in floor and table lamps. See LI03-P for the relevant rules

LI03-P Proposed LPD to be modeled for spaces where lighting is not specified or partially specified is established correctly in the Compliance Form

90.1 2016/2019 Section 11

Table 11.5.1 #6, Column A, #c: Where no lighting exists or is specified, lighting power must be determined in accordance with the Building Area Method for the appropriate building type, based on the allowances in 90.1 Section 9.

90.1 2016/2019 Appendix G

Table G3.1 #6, proposed Column, #c: Where lighting neither exists nor is submitted with the design documents, lighting power must be modeled as minimally complying with the prescriptive requirements of 90.1 Section 9, Building Area Method.

Review Tips

1. This check should be performed for projects involving hotels, models, dormitories and multifamily occupancy types, or it Table 1 on the Lighting Space Types indicated design status as “Core and Shell”, or if lighting is listed on the General Information tab, “Renovations and Yet to be Designed Systems and Components” section. This logic is used to select this check on the Quality Control Checks tab.
2. Interior Lighting Counts tab Table 1 includes a column for entering floor area for which lighting is not specified in the proposed design. This may include spaces where lighting is not specified (e.g. in core and shell projects) or where lighting is partially specified. Partially specified lighting is common in residential occupancies. For example, in hotel guestrooms, hard-wired fixtures may be specified in bathrooms and hallways, to be supplemented by plug-in table or floor lamps. These plug-in fixtures are often not shown on the lighting drawings, or the lighting plans may refer to the power and furniture plans for supplemental and task lighting.

?	Exempt Lighting Application?	No	No	No	No	No	No	No	No	No	No	No	
?	Decorative Lighting	No	No	No	No	No	No	No	No	No	No	No	Totals:
?	Sales Area Merchandise Highlighting	No	No	No	No	No	No	No	No	No	No	No	?
Total for Area (ft²):	109,661	Total Fixture Counts:	100	-	62	120	369	-	-	-	-	-	-

? Space/Building Area Type (90.1-Section 9)	? Area (ft²)	? RCR LPD Adjustment per Section 9.6.4?	FIXTURE COUNTS Enter fixture counts for each thermal block. If Rated Input Wattage is entered as W/ft², enter fixture length in linear feet (LnFt).										Area Where Proposed Lighting is Not Specified [ft²]
Corridor/All Other	604	No	10										
Storage Room/<50 ft^2	49	No			1								
Stairwell	92	No			2								
Stairwell	92	No			2								
Dwelling Unit	963	No											963
Dwelling Unit	941	No											941
Dwelling Unit	943	No											943
Dwelling Unit	954	No											954

_App_A_2016 | Lighting Space Types | **Interior Lighting Counts** | Interior Lighting Model Inputs | ...

3. On projects that include residential occupancies (hotels, motels, dormitories, multifamily) but have no inputs in the “Area where proposed lighting is not specified”, spot-check lighting plans for a sample of residential spaces to confirm that hard-wired lighting is specified in spaces such as guest rooms and is sufficient to meet IESNA-recommended lighting levels. If it is determined that lighting is not fully specified, request that the floor area with no lighting is reported in the Compliance Form as shown above.

LI03-B Baseline/budget Lighting Power Density (LPD) is established correctly in the Compliance Form

90.1 2016/2019 Section 11

Table 11.5.1 No6 Column B

The budget LPD must be determined using the same categorization procedure (building area or space-by-space method) and categories as the proposed design, with lighting power set equal to the maximum allowed for the corresponding method and category in 90.1 Section 9.2. Lighting in the proposed design that is specifically exempted in 90.1 Section 9.1.1, 9.2.2.3, or 90.1 Section 9.4.2 must be modeled in the baseline the same as in the proposed design. Exempt lighting, decorative and retail display lighting allowance can only be claimed if it is specified in addition to a general lighting and is separately controlled.

90.1 2016/2019 Appendix G

Table G3.1 #6, Baseline Building Performance column

The baseline LPD must be established using the space-by-space method based on 90.1 Table G3.7. Lighting in the proposed design that is specifically exempted in 90.1 Section 9.1.1, 9.2.2.3, or 9.4.2 must be modeled in the baseline the same as in the proposed design.

Review Tips

1. Baseline/budget interior lighting is found in the following tables of the Compliance Form:
   a. Table 1 on the Lighting Space Types tab shows whether project used space-by-space or building area method. (Only space-by-space method is allowed for Appendix G projects.)
   b. Space-by-space LPDs are shown in Table 1 of the Interior Lighting Counts tab, Baseline/Budget group of columns. These values are set automatically by the Compliance Form based on user-provided description of the building area types and space types.
2. Spot-check the baseline/budget LPDs in spaces where proposed LPD is substantially lower than the baseline/budget LPD (based on Table 1 of the Interior Lighting Counts tab). The exaggerated savings may be due to mistakes described below. LPD difference over 30% on Section 11 models and over 50% on Appendix G model should be flagged.

4. Common Mistakes
   a. Baseline LPD increased to include decorative lighting allowance
      - 90.1 Appendix G: the baseline LPD is always based on the values in 90.1 Table G3.7. There are no provisions for any additional allowances.
      - 90.1 Section 11: the baseline may be increased to include additional wattage up to the decorative lighting allowance specified in 90.1 Section 9.6.2 only if it meets the requirement of that section (e.g. is installed in addition to the general lighting, is automatically controlled separately from the general lighting and turned off during nonbusiness hours).

        Example: The proposed design includes decorative wall sconces in the corridors of a multifamily building. The sconces are controlled separately from the general ceiling lighting and have 0.7 W/ft^2 LPD calculated as described in 90.1 Section 9.1.3 and 90.1 Section 9.1.4.

Section 11: If the project used the space-by-space method, 0.7 W/ft2 can be added to the budget corridor LPD allowance. If the project uses the building area method, lighting in the budget design cannot be increased to include the decorative allowance. The proposed design must be modeled as specified and include both the general and decorative lighting.
Appendix G: the decorative lighting allowance cannot be added to the baseline. The proposed design must be modeled as specified and include both the general and decorative lighting.

b. LPD is based on an incorrect space type.
Using the incorrect space type in 90.1 Table G3.7 (Appendix G path) or 90.1 Section 9.6.1 (Section 11 path) may lead to an exaggerated baseline/budget LPD allowance.

Example: A project includes a large space that houses some mechanical equipment but is mostly used as a storage. Establishing the baseline LPD by applying the allowance for the Electrical/Mechanical space type (1.5W/SF based on Table G3.7 with PRM; 0.97 W/SF based on 90.1 Table 9.6.1 with Note 7 for ECB) to the entire space is incorrect. Instead, the baseline/budget allowance must be established by breaking the space into sub-spaces, as described in 90.1 Section 9.6.1 (a), with the storage room lighting allowance (0.63 W/SF ECB, 0.80 W/SF PRM) used for a portion of the space.

LI04-P Proposed lighting controls reported in the Compliance Form reflect design documents

90.1 2016/2019 Section 11

Table 11.5.1 #6 e,f:

- The lighting schedules in the proposed design shall reflect the mandatory automatic lighting control requirements in Section 9.4.1 (e.g., programmable controls or occupancy sensors).
- Design documents must include lighting controls required in 90.1 Section 9.4.1, since these requirements are mandatory.
- Automatic lighting controls included in the proposed design but not required by Section 9.4.1 may be modeled directly in the building simulation or be modeled in the building simulation through schedule adjustments determined by a separate analysis approved by the authority having jurisdiction. As an alternative to modeling such lighting controls, the proposed design lighting power may be reduced for each luminaire under control by dividing the rated lighting power of the luminaire per Section 9.6.3 and Table 9.6.3.

90.1 2016/2019 Appendix G

90.1 Table G3.1 #6: The specified daylighting controls must be modeled explicitly in the simulation tool, or through an adjustment determined by a separate approved analysis. Other specified automatic lighting controls included in the proposed design must be modeled by reducing the lighting schedule each hour by the Occupancy Sensor Reduction factors in 90.1 Table G3.7, including Notes b and c below the table.

Review Tips

1. Lighting controls specified for each space are reported in Table 1 of the Interior Lighting Counts tab. Spot-check large or representative space types (e.g., offices, corridors and conference rooms in an office building) to confirm that the specified lighting controls reported for these spaces in the Compliance Form reflect design documents.

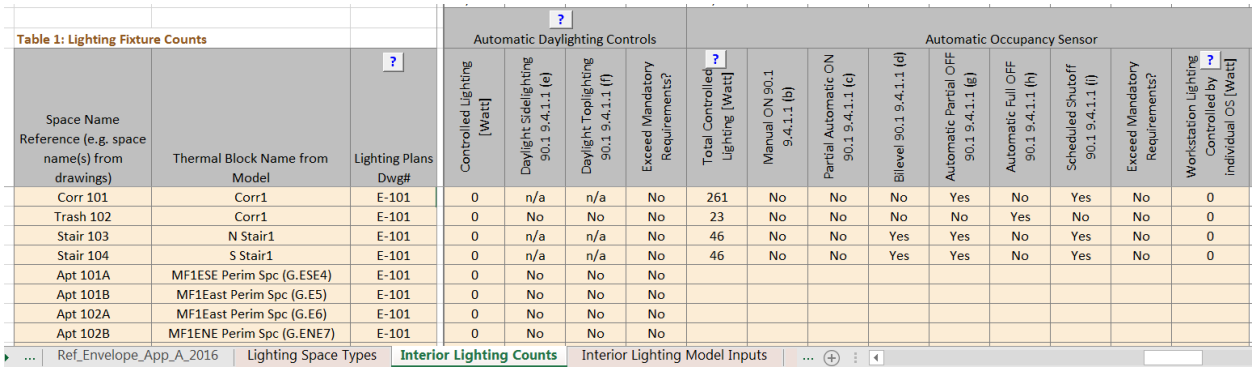


Table 1: Lighting Fixture Counts

Space Name Reference (e.g. space name(s) from drawings)	Thermal Block Name from Model	Lighting Plans Dwg#	Automatic Daylighting Controls: Controlled Lighting [Watt]	Daylight Sidelighting 90.1 9.4.1.1 (e)	Daylight Toplighting 90.1 9.4.1.1 (f)	Exceed Mandatory Requirements?	Automatic Occupancy Sensor: Total Controlled Lighting [Watt]	Manual ON 90.1 9.4.1.1 (b)	Partial Automatic ON 90.1 9.4.1.1 (c)	Bilevel 90.1 9.4.1.1 (d)	Automatic Partial OFF 90.1 9.4.1.1 (g)	Automatic Full OFF 90.1 9.4.1.1 (h)	Scheduled Shutoff 90.1 9.4.1.1 (i)	Exceed Mandatory Requirements?	Workstation Lighting Controlled by individual OS [Watt]
Corr 101	Corr1	E-101	0	n/a	n/a	No	261	No	No	No	Yes	No	Yes	No	0
Trash 102	Corr1	E-101	0	No	No	No	23	No	No	No	No	Yes	No	No	0
Stair 103	N Stair1	E-101	0	n/a	n/a	No	46	No	No	Yes	Yes	No	Yes	No	0
Stair 104	S Stair1	E-101	0	n/a	n/a	No	46	No	No	Yes	Yes	No	Yes	No	0
Apt 101A	MF1ESE Perim Spc (G.ESE4)	E-101	0	No	No	No									
Apt 101B	MF1East Perim Spc (G.E5)	E-101	0	No	No	No									
Apt 102A	MF1East Perim Spc (G.E6)	E-101	0	No	No	No									
Apt 102B	MF1ENE Perim Spc (G.ENE7)	E-101	0	No	No	No									

... | Ref_Envelope_App_A_2016 | Lighting Space Types | **Interior Lighting Counts** | Interior Lighting Model Inputs | ...

2. Credit for daylighting and OS controls must only be applied to the portion of lighting in each thermal block that is being controlled and not to all lighting in the thermal block. The controlled wattage withing each space must be listed in the Compliance Form. Verify that it matches the design documents.

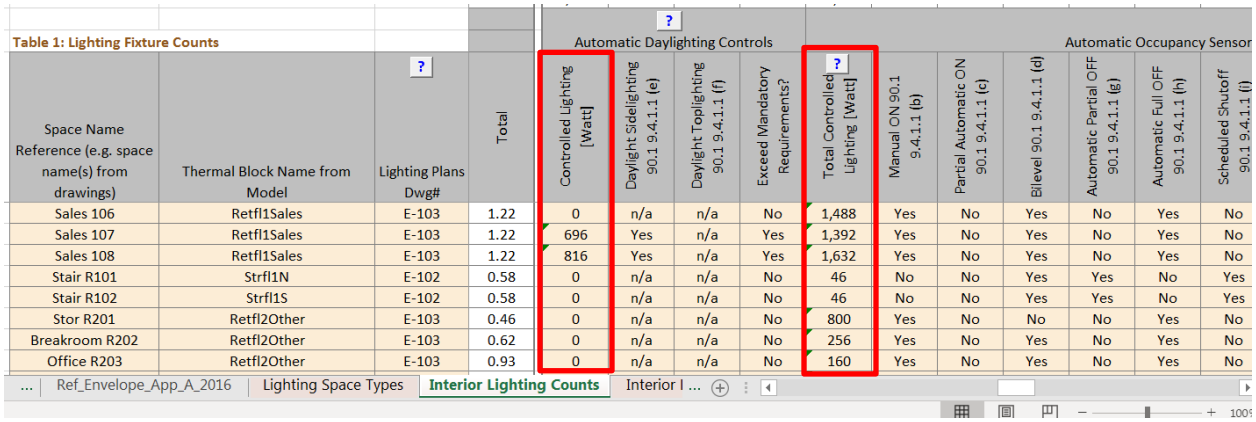


Table 1: Lighting Fixture Counts

Space Name Reference (e.g. space name(s) from drawings)	Thermal Block Name from Model	Lighting Plans Dwg#	Total	Automatic Daylighting Controls: Controlled Lighting [Watt]	Daylight Sidelighting 90.1 9.4.1.1 (e)	Daylight Toplighting 90.1 9.4.1.1 (f)	Exceed Mandatory Requirements?	Automatic Occupancy Sensor: Total Controlled Lighting [Watt]	Manual ON 90.1 9.4.1.1 (b)	Partial Automatic ON 90.1 9.4.1.1 (c)	Bilevel 90.1 9.4.1.1 (d)	Automatic Partial OFF 90.1 9.4.1.1 (g)	Automatic Full OFF 90.1 9.4.1.1 (h)	Scheduled Shutoff 90.1 9.4.1.1 (i)
Sales 106	Retfl1Sales	E-103	1.22	0	n/a	n/a	No	1,488	Yes	No	Yes	No	Yes	No
Sales 107	Retfl1Sales	E-103	1.22	696	Yes	n/a	Yes	1,392	Yes	No	Yes	No	Yes	No
Sales 108	Retfl1Sales	E-103	1.22	816	Yes	n/a	Yes	1,632	Yes	No	Yes	No	Yes	No
Stair R101	Strfl1N	E-102	0.58	0	n/a	n/a	No	46	No	No	Yes	Yes	No	Yes
Stair R102	Strfl1S	E-102	0.58	0	n/a	n/a	No	46	No	No	Yes	Yes	No	Yes
Stor R201	Retfl2Other	E-103	0.46	0	n/a	n/a	No	800	Yes	No	No	No	Yes	No
Breakroom R202	Retfl2Other	E-103	0.62	0	n/a	n/a	No	256	Yes	No	Yes	No	Yes	No
Office R203	Retfl2Other	E-103	0.93	0	n/a	n/a	No	160	Yes	No	Yes	No	Yes	No

... | Ref_Envelope_App_A_2016 | Lighting Space Types | **Interior Lighting Counts** | Interior I ...

3. Tips for Section 11 projects
   - Only the lighting controls in the proposed design that exceed the minimum requirements of 90.1 Section 9.4.1 may be modeled differently in the proposed design compared to the baseline. Examples of controls that exceed the minimum requirements include but are not limited to the occupancy sensors and daylighting controls where they are not required in 90.1 Section 9.4.1, Manual on control where it is not required, automatic full off where only partial off is required, continuous dimming where not required and lumen maintenance controls.
   - The standard does not specify the schedule adjustments to be used for capturing occupancy sensor savings, thus the values from 90.1 Table G3.7 Occupancy Sensor Reduction column should be used.

LI05-P Specified lighting controls meet mandatory requirements in 90.1 Section 9

Review tips

1. Table 1 of the Interior Lighting Counts tab lists the mandatory lighting control requirements for each space depending on the space type. The lighting control requirements in 90.1 2016 are significantly more comprehensive compared to 90.1 2010 - for example, many spaces with windows must have daylighting controls. Spot-check lighting controls specified in the design document for a sample of typical spaces to ensure that they meet the mandatory lighting requirements shown in the Compliance Form.

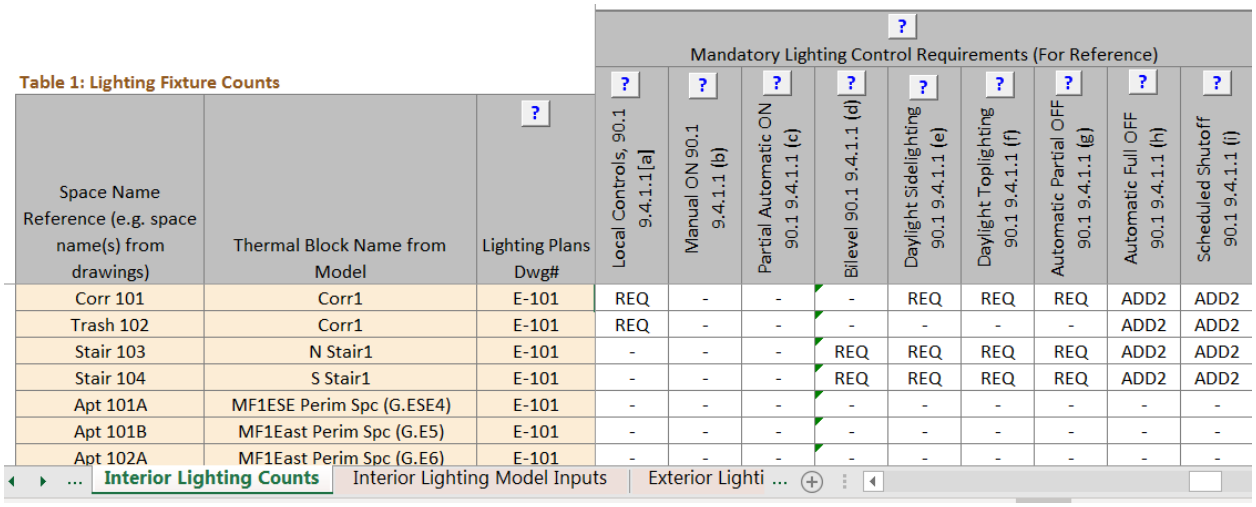


Table 1: Lighting Fixture Counts

Space Name Reference (e.g. space name(s) from drawings)	Thermal Block Name from Model	Lighting Plans Dwg#	Mandatory Lighting Control Requirements (For Reference)								
			Local Controls, 90.1 9.4.1.1[a]	Manual ON 90.1 9.4.1.1 (b)	Partial Automatic ON 90.1 9.4.1.1 (c)	Bilevel 90.1 9.4.1.1 (d)	Daylight Sidelighting 90.1 9.4.1.1 (e)	Daylight Toplighting 90.1 9.4.1.1 (f)	Automatic Partial OFF 90.1 9.4.1.1 (g)	Automatic Full OFF 90.1 9.4.1.1 (h)	Scheduled Shutoff 90.1 9.4.1.1 (i)
Corr 101	Corr1	E-101	REQ	-	-	-	REQ	REQ	REQ	ADD2	ADD2
Trash 102	Corr1	E-101	REQ	-	-	-	-	-	-	ADD2	ADD2
Stair 103	N Stair1	E-101	-	-	-	REQ	REQ	REQ	REQ	ADD2	ADD2
Stair 104	S Stair1	E-101	-	-	-	REQ	REQ	REQ	REQ	ADD2	ADD2
Apt 101A	MF1ESE Perim Spc (G.ESE4)	E-101	-	-	-	-	-	-	-	-	-
Apt 101B	MF1East Perim Spc (G.E5)	E-101	-	-	-	-	-	-	-	-	-
Apt 102A	MF1East Perim Spc (G.E6)	E-101	-	-	-	-	-	-	-	-	-

... Interior Lighting Counts | Interior Lighting Model Inputs | Exterior Lighti ...

2. This check is performed automatically in the Compliance Form.

LI05–B Baseline/budget lighting controls are established correctly in the Compliance Form

90.1 2016/2019 Section 11

Table 11.5.1 #6 c: Mandatory automatic lighting controls required by Section 9.4.1 must be modeled the same as the proposed design.

Daylighting controls must be modeled explicitly in the simulation tool, or as an adjustment determined by a separate approved analysis. The standard does not specify the schedule adjustments to be used for capturing occupancy sensor savings, thus the values from Table G3.7 Occupancy Sensor Reduction column should be used.

90.1 2016/2019 Appendix G

Table G3.1 #6: No occupancy or daylighting controls should be modeled, except the lighting schedules for the employee lunch and break rooms, conference/meeting rooms and classrooms (not including shop classrooms, laboratory classrooms and preschool through 12th-grade classrooms) must reflect the reduced runtime hours due to occupancy sensors.

Review Tips

1. Baseline/budget lighting controls for each space are determined automatically and are shown in Table 1 of the Interior Lighting Counts tab of the Compliance form. This check is automatically completed in the Quality Control Checks tab of the Compliance Form.

LI06-B Modeled interior lighting peak demand is consistent with the baseline interior lighting wattage reported in the Compliance Form

Review Tips

1. Table 2 of the Compliance Calculations tab shows non-coincident peak demand for interior lighting. The value is taken from the simulation reports and reflects the maximum modeled interior lighting load (kW). Peak lighting demand depends on the modeled lighting wattage, the hourly lighting schedule, adjustments to the hourly schedule to reflect reduced runtime due to occupancy sensors (if applicable) and modeled daylighting controls. The modeled interior lighting peak demand may be compared to the interior lighting wattage reported on the Interior Lighting Model Inputs tab Table 1 to verify the following for Appendix G projects:

   $MLD_{base} > TLW_{base}$ indicates an error in the baseline model because the modeled non-coincident peak demand cannot exceed the maximum wattage reported in the Compliance Form. When this check fails, the model inputs or the baseline lighting wattage reported in the Compliance Form must be corrected.

   MLD = modeled noncoincident lighting peak demand from simulation reports[kW]
   TLW = total lighting wattage from Table 1 of the Lighting Model Inputs tab [kW]

   Optionally, a similar check may be completed for Appendix G proposed design and Section 11 budget and proposed design. However, for these models the coincident peak demand is expected to be lower than the total lighting wattage reported in the compliance form due to occupancy sensor and daylighting controls. A multiplier of 0.7 may be used to roughly approximate the impact of such controls on coincident demand, as follows:

   MLD prop < 0.7*TLW prop
   MLD budget >0.7* TLW budget

As part of this check, it is also helpful to verify that the non-coincident lighting peak demand reported in the Compliance Calculations tab Table 2 matches simulation reports.

eQUEST Reports	PS-E
Trane TRACE 700	LEED Summary Section 1.6
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Demand End Use Components Summary' report, 'End Uses' section
OpenStudio	eplustbl.html 'Demand End Use Components Summary' report, 'End Uses' section
Carrier HAP v5	"LEED Summary" report, Section 2, "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use".
Design Builder	LEED Summary Reports in Output Summary Document

LI07-B, LI07-P Baseline/budget and proposed wattage entered into simulation tool reflects values reported in the Compliance Form.

Review Tips

Proposed and baseline (budget) LPDs and floor areas may be correctly reported in the submittal, but not match the modeling inputs. For example, there may be a difference in the areas of different space types reported in the submittal compared to what was modeled due to incorrect assignment of the space types to the modeled thermal blocks. Depending on the reporting capabilities of the simulation tool, the following steps should be followed to verify the inputs.

a. Review simulation reports to confirm that the total modeled baseline (budget) and proposed wattage reported in the Compliance Form matches the modeled values.

b. Spot-check simulation reports showing inputs for individual thermal blocks, to confirm that the entered baseline (budget) and proposed LPDs reflect the values reported in Table 2 of the Interior Lighting Model Inputs tab. Focus on the larger thermal blocks with high lighting wattage, as input discrepancies for these thermal blocks may be impactful, and spot-check the rest. Refer to the table in the Interior Lighting section on the Quality Control Tab to identify thermal blocks that account for the greatest total lighting wattage.

Space Type, Thermal Block, and Fixture Type Rank by Total Wattage

Rank based Upon Total Wattage Associated with Each	Space Types	Thermal Blocks	Fixture Types
	Name, Total Wattage	Name, Total Wattage	Name, Total Wattage
1	Dwelling Unit, 45,600	Retfl1Sales, 5,904	E, 17,712
2	Sales Area, 17,712	Retfl2Sales, 5,904	D, 3,840
3	Corridor/All Other, 2,610	Retfl3Sales, 5,904	A, 2,610
4	Storage Room/≥50 ft^2, 2,400	MF1ESE Perim Spc (M.ESE15), 4,620	C, 1,426
5	Stairwell, 1,196	MF1WSW Perim Spc (M.WSW22), 4,620	
6	Lounge/Breakroom/All Other, 768	MF1ENE Perim Spc (M.ENE18), 4,578	
7	Office/Enclosed, 480	MF1WNW Perim Spc (M.WNW19), 4,578	
8	Storage Room/<50 ft^2, 230	MF1East Perim Spc (M.E17), 4,524	
9	Restroom/ All Other, 192	MF1West Perim Spc (M.W20), 4,524	
10		MF1East Perim Spc (M.E16), 4,518	

Some of the modeled thermal blocks include spaces of different types, thus the modeled baseline (budget) LPD for some thermal blocks may represent area-weighted average of the LPDs prescribed by the standard for individual space types. For example, if 75% of the floor area in a thermal block is an office occupancy (1.1 W/SF PRM baseline LPD) and the remaining 25% is a restroom occupancy (0.9 W/SF PRM baseline LPD), the baseline LPD of 1.1*0.75+0.9*0.25=1.05 W/SF should be modeled. These calculations are automated in the compliance form with the results included in the Lighting Model Inputs, Table 2.

eQUEST Reports	LV-B, CSV Space Loads Report
Trane TRACE 700	Room Information entered values report
Trane TRACE 3D Plus	Lighting and Daylighting Summary report

IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Lighting Summary' report, 'Interior Lighting' section
OpenStudio	eplustbl.html 'Lighting Summary' report, 'Interior Lighting' section
Carrier HAP v5	"Space Input Data" report.
Design Builder	Lighting sheet in LEED Minimum Energy Performance Calculator (.xlsm)

LI08-B, LI08-P Occupancy sensor controls in the baseline/budget and proposed design are modeled as reported in the Compliance Form

Since occupancy sensors are modeled by reducing hourly values in the lighting schedule, the review should focus on verifying that modified schedule reflect the occupancy sensors reported in the compliance form including the following:

a. Reduction in hourly lighting schedule fractions does not exceed the allowed limit
b. Reduction in hourly lighting schedule fractions is only applied to modeled lighting power for which occupancy sensors are specified and not all lighting.

eQUEST Reports	
Trane TRACE 700	
Trane TRACE 3D Plus	
IESVE SOFTWARE	
EnergyPlus	
OpenStudio	
Carrier HAP v5	
Design Builder	

LI09-B, LI09-P Daylighting controls in the baseline/budget and proposed design are modeled as reported in the Compliance Form

Verify simulation reports to confirm that daylighting controls are modeled as reported in the Compliance Form. Focus on the following:

a. Daylighting controls are applied only to the lighting fixtures that have such controls based on the information provided in the Compliance Form
b. Modeled daylighting control settings are as specified including but not limited to the target illuminance levels and continuous versus stepped dimming.

eQUEST Reports	
Trane TRACE 700	
Trane TRACE 3D Plus	
IESVE SOFTWARE	
EnergyPlus	
OpenStudio	

Carrier HAP v5	
Design Builder	

LI10 Modeled interior lighting runtime hours are realistic

Review Tips

1. The check is automatically performed in the Quality Control Checks tab of the Compliance Form.
2. Modeled lighting schedules describe how lights are used throughout the day and during different days of the week (e.g., weekdays vs weekends). The lighting schedules are comprised of 8760 values that represent percentage of the design wattage that is lit during each hour of the year. Hourly value of 1 indicates that 100% of the specified lighting is on during that hour. Hourly value of 0.05 indicates that 5% of the specified lighting is on during that hour. Effective Full Load Hours (EFLH) is equal to the sum of the hourly schedule fractions over the year. EFLH represent the number of hours lights must be fully on in order to consume the equivalent amount of energy.

   EFLH = LEU / TLW
   LEU = simulated annual lighting energy use [kWh]
   TLW = total lighting wattage from Table 1 of the Lighting Model Inputs tab [kW]

   90.1 Section 9.4.1.1 requires turning off most non-emergency lights during unoccupied periods. Furthermore, during the hours when the building is occupied, not all lights are on at all times due to occupancy sensors, daylighting controls and use of manual lighting controls. Typical lighting EFLH for common building types without accounting for controls are included in Appendix C to this Manual.
3. EFLH may be used to perform the following checks:
   a) EFLH in the Appendix G baseline do not exceed typical provided in Appendix C. While EFLHs significantly higher (e.g. by more than 20%) than those provided in Appendix C may be justified by non-standard building operation (e.g. an office building occupied 16 hours a day), unrealistic values should be flagged by reviewers because it exaggerates the lighting-related performance penalty/credit. Too low EFLH underestimates the lighting penalty/credit.
   b) EFLH for Section 11 budget and proposed design models are the same unless proposed design has improved lighting controls reported in Table 1 of the Interior Lighting Counts tab

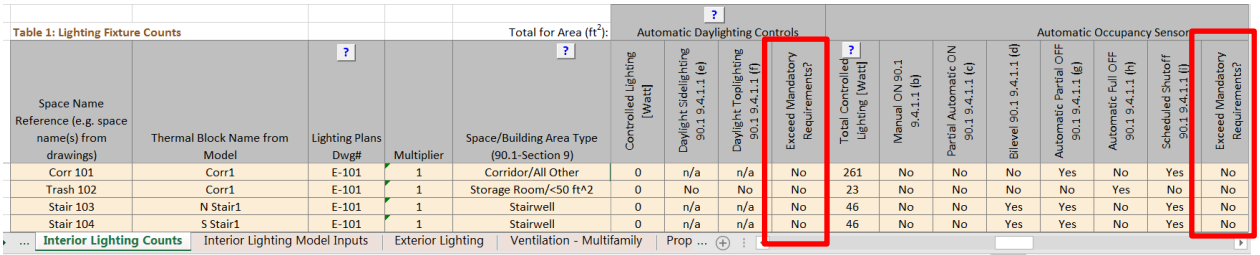


Table 1: Lighting Fixture Counts — Total for Area (ft²):

Space Name Reference (e.g. space name(s) from drawings)	Thermal Block Name from Model	Lighting Plans Dwg#	Multiplier	Space/Building Area Type (90.1-Section 9)	Automatic Daylighting Controls: Controlled Lighting [Watt]	Daylight Sidelighting 90.1 9.4.1.1 (e)	Daylight Toplighting 90.1 9.4.1.1 (f)	Exceed Mandatory Requirements?	Automatic Occupancy Sensor: Total Controlled Lighting [Watt]	Manual ON 90.1 9.4.1.1 (b)	Partial Automatic ON 90.1 9.4.1.1 (c)	Bilevel 90.1 9.4.1.1 (d)	Automatic Partial OFF 90.1 9.4.1.1 (g)	Automatic Full OFF 90.1 9.4.1.1 (h)	Scheduled Shutoff 90.1 9.4.1.1 (i)	Exceed Mandatory Requirements?
Corr 101	Corr1	E-101	1	Corridor/All Other	0	n/a	n/a	No	261	No	No	No	Yes	No	Yes	No
Trash 102	Corr1	E-101	1	Storage Room/<50 ft^2	0	No	No	No	23	No	No	No	No	Yes	No	No
Stair 103	N Stair1	E-101	1	Stairwell	0	n/a	n/a	No	46	No	No	Yes	Yes	No	Yes	No
Stair 104	S Stair1	E-101	1	Stairwell	0	n/a	n/a	No	46	No	No	Yes	Yes	No	Yes	No

... | Interior Lighting Counts | Interior Lighting Model Inputs | Exterior Lighting | Ventilation - Multifamily | Prop ...

eQUEST Reports	BEPU
Trane TRACE 700	LEED Summary Section 1.6

Trane TRACE 3D Plus	Lighting and Daylighting Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Lighting Summary' report, 'Interior Lighting' section
OpenStudio	eplustbl.html 'Lighting Summary' report, 'Interior Lighting' section
Carrier HAP v5	"LEED Summary" report, Section 2, "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use".
Design Builder	LEED Summary Reports in Output Summary Document

LI11 The difference in the interior lighting annual energy use of the baseline(budget) and proposed design is reasonable

Review Tips

1. The difference between the baseline (budget) and proposed annual lighting energy use (kWh) is driven by the difference in the lighting wattages and controls of the two models. The expected patterns are described below.

   $TLW_{prop} * LCC / LTW_{budget} \sim LEU_{prop} / LEU_{budget}$

   LCC = proposed design lighting controls credit.

   - For Appendix G, LCC=0.7 may be assumed (i.e. ~30% reduction in lighting energy due to 90.1 mandatory lighting controls and any additional controls that are specified).
   - For Section 11, LCC=1 if the proposed design does not have any lighting controls in addition to those required by 90.1 2016, or ~ 0.9 if additional lighting controls are specified.

   Difference in the lighting energy use between baseline/budget and proposed design that does not follow this expected pattern may indicate that lighting was not simulated correctly and should be flagged in the review. However, the expected change in lighting energy use may be different on projects using space-by-space method, as shown in examples below.

   Example 1: 60,000 SF dormitory building includes 30,000 SF of dorm rooms (dormitory living quarters space type) with 0.3 W/SF specified lighting and 30,000 SF corridors (corridor space type) with 0.8 W/SF specified lighting. Corridor lighting has bilevel occupancy sensor controls meeting the minimum requirements in 90.1 Table 9.6.1. The project follows ECB and uses the building area method for the lighting calculations

   Based on 90.1 Table 9.5.1, the building area allowance is 0.61W/SF (90.1 Table 9.5.1). This LPD must be modeled for all spaces in the budget model. The proposed LPD is (30,000*0.3+30,000*0.8)/60,000=0.55 and must be modeled in all spaces. The annual lighting energy use in the proposed design is expected to be 0.55/0.61 ~ 90% of the budget lighting energy use.

   Example 2: Same project as in Example 1, but space-by-space method is used.

90.1 Table 9.6.1 has an allowance of 0.54 W/SF for dormitory living quarters and 0.66 W/SF for corridors. Lights are typically on 3-4 hours per day in the living quarters and 24 hours per day in corridors. Based on 90.1 Table G3.7, bi-level lighting controls in corridors result in 25% runtime reduction that will be applied to both the budget and proposed lighting. Based on the above assumptions, the proposed lighting energy use is expected to be (0.3*30,000*4+0.8*30,000*24*(1-0.25)/(0.54*30,000*4+0.66*30,000*24*(1-0.25)) ~ 110% of the budget lighting energy use.

eQUEST Reports	BEPU
Trane TRACE 700	LEED Summary Section 1.6
Trane TRACE 3D Plus	Lighting and Daylighting Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Lighting Summary' report, 'Interior Lighting' section
OpenStudio	eplustbl.html 'Lighting Summary' report, 'Interior Lighting' section
Carrier HAP v5	"LEED Summary" report, Section 2, "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use".
Design Builder	LEED Summary Reports in Output Summary Document

Lighting, Exterior (LE)

Overview

Lighting Exterior check group addresses exterior lighting and controls. Table 8 summarizes the checks included in this group.

Table 8: Lighting, Exterior Checks Overview

	Type of Check	Proposed Design	Baseline/Budget Design
Lighting Power	CF inputs reflect design documents	LE01-P	NA
	CF inputs reflect requirements of 11/G	NA	LE01-B
	Meet mandatory requirements	LE02-P	NA
	Simulation inputs consistent with CF	LE03-P	LE03-B
	Simulation outputs consistent with CF	NA	NA
Lighting Controls	CF inputs reflect design documents	LE04-P	NA
	CF inputs reflect requirements of 11/G	NA	LE04-B
	Meet mandatory requirements	LE05-P	NA
	Simulation inputs consistent with CF	NA	NA
	Simulation outputs consistent with CF	LE06-P, LE07	LE06-B, LE07
LEGEND			
PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form			

The following strategies may be used to prioritize the review:

1. For checks that verify the specified fixture wattages, focus on fixtures that account for the largest total exterior wattage on the project and spot-check the rest.
2. For checks that verify the specified fixture counts, focus on exterior application types that account for the largest total wattage and spot-check the rest.
3. Exterior lighting allowances and controls prescribed in 90.1 Section 9 are mandatory and must be met where applicable. Perform the checks to verify that mandatory requirements are met using the prioritization techniques described in #1 and 2 above.
4. For Section 11 projects, exterior lighting trade-offs are not allowed (i.e., the exterior lighting is not an impactful end use), thus review is limited to verifying that the reported exterior lighting wattage and controls are as specified and meet the mandatory requirements.

LE01-B Baseline/Budget exterior lighting Power is established correctly in the Compliance Form

90.1 2016/2019 Appendix G

Table G3.1 No 6, Baseline Building Performance column

Exterior lighting in areas identified as “Tradable Surfaces” in Table G3.6 must be modeled with the baseline lighting power shown in Table G3.6. Other exterior lighting must be modeled the same in the baseline building design as in the proposed design.

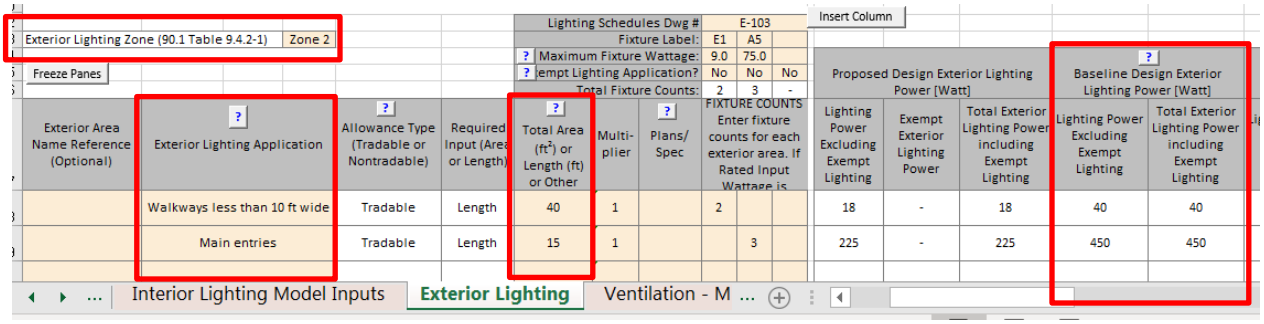
90.1 2016/2019 Section 11

Table 11.5.1 No 1 Column B

Except as specifically instructed in this table, all building systems and equipment must be modeled identically in the budget building design and proposed design. Exterior lighting is not explicitly listed in Table 11.5.1, this is not a trade-off opportunity and must be modeled the same in the Budget building as specified in the proposed design.

Review Tips

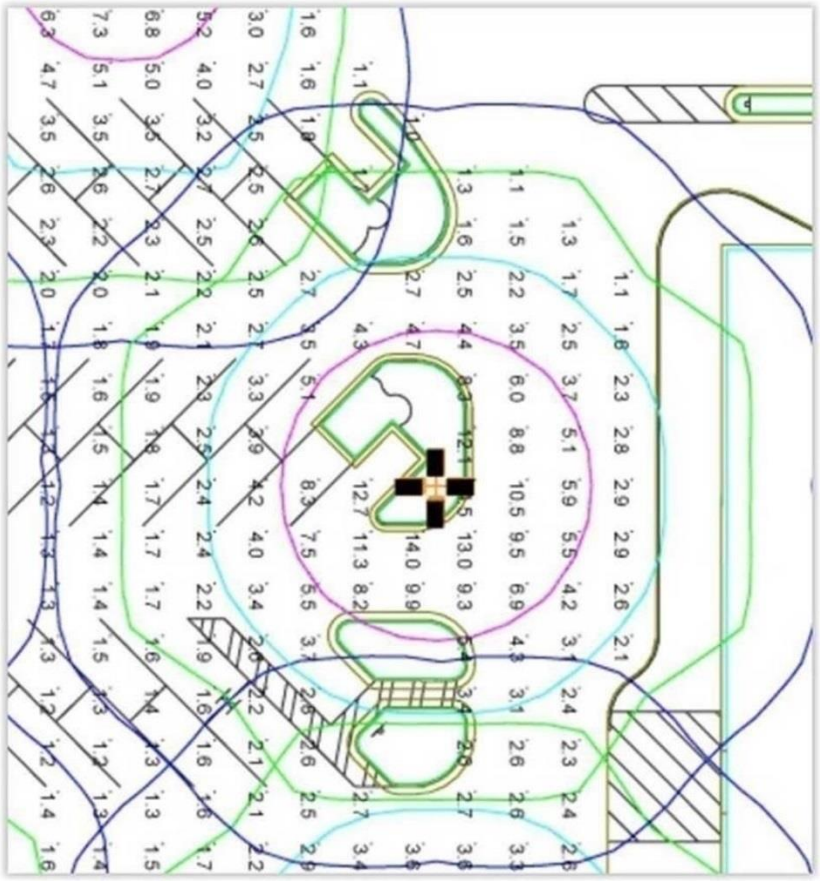
1. Baseline/budget exterior lighting wattage is shown in Table 1 of the Exterior Lighting tab. It is established automatically based on the following user inputs:
    a. Project's exterior lighting zone based on 90.1 Table 9.4.2-1
    b. Exterior lighting applications for which lighting is specified in the proposed design
    c. The surface area or length of the exterior lighting application (e.g., area of the parking that or length of entrance door) that has exterior lighting specified in the proposed design.



2. Confirm that an appropriate exterior lighting zone is selected for the project based on the definitions below from Table 9.4.3-1:
    a. Zone 0: Undeveloped areas within national parks, state parks, forest land, rural areas, and other undeveloped areas as defined by the authority having jurisdiction
    b. Zone 1: Developed areas of national parks, state parks, forest land, and rural areas
    c. Zone 2: Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
    d. Zone 3: All other areas
    e. Zone 4: High-activity commercial districts in major metropolitan areas as designated by the local jurisdiction

    Some AHJ and RAs may specify the exterior lighting zones that must be used based on the project address.

2. Use Table 1 of the Exterior Lighting tab to identify exterior lighting applications with the greatest different in wattage between the baseline and proposed design. Refer to the exterior lighting plans drawings to confirm that entered surface area or length are not exaggerated. The input must reflect the area or length of the surface in the proposed building that is illuminated to some industry standard, such as the IESNA Handbook. It is the responsibility of the design team to identify the illumination design standard and the area actually illuminated, as illustrated in the following figure.



a. Only the areas that are illuminated without obstruction may be included.
b. Each portion of the illuminated area must only be assigned one lighting application consistent with the actual use of the area. Any overlapping area of another lighting application, such as a pathway crossing the parking lot, must be subtracted from the area of the other lighting application.
c. The allowed area of a site roadway, driveway, sidewalk, walkway or bikeway should be determined as either the actual paved area plus 5 feet on either side of the centerline path of travel; or a 25-foot-wide area running along the axis of the path of travel and including as much of the paved area of the site roadway, driveway, sidewalk, walkway or bikeway as possible.[13]

3. Common Mistakes
   a. Modeling different exterior lighting between the budget and proposed design with the ECB path.
   b. Including areas of the proposed design that are not illuminated, or incorrectly accounting for partially illuminated areas, when calculating the baseline exterior lighting power. For example, if proposed design has an uncovered parking lot that has no lighting specified, the exterior lighting allowance for the uncovered parking areas in 90.1 Table G3.6 cannot be included in the baseline.

[13] California Title 24

c. Double-counting areas when calculating the baseline exterior lighting power allowance. For example, the baseline lighting allowance for the walkway that crosses an illuminated parking lot can be determined based on the parking lot allowance, or walkway allowance in 90.1 Table G3.6, but not both. If walkway allowance is used, the walkway area calculated as described in #3 above must be subtracted from the parking lot area used to calculate the parking lot baseline lighting allowance.
d. Modeling baseline lighting for non-tradeable surfaces based on the full allowance in 90.1 Table 3.6. The baseline non-tradeable lighting must be modeled as specified in 90.1 Table G3.6 or based on the proposed lighting for each non-tradeable application, whichever is lower.

LE01-P Proposed exterior lighting power reported in the Compliance Form reflects design documents.

90.1 2016/2019 Section 11

Table 11.5.1 #6 Column A (a) and (b).

Where a complete lighting system exists, the actual lighting power should be used in the model. Where a complete lighting system has been designed, lighting power must be determined in accordance with Sections 9.1.3 and 9.1.4.

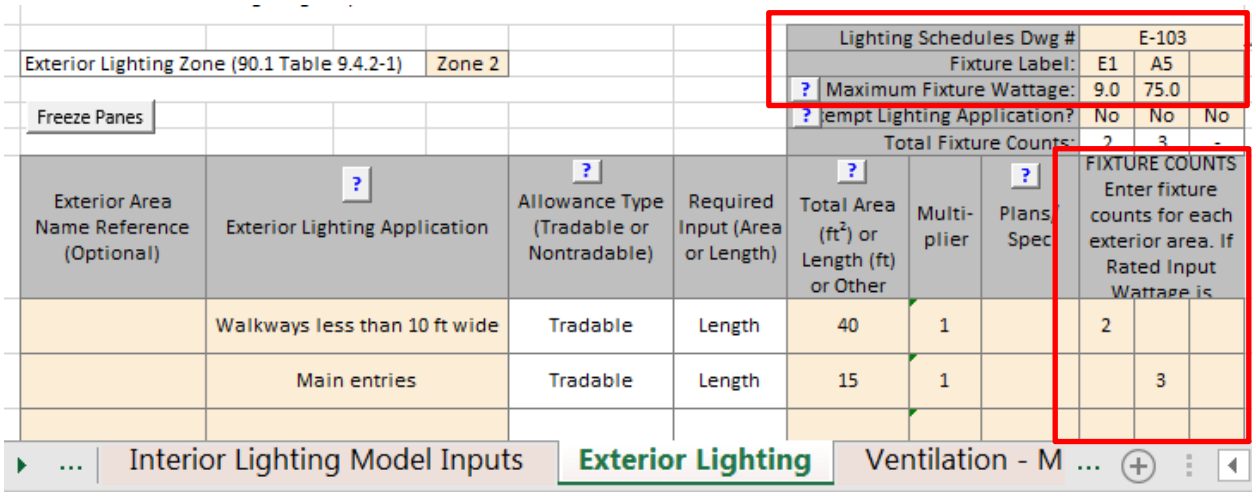
90.1 2016/2019 Appendix G

Table G3.1 No.6 (a), (b), (d)

a. Where complete lighting system exists (e.g. in a renovation project where lighting is left as is), the actual lighting power must be modeled.
b. Where a lighting system has been designed, lighting power must be determined in accordance with 90.1 Sections 9.1.3 and 9.1.4.
c. The input wattage of specified fixtures must include all power used by the fixture including lamps, ballasts, transformers and control devices and be based on the manufacturers' labeled maximum wattage of the luminaire. The lamp and ballast combination shown on drawings may result in lower input wattage that the maximum rated and thus cannot be used for compliance calculations.

Review Tips

1. The exterior lighting wattage is reported in Table 1 of the Exterior Lighting tab and include the following:
   a. Lighting fixtures used for exterior lighting applications and the maximum fixture rated wattage for each.
   b. Number of fixtures of each type specified for each exterior lighting application



Exterior Lighting Zone (90.1 Table 9.4.2-1)	Zone 2

Freeze Panes

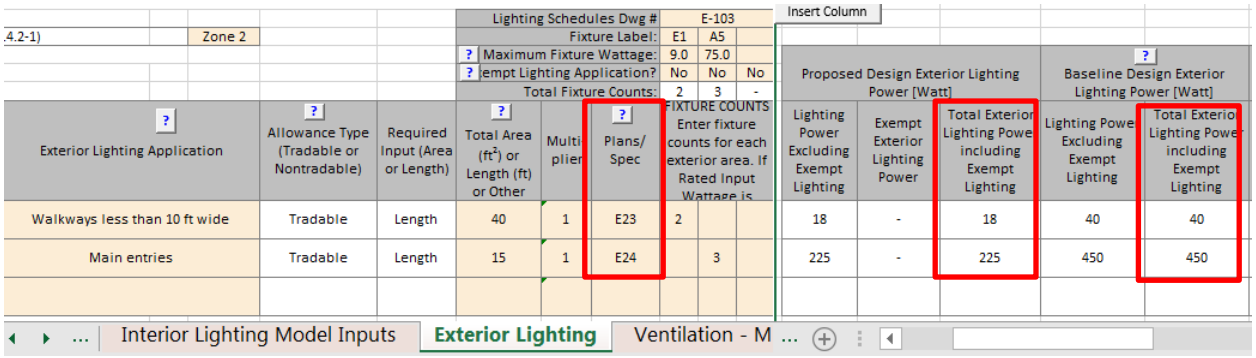
				Lighting Schedules Dwg #	E-103		
				Fixture Label:	E1	A5	
				? Maximum Fixture Wattage:	9.0	75.0	
				? Exempt Lighting Application?	No	No	No
				Total Fixture Counts:	2	3	-

Exterior Area Name Reference (Optional)	? Exterior Lighting Application	? Allowance Type (Tradable or Nontradable)	Required Input (Area or Length)	? Total Area (ft^2) or Length (ft) or Other	Multi-plier	? Plans/ Spec	FIXTURE COUNTS Enter fixture counts for each exterior area. If Rated Input Wattage is		
	Walkways less than 10 ft wide	Tradable	Length	40	1		2		
	Main entries	Tradable	Length	15	1			3	

... Interior Lighting Model Inputs | Exterior Lighting | Ventilation - M ...

3. Use Table 1 of the Exterior Lighting tab to identify lighting fixtures that contribute the most toward the total specified lighting wattage based on the product of the Maximum Rated Fixture Wattage and Total Fixture Counts. Refer to the Lighting Schedule drawings to establish the manufacture and model number for the fixtures. Check the manufacturer information to confirm that the maximum rated fixture wattage reported in the compliance form reflects manufacturer's data.

4. Use Table 1 of the Exterior Lighting tab to identify exterior lighting applications with the greatest different in wattage between the baseline and proposed design. (The top contributors are also shown on the QC tab.) Refer to the exterior lighting plans drawings to confirm that fixture types and counts for these spaces reported in the Compliance Form match design documents.



.4.2-1)	Zone 2

Insert Column

				Lighting Schedules Dwg #	E-103		
				Fixture Label:	E1	A5	
				? Maximum Fixture Wattage:	9.0	75.0	
				? Exempt Lighting Application?	No	No	No
				Total Fixture Counts:	2	3	-

? Exterior Lighting Application	? Allowance Type (Tradable or Nontradable)	Required Input (Area or Length)	? Total Area (ft^2) or Length (ft) or Other	Multi plier	? Plans/ Spec	FIXTURE COUNTS Enter fixture counts for each exterior area. If Rated Input Wattage is			Proposed Design Exterior Lighting Power [Watt]			? Baseline Design Exterior Lighting Power [Watt]	
									Lighting Power Excluding Exempt Lighting	Exempt Exterior Lighting Power	Total Exterior Lighting Power including Exempt Lighting	Lighting Power Excluding Exempt Lighting	Total Exterior Lighting Power including Exempt Lighting
Walkways less than 10 ft wide	Tradable	Length	40	1	E23	2			18	-	18	40	40
Main entries	Tradable	Length	15	1	E24		3		225	-	225	450	450

... Interior Lighting Model Inputs | Exterior Lighting | Ventilation - M ...

5. Common Mistakes
   a) Proposed fixture wattage is based on the specified lamps and not the manufacturer's labeled maximum wattage of the luminaire
   b) Exterior lighting wattage is excluded for compliance calculations. Submittals with no exterior lighting should be flagged.

LE02-P Specified exterior lighting meets 90.1 mandatory requirements.

Review Tips

1. Table 2 of the Exterior Lighting tab shows the total specified exterior lighting wattage alongside the total exterior lighting power allowance in Table 9.4.2.2. Since the exterior lighting requirements are

mandatory, projects where the total specified exterior lighting exceeds the exterior lighting power allowance should be flagged as not complying with 90.1.

Table 2: Exterior Lighting to Be Modeled

Instructions

1. The table shows the modeling inputs for exterior lighting.
2. The same schedules reflecting the mandatory exterior lighting controls are to be modeled in the baseline/budget and proposed design models.

Type	Proposed Design Lighting Power including Exempt Lighting [Watt]	Baseline Design [Watt] including Exempt Lighting	Total Exterior Lighting Power Allowance, per 90.1 Table 9.4.2-2 + Exempt [Watt]	% Savings of Proposed Design Relative to Allowance
Total Tradeable	243	490	230	-5.7%
Total Non-tradeable	-	-	-	-
Base Site Allowance	-	-	400	-
Total	243	490	630	61.4%

... | Interior Lighting Model Inputs | **Exterior Lighting** | Ventilation - Mult

2. Table 1 of the Exterior Lighting tab shows the total wattage of exterior lighting specified for the individual non-tradeable exterior lighting applications alongside their corresponding lighting power allowances from Table 9.4.2.2-2. Projects where specified lighting for at least one non-tradeable exterior lighting application exceeds the corresponding allowance should be flagged as not complying with 90.1.

			Lighting Schedules Dwg #			E-103			Insert Column							
4.2-1)	Zone 2				Fixture Label:	E1	A5	A10								
					Maximum Fixture Wattage:	9.0	75.0	34.5								
					Exempt Lighting Application?	No	No	No	Proposed Design Exterior Lighting Power [Watt]			Baseline Design Exterior Lighting Power [Watt]			Individual Lighting Power Allowance [Watt]	
					Total Fixture Counts:	2	3	5								
Exterior Lighting Application	Allowance Type (Tradable or Nontradable)	Required Input (Area or Length)	Total Area (ft^2) or Length (ft) or Other	Multi-plier	Plans/ Spec	FIXTURE COUNTS Enter fixture counts for each exterior area. If Rated Input Wattage is			Lighting Power Excluding Exempt Lighting	Exempt Exterior Lighting Power	Total Exterior Lighting Power including Exempt Lighting	Lighting Power Excluding Exempt Lighting	Total Exterior Lighting Power including Exempt Lighting	Lighting Power Excluding Exempt Lighting	Individual Lighting Power Allowance Including Exempt
Walkways less than 10 ft wide	Tradable	Length	40	1	E23	2			18	-	18	40	40	20	20
Main entries	Tradable	Length	15	1	E24		3		225	-	225	450	450	210	210
Building Facades, Area	Nontradable	Area	2000	1	E35			5	173	-	173	173	173	173W (up to 200W)	173W (up to 200W)

... | Interior Lighting Model Inputs | **Exterior Lighting** | Ventilation - Mu ...

LE03-B, LE03-P Modeled baseline/budget and proposed exterior lighting power reflects the wattages reported in the Compliance Form.

Review Tips

1. The modeled baseline/budget exterior lighting wattage must reflect the values reported in Table 2 of the Exterior Lighting tab.

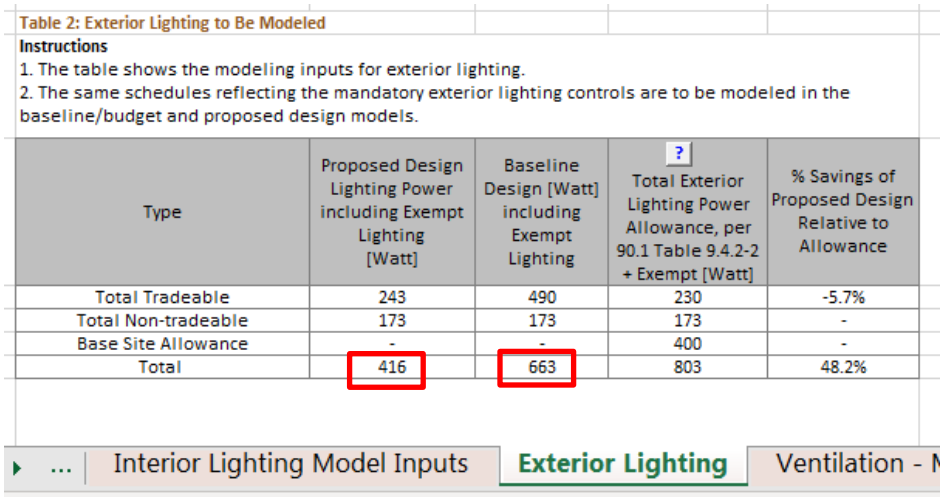


Table 2: Exterior Lighting to Be Modeled

Instructions

1. The table shows the modeling inputs for exterior lighting.
2. The same schedules reflecting the mandatory exterior lighting controls are to be modeled in the baseline/budget and proposed design models.

Type	Proposed Design Lighting Power including Exempt Lighting [Watt]	Baseline Design [Watt] including Exempt Lighting	Total Exterior Lighting Power Allowance, per 90.1 Table 9.4.2-2 + Exempt [Watt]	% Savings of Proposed Design Relative to Allowance
Total Tradeable	243	490	230	-5.7%
Total Non-tradeable	173	173	173	-
Base Site Allowance	-	-	400	-
Total	416	663	803	48.2%

... | Interior Lighting Model Inputs | Exterior Lighting | Ventilation - M

2. Depending on the reporting capabilities of the simulation tool used on the project, the inputs can be verified in the input or output reports, as follows:
   - Use simulation input reports to verify that the exterior lighting wattage entered into the simulation tool matches the wattage reported in the submittal
   - Use simulation output reports to verify that the modeled lighting peak demand does not exceed the exterior lighting wattage reported in the submittal. The exterior lighting peak demand occurs at night and thus does not coincide with the building overall electricity peak which occurs in the late afternoon for most building types.

     PLD <= LTW
     PLD [kW] = peak exterior lighting demand based on the simulation output reports
     LTW [kW] = design exterior lighting wattage reported in the submittal

eQUEST Reports	PS-E
Trane TRACE 700	LEED Summary Section 1.4, Plant Information entered values report
Trane TRACE 3D Plus	Utility Peak Demand Summary
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Lighting Summary' report, 'Exterior Lighting' section
OpenStudio	eplustbl.html 'Lighting Summary' report, 'Exterior Lighting' section
Carrier HAP v5	Input Data: "Building Input Data" report. Output Data: "LEED Summary" Report, Section 2 "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use".
Design Builder	Exterior Lighting Table in Output Summary Document

LE04-P Exterior lighting controls reported in the Compliance Form reflect design documents

Refer to the Exterior Lighting tab of the Compliance Form to confirm that the exterior lighting controls are reported as specified. Focus on exterior lighting applications that account for the largest reported exterior lighting wattage.

LE04-B Exterior lighting controls reported in the Compliance Form for the baseline/budget design are established correctly

Exterior lighting controls must be the same in the baseline/budget as in the proposed design. No trade-offs in this area are allowed by either Section 11 or Appendix G.

LE05-P Specified exterior lighting controls meet 90.1 mandatory requirements

90.1 2016/2019 Section 11 and Appendix G

Section 9.4.1.4 includes exterior lighting control requirements. This section is mandatory, and thus must be met by project documenting compliance following Section 11 or Appendix G.

Review Tip

Review design documents to confirm that exterior lighting controls required in Section 9.4.1.4 are met.

LE06–P Modeled exterior lighting runtime hours in the proposed design are reasonable

Review Tips

1. Following Section 9.4.1.4, the exterior lighting must be controlled to turn off when sufficient lighting is available and turned off, or operate at wattage reduced by at least 30%, during non-business hours. These controls are mandatory and thus must be specified on all projects. Thus, the modeled exterior lighting runtime may be up to 12 hours / day (4,380 hours per year) for facilities opened 24/7, such as hospitals. Lower runtime (e.g. 6 hours per day) is expected for other building types due to lighting control requirements in 90.1 Section 9.4.1.4.

   EFLH= LEU / LTW
   EFLH [hrs/yr] = exterior lighting effective full load hours
   LEU [kWh] = annual exterior lighting energy use, based on the simulation output reports

The review check should be performed only for Appendix G projects.

- EFLH>4380 should be flagged as a likely error
- EFLH<2190 (less than 6 hours per day) are reasonable for non-24/7 facilities and should be accepted.
- EFLH between 2190 and 4380 should be investigated on Appendix G project that have proposed exterior lighting energy use significantly lower than the baseline.

eQUEST Reports	BEPU
Trane TRACE 700	LEED Summary Section 1.6
Trane TRACE 3D Plus	LEED Summary Section 1.6

IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Lighting Summary' report, 'Exterior Lighting' section
OpenStudio	eplustbl.html 'Lighting Summary' report, 'Exterior Lighting' section
Carrier HAP v5	"LEED Summary" report, Section 2 "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use".
Design Builder	Lighting sheet in LEED Minimum Energy Performance Calculator (.xlsm)

LE07 Difference between the baseline/budget and proposed exterior lighting energy is as expected

Review Tips

1. 90.1 2016/2019 Section 11: Since exterior lighting is not a trade-off opportunity, the annual exterior lighting kWh must be the same in the budget and proposed design. Section 11 project with different exterior lighting energy use in budget vs proposed design should be flagged.

2. 90.1 Appendix G: Since the exterior lighting controls (i.e. lighting runtime) must be the same between the baseline and proposed design, the difference in the annual baseline versus proposed exterior lighting use is expected to be directly proportional to the difference in the exterior lighting wattage reported in the Table 2 of the Exterior Lighting tab of the Compliance Form. For example, if the proposed exterior lighting wattage reported in the submittal is 20% lower than the baseline, the proposed exterior lighting kWh are expected to be also 20% lower than the baseline exterior lighting kWh. Projects where this relationship does not hold should be flagged.

   Appendix G: $LTW_{prop} / LTW_{base} = LEU_{prop} / LEU_{base}$
   Section 11: $LEU_{prop} = LEU_{budget}$

eQUEST Reports	BEPU
Trane TRACE 700	LEED Summary Section 1.6
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Lighting Summary' report, 'Exterior Lighting' section
OpenStudio	eplustbl.html 'Lighting Summary' report, 'Exterior Lighting' section
Carrier HAP v5	"LEED Summary" report, Section 2 "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use".
Design Builder	Lighting sheet in LEED Minimum Energy Performance Calculator (.xlsm)

Plug, Process and Other Loads (PPO)

Overview

This category includes receptacle loads, non-HVAC motors, process loads, refrigeration equipment, elevators and other systems and components reported on Plug, Process and Other Loads tab of the Compliance Form. Some of these systems, such as certain refrigeration equipment and elevators, are regulated by 90.1, while others are not. Table 9 summarizes the checks included in this group.

Table 9: Plug, Process and Other Loads Checks Overview

	Type of Check	Proposed Design	Baseline/Budget Design
Miscellaneous and Process Equipment	CF inputs reflect design documents		
	CF inputs reflect requirements of 11/G	PPO02-P	PPO02-B, PPO03
	Simulation inputs consistent with CF	PPO04-P	PPO04-B
	Simulation outputs consistent with CF	PPO01	PPO01
Commercial Refrigerators and Freezers	CF inputs reflect design documents	PPO05-P	
	CF inputs reflect requirements of 11/G		PPO05-B
	Meet mandatory requirements		
	Simulation inputs/outputs consistent with CF	PPO06	PPO06
Regulated Motors	CF inputs reflect design documents	PPO07-P	
	CF inputs reflect requirements of 11/G		PPO07-B
	Meet mandatory requirements		
	Simulation inputs/output consistent with CF	PPO08	PPO08
Elevators	CF inputs reflect design documents	PP009-P	
	CF inputs reflect requirements of 11/G		PPO09-B
	Simulation inputs/outputs consistent with CF	PPO10	PPO10
Combined Heat and Power	CF inputs reflect design documents	PPO11-P	PPO11-B
	CF inputs reflect requirements of 11/G		
	Simulation inputs/outputs consistent with CF	PPO12	PPO12

LEGEND

PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form

Table 10 illustrates whether trade-offs are allowed for systems and components included in the PPO category by Section 11 and Appendix G. If trade-offs are not allowed, the review should be limited to verifying that the energy use of the associated systems and equipment is the same in the baseline/budget and proposed designs. No other checks are necessary.

Table 10: 90.1 Trade-off Limits for Plug, Process and Other Loads

	2016 Section 11	2019 Section 11	2016 Appendix G		2019 Appendix G	
			Min. compliance	Above code	Min. compliance	Above code
Miscellaneous plug and process equipment	No	No	No	Yes	No	Yes
Commercial refrigerators and freezers	No	Yes	Yes	Yes	Yes	Yes
Regulated Motors	Yes	Yes	Yes	Yes	Yes	Yes
Elevators	No	No	Yes	Yes	Yes	Yes
Combined Heat and Power	Recovered Heat Only	Recovered Heat Only	Recovered Heat Only	Recovered Heat Only	Recovered Heat Only	Recovered Heat Only

In addition, skip review checks for the following systems and components if they are not reported in the Compliance Form and are not expected to be specified:

a. Elevators in buildings two stories or less
b. Commercial refrigerators and freezers in building types other than convention center, retail, school/university, dining, health care clinic, hospital or warehouse
c. Regulated motors in buildings 10 stories or less
d. Combined heat and power in any project

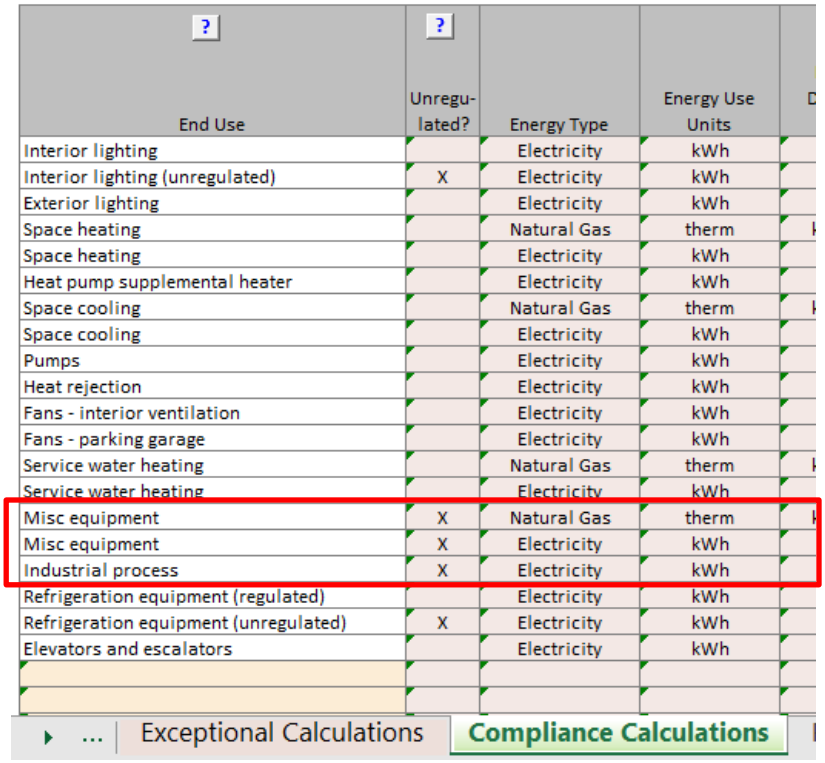
Within the given type of equipment, focus on verifying units with the highest contribution to the total energy use of that category or that are representative and spot-check the rest. For example, if project includes 10 passenger elevators of the same type and two service elevators, the review should focus on the passenger elevator.

PPO01 The difference between the modeled baseline/budget and proposed misc. equipment and process energy use is as expected

Review Tips

1. Modeled energy use from miscellaneous equipment and industrial is reported in Table 2 of the Compliance Calculations tab
   a) 90.1 2016/2019 Section 11 or 90.1 2016/2019 Appendix G minimum code compliance: Modeled energy use of miscellaneous loads must be the same for the baseline/budget and proposed design. Difference in reported energy use should be flagged as an error.

   b) 90.1 2016/2019 Appendix G when documenting above code performance
   Energy use of the baseline may differ from proposed design. Complete checks PPO02 and PPO03 to confirm that the difference is justified.



End Use	Unregu-lated?	Energy Type	Energy Use Units
Interior lighting		Electricity	kWh
Interior lighting (unregulated)	X	Electricity	kWh
Exterior lighting		Electricity	kWh
Space heating		Natural Gas	therm
Space heating		Electricity	kWh
Heat pump supplemental heater		Electricity	kWh
Space cooling		Natural Gas	therm
Space cooling		Electricity	kWh
Pumps		Electricity	kWh
Heat rejection		Electricity	kWh
Fans - interior ventilation		Electricity	kWh
Fans - parking garage		Electricity	kWh
Service water heating		Natural Gas	therm
Service water heating		Electricity	kWh
Misc equipment	X	Natural Gas	therm
Misc equipment	X	Electricity	kWh
Industrial process	X	Electricity	kWh
Refrigeration equipment (regulated)		Electricity	kWh
Refrigeration equipment (unregulated)	X	Electricity	kWh
Elevators and escalators		Electricity	kWh

PPO02–P Proposed design miscellaneous unregulated plug and process loads reported in the Compliance Form are as expected.

90.1 2016 Section 11

Table 11.5.1 #12

- Unregulated receptacle and process loads must be estimated based on the building area type or space type category and included in the simulations and when calculating the energy cost budget and design energy cost.
- All end-use load components within and associated with the building must be modeled including but not limited to exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.

Table 11.5.1 Sections 13 allow excluding components if their energy use does not affect the energy use of systems and components that are being considered for trade-off and the prescriptive requirements applicable to the excluded component are met.

Table 11.5.1 Section 14 allows excluding components that cannot be explicitly modeled by the simulation program if their energy impact on the trade-offs is not significant.

90.1 2019 Section 11

Table 11.5.1 #12

The requirements for modeling unregulated loads are aligned with 90.1 2016 quoted above. The references to Table 11.5.1 Section 13 and 14 were removed, however the exceptions still apply because they are covered in the updated Table 11.5.1 Section 14 that addresses all systems and components in the proposed design.

90.1 2016/2019 Appendix G:

Table G3.1 #12:

Unregulated receptacle and process loads, such as those for office and other equipment, must be estimated based on the building area type or space type category and must always be included in simulations of the building.

Review Tips

1. Miscellaneous unregulated plug loads are reported in Tables 1 of the Plug, Process and Other Loads tab of the Compliance Form. The table includes the default values established as described in Appendix C of this manual based on the building area types applicable to the project. Proposed EPD significantly deviating from the provided default values without sufficient justifications included in the Notes field below the table should be flagged in the review.

Table 1: Miscellaneous Equipment Loads

Instructions

1. Document the modeling inputs and methodology used to model miscellaneous equipment loads in the proposed and baseline/budget design.

Building Area Type	Default Miscellaneous Equipment Load, Building Area Method (for Reference)				Modeled Misc. Equipment Loads				
	Building Area [ft²]	Default Misc. Equipment Power Density [W/ft²]	Total Equipment Power [kW]	Equivalent Full Load Hours	Modeling Method	Basis of Assumed Equipment Power Density	Proposed EPD [W/ft²]	Baseline EPD [W/ft^2]	Same Schedules Used in Proposed and Baseline design?
	A	EPD	A x EPD						
Multifamily, common spaces	8,365	0.20	1.7	3,285	Space Type Category	Other (please explain in the notes field below)	0.2	0.2	Yes
Retail	24,750	0.30	7.4	4,526	Building Area Type	Other (please explain in the notes field below)	0.3	0.3	Yes

2. Process equipment is reported in Table 4 of the Plug, Process and Other Loads tab in the Compliance Form.

PPO02–B Miscellaneous unregulated baseline/budget plug and process loads reported in the Compliance Form are the same as proposed unless allowed to differ.

90.1 2016/2019 Section 11

Table 11.5.1 #12

Miscellaneous receptacle and process loads in the budget design must be identical to the proposed design.

90.1 2016/2019 Appendix G

Table G3.1 #12

Energy used for cooking equipment, receptacle loads, computers, medical or laboratory equipment, and manufacturing and industrial process equipment not specifically identified in the standard, power and energy rating or capacity of the equipment must be identical between the proposed building performance and the baseline building performance.

Exceptions: When quantifying performance that exceeds the requirements of Standard 90.1 (but not when using the Performance Rating Method as an alternative path for minimum standard compliance per Section 4.2.1.1) variations of the power requirements, schedules, or control sequences of the equipment modeled in the baseline building design from those in the proposed design shall be approved by the rating authority based on documentation that the equipment installed in the proposed design represents a significant verifiable departure from documented current conventional practice. The burden of this documentation is to demonstrate that accepted conventional practice would result in

baseline building equipment different from that installed in the proposed design. Occupancy and occupancy schedules shall not be changed.

Review Tips

1. Miscellaneous unregulated plug and process loads assumed for the baseline/budget design are reported in Table 1 of the "Plug, Process and Other Loads" tab of the Compliance Form. The baseline/budget equipment power density (EPD) must be equal to proposed except when the

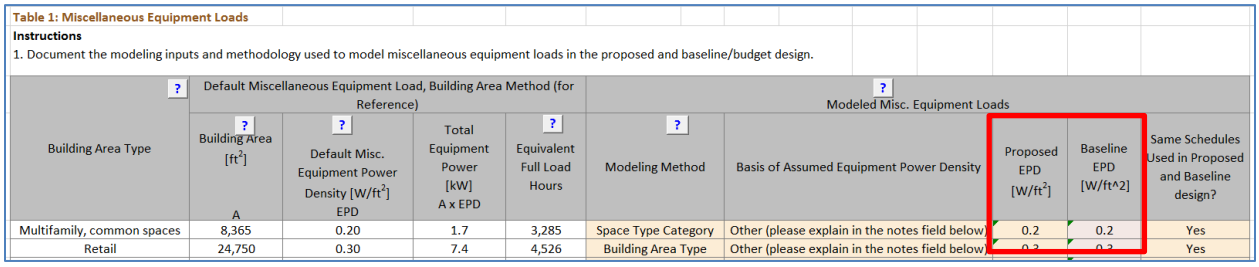


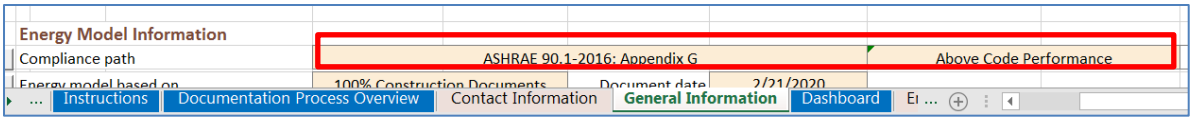
Table 1: Miscellaneous Equipment Loads

Instructions

1. Document the modeling inputs and methodology used to model miscellaneous equipment loads in the proposed and baseline/budget design.

Building Area Type	Default Miscellaneous Equipment Load, Building Area Method (for Reference)				Modeled Misc. Equipment Loads				
	Building Area [ft²] A	Default Misc. Equipment Power Density [W/ft²] EPD	Total Equipment Power [kW] A x EPD	Equivalent Full Load Hours	Modeling Method	Basis of Assumed Equipment Power Density	Proposed EPD [W/ft²]	Baseline EPD [W/ft^2]	Same Schedules Used in Proposed and Baseline design?
Multifamily, common spaces	8,365	0.20	1.7	3,285	Space Type Category	Other (please explain in the notes field below)	0.2	0.2	Yes
Retail	24,750	0.30	7.4	4,526	Building Area Type	Other (please explain in the notes field below)	0.3	0.3	Yes

project is documenting above-code performance following 90.1 Appendix G, as indicated in the General Model Information section of the General Information tab. In this case, supporting documentation must be included in the submittal to justify the modeled difference.



2. Review supporting documentation to verify that the methodology and assumptions used to establish the baseline and proposed EPDs are substantiated as required in Table G3.1 #12 Exception quoted above.

PPO03 Miscellaneous unregulated plug and process load schedules reported in the Compliance Form for the baseline/budget design are the same as for the proposed design unless allowed to differ.

90.1 2016/2019 Section 11

Table 11.5.1 #4

The schedules must be typical of the proposed design as determined by the designer and approved by the authority having jurisdiction, and the same for the proposed design and budget building design.

90.1 2016 Appendix G

Table G3.1 #4

The schedules must be typical of the proposed building type as determined by the designer and approved by the rating authority.

Table G3.1 #12

Occupancy and occupancy schedules must not be changed when documenting savings as allowed in Table G3.1 #12 exception.

90.1 2019 Appendix G

Table G3.1 #4

The schedules must be typical of the proposed building type as determined by the designer and approved by the rating authority.

Table G3.1 #12

- Receptacle schedules must be the same as the proposed design before the receptacle power credit is applied.
- Occupancy and occupancy schedules must not be changed when documenting savings as allowed in Table G3.1 #12 exception.

Review Tips

1. Confirm that the same schedules are used in the baseline/budget and proposed design based on Table 1 of the Plug, Process and Other Loads tab. Schedules are only allowed to differ for 90.1 2019 Appendix G projects due to office receptacle controls.

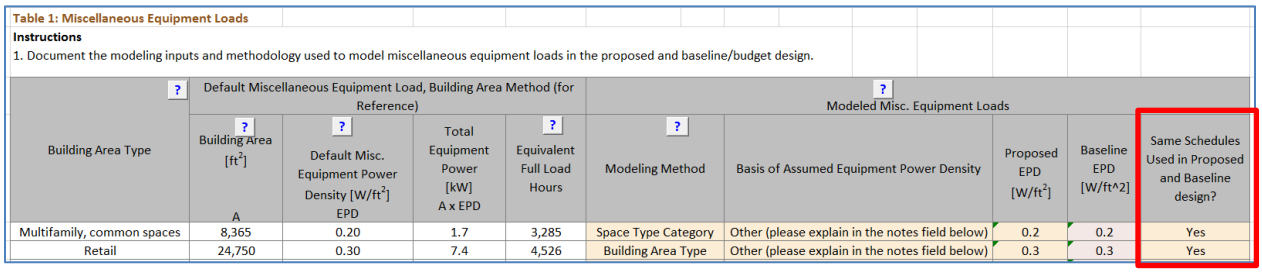


Table 1: Miscellaneous Equipment Loads

Instructions

1. Document the modeling inputs and methodology used to model miscellaneous equipment loads in the proposed and baseline/budget design.

Building Area Type	Default Miscellaneous Equipment Load, Building Area Method (for Reference)				Modeled Misc. Equipment Loads				
	Building Area [ft²] A	Default Misc. Equipment Power Density [W/ft²] EPD	Total Equipment Power [kW] A x EPD	Equivalent Full Load Hours	Modeling Method	Basis of Assumed Equipment Power Density	Proposed EPD [W/ft²]	Baseline EPD [W/ft^2]	Same Schedules Used in Proposed and Baseline design?
Multifamily, common spaces	8,365	0.20	1.7	3,285	Space Type Category	Other (please explain in the notes field below)	0.2	0.2	Yes
Retail	24,750	0.30	7.4	4,526	Building Area Type	Other (please explain in the notes field below)	0.3	0.3	Yes

2. The allowed office receptacle control credit is reflected in Table 10 of the Plug, Process and Other Loads tab of the Compliance Form.

PPO04 Miscellaneous plug and process loads are modeled as reported in the Compliance Form.

Review simulation reports listed above to verify that the plug and process loads are modeled as reported. Energy use from miscellaneous equipment and industrial is reported in Table 2 of the Compliance Calculations tab.

eQUEST Reports	BEPU
Trane TRACE 700	Energy Cost Budget report
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'LEED Summary' report
OpenStudio	eplustbl.html 'LEED Summary' report
Carrier HAP v5	"LEED Summary" report, Section 2 "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use".
Design Builder	Output_Performance_1 sheet in LEED Minimum Energy Performance Calculator (.xlsm)

PPO05-P Regulated commercial refrigerators & freezers reported in the Compliance Form for the proposed design reflect design documents

90.1 2016 Section 11

Table 11.5.1 #12 Column A: All endues load components within and associated with the building must be modeled including, but not limited to refrigeration equipment.

Table 6.8.1-13 Commercial Refrigeration—Minimum Efficiency Requirements
Minimum efficiency requirements specified in the table are mandatory and must be met by the specified units.

90.1 2019 Section 11

Table 11.5.1 #13 Column A: Where refrigeration equipment in the proposed design is rated in accordance with AHRI 1200, the rated energy use shall be modeled. Otherwise, the proposed design shall be modeled using the actual equipment capacities and efficiencies.

Table 6.8.1-11 Commercial Refrigerators, Commercial Freezers, and Refrigeration—Minimum Efficiency Requirements
Minimum efficiency requirements specified in the table are mandatory and must be met by the specified units.

90.1 2016 Appendix G

Table G3.1 #17 Proposed Building Performance Column: The proposed design shall be modeled using the actual equipment capacities and efficiencies.

Table 6.8.1-13 Commercial Refrigeration—Minimum Efficiency Requirements Minimum efficiency requirements specified in the table are mandatory and must be met by the specified units.

90.1 2019 Appendix G

Table G3.1 #17 Proposed Building Performance Column: Where refrigeration equipment in the proposed design is rated in accordance with AHRI 1200, the rated energy use shall be modeled. Otherwise, the proposed design shall be modeled using the actual equipment capacities and efficiencies.

Table 6.8.1-11 Commercial Refrigerators, Commercial Freezers, and Refrigeration—Minimum Efficiency Requirements: Minimum efficiency requirements specified in the table are mandatory and must be met by the specified units.

Review Tips

1. Specified regulated refrigerators and freezers are reported in Table 3 of the Plug, Process and Other Loads tab. Cross-check information provided in the Compliance Form to design documents for a sample of units focusing on the units that account for largest difference between baseline and proposed design accounting for unit quantity. Reference to appropriate design documents where each unit is described must be provided in the last column of Table 3. If details that must be captured in Table 3 are not available in the design documents, request equipment cutsheets or manufacturer literature.

Table 3: Regulated Commercial Refrigerators & Freezers

Instructions

1. Fill in the table below for refrigeration equipment regulated in 90.1 Table 6.8.1-12 and 6.8.1-13.

Equipment Category	Equipment Family	Condensing Unit Configuration	Rating Temperature	Equipment Tag from Design Documents (if Available)	Equipment Classification	V, ft^3 or TDA, ft^2	Enter V, ft^3 or TDA, ft^2	Qty of Units	Proposed kWh/Day per Unit	Baseline Design kWh/Day per Unit	ASHRAE 90.1 - 2016 Prescriptive Requirement kWh/Day/Unit
Self-Contained Commercial Refrigerators and Commercial Freezers With and Without Doors	Horizontal Open (HZO)	Self-Contained (SC)	38F (Medium)	REF12	HZO.SC.M	TDA	250	3	175.0	290.55	198.05

2. Verify that proposed kWh/day do not exceed corresponding 90.1 requirements shown in the table. Since these requirements are mandatory, all specified units must have lower rated kWh/Day consumption.

PPO05-B Baseline/budget design for the regulated commercial refrigerators & freezers reported in the Compliance Form is established correctly

90.1 2016 Section 11

Table 11.5.1 #12 Column B

Receptacle, motor, and process loads shall be modeled and estimated based on the building area type or space type category and shall be assumed to be identical in the proposed and budget building designs.

90.1 2019 Section 11

Table 11.5.1 #13 Column B

Where refrigeration equipment is specified in the proposed design and listed in Table 6.8.1-13, the budget building design shall be modeled as specified in Table 6.8.1-13 using the actual equipment capacities. If the refrigeration equipment is not listed in Table 6.8.1-13, the budget building design shall be modeled the same as the proposed design.

90.1 2016/2019 Appendix G

Table G3.1 #13/#17 Baseline Building Performance Column

- Where refrigeration equipment is specified in the proposed design and listed in Tables G3.10.1 and G3.10.2, the baseline building design shall be modeled as specified in Tables G3.10.1 and G3.10.2 using the actual equipment capacities.
- If the refrigeration equipment is not listed in Tables G3.10.1 and G3.10.2, the baseline building design shall be modeled the same as the proposed design.

Review Tips

1. Energy use of the regulated refrigerators and freezers in the baseline/budget design is established automatically in Table 3 of the Plug, Process and Other Loads tab. However, the calculations are based on the characteristic of the corresponding proposed unit reported in Table 3 below, thus the related inputs should be verified. Cross-check information provided in the Compliance Form to design documents for a sample of units focusing on the units that account for largest difference between baseline and proposed design accounting for unit quantity. Reference to appropriate design documents where each unit is described must be provided in the last column of Table 3. If details that must be captured in Table 3 are not available in the design documents, request equipment cutsheets or manufacturer literature.

Table 3: Regulated Commercial Refrigerators & Freezers

Instructions

1. Fill in the table below for refrigeration equipment regulated in 90.1 Table 6.8.1-12 and 6.8.1-13

Equipment Category	Equipment Family	Condensing Unit Configuration	Rating Temperature	Equipment Tag from Design Documents (if Available)	Equipment Classification	V, ft³ or TDA, ft²	Enter V, ft³ or TDA, ft²	Qty of Units	Proposed kWh/Day per Unit	Baseline Design kWh/Day per Unit	ASHRAE 90.1 - 2016 Prescriptive Requirement kWh/Day/Unit
Self-Contained Commercial Refrigerators and Commercial Freezers With and Without Doors	Horizontal Open (HZO)	Self-Contained (SC)	38F (Medium)	REF12	HZO.SC.M	TDA	250	3	175.0	290.55	198.05

2. The check may be skipped if the modeled difference between the baseline/budget and proposed design is small.

PPO06 Regulated refrigerators and freezers are modeled as reported in the Compliance Form for the baseline/budget and proposed design.

Review Tips

1. Since regulated refrigerators and freezers are rated in kWh/day, annual energy use reported in Table 2 of the Compliance Calculations tab, "Refrigeration Equipment, regulated" row should be equal to the total value shown in Table 8 of the Plug, Process and Other Loads tab. Discrepancies should be flagged.
2. Common Mistakes
    a) 90.1 2016 Section 11:
        - Claiming credit for better than code regulated refrigeration systems on projects following. (Budget and proposed design must be modeled the same.)
    b) 90.1 2016/2019 Appendix G:
        - Reporting all refrigeration systems as unregulated loads on the Compliance Calculations tab. Energy used by units included in 90.1 2016/2019 Table 6.8.1-13/6.8.1-11 must be reported under "Refrigerate Equipment, regulated"
    c) Refrigeration equipment is not reported or modeled for projects involving building types that likely have it such as supermarkets, large office buildings, hospitals, schools that have cafeteria, etc.
    d) Modeled energy use deviates from annual energy use inferred in kWh/Day efficiency ratings.
    e) Internal gains/losses to space where refrigeration systems are located are not modeled correctly. Refer to PNNL Performance Rating Method Reference Manual[14] Section 3.3.6 for methodology for determining internal gains/losses for packaged refrigeration units versus units with remote condensers.

PPO07-P Regulated Motors reported in the Compliance Form for the proposed design reflect design documents

90.1 2016/2019 Section 11

Table 11.5.1 #12, Column A

Receptacle, motor, and process loads shall be modeled and estimated based on the building area type or space type category and shall be assumed to be identical in the proposed and budget building

[14] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26917.pdf

designs. All end-use load components within and associated with the building shall be modeled, … including but not limited to parking garage ventilation fans… and escalators.

90.1 2016/2019 Appendix G

Table G3.1#12, Proposed Building Performance column

a. Where power and other systems covered by Sections 8 and 10 have been designed and submitted with design documents, those systems shall be determined in accordance with Sections 8 and 10.
b. Where power and other systems covered by Sections 8 and 10 have not been submitted with design documents, those systems shall comply with but not exceed the requirements of those sections.

Review Tips

1. All motors that have efficiency requirements prescribed in 90.1 Section 10 are considered regulated. Regulated motors are reported in Table 5 on the Plug, Process and other Loads tab of the Compliance Form. Typically, only larger motors including but not limited to water booster pumps and garage exhaust fans should be individually reported.
2. Cross-check larger motors included in Table 5 with the design documents referenced in the Plans/Specs row of the table to confirm alignment in the reported motor HP, type, qualntity and efficiency.
3. Confirm that specified efficiency is not below the minimum required in 90.1 Section 10. For most types of motors, the requirements are included in the Minimum Efficiency column of Table 5 on the Plug, Process and other Loads tab.

PPO07-B Regulated Motors reported in the Compliance Form for the baseline/budget design are established correctly

90.1 2016/2019 Section 11

Table 11.5.1 #12, Column B: Same as proposed

90.1 2016/2019 Appendix G

Table G3.1#12, Baseline Building Performance column

Motors shall be modeled as having the efficiency ratings found in Table G3.9.1 Other systems covered by Section 10 … shall be modeled as identical to those in the proposed design, including schedules of operation and control of the equipment.

Review Tips

1. Parameters of the baseline/budget motors are auto-populated in the Table 5 of the Plug, Process and other Loads tab.
2. Equivalent Full Load Hours must be the same for the baseline/budget and proposed design

PPO08 Regulated Motors are modeled as reported in the Compliance Form for the baseline/budget and proposed design.

Review Tips

Review simulation reports to verify alignment with the values reported in the Compliance Form.

eQUEST Reports	
Trane TRACE 700	

Trane TRACE 3D Plus	
IESVE SOFTWARE	
EnergyPlus	
OpenStudio	
Carrier HAP v5	
Design Builder	

PPO09-P Elevators reported in the Compliance Form for the proposed design reflect design documents

90.1 2016/2019 Section 11

Table 11.5.1 #12, Column A

All end-use load components within and associated with the building shall be modeled, … including but not limited to … elevators and escalators.

90.1 2016/2019 Appendix G

Table G3.1#16, Proposed Building Performance column

Where the proposed design includes elevators, the elevator motor, ventilation fan, and light load shall be included in the model. The cab ventilation fan and lights shall be modeled with the same schedule as the elevator motor.

Review Tips

1. Specified elevators are described in Table 6a of Plug, Process and Other Loads tab. Cross-check information provided in the table with the design documents that must be referenced in the last column of the table for each elevator. Focus on elevators that account for the greatest annual motor energy use based on Table 6b.

PPO09-B Elevators reported in the Compliance Form for the baseline/budget design are established correctly

90.1 2016/2019 Section 11

Table 11.5.1 #12, Column B: Same as proposed

90.1 2016/2019 Appendix G

Table G3.1#16, Baseline Building Performance column

Where the proposed design includes elevators, the baseline building design shall be modeled to include the elevator cab motor, ventilation fans, and lighting power. Calculations are provided to determine baseline elevator peak motor power. The elevator motor use shall be modeled with the same schedule as the proposed design. When included in the proposed design, the baseline elevator cab ventilation fan shall be 0.33 W/cfm and the lighting power density shall be 3.14 W/ft2; both operate continuously.

Review Tips

1. Energy use of the baseline elevators is established automatically based on the details provided for the prosed elevators and is shown in Table 6b of Plug, Process and Other Loads tab.

PPO10 Elevators are modeled as reported in the Compliance Form for the baseline/budget and proposed design.

Review Tips

1. The total elevator energy use for the baseline/budget and proposed design should be as shown in the Totals row of Table 6b.

PPO11-P Combined Heat and Power (CHP) systems reported in the Compliance Form for the proposed design reflect design documents and electricity generation and recovered energy reported in submittal is reasonable.

90.1 2016/2019 Section 11, 90.1 2016/2019 Appendix G

Table 11.5.1, Table G3.1: The proposed design must be consistent with the design documents

Review Tips

1. The specified CHP systems are reported in Table 7 of the Plug, Process and other Loads tab. The provided information must at minimum include the generator ownership, type, quantity, total generation capacity (kW) at design conditions, thermal and electrical efficiency at design conditions, controls, schedule of operation, fuel used, where the recovered heat is used (e.g. absorption chillers, space heating loop, service water heating loop, etc.), specified back-up systems when recovered heat is not available and parasitic losses (e.g. air handling unit to cool the intake air).
2. Verify that the required information is provided and reflects design documents.

PPO11-B CHP systems reported in the Compliance Form for the baseline/budget design are established correctly

90.1 2016 Section 11:

Based on **Table 11.5.1 #1 Column B**, all building systems and equipment must be modeled identically in the budget and proposed design except as specifically instructed. Since **Table 11.5.1** does not cover CHP systems, the budget building design and the proposed design must be modeled with the same CHP system that is specified for the proposed design. Following **Section 11.4.3.2**, where CHP waste heat is recovered in the proposed design, the budget building design must be based on the energy source used as the backup energy source, or electricity if no backup energy source has been specified. In the proposed design, the recovered waste heat must not be considered purchased energy and must be subtracted from the proposed design energy consumption, thus contributing to the performance credit. The requirement was further clarified by adding the explicit language to that section in the 2019 edition of the standard.

90.1 2019 Section 11

11.4.3.2: Where the proposed design includes on-site electricity generation systems other than on-site renewable energy systems, the baseline design shall include the same generation systems excluding its site recovered energy.

90.1 2016 Appendix G

Based on **Table G3.1 #1 Baseline Building column**, all building systems and equipment must be modeled identically in the baseline and proposed design except as specifically instructed. Since 90.1 Appendix G does not cover CHP systems, the baseline must be modeled with the same CHP system that is specified for the proposed design. The recovered waste heat of the specified CHP system must not be considered purchased energy and must be subtracted from the proposed design energy consumption following **Section G2.4.1**, thus contributing to the performance credit.

90.1 2019 Appendix G

G2.4.2: Where the proposed design includes on-site electricity generation systems other than on-site renewable energy systems, the baseline design shall include the same generation systems excluding its site-recovered energy.

Review Tips

1. Confirm that the baseline CHP system is established correctly. It must be the same as the proposed system in all respect except without energy recovery.
2. Common mistake includes not modeling CHP in the baseline and instead assume that all electricity is purchased from grid.

PPO12 CHP systems are modeled as reported in the Compliance Form for the baseline/budget and proposed design.

Review Tips

1. Review simulation reports to verify that CHP systems are modeled as reported in the Compliance Form.
2. If the CHP system is modeled using exceptional calculation methods, perform checks EC01-EC03
3. Irrespective of whether the CHP is modeled in the simulation tool or through exceptional calculations method, the amount of electricity generated by CHP is expected to be the same in the baseline (budget) and proposed design. The value of the recovered heat should be subtracted from the proposed design energy cost but not from the baseline. Similar patterns should be verified in the simulation output reports if CHP is incorporated in the simulation.

Service Water Heating (SWH)

Overview

The service water heating category covers parameters related to the service water heating equipment and demand. Table 11 summarizes the checks included in this group.

Table 11: Service Water Heating Quality Control Checks Overview

	Type of Check	Proposed Design	Baseline/Budget Design
SWH System Components	CF inputs reflect design documents	SWH01-P, SWH03-P	NA
	CF inputs reflect requirements of 11/G	NA	SWH01-B, SWH03-B
	Meet mandatory requirements	SWH02-P	NA
	Simulation inputs consistent with CF	SWH05-P	SWH05-B
	Simulation outputs consistent with CF	NA	NA
Hot Water Demand	CF inputs reflect design documents	SWH04-P	NA
	CF inputs reflect requirements of 11/G	NA	SWH04-B
	Meet mandatory requirements	NA	NA
	Simulation inputs consistent with CF	NA	NA
	Simulation outputs consistent with CF	SWH06, SWH07	SWH06, SWH07
LEGEND			
PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form			

The following strategies may be used to prioritize the review:

1. If there are multiple water heater types, the review should focus on water heaters with the largest capacity or a representative smaller unit.
2. Hot water demand checks should only be performed for Appendix G projects where different hot water demand is reported in the Compliance Form for the baseline versus proposed design.

SWH01-P Proposed SWH system type, efficiency and capacity reported in the Compliance Form reflects design documents

90.1 2016/2019 Section 11

Table 11.5.1 Column A #11

The service water-heating system type and all related performance parameters, such as equipment capacities and efficiencies, in the proposed design are determined as follows:

- Where a complete service water-heating system exists, the model must reflect the actual system type using actual component capacities and efficiencies.
- Where a service water-heating system has been designed and submitted with design documents, the service water-heating model must be consistent with design documents.
- Where no service water-heating system exists or has been submitted with the design documents, no service water heating must be modeled.
- Piping losses must not be modeled.

90.1 2016/2019 Appendix G

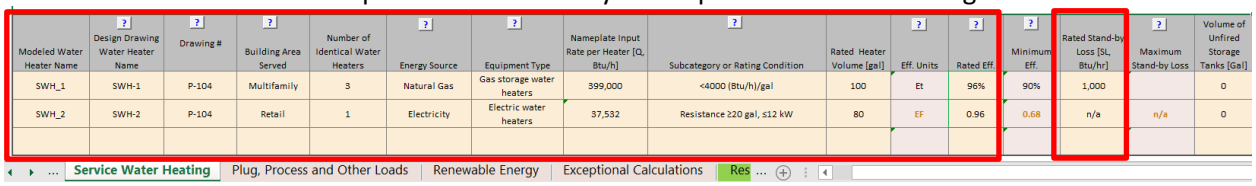
Table G3.1 #11, Proposed Building Performance

The service water-heating system type and all related performance parameters, such as equipment capacities and efficiencies, in the proposed design must be determined as follows:

1. Where a complete service water-heating system exists, the proposed design must reflect the actual system type using actual component capacities and efficiencies.
2. Where a service water-heating system has been designed and submitted with design documents, the service water heating model must be consistent with design documents.
3. Where no service water-heating system exists or has been designed and submitted with design documents but the building will have service water-heating loads, a service water-heating system must be modeled that matches the system type in the baseline building design, serves the same water-heating loads, and comply with but not exceed the requirements of Section 7.
4. For buildings that will have no service water-heating loads, no service water-heating system is modeled.
5. Piping losses must not be modeled.

Review Tips

1. Proposed SWHs are listed in Table 1 of the Service Water Heating tab. If project includes multiple water heaters, identify SWH types with the highest total nameplate input rate calculated as the product of the number of heaters and nameplate input rate per heater, and focus the review on these units only.
2. Cross-check information provided for the SHWs in the design documents with the inputs in Table 1. The reference to drawings/specs where information for each heater is available should be included in Table 1 for each heater. Request cutsheets if any of the parameters are missing.



Modeled Water Heater Name	Design Drawing Water Heater Name	Drawing #	Building Area Served	Number of Identical Water Heaters	Energy Source	Equipment Type	Nameplate Input Rate per Heater [Q, Btu/h]	Subcategory or Rating Condition	Rated Heater Volume [gal]	Eff. Units	Rated Eff.	Minimum Eff.	Rated Stand-by Loss [SL, Btu/hr]	Maximum Stand-by Loss	Volume of Unfired Storage Tanks [Gal]
SWH_1	SWH-1	P-104	Multifamily	3	Natural Gas	Gas storage water heaters	399,000	<4000 (Btu/h)/gal	100	Et	96%	90%	1,000		0
SWH_2	SWH-2	P-104	Retail	1	Electricity	Electric water heaters	37,532	Resistance ≥20 gal, ≤12 kW	80	EF	0.96	0.68	n/a	n/a	0

Service Water Heating | Plug, Process and Other Loads | Renewable Energy | Exceptional Calculations | Res ...

SWH02 -P Proposed SWH system efficiency reported in the Compliance Form meets the mandatory requirements of 90.1 Section 8.

Review Tips

1. Confirm that the rated efficiency exceeds the minimum required efficiency and that the rated stand-by loss is below the maximum listed in Table 1. These reference values are based on 90.1 Table 7.8 and are mandatory. Failure to meet these requirements should be flagged. For most SWHs, the reference values will be determined automatically. If the auto-populated default is over-written, the value is shown in brown font and should be confirmed.

SWH02-B Baseline/budget SWH system type, efficiency and capacity reported in the Compliance Form is established correctly

90.1 2016/2019 Section 11

Table 11.5.1 Column B #11

The SWH system type and fuel must be the same as in the proposed design, except a dedicated SWH system must be modeled if the proposed design has a combination space/service water heating system.

Storage tank volume in the budget design must be the same as in the proposed design. Piping losses must not be modeled

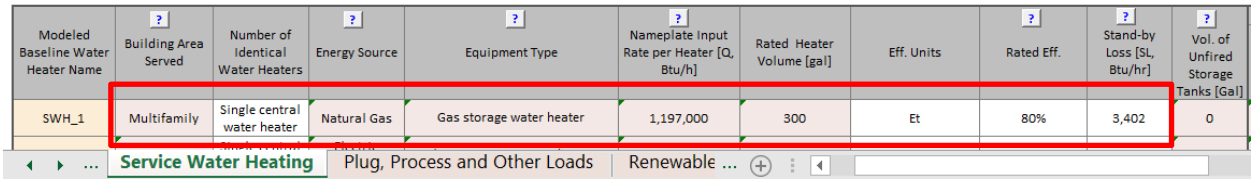
90.1 2016/2019 Appendix G

Table G3.1 Baseline Building Performance column #11

The SWH system type and fuel must be as prescribed in 90.1 Table G3.1.1-2 based on the building type, irrespective of system type and fuel source in the proposed design. For example, all multifamily occupancies have a central gas storage water heater; all office occupancies have a central electric resistance storage water heater. In mixed use buildings, e.g. in a building with multifamily occupancy on the top 10 floors and office occupancy on the lower 3 floors, a separate baseline SWH system type must be modeled for each occupancy. Storage tank volume in the budget design must be the same as in the proposed design.

Review Tips

1. Baseline/budget SWHs are listed in Table 2 of the Service Water Heating tab. All values are set automatically by applying the appropriate 90.1 rules to the project. Default values over-written by the modeler are shown in brown bold font in the table and should be verified by reviewer.



Modeled Baseline Water Heater Name	Building Area Served	Number of Identical Water Heaters	Energy Source	Equipment Type	Nameplate Input Rate per Heater [Q, Btu/h]	Rated Heater Volume [gal]	Eff. Units	Rated Eff.	Stand-by Loss [SL, Btu/hr]	Vol. of Unfired Storage Tanks [Gal]
SWH_1	Multifamily	Single central water heater	Natural Gas	Gas storage water heater	1,197,000	300	Et	80%	3,402	0

2. Common mistakes:
    - Assuming distributed water heaters in the Appendix G baseline when there are distributed water heaters in the proposed design. Baseline always have a central water heater for each building occupancy type. Multiple service water heaters may only be included in mixed-use buildings.
    - Where proposed design has distributed water heaters, assuming that the capacity of the central baseline water heater is equal to the sum of capacities of the specified water heaters. Instead, baseline system must be sized according to the provisions of 90.1 Section 7.4.1 to avoid excessive oversizing and low operating efficiency.
    - Where proposed design has combination space/service water heating boiler, assuming that the capacity of the central baseline water heater is equal to the capacity of the specified space/service water heating boiler. Instead, baseline system must be sized according to the provisions of 90.1 Section 7.4.1 to avoid excessive oversizing and low operating efficiency.

SHW03-P The ancillary components of the proposed SWH system reported in the Compliance Form reflect design documents

90.1 2016/2019 Section 11, 90.1 2016/2019 Appendix G

Based on Tables 11.5.1 #11 and G3.1 #11, ancillary components include recirculation pumps, service hot water preheat and condenser heat recovery.

Review Tips

1. Table 1 includes fields for specifying recirculation pumps and hot water reheat strategies, if applicable. The review check should be completed for projects with entries in either of these fields on if service water heating is identified as one of the impactful end uses.
2. Cross-check information provided in the table with the design documents to verify alignment.

SHW03-B Ancillary components of the baseline/budget SWH system reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.1 Column B #11 Exception 3

For 24-hour facilities that meet the prescriptive criteria for use of condenser heat recovery systems described in Section 6.5.6.2, a system meeting the requirements of that section must be included in the baseline building design, regardless of the exceptions to Section 6.5.6.2. If a condenser heat recovery system meeting the requirements described in Section 6.5.6.2 cannot be modeled, the requirement for including such a system in the actual building must be met as a prescriptive requirement in accordance with Section 6.5.6.2 and no heat recovery system must be included in the proposed design or budget building design.

90.1 2016/2019 Appendix G

Table G3.1 #11, Baseline Building Performance column, (e) & (f)

- For large, 24-hour-per-day facilities that meet the prescriptive criteria for use of condenser heat recovery systems described in Section 6.5.6.2, a system meeting the requirements of that section shall be included in the baseline building design regardless of the exceptions to Section 6.5.6.2. If a condenser heat recovery system meeting the requirements described in Section 6.5.6.2 cannot be modeled, the requirement for including such a system in the actual building must be met as a prescriptive requirement in accordance with Section 6.5.6.2, and no heat recovery system would be included in the proposed design or baseline building design.
- Where recirculation pumps are used to ensure prompt availability of service water-heating at the end use, the energy consumption of such pumps must be calculated explicitly.

Review Tips

1. The ancillary components of service hot water systems are reported in Table 2 of the Service Water Heating tab. The values are auto populated but may be over-written. The overwritten defaults should be verified to confirm that they are justified.

SHW04-P Proposed service hot water demand reported in the Compliance Form is reasonable.

90.1 2016/2019 Section 11/Appendix G

Table 11.5.1 Column B #11, Table G3.1 #11 Baseline Building Performance column: Service water-heating energy consumption shall be calculated explicitly based on the volume of service water heating required, the entering makeup water, and the leaving service water heating temperatures. Entering water temperatures shall be estimated based on the location. Leaving temperatures shall be based on the end-use requirements.

Review Tips

1. The check should only be performed for Appendix G projects if hot water demand reported in the Compliance Form is different between the baseline/budget and proposed.
2. SHW demand assumptions are provided in Tables 4 - 6 of the Service Water Heating tab.
   a. Table 4 calculates SHW demand for multifamily projects based on the entered flow rates for the specified fixtures in showers and sinks, average supply SHW temperature, entering cold water temperature and temperature at the fixture point of use. The calculations are based on requirements of the EPA ENERGY STAR Multifamily Simulation Guidelines[15]. Verify that entered flow rates match design documents.
   b. Table 5 shows default service hot water use for non-residential building types. The default values are based on typical hot water use in buildings of similar type provided in ASHRAE 90.1 2013 User's Manual. If default is overwritten, the input is shown in brown font and should be verified.

SWH04-B Difference between the baseline/budget and proposed hot water demand reported in the Compliance Form is as allowed

90.1 2016 Section 11

Change in service water heating load is not listed as a trade-off opportunity in the section, thus must be modeled the same in the budget and proposed design. This is further clarified in the updates to this section incorporated into 2019 edition of 90.1 shown below.

90.1 2019 Section 11

Table 11.5.1 Column B #11: Service water loads and use shall be the same for both the proposed design and baseline building design and typical of the proposed building type.

90.1 2016/2019 Appendix G

Table G3.1 #11 Baseline Building Performance column: Exception to (h) states that service water-heating use can be reduced due to the following:

- water conservation measures that reduce the physical volume of service water required. Examples include low-flow shower heads.
- reducing the required temperature of service mixed water, by increasing the temperature, or by increasing the temperature of the entering makeup water. Examples include alternative sanitizing technologies for dishwashing and heat recovery to entering makeup water.
- reducing the hot fraction of mixed water to achieve required operational temperature. Examples include shower or laundry heat recovery to incoming cold-water supply, reducing the hot-water fraction required to meet required mixed-water temperature.

Such reductions must be demonstrated by calculations.

2019 edition includes the following clarification in **Table G3.1 #1, Baseline Building column**: Where the baseline building systems and equipment are permitted to be different from the proposed design but

[15] ENERGY STAR Multifamily Highrise Program Simulation Guidelines – Appendix G 90.1 2016 Version 1.0

are not prescribed in this appendix, the baseline must be determined based on the following, in the order of priority:

- Requirements in Sections 5 through 10
- Requirements of other efficiency or equipment codes or standards applicable to the design of the building systems and equipment

Review Tips

1. Hot water demand is reported in Table 4 of the Service Water Heating tab for the residential occupancies and in Table 5 for all others.

2. Section 11: the amount of service hot water consumed in the building is not a trade-off opportunity and must be modeled the same in the budget building and the proposed design.

3. Appendix G:
    a) Projects may document reduction in demand provided the methodology is approved by the building official. For example, on projects with low-flow fixtures, hot water demand in the Proposed Design may be reduced to reflect the lower flow rates of the installed fixtures compared to the maximum flow allowed by the applicable code or standard.
    b) Table 4 of the Service Water Heating tab automatically calculates savings from common water-savings technologies found on residential projects such as low flow plumbing fixtures and EnergyStar appliances. Baseline values are set by defaults and should be verified if overwritten.
4. Common Mistakes
    a) Modeling hot water demand reduction on projects following Section 11.
    b) Using baseline flow rate based on requirements of the outdated standard such as Energy Policy Act 1992 (EPACT 1992). The baseline must be based on the maximum allowed flow rates of the applicable codes such as state International Plumbing Code.

SWH05-B, SWH05-P Modeled baseline/budget and proposed SWH system type, efficiency, capacity and ancillary features reflect parameters reported in the Compliance Form

Review Tips

1. Review the simulation reports to confirm that the modeled SWH system parameters are as reported in the Compliance Form.

eQUEST	PS-A
Trane TRACE 700	Plant Information entered values report
Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Service Water Heating' section
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Service Water Heating' section
Carrier HAP v5	"Plant Input Data" report, "Boiler Input Data" report.

Design Builder	Service Water Heating sheet in LEED Minimum Energy Performance Calculator (.xlsm)

SWH06 Difference in the baseline/budget and proposed hot water use is reasonable based on the system parameters reported in the Compliance Form

Review Tips

1. Section 11: Since the budget SWH system must be of the same type and use the same fuel as the proposed system and the reduction in the hot water demand is not a trade-off opportunity, the difference in SWH energy use between the budget and proposed design depends only on the difference in efficiencies of the budget and proposed systems.

   $SWH\_Use_{prop} * SWH\_Eff_{prop} = SWH\_Use_{budget} * SWH\_Eff_{budget}$

   SWH_Use [MMBtu] = the annual SWH use from simulation output reports
   SWH_Eff = SWH efficiency reported in the submittal

Projects that don't show this pattern should be flagged and explanation and supporting documentation should be requested. Higher savings may be demonstrated by projects that have solar hot water preheat as allowed by 90.1 Section 11.4.3.1, or other means of service hot water preheat, such as use of condenser heat recovery, that differs between the budget and proposed design. This check is automated in the Compliance Form.

2. 90.1 Appendix G: The baseline SWH system may be of a different type and use a different fuel than the proposed SWH system and there may be difference in hot water demand between the baseline and proposed design, thus this check cannot be effectively performed.

eQUEST Reports	BEPU
Trane TRACE 700	Equipment Energy Consumption report
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	Plant Loops & Equipment Report, Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	
OpenStudio	
Carrier HAP v5	"Monthly Simulation Results" report for an SHW plant.
Design Builder	Service Water Heating sheet in LEED Minimum Energy Performance Calculator (.xlsm)

SWH05- P Modeled proposed SWH effective full load hours are reasonable

Review Tips

1. SWH effective full load hours are equal to the ratio of the annual service water heating energy use from the simulation outputs to the reported service water heater capacity. Effective full load hours which are higher than typical included in Appendix C may indicate that modeled service water

heating demand exceeds the values anticipated by the design team and that the modeled service water heater energy use is exaggerated. EFLH exceeding typical by more than 25%, or exceeding 8760 hours per year, should be flagged.

eQUEST Reports	BEPU
Trane TRACE 700	Equipment Energy Consumption report
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	Room Loads Report, Zone Loads Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'LEED Summary' report, 'EAp2-4/5. Performance Rating Method Compliance' section
OpenStudio	eplustbl.html 'LEED Summary' report, 'EAp2-4/5. Performance Rating Method Compliance' section
Carrier HAP v5	"Monthly Simulation Results" report for an SHW plant.
Design Builder	Service Water Heating sheet in LEED Minimum Energy Performance Calculator (.xlsm)
Energy Gauge	

Airside HVAC (AHVAC)

Overview

This group of checks covers air-side systems including type, heating and cooling efficiency and controls. In addition, it covers fan systems and controls, mechanical ventilation including ventilation rate, controls and exhaust air energy recovery, and economizer. Table 12 summarizes the checks included in this group.

Table 12: Air-side HVAC Quality Control Checks Overview

	Type of Check	Proposed Design	Baseline/Budget Design
Thermal Blocks	CF inputs reflect design documents	AHVAC01-P	NA
	CF inputs reflect requirements of 11/G	AHVAC01-P	NA
	Simulation inputs consistent with CF	AHVAC02-P	AHVAC02-B
AHVAC System Type, Heating & Cooling	CF inputs reflect design documents	AHVAC03-P(system type) AHVAC05-P(capacity) AHVAC07–P (efficiency)	NA
	CF inputs reflect requirements of 11/G	AHVAC08-P(efficiency) AHVAC09-P(eff. w/o fan pwr) AHVAC10-P(p. curves)	AHVAC03-B(system type) AHVAC05-B (capacity) AHVAC08-B (efficiency) AHVAC09-B eff. w/o fan pwr) AHVAC10-B(p. curves)

	Meet mandatory requirements	AHVAC08–P (efficiency)	NA
	Simulation inputs consistent with CF	AHVAC04-P(system type) AHVAC06-P(capacity) AHVAC11-P(efficiency)	AHVAC04-B (system type) AHVAC06-B (capacity) AHVAC11-B (efficiency)
	Simulation outputs consistent with CF	AHVAC13–P(h. efficiency), AHVAC12-P(c. efficiency) AHVAC31-P(monthly c. h. pattern)	AHVAC13–B (h. efficiency), AHVAC12-B (c. efficiency), AHVAC31-B (monthly c. h. pattern)
Fans	CF inputs reflect design documents	AHVAC14-P(flow), AHVAC15-P(power), AHVAC16-P(flow, T)	NA
	CF inputs reflect requirements of 11/G	AHVAC17-P(fan curves)	AHVAC14-B(flow), AHVAC15-B(power), AHVAC16-B(flow, T), AHVAC17-B(fan curves)
	Simulation inputs consistent with CF	AHVAC18-P(power, flow, control)	AHVAC18-B(power, flow, control)
	Simulation outputs consistent with CF	AHVAC19-P, AHVAC20-P	AHVAC19-B, AHVAC20-B
Ancillary	CF inputs reflect design documents	AHVAC21-P (economizer), AHVAC23–P (ventilation), AHVAC24-P (DCV), AHVAC27-P (energy recovery), AHVAC29-P(other)	NA
	CF inputs reflect requirements of 11/G		AHVAC21-B (economizer), AHVAC23–B (ventilation), AHVAC24-B (DCV) AHVAC27-B (energy recovery)
	Meet mandatory requirements	AHVAC25-P (DCV)	NA
	Simulation inputs consistent with CF	AHVAC22-P (economizer) AHVAC26-P (ventilation and DCV), AHVAC28-P(energy recovery), AHVAC31-P(other)	AHVAC22-B(economizer) AHVAC26-B (ventilation and DCV), AHVAC28-B(energy recovery)
LEGEND			

PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form

90.1 Section 6 has mandatory minimums for heating and cooling system efficiencies and ventilation controls. Checks verifying mandatory requirements should be completed where applicable.

In addition, checks should focus on air-side systems with the highest heating or cooling capacity, design and ventilation flow rates and spot-checking the rest. A table in the Air-side HVAC section of the Quality Control Checks tab ranks air-side systems based on these criteria and should be used to identify systems to be reviewed. For example, if a multifamily project includes a rooftop unit serving common corridors and a water-source heat pumps serving each apartment, the rooftop unit and several representative heat pump systems should be reviewed.

AHVAC01–P Thermal blocks are established correctly

90.1 2016/2019 Appendix G

11.7.2 g and G1.3.2 i: A diagram showing the *thermal blocks* used in the computer simulation must be submitted.

90.1 2016/2019 Section 11 and Appendix G

90.1 Table 11.5.1 #7 and G3.1 #7

Thermal blocks must be based on the HVAC zones specified in the proposed design. Where HVAC zones are defined on the drawings, each HVAC zone must be modeled as a separate thermal block. Different HVAC zones may be combined into a single thermal block if all of the following applies:

- zones have similar occupancy types (e.g., include primarily office spaces)
- have windows facing the same orientation, or their orientations vary by less than 45 degrees
- are served by the same kind of HVAC system

Thermal blocks in the baseline (budget) design must be the same as in the proposed design.

90.1 Table 11.5.1 #8 and Table G3.1 #8 Special rules apply to projects with no HVAC zones designed. Thermal blocks in the baseline (budget) design must be the same as in the proposed design.

90.1 Table 11.5.1 #8 and Table G3.1 #9

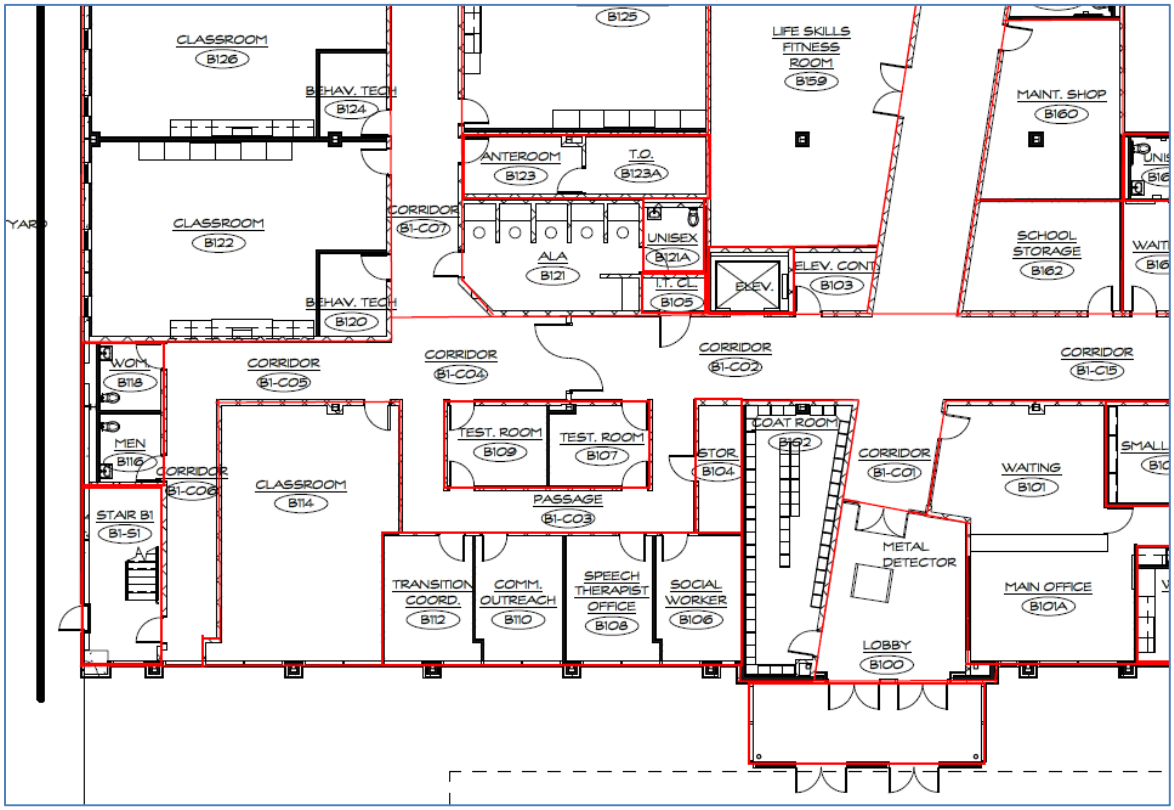
Residential occupancies such as multifamily must be modeled using at least one thermal block per dwelling unit, except units facing the same orientations may be combined into one thermal block. Corner units and units with roof or floor loads may only be combined with units sharing the same features. Thermal blocks in the baseline (budget) design must be the same as in the proposed design.

Review Tips

1. The submittal package for projects following Appendix G or 2019 Section 11 must include a diagram showing the thermal blocks used in the computer simulation. Refer to the Review Checklist tab #15 to identify the name of the file or document with the necessary information. The diagram should include the labels corresponding to the block names used in the simulation, or a description of the thermal block naming convention used. For example, the names of the thermal blocks may be based on space names shown on architectural drawings. Request thermal block diagram if it is not

included in the submittal package or lacks the necessary details. Even though it is not required for projects following 90.1 2016 Section 11, reviewer may still choose to request it to help verify that the relevant requirements of 90.1 are met.

Figure 7: Sample Thermal Blocks Used in the Computer Simulation



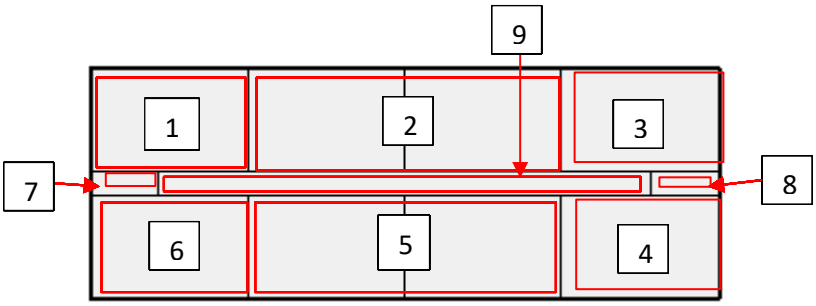
2. The thermal blocks are summarized in Table 2 of the Interior Lighting Model Inputs tab. Spot-check the table to confirm alignment with the submitted diagram.
3. The relevant 90.1 rules set the minimum level of details to which the project's floor plans must be captured in the model. HVAC zone may include one or more spaces where indoor conditions (e.g., temperature) are maintained by a single sensor (e.g., thermostat). Refer to Table 1 of the Interior Lighting Counts tab where detailed information for thermal blocks is provided. Spot check a sample of larger or typical thermal blocks with the submitted block diagram and mechanical plans drawings to confirm that the rules we correctly applied to the project.

Table 1: Lighting Fixture Counts — Total for Area (ft²): 109,661

Space Name Reference (e.g. space name(s) from drawings)	Thermal Block Name from Model	Lighting Plans Dwg#	Multiplier	Space/Building Area Type (90.1-Section 9)	Area (ft²)	RCR LP per Se
Corr 101	Corr1	E-101	1	Corridor/All Other	604	
Trash 102	Corr1	E-101	1	Storage Room/<50 ft^2	49	
Stair 103	N Stair1	E-101	1	Stairwell	92	
Stair 104	S Stair1	E-101	1	Stairwell	92	
Apt 101A	MF1ESE Perim Spc (G.ESE4)	E-101	1	Dwelling Unit	963	

... Lighting Space Types | Interior Lighting Counts | Interior Lighting ...

Example: A ten story multifamily building with eight apartments, corridor and stairwells on each floor would be modeled with 27 thermal blocks (highlighted in red in the figure below), including nine thermal blocks on top and bottom floors and another 9 thermal blocks on a typical middle floor to which a multiplier of 8 is applied to indicate that there are eight such floors in the building.



AHVAC02-B,P Thermal blocks are modeled as reported in the Compliance Form

Review Tips

1. Spot-check simulation reports to verify that the modeled thermal blocks for the baseline/budget and proposed design reflect thermal blocks reported in Table 2 of the Interior Lighting Model Inputs tab.

eQUEST Reports	SV-A
Trane TRACE 700	Room Information entered values report
Trane TRACE 3D Plus	NA
IESVE SOFTWARE	Plant Loops & Equipment Report, Space Loads & Ventilation Report, Room Loads Report, Zone Loads Report, System Loads Report, Detailed Simulation Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Input Verification and Results Summary' report, 'Zone Summary' section, and 'Initialization Summary' report, 'Zone Information' section
OpenStudio	eplustbl.html 'Input Verification and Results Summary' report, 'Zone Summary' section, and 'Initialization Summary' report, 'Zone Information' section
Carrier HAP v5	"Air System Input Data" reports.
Design Builder	Zone Sensible Heating/Cooling Tables in Output Summary Document

AHVAC03–P All specified air-side HVAC systems are reported in the Compliance Form

Review Tips

1. Each HVAC system shown on mechanical schedules must be included in the Compliance Form. Cross-check information provided in Table 1a of the Proposed HVAC with the Mechanical Schedules to confirm that all specified air-side systems are reported.
2. Common Mistakes

a) Supplemental systems such as electric resistance unit heaters and baseboards that are often specified for mechanical rooms, stairwells and bathrooms not reported in the Compliance Form.

AHVAC03–B Baseline/budget system types reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Each HVAC system specified in the proposed design must have a corresponding baseline system established following 90.1 **Figure 11.5.2**, **Table 11.5.2-1** and accompanying notes.

90.1 2016/2019 Appendix G

Baseline HVAC system type and description must be based on 90.1 **Section G3.1.1**. Mixed use buildings that include both residential and non-residential building types with non-predominant conditions accounting for more than 20,000 SF of conditioned floor area must have a separate baseline system type established for each set of conditions. The following baseline systems apply to New York climate zones 4a, 5a, 6a:

- All residential occupancies (dormitory, hotel, motel and multifamily):
  System 1 – PTAC
- All public assembly occupancies (houses of worship, auditoriums, movie theaters, performance theaters, concert halls, arenas, enclosed stadiums, ice rinks, gymnasiums, convention centers, exhibition centers and natatoriums):
  System 3—PSZ-AC if <120,000 ft2
  System 12—SZ-CV-HW if >= 120,000 ft2
- Heated-only storage (e.g. warehouse) meeting the definition of non-predominant conditions, or certain heated-only spaces such as storage rooms, stairwells, electrical/mechanical rooms (90.1 Section G3.1.1 e):
  System 9—Heating and ventilation
- All other non-residential:
  System 3—PSZ-AC if 3 floors or fewer and <25,000 ft^2
  System 5—Packaged VAV with reheat if 4 or 5 floors and <25,000 ft^2 or 5 floors or fewer and 25,000 ft2 to 150,000 ft^2
  System 7—VAV with reheat if more than 5 floors or >150,000 ft^2

Review Tips – 90.1 Section 11

1. Budget HVAC system types are reported in Table 1a of the Budget Section 11 tab. Since Section 11 requires that each system in the proposed design has a corresponding budget system, the default budget system types are set in the table by applying the appropriate rules of Section 11 to each proposed system. The over-written defaults are shown in brown bold font and should be verified.

Modeled Budget Sys Name	Correspon-ding Proposed System	Areas Served	System Type (Figure 11.5.2)	Qty
Cor_Sys	Cor_Sys	Corridors	System 10 - Packaged terminal air conditioner	1
UH_HW	UH_HW	Stairs	System 11 - Packaged rooftop air conditioner	26
Retail_Sys	Retail_Sys	Retail	System 11 - Packaged rooftop air conditioner	6
Apt_Sys	Apt_Sys	Apartments	System 10 - Packaged terminal air conditioner	80
DOAS_Sys	DOAS_Sys	Apartments	System 10 - Packaged terminal air conditioner	1

Review Tips – 90.1 Appendix G

2. Baseline HVAC system types are reported in Table 1a of the Baseline HVAC App G tab. Spot-check to confirm that the baseline systems were established correctly based on the applicable 90.1 rules.

Modeled Sys Name	System Type	Applicable Exception, If Any	Zoning	Areas Served	Qty
UH_Stairs	System 9 - Heating and ventilation	G3.1.1 (e)	System per Block	Stairs	26
PSZ_Retail	System 3 - PSZ-AC	G3.1.1 (b)	System per Block	Retail	6
PTAC_Apts	System 1 - PTAC		System per Block	Apartments and Corridors	90

3. Common Mistakes
   a. Baseline HVAC heating fuel source based on the heating source used in the proposed design instead of based on the project's climate zone. For example, a project in climate zone 4A that has electric heating in the proposed design (with heating provided by
   b. Modeling dedicated outdoor air system (DOAS) in the baseline on projects with DOAS in the proposed design. Instead, heating, cooling and ventilation in the baseline design is provided by systems determined following 90.1 Section G3.1.1.
   c. System 5 - 8 are not modeled as System per floor; instead, multiple systems per floor are modeled to maintain the same arrangement as in the proposed design. This impacts a baseline systems individual OA to supply ratio which determines baseline energy recovery requirements and may also affect the baseline system efficiency.

AHVAC04–B,P All baseline/budget and proposed air-side HVAC systems reported in the Compliance Form are modeled.

Review Tips

1. Spot-check simulation reports to confirm that all proposed air-side systems reported on Table 1a of the Proposed HVAC tab are modeled and reflect the reported system type and fuel.
2. Spot-check simulation reports to confirm that all budget/baseline air-side HVAC systems reported in Table 1a of the Budget HVAC Section 11/ Baseline HVAC App G or tabs are modeled and reflect the reported system type and fuel.
3. Confirm alignment between heating/cooling fuel sources reported in the Compliance Form for baseline/budget and proposed design with modeling results. For example, if some systems reported

in the Compliance Form use electric resistance heat, simulation output reports must show electricity consumption under space heating end use.

4. Common Mistakes

    a) Using incorrect "template" within the simulation tool to model specified system type, such as a constant volume system template to model a variable volume system.
    b) Omitting electric resistance space heaters and radiators from the model

eQUEST Reports	SV-A (includes all air-side systems), SS-P, DOE-2 Help (established modeled system type based on SV-A and enter it into DOE-2 Help "search" box to see typical applications), BEPU (check that electricity is reported under heating end use if electric resistance heaters are specified) The following system types are commonly used to model PRM Baseline systems: System 1 – PTAC or PSZ-AC System 3 – PSZ – AC System 5 – PVAVS System 7 – VAVS System 9 – UHT
Trane TRACE 700	System Information entered values report for system type and Energy Cost Budget report for space heating end use
Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, Space Loads & Ventilation Report, Room Loads Report, Zone Loads Report, System Loads Report, Detailed Simulation Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Component Sizing Summary' report, 'AirLoopHVAC' section
OpenStudio	eplustbl.html 'Component Sizing Summary' report, 'AirLoopHVAC' section
Carrier HAP v5	Input Data: "Air System Input Data" report. Output Data: "Monthly Simulation Results" report for an Air System
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC05–P Heating and cooling types and capacities of the proposed air-side HVAC systems reported in the Compliance Form reflect Design Documents.

Review Tips

1. Heating and cooling types and capacities of the air-side HVAC systems are reported in Table 1a of the Proposed HVAC tab. Cross-check the provided information with the design documents for a sample of systems to confirm alignment.

						Heating System Type and Capacity							
Modeled System Name	Drawing System Name(s)	Drawing Plans/ Spec	Areas Served	Quantity	Single-zone or Multi-zone?	Equipment Type	Heat Pump Type	Fuel Type / Heating Source	Total Capacity for Qty Listed	Cap. Units	Preheat Coil Heating Source	Reheat Type	Perimeter Radiati
Cor_Sys	RTU_1	M-101	Corridors	1	Single Zone Non-Residential	Unit Heater	n/a	Electric Resistance	78	kBtu/h	No preheat coil	None	No
UH_HW	UH_1	M-102	Stairs	26	Single Zone Non-Residential	Unit Heater	n/a	Electric Resistance	35	kBtu/h	No preheat coil	None	No
Retail_Sys	AHU_1	M-101	Retail	6	Single Zone Non-Residential	Central Furnace	n/a	Natural Gas	900	kBtu/h	No preheat coil	None	No
Apt_Sys	FCU_1-80	M-103	Apartments	80	Single Zone Residential	Heat Pump	VRF w/Heat Recovery Air Source	n/a	2,240	kBtu/h	No preheat coil	None	No
DOAS_Sys	DOAS_1	M-103	Apartments	1	Single Zone Residential	Central Furnace	n/a	Natural Gas	1,260	kBtu/h	No preheat coil	None	No

AHVAC05–B Heating and cooling types and capacities of the baseline/budget air-side HVAC systems reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

The equipment capacities for the budget building design must be sized proportionally to the capacities in the proposed design based on sizing runs, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs must be the same for both the proposed design and budget building design (**90.1 Section 11.5.2 i**). The capacity of each system in the budget building should have a reasonable correlation to the corresponding system in the proposed design. For example, if proposed design has a less efficient envelope compared to the budget design, budget system capacities are expected to be lower compared to the corresponding proposed system.

90.1 2016/2019 Appendix G

The coil capacities for the baseline systems must be based on sizing runs for each orientation (**90.1 Table G3.1, No. 5 a**) and oversized by 15% for cooling and 25% for heating; i.e., the ratio between the cooling/heating capacities used in the annual simulations and the capacities determined by the sizing runs must be 1.15/1.25. Weather conditions used in sizing runs must be based either on hourly historical weather files with typical peak conditions, or 99.6% heating design temperatures and 1% dry-bulb and 1% wet-bulb cooling design temperatures from 90.1 Appendix D, as illustrated below.

Figure 41: Example Design Conditions from 90.1 Appendix D

TABLE D-1 U.S. and U.S. Territory Climatic Data *(Continued)*

State/City	Latitude	Longitude	Elev., ft	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		Number of Hours 8 a.m.–4 p.m.
							Dry-Bulb	Wet-Bulb	
						99.6%	1.0%	1.0%	$55 < T_{db} < 69$
(New York cont.)									
Cortland	42.60 N	76.18 W	1129	7168	2225	NA	NA	NA	NA
Elmira/Chemung Co	42.17 N	76.90 W	951	6845	2420	–2	87	71	NA
Geneva Research Farm	42.88 N	77.03 W	718	6939	2364	NA	NA	NA	NA
Glens Falls FAA AP	43.35 N	73.62 W	321	7635	2182	–10	85	71	NA

Review Tips – Section 11

1. Heating and cooling types and capacities of the baseline air-side HVAC systems are reported in Table 1a of the Budget HVAC Section 11 tab of the Compliance Form.
2. Capacity of each system in the budget building should have a reasonable correlation to the corresponding system in the proposed design. For example, if the proposed design has a less efficient envelope compared to the budget design, the budget system capacities are expected to be lower compared to the corresponding proposed system.

Review Tips – 90.1 Appendix G

1. Heating and cooling types and capacities of the baseline air-side HVAC systems are reported in Table 1a of the Baseline HVAC Section 11 tab of the Compliance Form.

Modeled Sys Name	System Type	Areas Served	Qty	Heating				Cooling		
				Equipment Type	Fuel Type / Heating Source	Total Capacity	Cap. Units	Equipment Type	Total Capacity	Cap. Units
UH_Stairs	System 9 - Heating and ventilation	Stairs	26	Fossil Fuel Furnace	Natural Gas	53	kBtu/h	None	-	kBtu/h
PSZ_Retail	System 3 - PSZ-AC	Retail	6	Fossil Fuel Furnace	Natural Gas	1,204	kBtu/h	Direct Expansion	768	kBtu/h
PTAC_Apts	System 1 - PTAC	Apartments and Corridors	90	Hot-Water Fossil Fuel Boiler	Natural Gas	1,898	kBtu/h	Direct Expansion	2,088	kBtu/h

2. Heating and cooling types are shown in the Equipment Type columns and are auto-populated based on user selection in System Type column.
3. The values entered in the Total Capacity columns for heating and cooling must be based on the simulation results.
4. The cooling capacity inputs should be compared to the typical shown in Table 13. Projects with lower SF/Ton should be flagged as they may have an overly lenient (less efficient than required) baseline. Exaggerated baseline cooling system capacity may lead to the system operating at low fraction of design capacity for most of the year, lowering the annual average efficiency. For projects with constant volume systems in the baseline (budget), this will also exaggerate the baseline (budget) fan energy use. In addition, if project uses a utility rate structures with demand charges, this will exaggerate the baseline (budget) demand charges and energy cost.

   The issue may be caused by one or more of the following:
   a) Design conditions are not entered correctly
   b) Higher than typical internal gains from lighting, occupancy or miscellaneous equipment during design day
   c) Lower than typical modeled design cooling temperature
   d) Cooling is oversized by more than 15% to reduce number of hours for which cooling load is not met in the simulation. However, the unmet load hours are often due to simulation mistakes and should be addressed in lieu of increasing cooling capacity. For example, cooling schedule may allow temperatures to go up significantly during unoccupied hours resulting in higher than expected load when the building switches to occupied mode.

Table 13: Cooling Capacity Rule of Thumb[16]

Occupancy Type	Cooling Load, SF/Ton 1 Ton = 12,000 Btu/hr = 12 MBH
Apartment high-rise	400 - 450
Public assembly	250 - 400
Schools – universities	185 - 240
Hotels, motels, dormitories	300 - 350
Office buildings	280 - 360

[16] ASHRAE Pocket Guide for Air Conditioning, Heating, Ventilation, Refrigeration (I-P Edition), 7th Edition

AHVAC06–B,P Heating and cooling capacities of the air-side HVAC systems are modeled as reported in the Compliance Form

Review Tips

1. Spot-check simulation reports to verify that modeled heating and cooling capacities for a sample of air-side HVAC systems reflect values reported in the Compliance Form. (See Table 1a of the Proposed HVAC tab for reported capacities of the proposed systems; see Table 1a of the Budget HVAC Section 11/ Baseline HVAC App G or tabs for budget/baseline system capacities that must be modeled.
2. For Appendix G baseline systems, use simulation input and output reports to verify that the ratio of the baseline system capacity to the simulated peak load is approximately 15% for cooling and 25% for heating. The oversizing may be higher due to the difference in internal gain and weather used for equipment sizing versus the annual simulation. Oversizing significantly higher than 15% should be flagged.
3. For Section 11 budget systems:
    a) use simulation input and output reports to confirm that the ratio of equipment heating/cooling capacity to the simulated heating/cooling peak load should be the same or very similar for the budget systems as for the corresponding systems in the proposed design, based on the simulation output reports.
    b) Calculate the effective heating/cooling full load hours (EFLH) as the ratio of the annual heating/cooling load to the heating/cooling equipment capacity. The effective heating/cooling EFHL should be similar between the proposed systems and the respective budget systems.
4. Common Mistakes:
    a) Having the software auto-size the <u>proposed</u> systems instead of using heating and cooling capacities specified on mechanical schedules.

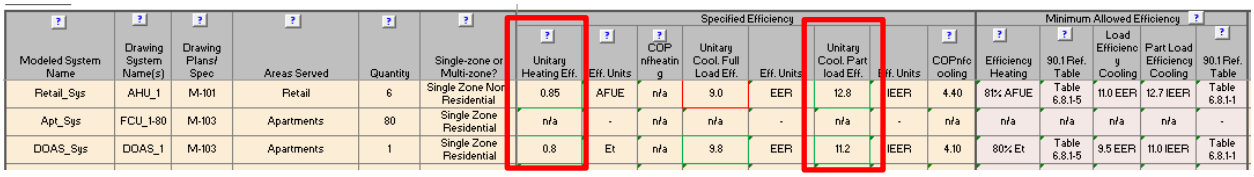
eQUEST Reports	LS-C (design conditions), SS-P (oversizing for baseline/budget systems), SV – A (modeled capacity)
Trane TRACE 700	System Information entered values report
Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, Space Loads & Ventilation Report, Room Loads Report, Zone Loads Report, System Loads Report, Detailed Simulation Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'Component Sizing Summary' report, also available in the 'Equipment Summary' report, 'HVAC Sizing Summary' report, 'Coil Sizing Summary' section, and 'Coil Sizing Details' report if more sizing information is needed
OpenStudio	eplustbl.html 'Component Sizing Summary' report, also available in the 'Equipment Summary' report, 'HVAC Sizing Summary' report, 'Coil Sizing Summary' section, and 'Coil Sizing Details' report if more sizing information is needed
Carrier HAP v5	"Air System Input Data" reports.

Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC07–P Reported air-side HVAC systems cooling and heating efficiencies reflect design documents.

Review Tips

1. Heating and cooling types and capacities of the air-side HVAC systems are reported in Table 1a of the Proposed HVAC tab. Cross-check the provided information with the design documents for a sample of systems to confirm alignment.
2. 90.1 Section 6 includes tables with the minimum efficiency requirements for different types of HVAC systems. These requirements are mandatory and must be met by all specified systems. The requirements applicable to each specified system are shown in Table 1a. Efficiencies that are below the required minimum are highlighted in red and must be noted in the review comments.

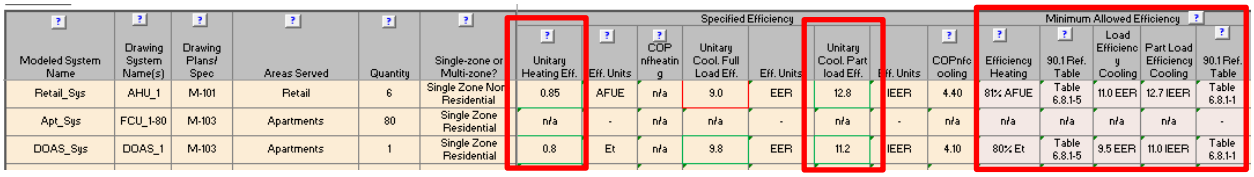


						Specified Efficiency								Minimum Allowed Efficiency				
Modeled System Name	Drawing System Name(s)	Drawing Plans/ Spec	Areas Served	Quantity	Single-zone or Multi-zone?	Unitary Heating Eff.	Eff. Units	COP nfheating	Unitary Cool. Full Load Eff.	Eff. Units	Unitary Cool. Part load Eff.	Eff. Units	COPnfcooling	Efficiency Heating	90.1 Ref. Table	Load Efficiency Cooling	Part Load Efficiency Cooling	90.1 Ref. Table
Retail_Sys	AHU_1	M-101	Retail	6	Single Zone Nor Residential	0.85	AFUE	n/a	9.0	EER	12.8	IEER	4.40	81% AFUE	Table 6.8.1-5	11.0 EER	12.7 IEER	Table 6.8.1-1
Apt_Sys	FCU_1-80	M-103	Apartments	80	Single Zone Residential	n/a	-	n/a	n/a	-	n/a	-	n/a	n/a	n/a	n/a	n/a	-
DOAS_Sys	DOAS_1	M-103	Apartments	1	Single Zone Residential	0.8	Et	n/a	9.8	EER	11.2	IEER	4.10	80% Et	Table 6.8.1-5	9.5 EER	11.0 IEER	Table 6.8.1-1

AHVAC08–P Cooling and heating efficiencies of the specified air-side HVAC systems meet the mandatory minimums in 90.1 Section 6

Review Tips

1. 90.1 Section 6 includes tables with the minimum efficiency requirements for different types of HVAC systems. These requirements are mandatory and must be met by all specified systems. The requirements applicable to each specified system are shown in Table 1a of the Proposed HVAC tab. Efficiencies that are below the required minimum are highlighted in red and should be flagged.



						Specified Efficiency								Minimum Allowed Efficiency				
Modeled System Name	Drawing System Name(s)	Drawing Plans/ Spec	Areas Served	Quantity	Single-zone or Multi-zone?	Unitary Heating Eff.	Eff. Units	COP nfheating	Unitary Cool. Full Load Eff.	Eff. Units	Unitary Cool. Part load Eff.	Eff. Units	COPnfcooling	Efficiency Heating	90.1 Ref. Table	Load Efficiency Cooling	Part Load Efficiency Cooling	90.1 Ref. Table
Retail_Sys	AHU_1	M-101	Retail	6	Single Zone Nor Residential	0.85	AFUE	n/a	9.0	EER	12.8	IEER	4.40	81% AFUE	Table 6.8.1-5	11.0 EER	12.7 IEER	Table 6.8.1-1
Apt_Sys	FCU_1-80	M-103	Apartments	80	Single Zone Residential	n/a	-	n/a	n/a	-	n/a	-	n/a	n/a	n/a	n/a	n/a	-
DOAS_Sys	DOAS_1	M-103	Apartments	1	Single Zone Residential	0.8	Et	n/a	9.8	EER	11.2	IEER	4.10	80% Et	Table 6.8.1-5	9.5 EER	11.0 IEER	Table 6.8.1-1

AHVAC08–B Baseline/budget air-side systems' heating and cooling efficiencies reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11:

All HVAC equipment in the budget building design must be modeled at the minimum part load and full load efficiencies in 90.1 Sections 6.4.

90.1 2016/2019 Appendix G

Baseline system efficiencies must be based on **90.1 Tables G3.5.1 through G3.5.6**.

Review Tips – 90.1 Section 11

1. Heating and cooling system efficiencies are reported in Table 1a of the Budget HVAC Section 11 tab. The defaults are based on the efficiency tables referenced in "90.1 Ref Table" column. Any over-written defaults which are shown in brown font should be confirmed by reviewer.

Modeled Budget Sys Name	Correspon-ding Proposed System	Budget Model Efficiency Heating				Budget Model Efficiency Cooling					
		Unitary Eff.	Eff. Units	Modeled Efficiency	90.1 Ref. Table	Unitary Full Load Eff.	Eff. Units	Unitary Part load Eff.	Eff. Units	COPnfcooling	90.1 Ref. Table
Cor_Sys	Cor_Sys	80%	Et	80% Et	Table 6.8.1-5	9.5	EER	11.0	IEER	3.78	Table 6.8.1-1
UH_HW	UH_HW				-	-	-	14.0	SEER	-	Table 6.8.1-1
Retail_Sys	Retail_Sys	80%	Et	80% Et	Table 6.8.1-5	9.8	EER	11.4	IEER	3.58	Table 6.8.1-1

Review Tips – 90.1 Appendix G

1. Heating and cooling system efficiencies are reported in Table 1a of the Baseline HVAC App G tab and are auto-populated based on user inputs in the System Type column and the Total Capacity columns for heating and cooling. In addition, the appropriate simulation inputs for heating and cooling efficiency are automatically established and shown in the Modeled Efficiency and COPnfcooling columns. The calculations reflect 90.1 requirements for extracting fan power from efficiency rating.

Modeled Sys Name	System Type	Baseline Efficiency Heating			Baseline Efficiency Cooling				
		Unitary Eff.	Eff. Units	Modeled Efficiency	Unitary Full Load Eff.	Eff. Units	Unitary Part load Eff.	Eff. Units	COPnfcooling
UH_Stairs	System 9 - Heating and ventilation	80%	Ec	78% Et	-	-	-	-	-
PSZ_Retail	System 3 - PSZ-AC	78% or 80%	AFUE or Et	80% Et	10.1	EER	-	-	3.52
PTAC_Apts	System 1 - PTAC	-	-	-	9.3	EER	-	-	2.88

AHVAC09–P Modeling inputs for the proposed heating and cooling efficiency are provided in the Compliance Form and established correctly

90.1 2016/2019 Section 11 and Appendix G

90.1 Section 11.5.2, Table G3.1 #10

The modeled efficiency of the proposed systems must be adjusted to remove the supply fan energy corresponding to the conditions at which the unit was tested by the manufacturer. This requirement applies to all systems with a cooling efficiency rating expressed as EER and SEER. The cooling efficiency with the fan energy excluded is referred to as COPnfcooling must be calculated based on manufacturer data at AHRI Rating Conditions, as follows (see also the 90.1 User's Manual):

Indoor Fan Power [W] = (Gross Cooling [Btu/h]-Net Cooling [Btu/h])/3.413[Btu/h x W]

COPnfheating = Gross Heating [Btu/h]/(Total Input Power [W] - Indoor Fan Power [W]) x 3.413 [Btu/hx W])

90.1 2016/2019 Appendix G

Review Tips

1. COPnfcool and COPnfheat for each proposed HVAC system with DX heating or cooling is included in Table 1a of the Proposed HVAC tab. Confirm that it is calculated as appropriate for a sample of HVAC systems and comment if incorrect. Focus the review on DX systems with the highest heating/cooling capacities and spot-check the rest.
2.

Modeled System Name	Drawing System Name(s)	Specified Efficiency								Minimum Allowed Efficiency					Basis of Modeled Performance Curves
		Unitary Heating Eff.	Eff. Units	COP nfheating	Unitary Cool. Full Load Eff.	Eff. Units	Unitary Cool. Part load Eff.	Eff. Units	COPnfcooling	Efficiency Heating	90.1 Ref. Table	Load Efficiency Cooling	Part Load Efficiency Cooling	90.1 Ref. Table	
Cor_Sys	RTU_1	0.82	Et	n/a	12.0	EER	13.0	IEER	4.14	80% Et	Table 6.8.1-5	11.0 EER	12.7 IEER	Table 6.8.1-1	Performance Rating Method Reference Manual
UH_HW	UH_1	n/a	-	n/a	n/a	-	n/a	-	n/a	n/a	n/a	n/a	n/a	-	n/a
Retail_Sys	AHU_1	0.8	Et	n/a	11.1	EER	12.8	IEER	4.40	80% Et	Table 6.8.1-5	11.0 EER	12.7 IEER	Table 6.8.1-1	Performance Rating Method Reference Manual
Apt_Sys	FCU_1-80	n/a	-	n/a	n/a	-	n/a	-	n/a	n/a	n/a	n/a	n/a	-	n/a
DOAS_Sys	DOAS_1	0.8	Et	n/a	9.8	EER	11.2	IEER	4.10	80% Et	Table 6.8.1-5	9.5 EER	11.0 IEER	Table 6.8.1-1	Performance Rating Method Reference Manual

Example: The specified air-handling unit has the following rated performance based on the manufacturer's catalog:

Gross Cooling Capacity – Full Load [Btu/hr]	103,000
EER / IEER	12.6 / 22.5
AHRI Net Cooling Capacity – Full Load [Btu/hr]	99,000
System Power [kW]	7.86

Indoor Fan Power [W]= (Gross Cooling [Btu/h] – Net Cooling [Btu/h])/3.413 [Btu/h x W]=
(103,000-99,000)/3.412=1,172 [W]

COP_{nfcool} = Gross Cooling [Btu/h] / ((System Power [W] – Indoor Fan Power[W])*3.412[Btu/h x W] =
103,000/((7,860 – 1,172)*3.412)=0.2214

AHVAC09–B Modeling inputs for the baseline/budget heating and cooling efficiency are provided in the Compliance Form and established correctly

90.1 2016/2019 Section 11

Section 11.5.2 c: For Systems 3,4,6,8,9,10,11, supply fan energy at AHRI test conditions must be extracted from efficiency rating using the provided methodology.

90.1 2016/2019 Appendix G

Section G3.1.2.1: For Systems 1 – 6, supply fan energy at AHRI test conditions must be extracted from efficiency rating using the provided methodology.

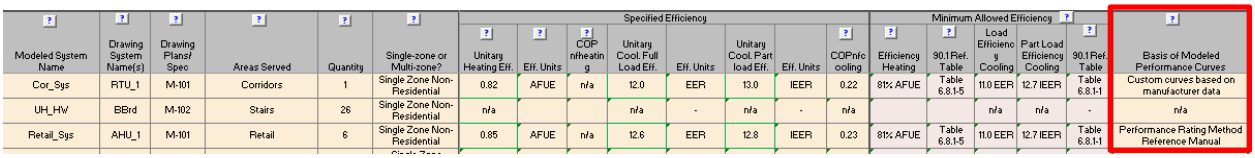
Review Tips

1. The appropriate simulation inputs for heating and cooling efficiency are automatically established and shown in the Modeled Efficiency and COPnfcooling columns in Table 1a of the Baseline HVAC App G or Budget HVAC Section 11, depending on the compliance path. The calculations reflect 90.1 requirements for extracting fan power from efficiency ratings. For Section 11 projects, the defaults may be over-written by modeler the. The custom values may be verified.

AHVAC10-P The heating & cooling performance curves used in the proposed design simulation are based on an approved source

Review Tips

1. The modeled performance curves reflect variations in efficiency and capacity of the specified equipment at the range of operating conditions. The basis of the modeled performance curves must be specified in Table 1a of the Proposed HVAC tab.



Modeled System Name	Drawing System Name(s)	Drawing Plans/ Spec	Areas Served	Quantity	Single-zone or Multi-zone?	Specified Efficiency								Minimum Allowed Efficiency					Basis of Modeled Performance Curves
						Unitary Heating Eff.	Eff. Units	COP nheating	Unitary Cool. Full Load Eff.	Eff. Units	Unitary Cool. Part load Eff.	Eff. Units	COPnfc cooling	Efficiency Heating	90.1 Ref. Table	Load Efficiency Cooling	Part Load Efficiency Cooling	90.1 Ref. Table	
Cor_Sys	RTU_1	M-101	Corridors	1	Single Zone Non-Residential	0.82	AFUE	n/a	12.0	EER	13.0	IEER	0.22	81% AFUE	Table 6.8.1-5	11.0 EER	12.7 IEER	Table 6.8.1-1	Custom curves based on manufacturer data
UH_HW	BBrd	M-102	Stairs	26	Single Zone Non-Residential	n/a			n/a	-	n/a	-	n/a			n/a	n/a	-	n/a
Retail_Sys	AHU_1	M-101	Retail	6	Single Zone Non-Residential	0.85	AFUE	n/a	12.6	EER	12.8	IEER	0.23	81% AFUE	Table 6.8.1-5	11.0 EER	12.7 IEER	Table 6.8.1-1	Performance Rating Method Reference Manual

The performance curves may be available from equipment manufacturers or developed based on the performance data provided by the manufacturer. If the performance curves for the specified equipment are not available, the default curves from the ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual[17] may be used.

2. When custom performance curves based on manufacturer data are used for any of the systems, the supporting documentation must be provided. Refer to Submittal Checklist tab #21 to confirm that it is included in the submittal. The provided calculations may be reviewed for a sample of performance curves. Alternatively, reviewer may verify that, based on the simulation reports, the realized annual average efficiency is similar to the rated IEER of the unit.

AHVAC10-B The heating & cooling performance curves used in the baseline/budget design simulation are based on an approved source

Review Tips

1. The modeled performance curves reflect variations in efficiency and capacity of the specified equipment at the range of operating conditions. The basis of the modeled performance curves must be specified in the last column of Table 1a on the Baseline HVAC App G tab for Appendix G projects and on the Budget HVAC Section 11 tab for Section 11 projects. The curves from the ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual[18] should be used; projects with other sources selected may be flagged for further review. The modeled performance curves may be verified by checking that, based on the simulation reports, the realized annual average efficiency is similar to the rated IEER of the unit.

[17] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26917.pdf

[18] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26917.pdf

AHVAC11–B,P Modeled heating and cooling efficiency of the air-side systems reflect values reported in the Compliance

Review Tips

1. Use simulation reports to spot-check that the modeled cooling and heating efficiencies is as reported for selected air-side systems as follows:
    a) $COP_{nfcooling}$ and $COP_{nfheating}$ reported in the Compliance Form is aligned with the simulation reports. The reported values are found in Table 1a of the Proposed HVAC for the proposed systems and in Table 1a of the Budget HVAC Section 11/ Baseline HVAC App G tabs for budget/baseline systems.
    b) Warm-air furnaces may have efficiency expressed as the Annual Fuel Utilization Efficiency (AFUE), thermal efficiency (Et) or combustion efficiency (Ec). The conversions below (from the Performance Rating Method Reference Manual) may be used if the efficiency input supported by the simulation tool differs from the efficiency metric available from the manufacturer for the specified equipment:

    Et=0.0051427 x AFUE + 0.3989
    Et=Ec – 2%

The calculations is performed automatically for the baseline/budget systems and results are shown in Table 1a of the Baseline HVAC App G/Budget HVAC Section 11 tabs.

	Baseline Efficiency Heating			Baseline Efficiency Cooling					
Modeled Sys Name	Unitary Eff.	Eff. Units	Modeled Efficiency	Unitary Full Load Eff.	Eff. Units	Unitary Part load Eff.	Eff. Units	COPnfcooling	Basis of Modeled Performance Curves
UH_Stairs	80%	Ec	78% Et	-	-	-	-	-	Performance Rating Method Reference Manual
PSZ_Retail	78% or 80%	AFUE or Et	80% Et	10.1	EER	-	-	3.52	Performance Rating Method Reference Manual
PTAC_Apts	-	-	-	9.3	EER	-	-	2.88	Performance Rating Method Reference Manual

eQUEST Reports	SS-P, SV-A, PS-E (heat pump supplement)
Trane TRACE 700	Plant Information entered values report
Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	BPRM Report
EnergyPlus	eplustbl.html ‘Equipment Summary’ report, ‘DX Cooling Coils’ section
OpenStudio	eplustbl.html ‘Equipment Summary’ report, ‘DX Cooling Coils’ section
Carrier HAP v5	“Air System Input Data” reports.
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC12–B,P Annual average realized DX cooling and heating system efficiencies reflect expected performance at the range of actual conditions

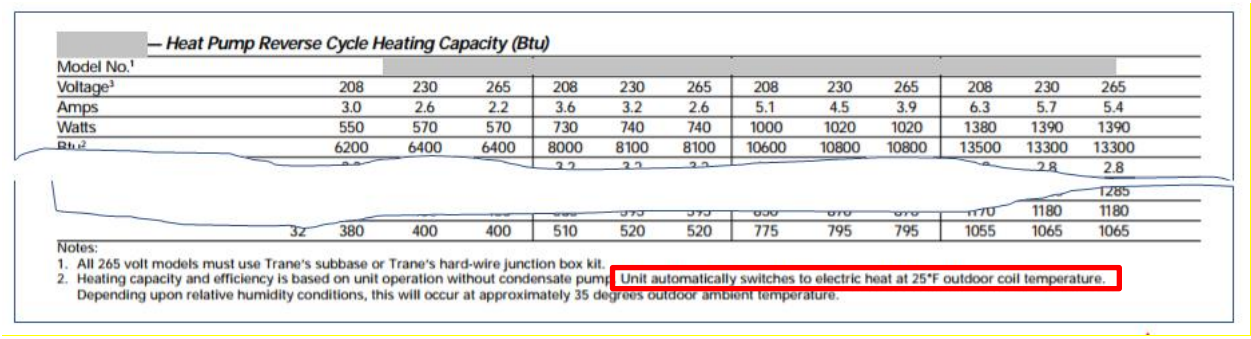
Review Tips

1. Background: The average annual cooling efficiency is the ratio of the annual cooling load to the annual cooling energy from the simulation output reports. It reflects the realized performance of the

modeled system. Most simulation tools used for compliance modeling describe cooling system performance through the rated efficiency and performance curves that capture impact of part load, indoor and outdoor temperatures and various other design, operational and site parameters on system performance. The realized efficiency is typically different from the rated full load efficiency and is similar to IEER (part load efficiency)

2. The check should be performed when cooling is an impactful end use on the project or when heat pumps account for significant share of heating capacity.
3. Calculate the realized efficiency based on the modeling results for a sample of air-side systems and compare the result to the rated part-load efficiency. Systems with substantial difference between modeled and rated part load efficiency should be flagged. Lower than expected realized efficiency for the baseline/budget systems and higher than expected realized efficiency for the proposed systems is of especial concern since it may be due to modeling discrepancies and lead to overly optimistic compliance outcomes.
4. Common Mistakes
   a. Using inappropriate performance curves, such as software default performance curves instead of the performance curves provided in the PRM RM.
   b. Modeled heat pumps incorrectly account for performance degradation at low ambient temperatures including the use of electric resistance heat. In heating-dominated climate, the average realized heat pump heating efficiency is expected to be worse than the manufacturer's rating at 47°F and slightly over the manufacture's rating 17°F. For units that operate in electric resistance mode below 40 F, the average efficiency will be slightly higher than 1.

      For example, air-source heat pumps (ASHPs) often operate in the heat pump mode only down to 35F and use electric resistance heating at the lower temperatures. Reviewers should request equipment cut sheets documenting low-temperature performance of the specified equipment, because it has significant impact on heating energy use and should be reflected in the average annual realized efficiency including heat pump supplement. See sample air-source heat pump specification below describing low temperature operation.



— Heat Pump Reverse Cycle Heating Capacity (Btu)

Model No.[1]												
Voltage[3]	208	230	265	208	230	265	208	230	265	208	230	265
Amps	3.0	2.6	2.2	3.6	3.2	2.6	5.1	4.5	3.9	6.3	5.7	5.4
Watts	550	570	570	730	740	740	1000	1020	1020	1380	1390	1390
Btu/[2]	6200	6400	6400	8000	8100	8100	10600	10800	10800	13500	13300	13300
											2.8	2.8
												1285
32	380	400	400	510	520	520	775	795	795	1055	1180	1180
32	380	400	400	510	520	520	775	795	795	1055	1065	1065

Notes:
1. All 265 volt models must use Trane's subbase or Trane's hard-wire junction box kit.
2. Heating capacity and efficiency is based on unit operation without condensate pump. Unit automatically switches to electric heat at 25°F outdoor coil temperature. Depending upon relative humidity conditions, this will occur at approximately 35 degrees outdoor ambient temperature.

eQUEST Reports	SS-P
Trane TRACE 700	Equipment Energy Consumption report for the total equipment consumption and Building Cool/Heat Demand report from the Visualizer for the total loads
Trane TRACE 3D Plus	Site Consumption Summary for the consumption and Site Load Profile for the loads

IESVE SOFTWARE	Plant Loops & Equipment Report, System Loads Report, BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'Annual Building Utility Performance' report, 'End Uses By Subcategory' section
OpenStudio	eplustbl.html 'Annual Building Utility Performance' report, 'End Uses By Subcategory' section
Carrier HAP v5	"Monthly Simulation Results" reports for air-side DX HVAC systems. Use annual totals for "cooling equipment load", "cooling input kWh", "supply fan kWh".
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC13–B,P Average realized heating efficiency of air-side systems reflect expected performance.

Review Tips

1. Background: The average heating system efficiency is the ratio of the annual heating load to the annual heating energy use of the system, with both values taken from the simulation output reports.

2. The check should be performed when heating is an impactful end use. Calculate the realized efficiency based on the modeling results for a sample of air-side systems and compare the result to the rated part-load efficiency. Systems with substantial difference between modeled and rated part load efficiency should be flagged. Lower than expected realized efficiency for the baseline/budget systems and higher than expected realized efficiency for the proposed systems is of especial concern since it may be due to modeling discrepancies and lead to overly optimistic compliance outcomes.
3. For warm air furnaces with an AFUE rating, the average realized efficiency is expected to be similar to AFUE. For other units, the average realized efficiency is expected to be about 5% below thermal efficiency, based on the furnace part load efficiency curves included in the Performance Rating Method Reference Manual. For example, if a unit is rated at Ec=80%, its Et = Ec – 2% = 78% and the average efficiency is expected to be ~ 73%. The average efficiencies exceeding the above estimates should be flagged.
4. Efficiency degradation at part load is not prescribed in 90.1, but the average annual baseline (budget) efficiency below 75% should be flagged in the review. Table 14 shows efficiency degradation based on the performance curves in the Performance Rating Method Reference Manual. For example, furnace operates at 74% efficiency when the heating load is equal to the half of its rated capacity.

   Table 14: Fossil Fuel Furnace Part Load Efficiency Degradation

% of Design Load $Q_{partload}/Q_{rated}$	100%	90%	80%	70%	60%	50%	40%	30%	25%
Realized Furnace Efficiency	80%	79%	78%	77%	76%	74%	73%	71%	70%

5. Common mistakes
   a) Modeling the baseline/budget systems as having continuously on pilot light.

eQUEST Reports	SS-P, SV-A, PS-E (heat pump supplement)

Trane TRACE 700	Equipment Energy Consumption report for the total equipment consumption and Building Cool/Heat Demand report from the Visualizer for the total loads
Trane TRACE 3D Plus	Site Consumption Summary for the consumption and Site Load Profile for the loads
IESVE SOFTWARE	BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'Annual Building Utility Performance' report, 'End Uses By Subcategory' section
OpenStudio	eplustbl.html 'Annual Building Utility Performance' report, 'End Uses By Subcategory' section
Carrier HAP v5	"Monthly Simulation Results" reports for air-side DX HVAC systems. For fuel-fired heaters: Use annual totals for "heating equipment load", "heating input" For heat pumps: Use annual totals for heating equipment load, heating input kWh", "supply fan kWh".
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC14-P Design supply, return, relief and exhaust fans' flow rates reported in the Compliance Form are as specified in the Design Documents

Review Tips

1. Design flow rates for the specified supply, return, relief and exhaust fans are listed in Table 2a of the Proposed HVAC tab. Cross-check Compliance Form inputs with the information provided in the mechanical schedules for a sample of specified systems to ensure alignment.

		Supply Fan						Relief/Return Fan					Exhaust Fan				
Modeled System Name	Fan Operation, Occupied Hours	Total Supply CFM	Total Outdoor Air CFM	Total BHP	Motor Eff.	Fan Flow Control	kW	Total CFM	Total BHP	Motor Eff.	Fan Flow Control	kW	Total CFM	Total BHP	Motor Eff.	Fan Flow Control	kW
Cor_Sys	Continuous	4,000	363	2.5	89.5%	Constant volume	2.08	4,000	1.5	89.5%	Constant volume	1.25					
UH_HW	Cycling	1,500	0	0.5	89.5%	Constant volume, cycling	0.42										
Retail_Sys	Continuous	14,500	5,812	10.0	89.5%	Constant volume	8.34	13,500	5.0	86.5%	Constant volume	4.31					
Apt_Sys	Cycling	48,000	0	10.0	82.0%	Constant volume, cycling	9.1										
DOAS_Sys	Continuous	6,400	6,400	5.0	89.5%	Constant volume	4.17						6,400	3.0	89.5%	Constant volume	2.5

The figure below illustrates how fan system performance is typically shown in the design documents.

					SUPPLY FAN DATA											
SYMBOL	MANUFACTURER/ MODEL NUMBER	LOCATION	UNIT SIZE	CFM	FAN TYPE	MIN O.A. (CFM)	O.A. (CFM)	ESP (IN WG)	TSP (IN WG)	SPEED (RPM)	BHP	MOTOR DATA				VFD REQ'D (DIV.23)
												HP	RPM	VOLTS	PH	
AHU-1	TRANE CLIMATE CHANGER	NORTH PENTHOUSE 318	17	8,000	PL	900	3500	2.0	4.58	2431	9.65	5.0	1800	208	3	YES
AHU-2		SOUTH PENTHOUSE 302	30	15,000	PL	930	4230	2.0	4.89	3191	19.99	7.5	1800	208	3	YES

AHVAC14–B Baseline/budget design fans flow rates reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Section 11.5.2 g: Design supply air rates for the budget building must be based on a supply-air-to-room-air temperature difference of 20°F. If return or relief fans are specified in the proposed design, the budget building design must also have the same fan type sized for the budget system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.

90.1 2016/2019 Section 11

Section G3.1.2.8: Design supply airflow rates must be based on a supply-air-to-room temperature difference of 20°F or the minimum baseline ventilation rate, whichever is greater. If return or relief fans are specified in the proposed design, the baseline building design must also have fans serving the same functions and sized for the baseline system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.

Review Tips – Section 11

1. Design flow rate of the budget systems is reported in Table 2a of the Budget HVAC Section 11 tab.

		Supply Fan					Relief/Return Fan				Exhaust Fan			
Modeled Budget Sys Name	Corresponding Proposed System	Total Supply CFM	Total Outdoor Air CFM	Total BHP	Motor Eff.	kW	Total CFM	Total BHP	Motor Eff.	kW	Total CFM	Total BHP	Motor Eff.	kW
Cor_Sys	Cor_Sys	2,000	363	2.5	89.5%	2.08	1,800	1.5	86.5%	1.29	0			
Retail_Sys	Retail_Sys	5,500	5,812	4.57	89.5%	3.81	4,950	2.29	89.5%	1.91	0			

2. Supply fan flow is a user inputs and must reflect the value determined through simulation. Relief/return and exhaust flows are auto-populated in the compliance form based on the 90.1 requirements quoted above. Spot-check supply fan flow rates for a sample of air-side systems compared to typical show in Table 15 and outliers should be flagged.
3.

Table 15: Typical Supply Air Flow Rates[19]

Occupancy Type	Supply Air CFM/SF
Apartment high-rise	0.5 – 0.8
Office buildings	0.8 – 1.6

4. Common Mistakes
    a) The causes for higher than expected design flow rates are similar to those that lead to exaggerated cooling loads described in AHVAC05-B.
    b) Sizing flow based on supply air to room air temperature difference less than 20°F exaggerates the flow.
    c) For Appendix G, exaggerated design flow rate may also be caused by applying the over-sizing factor in 90.1 Section G3.1.2.2 to design flows in addition to coil capacities, which is incorrect – only coil capacities must be oversized.

Review Tips – Appendix G

1. Design flow rate of the baseline systems is reported in Table 3b of the Baseline HVAC App G tab. The flows may be compared to typical shown in Table 15 above.
2. Common Mistakes
    a) Refer to common mistakes listed for this check under Section 11
    b) The exaggerated design flow rate may also be caused by applying the over-sizing factor in 90.1 Section G3.1.2.2 to design flows in addition to coil capacities, which is incorrect – only coil capacities must be oversized.

[19] ASHRAE Pocket Guide for Air Conditioning, Heating, Ventilation, Refrigeration (I-P Edition), 7th Edition

AHVAC15-P Design supply, return, relief and exhaust fan power reported in the Compliance Form is as specified in the design documents

Review Tips

1. Design power of the specified supply, return, relief and exhaust fans is listed in Table 2a of the Proposed HVAC tab for all specified systems. Cross-check Compliance Form inputs with the information provided in the mechanical schedules for a sample of the specified systems to ensure alignment.
2. Common Mistakes

    a) External static pressure (ESP in Figure 39) is used in lieu of the total static pressure (TSP). This significantly under-estimates the proposed fan energy.
    b) Only supply fan power is entered. Other specified fans such as return, exhaust and relief omitted from the template.

AHVAC15-B Baseline/budget fan power reported in the Compliance Form is established correctly

90.1 2016/2019 Section 11

Section 11.5.2 h

BHP per CFM of supply air, including the effect of belt losses but excluding motor and motor drive losses must be the same as the proposed design or up to the limit prescribed in 90.1 Section 6.5.3.1, whichever is smaller. If this limit is reached, BHP of each fan must be proportionally reduced until the limit is met. Fan electrical power must be determined by dividing the calculated fan BHP by the minimum motor efficiency in 90.1 Section 10.4.1 for the appropriate motor size for each fan.

90.1 2016/2019 Appendix G

Section G3.1.2.9

The section provides formulas for calculating the total combined power of supply, return, exhaust and relief fans excluding fan-powered *VAV* boxes. For Systems 3 – 8 and 12 - 13, the baseline BHP allowance provided in 90.1 Table G3.1.2.9 may be increased to account for certain design features included in the proposed design. Common examples of the allowed baseline pressure drop adjustments include proposed systems with MERV 9 or higher air filters, sound attenuation devices and ducted returns (90.1 Table 6.5.3.1-2).

Review Tips – 90.1 Section 11

1. Fan power for individual HVAC systems in the budget design is included in Table 2a of the Budget HVAC Section 11 tab and is calculated automatically by applying the applicable 90.1 rules quoted above. The total budget power by fan type is shown in Table 3. Since these values are auto populated in the Compliance Form, they do not need to be checked.

					Supply Fan					Relief/Return Fan				Exhaust Fan			
Modeled Budget Sys Name	Corresponding Proposed System	Fan Operation Occ. Hours	Fan Speed Control	Fan System Total BHP	Total Supply CFM	Total Outdoor Air CFM	Total BHP	Motor Eff.	kW	Total CFM	Total BHP	Motor Eff.	kW	Total CFM	Total BHP	Motor Eff.	kW
Cor_Sys	Cor_Sys	Continuous	Two-speed	4.0	2,000	363	2.5	89.5%	2.08	1,800	1.5	86.5%	1.29	0			
Retail_Sys	Retail_Sys	Continuous	Two-speed	6.86	5,500	5,812	4.57	89.5%	3.81	4,950	2.29	89.5%	1.91	0			

Review Tips – 90.1 Appendix G

1. The allowed pressure drop adjustments for calculating the total baseline fan power allowance are entered in Table 2a of the Baseline HVAC App G tab. Spot-check sample systems to confirm that the design flow rate CFM_D entered for each category includes only flow to the zones that include the allowed device in the proposed design. For example, if in the proposed design sound attenuation is specified only for some of the zones, CFM_D entered in the sound attenuation column must include only supply flow to these zones in the baseline design and not the total supply flow of the baseline system. Spot-check should focus on baseline systems with high CFM_D.

Modeled Sys Name	Fan Control	Supply CFM,	Pressure Drop Adjustments: CFMd = the design airflow through each applicable device from Table 6.5.3.1-2 in cubic feet per minute; PD = each applicable pressure drop adjustment from Table 6.5.3.1-2 in in. of water																		
			Ducted Exhaust or Return Required by Code	Return or Exhaust Air Control Device	Exhaust Filters, Scrubbers, or Similar Treatments		MERV 9 through 12	MERV 13 through 15	MERV 16 & Greater & Electronically Enhanced Filters		Carbon and Other Gas-Phase Air Cleaners		Biosafety Cabinet		Energy Recovery Device		Evaporative Humidifier/ Cooler Coil	Sound Attenuation Sections	Ex. System Serving Fume Hoods	Lab and Vivarium Exhaust Systems	Non-Mechanical Cooling
			CFMd	CFMd	CFMd	PD [in w.c.]	CFMd	CFMd	CFMd	PD [in w.c.]	CFMd	PD [in w.c.]	CFMd	PD [in w.c.]	CFMd	PD [in w.c.]	CFMd	CFMd	CFMd	CFMd	Ft	CFMnmc
UH_Stairs	CV	1,139																			-
PSZ_Retail	CV	14,441					14,441											6,000				-
PTAC_Apts	CV	[illegible]																				

Confirm that all devices included in Table 2a for the baseline are also included in the Proposed HVAC tab Table 3, and the total CFM_D are similar between the baseline and proposed design except for energy recovery and ducted return as described in the Common Mistakes below.

Modeled System Name	Pressure Drop Adjustments: CFMd = the design airflow through each applicable device from Table 6.5.3.1-2 in cubic feet per minute; PD = each applicable pressure drop adjustment from Table 6.5.3.1-2 in in. of water																
	Ducted exhaust or return required by code	Return or exhaust air control device	Exhaust filters, scrubbers, or similar treatments		MERV 9 through 12	MERV 13 through 15	MERV 16 & greater & electronically enhanced filters		Carbon and other gas-phase air cleaners		Biosafety cabinet		Energy recovery device		Evaporative humidifier/ cooler coil	Sound attenuation section	Ex. system serving fume hoods
	CFMd	CFMd	CFMd	PD [in w.c.]	CFMd	CFMd	CFMd	PD [in w.c.]	CFMd	PD [in w.c.]	CFMd	PD [in w.c.]	CFMd	PD [in w.c.]	CFMd	CFMd	CFMd
Cor_Sys													363	1.2			
UH_HW																	
Retail_Sys													5,812	1.2			
Apt_Sys																	
DOAS_Sys													6,400	1.2			

2. The total design power of the baseline supply, return, relief and exhaust fans is shown in the second half of Table 2a of the Baseline HVAC App G. The total for all fans is calculated by applying the formulas in G3.1.2.9 to the user-specified supply flow rate accounting for the applicable pressure drop adjustments discussed above, and is allocated to the baseline supply, return, relief and exhaust fans based on user-entered values in the % of Total Fan Power columns for the corresponding fans.

Modeled Sys Name	Baseline Fan Power										
	Total BHP	Fan Motor Eff.	Total Fan System Power	Supply Fan Power		Return/Relief Fan Power		Exhaust Fan Power		Terminal Units	Basis of Fan Part-Flow Power Curves
	bhp	%	kW	% of Total Fan Power	kW	% of Total Fan Power	kW	%	kW	kW	
UH_Stairs	0.40	82.5%	0.36	100.0%	0.36	0%					n/a
PSZ_Retail	15.26	91.0%	12.51	66.0%	8.26	34.0%	4.25				n/a
PTAC_Apts	20.48	92.4%	16.54	80.4%	13.29	6.5%	1.08	13.1%	2.16		n/a

Optionally, cross-check user-specified allocation of fan power between supply, return/relief and exhaust fans for a sample of systems to verify consistency with how the fan power is allocated to these fans in the proposed design.

3. Common Mistakes
   a. CFM_D is entered in Table 2a for the baseline systems that have exhaust air energy recovery in the proposed design, but no exhaust air energy recovery in the baseline. Based on Table G3.1.2.9 Note 2, the pressure drop credit may only be claimed when the baseline system has energy recovery.

b. CFM_D is entered in Table 2a for the baseline systems that have ducted return in the proposed design, but the ducted return is not required by applicable code. In these cases, baseline should be assumed to have no ducted return.

c. Power of exhaust or DOAS fans specified in the proposed design is added to the baseline fan power allowance determined following 90.1 Section G3.1.2.9. Instead, the baseline fan power allowance is inclusive of all baseline fans.

AHVAC16-P Air flow and supply temperature controls reported in the Compliance Form for the proposed design are as specified in the design documents

Review Tips

1. Air flow control method for each specified air-side HVAC system is reported in Table 1a of the Proposed HVAC tab.

		Supply Fan					
Modeled System Name	Fan Operation, Occupied Hours	Total Supply CFM	Total Outdoor Air CFM	Total BHP	Motor Eff.	Fan Flow Control	kW
Cor_Sys	Continuous	4,000	363	2.5	89.5%	Variable flow, VSD w/SP reset	2.08
UH_HW	Cycling	1,500	0	0.5	89.5%	Constant volume, cycling	0.42
Retail_Sys	Continuous	14,500	5,812	10.0	89.5%	Constant volume	8.34

Additional details are included in Table 4 of the Proposed HVAC tab.

	Air-side Controls			
Modeled System Name	Min. Vol. Set Points for VAV Boxes, % of Peak	Design Supply Air Temp., °F (Cooling)	Supply Air Temperature Control (Cooling)	Supply Air Temperature Control (Cooling) Settings
Cor_Sys	30.0%	55	Fixed (constant)	55F

Cross-check Compliance Form inputs with the information provided in the mechanical schedules and specifications for a sample of the specified systems to ensure alignment.

2. Refer to Table 2b for a bird-eye view of the specified fan systems and controls.

Table 2b: Fan System Design and Outdoor Air Flows, Power and Controls Summary

Fan Type	Constant Volume			Variable Flow			Two-speed			Constant Volume, Cycling		
	CFM	kW	kW/CFMs	CFM	kW	kW/CFMs	CFM	kW	kW/CFMs	CFM	kW	kW/CFMs
Supply Fan (SF)	20,900	12.5	0.0006	4,000	2.08	0.00052	0	0	0	49,500	9.51	0.00019
Relief/Return Fan (RF)	13,500	4.31	0.00021	4,000	1.25	0.00031	0	0	0	0	0	0
Exhaust Fan (EF)	6,400	2.5	0.00012	0	0	0	0	0	0	0	0	0
Subtotal	40,800	19.32	0.00092	8,000	3.33	0.00083	0	0	0	49,500	9.51	0.00019
Terminal Units Fan (TUF)		0			0			0			0	
Total		19.32			3.33			0			9.51	

AHVAC16–B Baseline (budget) air flow and supply temperature control is established correctly

90.1 2016/2019 Section 11

Section 11.5.2: Supply and return/relief system fans shall be modeled as operating at least whenever the spaces served are occupied, except as specifically noted in 90.1 Table 11.5.2-1. Minimum volume set points for VAV reheat boxes shall be 30% of zone peak airflow or the minimum ventilation rate, whichever is larger (90.1 Table 11.5.2-1 Note b). Baseline supply, return, or relief fans in Systems 1-4 must be modeled assuming a variable-speed drive and fan part-load performance in 90.1 Section

G3.1.3.15 (see Table 6 below). If the proposed design's system has a DDC at the zone level, static pressure set-point reset based on Section 6.5.3.2.3 must be modeled in the budget design.

Table 11.5.2 – 1: The supply air temperature for cooling shall be reset higher by 5°F under the minimum cooling load conditions for all budget VAV systems with reheat.

90.1 2016/2019 Appendix G

Table G3.1.3.15: For baseline Systems 5 and 7, the minimum volume set points for VAV reheat boxes must be 30% of zone peak airflow, the minimum outdoor airflow rate, or the airflow rate required to comply with the applicable codes or accreditation standards, whichever is larger. The part load performance of VAV system supply fans must have the part-load performance characteristics specified in 90.1 Table G3.1.3.15. There is no static pressure set-point reset in the baseline.

Section G3.1.3.12: The air temperature for cooling shall be reset higher by 5°F under the minimum cooling load conditions for Systems 5 – 8.

Review Tips

1. Appendix G: Baseline flow and temperature controls for the baseline VAV systems is shown in Table 3a of the Baseline HVAC App G tab. The values are set automatically based on the relevant 90.1 rules quoted above and should only be checked if any auto-populated defaults are over-written. (Such values will be shown in brown font.)

Modeled Sys Name	Air-side Controls		
	Min. Flow Set Points % (VAV reheat boxes & Sys. 11)	If Min. Setpoints >30%, Describe Reason	Supply Air Temp. Reset under Min. Cooling Load, F
UH_Stairs	n/a	n/a	n/a
PSZ_Retail	30.0%	n/a	Reset higher by 5°F
PTAC_Apts	n/a	n/a	n/a

2. Section 11: Fan speed control of the budget HVAC systems is shown in Table 2a of the Budget HVAC Section 11 tab. Minimum flow setpoints in temperature reset under minimum cooling load conditions for VAV systems are shown in Table 3. The values are set automatically based on the relevant 90.1 rules quoted above and should only be checked if any auto-populated defaults are over-written. (Such values will be shown in brown font.)

AHVAC17-P Fan power performance curves reported for the proposed design in the Compliance Form are based on an approved source

Review Tips

1. The modeled performance curves reflect correlation between energy used by the fan and flow rate relative to the design maximum. The input applies only to the variable flow systems, and must be provide in the last column of Table 2a of the Proposed HVAC tab. The default VAV performance curves included in 90.1 Table G3.1.3.15 and the fan curves provided in ANSI/ASHRAE/IES Standard

90.1-2016 Performance Rating Method Reference Manual, Table 50 should be used, depending on the specified flow control strategy[20].

2. The curves should be reviewed for a sample of HVAC systems if ventilation fans are an impactful end use and performance curves other than 90.1 default are specified.
3. Supporting documentation must be included in the submittal if the basis of the performance curves is specified as "Other" in Table 2a. Refer to the Submittal Checklist tab #18 to confirm that the necessary documentation is included in the submittal.

AHVAC17-B Fan power performance curves used in the simulation are based on an approved source

Review Tips

1. The fan performance curves for VAV systems are specified in the last column of Table 2a Baseline HVAC App G tab or Budget HVAC Section 11 tab and must be based on 90.1 Table G3.1.3.15. The values are auto-populated and don't need to be checked.

AHVAC18– B, P Fan power, flow rate and controls are modeled as reported in the Compliance Form

Review Tips

1. Spot-check simulation reports to verify that the following simulation inputs reflect information provided in the Compliance Form:

    a. power of supply, exhaust, return and relief fans (Watt)
    b. supply, exhaust, return and relief flow (CFM)
    c. minimum flow fraction for representative thermal blocks

    The review should focus on HVAC systems with large air flow.

eQUEST Reports	SS-P, SV-A, SS-L, ERV Energy Recovery Summary (for projects with ERV)
Trane TRACE 700	Room Information entered values report for flows, System Information entered values report for fan power
Trane TRACE 3D Plus	System Component Summary for fan power and flow rate, System Cooling Checksums for minimum flow
IESVE SOFTWARE	System Loads Report, Space Loads & Ventilation Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Fans' section
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Fans' section
Carrier HAP v5	"Air System Sizing Summary", "Zone Sizing Summary" system design reports.
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

[20] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26917.pdf

AHVAC19–B, P Modeled peak demand of ventilation fans is generally consistent with design fan power and control reported in the Compliance Form

Review Tips

1. Spot-check simulation reports for a sample of HVAC systems with high air flows in the proposed and baseline/budget design to find the non-coincident peak demand for the system fans. Compare the simulated values to the estimates obtained as described below. Flag proposed systems with the simulated non-coincident peak demand is lower than estimated. Flag baseline/budget systems that have simulated non-coincident peak demand that is higher than expected.
   a. For the constant volume systems, the peak demand is equal to the design fan kW.
   b. Variable volume system fans often reach the maximum flow no greater than 70% of the design CFM, drawing approximately 50% of the design power (Table 16).

2. These relationships may also be used to verify fan energy use patterns for the project as a whole, for example to confirm that the fan power reported in Table 2b of the Baseline HVAC App G tab (shown below) or Table 2b of the Budget HVAC Section 11 tab is generally consistent with non-coincident peak demand reported in the Compliance Calculations tab Table 2 for both baseline/budget and proposed designs.

Table 2b: Fan System Design, Power and Controls Summary

Fan Type	Constant Volume						Variable Volume					
	Proposed Design			Baseline Design			Proposed Design			Baseline Design		
	CFM	kW	kW/CFMs	CFM	kW	kW/CFMs	CFM	kW	kW/CFMs	CFM	kW	kW/CFMs
Supply Fan (SF)	74,400	24.1	0.00032	70,766	21.91	0.00031	0	0	0	0	0	0
Relief/Return Fan (RF)	17,500	5.56	0.00007		5.34		0	0	0		0	
Exhaust Fan (EF)	6,400	2.5	0.00003		2.16		0	0	0		0	
Subtotal	98,300	32.16	0.00043	70,766	29.41	0.00042	0	0	0	0	0	0
Terminal Units Fan (TUF)		0			0			0			0	
Total		32.16			29.41			0			0	

eQUEST Reports	SS-H, SS-P
Trane TRACE 700	Equipment Energy Consumption report
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Fans' section, 'Demand End Use Components Summary' report. The user may need to set the fan subcategory field to report out for a fan pump if several are present.
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Fans' section, 'Demand End Use Components Summary' report. The user may need to set the fan subcategory field to report out for a fan pump if several are present.
Carrier HAP v5	Peak fan kW for CAV system individual fans: "Air System Sizing Summary" design report. Peak fan kW for VAV system individual fans must be derived by exporting full year hourly simulation results to CSV ("Hourly Simulation Results" report, CSV option), and parsing in Excel to identify peak demand.
Design Builder	Fans Table in EnergyPlus Output Summary Document

AHVAC20–B, P Modeled equivalent full load hours of the ventilation fans are as expected.

Review Tips

1. Background: The EFLH of the fan system is the ratio of the fan energy use to fan peak demand. If project has only the constant volume systems that run continuously when building is occupied, the fan EFLH will be slightly higher than the number of hours per year when the building is occupied, accounting for the energy consumed by the cycling fans during unoccupied hours and system runtime to bring the building to occupied temperatures in the morning.
2. Calculate EFLH for a for a sample of baseline/budget systems with high fan power reported in Table 2a of the Baseline HVAC App G or Budget HVAC Section 11 and check for the following patterns:
   a. Part load performance of the baseline VAV systems are shown in the second row of Table 6 (Multizone VAV with VSD and fixed static pressure setpoint). If all baseline (budget) systems are variable air volume, the average flow during occupied hours is typically about 60% of the design flow, with the fan system drawing ~41% of the design power based on Table 6. Thus, the EFLH are expected to be ~ 41% of the number of occupied hours per year.
   b. For the constant volume systems, EFLH are expected to be slightly higher than the total number of hours building is occupied, since the baseline/budget systems must be modeled as running continuously during occupied hours and cycle with load during un-occupied hours.

   The baseline fan EFLH that exceed expectation should be flagged and may indicate incorrect modeled fan system control.

   Table 16: Fraction of VAV Fan Power at Reduced Flow (PRM RM)

% of Design Flow	100%	90%	80%	70%	60%	50%	40%	30%	25%	20%	10%
Multizone VAV with VSD and fixed static pressure setpoint	1.00	0.83	0.68	0.54	0.41	0.30	0.21	0.13	0.10	0.07	0.03
Multi zone VAV with static pressure reset	1.00	0.75	0.55	0.39	0.27	0.18	0.12	0.09	0.07	0.06	0.05
Single zone VAV fan	1.00	0.73	0.52	0.36	0.24	0.15	0.09	0.06	0.05	0.04	0.03

   c. Common Mistakes:
      - Modeled minimum flow for VAV systems are higher than 30%
      - Fans are modeled as running continuously instead of cycling with load during un-occupied hours.

3. Calculate EFLH for a for a sample of proposed systems with high fan power reported in Table 2a of the Baseline HVAC App G or Budget HVAC Section 11 and check for the patterns described for the baseline/budget systems. The proposed fan system EFLH that are lower than expected should be flagged. Common mistakes include the following:

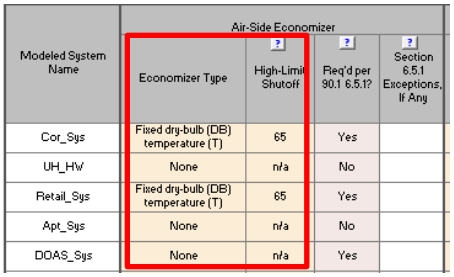
- Modeling fans that supply ventilation air as cycling with load instead of running continuously during occupied hours results in significantly under-estimate fan, heating and cooling energy use.

eQUEST Reports	SS-P
Trane TRACE 700	Equipment Energy Consumption report
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Fans' section, 'Annual Building Utility Performance Summary' report. The user may need to set the fan subcategory field to report out for a fan pump if several are present.
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Fans' section, 'Annual Building Utility Performance Summary' report. The user may need to set the fan subcategory field to report out for a fan pump if several are present.
Carrier HAP v5	Design Fan kWs: "Air System Sizing Summary" or "Zone Sizing Summary" system design reports:. Annual fan kWh for individual fans: "Monthly Simulation Results" reports.
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC21-P Air-side economizers reported in the Compliance Form are as specified in the design documents

Review Tips

1. The specified economizer controls are reported in Table 4 of the Proposed HVAC tab. Cross-check the provided information with the design documents for a sample of HVAC systems to ensure alignment.



Modeled System Name	Air-Side Economizer			
	Economizer Type	High-Limit Shutoff	Req'd per 90.1 6.5.1?	Section 6.5.1 Exceptions, If Any
Cor_Sys	Fixed dry-bulb (DB) temperature (T)	65	Yes	
UH_HW	None	n/a	No	
Retail_Sys	Fixed dry-bulb (DB) temperature (T)	65	Yes	
Apt_Sys	None	n/a	No	
DOAS_Sys	None	n/a	Yes	

2. The check should be completed where cooling is an impactful end use except in climate zones 0 and 1
3. Projects without economizers are expected to have higher cooling energy use in fall, winter and spring and higher simultaneous heating & cooling during these months.

AHVAC21-B Air-side economizers reported in the Compliance Form for the baseline/budget systems are established correctly

90.1 2016/2019 Section 11

Table 11.5.2-4

Each system in the budget building must have the same economizer type (outdoor air or water) as the corresponding system in the proposed design. If economizer is not specified in the proposed design, an air-side economizer must be modeled in the budget building where required in Section 6.5.1. For example, in New York climate zones 4A, 5A, 6A economizers must be modeled for budget systems with cooling capacity of 54 kBtu/hr or greater, unless exceptions apply. The high-limit shutoff must be modeled per 90.1 Table 11.5.2-4.

90.1 2016/2019 Appendix G

Section G3.1.2.6: Economizers must not be included in baseline HVAC System 1,2,9 and 10. Air economizers must be included in baseline HVAC Systems 3 through 8 and 11, 12 and 13 (unless exception to 90.1 Section G3.1.2.6 apply), based on climate as specified in 90.1 Table G3.1.2.6. For example, projects in New York climate zone 4A do not have an economizer in the baseline. Projects in climate zone 5A and 6A must be modeled with an economizer in the baseline. Economizer high-limit shutoff temperature must be modeled per Table G3.1.2.7.

Review Tips

1. Air-side economizers are shown in Table 3a of the Baseline HVAC App G and in Table 3 of the Budget HVAC Section 11 (shown below). The values are auto-populated based on the applicable rules of Section 11 or Appendix G. Over-written defaults are shown in brown font and should be verified by reviewer.

Modeled Budget Sys Name	Corresponding Proposed System	Air-Side Economizer			
		Req'd per 90.1 6.5.1?	Applicable Section 6.5.1 Exceptions, If Any	Economizer Type	High-Limit Shutoff
Cor_Sys	Cor_Sys	Yes		Fixed dry-bulb (DB) temperature (T)	TOA>75
UH_HW	UH_HW	No		None	
Retail_Sys	Retail_Sys	No	6.5.1 Exc. 3	None	

AHVAC22-P, AHVAC22-B Air-side economizers in the baseline/budget and proposed design is modeled as reported in the Compliance Form

Review simulation reports to verify that air-side economizer is modeled as reported in the Compliance Form.

eQUEST Reports	
Trane TRACE 700	
Trane TRACE 3D Plus	
IESVE SOFTWARE	
EnergyPlus	
OpenStudio	
Carrier HAP v5	
Design Builder	

AHVAC23–P Design ventilation rates reported in the Compliance Form are consistent with the design documents

Review Tips

1. Outdoor air rates are reported in Table 2a of the Proposed HVAC tab. Cross-check reported rates with the design documents for a sample of specified systems to verify alignment.

Modeled System Name	Fan Operation, Occupied Hours	Supply Fan					
		Total Supply CFM	Total Outdoor Air CFM	Total BHP	Motor Eff.	Fan Flow Control	kW
Cor_Sys	Continuous	4,000	363	2.5	89.5%	Constant volume	2.08
UH_HW	Cycling	1,500	0	0.5	89.5%	Constant volume, cycling	0.42
Retail_Sys	Continuous	14,500	5,812	10.0	89.5%	Constant volume	8.34
Apt_Sys	Cycling	48,000	0	10.0	82.0%	Constant volume, cycling	9.1
DOAS_Sys	Continuous	6,400	6,400	5.0	89.5%	Constant volume	4.17

AHVAC23–B Baseline/budget ventilation rates reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

90.1 Section 11.5.2 d: Minimum outdoor air ventilation rates must be the same in the budget building design and proposed design.

90.1 2016/2019 Appendix G

90.1 Section G3.1.2.5: Minimum ventilation system outdoor air intake flow must be the same for the proposed design and baseline building design, with the following exceptions.

1. Baseline may have higher OA flow compared to the proposed design if the following applies:
   a) The proposed system has Demand Control Ventilation AND the outdoor air capacity is less than or equal to 3000 cfm serving areas with an average design capacity of 100 people per 1000 ft^2 or less (90.1 Section G3.1.2.5 Exception 1).
   b) The proposed system has zone air distribution effectiveness Ez > 1.0 based on ASHRAE Standard 62.1 Table 6-2 (90.1 Section G3.1.2.5 Exception 1).
2. The baseline must have a lower OA flow compared to the proposed design if the specified ventilation rate exceeds the minimum required by the applicable building code (90.1 Section G3.1.2.5 Exception 3). Ventilation rates may also differ between the baseline and proposed design for systems serving laboratory spaces (90.1 Section G3.1.2.5 Exception 4).

Review Tips - 90.1 Section 11

1. Baseline ventilation rates are reported in Table 2a of Budget HVAC Section 11 tab and is set to be equal to the corresponding budget system.

Modeled Budget Sys Name	Corresponding Proposed System	Total Supply CFM	Total Outdoor Air CFM	Supply Fan Total BHP
Cor_Sys	Cor_Sys	2,000	363	2.5
Retail_Sys	Retail_Sys	5,500	5,812	4.57

Review Tips - 90.1 Appendix G

2. Baseline ventilation rates are reported in Table 3a of Baseline HVAC App G tab. For each baseline system, the modeled ventilation rate must be provided and it must be stated whether that ventilation rate is equal to the ventilation provided to the corresponding HVAC zones in the proposed design (which is the default selection) or whether it deviates from the proposed design due to exceptions to G3.1.2.5.

Modeled Sys Name	Fan Air Flow		
	Design Supply CFM	Minimum Outdoor Air (OA) CFM	Method Used to Establish OA CFM (G3.1.2.5)
UH_Stairs	1,199	300	Lower than Proposed (G3.1.2.5 Exception 3)
PSZ_Retail	14,441	5,812	Higher than Proposed (G3.1.2.5 Exception 2)
PTAC_Apts	55,126	6,763	Equal to Proposed

3. Table 3b shows side-by-side the total OA rate reported in the Compliance Form for the baseline and proposed design. Confirm consistency between Table 3a are 3b. For example, if Table 3a indicates that the ventilation rate in all baseline systems is modeled as “Equal to Proposed”, the baseline and proposed rates are expected to be the same in Table 3b.

Fan Flow Control	Supply CFM,		OA CFM	
	Proposed Design	Baseline Design	Proposed Design	Baseline Design
Constant	74,400	70,766		
Variable Volume	0	0		
Total	74,400	70,766	12,575	12,875

4. Common Mistakes

a) It is not uncommon for specified ventilation rates to exceed the minimum required. In this case, the baseline ventilation would be lower than what is specified in the proposed design but this penalty is often not modeled. For example, based on the NYS Mechanical Code, the minimum ventilation rate in the corridors of apartment buildings is 0.06 CFM/SF. If the specified ventilation exceeds this minimum, the ventilation rate in the baseline design must be modeled as 0.06 CFM/CF. Ventilation in the proposed design must be as specified and will be higher than in the baseline.

AHVAC24–P Demand control ventilation reported in the Compliance Form for the proposed design is consistent with the design documents

Review Tips

1. Demand control ventilation (DCV) is reported in Table 4 of the Proposed HVAC tab. Cross-check information provided in the table with the design documents for a sample of specified systems to verify alignment.

Modeled System Name	Demand Control Ventilation (DCV)				Exhaust Air Energy Recovery						
	DCV Specified?	Design Occ. Density for Ventilation, [people per 1000 ft²]	DCV Required? (90.1 Section 6.4.3.8)	Section 6.4.3.8 Exceptions, If Any	System Type	OA CFM	Exhaust CFM	Enthalpy Recovery Ratio %	Ventila-tion Sys. Operates < 8000 Hrs/Yr?	Req'd per 90.1 Section 6.5.6.1?	Section 6.5.6.1 Exceptions, If Any
Cor_Sys	No	5	No		Heat Exchanger	363	363	75.0%	No	No	
UH_HW	No	5	No		None	0	0		Yes	No	
Retail_Sys	Yes	15	No		Heat Exchanger	5,812	4,812	75.0%	Yes	No	
Apt_Sys	No	10	No		None	0	0		No	No	
DOAS_Sys	No	25	No	6.4.3.8 Exc. 1	Heat Exchanger	6,400	6,400	75.0%	No	Yes	

AHVAC25–P Demand control ventilation reported in the Compliance Form for the proposed design meets mandatory requirements in 90.1 Section 6

Review Tips

1. Demand control ventilation may be required by 90.1 Section 6.5.3.8. These requirements are mandatory and thus DCV must be specified for systems where it is required. The applicability of the requirements are established automatically in Table 4 of the Proposed HVAC tab based on user-entered design and OA flow rates and occupant density. The default may be over-written by user if exceptions to 90.1 Section 6.5.3.8 apply. The over-written values are shown in bold brown font and applicable exception must be listed. Verify that DCV is specified where required.

Modeled System Name	Demand Control Ventilation (DCV)				Exhaust Air Energy Recovery						
	DCV Specified?	Design Occ. Density for Ventilation, [people per 1000 ft²]	DCV Required? (90.1 Section 6.4.3.8)	Section 6.4.3.8 Exceptions, If Any	System Type	OA CFM	Exhaust CFM	Enthalpy Recovery Ratio %	Ventila-tion Sys. Operates < 8000 Hrs/Yr?	Req'd per 90.1 Section 6.5.6.1?	Section 6.5.6.1 Exceptions, If Any
Cor_Sys	No	5	No		Heat Exchanger	363	363	75.0%	No	No	
UH_HW	No	5	No		None	0	0		Yes	No	
Retail_Sys	Yes	15	No		Heat Exchanger	5,812	4,812	75.0%	Yes	No	
Apt_Sys	No	10	No		None	0	0		No	No	
DOAS_Sys	No	25	No	6.4.3.8 Exc. 1	Heat Exchanger	6,400	6,400	75.0%	No	Yes	

AHVAC25–B Demand control ventilation reported in the Compliance Form for the baseline/budget design is established correctly.

90.1 2016/2019 Section 11

90.1 2016/2019 Appendix G

Review Tips

1. Demand Control Ventilation requirements applicable to each baseline/budget HVAC system are shown in Table 3 of Budget HVAC Section 11 tab or Table 3a of the Baseline HVAC App G tab. The

values are auto-populated in the Compliance Form based on user-specified maximum occupant density. Overwritten defaults should be reviewed to verify that the exception referenced in the Compliance Form is properly applied.

AHVAC26– B, P Ventilation rate and control are modeled as reported in the Compliance Form

Review Tips

1. Spot-check a sample of air-side HVAC systems to confirm that the minimum design ventilation rate CFM and DCV controls are modeled as reported in the Compliance Form for the corresponding systems.

eQUEST Reports	SV-A;
Trane TRACE 700	Room Information entered values report for ventilation rate, System Information entered values report for ventilation controls
Trane TRACE 3D Plus	Outside Air and ASHRAE 62.1 Analysis report
IESVE SOFTWARE	Space Loads & Ventilation Report, ASHRAE 62.1 Report, System Loads Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Standard 62.1 Summary' report, 'Zone Ventilation Parameters' and 'System Ventilation Parameters' sections
OpenStudio	eplustbl.html 'Standard 62.1 Summary' report, 'Zone Ventilation Parameters' and 'System Ventilation Parameters' sections
Carrier HAP v5	Input Data: "Air System Input Data" reports. Output Data: "Ventilation Sizing Summary" report.
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC27–P Exhaust air energy recovery reported in the Compliance Form reflects design documents

Review Tips

1. Exhaust air energy recovery is reported in Table 4 of the Proposed HVAC tab. Cross-check information provided in the table with the design documents for a sample of specified systems to verify alignment.

Modeled System Name	Exhaust Air Energy Recovery						
	System Type	OA CFM	Exhaust CFM	Enthalpy Recovery Ratio %	Ventila-tion Sys. Operates < 8000 Hrs/Yr?	Req'd per 90.1 Section 6.5.6.1?	Section 6.5.6.1 Exceptions, If Any
Cor_Sys	Recovery Wheel	363	363	75.0%	No	No	
UH_HW	None	0	0		Yes	No	
Retail_Sys	Heat Exchanger	5,812	4,812	75.0%	Yes	No	

AHVAC27–B Exhaust air energy recovery reported in the Compliance Form for the budget/baseline design is established correctly

90.1 2016/2019 Section 11

Section 11.5.2 d: Exhaust air heat recovery must be included in the budget building systems if required by 90.1 Section 6.5.6.1. For example, all systems in climate zones 4A, 5A, 6A operating 8,000 or more hours per year must have energy recovery (90.1 Section 6.5.6.1-2), unless exceptions apply.

90.1 2016/2019 Appendix G

Section G3.1.2.10: Individual fan systems that have design supply air capacity of 5,000 cfm or greater AND a minimum design outdoor air supply of 70% or greater must have an energy recovery system with at least 50% enthalpy recovery ratio. 50% enthalpy recovery ratio means a change in the enthalpy of the outdoor air supply equal to 50% of the difference between the outdoor air and return air at design conditions. The most common exception to this rule applies to projects where the largest exhaust source is less than 75% of the design outdoor airflow and that don't have exhaust air energy recovery in the proposed design (90.1 Section G3.1.2.10 Exception 6). An example of such configuration includes rooftop units supplying ventilation in multifamily buildings, with exhaust from apartment kitchens and bathrooms via multiple rooftop exhaust fans that serve vertical stacks of apartments.

Review Tips

1. Exhaust air energy recovery that must be modeled in the budget/baseline systems is shown in Table 3 of the Budget HVAC Section 11 tab or Table 3a of the Baseline HVAC App G tab. The values are auto populated based on the applicable rules of Section 11 and Appendix G. Over-written defaults should be verified.

AHVAC28–B, P Modeled exhaust air energy recovery is as reported in the Compliance Form

Review Tips

1. Spot-check a sample of HVAC systems with the highest ventilation flow to confirm that the exhaust energy recovery is modeled as reported in the Compliance Formincluding the following:
   - system type (e.g. enthalpy wheel, runaround coil, heat exchanger)
   - rated recovery effectiveness
   - supply and exhaust flow through the energy recovery device
   - controls (e.g. to allow economizer operation when appropriate)
   - added static pressure drop
2. Common mistakes:
   a. Increased static pressure drop (and increased fan energy) and parasitic losses such as energy to operate recovery wheel and to provide defrost is not included in the proposed design model, exaggerating the benefit of energy recovery.
   b. Modeled outdoor and exhaust air flow CFM passing through energy recovery device does not reflect design documents.

eQUEST Reports	ERV Energy Recovery Summary
Trane TRACE 700	System Information entered values report for type, effectiveness, controls and added static pressure drop, System Checksums report for flow rates

Trane TRACE 3D Plus	NA
IESVE SOFTWARE	System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'Component Sizing Summary' report, ' HeatExchanger:AirToAir:SensibleAndLatent' section, System Information entered values report for type, effectiveness, controls and added static pressure drop
OpenStudio	eplustbl.html 'Component Sizing Summary' report, ' HeatExchanger:AirToAir:SensibleAndLatent' section, System Information entered values report for type, effectiveness, controls and added static pressure drop
Carrier HAP v5	Energy Recovery Data: "Air System Input Data" reports. Flow rates: "Ventilation Sizing Summary" system design report.
Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

AHVAC29–P Additional HVAC efficiency measures reported in the Compliance Form are allowed for trade-off and reflect design documents

Review Tips

1. Additional HVAC Efficiency Measures inputs at the bottom of the Proposed HVAC tab may describe additional system and components affecting HVAC energy use of the proposed design but not covered elsewhere in the Compliance Form, such as thermal energy storage and ventilated façade. The following must be listed for each measure:
    a) The key system parameters
    b) An explanation of the source of expected savings
    c) Whether the measure was modeled explicitly in the simulation tool or through exceptional calculations.
2. Verify the following for each listed system and component:
    a) The reported measure involves systems and components are allowed for trade-offs
    b) That the key reported efficiency parameters reflect design documents and manufacturer literature
    c) The exceptional calculations are submitted as applicable and are based on peer-reviewed methods and not proprietary vendor's tools. Also refer to checks in the Exceptional Calculations (EC) group.

AHVAC30-P Additional HVAC efficiency measures were modeled for the proposed design as described in the Compliance Form

Review Tips

Review simulation input/output reports to confirm that additional HVAC efficiency measures reported for the proposed design in the Compliance Form are supported by the simulation tool and were modeled explicitly. Systems and components that are not explicitly supported must be reported as exceptional calculations method.

AHVAC31–B,P Modeled monthly patterns of heating and cooling loads are as expected with no excessive simultaneous heating and cooling

Review Tips

1. Background

Typical single zone systems such as Appendix G Baseline System 1 – PTAC or System 3 – PSZ operate either in heating or cooling mode, thus no simultaneous heating and cooling is expected on system level. In models with only single zone systems, such as in Appendix G baseline for a multifamily building, only a minimal simultaneous heating and cooling is expected on building level – for example, on a mild spring day, PTACs in the West-facing apartments may operate in cooling mode, while PTACs in North-facing apartments may operate in heating mode.

Typical multizone systems such as Appendix G Baseline System 5 and 7 have some simultaneous heating and cooling on system level as well as building level due to reheat, however it is expected to be low due to requirements in 90.1 Section 6.5.2.

2. Check monthly pattern of heating and cooling energy use on air-side system level and building level to confirm that patterns are as expected. Excessive simultaneous heating and cooling is often the reason for heating/cooling energy use exceeding typical based on the benchmarks.

3. Common Mistakes
   a. Section G3.1.1 Exception b was not followed, which may lead to one zone having significantly higher cooling load than the rest of the zones served by the same baseline VAV system, leading to excessive reheat to prevent overcooling of those other zones.
   b. Temperature reset required in 90.1 Section G3.1.3.12 (PRM) and 90.1 Table 11.5.2-1 Note b (ECB) was not properly modeled.
   c. Supply temperature reset required during periods of low cooling load was not modeled resulting in excessive reheat.
   d. VAV minimum flow setpoint was not modeled as required in 90.1 Section G3.1.3.13 (PRM) and 90.1 Table 11.5.2-1 Note b (ECB).
   e. Minimum flow fraction was not modeled correctly on VAV systems. For example, 0.4 CFM/SF minimum flow may be modeled instead of 30% of the zone peak as required for Appendix G baseline VAV systems.
   f. Economizer was not modeled where required.

eQUEST Reports	SS-C; SS-D (summer heating load exceeds 20% of winter heating load) ; SS-E
Trane TRACE 700	Building Cool/Heat Demand report from the Visualizer
Trane TRACE 3D Plus	Site Load Profile report
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'BUILDING ENERGY PERFORMANCE' report. Requires the user request Output:Table:Monthly report.
OpenStudio	eplustbl.html 'BUILDING ENERGY PERFORMANCE' report. Requires the user request Output:Table:Monthly report.
Carrier HAP v5	Building level data: "Monthly Energy Use by System Component" report. Individual system level data: "Monthly Simulation Results" reports.

Design Builder	Air-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

Waterside HVAC (WHVAC)

Overview

This group of checks covers water-side HVAC systems including chiller and boiler type, capacity efficiency and controls, chilled and hot water loop pumps and controls, and heat rejection. In addition, there are several checks to verify general consistency between simulation inputs and outputs, such as that when pumps are reported for the baseline/budget or proposed design, simulation results show pump energy use; that if electric resistance heating is reported in the compliance form, simulation results show heating energy use for electricity, etc. Table 17 summarizes the checks included in this group.

The following strategies may be used to prioritize the review:

1. Checks should focus on water-side systems with the highest heating or cooling capacity and spot-checking the rest.
2. 90.1 Section 6 has mandatory minimums for heating and cooling system efficiencies and ventilation controls. Checks verifying mandatory requirements should be completed where applicable.

Table 22: Water-side HVAC Quality Control Checks Overview

	Type of Check	Proposed Design	Baseline/Budget Design
Chiller Plant	CF inputs reflect design documents	WHVAC01-P (chiller), WHVAC04-P(loop T), WHVAC06-P(pump), WHVAC10-P(ht rej)	NA
	CF inputs reflect requirements of 11/G	NA	WHVAC01-B (chiller), WHVAC04-B(loop T), WHVAC06-B (pump), WHVAC10-B(ht rej)
	Meet mandatory requirements	WHVAC01-P (chiller)	
	Simulation inputs consistent with CF	WHVAC02-P (chiller), WHVAC05-P(loop T), WHVAC07-P (pump), WHVAC08-P(loop flw), WHVAC11-P(ht rej)	WHVAC02-B (chiller), WHVAC05-B(loop T), WHVAC07-B (pump), WHVAC08-B(loop flw), WHVAC11-B(ht rej)
	Simulation outputs consistent with CF	WHVAC03-P (chiller), WHVAC09-P(pump)	WHVAC03-B (chiller), WHVAC09-B(pump)
Boiler Plant	CF inputs reflect design documents	WHVAC12-P (boiler), WHVAC15-P (loop T), WHVAC17–P(pump)	NA
	CF inputs reflect requirements of 11/G	NA	WHVAC12-B (boiler), WHVAC15-B (loop T)
	Meet mandatory requirements	WHVAC12-P (boiler)	NA
	Simulation inputs consistent with CF	WHVAC13-P (boiler), WHVAC16-P (loop T), WHVAC18–P(pump), WHVAC19–P(loop flow)	WHVAC13-B (boiler), WHVAC15-B (loop T), WHVAC18–B(pump), WHVAC19–P(loop flow)
	Simulation outputs consistent with CF	WHVAC14-P (boiler), WHVAC20-P (pump), WHVAC21-P(pump), WHVAC22-P(h.energy)	WHVAC14-B (boiler), WHVAC20-B (pump), WHVAC21-B(pump) WHVAC22-B(h.energy)

LEGEND

PASS/FAIL/NA outcome is determined automatically in the Quality Control Checks tab of the Compliance Form

WHVAC01-P Proposed chillers reported in the Compliance Form reflect design documents and meet the minimum efficiency requirements.

Review Tips

1. Specified chillers are reported in Table 6a of the Proposed HVAC tab.

2. Verify that chiller type, quantity, capacity and rated full and part load efficiency listed in the table reflect design documents. A reference to the place in the design documents where the reported information is found must be listed in a dedicated field below the table.

Modeled Plant Name	Chiller										
	Chiller Type	Condenser Type	Number of Chillers	Total Capacity (ton)	Efficiency Units (Table 6.8.1-3)	Full load Efficiency	Part Load Efficiency IPLV	Minimum Efficiency Full Load Path A/Path B	Minimum Efficiency Part Load Path A/Path B	Ass.CHW Loop	Basis of Modeled Performance Curves
C_1	Screw	Air-cooled	2	110	EER	10.5	13.8	10.100/9.700	13.700/15.800	CHW_Loop	Performance Rating Method RM

3. Verify that efficiency of the specified chillers meets the minimum required in 90.1 Table 6 for either Path A or Path B. The applicable requirements are quoted in Table 6a. If the specified chillers don't meet the requirements of either Path A or Path B, or if the default minimum requirements are over-written, the submittal must be flagged. These requirements are mandatory and must be met.
4. Variations in chiller performance at a range of operating conditions is typically simulated using performance curves. The basis of performance curves may include the following:
    a) PNNL Performance Rating Method Reference Manual
    b) Custom curves based on chiller performance data from the equipment manufacturer

If custom curves are used, confirm that supporting information is included in the submittal as required (Submittal Checklist #19). The provided curves may be directly reviewed. Alternatively, the annual average achieved chiller efficiency may be verifies to confirm general alignment with the rated part load efficiency (see WHVAC03). Reviewer may also request that the default performance curves from PNNL Performance Rating Method Reference Manual for the specified chiller type are used.

WHVAC01–B Properties of the baseline/budget chillers reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.2-1 Note e: The chiller plant of budget Systems 1, 2, 5 and 7 must be modeled with chiller quantity based on **Table 11.5.2-2** and chiller type based on **Table 11.5.2-3**. If proposed design includes both electric and fossil fuel chillers, the budget building design must have chillers with the same fuel types and capacity allocation between electric and fossil fuel. If the proposed design uses purchased chilled water, the chillers should not be explicitly modeled in the budget design and chilled-water costs shall be as determined in **Section 11.4.3**. Budget chillers efficiency must be based on Table 6.8.1-3 Path A (**11.5.2 – 1 Note c**).

90.1 2016/2019 Appendix G

Section G3.1.3.7 Baseline Systems 7, 8, 11, 12 and 13 must be modeled with electric chillers, except for projects that use purchased chilled water (**Sections G3.1.1.3.2** and **G3.1.1.3.3**). The number of chillers, chiller type and efficiency must be established based on the baseline cooling load as described in **Tables G3.1.3.7** and **G3.5.3**.

Review Tips – Appendix G

1. Baseline chillers are shown in Table 4a of the Baseline HVAC Section 11/Baseline HVAC App G tab. User inputs are limited to the building peak cooling load and the basis of the modeled performance

curves. The rest of the fields are auto-populated based on the applicable Appendix G rules and are non-editable.

2. Verify that the entered building peak cooling load reflects simulation results for the baseline model
3. Verify that PNNL Performance Rating Method Reference Manual (PRM RM) is selected as the basis for baseline performance curves. While chiller performance curves are not prescribed in 90.1, the PRM RM curves are peer-reviewed and reflect the intent of the requirements.

Cooling Plant Designation	Building Peak Cooling Load (Ton)	Chiller					Basis of Modeled Performance Curves
		Chiller Type	Condenser Type	Number of Chillers	Full Load Efficiency, FL [kW/ton]	Part Load Efficiency, IPLV.IP [kW/ton]	
Chiller 1	200	Screw	Water-cooled	1	0.718	0.629	PRM RM

Review Tips – Section 11

1. Chillers included in the budget design are shown in Table 4a of the Budget HVAC Section 11 tab. User inputs are limited to the chiller plant capacity, fuel type and the basis of the modeled performance curves. The rest of the fields are auto-populated based on the applicable rules of Section 11 and are non-editable.

Modeled Plant Name(s)	Chiller Plant								
	Total Chiller Plant Capacity (Ton)	Fuel Type	Number of Chillers	Chiller Type	Condenser Type	Eff. Units (Table 6.8.1-3)	Full Load Eff. (Path A)	Part Load Eff. (Path A	Basis of Modeled Performance Curves
CH-1	120	Electricity	1	Screw	Water-cooled	kW/ton	0.720	0.560	PRM RM

2. Verify that the entered chiller capacity reflects simulation results for the budget model
3. Verify that PNNL Performance Rating Method Reference Manual (PRM RM) is selected as the basis for baseline performance curves. While chiller performance curves are not prescribed in 90.1, the PRM RM curves are peer-reviewed and reflect the intent of the requirements.

WHVAC02 - B,P: Chillers are modeled as reported in the Compliance Form

Review Tips

1. Review simulation reports to verify that the modeled chiller type, capacity and efficiency matches information provided in the Compliance Form.
   The following conversions may be used if chiller efficiency provided in the Compliance Form is expressed in different units than simulation tool inputs.

   EER = COP*3.412
   EER = 12/ [kW/ton]

eQUEST Reports	PV-A
Trane TRACE 700	Plant Information entered values report
Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, System Loads Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report

EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
Carrier HAP v5	"Plant Input Data", "Chiller Input Data", "Cooling Tower Input Data" reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC03-B, P Average annual realized chiller efficiency is as expected

Review Tips

1. Background

   The annual average realized chiller efficiency is the ratio of the annual load on the chiller to the annual energy used by the chiller. The average realized efficiency is expected to be similar to chiller part load efficiency. Different than expected average efficiency may be due to the following:

   a) Inappropriate performance curves (e.g., using software defaults or incorrect custom performance curves)
   b) Incorrect rated full load efficiency input
   c) Incorrect CHW loop controls such as design supply water temperature and temperature drop
   d) Chiller operating conditions significantly different from AHRI rated conditions.

2. The following should be flagged as it may result in overly optimistic compliance outcomes:
   a) Average realized baseline (budget) chiller efficiency worse than expected
   b) Average annual realized proposed chiller efficiency better than expected

eQUEST Reports	PS-C
Trane TRACE 700	Equipment Energy Consumption report for the total equipment consumption and Building Cool/Heat Demand report from the Visualizer for the total loads
Trane TRACE 3D Plus	Site Consumption Summary for the consumption and Site Load Profile for the loads
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
Carrier HAP v5	"Monthly Simulation Results" report. Use annual totals of "Chiller Output" and "Chiller Input kWh".
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC04-P: Proposed chilled water loop configuration and temperature controls reported in the Compliance Form reflect design documents.

Review Tips

1. Chilled water (CHW) plant loop arrangement (e.g. primary/secondary) and controls are reported in Table 5a of the Compliance Form.

Modeled Loop Name	General Description		Primary Loop									
	Loop Type	Configuration	Pump Control Type	Design Flow GPM	Variable Speed Drive?	Minimum Flow Fraction, %	Pump Qty	Total Pump BHP	Pump Motor Efficiency	Design Supply T (F)	Design Delta T (F)	Supply Temperature Reset Logic
CHW_Loop	Chilled Water, On-site Plant	Primary only	Variable speed-variable flow	260	Yes	25.0%	1	5	91.0%	44	12	44°F at OAT 80°F and above, 54°F at OA temps 60°F & below, & ramped linearly between 44°F & 54°F

2. Verify that the reported CHW loop configuration and controls reported in the Compliance Form reflect design documents. The applicable design documents are referenced in a dedicated field below the table.

WHVAC04–B Baseline/budget chilled water loop configuration and temperature controls reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.2-1 Note e: 44°F design chilled-water supply temperature and 56°F return temperature must be modeled. The chilled-water supply water temperature must be reset in accordance with 90.1 Section 6.5.4.4.

90.1 2016/2019 Appendix G

The chilled-water design supply temperature for Systems 7,8,11,12 and 13 must be modeled at 44°F and return water temperature at 56°F (**Section G3.1.3.8**). Supply temperature must be reset based on outdoor dry-bulb temperature using the following schedule: 44°F at 80°F and above, 54°F at 60°F and below and ramped linearly between 44°F and 54°F at temperatures between 80°F and 60°F (**Section G3.1.3.9**). Exceptions apply to chilled water systems serving computer rooms or using purchased chilled water (**exception to Section G3.1.3.9**).

Review Tips

1. CHW plant loop arrangement and controls are reported in Table 6a of the Budget HVAC Section 11 tab (shown) or Table 6a of the Baseline HVAC App G tab, depending on the compliance path followed by the project. The inputs are auto-populated based on the applicable requirements of 90.1. Over-written defaults are shown in brown font and should be verified.

Modeled Loop Name(s)	Corresponding Proposed Loop (if Applicable)	General Description		Primary Loop						Loop Temperature Control	
		Loop Type	Configuration	Flow Controls	Total Design Flow GPM	VSD?	Minimum Flow Fraction, %	Pump Qty	Pump W/GPM	Design Supply and Return Temperature	Temperature Reset Control Strategy
CHW Loop 1	CHW_Loop	Chilled Water, On-site Plant	Primary only	Variable Flow	300	Yes	30.0%	1	15.77	CHW design supply temp.: 44°F & return water temp.: 56°F	Automatically reset supply water temps. by representative building loads (including return water temp.) or by OAT

WHVAC05-B,P Chilled water loop configuration and temperature controls are modeled as reported in the Compliance Form

Review Tips

Use simulation reports to verify that the modeled chilled water loop configuration (i.e. primary/secondary) and temperature controls are modeled as reported in the Compliance Form.

eQUEST Reports	NA
Trane TRACE 700	Plant Information entered values report
Trane TRACE 3D Plus	Plant Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	Plant Information entered values report
OpenStudio	Plant Information entered values report
Carrier HAP v5	"Plant Input Data" reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC06-P: Proposed chilled water pump system parameters reported in the Compliance Form reflect design documents

Review Tips

1. Details of the specified CHW pumps are reported in Table 5a of the Proposed HVAC tab. Verify alignment between Compliance Form and design documents. (The applicable design documents must be listed below the table.)

Modeled Loop Name	General Description		Primary Loop							
	Loop Type	Configuration	Pump Control Type	Design Flow GPM	Variable Speed Drive?	Minimum Flow Fraction, %	Pump Qty	Total Pump BHP	Pump Motor Efficiency	Design Supply T (F)
CHW_Loop	Chilled Water, On-site Plant	Primary only	Variable speed-variable flow	260	Yes	25.0%	1	5	91.0%	44

2. If values provided on drawings (Figure 42) must be expressed in different units, the conversions must be documented in the submittal. Common conversions are included below.

   Pump Power [W] = BHP*746 / Effy
   Effy = pump motor efficiency

Figure 42: Pump Design

UNIT NO	LOCATION	SYSTEM SERVED	FLUID	GPM	MAX TEMP °F	HEAD FT	MAX BHP
P-1	MECHANICAL ROOM	HEATING HOT WATER	WATER	105	200°F	82	3.49
P-2	MECHANICAL ROOM	HEATING HOT WATER	WATER	105	200°F	82	3.49

NOTES:
1. P-1 & P-2 PUMP MOTORS SHALL BE INVERTOR DUTY RATED FOR USE WITH VARIABLE FREQUENCY DRIVES.

WHVAC06–B Baseline/budget chilled water pump system parameters reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.2-1 Note e: The pump system power for each pumping system shall be the same as for the proposed design. If the proposed design has no chilled-water pumps, the budget building design pump power shall be 22 W/gpm (equal to a pump operating against a 75 ft head, 65% combined impeller and motor efficiency). The chilled-water system shall be modeled as primary-only variable flow with flow maintained at the design rate through each chiller using a bypass. Chilled-water pumps must be modeled as riding the pump curve or with variable-speed drives when required in 90.1 Section 6.5.4.2. Each chiller shall be modeled with separate condenser water and chilled-water pumps interlocked to operate with the associated chiller.

90.1 2016/2019 Appendix G

Section G3.1.3.10 Chilled-water systems shall be modeled as primary/secondary with constant flow primary loop and variable-flow secondary loop. For systems with a cooling capacity of 300 tons or more, the secondary pump shall be modeled with variable-speed drives and a minimum flow of 25% of the design flow rate. For systems with less than 300 tons cooling capacity, the secondary pump shall be modeled as riding the pump curve. The baseline building constant-volume primary pump power shall be modeled as 9 W/gpm and the variable-flow secondary pump power shall be modeled as 13 W/gpm at design conditions. See **Section G3.1.3.10** for chilled water pump system parameters for baseline systems serving computer rooms (System 11) and projects with purchased chilled water (**Section G3.1.1.3.2** and **G3.1.1.3.3**).

Review Tips

1. Parameters of the baseline CHW pumps are reported in Table 6a of the Baseline HVAC App G tab (shown) or Budget HVAC Section 11 tab. All required inputs are auto-populated based on the applicable 90.1 rules. Over-written defaults should be checked.

Loop Designation	General Description		Primary Loop						Secondary Loop					
	Loop Type	Config-uration	Flow Controls	Total Design Flow GPM	VSD?	Minimum Flow Fraction, %	Pump Qty	Pump W/GPM	Flow Controls	Total Design Flow GPM	VSD?	Minimum Flow Fraction, %	Pump Qty	Pump W/GPM
BL CHW	Chilled Water, On-site Plant	Primary/Secondary	Fixed speed, constant flow	175	No	-	1	9.0	Fixed speed, variable flow	300	No	25.0%	1	13.0

WHVAC07–B, P CHW pumps are modeled as reported in the Compliance Form

Review Tips

1. Review simulation reports to verify that chilled water pumps were modeled as reported in the Compliance form including pump design flow (GPM), power (kW, or BHP and motor efficiency) and flow control (one/two speed, VSD).

eQUEST Reports	PV-A
Trane TRACE 700	Plant Information entered values report for power and flow control. Equipment Energy Consumption report to calculate pump gpm. There is no entry for pump motor efficiency. It is assumed to be 75% in the calculation engine.

Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Pumps' section, 'Component Sizing Summary' report
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Pumps' section, 'Component Sizing Summary' report
Carrier HAP v5	"Plant Input Data" reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC08 (B, P) CHW loops flow control is modeled as reported in the Compliance Form

Review Tips

1. Review simulation reports to confirm that CHW loop configuration (i.e. primary/secondary), design flow (GPM) and flow control (three-way or two-way valves) are modeled as reported in the Compliance Form.

eQUEST Reports	PV-A
Trane TRACE 700	Plant Information entered values report. Equipment Energy Consumption report to calculate pump gpm.
Trane TRACE 3D Plus	Plant Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	Plant Information entered values report, eplustbl.html 'Component Sizing Summary' report, 'Plant Loop' section
OpenStudio	Plant Information entered values report, eplustbl.html 'Component Sizing Summary' report, 'Plant Loop' section
Carrier HAP v5	"Plant Input Data" reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC09-B,P Modeled annual chilled water pump energy is as expected

Review Tips

1. Background: Pump energy depends on pump design BHP, pump motor efficiency, whether the flow is constant or variable, with two-way valves in the loop, whether there is a VSD on pump motor and VSD controls such as differential pressure reset. The typical power draw at part load conditions is shown in Table 7, based on the same part load operation assumptions as for the part load cooling efficiency (IPLV), including 1% at 100% of the load, 42% at 25% of the load, 45% at 50% of the load and 12% at 25% of the load).

Table 7: Pump Performance at Part Load Conditions

P_{pump}/P_{design}	100%	90%	80%	70%	60%	50%	40%	30%	25%	20%	10%	Avg %
Riding Curve	1.03	0.92	0.86	0.82	0.79	0.75	0.70	0.62	0.56	0.48	0.28	0.78
VSD, no reset	1.01	0.81	0.64	0.51	0.39	0.30	0.23	0.16	0.14	0.11	0.05	0.43
VSD, pd reset	1.01	0.77	0.57	0.41	0.28	0.18	0.11	0.06	0.04	0.03	0.01	0.34

P_{pump} [W] = pump power at part load
P_{design} [W] = pump power at design load

The annual pump energy use may be estimated as follows:

PEU= P_{design} * Avg% * HRS
PEU [kWh] = estimated annual pump energy use
HRS = number of hours per year the building is occupied
Avg% = the average pump power draw from Table 7 depending on pump capacity control

2. Compare simulated pump energy use to PEU estimated above. The following should be flagged:
   - Simulated baseline pump energy use exceeding estimated PEU by more than 25%
   - Simulated proposed pump energy use below 75% of the estimated PEU

eQUEST Reports	PS-C
Trane TRACE 700	Equipment Energy Consumption report for pump kW and kWh, Library Members entered values report for number of occupied hours/year
Trane TRACE 3D Plus	System Component Summary report for pump inputs, Site Consumption Summary report for pump energy consumption
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Annual Building Utility Performance Summary' report, 'End Uses By Subcategory' section. The user may need to set the pump subcategory field to report out for a specific pump if several are present.
OpenStudio	eplustbl.html 'Annual Building Utility Performance Summary' report, 'End Uses By Subcategory' section. The user may need to set the pump subcategory field to report out for a specific pump if several are present.
Carrier HAP v5	"Monthly Simulation Results" report for plants.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC10–P Proposed heat rejection system reported in the Compliance Form reflects design documents

Review Tips

1. Parameters of the proposed condenser water (CW) loop are reported in Table 5a of the Proposed HVAC tab. Verify that information included in the Compliance Form reflects design documents.
2. Cooling tower details are reported in Table 6a of the Proposed HVAC tab. Verify that information included in the Compliance Form reflects design documents.

WHVAC10–B Baseline/budget heat rejection system reported in the Compliance Form is established correctly

90.1 2016/2019 Section 11

Table 11.5.2-1 Note e The heat-rejection device is an open-circuit axial-fan cooling tower with variable-speed fan control if required in 90.1 Section 6.5.5 and must meet the performance requirements of 90.1 Table 6.8.1-7. Condenser water design supply temperature and controls must be as described in 90.1 Table 11.5.2-1 Note e. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no condenser water pumps, the budget building design pump power must be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% combined impeller and motor efficiency).

90.1 2016/2019 Appendix G

Section G3.1.3.11 The heat-rejection device is an axial-fan open-circuit cooling tower with variable speed fan control and efficiency of 38.2 gpm/hp at the conditions specified in 90.1 Table 6.8.1-7. Temperature controls must be as described in 90.1 Section G3.1.3.11 and 90.1 Table G3.1.3.11. The condenser-water pump power shall be 19 W/gpm and modeled as constant volume.

Review Tips – Appendix G.

1. Baseline cooling tower(s) are described in Table 4a of the Baseline HVAC App G tab. The prescribed inputs are auto-populated based on the applicable 90.1 rules and are non-editable.

Cooling Plant Designation	Cooling Tower (90.1 G3.1.3.11, PRM RM Section 3.7.3)										Other
	Cooling Tower Type	Cooling Tower Quantity	Fan Control	Efficiency [GPM/HP]	Design Flow per Tower [GPM]	0.4% Evaporation Design Wet-bulb Temp.	Design Temp. Rise, °F	Approach	Leaving Water Temp., °F	Basis of Modeled Performance Curves	Integrated Fluid Economizer?
Chiller 1	Axial-fan, open-circuit, single cell	1	Variable speed	38.2			10	26	75	PRM RM	No

2. Baseline condenser loop is described in Table 6a of the Baseline HVAC App G tab. The prescribed fields are auto populated based on 90.1 rules. Over-written defaults are shown in brown font and should be verified to confirm that changes are justified.

Loop Designation	General Description		Primary Loop					
	Loop Type	Config-uration	Flow Controls	Total Design Flow GPM	VSD?	Minimum Flow Fraction, %	Pump Qty	Pump W/GPM
BL CW	Condenser Water	Primary only	Fixed speed, constant flow	60	No	-	1	19.0

Review Tips – Section 11

1. Budget cooling tower(s) are described in Table 4a of the Budget HVAC Section 11 tab. Budget condenser water loop parameters are shown in Table 6a. The prescribed inputs are auto-populated with default based on the applicable rules of Section 11. Over-written defaults are shown in brown font and should be verified to confirm that changes are justified.

WHVAC11-B,P Heat rejection system is modeled as reported in the Compliance Form

Review Tips

Verify that modeled parameters of the heat rejection system(s) are as reported in the Compliance Form.

eQUEST Reports	PV-A
Trane TRACE 700	Plant Information entered values report, Library Members entered values report
Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
Carrier HAP v5	"Cooling Tower Input Data" report.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC12-P Proposed space heating boilers reported in the Compliance Form reflect design documents and meet the minimum efficiency requirements

Review Tips

1. Specified space heating boilers are reported in Table 7a of the Proposed HVAC tab.
2. Confirm that reported boiler type, fuel source, quantity, capacity and efficiency reflect design documents. The design documents where the information may be found (e.g. drawing number) must be included in a dedicated field below the table.

Modeled Heating Plant Name	Heating Plants								
	Type	Fuel	Number of Boilers/Heat Pump Chillers	Total Output Capacity, Btu/hr	Eff. Units	Efficiency	Minimum Efficiency	Associated Loop	Basis of Modeled Performance Curves
B_1	Boiler, HW, Condensing	Natural Gas	2	3,000,000	Et	93%	80%	HW_Loop	Manufacturer data

3. Verify that efficiency of the specified spacy heating boilers meets 90.1 minimum efficiency requirements. (The applicable requirements are quoted in Table 7a.) If the specified boilers have lower efficiency or if the default minimum requirements are over-written, the submittal must be flagged. These requirements are mandatory and must be met.
4. Variations in boiler performance at a range of operating conditions is typically simulated using performance curves. The basis of the modeled performance curves may include the following:
    c) PNNL Performance Rating Method Reference Manual
    d) Custom curves based on chiller performance data from the equipment manufacturer

   If custom curves are used, confirm that supporting information is included in the submittal as required (Submittal Checklist #21). The provided curves may be directly reviewed. Alternatively, the annual average achieved boiler efficiency may be verifies to confirm general alignment with the

rated efficiency (see WHVAC14). Reviewer may also request that the default performance curves from PNNL Performance Rating Method Reference Manual for the specified boiler type are used.

WHVAC12–B Properties of the space heating boilers in the budget/baseline design reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.2 – 1, Note f: The budget building design boiler plant must be modeled with a single boiler if the budget building design plant load is 600,000 Btu/h or less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers must be staged as required by the load. Boilers must use the same fuel as the proposed building design and be natural draft. Boiler efficiency must be the minimum required in 90.1 Table 6.8.1-6. If the proposed design uses purchased hot water or steam, then purchased water or steam must also be used in the budget design in lieu of boilers and the hot-water or steam costs must be based on actual utility rates.

90.1 2016/2019 Section 11

Section G3.1.3.2: The boiler plant for baseline System 1, 5 and 7 must be natural draft and use natural gas. If natural gas is not available on-site as determined by AHJ, the boiler plant must use propane. Purchased heat must be modeled in the baseline instead of on-site boiler for projects that use purchased heat in the proposed design (**Section G3.1.1.1**). The on-site baseline boiler plant must be modeled with a single boiler if the baseline plant serves a conditioned floor area of 15,000 ft^2 or less and with two equally sized boilers for plants serving more than 15,000 ft^2. The boilers must be staged as required by the load.

Review Tips

1. For Appendix G projects, the baseline space heating boilers are reported in Table 5a of the Baseline HVAC App G tab (shown). For Section 11 projects, budget design boilers are shown in Table 5a of the Budget HVAC Section 11 tab.

Boiler Plant Designation	Boiler Plants					
	Type	Fuel	Number of Boilers	? Total Input Capacity, Btu/hr	Efficiency (Table G3.5.6)	? Basis of Modeled Performance Curves
Boiler 1	HW, Natural Draft	Natural Gas	2	1,872,000	75% Et	PRM RM

   The fields are auto-populated except for the following:
   a) Total Input Capacity is a user input and must reflect sizing determined in the baseline model. See WHVAC13 for the applicable simulation reports.)
   b) Basis of the modeled performance curves must be set to Performance Rating Method Reference Manual (PRM RM). While the performance curves are not prescribed in 90.1, PRM RM reflect the industry standard defaults.

   Overwritten defaults (if any) are shown in brown font and should be flagged by reviewer.

WHVAC-13–B,P Space heating boilers are modeled as reported in the Compliance Form

Review Tips

The proposed boiler quantity, type, capacity and efficiency is modeled as reported. The following relationships may be used when necessary to convert between different efficiency units:

a. From AFUE to Et:
   75%<=AFUE<80%: Et=0.1xAFUE+72.5%
   all other: Et=0.875 x AFUE + 10.5%
b. From Ec to Et: Et=Ec-2%

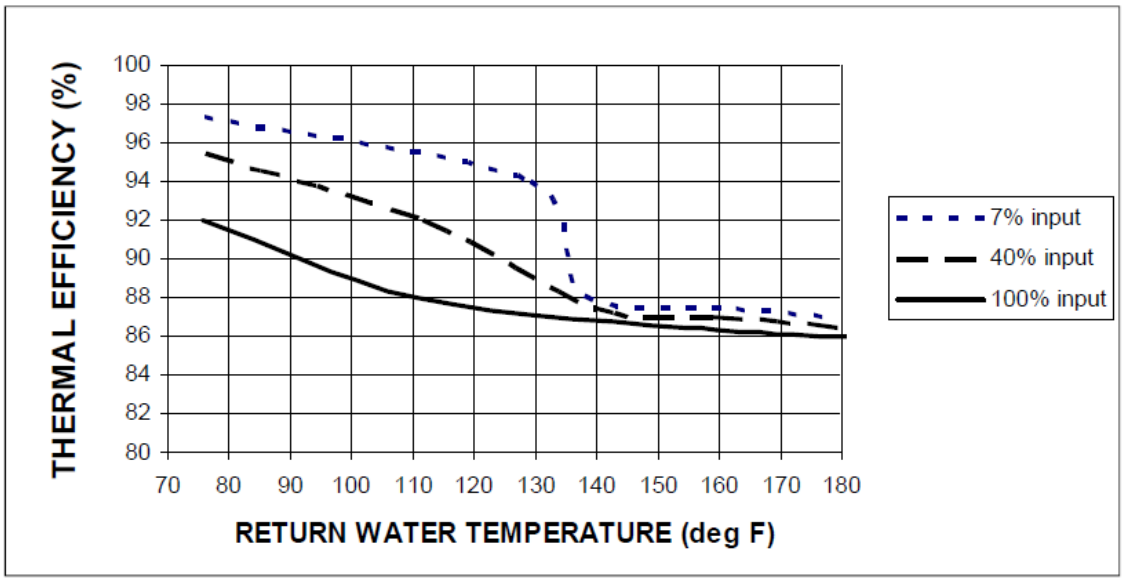
eQUEST Reports	PV-A
Trane TRACE 700	Plant Information entered values report
Trane TRACE 3D Plus	System Component Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report
Carrier HAP v5	"Plant Input Data", "Boiler Input Data", "Chiller Input Data" (for A2W or W2W heat pumps) reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC14–B,P Average annual realized boiler efficiency is as expected

Review Tips

1. Background

The annual average realized boiler efficiency is the ratio of the annual load on the boiler to the annual boiler energy use, as shown on simulation output reports. The average realized efficiency is expected to be lower than the rated efficiency. For example, the rated efficiency of condensing boilers corresponds to 80F return water temperature. A much higher design return water temperature is common (see WHVAC15-P), resulting in a significantly lower realized efficiency of condensing boilers, as illustrated below based on manufacturer data for a sample unit.



2. Common Mistakes
    a. Average annual realized efficiency over 86% for condensing boilers included in the proposed designs that with the specified return water temperature of 160F should be flagged as it is likely overly optimistic. Review comment should request cut sheets for the boiler with AHRI efficiency and performance characteristics at various return water temperature and loads to justify the modeled performance. Higher than expected average efficiency may be due to the following:
        - Inappropriate performance curves (e.g., using software defaults or incorrect custom performance curves)
        - Incorrect rated full load efficiency input
        - Incorrect HW loop controls such as lower than specified supply water temperature or higher than specified design temperature drop
    b. Budget/baseline space heating boilers are natural draft. The average realized annual efficiency below 72% / 68% for the natural draft boilers that have 80% / 75% rated efficiency should be flagged. The expected part load efficiency degradation of such boilers based on the performance curves in PRM RM results in the efficiencies shown in Table 18**.** The annual average efficiency of a boiler that operates at 75% of design capacity 43% of the time, 50% of design capacity 45% of the time and 25% of design capacity 12% of the time is shown in Typ. Avg. column of Table 9. The average annual boiler efficiency that is lower than expected should be flagged and may be due to the following:
        - Budget/baseline boilers are oversized by more than 25% and run at low part load for most of the year.
        - Budget/baseline boilers are not controlled correctly in the model.
        - Inappropriate performance curves (e.g., using software defaults or incorrect custom performance curves)

Table 18: Natural Draft Boiler Efficiency at Part Load Conditions

% of Design Load	100%	90%	80%	70%	60%	50%	40%	30%	25%	Typ. Avg.
80% efficient boiler (Note 1)	80%	79%	77%	76%	74%	71%	68%	64%	61%	72%
75% efficient boiler (Note 2)	75%	74%	72%	71%	69%	67%	64%	60%	57%	68%

Note 1: All ECB budget boilers and PRM baseline boilers with heating capacity over 2,500 kBtu/h or under 300 kBtu/h
Note 2: PRM baseline boilers with 300 kBtu/h – 2,500 kBtu/h

eQUEST Reports	PS-C
Trane TRACE 700	Equipment Energy Consumption report for the total equipment consumption and Building Cool/Heat Demand report from the Visualizer for the total loads
Trane TRACE 3D Plus	Site Consumption Summary for the consumption and Site Load Profile for the loads
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report, 'Annual Building Utility Performance Summary' report, 'End Uses By Subcategory' section. The user may need to set the boiler subcategory field to report out for a specific boiler if several are present.
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Central Plant' section, 'Component Sizing Summary' report, 'Annual Building Utility Performance Summary' report, 'End Uses By Subcategory' section. The user may need to set the boiler subcategory field to report out for a specific boiler if several are present.
Carrier HAP v5	"Monthly Simulation Results" report for a hot water plant. Use annual totals for "Boiler Output" and "Boiler Input".
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC15-P Proposed hot water loop configuration temperature controls reported in the Compliance Form reflect design documents

Review Tips

1. The configuration (primary/secondary) and temperature controls of the specified hot water loops are shown in Table 5a of the Proposed HVAC tab.

Loop Type	Configuration	Design Supply T (F)	Design Delta T (F)	Supply Temperature Reset Logic
Hot Water, On-site Plant	Primary only	160	50	160°F at OAT 20°F and below,100°F at OA temps 60°F & above, & ramped linearly between 100°F & 160°F

2. Verify that the reported hot water loop configuration and controls including design supply and return water temperature and temperature reset reflect design documents. Controls may have significant impact on the realized efficiency. For example, the rated efficiency of condensing boilers corresponds to 80F return water temperature. A much higher design return water temperature is common, such as 160 F shown below, resulting in a significantly lower realized efficiency (see

WHVAC13).

DESIGNATION	LOCATION	SERVICE	NOMINAL CAPACITY BOILER MBH	GROSS INPUT MBTU/HR	NET OUTPUT MBTU/HR	BURNER PERFORMANCE DATA GAS FUEL TYPE	GAS FIRING RATE (SCFH)	GAS TRAIN SIZE (IN)	MIN/MAX PRE.(IN W.C.)	ELECTICAL BOILER POWER FLA	MCB	V/□/Hz	HOT WATER GPM	MAX PD (FT)	EWT (°F)	LWT (°F)
B-1D-1&2	MECH. ROOM	HEATING	1,000	1,000	870	NG	1,000	1	4/14	13	20	120/1/60	12/175	6.47	180	160

WHVA15–B Budget/baseline hot water loop configuration and temperature controls reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.2 – 1, Note f: The hot-water space heating loop must be modeled with 180°F design supply temperature and 130°F return temperature. The supply water temperature must be reset in accordance with 90.1 Section 6.5.4.4.

90.1 2016/2019 Appendix G

The hot-water space heating loop must be modeled with 180°F design supply and 130°F design return temperature (**90.1 Section G3.1.3.3**). Hot-water supply temperature must be reset based on outdoor dry-bulb temperature using the following schedule: 180°F at 20°F and below, 150°F at 50°F and above and ramped linearly between 180°F and 150°F at temperatures between 20°F and 50°F (**G3.1.3.4**). See Exception to 90.1 Section G3.1.3.4 for projects that use purchased heat in the proposed design.

Review Tips

1. HW plant loop arrangement and controls are reported in Table 6a of the Budget HVAC Section 11 tab (shown) or Table 6a of the Baseline HVAC App G tab, depending on the compliance path followed by the project. The inputs are auto-populated based on the applicable requirements of 90.1. Over-written defaults are shown in brown font and should be verified.

WHVAC16-B,P Hot water loops temperature controls are modeled as reported in the Compliance Form

Review Tips

Use simulation reports to verify that the modeled hot water loop configuration and controls such as supply and return hot water temperature and temperature reset are modeled as reported in the Compliance Form.

eQUEST Reports	NA
Trane TRACE 700	Library Members entered values report
Trane TRACE 3D Plus	Plant Summary report
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	
OpenStudio	
Carrier HAP v5	“Plant Input Data” reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)
Energy Gauge	

WHVAC17–P Proposed hot water pump system parameters reported in the Compliance Form reflect design documents

Review Tips

1. Details of the specified HW pumps are reported in Table 5a of the Proposed HVAC tab. Verify alignment between Compliance Form and design documents. (The applicable design documents must be listed below the table.)

WHVAC17–B Baseline/budget hot water pumps reported in the Compliance Form are established correctly

90.1 2016/2019 Section 11

Table 11.5.2 – 1, Note f: Pump system power for each pumping system must be the same as for the proposed building design; if the proposed building design has no hot-water pumps, the budget building design pump power must be 19 W/gpm, which is equal to a pump operating against a 60 ft head, 60% combined impeller and motor efficiency. The hot-water system shall be modeled as primary-only with continuous variable flow. The hot-water pumps must be modeled as riding the pump curve or with variable-speed drives when required by 90.1 Section 6.5.4.2.

90.1 2016/2019 Appendix G

Section G3.1.3.5: The baseline building design hot-water pump power must be 19 W/gpm. The pumping system must be primary-only with continuous variable flow and a minimum of 25% of the design flow rate. Hot-water systems serving 120,000 ft2 or more must be modeled with variable-speed drives and systems serving less than 120,000 ft2 must be modeled as riding the pump curve.

Review Tips

1. Parameters of the baseline HW pumps are reported in Table 6a of the Baseline HVAC App G tab (shown) or Budget HVAC Section 11 tab. All required inputs are auto-populated based on the applicable 90.1 rules. Over-written defaults should be checked.

WHVAC18-B,P Hot water pumps are modeled as reported in the Compliance Form

Review Tips

1. Review simulation reports to verify that hot water pumps were modeled as reported in the Compliance form including pump design flow (GPM), power (kW, or BHP and motor efficiency) and flow control (one/two speed, VSD).

eQUEST Reports	PV-A
Trane TRACE 700	Plant Information entered values report. Equipment Energy Consumption report and Library Members entered values report to calculate pump gpm. There is no entry for pump motor efficiency. It is assumed to be 75% in the calculation engine.
Trane TRACE 3D Plus	System Component Summary report

IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	eplustbl.html 'Equipment Summary' report, 'Pumps' section, 'Component Sizing Summary' report
OpenStudio	eplustbl.html 'Equipment Summary' report, 'Pumps' section, 'Component Sizing Summary' report
Carrier HAP v5	"Plant Input Data" reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC19-B,P Hot water loops flow control is modeled as reported in the Compliance Form

1. Review simulation reports to confirm that HW loop configuration (i.e. primary/secondary), design flow (GPM) and flow control (three-way or two-way valves) are modeled as reported in the Compliance Form.

eQUEST Reports	PV-A
Trane TRACE 700	Plant Information entered values report. Equipment Energy Consumption report and Library Members entered values report to calculate pump gpm.
Trane TRACE 3D Plus	Plant Summary
IESVE SOFTWARE	Plant Loops & Equipment Report, BPRM Report, Detailed Simulation Report, Florida Energy Code Compliance Report or California Title 24 Certificate of Compliance Report
EnergyPlus	Plant Information entered values report, eplustbl.html 'Component Sizing Summary' report, 'Plant Loop' section
OpenStudio	Plant Information entered values report, eplustbl.html 'Component Sizing Summary' report, 'Plant Loop' section
Carrier HAP v5	"Plant Input Data" reports.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

WHVAC20-B,P Modeled annual hot water pump energy is as expected

Review Tips

1. Follow the steps described for HVAVC09 to confirm that the modeled annual hot water pump energy is as expected.

eQUEST Reports	PS-C
Trane TRACE 700	Equipment Energy Consumption report for pump kW and kWh, Library Members entered values report for number of occupied hours/year
Trane TRACE 3D Plus	System Component Summary report for pump inputs, Site Consumption Summary report for pump energy consumption
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report

EnergyPlus	eplustbl.html 'Annual Building Utility Performance Summary' report, 'End Uses By Subcategory' section. The user may need to set the pump subcategory field to report out for a specific pump if several are present.
OpenStudio	eplustbl.html 'Annual Building Utility Performance Summary' report, 'End Uses By Subcategory' section. The user may need to set the pump subcategory field to report out for a specific pump if several are present.
Carrier HAP v5	"Monthly Simulation Results" report for a hot water plant.
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)
Energy Gauge	

WHVAC21 Pump energy use is reported on the Compliance Calculations tab if applicable.

Review Tips

1. If proposed/budget/baseline design includes chilled water, hot water or condenser loops based on the information reported in the Compliance Form (as noted below), pumps are expected to be modeled and non-zero "Pump" end use in expected to be reported on the Compliance Calculations tab Table 2. Loops are found on the following locations within the Compliance Form:
    - Proposed HVAC tab Table 5a
    - Baseline HVAC App G tab Table 6a
    - Budget HVAC Section 11 tab Table 6a

2. The following should be flagged in the review comments:
    a) Model is expected to have pumps, but no pump energy is reported
    b) Model is not expected to have pumps, but pump energy is reported.

WHVAC22 Modeled budget/baseline and proposed heating energy use by fuel is consistent with heating energy source reported in the Compliance Form

Review Tips – Section 11

1. When **Section 11.5.2 j** is properly applied to determine the budget HVAC system, the allocation of heating and cooling energy use between fuels is expected to be similar in the budget building and the proposed design. For example, if based on the simulation output reports about one third of the annual heating MMBtu is associated with natural gas and two thirds with electricity, similar allocation is expected in the budget design. Explanation should be requested when allocation of heating energy use between fuels differ by more than 15% in the budget design vs proposed design. For example, if in the budget design heating energy MMBtu are split 50/50 between electricity and gas, and in the proposed design the split is 30/70.

2. All fuel types reported in the Proposed HVAC tab Table 1a or 7a should have the corresponding modeled energy use reported for the proposed design in the Compliance Calculations tab Table 2. All fuel types that are not listed in the above-referenced tables of the Proposed HAC tab are expected to have no energy user reported in the Compliance Calculations tab.

3. All heating fuels reported in the Budget HVAC Section 11 tab Table 1a or 5a should have the corresponding modeled energy use reported for the budget design in the Compliance Calculations

tab Table 2. All fuel types that are not listed in the above-referenced tables of the Proposed HAC tab are expected to have no energy user reported in the Compliance Calculations tab.

Review Tips – Appendix G

1. All fuel types reported in the Proposed HVAC tab Table 1a or 7a should have the corresponding modeled energy use reported for the proposed design in the Compliance Calculations tab Table 2. All fuel types that are not listed in the above-referenced tables of the Proposed HAC tab are expected to have no energy user reported in the Compliance Calculations tab.

2. All heating fuels reported in the Baseline HVAC App G tab Table 1a or 5a should have the corresponding modeled energy use reported for the budget design in the Compliance Calculations tab Table 2. All fuel types that are not listed in the above-referenced tables of the Proposed HAC tab are expected to have no energy user reported in the Compliance Calculations tab.

3. Common mistake includes modeling electric heating in the baseline for projects located in climate zones 3B, 3C and 4-8. Based on 90.1 Table G3.1.1-3 and G3.1.1-4, such projects should have no electric heating in the baseline model.

eQUEST Reports	BEPU
Trane TRACE 700	Energy Cost Budget report
Trane TRACE 3D Plus	LEED Summary Section 1.6
IESVE SOFTWARE	Plant Loops & Equipment Report, Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report, Detailed Simulation Report
EnergyPlus	eplustbl.html 'Annual Building Utility Performance Summary' report
OpenStudio	eplustbl.html 'Annual Building Utility Performance Summary' report
Carrier HAP v5	"LEED Summary" report, Section 2 "Minimum Energy Performance Calculator", table titled "Proposed Energy Summary by End Use"
Design Builder	Water-Side HVAC sheet in LEED Minimum Energy Performance Calculator (.xlsm)

Renewable Energy (RE)

Renewable Energy Checks Overview

This group of quality control checks focus on verifying renewable thermal and electricity generation systems. The checks only apply to projects that include such systems.

RE01 The renewable electricity generation systems reported in the Compliance Form reflect design documents

Review Tips

Renewable electricity generation systems are reported in on the Renewable Energy tab Tables 1 and 2. Confirm that all required information is provided and consistent with the design documents.

PV system details included in the submittal must at minimum include system type, orientation and generation capacity (kW). If PV system was not modeled explicitly in the whole building simulation tool

used for the project, the external calculations used to estimate electricity generation must be included in the submittal as described in Exceptional Calculations group of QC checks.

RE02 The renewable thermal energy systems reported in the Compliance Form reflect design documents

Review Tips

Renewable thermal energy systems are reported in Table 3 of the Renewable Energy tab.

RE03 Savings from renewable energy savings reported in the Compliance Form are substantiated

Review Tips

1. Refer to Table 4 in the Renewable Energy Tab
2. To verify that the reported PV system electricity generation is reasonable, calculate the system EFLH that is equal to the ratio of the reported annual electricity generation (kWh) to the total rated PV system capacity (kW).
3. If renewable energy was modeled in the whole building simulation tool, verify that savings reported in the Compliance Form reflect simulation results based on the simulation reports referenced below.
4. Projects often model renewable energy using external calculations.

eQUEST Reports	NA
Trane TRACE 700	LEED Summary Section 1.4
Trane TRACE 3D Plus	NA
IESVE SOFTWARE	Energy Model Output Report, PRM Compliance Report, ECB Compliance Report, BPRM Report
EnergyPlus	eplustbl.html 'LEED Summary' report, section L-1 Renewable Energy Source Summary
OpenStudio	eplustbl.html 'LEED Summary' report, section L-1 Renewable Energy Source Summary
Carrier HAP v5	NA. On-site renewable energy generation is calculated external to the program.
Design Builder	LEED Summary Reports in EnergyPlus Output Summary Document

RE04 Contribution of renewable energy toward compliance does not exceed the allowed limit

90.1 2016/2019 Section 11

11.4.3.1: The reduction in design energy cost associated with on-site renewable energy shall be no more than 5% of the calculated energy cost budget.

90.1 2016 Appendix G

There is no limit on the contribution of renewable energy toward compliance. However, such contribution should be verified to ensure that it is not overly optimistic.

90.1 2019 Appendix G

4.2.1.1: The formula used to establish compliance provided in this section limits contribution of renewable energy toward compliance to no greater than 5% of the baseline energy cost.

Review Tips

1. The applicable cap is automatically accounted for in the Compliance Calculations tab of the Compliance Form.

2. 90.1 Section 3 defines on-site renewable energy as "… energy generated from renewable sources produced at the building site." Based on this definition, savings associated with systems such as PV panels, solar service water preheaters, etc. are subject to the cap. As with any systems, the renewable energy systems can only contribute toward compliance if they are included in the permit application.

3. Example

Q: A project following the ECB path has modeled an energy cost budget of $100,000. The modeled proposed energy cost is $98,000 including $8,000 savings from on-site PV panels which were explicitly modeled in the simulation tool and are included in the permit application. Does the project comply with ECB?

A: The proposed energy cost without accounting for on-site renewables is $98,000+$8,000=$106,000. The allowed maximum contribution of renewable energy toward savings is 5%*100,000=$5,000. The proposed energy cost with the allowed renewable energy savings is $106,000-$5,000=$101,000, which exceeds the energy cost budget. The project does not comply with the ECB.

Exceptional Calculations (EC)

EC Review Checks Overview

This group of quality control checks focus on verifying calculations performed outside of the whole building simulation tool. The checks only apply to projects that include such calculations.

EC01 Documentation submitted for each exceptional calculation method reported in the Compliance Form meets 90.1 requirements.

90.1 2016/2019 Section 11

Section 11.4.5

When the simulation program does not model a design, material, or device in the proposed design, an exceptional calculation method must be used. Where there are multiple designs, materials, or devices that the simulation program does not model, each must be calculated separately, and exceptional savings determined for each. The following documentation must be submitted for each exceptional calculation method:

a. Theoretical and empirical information verifying the method's accuracy, and step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.
b. Copies of all spreadsheets used to perform the calculations.

c. A sensitivity analysis of energy consumption when each of the input parameters that are estimated is varied from half to double the value assumed.

90.1 2016/2019 Appendix G

Section G2.5

When the simulation program does not model a design, material, or device in the proposed design, an exceptional calculation method must be used. Where there are multiple designs, materials, or devices that the simulation program does not model, each must be calculated separately, and exceptional savings determined for each. The following documentation must be submitted for each exceptional calculation method:

a. Step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.
b. Copies of all spreadsheets used to perform the calculations.
c. A sensitivity analysis of energy consumption when each of the input parameters is varied from half to double the value assumed.
d. The calculations must be performed on a time-step basis consistent with the simulation program used.

Review Tip.

1. Exceptional calculations are listed in Table 1 of the Exceptional Calculations tab of the Compliance Form. Prioritize review of exceptional calculations that are expected to generate the greatest savings based on the information provided in Table 2 of the tab.
2. Refer to Submittal Checklist #35 for the list of files and documents substantiating the exceptional calculations. Locate the material and confirm that the provided details meet 90.1 requirements quoted above for each exceptional calculation.
3. Common mistakes
    a. Submittal includes screenshots or printouts of the calculations but not the spreadsheet files where formulas can be examined.
    b. Savings are estimated using proprietary calculators from the vendor of specified system and equipment.
    c. Calculation methodology not based on peer-reviewed reference or fundamental principles of physics or thermodynamics.
    d. The whole building simulation tool used on the project must be able to explicitly model all systems and components of the baseline/budget design (Section G2.2.1 b, Section 11.4.1.1 h), thus exceptional calculations may only apply to the proposed design.

EC02 Calculation methodology is acceptable and inputs reflect specified systems and equipment

90.1 2016/2019 Section 11 and Appendix G

90.1 Sections 11.4.5, G2.5

Each exceptional calculation is subject to approval by the authority having jurisdiction or rating authority

Review Tip.

1. Section 11 and Appendix G require that all building systems and equipment are modeled identically in the baseline/budget and proposed design except when specifically allowed to be different (see Table 11.5.1 No 1 and Table G3.1 No 1. Confirm that system or equipment that is the subject of exceptional calculation method is an allowed trade-off opportunity.
2. Verify methodology used for the exceptional calculation methods to confirm that it is acceptable
3. Confirm that calculation inputs reflect properties of the relevant systems and equipment specified in the design documents.
4. Ensure that operating conditions assumptions and other inputs not inherent in system design are conservative and do not exaggerate savings.
5. Verify that applicable interactive effects are accounted for.

EC03 Contribution of exceptional calculations toward compliance does not exceed the allowed limits

90.1 2016/2019 Section 11

There is no limit on the contribution of savings documented via exceptional calculations toward compliance.

90.1 2016/2019 Appendix G

Section G2.5: When the simulation program does not model a design, material, or device associated with the proposed design, an approved exceptional calculation method may be used. The total Exceptional Savings must not account for more than half of the difference between the baseline building performance and the proposed building performance.

Review Tips

1. The required cap is automatically accounted for in the Compliance Calculations tab of the Compliance Form based on the compliance path followed by the project.
2. Even though Section 11 does not limit contribution of exceptional calculations toward compliance, the AHJ may choose to limit contribution of exceptional calculations towards trade-offs since such calculations often involve in-house spreadsheets developed by the Permit Applicant and are not peer-reviewed, or based on savings estimates by the vendor of the system and component being specified.
3. Example

   Q: The modeled baseline energy cost is $100,000 and the modeled proposed energy cost is $92,000. In addition, the submittal includes $7,000 savings from a ventilated façade which could not be modeled in the simulation tool. The savings were determined using exceptional calculations and documented as required in 90.1 Section G2.5. What proposed building performance should be used to calculate PRM compliance following 90.1 Section G1.2.2?

   A: The difference between the baseline and proposed energy cost without accounting for exceptional calculations is $100,000-$92,000=$8,000. The savings from exceptional calculations are greater than $8,000*0.5=$4,000, thus the allowed contribution of the exceptional calculations toward savings is capped at $4,000. The proposed energy cost that must be used in the compliance

calculations is $92,000-$4,000=$88,000. The Performance Cost Index is equal to $88,000 / $100,000=0.88.

7. Simulation Reports

Carrier HAP v5

1. Carrier HAP v5 is a licensed product. Product details available at https://www.carrier.com/commercial/en/us/software/hvac-system-design/hourly-analysis-program/. Product licensinging information available at https://www.carrier.com/commercial/en/us/software/hvac-system-design/software-ordering/.
2. HAP has an extensive help system. Information about report options and the content of output reports is found in Sections 9.6 (Weather), 14.0 (System Design), 15.0 (Plant Design), and 16.0 (Energy Simulations).
3. program operating information is found in Chapter 1 (Getting Started), Chapter 2 (Tutorials), Chapters 3 and 4 (Example Problems), and Chapters 5-8 (Applications).
4. Free training videos are available at https://www.carrier.com/commercial/en/us/software/hvac-system-design/software-support/hap-training-videos.

General

1. Reports can be viewed, printed, or exported. When exporting, the report must be viewed first; the export option appears in the Report Viewer window.

Simulation Reports to Be Submitted

HAP reports providing data needed for the compliance tasks described in this manual are listed below, arranged by subject.

A. Building-Level Output Reports

A1. LEED Summary Report
A2. Energy Budget by System Component
A3. Energy Budget by Energy Type
A4. Monthly Energy Use by System Component Report
A5. Billing Details Report

B. Plant-Level Output Reports

B1. (Plant) Monthly Simulation Results

C. Air-Side HVAC System-Level Output Reports

C1. (Air System) Monthly Simulation Results Report
C2. (Air System) Hourly Simulation Results, CSV Version
C3. Air System Sizing Summary Report
C4. Zone Sizing Summary Report
C5. Ventilation Sizing Summary Report
C6. Air System Design Load Summary Report

D. Input Data Reports

D1. Building Input Data Report
D2. Plant Input Data Report
D3. Air System Input Data Report
D4. Simulation Weather Summary Report,
D5. Space Input Data
D6. Wall Constructions Report
D7. Roof Constructions Report
D8. Window Constructions Report
D9. Chiller Input Data Report
D10. Cooling Tower Input Data Report
D11. Boiler Input Data Report
D12. Electric Rate Input Data Report
D13. Fuel Rate Input Data Report

Annotated Reports

A. Building-Level Output Reports

A1.1 LEED Summary Report – Part 1 of 2

LEED v4 EA Credit Optimize Energy Performance Summary Report

DOE Benchmark - Large Office - 2016 - Zone 4A — 12/30/2019
Carrier Corporation — 04:54PM

1. REPORT AND PROJECT INFORMATION

General
Simulation Program Name and Version ..... **Hourly Analysis Program 5.11**
Simulation Weather File Name ..... **Baltimore, Maryland (TM2)**

Building Designations
Proposed Building ..... **Proposed Building**
Baseline - 0° ..... **[B000] Baseline Building**
Baseline - 90° ..... **[B090] Baseline Building**
Baseline - 180° ..... **[B180] Baseline Building**
Baseline - 270° ..... **[B270] Baseline Building**

Space Summary

	Proposed Design	Baseline
Conditioned Floor Area (ft²)	498,637	498,637
Unconditioned Floor Area (ft²)	0	0
Total Floor Area (ft²)	498,637	498,637

SG5 – Conditioned floor area

BE6, BE8, BE7, BE9 – Opaque envelope areas, fenestration areas, Baseline and Proposed orientations

2. MINIMUM ENERGY PERFORMANCE CALCULATOR

SHADING AND FENESTRATION

Building Massing and Zoning

Above-Grade Wall & Vertical Glazing Areas

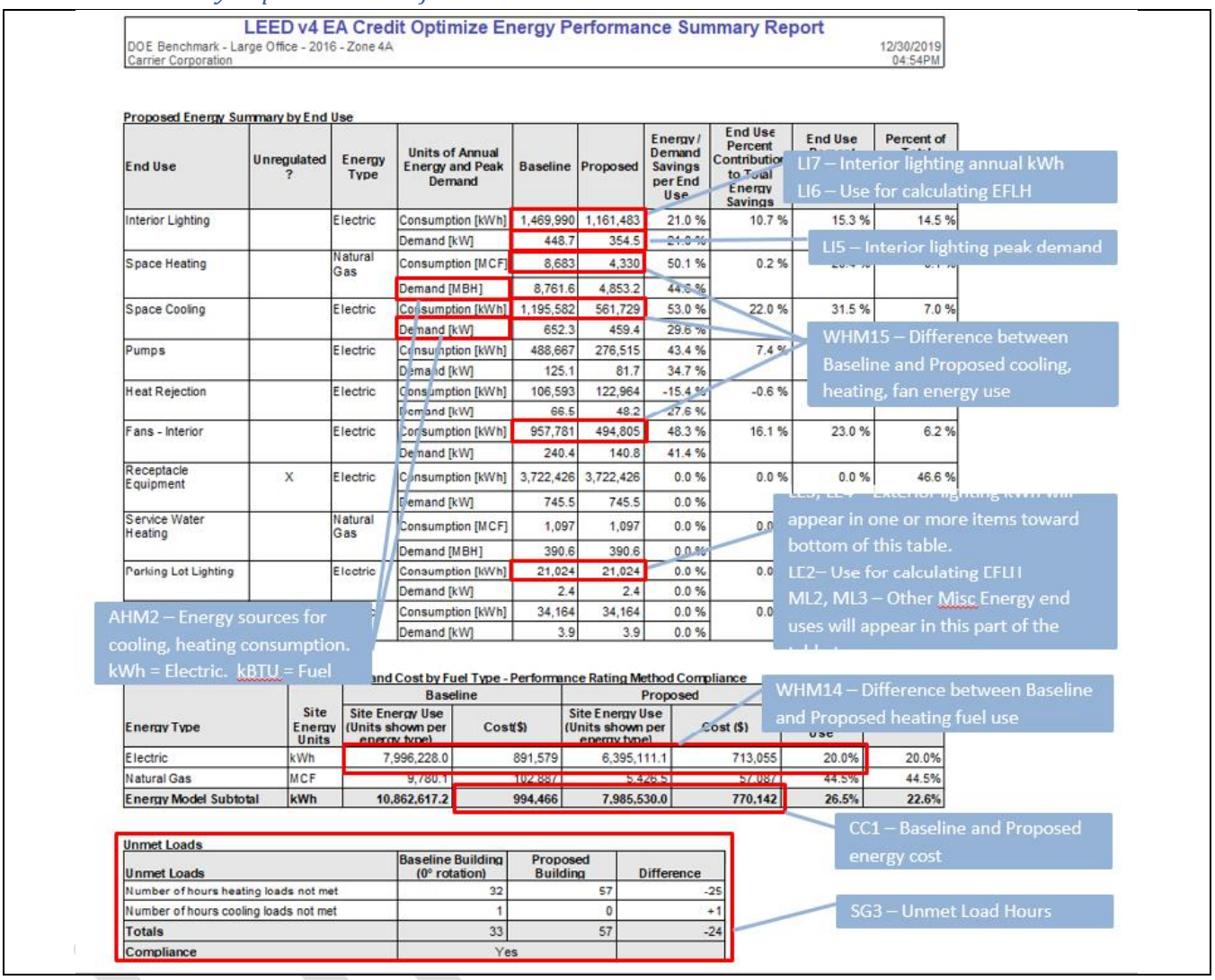
Orientation	Baseline Design (0° rotation)			Proposed Design		
	Gross Above-Grade Wall Area	Vertical Glazing Area		Gross Above-Grade Wall Area	Vertical Glazing Area	
	(ft²)	(ft²)	(% WWR)	(ft²)	(ft²)	(% WWR)
North	37,440	14,976	40.0	37,440	14,976	40.0
North-Northeast	0	0	0.0	0	0	0.0
Northeast	0	0	0.0	0	0	0.0
East-Northeast	0	0	0.0	0	0	0.0
East	24,960	9,984	40.0	24,960	9,984	40.0
East-Southeast	0	0	0.0	0	0	0.0
Southeast	0	0	0.0	0	0	0.0
South-Southeast	0	0	0.0	0	0	0.0
South	37,440	14,976	40.0	37,440	14,976	40.0
South-Southwest	0	0	0.0	0	0	0.0
Southwest	0	0	0.0	0	0	0.0
West-Southwest	0	0	0.0	0	0	0.0
West	24,960	9,984	40.0	24,960	9,984	40.0
West-Northwest	0	0	0.0	0	0	0.0
Northwest	0	0	0.0	0	0	0.0
North-Northwest	0	0	0.0	0	0	0.0
Total	**124,800**	**49,920**	**40.0**	**124,800**	**49,920**	**40.0**

Roof & Skylight Areas

Baseline Design (0° rotation)			Proposed Design		
Gross Roof Area	Skylight Area		Gross Roof Area	Skylight Area	
(ft²)	(ft²)	(%)	(ft²)	(ft²)	(%)
38,357	0	0.0	38,357	0	0.0

XXX

A1.2 LEED Summary Report – Part 2 of 2



LEED v4 EA Credit Optimize Energy Performance Summary Report

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
04:54PM

Proposed Energy Summary by End Use

End Use	Unregulated ?	Energy Type	Units of Annual Energy and Peak Demand	Baseline	Proposed	Energy / Demand Savings per End Use	End Use Percent Contribution to Total Energy Savings	End Use	Percent of
Interior Lighting		Electric	Consumption [kWh]	1,469,990	1,161,483	21.0 %	10.7 %	15.3 %	14.5 %
			Demand [kW]	448.7	354.5	21.0 %			
Space Heating		Natural Gas	Consumption [MCF]	8,683	4,330	50.1 %	0.2 %		
			Demand [MBH]	8,761.6	4,853.2	44.6 %			
Space Cooling		Electric	Consumption [kWh]	1,195,582	561,729	53.0 %	22.0 %	31.5 %	7.0 %
			Demand [kW]	652.3	459.4	29.6 %			
Pumps		Electric	Consumption [kWh]	488,667	276,515	43.4 %	7.4 %		
			Demand [kW]	125.1	81.7	34.7 %			
Heat Rejection		Electric	Consumption [kWh]	106,593	122,964	-15.4 %	-0.6 %		
			Demand [kW]	66.5	48.2	27.6 %			
Fans - Interior		Electric	Consumption [kWh]	957,781	494,805	48.3 %	16.1 %	23.0 %	6.2 %
			Demand [kW]	240.4	140.8	41.4 %			
Receptacle Equipment	X	Electric	Consumption [kWh]	3,722,426	3,722,426	0.0 %	0.0 %	0.0 %	46.6 %
			Demand [kW]	745.5	745.5	0.0 %			
Service Water Heating		Natural Gas	Consumption [MCF]	1,097	1,097	0.0 %	0.0		
			Demand [MBH]	390.6	390.6	0.0 %			
Parking Lot Lighting		Electric	Consumption [kWh]	21,024	21,024	0.0 %	0.0		
			Demand [kW]	2.4	2.4	0.0 %			
			Consumption [kWh]	34,164	34,164	0.0 %	0.0		
			Demand [kW]	3.9	3.9	0.0 %			

LI7 – Interior lighting annual kWh
LI6 – Use for calculating EFLH

LI5 – Interior lighting peak demand

WHM15 – Difference between Baseline and Proposed cooling, heating, fan energy use

appear in one or more items toward bottom of this table.
LL2– Use for calculating EFLH
ML2, ML3 – Other Misc Energy end uses will appear in this part of the

AHM2 – Energy sources for cooling, heating consumption. kWh = Electric. kBTU = Fuel

and Cost by Fuel Type - Performance Rating Method Compliance

Energy Type	Site Energy Units	Baseline		Proposed			
		Site Energy Use (Units shown per energy type)	Cost($)	Site Energy Use (Units shown per energy type)	Cost ($)		
Electric	kWh	7,996,228.0	891,579	6,395,111.1	713,055	20.0%	20.0%
Natural Gas	MCF	9,780.1	102,887	5,426.51	57,087	44.5%	44.5%
Energy Model Subtotal	**kWh**	**10,862,617.2**	**994,466**	**7,985,530.0**	**770,142**	**26.5%**	**22.6%**

WHM14 – Difference between Baseline and Proposed heating fuel use

CC1 – Baseline and Proposed energy cost

Unmet Loads

Unmet Loads	Baseline Building (0° rotation)	Proposed Building	Difference
Number of hours heating loads not met	32	57	-25
Number of hours cooling loads not met	1	0	+1
Totals	33	57	-24
Compliance	Yes		

SG3 – Unmet Load Hours

A2. Energy Budget by System Component Report

Energy Budget by System Component - Proposed Building

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
05:21PM

1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	17,561,050	35.218
Heating Coil Loads	3,466,260	6.951
Grand Total	**21,027,314**	**42.170**

2. Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
Air System Fans	1,688,312	3.386	6,029,687	12.092
Cooling	1,916,619	3.844	6,845,067	13.728
Heating	5,426,520	10.883	5,426,520	10.883
Pumps	943,471	1.892	3,369,538	6.758
Heat Rejection Fans	419,555	0.841	1,498,412	3.005
HVAC Sub-Total	**10,394,477**	**20.846**	**23,169,223**	**46.465**
Lights	3,963,001	7.948	14,153,574	28.385
Electric Equipment	12,701,067	25.472	45,360,952	90.970
Misc. Electric	188,299	0.378	672,498	1.349
Misc. Fuel Use	0	0.000	0	0.000
Non-HVAC Sub-Total	**16,852,367**	**33.797**	**60,187,024**	**120.703**
Grand Total	**27,246,844**	**54.643**	**83,356,247**	**167.168**

SG5 – Site EUI

Notes:
1. 'Cooling Coil Loads' is the sum of all air system cooling coil loads.
2. 'Heating Coil Loads' is the sum of all air system heating coil loads.
3. Site Energy is the actual energy consumed.
4. Source Energy is the site energy divided by the electric generating efficiency (28.0%).
5. Source Energy for fuels equals the site energy value.
6. Energy per unit floor area is based on the gross building floor area.
   Gross Floor Area ..... **498637.1** ft²
   Conditioned Floor Area ..... **498637.1** ft²

A3. Energy Budget by Energy Type Report

Energy Budget by Energy Source - Proposed Building

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation
12/30/2019
05:21PM

1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	17,561,050	35.218
Heating Coil Loads	3,466,260	6.951
Grand Total	**21,027,314**	**42.170**

2. Energy Consumption by Energy Source

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
HVAC Components				
Electric	4,967,872	9.963	17,742,400	35.582
Natural Gas	5,426,520	10.883	5,426,520	10.883
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Hot Water	0	0.000	0	0.000
Remote Steam	0	0.000	0	0.000
Remote Chilled Water	0	0.000	0	0.000
HVAC Sub-Total	**10,394,391**	**20.846**	**23,168,920**	**46.465**
Non-HVAC Components				
Electric	16,852,786	33.798	60,188,516	120.706
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Hot Water	0	0.000	0	0.000
Remote Steam	0	0.000	0	0.000
Non-HVAC Sub-Total	**16,852,786**	**33.798**	**60,188,516**	**120.706**
Grand Total	**27,247,177**	**54.643**	**83,357,436**	**167.171**

Notes:
1. 'Cooling Coil Loads' is the sum of all air system cooling coil loads.
2. 'Heating Coil Loads' is the sum of all air system heating coil loads.
3. Site Energy is the actual energy consumed.
4. Source Energy is the site energy divided by the electric generating efficiency (28.0%).
5. Source Energy for fuels equals the site energy value.
6. Energy per unit floor area is based on the gross building floor area.
   Gross Floor Area ..... **498637.1** ft²
   Conditioned Floor Area ..... **498637.1** ft²

ML2 – Site EUI of miscellaneous end uses, by energy type.

A4. Monthly Energy Use by System Component Report

Monthly Energy Use by Component - Proposed Building

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation
12/30/2019
05:21PM

1. Monthly Energy Use by System Component

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air System Fans (kWh)	41778	37237	39720	39438	41133	42281	46000	44168	41204	41613	38345	41900
Cooling												
Electric (kWh)	17125	15327	20053	21643	49198	81980	110105	102733	63314	38044	25046	17160
Natural Gas (MCF)	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Oil (na)	0	0	0	0	0	0	0	0	0	0	0	0
Propane (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote HW (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote CW (na)	0	0	0	0	0	0	0	0	0	0	0	0
Heating												
Electric (kWh)	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas (MCF)	1144	848	579	357	160	97	96	93	142	318	566	1026
Fuel Oil (na)	0	0	0	0	0	0	0	0	0	0	0	0
Propane (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote HW (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0	0	0	0	0	0	0	0
			1922	18569	24025	28429	32931	31561	25624	22044	19552	18782
			4008	6095	13574	18585	21532	20639	16401	10181	6274	1927
			94739	97300	98403	93636	101436	94739	97300	101436	90603	101436
			310089	308805	315805	303089	320485	310089	308805	320485	298408	320485
			4687	4536	4687	4536	4687	4687	4536	4687	4536	4687
			0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0	0	0	0	0	0	0	0

AHM14 – Monthly patterns of cooling and heating loads.

Note: While this report lists monthly *energy use* rather than aggregated loads, it can be used as a proxy for judging load profiles. If this is not sufficient, the HVAC system and plant load profiles are found on the Monthly Simulation Results reports but for individual HVAC air-side systems and plants.

A5. Billing Details Report

Billing Details - Electric - Proposed Building

DOE Benchmark - Large Office - 2016 - Zone 4A — 01/02/2020 05:04PM
Carrier Corporation

1. Component Charges

Billing Period	Energy Charges ($)	Demand Charges ($)	Customer Charges ($)	Taxes ($)	Total Charge ($)
Jan	58,584	0	0	0	58,584
Feb	52,058	0	0	0	52,058
Mar	56,984	0	0	0	56,984
Apr	57,431	0	0	0	57,431
May	63,267	0	0	0	63,267
Jun	66,242	0	0	0	66,242
Jul	73,721	0	0	0	73,721
Aug	70,416	0	0	0	70,416
Sep	64,465	0	0	0	64,465
Oct	62,303	0	0	0	62,303
Nov	55,855	0	0	0	55,855
Dec	58,587	0	0	0	58,587
Totals	739,914	0	0	0	739,914

2. Totals

Billing Period	Total Charges ($)	Total Consumption (kWh)	Avg Price ($/kWh)
Jan	58,584	506,346	0.1157
Feb	52,058	449,943	0.1157
Mar	56,984	492,519	0.1157
Apr	57,431	496,381	0.1157
May	63,267	546,820	0.1157
Jun	66,242	572,532	0.1157
Jul	73,721	637,170	0.1157
Aug	70,416	608,611	0.1157
Sep	64,465	557,178	0.1157
Oct	62,303	538,484	0.1157
Nov	55,855	482,759	0.1157
Dec	58,587	506,370	0.1157
Totals	739,914	6,395,111	0.1157

UR2 – Virtual rate. Separate reports for each energy source

S

B. Plant-Level Output Reports

B1.1 (Plant) Monthly Simulation Reports (SWH Example)

Monthly Simulation Results for SHW w Integral Tank + Heater

DOE Benchmark - Large Office - 2016 - Zone 4A — 12/30/2019 05:37PM
Carrier Corporation

Plant Simulation Results (Table 1):

Month	Service HW Load (kBTU)	HW Storage Tank Losses (kBTU)	SHW Piping Losses (kBTU)	Plant Heating Load (kBTU)	Boiler Output (kBTU)	Boiler Input - Gas (kBTU)	Boiler Misc. Electric (kWh)
January	76468	2314	0	76468	76468	93253	0
February	68959	2089	0	68959	68959	84097	0
March	75658	2311	0	75658	75658	92265	0
April	75025	2241	0	75025	75025	91494	0
May	74067	2309	0	74067	74067	90326	0
June	75025	2241	0	75025	75025	91494	0
July	78059	2316				95193	0
August	74067	2309				90325	0
September	75025	2241				91494	0
October	76468	2314				93253	0
November	72624	2236				88566	0
December	78058	2316				95193	0
Total	899503	27237	0	899503	899503	1096955	0

SWH5 – Annual SWH load.

SWH4 – Annual SHW load used for calculating EFLH

B1.2 (Plant) Monthly Simulation Reports (Chilled Water Plant Example)

Monthly Simulation Results for Chilled Water Plant

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
05:38PM

Plant Simulation Results (Table 1) :

Month	Cooling Coil Load (kBTU)	Plant Cooling Load (kBTU)	Chiller Output (kBTU)	Chiller Input (kWh)	Primary Water Dist. Pump (kWh)	Secondary Water Dist. Pump (kWh)	Condenser Water Pump (kWh)
January	643740	662195	662195	17125	4910	2378	11048
February	573345	590014	590014	15327	4435	2148	9979
March	746175	765291	765291	20053	5075	2403	11420
April	863709	882190	882190	21643	4904	2327	11034
May	1681211	1706494	1706494	49198	6481	2754	14583
June	2402942	2435039	2435039	81980	7676	3447	17271
July	2956712	2995209	2995209	110105	8851	4165	19914
August	2791353	2827700	2827700	102733	8507	3882	19142
September	2020913	2048641	2048641	63314	6923	2933	15578
October	1343618	1366315	1366315	38044	5887	2608	13246
November	892734	912410	912410	25046	5174	2397	11642
December	644603	663060	663060	17160	4910	2378	11048
Total	17561050	17854560	17854560	561729	73736	33820	165904

Plant Simulation Results (Table 2) :

Month	Heat Rejection Fan (kWh)
January	2023
February	1724
March	4008
April	6095
May	13574
June	18585
July	21532
August	20639
September	16401
October	10181
November	6274
December	1927
Total	122965

WHM6 – Calculate annual realized chiller efficiency using "Chiller Output" annual total and "Chiller Input" annual total.

WHM7 – Annual chilled water pump energy use

B1.3 (Plant) Monthly Simulation Reports (Hot Water Plant Example)

Monthly Simulation Results for Hot Water Plant

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
05:38PM

Plant Simulation Results (Table 1):

Month	Heating Coil Load (kBTU)	Plant Heating Load (kBTU)	Boiler Output (kBTU)	Boiler Input - Gas (kBTU)	Boiler Misc. Electric (kWh)	Primary Water Dist. Pump (kWh)
January	841262	840743	840743	1050928	0	480
February	611806	611452	611452	764315	0	391
March	389710	389453	389453	486816	0	329
April	212927	212698	212698	265873	0	305
May	55956	55800	55800	69750	0	207
June	4113	4085	4085	5107	0	36
July	264	262	262	328	0	2
August	2468	2445	2445	3056	0	30
September	40752	40610	40610	50762	0	190
October	180150	179922	179922	224903	0	302
November	382009	381743	381743	477179	0	338
December	744843	744431	744431	930539	0	445
Total	**3466260**	**3463645**	**3463645**	**4329556**	**0**	**3056**

WHM13 – Calculate annual realized boiler efficiency using "Boiler Output" annual total and "Boiler Input" annual total.

WHM12 – Hot water pump annual energy use.

C. Air-Side HVAC System-Level Output Reports

C1. (Air System) Monthly Simulation Reports

Monthly Simulation Results for Single-Zone RTU

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation

AHM2 – Output data indicates cooling or heating source: kWh for electric, kBTU for fuel

Air System Simulation Results (Table 1):

Month	Central Cooling Coil Load (kBTU)	Central Cooling Eqpt Load (kBTU)	Central Unit Clg Input (kWh)	Central Heating Coil Load (kBTU)	Central Heating Eqpt Load (kBTU)	Central Heating Coil Input (kBTU)	Central Heating Misc. Electric (kWh)
January	0	0	0	9816	9813	11967	0
February	0	0	0	5377	5377	6557	0
March	362	362	20	2311	2311	2819	0
April	414	414	23	813	813	992	0
May	5115		8	159	159	194	0
June	14391		0	2	2	3	0
July	20844		0	0	0	0	0
August	20344		5	0	0	0	0
September	10298	10298	568	12	12	15	0
October	4514	4514	241	401	401	489	0
November	989	989	52	1640	1640	2000	0
December	0	0	0	7278	7278	8875	0
Total	77271	77271	4346	27809	27806	33909	0

AHM14 – Monthly patterns of cooling and heating loads.

Air System Simulation Results (Table 2):

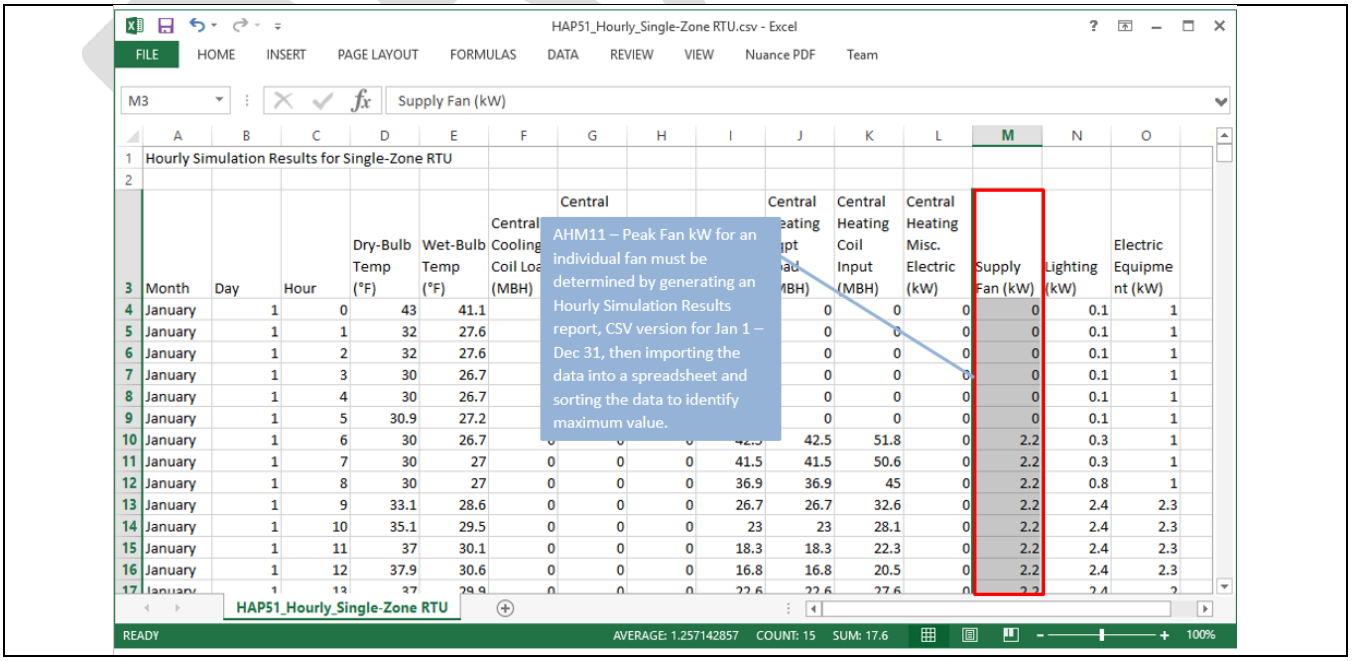
Month	Supply Fan (kWh)	Lighting (kWh)	Electric Equipment (kWh)
January	794	686	979
	617	602	872
	484	641	947
	363	658	943
	280	666	965
	270	634	926
	293	686	979
August	294	641	947
September	297	658	943
October	330	686	979
November	450	613	912
December	801	686	979
Total	5273	7859	11371

AHM12 – Annual energy use for individual fans in a system.

AHM8 – Calculate average realized air-side heating efficiency using annual totals for "Heating Eqpt Load" and "Heating Input kBTU".

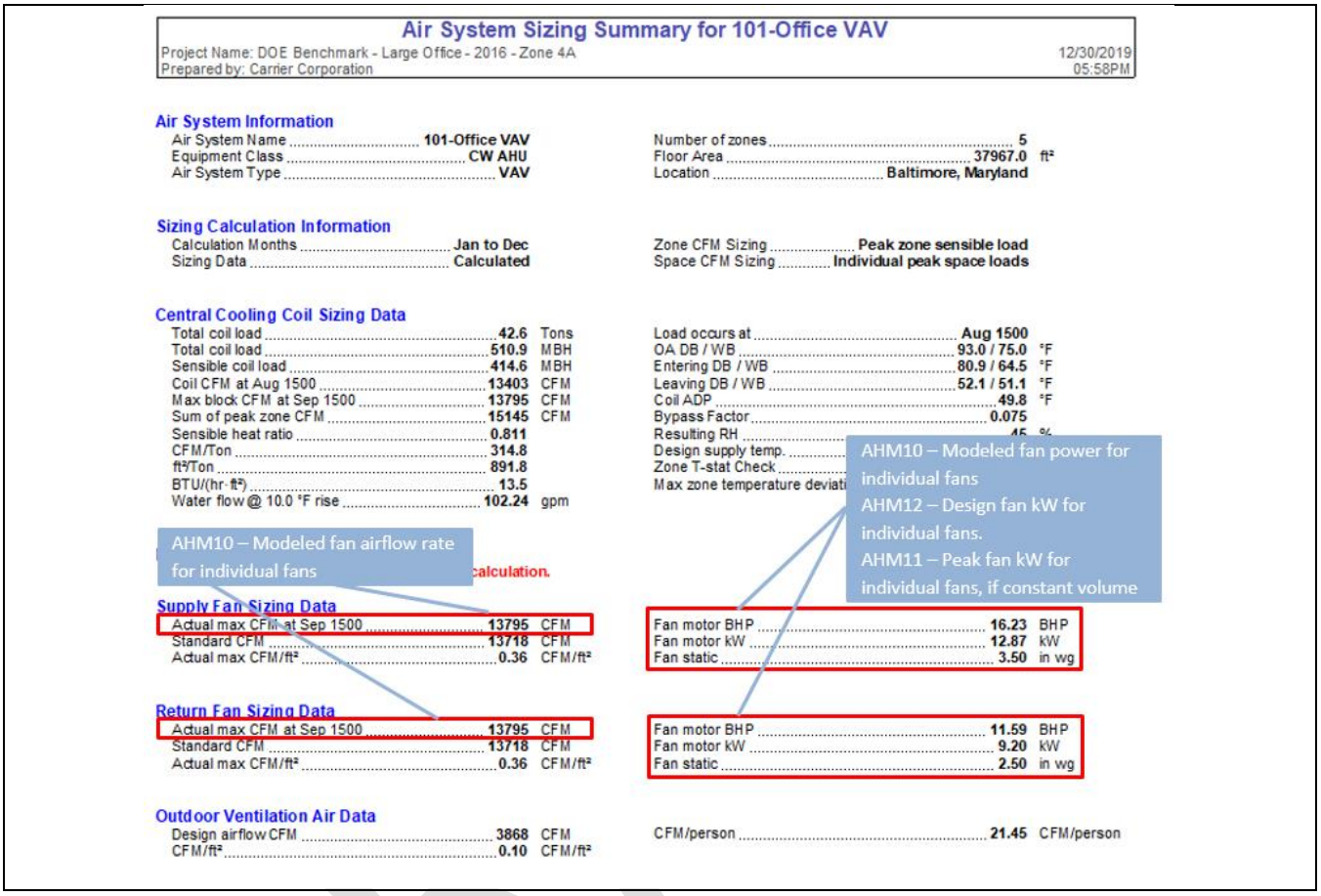
AHM6 – Calculate average realized DX cooling efficiency using annual totals for "Cooling Eqpt Load", "Cooling Input kWh", and "Supply Fan kWh"

C2. (Air System) Hourly Simulation Results, CSV Version



AHM11 – Peak Fan kW for an individual fan must be determined by generating an Hourly Simulation Results report, CSV version for Jan 1 – Dec 31, then importing the data into a spreadsheet and sorting the data to identify maximum value.

C3. Air System Sizing Summary Report



Air System Sizing Summary for 101-Office VAV

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation

12/30/2019
05:58PM

Air System Information

Air System Name	101-Office VAV		Number of zones	5	
Equipment Class	CW AHU		Floor Area	37967.0	ft²
Air System Type	VAV		Location	Baltimore, Maryland	

Sizing Calculation Information

Calculation Months	Jan to Dec		Zone CFM Sizing	Peak zone sensible load	
Sizing Data	Calculated		Space CFM Sizing	Individual peak space loads	

Central Cooling Coil Sizing Data

Total coil load	42.6	Tons	Load occurs at	Aug 1500	
Total coil load	510.9	MBH	OA DB / WB	93.0 / 75.0	°F
Sensible coil load	414.6	MBH	Entering DB / WB	80.9 / 64.5	°F
Coil CFM at Aug 1500	13403	CFM	Leaving DB / WB	52.1 / 51.1	°F
Max block CFM at Sep 1500	13795	CFM	Coil ADP	49.8	°F
Sum of peak zone CFM	15145	CFM	Bypass Factor	0.075	
Sensible heat ratio	0.811		Resulting RH	45	%
CFM/Ton	314.8		Design supply temp.		
ft²/Ton	891.8		Zone T-stat Check		
BTU/(hr·ft²)	13.5		Max zone temperature deviati		
Water flow @ 10.0 °F rise	102.24	gpm			

AHM10 – Modeled fan airflow rate for individual fans

AHM10 – Modeled fan power for individual fans
AHM12 – Design fan kW for individual fans.
AHM11 – Peak fan kW for individual fans, if constant volume

calculation.

Supply Fan Sizing Data

Actual max CFM at Sep 1500	13795	CFM	Fan motor BHP	16.23	BHP
Standard CFM	13718	CFM	Fan motor kW	12.87	kW
Actual max CFM/ft²	0.36	CFM/ft²	Fan static	3.50	in wg

Return Fan Sizing Data

Actual max CFM at Sep 1500	13795	CFM	Fan motor BHP	11.59	BHP
Standard CFM	13718	CFM	Fan motor kW	9.20	kW
Actual max CFM/ft²	0.36	CFM/ft²	Fan static	2.50	in wg

Outdoor Ventilation Air Data

Design airflow CFM	3868	CFM	CFM/person	21.45	CFM/person
CFM/ft²	0.10	CFM/ft²			

C4.1 Zone Sizing Summary Report (Central System Example)

Zone Sizing Summary for 301-Office VAV w PFPMBX

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation
12/30/2019 05:59PM

Air System Information

Air System Name ..... 301-Office VAV w PFPMBX
Equipment Class ..... CW AHU
Air System Type ..... VAV
Number of zones 5
Floor Area ..... 37967.0 ft²
Location ..... Baltimore, Maryland

Sizing Calculation Information

Calculation Months ..... Jan to Dec
Sizing Data ..... Calculated
Zone CFM Sizing .....
Space CFM Sizing ..... Ind

AHM10 – Modeled terminal fan airflow rate for fan powered mixing box terminals

Zone Terminal Sizing Data

AHM10 – Minimum airflows for VAV.

Zone Name	Design Supply Airflow (CFM)	Minimum Supply Airflow (CFM)	Zone CFM/ft²	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Unit Coil Load (MBH)	Zone Htg Unit Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
301-North	1916	344	0.57	57.6	5.77	0.0	0.00	1596
302-East	1898	222	0.87	38.0	3.80	0.0	0.00	1060
303-South	3383	344	1.00	57.6	5.77	0.0	0.00	1596
304-West	2303	222	1.06	38.0	3.80	0.0	0.00	1060
305-Core	6140	2737	0.23	160.5	16.06	0.0	0.00	1599

C4.2 Zone Sizing Summary Report (Terminal System Example))

Zone Sizing Summary for Fan Coil Units

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation
01/02/2020 03:44PM

Air System Information

Air System Name ..... Fan Coil Units
Equipment Class ..... TERM
Air System Type 4P-FC
Number of zones 5
Floor Area ..... 37967.0 ft²
Location ..... Baltimore, Maryland

Sizing Calculation Information

Calculation Months ..... Jan to Dec
Sizing Data ..... Calculated
Zone CFM Sizing ..... Sum of space airflow rates
Space CFM Sizing ..... Individual peak space loads

Terminal Unit Sizing Data - Cooling

AHM10 – Minimum airflows for VAV.

Zone Name	Total Coil Load (MBH)	Sens Coil Load (MBH)	Coil Entering DB / WB (°F)	Coil Leaving DB / WB (°F)	Water Flow @ 10.0 °F (gpm)	Time of Peak Coil Load	Zone CFM/ft²
201-North	50.8	43.0	76.5 / 65.0	58.6 / 57.6	10.17	Jul 1700	0.67
202-East	51.6	45.9	76.8 / 64.4	58.0 / 56.8	10.32	Jul 0900	1.05
203-South	83.9	77.4	76.5 / 64.4	58.7 / 57.5			
204-West	57.1	51.9	76.4 / 64.6	58.8 / 57.7			
205-Core	196.9	141.5	76.2 / 66.2	58.5 / 57.6			

AHM10 – Modeled terminal fan power and airflow rate for fan coil or WSHP terminals. powered mixing box terminals

Terminal Unit Sizing Data - Heating, Fan, Ventilation

Zone Name	Heating Coil Load (MBH)	Heating Coil Ent/Lvg DB (°F)	Htg Coil Water Flow @20.0 °F (gpm)	Fan Design Airflow (CFM)	Fan Motor (BHP)	Fan Motor (kW)	OA Vent Design Airflow (CFM)
201-North	42.0	69.4 / 86.8	4.20	2245	0.332	0.263	344
202-East	27.6	69.6 / 80.9	2.77	2273	0.336	0.267	222
203-South	42.5	69.9 / 79.7	4.26	4036	0.597	0.473	344
204-West	28.6	69.9 / 79.5	2.86	2760	0.408	0.324	222
205-Core	0.0	0.0 / 0.0	0.00	7427	1.098	0.871	2737

C5. Air System Design Load Summary Report

Air System Design Load Summary for 301-Office VAV w PFPMBX

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation

12/30/2019
06:01PM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1500 COOLING OA DB / WB 93.0 °F / 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 11.0 °F / 8.6 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	4160 ft²	85990	-	4160 ft²	-	-
Wall Transmission	6240 ft²	2304	-	6240 ft²	23676	-
Roof Transmission	37967 ft²	12027	-	37967 ft²	72775	-
Window Transmission	4160 ft²	23131	-	4160 ft²	93267	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	26995 W	58937	-	0	0	-
Task Lighting	0 W	0	-	0		
Electric Equipment	25628 W	82179	-	0		
People	180	31080	36970	0		
Infiltration	-	10053	14298	-		
Miscellaneous	-	0	0	-		
Safety Factor	0% / 0%	0	0	0%		
>> Total Zone Loads	-	305699	51269	-		
Zone Conditioning	-	312279	51269	-	217553	-21
Plenum Wall Load	31%	2463	-	0	0	-
Plenum Roof Load	70%	28063	-	0	0	-

BE11 – Envelope component loads for peak conditions. Can generate for specific design day hour or for time of peak coil load.

C6. Ventilation Sizing Summary Report

Ventilation Sizing Summary for 201-Office VAV

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation

12/30/2019
06:02PM

1. Summary

Ventilation Sizing Method	ASHRAE Std 62.1-2016	
Design Condition	Minimum flow (heating)	
Occupant Diversity (D)	1.000	
Uncorrected Outdoor Air Intake (Vou)	3094	CFM
System Ventilation Efficiency (Ev)	0.800	
Outdoor Air Intake (Vot)	3868	CFM

AHM9 – Modeled outdoor ventilation airflow rate.

AHM13 – This is the ventilation side airflow for an air-to-air heat recovery device. Exhaust side airflow not documented in reports.

2. Space Ventilation Analysis

Zone Name / Space Name	Mult.	Minimum Supply Air (CFM) (Vpz)	Space Floor Area (ft²) (Az)	Area Outdoor Air Rate (CFM/ft²) (Ra)	Time Averaged Occupancy (Occupants) (Pz)	Rate (CFM/person) (Rp)	Distribution Effectiveness (Ez)	Outdoor Air (CFM) (Voz)	Outdoor Air (CFM) (Vbz)	Space Ventilation Efficiency (Evz)
201-North										
201-North	1	344	3373.9	0.06	14.5	5.00	0.8	**344**	*275*	0.800
202-East										
202-East	1	222	2174.3	0.06	9.3	5.00	0.8	**222**	*177*	0.800
203-South										
203-South	1	344	3373.9	0.06	14.5	5.00	0.8	**344**	*275*	0.800
204-West										
204-West	1	222	2174.3	0.06	9.3	5.00	0.8	**222**	*177*	0.800
205-Core										
205-Core	1	2737	26870.6	0.06	115.5	5.00	0.8	**2737**	*2190*	0.800
Totals (incl. Space Multipliers)		**3868**							**3094**	**0.800**

D. Input Data Reports

D1. Building Input Data Report

Proposed Building Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
01:53PM

1. General Details:

Building Name ..... **Proposed Building**

2. Plants Included in this Building:

Plant Name
Chilled Water Plant
Hot Water Plant

3. Air Systems Included in this Building:

System Name	Mult.
001-Basement VAV	1
002-Basement Data Center	1
101-Office VAV	1
106-Data Center	1
201-Office VAV	10
206-Data Center	10
301-Office VAV	1
306-Data Center	1

LE2 – Exterior Lighting data will be found in this table.

4: Miscellaneous Energy

Name	Process Load	Energy/Fuel Type	Peak Use	Schedule
Parking Lot Lighting	No	Electric	2.4 kW	Parking Lot Lighting Sched
Facade Lighting	No	Electric	3.9 kW	Facade Lighting Sched

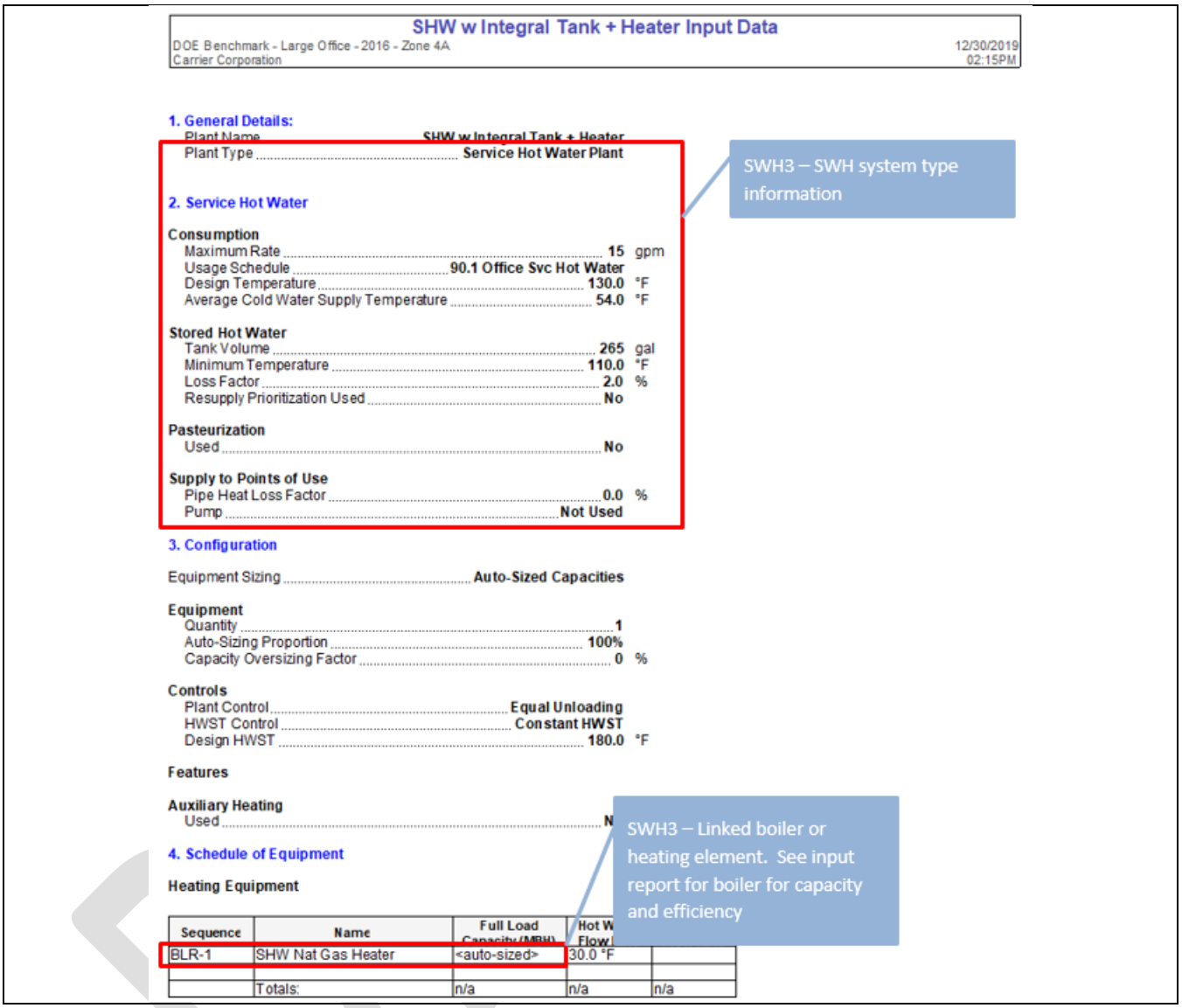
5: Meters

Electric ..... **Maryland - EIA 2018**
Natural Gas ..... **Maryland - EIA 2018**

6: Miscellaneous Data

Average Building Power Factor ..... **100.00 %**
Source Electric Generating Efficiency ..... **28.00 %**
Additional Floor Area ..... **0.0 ft²**

D2.1 Plant Input Data Report (SWH Example)



SHW w Integral Tank + Heater Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
02:15PM

1. General Details:

Plant Name ..... SHW w Integral Tank + Heater
Plant Type ..... Service Hot Water Plant

2. Service Hot Water

Consumption
Maximum Rate ..... 15 gpm
Usage Schedule ..... 90.1 Office Svc Hot Water
Design Temperature ..... 130.0 °F
Average Cold Water Supply Temperature ..... 54.0 °F

Stored Hot Water
Tank Volume ..... 265 gal
Minimum Temperature ..... 110.0 °F
Loss Factor ..... 2.0 %
Resupply Prioritization Used ..... No

Pasteurization
Used ..... No

Supply to Points of Use
Pipe Heat Loss Factor ..... 0.0 %
Pump ..... Not Used

SWH3 – SWH system type information

3. Configuration

Equipment Sizing ..... Auto-Sized Capacities

Equipment
Quantity 1
Auto-Sizing Proportion 100%
Capacity Oversizing Factor ..... 0 %

Controls
Plant Control ..... Equal Unloading
HWST Control ..... Constant HWST
Design HWST ..... 180.0 °F

Features

Auxiliary Heating
Used ..... N

4. Schedule of Equipment

Heating Equipment

Sequence	Name	Full Load Capacity (MBH)	Hot W Flow	
BLR-1	SHW Nat Gas Heater	<auto-sized>	30.0 °F	
	Totals:	n/a	n/a	n/a

SWH3 – Linked boiler or heating element. See input report for boiler for capacity and efficiency

D2.2 Plant Input Data Report (CW Plant Example – Part 1 of 2)

Chilled Water Plant Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
02:16PM

1. General Details:

Plant Name ..... Chilled Water Plant
Plant Type ..... Chiller Plant

2. Air Systems served by Plant:

Air System Name	Mult.
001-Basement VAV	1
002-Basement Data Center	1
101-Office VAV	1
106-Data Center	1
201-Office VAV	10
206-Data Center	10
301-Office VAV	1
306-Data Center	1

3. Configuration

Equipment Sizing ..... Auto-Sized Capacities

Equipment

Quantity 2
Auto-Sizing Proportion ..... Equally Sized
Capacity Oversizing Factor ..... 15 %

Controls

Plant Control ..... Sequenced
LCHWT Control ..... Reset by OAT Schedule
Design LCHWT ..... 44.0 °F
Design LCHWT used when OAT greater than ..... 80.0 °F
Maximum LCHWT ..... 54.0 °F
Maximum LCHWT used when OAT less than ..... 60.0 °F

WHM2 – Plant controls including chilled water reset

Features

Free Cooling ..... Used
Type of Free Cooling ..... Integrated Waterside Econzomizer
Heat Exchanger Approach ..... 3.0 °F
Cooling Tower Configuration ..... Individual

4. Schedule of Equipment

Cooling Equipment

Sequence	Name	Full Load Capacity (Tons)	Cooler Flow Rate	Condenser Flow Rate	Cooling Tower Name	Tower Flow Rate
CH-1	90.1-2016 Chiller (Min ECWT = 75)	<auto-sized>	2.400 gpm/Ton	3.000 gpm/Ton	Cooling Tower at 3 gpm/ton	3.000 gpm/Ton
CH-2	90.1-2016 Chiller (Min ECWT = 75)	<auto-sized>	2.400 gpm/Ton	3.000 gpm/Ton	Cooling Tower at 3 gpm/ton	3.000 gpm/Ton
	Totals:	n/a	n/a	n/a		n/a

WHM1 – Quantity and linked chillers. See input data report for linked chillers for capacity, efficiency information.

D2.3 Plant Input Data Report (CW Plant Example – Part 2 of 2)

Chilled Water Plant Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019

WHM4 – Primary or Primary/Secondary, constant or variable speed/flow.

5. Distribution

Chilled Water Distribution System
Type ..... **Primary/Secondary, Variable Speed Secondary**
Cooling Coil Delta-T at Design ..... **10.0** °F
Pipe Heat Gain Factor ..... **0.0** %

Fluid Properties
Fluid ..... **Fresh Water**
Density ..... **62.4** lb/ft³
Specific Heat Capacity ..... **1.00** BTU / (lb·°F)

WHM3, WHM4 – Chilled water pump flow, power, efficiency, minimum flow.

Primary Loop

Pump for Eqpt.	Flow Rate	Pump [W/gpm]	Mechanical Efficiency (%)	Electrical Efficiency (%)
CH-1	2.400 gpm/Ton	11.0	70.0	94.0
CH-2	2.400 gpm/Ton	11.0	70.0	94.0

Secondary Loop

Pump for Eqpt.	Flow Rate	Pump [W/gpm]	Mechanical Efficiency (%)	Electrical Efficiency (%)
<Shared>	<Auto-sized>	11.0	70.0	94.0

Control Head ..... **5.0** ft wg
Minimum Pump Flow ..... **25.0** %

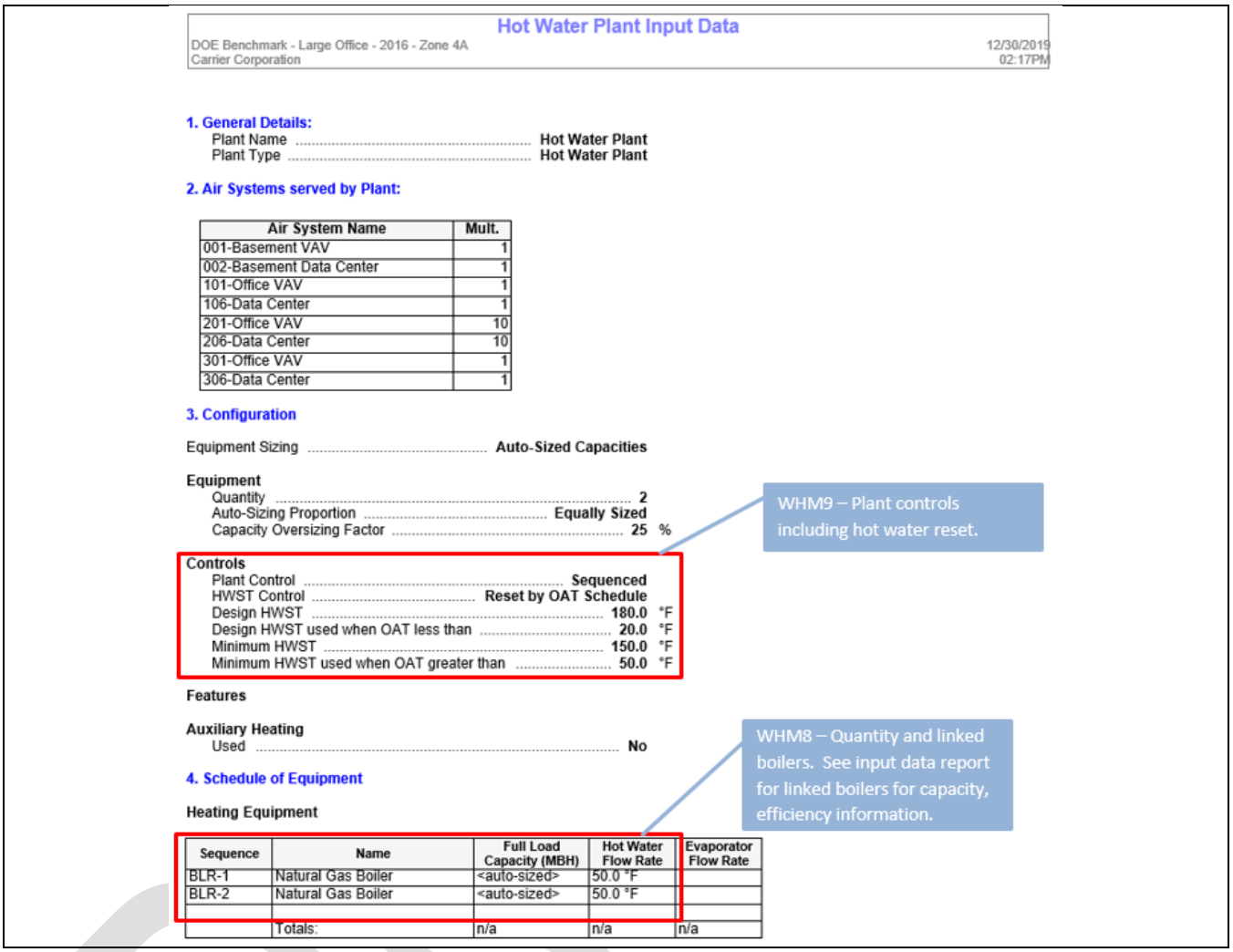
6. Condenser Water

Configuration
Pump Control ..... **Constant Flow / Constant Speed**

Pumps

Pump for Eqpt.	Flow Rate	Pump [W/gpm]	Mechanical Efficiency (%)	Electrical Efficiency (%)
CH-1	3.000 gpm/Ton	19.0	70.0	94.0
CH-2	3.000 gpm/Ton	19.0	70.0	94.0

D2.4 Plant Input Data Report (HW Plant Example – Part 1 of 2)



Hot Water Plant Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019
02:17PM

1. General Details:

Plant Name ..... Hot Water Plant
Plant Type ..... Hot Water Plant

2. Air Systems served by Plant:

Air System Name	Mult.
001-Basement VAV	1
002-Basement Data Center	1
101-Office VAV	1
106-Data Center	1
201-Office VAV	10
206-Data Center	10
301-Office VAV	1
306-Data Center	1

3. Configuration

Equipment Sizing ..... Auto-Sized Capacities

Equipment

Quantity 2
Auto-Sizing Proportion ..... Equally Sized
Capacity Oversizing Factor ..... 25 %

WHM9 – Plant controls including hot water reset.

Controls

Plant Control ..... Sequenced
HWST Control ..... Reset by OAT Schedule
Design HWST ..... 180.0 °F
Design HWST used when OAT less than ..... 20.0 °F
Minimum HWST ..... 150.0 °F
Minimum HWST used when OAT greater than ..... 50.0 °F

Features

Auxiliary Heating

Used ..... No

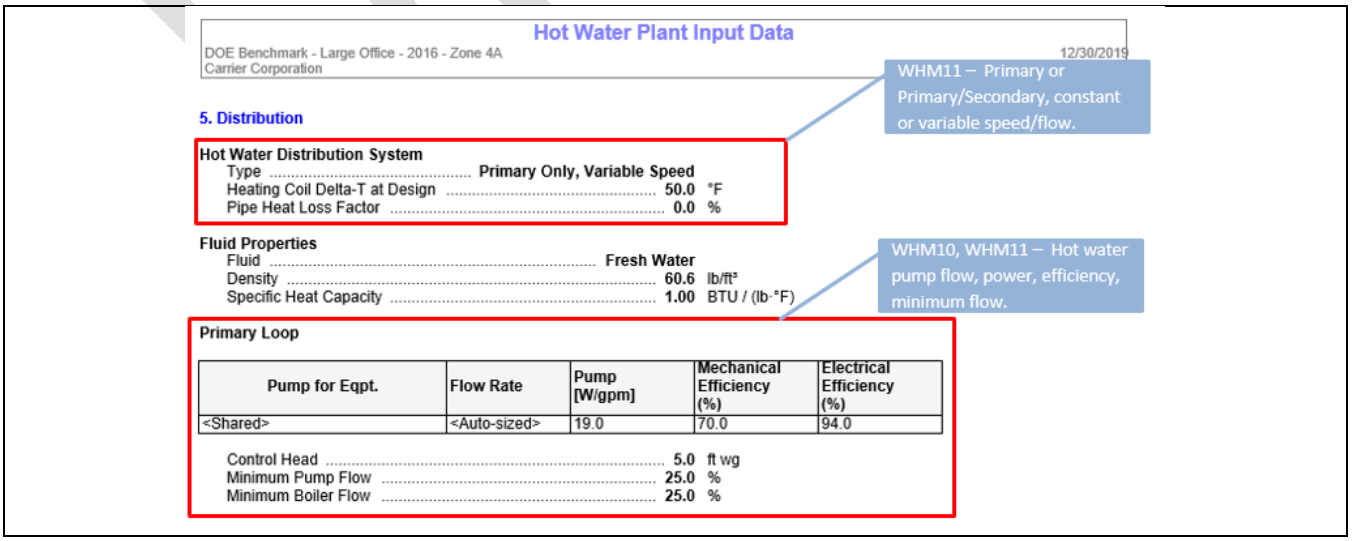
4. Schedule of Equipment

Heating Equipment

WHM8 – Quantity and linked boilers. See input data report for linked boilers for capacity, efficiency information.

Sequence	Name	Full Load Capacity (MBH)	Hot Water Flow Rate	Evaporator Flow Rate
BLR-1	Natural Gas Boiler	<auto-sized>	50.0 °F	
BLR-2	Natural Gas Boiler	<auto-sized>	50.0 °F	
	Totals:	n/a	n/a	n/a

D2.5 Plant Input Data Report (HW Plant Example – Part 2 of 2)



Hot Water Plant Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/30/2019

WHM11 – Primary or Primary/Secondary, constant or variable speed/flow.

5. Distribution

Hot Water Distribution System

Type ..... Primary Only, Variable Speed
Heating Coil Delta-T at Design ..... 50.0 °F
Pipe Heat Loss Factor ..... 0.0 %

Fluid Properties

Fluid ..... Fresh Water
Density ..... 60.6 lb/ft³
Specific Heat Capacity ..... 1.00 BTU / (lb·°F)

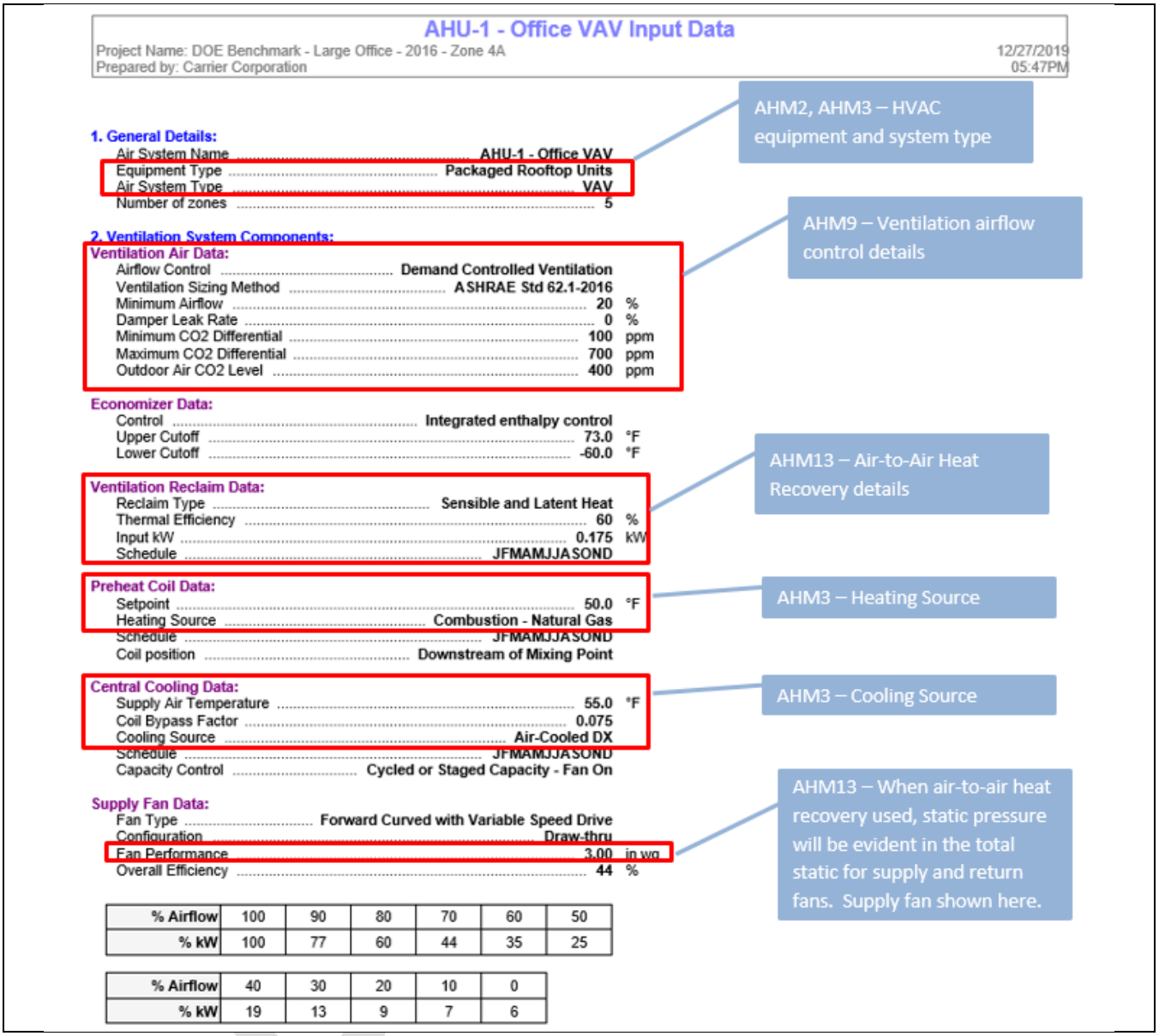
WHM10, WHM11 – Hot water pump flow, power, efficiency, minimum flow.

Primary Loop

Pump for Eqpt.	Flow Rate	Pump [W/gpm]	Mechanical Efficiency (%)	Electrical Efficiency (%)
<Shared>	<Auto-sized>	19.0	70.0	94.0

Control Head ..... 5.0 ft wg
Minimum Pump Flow ..... 25.0 %
Minimum Boiler Flow ..... 25.0 %

D3.1 Air System Input Data Report (part 1 of 3)



AHU-1 - Office VAV Input Data

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation

12/27/2019
05:47PM

1. General Details:

Air System Name	AHU-1 - Office VAV
Equipment Type	Packaged Rooftop Units
Air System Type	VAV
Number of zones	5

2. Ventilation System Components:

Ventilation Air Data:

Airflow Control	Demand Controlled Ventilation	
Ventilation Sizing Method	ASHRAE Std 62.1-2016	
Minimum Airflow	20	%
Damper Leak Rate	0	%
Minimum CO2 Differential	100	ppm
Maximum CO2 Differential	700	ppm
Outdoor Air CO2 Level	400	ppm

Economizer Data:

Control	Integrated enthalpy control	
Upper Cutoff	73.0	°F
Lower Cutoff	-60.0	°F

Ventilation Reclaim Data:

Reclaim Type	Sensible and Latent Heat	
Thermal Efficiency	60	%
Input kW	0.175	kW
Schedule	JFMAMJJASOND	

Preheat Coil Data:

Setpoint	50.0	°F
Heating Source	Combustion - Natural Gas	
Schedule	JFMAMJJASOND	
Coil position	Downstream of Mixing Point	

Central Cooling Data:

Supply Air Temperature	55.0	°F
Coil Bypass Factor	0.075	
Cooling Source	Air-Cooled DX	
Schedule	JFMAMJJASOND	
Capacity Control	Cycled or Staged Capacity - Fan On	

Supply Fan Data:

Fan Type	Forward Curved with Variable Speed Drive	
Configuration	Draw-thru	
Fan Performance	3.00	in wg
Overall Efficiency	44	%

% Airflow	100	90	80	70	60	50
% kW	100	77	60	44	35	25

% Airflow	40	30	20	10	0
% kW	19	13	9	7	6

AHM2, AHM3 – HVAC equipment and system type

AHM9 – Ventilation airflow control details

AHM13 – Air-to-Air Heat Recovery details

AHM3 – Heating Source

AHM3 – Cooling Source

AHM13 – When air-to-air heat recovery used, static pressure will be evident in the total static for supply and return fans. Supply fan shown here.

D3.3 Air System Input Data Report (part 2 of 3)

AHU-1 - Office VAV Input Data

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation

12/27/2019
05:47PM

Return Fan Data:

Fan Type ..... **Forward Curved with Variable Speed Drive**
Fan Performance ..... **2.00** in wg
Overall Efficiency ..... **44** %

% Airflow	100	90	80	70	60	50
% kW	100	77	60	44	35	25

% Airflow	40	30	20	10	0
% kW	19	13	9	7	6

3. Zone Components:
Space Assignments:

Zone 1: 101-North	
101-North	x1
Zone 2: 102-East	
102-East	x1
Zone 3: 103-South	
103-South	x1
Zone 4: 104-West	
104-West	x1
Zone 5: 105-Core	
105-Core	x1

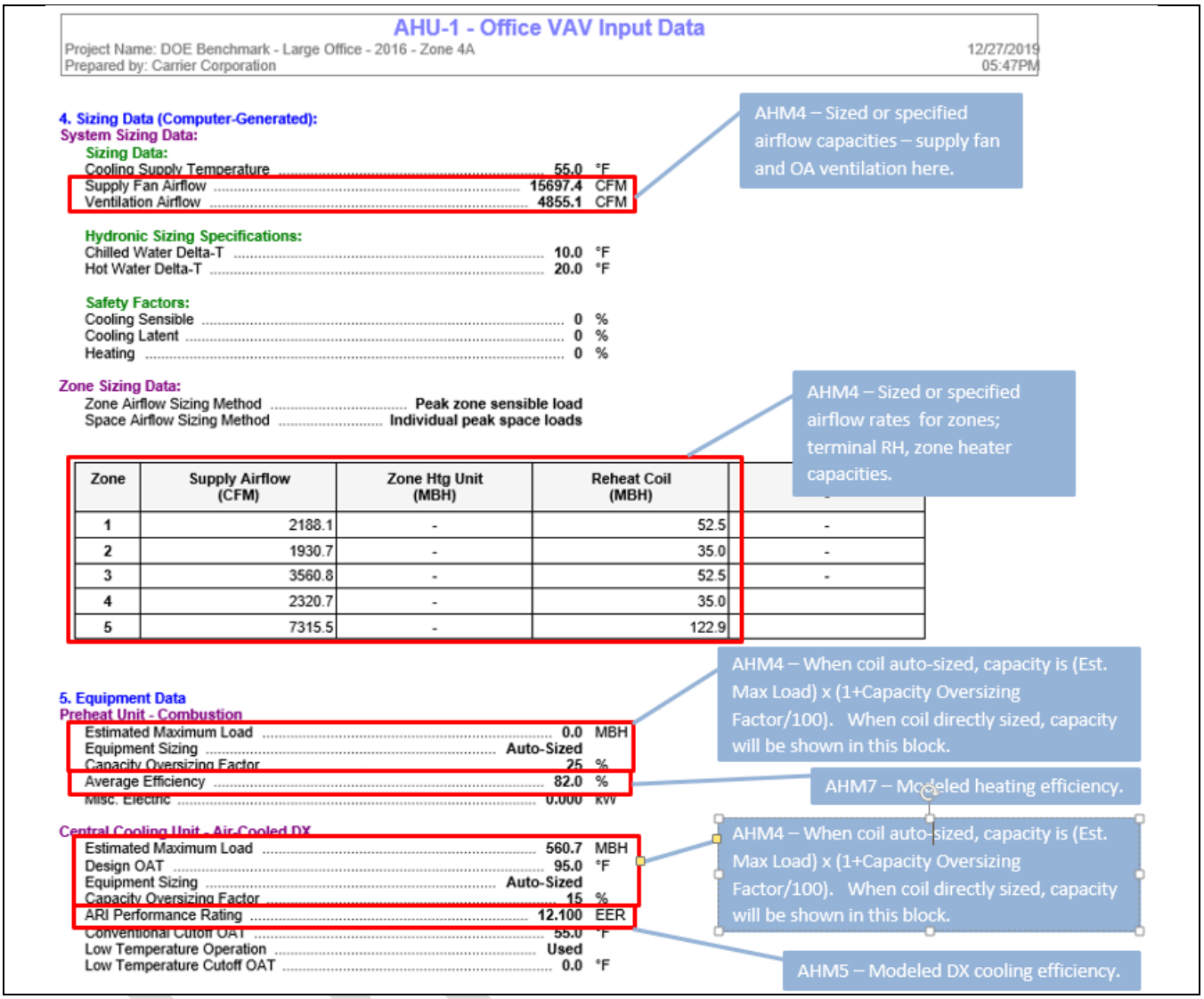
AHM1 – Thermal blocking shown here – configuration of spaces into thermal zones.

Thermostats and Zone Data:

Zone	Cooling T-Stat Occ. (°F)	Cooling T-Stat Unocc. (°F)	Heating T-Stat Occ. (°F)	Heating T-Stat Unocc. (°F)	T-Stat Throttling Range (°F)	Diversity Factor (%)	Direct Exhaust Airflow (CFM)	Direct Exhaust Fan (kW)
1	75.0	80.0	70.0	65.0	1.50	100	0.0	0.0
2	75.0	80.0	70.0	65.0	1.50	100	0.0	0.0
3	75.0	80.0	70.0	65.0	1.50	100	0.0	0.0
4	75.0	80.0	70.0	65.0	1.50	100	0.0	0.0
5	75.0	80.0	70.0	65.0	1.50	100	0.0	0.0

Thermostat Schedule ..... **Fan/Tstat Offices**
Unoccupied Cooling is ..... **Available**

D3.2 Air System Input Data Report (part 3 of 3)



AHU-1 - Office VAV Input Data

Project Name: DOE Benchmark - Large Office - 2016 - Zone 4A
Prepared by: Carrier Corporation
12/27/2019
05:47PM

AHM4 – Sized or specified airflow capacities – supply fan and OA ventilation here.

4. Sizing Data (Computer-Generated):
System Sizing Data:
Sizing Data:

Cooling Supply Temperature	55.0	°F
Supply Fan Airflow	15697.4	CFM
Ventilation Airflow	4855.1	CFM

Hydronic Sizing Specifications:

Chilled Water Delta-T	10.0	°F
Hot Water Delta-T	20.0	°F

Safety Factors:

Cooling Sensible	0	%
Cooling Latent	0	%
Heating	0	%

Zone Sizing Data:

Zone Airflow Sizing Method	Peak zone sensible load
Space Airflow Sizing Method	Individual peak space loads

AHM4 – Sized or specified airflow rates for zones; terminal RH, zone heater capacities.

Zone	Supply Airflow (CFM)	Zone Htg Unit (MBH)	Reheat Coil (MBH)	
1	2188.1	-	52.5	-
2	1930.7	-	35.0	-
3	3560.8	-	52.5	-
4	2320.7	-	35.0	
5	7315.5	-	122.9	

AHM4 – When coil auto-sized, capacity is (Est. Max Load) x (1+Capacity Oversizing Factor/100). When coil directly sized, capacity will be shown in this block.

5. Equipment Data
Preheat Unit - Combustion

Estimated Maximum Load	0.0	MBH
Equipment Sizing	Auto-Sized	
Capacity Oversizing Factor	25	%
Average Efficiency	82.0	%
Misc. Electric	0.000	kW

AHM7 – Modeled heating efficiency.

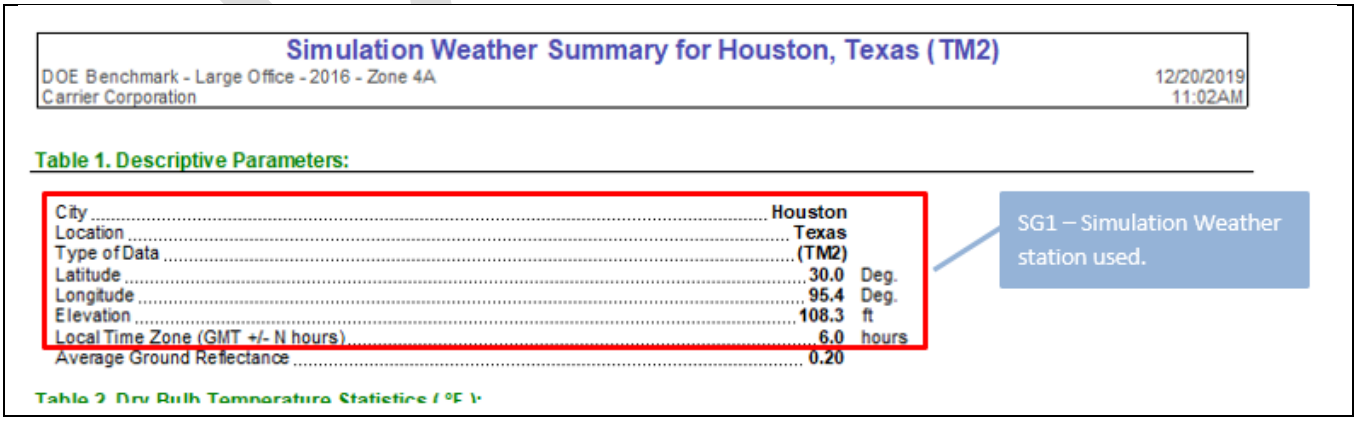
Central Cooling Unit - Air-Cooled DX

Estimated Maximum Load	560.7	MBH
Design OAT	95.0	°F
Equipment Sizing	Auto-Sized	
Capacity Oversizing Factor	15	%
ARI Performance Rating	12.100	EER
Conventional Cutoff OAT	55.0	°F
Low Temperature Operation	Used	
Low Temperature Cutoff OAT	0.0	°F

AHM4 – When coil auto-sized, capacity is (Est. Max Load) x (1+Capacity Oversizing Factor/100). When coil directly sized, capacity will be shown in this block.

AHM5 – Modeled DX cooling efficiency.

D4. Simulation Weather Summary Report



Simulation Weather Summary for Houston, Texas (TM2)

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation
12/20/2019
11:02AM

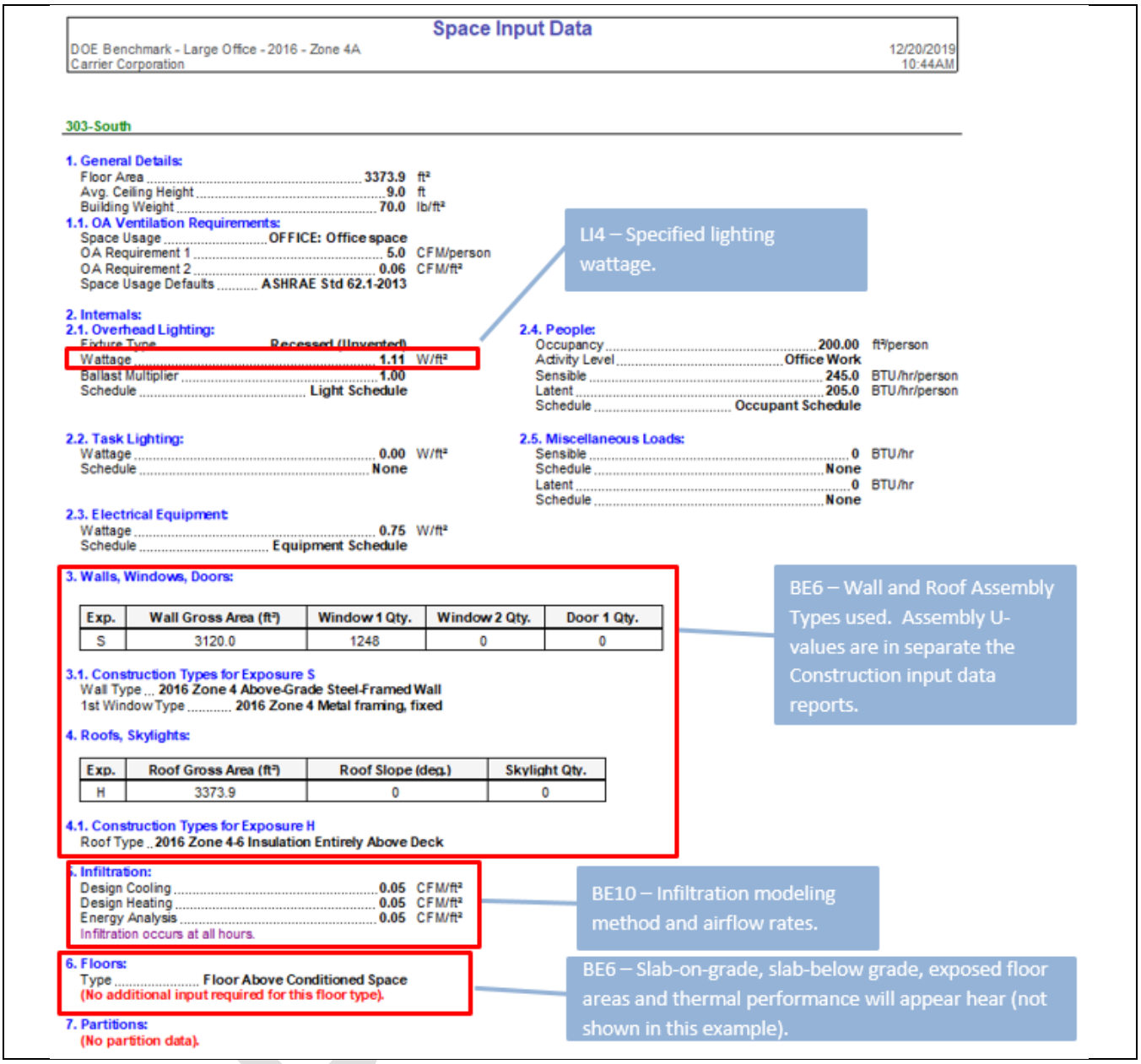
Table 1. Descriptive Parameters:

City	Houston	
Location	Texas	
Type of Data	(TM2)	
Latitude	30.0	Deg.
Longitude	95.4	Deg.
Elevation	108.3	ft
Local Time Zone (GMT +/- N hours)	6.0	hours
Average Ground Reflectance	0.20	

SG1 – Simulation Weather station used.

Table 2. Dry Bulb Temperature Statistics (°F):

D5. Space Input Data Report



Space Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/20/2019
10:44AM

303-South

1. General Details:
Floor Area ..... 3373.9 ft²
Avg. Ceiling Height ..... 9.0 ft
Building Weight ..... 70.0 lb/ft²

1.1. OA Ventilation Requirements:
Space Usage ..... OFFICE: Office space
OA Requirement 1 ..... 5.0 CFM/person
OA Requirement 2 ..... 0.06 CFM/ft²
Space Usage Defaults ..... ASHRAE Std 62.1-2013

2. Internals:
2.1. Overhead Lighting:
Fixture Type ..... Recessed (Unvented)
Wattage ..... 1.11 W/ft²
Ballast Multiplier 1.00
Schedule ..... Light Schedule

LI4 – Specified lighting wattage.

2.2. Task Lighting:
Wattage ..... 0.00 W/ft²
Schedule ..... None

2.3. Electrical Equipment:
Wattage ..... 0.75 W/ft²
Schedule ..... Equipment Schedule

2.4. People:
Occupancy ..... 200.00 ft²/person
Activity Level ..... Office Work
Sensible ..... 245.0 BTU/hr/person
Latent ..... 205.0 BTU/hr/person
Schedule ..... Occupant Schedule

2.5. Miscellaneous Loads:
Sensible ..... 0 BTU/hr
Schedule ..... None
Latent ..... 0 BTU/hr
Schedule ..... None

3. Walls, Windows, Doors:

Exp.	Wall Gross Area (ft²)	Window 1 Qty.	Window 2 Qty.	Door 1 Qty.
S	3120.0	1248	0	0

3.1. Construction Types for Exposure S
Wall Type ... 2016 Zone 4 Above-Grade Steel-Framed Wall
1st Window Type ..... 2016 Zone 4 Metal framing, fixed

BE6 – Wall and Roof Assembly Types used. Assembly U-values are in separate the Construction input data reports.

4. Roofs, Skylights:

Exp.	Roof Gross Area (ft²)	Roof Slope (deg.)	Skylight Qty.
H	3373.9	0	0

4.1. Construction Types for Exposure H
Roof Type .. 2016 Zone 4-6 Insulation Entirely Above Deck

5. Infiltration:
Design Cooling ..... 0.05 CFM/ft²
Design Heating ..... 0.05 CFM/ft²
Energy Analysis ..... 0.05 CFM/ft²
Infiltration occurs at all hours.

BE10 – Infiltration modeling method and airflow rates.

6. Floors:
Type ..... Floor Above Conditioned Space
(No additional input required for this floor type).

BE6 – Slab-on-grade, slab-below grade, exposed floor areas and thermal performance will appear hear (not shown in this example).

7. Partitions:
(No partition data).

D6. Wall Constructions Report

Wall Constructions

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/20/2019
10:24AM

2016 Zone 4 Above-Grade Steel-Framed Wall

Wall Details

Outside Surface Color	Medium	
Absorptivity	0.675	
Overall U-Value	0.064	BTU/(hr·ft²·°F)

BEP6 – Wall Assembly overall U-value

Wall Layers Details (Inside to Outside)

Layers	Thickness in	Density lb/ft³	Specific Ht. BTU / (lb·°F)	R-Value (hr·ft²·°F)/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68000	0.0
Gypsum Board	0.625	50.0	0.26	0.56000	2.6
Board Insulation	1.080	2.0	0.22	7.50000	0.2
Batt insulation + Steel Studs	3.500	50.0	0.20	6.00000	14.6
5/8-in gypsum board	0.625	50.0	0.26	0.56004	2.6
Stucco	0.400	116.0	0.20	0.08000	3.9
Outside surface resistance	0.000	0.0	0.00	0.17000	0.0
Totals	**6.230**	-		**15.55004**	**23.9**

D7. Roof Constructions Report

Roof Constructions

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/20/2019
10:38AM

2016 Zone 4-6 Insulation Entirely Above Deck

Roof Details

Outside Surface Color	Medium	
Absorptivity	0.675	
Overall U-Value	0.032	BTU/(hr·ft²·°F)

BEP6 – Roof Assembly overall U-value

Roof Layers Details (Inside to Outside)

Layers	Thickness in	Density lb/ft³	Specific Ht. BTU / (lb·°F)	R-Value (hr·ft²·°F)/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.61000	0.0
22 gage steel deck	0.034	489.0	0.12	0.00011	1.4
Board Insulation	2.900	2.0	0.22	30.00000	0.5
Outside surface resistance	0.000	0.0	0.00	0.17000	0.0
Totals	**2.934**	-		**30.78011**	**1.9**

D9. Window Constructions Report

Window Constructions

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/20/2019
12:00PM

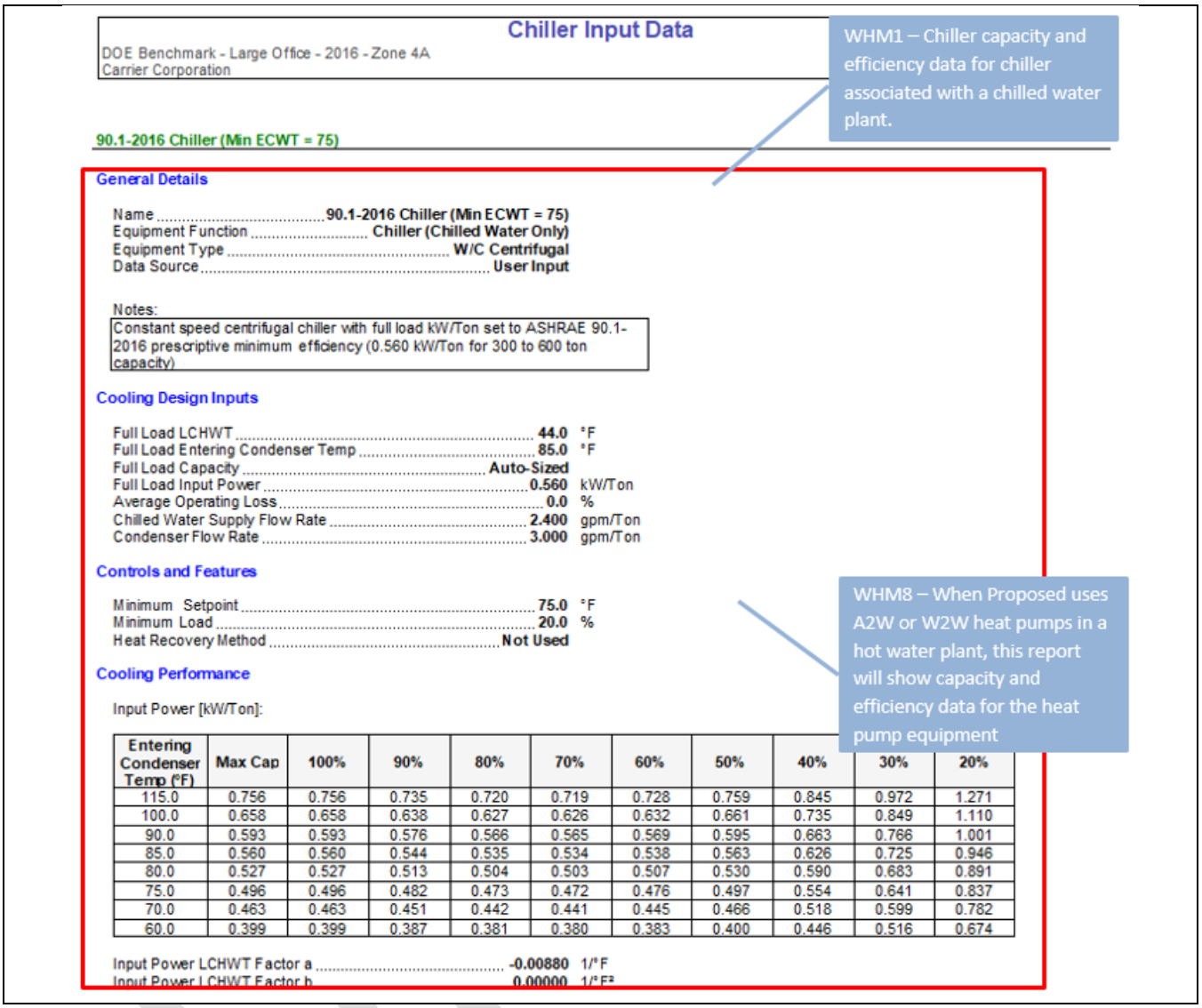
2016 Zone 4 Metal framing, fixed

Window Details:

Detailed Input	No	
Height	5.00	ft
Width	3.00	ft
Overall U-Value	0.380	BTU/(hr·ft²·°F)
Overall Shade Coefficient	0.414	

BEP8 – Window performance values. SHGC – SC x 0.87.

D9. Chiller Input Data Report



Chiller Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

WHM1 – Chiller capacity and efficiency data for chiller associated with a chilled water plant.

90.1-2016 Chiller (Min ECWT = 75)

General Details

Name ..... 90.1-2016 Chiller (Min ECWT = 75)
Equipment Function ..... Chiller (Chilled Water Only)
Equipment Type ..... W/C Centrifugal
Data Source ..... User Input

Notes:
Constant speed centrifugal chiller with full load kW/Ton set to ASHRAE 90.1-2016 prescriptive minimum efficiency (0.560 kW/Ton for 300 to 600 ton capacity)

Cooling Design Inputs

Full Load LCHWT ..... 44.0 °F
Full Load Entering Condenser Temp ..... 85.0 °F
Full Load Capacity ..... Auto-Sized
Full Load Input Power ..... 0.560 kW/Ton
Average Operating Loss ..... 0.0 %
Chilled Water Supply Flow Rate ..... 2.400 gpm/Ton
Condenser Flow Rate ..... 3.000 gpm/Ton

Controls and Features

Minimum Setpoint ..... 75.0 °F
Minimum Load ..... 20.0 %
Heat Recovery Method ..... Not Used

WHM8 – When Proposed uses A2W or W2W heat pumps in a hot water plant, this report will show capacity and efficiency data for the heat pump equipment

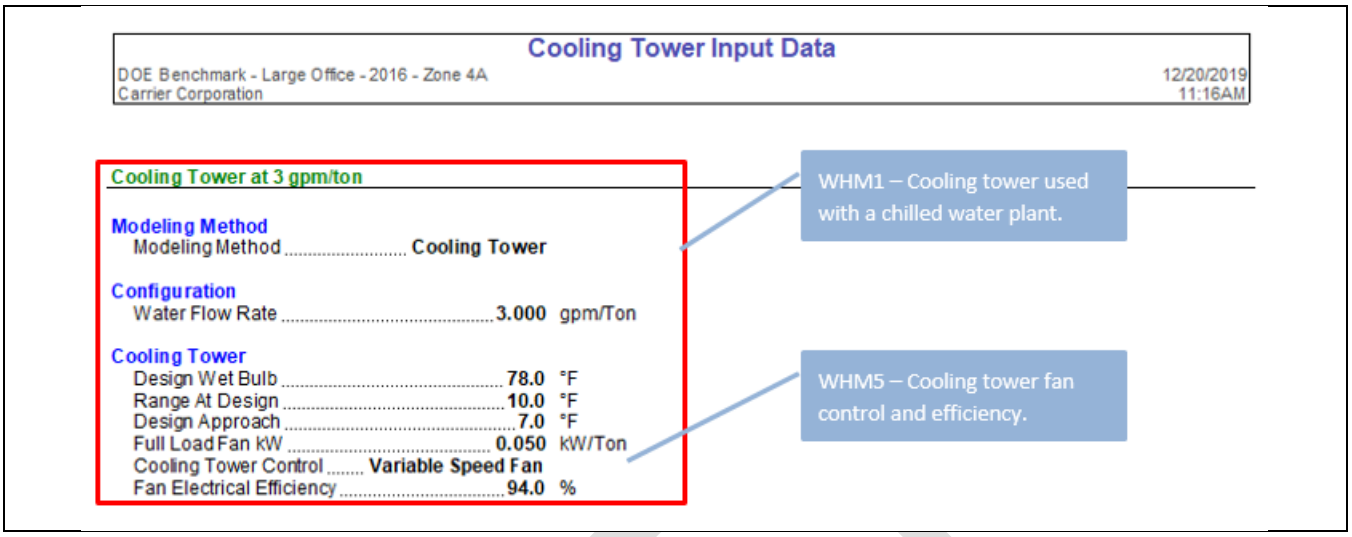
Cooling Performance

Input Power [kW/Ton]:

Entering Condenser Temp (°F)	Max Cap	100%	90%	80%	70%	60%	50%	40%	30%	20%
115.0	0.756	0.756	0.735	0.720	0.719	0.728	0.759	0.845	0.972	1.271
100.0	0.658	0.658	0.638	0.627	0.626	0.632	0.661	0.735	0.849	1.110
90.0	0.593	0.593	0.576	0.566	0.565	0.569	0.595	0.663	0.766	1.001
85.0	0.560	0.560	0.544	0.535	0.534	0.538	0.563	0.626	0.725	0.946
80.0	0.527	0.527	0.513	0.504	0.503	0.507	0.530	0.590	0.683	0.891
75.0	0.496	0.496	0.482	0.473	0.472	0.476	0.497	0.554	0.641	0.837
70.0	0.463	0.463	0.451	0.442	0.441	0.445	0.466	0.518	0.599	0.782
60.0	0.399	0.399	0.387	0.381	0.380	0.383	0.400	0.446	0.516	0.674

Input Power LCHWT Factor a ..... -0.00880 1/°F
Input Power LCHWT Factor b ..... 0.00000 1/°F²

D10. Cooling Tower Input Data Report



Cooling Tower Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/20/2019
11:16AM

Cooling Tower at 3 gpm/ton

Modeling Method
Modeling Method ..... Cooling Tower

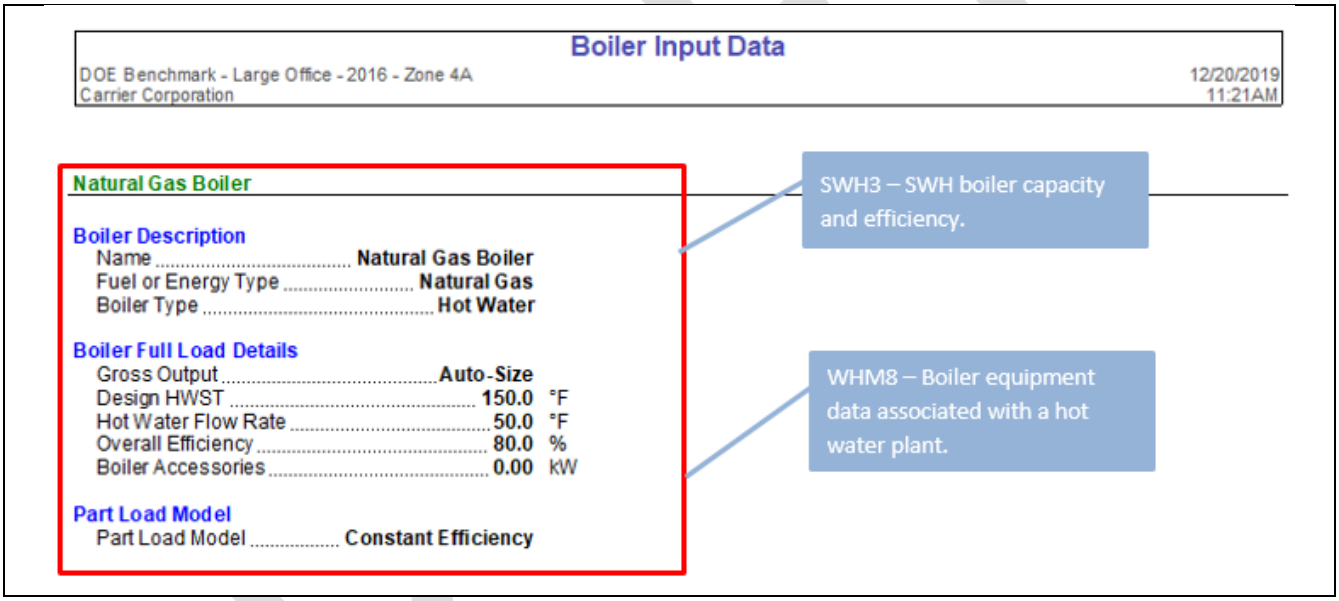
Configuration
Water Flow Rate ..... 3.000 gpm/Ton

Cooling Tower
Design Wet Bulb ..... 78.0 °F
Range At Design ..... 10.0 °F
Design Approach ..... 7.0 °F
Full Load Fan kW ..... 0.050 kW/Ton
Cooling Tower Control ..... Variable Speed Fan
Fan Electrical Efficiency ..... 94.0 %

WHM1 – Cooling tower used with a chilled water plant.

WHM5 – Cooling tower fan control and efficiency.

D11. Boiler Input Data Report



Boiler Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

12/20/2019
11:21AM

Natural Gas Boiler

Boiler Description
Name ..... Natural Gas Boiler
Fuel or Energy Type ..... Natural Gas
Boiler Type ..... Hot Water

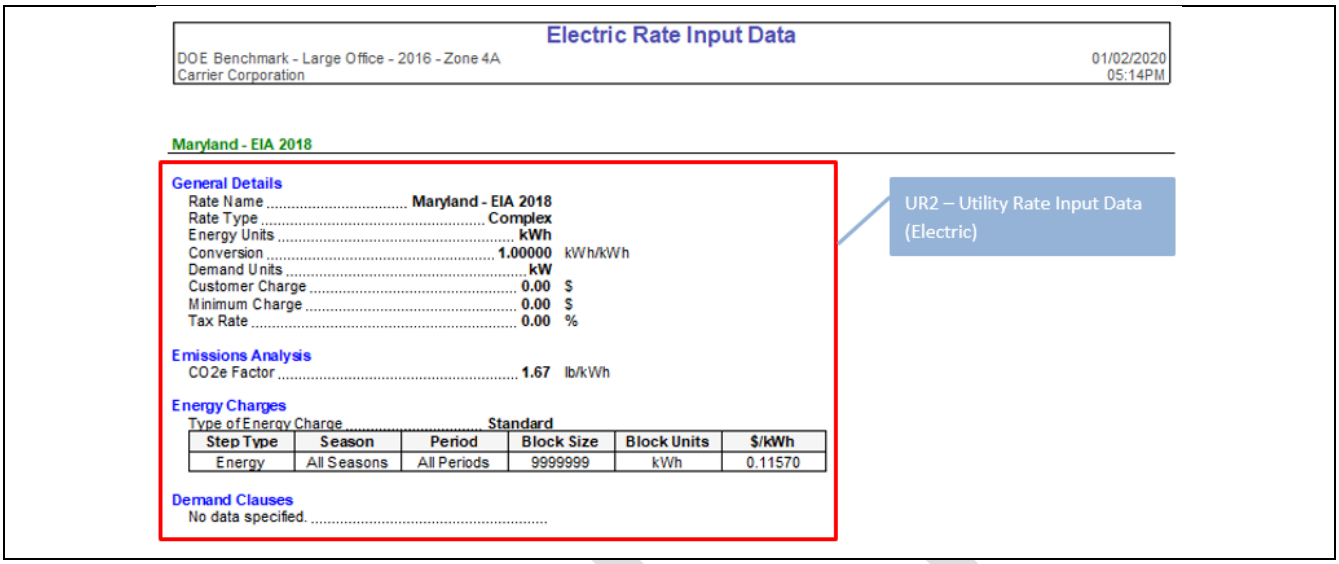
Boiler Full Load Details
Gross Output ..... Auto-Size
Design HWST ..... 150.0 °F
Hot Water Flow Rate ..... 50.0 °F
Overall Efficiency ..... 80.0 %
Boiler Accessories ..... 0.00 kW

Part Load Model
Part Load Model ..... Constant Efficiency

SWH3 – SWH boiler capacity and efficiency.

WHM8 – Boiler equipment data associated with a hot water plant.

D12. Electric Rate Input Data Report



Electric Rate Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

01/02/2020
05:14PM

Maryland - EIA 2018

General Details

Rate Name	Maryland - EIA 2018	
Rate Type	Complex	
Energy Units	kWh	
Conversion	1.00000	kWh/kWh
Demand Units	kW	
Customer Charge	0.00	$
Minimum Charge	0.00	$
Tax Rate	0.00	%

Emissions Analysis

CO2e Factor	1.67	lb/kWh

Energy Charges

Type of Energy Charge ..... Standard

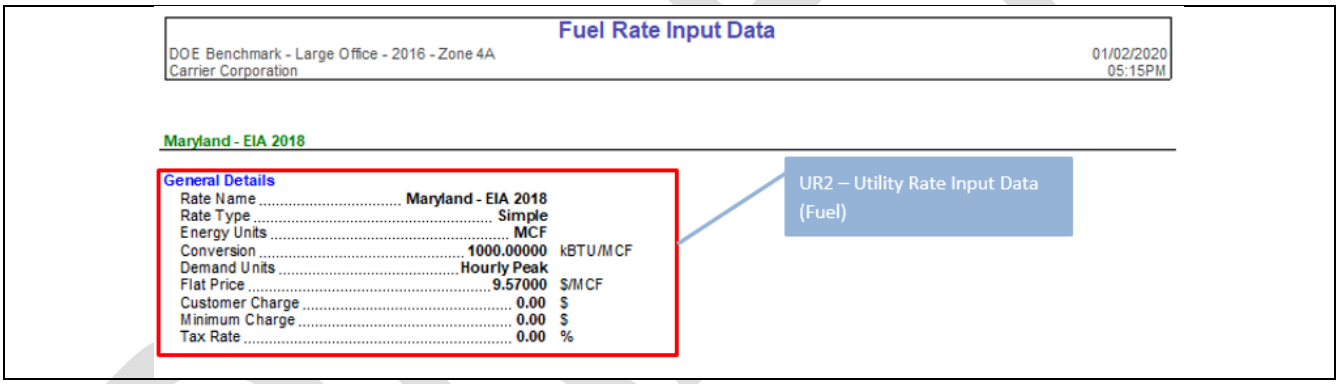
Step Type	Season	Period	Block Size	Block Units	$/kWh
Energy	All Seasons	All Periods	9999999	kWh	0.11570

Demand Clauses

No data specified. .....

UR2 – Utility Rate Input Data (Electric)

D13. Fuel Rate Input Data Report



Fuel Rate Input Data

DOE Benchmark - Large Office - 2016 - Zone 4A
Carrier Corporation

01/02/2020
05:15PM

Maryland - EIA 2018

General Details

Rate Name	Maryland - EIA 2018	
Rate Type	Simple	
Energy Units	MCF	
Conversion	1000.00000	kBTU/MCF
Demand Units	Hourly Peak	
Flat Price	9.57000	$/MCF
Customer Charge	0.00	$
Minimum Charge	0.00	$
Tax Rate	0.00	%

UR2 – Utility Rate Input Data (Fuel)

DesignBuilder

Resources

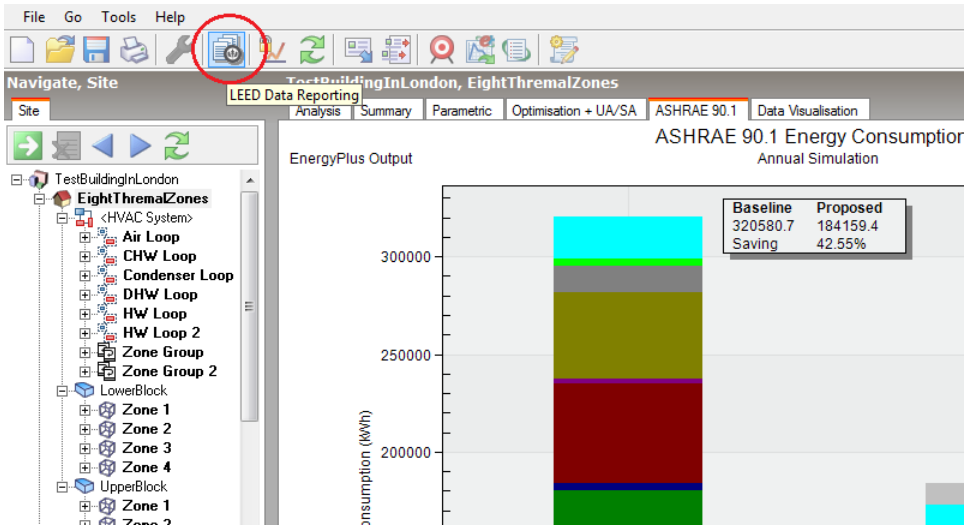
1. The DesignBuilder software can be downloaded from the DesignBuilder website. Licenses can be ordered from the buy page of the website or by contacting sales@designbuilder.co.uk.
2. The DesignBuilder online help system provides detailed information on modeling for ASHRAE 90.1 compliance and certification reporting, including An ASHRAE 90.1 modeling guide which can be downloaded in pdf format.
3. Free tutorial videos on a wide range of specific topics, including those related to ASHRAE 90.1 modeling are available from the DesignBuilder website.

General

1. The reports referred to below can be accessed from within DesignBuilder. The main sources of data are a) EnergyPlus summary output document, b) LEED submission calculator spreadsheet, c) simulated results and d) model input data.
2. The reports and relevant files submitted are in different format, such as html, csv, idf.

Simulation Reports to be Submitted

1. The EnergyPlus summary output document is provided in html format for both proposed and rotated baseline buildings. It is broken down into various report sections. The summary document can be viewed either from within DesignBuilder on the Summary tab of the Simulation screen or as an .htm file in a web browser.
2. LEED Minimum Energy Performance Calculator in .xlsm format contains similar but more organized data for submittal in the standard format required by LEED. This Excel file can be automatically generated by DesignBuilder via clicking the toolbar icon shown in the screenshot below after ASHRAE 90.1 simulations have been completed for both proposed and baseline buildings:



3. EnergyPlus input (.idf) files for both proposed and baseline buildings. Idf files can be viewed in a text editor such as notepad.
4. EnergyPlus simulated results file (.eso). These are most easily viewed through the freely available DesignBuilder ResultsViewer application which can be downloaded from the DesignBuilder website.

Annotated Reports

EnergyPlus Output Summary Document (eplustbl_P000.htm or eplustbl_Bxxx.htm, xxx can be 000, 090, 180 or 270 which denote baseline rotations)

General Table in Input Verification and Results Summary report

	Value
Program Version and Build	EnergyPlus, Version 8.9.0-40101eaafd, YMD=2019.11.28 14:25
RunPeriod	TESTBUILDINGINLONDON (01-01:31-12)
Weather File	LONDON/GATWICK - GBR IWEC Data WMO#=037760
Latitude [deg]	51.15
Longitude [deg]	-0.2
Elevation [ft]	203.42
Time Zone	0.00
North Axis Angle [deg]	0.00
Rotation for Appendix G [deg]	0.00
Hours Simulated [hrs]	8760.00

SG03: Weather

SG06: Number of hours modeled. Full year indicates

LEED Summary report

Sec1.1A-General Information

	Data
Weather File	TESTBUILDINGINLONDON (01-01:31-12) ** LONDON/GATWICK - GBR IWEC Data WMO#=037760
Total gross floor area [ft2]	9564.73
Principal Heating Source	Natural Gas

SG05: Conditioned Floor Area

EAp2-1. Space Usage Type

	Space Area [ft2]	Regularly Occupied Area [ft2]	Unconditioned Area [ft2]	Typical Hours/Week in Operation [hr/wk]
LOWERBLOCK:ZONE3	1110.86	1110.86	0.00	103.56
LOWERBLOCK:ZONE2	793.65	793.65	0.00	93.67
LOWERBLOCK:ZONE4	1750.10	1750.10	0.00	93.67
LOWERBLOCK:ZONE1	1250.36	1250.36	0.00	113.30
UPPERBLOCK:ZONE3	1037.30	1037.30	0.00	103.56
UPPERBLOCK:ZONE2	744.61	744.61	0.00	93.67
UPPERBLOCK:ZONE4	1676.54	1676.54	0.00	93.67
UPPERBLOCK:ZONE1	1201.31	1201.31	0.00	113.30
Totals	9564.73	9564.73	0.00	

EAp2-2. Advisory Messages

	Data
Number of hours heating loads not met	17.00
Number of hours cooling loads not met	0.00
Number of hours not met	17.00

SG08: Unmet

Opaque Exterior

	Construction	Reflectance	U-Factor with Film [Btu/h-ft2-F]	U-Factor no Film [Btu/h-ft2-F]	Gross Area [ft2]	Net Area [ft2]	Azimuth [deg]	Tilt [deg]	Cardinal Direction
LOWERBLOCK:ZONE3_WALL_3_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	423.07	253.84	0.00	90.00	N
LOWERBLOCK:ZONE3_WALL_4_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	346.25	207.75	270.00	90.00	W
LOWERBLOCK:ZONE2_WALL_2_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	346.25	207.75	90.00	90.00	E
LOWERBLOCK:ZONE2_WALL_3_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	302.26	181.36	0.00	90.00	N
LOWERBLOCK:ZONE4_WALL_4_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	545.50	327.30	270.00	90.00	W
LOWERBLOCK:ZONE4_WALL_5_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	423.07	253.84	180.00	90.00	S
LOWERBLOCK:ZONE1_WALL_2_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	545.50	327.30	90.00	90.00	E
LOWERBLOCK:ZONE1_WALL_5_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	302.26	181.36	180.00	90.00	S
UPPERBLOCK:ZONE3_WALL_3_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	423.07	253.84	0.00	90.00	N
UPPERBLOCK:ZONE3_WALL_4_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	346.25	207.75	270.00	90.00	W
UPPERBLOCK:ZONE3_ROOF_1_0_0	CZ4 NON-RES ROOF INS ENTIRELY ABOVE DECK R-19.9C.I. (3.5C.I.) U-.048 (.273)	0.30	0.048	0.050	1110.86	1037.30	180.00	0.00	
UPPERBLOCK:ZONE2_WALL_2_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	346.25	207.75	90.00	90.00	E
UPPERBLOCK:ZONE2_WALL_3_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	302.26	181.36	0.00	90.00	N
UPPERBLOCK:ZONE2_ROOF_1_0_0	CZ4 NON-RES ROOF INS ENTIRELY ABOVE DECK R-19.9C.I. (3.5C.I.) U-.048 (.273)	0.30	0.048	0.050	793.65	744.61	180.00	0.00	
UPPERBLOCK:ZONE4_WALL_4_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	545.50	327.30	270.00	90.00	W
UPPERBLOCK:ZONE4_WALL_5_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	423.07	253.84	180.00	90.00	S
UPPERBLOCK:ZONE4_ROOF_1_0_0	CZ4 NON-RES ROOF INS ENTIRELY ABOVE DECK R-19.9C.I. (3.5C.I.) U-.048 (.273)	0.30	0.048	0.050	1750.10	1676.54	180.00	0.00	
UPPERBLOCK:ZONE1_WALL_2_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	545.50	327.30	90.00	90.00	E
UPPERBLOCK:ZONE1_WALL_5_0_0	CZ4 NON-RES WALL STEEL-FRAMED R-13.1+R-7.4 (2.3+1.3) U-.064 (.365)	0.30	0.064	0.068	302.26	181.36	180.00	90.00	S
UPPERBLOCK:ZONE1_ROOF_1_0_0	CZ4 NON-RES ROOF INS ENTIRELY ABOVE DECK R-19.9C.I. (3.5C.I.) U-.048 (.273)	0.30	0.048	0.050	1250.36	1201.31	180.00	0.00	
LOWERBLOCK:ZONE3_GROUNDFLOOR_0_0_0	CZ4 NON-RES SLAB-ON-GRADE FLOOR UNHEATED R-0 (0.0) F-.73 (1.264) - 1	1.00		0.044	1110.86	1110.86	0.00	180.00	
LOWERBLOCK:ZONE2_GROUNDFLOOR_0_0_0	CZ4 NON-RES SLAB-ON-GRADE FLOOR UNHEATED R-0 (0.0) F-.73 (1.264) - 1	1.00		0.044	793.65	793.65	0.00	180.00	
LOWERBLOCK:ZONE4_GROUNDFLOOR_0_0_0	CZ4 NON-RES SLAB-ON-GRADE FLOOR UNHEATED R-0 (0.0) F-.73 (1.264) - 1	1.00		0.044	1750.10	1750.10	0.00	180.00	
LOWERBLOCK:ZONE1_GROUNDFLOOR_0_0_0	CZ4 NON-RES SLAB-ON-GRADE FLOOR UNHEATED R-0 (0.0) F-.73 (1.264) - 1	1.00		0.044	1250.36	1250.36	0.00	180.00	

Fans Table in Equipment Summary report

Fans

	Type	Total Efficiency [Btuh/Btuh]	Delta Pressure [psi]	Max Air Flow Rate [ft3/min]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-min/ft3]	Motor Heat In Air Fraction	End Use	Design Day Name for Fan Sizing Peak	Date/Time for Fan Sizing Peak
SYSTEM NO 7 AIR LOOP AHU EXTRACT FAN	Fan:VariableVolume	0.60	0.06	10463.69	3385.10	0.32	1.00	General		00
SYSTEM NO 7 AIR LOOP AHU SUPPLY FAN	Fan:VariableVolume	0.60	0.12	10463.69	6769.95	0.65	1.00	General		00

AHVAC19: Fan design value is reported

Interior Lighting Table in Lighting Summary report

Interior Lighting

	Zone	Lighting Power Density [Btu/h-ft2]	Zone Area [ft2]	Total Power [Btu/h]	End Use Subcategory	Schedule Name	Scheduled Hours/Week [hr]	Hours/Week > 1% [hr]	Full Load Hours/Week [hr]	Return Air Fraction	Conditioned (Y/N)	Consumption [kWh]
LOWERBLOCK:ZONE3	LOWERBLOCK:ZONE3	2.4722	1110.86	2746.33	General	ASHRAE 90.1 HVAC AVAILIBILTY - ASSEMBLY	124.01	122.28	122.28	0.0000	Y	5132.06
LOWERBLOCK:ZONE2	LOWERBLOCK:ZONE2	3.7401	793.65	2968.31	General	ASHRAE 90.1 HVAC AVAILIBILTY - RETAIL	91.04	89.60	89.60	0.0000	Y	4064.47
LOWERBLOCK:ZONE4	LOWERBLOCK:ZONE4	5.7369	1750.10	10040.12	Gener		91.04	89.60	89.60	0.0000	Y	13747.79
LOWERBLOCK:ZONE1	LOWERBLOCK:ZONE1	3.3280	1250.36	4161.21	Gener		50.90	113.30	49.97	0.0000	Y	3177.74
UPPERBLOCK:ZONE3	UPPERBLOCK:ZONE3	2.4722	1037.30	2564.45	Gen		124.01	122.28	122.28	0.0000	Y	4792.19
UPPERBLOCK:ZONE2	UPPERBLOCK:ZONE2	3.7401	744.61	2784.88	Gener		91.04	89.60	89.60	0.0000	Y	3813.30
UPPERBLOCK:ZONE4	UPPERBLOCK:ZONE4	5.7369	1676.54	9618.07	Gener		91.04	89.60	89.60	0.0000	Y	13169.89
UPPERBLOCK:ZONE1	UPPERBLOCK:ZONE1	3.3280	1201.31	3997.99	Gener		50.90	113.30	49.97	0.0000	Y	3053.10
Interior Lighting Total		4.0651	9564.73	38881.36								50950.54

LI07: Space-by-Space lighting definition for baseline building

Zone Sensible Cooling/Heating Tables in HVAC Sizing Summary report

Zone Sensible Cooling

	Calculated Design Load [Btu/h]	User Design Load [Btu/h]	User Design Load per Area [Btu/h-ft2]	Calculated Design Air Flow [ft3/min]	User Design Air Flow [ft3/min]	Design Day Name	Date/Time Of Peak {TIMESTAMP}	Thermostat Setpoint Temperature at Peak Load [F]	Indoor Temperature at Peak Load [F]	Indoor Humidity Ratio at Peak Load [lbWater/lbAir]	Outdoor Temperature at Peak Load [F]	Outdoor Humidity Ratio at Peak Load [lbWater/lbAir]	Minimum Outdoor Air Flow Rate [ft3/min]	Heat Gain Rate from DOAS [Btu/h]
LOWERBLOCK:ZONE3	13432.58	15447.47	13.91	569.388	654.796	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 17:00:00	78.80	78.79	0.01048	78.59	0.01011	188.903	0.00
LOWERBLOCK:ZONE2	14769.56	16984.99	21.40	675.913	777.300	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 09:30:00	78.80	78.76	0.01264	73.09	0.01011	285.670	0.00
LOWERBLOCK:ZONE4	50960.82	58604.94	33.49	2332.167	2681.992	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 16:10:00	78.80				.01011	1085.008	0.00
LOWERBLOCK:ZONE1	16266.48	18706.45	14.96	744.418	856.081	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 13:30:00	78.80				.01011	106.310	0.00
UPPERBLOCK:ZONE3	17391.36	20000.07	19.28	795.897	915.282	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 17:00:00	78.80				.01011	176.393	0.00
UPPERBLOCK:ZONE2	16286.16	18729.09	25.15	745.319	857.117	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 14:40:00	78.80	78.77	0.01211	80.96	0.01011	268.017	0.00
UPPERBLOCK:ZONE4	56522.68	65001.09	38.77	2586.700	2974.705	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 16:20:00	78.80	78.79	0.00966	79.49	0.01011	1039.399	0.00
UPPERBLOCK:ZONE1	19490.46	22414.03	18.66	891.960	1025.754	SUMMER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12) JUL	/15 14:10:00	78.80	78.80	0.00940	80.96	0.01011	102.140	0.00

The Design Load is the zone sensible load only. It does not include any system effects or ventilation loads.

AHVAC02: thermal blocks are modeled correctly

Zone Sensible Heating

	Calculated Design Load [Btu/h]	User Design Load [Btu/h]	User Design Load per Area [Btu/h-ft2]	Calculated Design Air Flow [ft3/min]	User Design Air Flow [ft3/min]	Design Day Name	Date/Time Of Peak {TIMESTAMP}	Thermostat Setpoint Temperature at Peak Load [F]	Indoor Temperature at Peak Load [F]	Indoor Humidity Ratio at Peak Load [lbWater/lbAir]	Outdoor Temperature at Peak Load [F]	Outdoor Humidity Ratio at Peak Load [lbWater/lbAir]	Minimum Outdoor Air Flow Rate [ft3/min]	Heat Gain Rate from DOAS [Btu/h]
LOWERBLOCK:ZONE3	14943.37	18679.21	16.82	255.570	319.462	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00357	24.08	0.00263	188.903	0.00
LOWERBLOCK:ZONE2	8159.16	10198.95	12.85	376.824	471.030	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00394	24.08	0.00263	285.670	0.00
LOWERBLOCK:ZONE4	17589.11	21986.38	12.56	812.338	1085.008	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00384	24.08	0.00263	1085.008	0.00
LOWERBLOCK:ZONE1	18905.14	23631.42	18.90	873.118	1091.397	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00376	24.08	0.00263	106.310	0.00
UPPERBLOCK:ZONE3	16660.29	20825.36	20.08	769.441	961.801	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00382	24.08	0.00263	176.393	0.00
UPPERBLOCK:ZONE2	9870.37	12337.96	16.57	455.854	569.818	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00395	24.08	0.00263	268.017	0.00
UPPERBLOCK:ZONE4	19490.01	24362.52	14.53	900.129	1125.162	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00385	24.08	0.00263	1039.399	0.00
UPPERBLOCK:ZONE1	20227.28	25284.10	21.05	934.179	1167.724	WINTER DESIGN DAY IN TESTBUILDINGINLONDON (01-01:31-12)	1/15 24:00:00	68.00	68.00	0.00378	24.08	0.00263	102.140	0.00

The Design Load is the zone sensible load only. It does not include any system effects or ventilation loads.

LEED Minimum Energy Performance Calculator

"General Information" sheet

Energy Model Information

Energy modeler	John Smith, Sustainable Building Solutions Ltd
Energy model based on	100% Construction Documents
Simulation program	EnergyPlus
Energy code used	ASHRAE 90.1 2010 Appendix G
Simulation weather file	GBR_LONDON_GATWICK_IWEC
Climate zone	4A

SG03: Weather

"Lighting" sheet

General Information			Baseline						Proposed				
				Section 9.6.3 Room Geometry Adjustment *(Only complete for spaces where credit is taken for room geometry)*							Section 9.6.2(c) Control Factor Adjustment		
Building ID	Table 9.6.1 Space Type	Total Space Type Area (sq m)	Maximum Allowance (W/sq m)	Luminaire Mounting Height (m)	Work-plane (m)	Room Perimeter Length (m)	Room Cavity Ratio	Total Baseline LPD Allowance (W/sq m)	Design LPD W/sq m)	Describe Automatic Lighting Controls	Lighting Power Under Control (W)	Table 9.6.2 adjust-ment	Design LPD (W/sq m)
Helpful Notes									• Lighting power should be modeled as designed (or installed) including all lighting system components (lamps and ballasts) • Enter the design (or installed) lighting power density (excluding any additional lighting lighting power from Section 9.6.2 or any process lighting) for this space type in the Proposed case. This value should not include Table G3.2 adjustments. • Credit for automatic lighting controls should be modeled using the appropriate power adjustment from Table G3.2, applied only to the controlled lighting power and not where required by 9.4.1. per Table G3.1#6(g) • Automatic daylighting controls must either be modeled directly in the simulation, or modeled using schedule adjustments determined by a separate daylighting analysis per Table				
EightThremalZo	Library - card file and cataloging	206	7.80				0.0	7.80	17.11				17.11
EightThremalZo	Retail - mall concourse	148	11.80				0.0	11.80	9.68				9.68
EightThremalZo	Sales area	325	18.10				0.0	18.10	13.80				13.80
EightThremalZo	Office - open plan	232	10.50				0.0	10.50	10.50				10.50
Total		911	12.81					12.81	13.04				13.04

LI07: Lighting power densities for the space-by-space method

Exterior Lighting

Instructions: Select the applicable exterior lighting categories and then complete the corresponding lighting table(s). An example of the expected level of detail has been provided for each input. Please refer to the column header notes for information about Appendix G modeling protocol. For any information not applicable to the project, simply enter "N/A".

Exterior Lighting Requirements

No additional lighting power allowance has been claimed in the baseline for surfaces that are not p… …e-counte…

LE03: Baseline Exterior Lighting Power

LE03: Proposed Exterior Lighting Power

Table 9.4.3A Exterior Lighting Zone

Lighting Zone	Zone Description	Base Allowance (W)

Input Parameter	Baseline	Proposed
Total modeled exterior lighting power, including base allowance, based on inputs above (kW)	0.0	0.0

Space by Space Method

If attempting to take additional credit/adjustments in the baseline for room geometry and/or in the proposed for automatic lighting controls, further work will be required. Taking the additional credit is optional.
Note: This method employs Addendum cg to 90.1-2010 due to contradictions in the originally published standard. If the project team does not wish to apply the addendum, provide a substantially similar spreadsheet to verify the inputs for the interior lighting power.

Are adjustments being taken for room geometry in the baseline? (Optional)	
Are adjustments being taken for automatic lighting controls beyond what is required by Section 9.4.1 in the proposed? (Optional)	

LE03: Baseline lighting control

LI07: Space-by-Space lighting definition for baseline building

General Information			Baseline						Proposed				
Building ID	Table 9.6.1 Space Type	Total Space Type Area (sq m)	Maximum Allowance (W/sq m)	Sec… (Only complete fo… Luminaire Mounting Height (m)	Work-plane (m)	Perimeter Length (m)	Room Cavity Ratio	…otal Baseline LPD Allowance (W/sq m)	Design LPD (W/sq m)	Describe Automatic Lighting Controls	Section 9.6.2(c) Control Factor Adjustment: Lighting Power Under Control (W)	Section 9.6.2(c) Control Factor Adjustment: Table 9.6.2 adjust-ment	Design LPD (W/sq m)
Helpful Notes									• Lighting power should be modeled as designed (or installed) including all lighting system components (lamps and ballasts) • Enter the design (or installed) lighting power density (excluding any additional lighting lighting power from Section 9.6.2 or any process lighting) for this space type in the Proposed case. This value should not include Table G3.2 adjustments. • Credit for automatic lighting controls should be modeled using the appropriate power adjustment from Table G3.2, applied only to the controlled lighting power and not where required by 9.4.1. per Table G3.1#6(g) • Automatic daylighting controls must either be modeled directly in the simulation, or modeled using schedule adjustments determined by a separate daylighting analysis per Table				
EightThremalZo	Library - card file and cataloging	206	7.80				0.0	7.80	17.11				17.11
EightThremalZo	Retail - mall concourse	1…	11.80				0.0	11.80	9.68				9.68
EightThremalZo	Sales area	325	18.10				0.0	18.10	13.80				13.80
EightThremalZo	Office - open plan	232	10.50				0.0	10.50	10.50				10.50
Total		911	12.81					12.81	13.04				13.04

"Service Water Heating" sheet

Service Water Heaters

Model Input Parameter		Baseline	Proposed
Helpful Notes:	• Condenser Heat Recovery - Verify that condenser heat recovery has been modeled in the Baseline if required by 6.5.6.2 and describe any condenser heat recovery modeled; otherwise enter "Not required" (example: preheats service hot water to 85°F (29°C))	• New systems: minimum performance requirements from Table 7.8 per Table G3.1#11(b) • Existing systems: actual system inputs per Table G3.1#11(a) • Model separate service water heating system when design uses combined system with space heating per Table G3.1#11(e) • Condenser heat recovery as required by 6.5.6.2 per Table G3.1#11(f)	• Service water heaters modeled as designed (or installed) per Table G3.1#11(a&b) • Where no service hot water system exists or has been specified but the building will have service hot water loads, a service hot water system should be modeled identical to the Baseline per Table G3.1#11(c) • For buildings with no service hot water loads, no service hot water system should be modeled per
Building ID		EightThremalZones	
System type and fuel		Heating with storage using Electricity	Heating with storage using Electricity
Input rating (kW, kBtu/h, etc.)		13.58 kW	13.98 kW
Efficiency (EF, SL, %, etc.)		90%	90%
Storage volume (L)		170	170
Storage temperature (°C)		55	55
Peak hot water demand (L/s)		0.076	0.079
Condenser heat recovery		Not required	Not required
Number of pumps		1	1
Total pump power (kW)		0	0
Type of pump		Variable speed	Variable speed

SWH05: SWH system type, efficiency, and capacity

"General HVAC" sheet

Baseline HVAC System Type(s)

Building ID	Model Input Parameter	Table G3.1.1A System Type (or Semiconditioned System Description)	G3.1.1 Exception (or Semiconditioned Capacity and Area)	Spaces Modeled
Helpful Notes	• Refer to Section G3.1.1 and Table G3.1.1A (including footnotes) for Primary HVAC System selection • A system with any combination of fossil fuel and electric heat is considered fossil/electric hybrid • Systems 1-4: each thermal block shall be modeled with its own system • Systems 5-10: each floor shall be modeled with a separate system • Additional system types for conditioned spaces only permitted using Exceptions to G3.1.1 (min 20,000 sq ft (1860 sq m) required for exception (a)) • Systems serving semiconditioned spaces should be modeled identically to the system in the Proposed case (see definition of space in Section 3.2 of ASHRAE 90.1 • For California Title-24 projects, type in the appropriate system type		• Conditioned: describe the exception from G3.1.1 used to model this additional Baseline system type (example: Exception (b) used since peak loads differ by more than 10 Btu/h-sq ft (0.03 kW/sq m)) • Semiconditioned: list the total system capacity and floor area it serves	• List the spaces modeled with the primary system type (example: all spaces except kitchen)
	All	System 7 - VAV with Reheat		
EightThremalZones				
EightThremalZones				

AHVAC04: Baseline HVAC system modelled

Proposed HVAC System Type(s)

Building ID	System Description	Spaces Modeled
Helpful Notes	• Describe each type of HVAC system included in the Proposed building (example: Constant volume single-zone ground source heat pumps with dedicated outdoor air units with energy recovery).	• List the s…ample: all spaces except kitchen). • The HVA…as equipment capacities and efficiencies, …per Table G3.1#10(a&b) • Where no heating system exists or has been designed, the classification is assumed to be electric and the heating system is modeled identically to the Baseline case per Table G3.1#10(c) • Where no cooling system exists or has been designed, the cooling system is modeled identically to the Baseline case per Table G3.1#10(d), unless using baseline HVAC system types 9 or 10.
EightThremalZ…	GSHP Water-to-water HP, Heated Floor, Chilled Beams	
EightThremalZ…		

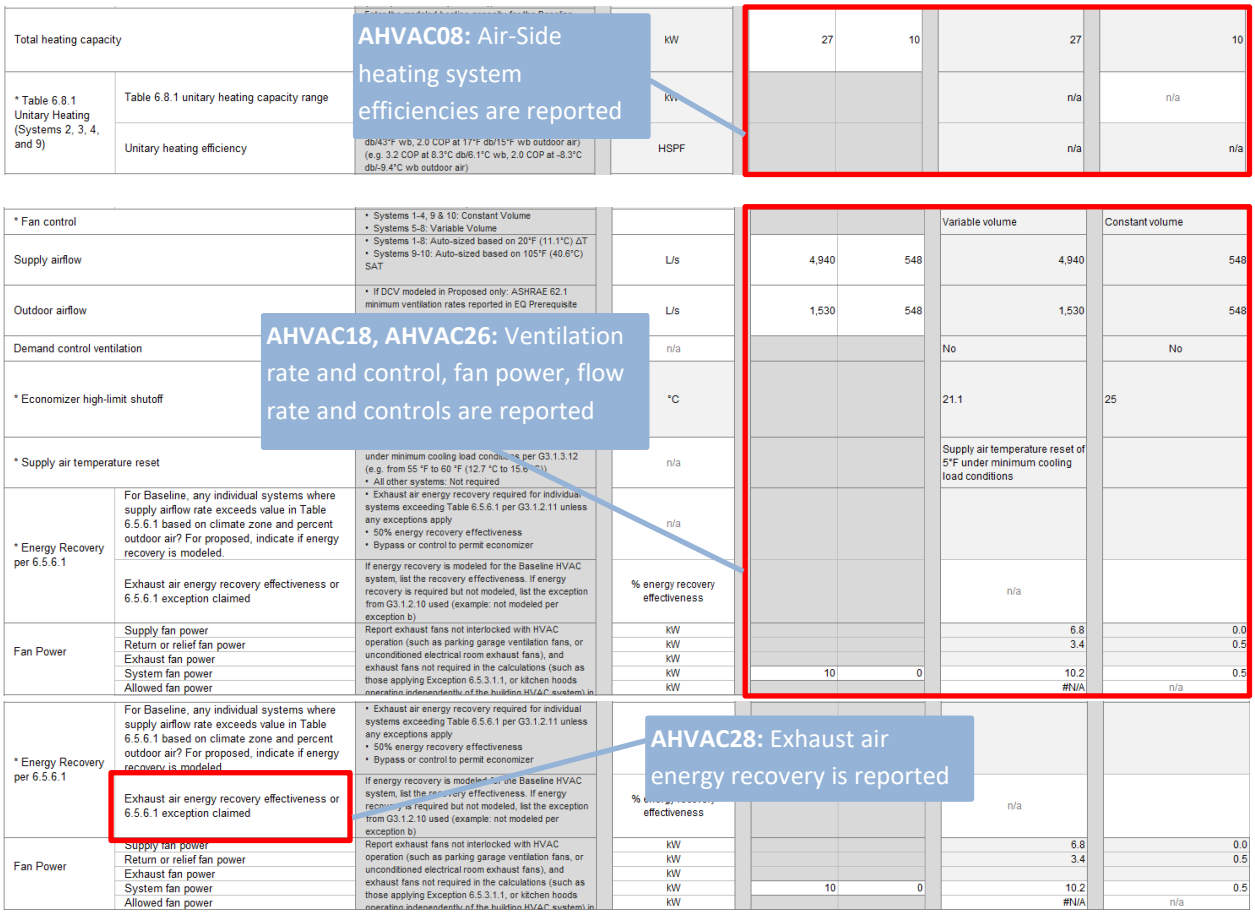
AHVAC04: Proposed HVAC system modelled

"Air-Side HVAC" sheet

Air-Side HVAC System Schedule Add Baseline Add Proposed

Model Input Parameter		Helpful Notes	Units	Totals Baseline	Totals Proposed	Baseline	Proposed
						Building ID: EightThremalZones	Building ID: EightThremalZones
						* System type: System No 7 Air Loop	* System type: Air Loop
						System designation(s)	System designation(s)
						Number of similar systems: 1	Number of similar systems: 1
Total cooling capacity		Enter the modeled cooling capacity for the Baseline HVAC system (or the total cooling capacity for a group of similar systems) (example: 105 kBtu/h (30.7 kW)) Note: Auto-sized with 15% oversizing per G3.1.2.2	kW	146	18	146	18
* Table 6.8.1 Unitary Cooling (Systems 1 through 6)	Table 6.8.1 unitary cooling capacity range	Enter the modeled unitary cooling capacity range for the Baseline HVAC system (or group of similar systems) in units consistent with the appropriate Table 6.8.1 (example: 11.0 EER (3.23 COP))	…W			n/a	n/a
	Unitary cooling efficiency	Units should be consistent with the ASHRAE 90.1 minimum efficiency rating requirements for this system type. If modeled units are different than ASHRAE 90.1 units (e.g. EIR rather than SEER), report both units. Since the packaged cooling efficiency ratings are calculated at ARI-rated conditions, the fans must also be broken out at ARI-rated conditions (fan power at ARI conditions is typically much lower than fan power at design conditions). If the simulation software does not perform this step automatically, provide the calculations. For the Baseline Case, the project team may use ASHRAE 90.1 – 2010 Addendum bl or the RMI EMIT translator as optional methods for breaking out the fan power. For the Proposed case, use the method documented in the ASHRAE 90.1 User's Manual to break out the fan power.	EER			n/a	n/a
	Unitary cooling part-load efficiency (if applicable)	Enter the modeled unitary cooling efficiency for the Baseline HVAC system (or group of similar systems) in units consistent with the appropriate Table 6.8.1 (example: 11.0 EER (3.23 COP))	IEER			n/a	n/a

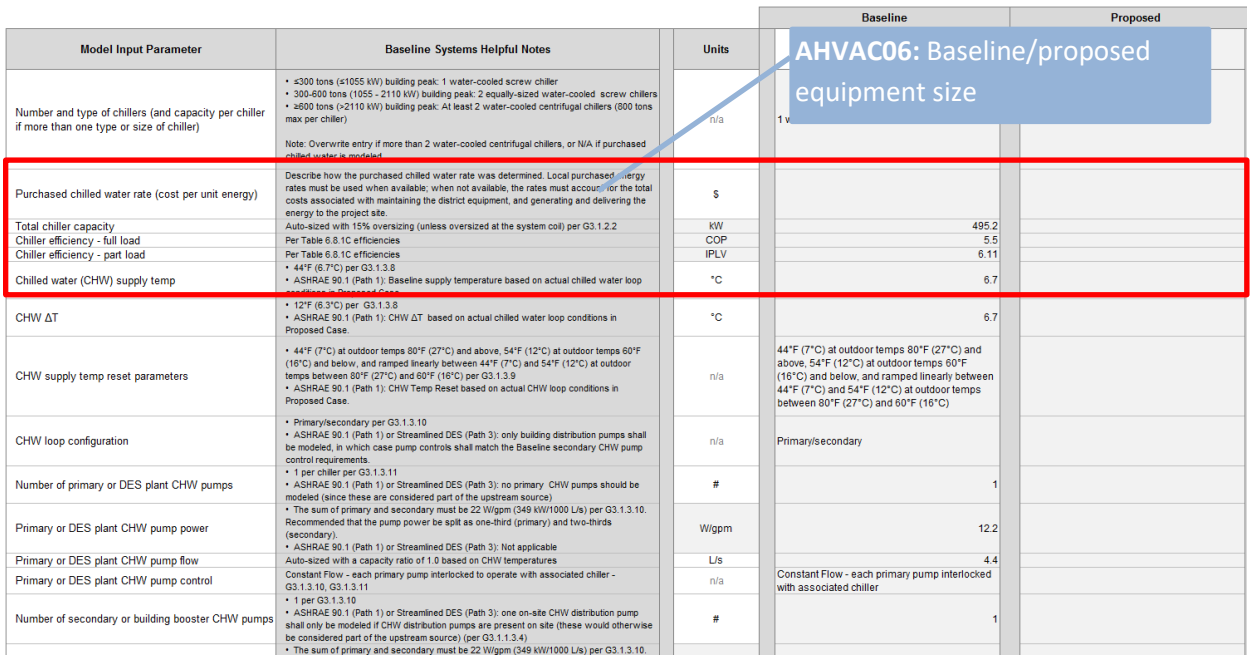
AHVAC06, AHVAC08 Air-Side HVAC system capacities and efficiencies



Total heating capacity			kW	27	10	27	10
* Table 6.8.1 Unitary Heating (Systems 2, 3, 4, and 9)	Table 6.8.1 unitary heating capacity range		kW			n/a	n/a
	Unitary heating efficiency	db/43°F wb, 2.0 COP at 17°F db/15°F wb outdoor air) (e.g. 3.2 COP at 8.3°C db/6.1°C wb, 2.0 COP at -8.3°C db/-9.4°C wb outdoor air)	HSPF			n/a	n/a
* Fan control		• Systems 1-4, 9 & 10: Constant Volume • Systems 5-8: Variable Volume				Variable volume	Constant volume
Supply airflow		• Systems 1-8: Auto-sized based on 20°F (11.1°C) ΔT • Systems 9-10: Auto-sized based on 105°F (40.6°C) SAT	L/s	4,940	548	4,940	548
Outdoor airflow		• If DCV modeled in Proposed only: ASHRAE 62.1 minimum ventilation rates reported in EQ Prerequisite	L/s	1,530	548	1,530	548
Demand control ventilation			n/a			No	No
* Economizer high-limit shutoff			°C			21.1	25
* Supply air temperature reset		under minimum cooling load conditions per G3.1.3.12 (e.g. from 55 °F to 60 °F (12.7 °C to 15.6 °C)) • All other systems: Not required	n/a			Supply air temperature reset of 5°F under minimum cooling load conditions	
* Energy Recovery per 6.5.6.1	For Baseline, any individual systems where supply airflow rate exceeds value in Table 6.5.6.1 based on climate zone and percent outdoor air? For proposed, indicate if energy recovery is modeled.	• Exhaust air energy recovery required for individual systems exceeding Table 6.5.6.1 per G3.1.2.11 unless any exceptions apply • 50% energy recovery effectiveness • Bypass or control to permit economizer	n/a				
	Exhaust air energy recovery effectiveness or 6.5.6.1 exception claimed	If energy recovery is modeled for the Baseline HVAC system, list the recovery effectiveness. If energy recovery is required but not modeled, list the exception from G3.1.2.10 used (example: not modeled per exception b)	% energy recovery effectiveness			n/a	
Fan Power	Supply fan power	Report exhaust fans not interlocked with HVAC operation (such as parking garage ventilation fans, or unconditioned electrical room exhaust fans), and exhaust fans not required in the calculations (such as those applying Exception 6.5.3.1.1, or kitchen hoods operating independently of the building HVAC system) in	kW			6.8	0.0
	Return or relief fan power		kW			3.4	0.5
	Exhaust fan power		kW				
	System fan power		kW	10	0	10.2	0.5
	Allowed fan power		kW			#N/A	n/a
* Energy Recovery per 6.5.6.1	For Baseline, any individual systems where supply airflow rate exceeds value in Table 6.5.6.1 based on climate zone and percent outdoor air? For proposed, indicate if energy recovery is modeled.	• Exhaust air energy recovery required for individual systems exceeding Table 6.5.6.1 per G3.1.2.11 unless any exceptions apply • 50% energy recovery effectiveness • Bypass or control to permit economizer	n/a				
	Exhaust air energy recovery effectiveness or 6.5.6.1 exception claimed	If energy recovery is modeled for the Baseline HVAC system, list the recovery effectiveness. If energy recovery is required but not modeled, list the exception from G3.1.2.10 used (example: not modeled per exception b)	% energy recovery effectiveness			n/a	
Fan Power	Supply fan power	Report exhaust fans not interlocked with HVAC operation (such as parking garage ventilation fans, or unconditioned electrical room exhaust fans), and exhaust fans not required in the calculations (such as those applying Exception 6.5.3.1.1, or kitchen hoods operating independently of the building HVAC system) in	kW			6.8	0.0
	Return or relief fan power		kW			3.4	0.5
	Exhaust fan power		kW				
	System fan power		kW	10	0	10.2	0.5
	Allowed fan power		kW			#N/A	n/a

"Water-Side HVAC" sheet

Chilled Water



Model Input Parameter	Baseline Systems Helpful Notes	Units	Baseline	Proposed
Number and type of chillers (and capacity per chiller if more than one type or size of chiller)	• ≤300 tons (≤1055 kW) building peak: 1 water-cooled screw chiller • 300-600 tons (1055 - 2110 kW) building peak: 2 equally-sized water-cooled screw chillers • ≥600 tons (>2110 kW) building peak: At least 2 water-cooled centrifugal chillers (800 tons max per chiller) Note: Overwrite entry if more than 2 water-cooled centrifugal chillers, or N/A if purchased chilled water is modeled	n/a	1 v	
Purchased chilled water rate (cost per unit energy)	Describe how the purchased chilled water rate was determined. Local purchased energy rates must be used when available; when not available, the rates must account for the total costs associated with maintaining the district equipment, and generating and delivering the energy to the project site.	$		
Total chiller capacity	Auto-sized with 15% oversizing (unless oversized at the system coil) per G3.1.2.2	kW	495.2	
Chiller efficiency - full load	Per Table 6.8.1C efficiencies	COP	5.5	
Chiller efficiency - part load	Per Table 6.8.1C efficiencies	IPLV	6.11	
Chilled water (CHW) supply temp	• 44°F (6.7°C) per G3.1.3.8 • ASHRAE 90.1 (Path 1): Baseline supply temperature based on actual chilled water loop conditions in Proposed Case	°C	6.7	
CHW ΔT	• 12°F (6.3°C) per G3.1.3.8 • ASHRAE 90.1 (Path 1): CHW ΔT based on actual chilled water loop conditions in Proposed Case.	°C	6.7	
CHW supply temp reset parameters	• 44°F (7°C) at outdoor temps 80°F (27°C) and above, 54°F (12°C) at outdoor temps 60°F (16°C) and below, and ramped linearly between 44°F (7°C) and 54°F (12°C) at outdoor temps between 80°F (27°C) and 60°F (16°C) per G3.1.3.9 • ASHRAE 90.1 (Path 1): CHW Temp Reset based on actual CHW loop conditions in Proposed Case.	n/a	44°F (7°C) at outdoor temps 80°F (27°C) and above, 54°F (12°C) at outdoor temps 60°F (16°C) and below, and ramped linearly between 44°F (7°C) and 54°F (12°C) at outdoor temps between 80°F (27°C) and 60°F (16°C)	
CHW loop configuration	• Primary/secondary per G3.1.3.10 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): only building distribution pumps shall be modeled, in which case pump controls shall match the Baseline secondary CHW pump control requirements.	n/a	Primary/secondary	
Number of primary or DES plant CHW pumps	• 1 per chiller per G3.1.3.11 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): no primary CHW pumps should be modeled (since these are considered part of the upstream source)	#	1	
Primary or DES plant CHW pump power	• The sum of primary and secondary must be 22 W/gpm (349 kW/1000 L/s) per G3.1.3.10. Recommended that the pump power be split as one-third (primary) and two-thirds (secondary). • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): Not applicable	W/gpm	12.2	
Primary or DES plant CHW pump flow	Auto-sized with a capacity ratio of 1.0 based on CHW temperatures	L/s	4.4	
Primary or DES plant CHW pump control	Constant Flow - each primary pump interlocked to operate with associated chiller - G3.1.3.10, G3.1.3.11	n/a	Constant Flow - each primary pump interlocked with associated chiller	
Number of secondary or building booster CHW pumps	• 1 per G3.1.3.10 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): one on-site CHW distribution pump shall only be modeled if CHW distribution pumps are present on site (these would otherwise be considered part of the upstream source) (per G3.1.1.3.4)	#	1	
	• The sum of primary and secondary must be 22 W/gpm (349 kW/1000 L/s) per G3.1.3.10.			

Hot Water or Steam

AHVAC06: Baseline/proposed equipment size

Model Input Parameter	Baseline Systems Helpful Notes	Units		
Number and type of boilers	• ≤15,000 sq ft (1400 m2): 1 natural draft hot water boiler • >15,000 sq ft (1400 m2): 2 equally-sized natural draft hot water boilers staged as required by the load	n/a	1 natural draft hot water boiler	1 boiler
Purchased heating rate (cost per unit energy)	Describe how the purchased heating rate was determined. Local purchased energy rates must be used when available; when not available, the rates must account for the total costs associated with maintaining the district equipment, and generating and delivering the energy to the project site.	$		
Total boiler capacity	Auto-sized with 25% oversizing (unless oversized at the system coil) per G3.1.2.2	MBH	98.8	183.5
Boiler efficiency	Per Table 6.8.1F minimum efficiencies	%	80	89
Hot water or steam (HHW) supply temp	• 180°F (82°C) per G3.1.3.3 • ASHRAE 90.1 (Path 1) or Full DES (Path 2): Purchased Energy - Baseline supply temperature based on actual HHW/Steam loop conditions in Proposed Case	°C	82.2	80
HHW ΔT	• 50°F (28°C) per G3.1.3.3 • ASHRAE 90.1 (Path 1): Baseline ΔT based on actual HHW/Steam loop conditions in Proposed Case	°C	27.8	10
HHW temp reset parameters	[illegible] (10°C) and above, and ramped linearly between 180°F (83°C) and 150°F (66°C) at outdoor temps between 20°F(-7°C) and 50°F (10°C) per G3.1.3.4 • ASHRAE 90.1 (Path 1): Baseline Temp Reset based on actual HHW/Steam loop conditions in Proposed Case	n/a	[illegible] below, 150°F (66°C) at outdoor temps 50°F (10°C) and above, and ramped linearly between 180°F (83°C) and 150°F (66°C) at outdoor temps between 20°F(-7°C) and 50°F (10°C)	
HHW loop configuration	• Primary-only per G3.1.3.5 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): Baseline pumps shall only be modeled if distribution pumps are present in the building, in which case buildings shall be modeled as primary-only per G3.1.3.5	n/a	Primary-only	
Number of primary or DES plant HHW pumps	• One pump • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): equal to the number of distribution pumps present in the building	#	1	
Primary or DES plant HHW pump power	• 19 W/gpm (301 kW/1000 L/s) per G3.1.3.5 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): - 14 W/gpm (222 kW/1000 L/s) per exception to G3.1.3.5 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3) - same as the W/gpm (kW/1000 L/s) for the Proposed Case pumps (or alternatively 14 W/gpm (222 kW/1000 L/s) limit from Addendum ai G3.1.3.5 would be acceptable)	W/gpm	22.9	
Primary or DES plant HHW pump flow	Auto-sized with a capacity ratio of 1.0 based on HHW temperatures	L/s	0.9	
Primary or DES plant HHW pump control	• <120,000 sq ft (11,160 m2): riding the pump curve • ≥120,000 sq ft (11,160 m2): variable speed	n/a	Riding the pump curve	
Number of secondary or building booster HHW pumps	Baseline is primary-only	#	N/A (Primary-only)	
Secondary or building booster HHW pump power	Baseline is primary-only	n/a	N/A (Primary-only)	
Secondary or building booster HHW pump flow	Baseline is primary-only	n/a	N/A (Primary-only)	
Secondary or building booster HHW pump control	Baseline is primary-only	n/a	N/A (Primary-only)	

Chilled Water

WHVAC02, WHVAC03, WHVAC04: Chilled water plant and controls, loop parameters and chiller efficiencies are

Model Input Parameter	Baseline Systems Helpful Notes	Units	Baseline EightThermalZones	Proposed EightThermalZones
Number and type of chillers (and capacity per chiller if more than one type or size of chiller)	[illegible]	n/a	1 water-cooled screw chiller	
Purchased chilled water rate (cost per unit energy)	[illegible]	$		
Total chiller capacity	Auto-sized with 15% oversizing (unless oversized at the system coil) per G3.1.2.2	kW	493.01	
Chiller efficiency - full load	Per Table 6.8.1C efficiencies	COP	5.5	
Chiller efficiency - part load	Per Table 6.8.1C efficiencies	IPLV	6.08	
Chilled water (CHW) supply temp	• 44°F (6.7°C) per G3.1.3.8 • ASHRAE 90.1 (Path 1): Baseline supply temperature based on actual chilled water loop conditions in Proposed Case.	°C	6.7	
CHW ΔT	• 12°F (6.3°C) per G3.1.3.8 • ASHRAE 90.1 (Path 1): CHW ΔT based on actual chilled water loop conditions in Proposed Case.	°C	6.7	
CHW supply temp reset parameters	• 44°F (7°C) at outdoor temps 80°F (27°C) and above, 54°F (12°C) at outdoor temps 60°F (16°C) and below, and ramped linearly between 44°F (7°C) and 54°F (12°C) at outdoor temps between 80°F (27°C) and 60°F (16°C) per G3.1.3.9 • ASHRAE 90.1 (Path 1): CHW Temp Reset based on actual CHW loop conditions in Proposed Case.	n/a	44°F (7°C) at outdoor temps 80°F (27°C) and above, 54°F (12°C) at outdoor temps 60°F (16°C) and below, and ramped linearly between 44°F (7°C) and 54°F (12°C) at outdoor temps between 80°F (27°C) and 60°F (16°C)	
CHW loop configuration	• Primary/secondary per G3.1.3.10 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): only building distribution pumps shall be modeled, in which case pump controls shall match the Baseline secondary CHW pump control requirements.	n/a	Primary/secondary	
Number of primary or DES plant CHW pumps	• 1 per chiller per G3.1.3.11 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): no primary CHW pumps should be modeled (since these are considered part of the upstream source)	#	1	
Primary or DES plant CHW pump power	• The sum of primary and secondary must be 22 W/gpm (349 kW/1000 L/s) per G3.1.3.10. Recommended that the pump power be split as one-third (primary) and two-thirds (secondary). • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): Not applicable	W/gpm	12.24	

WHVAC07: CHW pumps are modeled as reported

Number of primary or DES plant CHW pumps	• 1 per chiller per G3.1.3.11 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): no primary CHW pumps should be modeled (since these ar	#	1	
Primary or DES plant CHW pump power	• The sum of primary ar Recommended that the (secondary). • ASHRAE 90.1 (Path 1	W/gpm	12.24	
Primary or DES plant CHW pump flow	Auto-sized with a capa	L/s	4.4	
Primary or DES plant CHW pump control	Constant Flow - each p G3.1.3.10, G3.1.3.11	n/a	Constant Flow - each primary pump interlocked with associated chiller	
Number of secondary or building booster CHW pumps	• 1 per G3.1.3.10 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): one on-site CHW distribution pump shall only be modeled if CHW distribution pumps are present on site (these would otherwise be considered part of the upstream source) (per G3.1.1.3.4)	#	1	
Secondary or building booster CHW pump power	• The sum of primary and secondary must be 22 W/gpm (349 kW/1000 L/s) per G3.1.3.10. Recommended that the pump power be split as one-third (primary) and two-thirds (secondary). • ASHRAE 90.1 (Path 1): 16 W/gpm (254 kW/1000 L/s) per exception to G3.1.3.10 • California Title 24 (Path 4): Same W/gpm (kW/1000 L/s) as Proposed or 22 W/gpm (349 kW/1000 L/s)	W/gpm	12.24	
Secondary or building booster CHW pump flow	Auto-sized with a capacity ratio of 1.0 based on CHW temperatures	L/s	4.4	
Secondary or building booster CHW pump control	• <300 tons (1055kW): riding the pump curve • ≥300 tons (1055 kW): variable speed	n/a	Variable speed	n/a

Cooling Tower and Condenser Water

Model Input Parameter	Baseline Systems Helpful Notes	Units	EightThremalZones	EightThremalZones
Number of cooling towers or fluid coolers	1 per G3.1.3.11	#	1	
Cooling tower fan power	Minimum 38.2 gpm/hp (3 per Table 6.8.1G	HP	2.06	
Cooling tower fan control	Two-speed axial fans p	n/a	Two-speed axial fan	
Condenser water (CW) leaving temp	85°F (29°C) or 10°F (5.6 per G3.1.3.11	°C	29.44	29
CW ΔT	10°F (5.6°) per G3.1.3.1	°C	5.56	5
CW loop temp reset parameters	Maintain a 70°F (21°C) leaving water temperature where weather permits, floating up to leaving water temperature at design conditions per G3.1.3.11	n/a	70°F (21°C) leaving water where weather permits, floating up to leaving water temperature at design conditions	
Number of CW pumps	1 per chiller per G3.1.3.11	#	1	1
CW pump power	19 W/gpm (310 kW/1000 L/s) per G3.1.3.11	W/gpm	21.14	1.8
CW pump flow	Auto-sized with a capacity ratio of 1.0 based on CW temperatures	L/s	6.27	4.42
CW pump control	Riding the pump curve per G3.1.3.11	n/a	Riding the Pump Curve	Variable speed

WHVAC11: Heat rejection system is modeled as reported

Hot Water or Steam

Model Input Parameter	Baseline Systems Helpful Notes	Units	EightThremalZones	EightThremalZones
Number and type of boilers	ed as required	n/a	1 natural draft hot water boiler	1 boiler
Purchased heating rate (cost per unit energy)	energy rates the total costs ng the energy	$		
Total boiler capacity	1.2.2	MBH	394.8	183.47
Boiler efficiency		%	80	89
Hot water or steam (HHW) supply temp	pply	°C	82.22	80
HHW ΔT	tions in	°C	27.78	10
HHW temp reset parameters	oor temps 50°F C) at outdoor oop conditions	n/a	180°F (83°C) at outdoor temps 20°F (-7°C) and below, 150°F (66°C) at outdoor temps 50°F (10°C) and above, and ramped linearly between 180°F (83°C) and 150°F (66°C) at outdoor temps between 20°F(-7°C) and 50°F (10°C)	
HHW loop configuration	• Primary-only per G3.1.3.5 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): Baseline pumps shall only be modeled if distribution pumps are present in the building, in which case build shall be modeled as primary-only per G3.1.3.5	n/a	Primary-only	
Number of primary or DES plant HHW pumps	• One pump • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): equal to the number of distribution pumps present in the building	#	1	2
Primary or DES plant HHW pump power	• 19 W/gpm (301 kW/1000 L/s) per G3.1.3.5 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3): - 14 W/gpm (222 kW/1000 L/s) per exception to G3.1.3.5 • ASHRAE 90.1 (Path 1) or Streamlined DES (Path 3) - same as the W/gpm (kW/1000 L/s) for the Proposed Case pumps (or alternatively 14 W/gpm (222 kW/1000 L/s) limit from Addendum ai G3.1.3.5 would be acceptable)	W/gpm	15.2	1.8
Primary or DES plant HHW pump flow	Auto-sized with a capacity ratio of 1.0 based on HHW temperatures	L/s	3.22	2.94
Primary or DES plant HHW pump control	• <120,000 sq ft (11,160 m2): riding the pump curve • ≥120,000 sq ft (11,160 m2): variable speed	n/a	Riding the pump curve	
Number of secondary or building booster HHW pumps	Baseline is primary-only	#	n/a (Primary-only)	
Secondary or building booster HHW pump power	Baseline is primary-only	n/a	n/a (Primary-only)	
Secondary or building booster HHW pump flow	Baseline is primary-only	n/a	n/a (Primary-only)	
Secondary or building booster HHW pump control	Baseline is primary-only	n/a	n/a (Primary-only)	

WHVAC13, WHVAC14, WHVAC16, WHVAC18, WHVAC19: Hot plant and controls, loop parameters, hot water pumps and boiler efficiencies are modeled as expected

"Performance_Outputs_1" sheet

Performance Rating Method Compliance Report

End Use	Unregulated?	Energy Type	Units of Annual Energy and Peak Demand	Baseline	Proposed
Interior lighting		Electricity	Consumption (kWh)	51,085	37,132
			Demand (kW)	11	11
Exterior lighting		Electricity	Consumption (kWh)	2,190	2,190
			Demand (kW)	0.5	1
Space heating		Natural Gas	Consumption (kWh)	180,067	4,564
			Demand (kW)	88.6	33
Space cooling		Electricity	Consumption (kWh)	3,673	18,360
			Demand (kW)	9.5	27
Pumps		Electricity	Consumption (kWh)	3,592	713
			Demand (kW)	3.2	0
Heat rejection		Electricity	Consumption (kWh)	133	
			Demand (kW)	1.5	
Fans - interior ventilation		Electricity	Consumption (kWh)	13,475	8,744
			Demand (kW)	7.9	2
Fans - parking garage	x	Electricity	Consumption (kWh)		37,265
					13
Service water heating		Electricity		21,506	22,087
				9.3	10
Receptacle equipment	x	Electricity	Consumption (kWh)	44,726	10,605
			Demand (kW)	14.4	4

AHVAC04: Space heating end use

WHVAC22: Baseline and Proposed heating fuels

SG09: Heating, cooling and fan etc energy between the baseline and proposed

PPO01, PPO03: Miscellaneous loads

SG08: Unmet hours

Unmet Loads

Enter the non-coincident unmet load hours, consistent with the energy simulation output reports.

Unmet Loads	Baseline	Proposed
Number of hours heating loads not met	269	102
Number of hours cooling loads not met	0	125
Totals	269	227
Compliance	Yes	

Energy Sources

Enter each energy source serving the project, the units for the energy consumption and demand, and the associated utility rate name and tariff structure. the energy modeler. All project energy types and the demand and consumption units must be entered before entering energy simulation output data. Also enter the or site energy consumption and source energy consumption (generally, the IP units are Btu x 10^6, the SI site energy units are kWh, and the SI source energy

UR03: Brief description for utility structure can be added here

Energy Type	Energy Consumption Units	Demand Units	Utility Rate Name	Utility Rate Structure	Unit Conversion Factors	
					Energy Type Consumption Units to Site Energy Consumption (kWh)	Energy Type Consumption Units to Source Energy Consumption (kWh)
Electricity	kWh	kW	BLOCK ELECTRICITY AND DEMAND CHARGE	In block charges for both demand and energy, where energy < 20kWh, rate is 0.0474, between 20 kWh and 180 kWh, rate is 0.0424, energy > 180 kWh, rate is 0.0383; demand < 20W, rate is 5.38, between 20W and 80W, rate is 4.23, demand > 80W, rate is 3.60.	1.0000000	3.1400000
Natural Gas	kWh	kW	MONTHLY RATE GAS CHARGE	Charged in monthly rates (Jan to Dec): 0.031, 0.027, 0.024, 0.023, 0.022, 0.018, 0.018, 0.023, 0.025, 0.028, 0.033 and 0.035.	1.0000000	1.0500000
Site energy consumption units used to report energy consumption totals (sum of energy types)					kWh	
Source energy consumption units used to report energy consumption totals (sum of energy types)					kWh	

On-Site Renewable Energy Production

☐ The project building uses on-site renewable energy systems. (Optional)

Exceptional Calculation Methods

☐ The building energy analysis includes exceptional calculation methods. (Optional)

RE03: Renewable Energy

EC02: Exceptional Calculation

Performance Rating Method Compliance Report

BE21: Baseline not rotated or 4 rotations averaged

LI10: Interior Lighting Annual Energy

LI06: Interior Lighting Peak Demand

LI10: Lighting Full Load Hours – This needs to be calculated as FLH = Energy Use/Demand

LE03, LE06: Exterior Lighting Energy

		Energy Type	Units of Annual Energy and Peak Demand	Baseline	Proposed	Energy / Demand Savings per End-Use	Savings	Total Cost Savings	Percent of Total Proposed Site Energy Consumption
Interior lighting		Electricity	Consumption (kWh)	51,085	37,132	27.3%	10.3%	34.4%	20.1%
			Demand (kW)	11	11	6.0%			
Exterior lighting		Electricity	Consumption (kWh)	2,190	2,190	0.0%	0.0%	-0.1%	1.2%
			Demand (kW)	0.5	1	0.0%			
Space heating		Natural Gas	Consumption (kWh)	180,266	1,745	99.0%			
			Demand (kW)	88.6	28	68.7%			
Space cooling		Electricity	Consumption (kWh)	3,655	18,367	-402.5%			
			Demand (kW)	9.4	27	-186.2%			
Pumps			Consumption (kWh)	3,579	739	79.4%	2.1%	7.4%	0.4%
			Demand (kW)	3.2	0	87.6%			
Heat rejection			Consumption (kWh)	102		100.0%	0.1%	0.3%	0.0%
			Demand (kW)	1.5		100.0%			
Fans - interior			Consumption (kWh)			34.9%	3.5%	11.8%	4.7%
			Demand (kW)			80.2%			
Fans - parking garage	x	Electricity	Consumption (kWh)				-27.5%	-99.2%	20.1%
			Demand (kW)						
Service water heating		Electricity	Consumption (kWh)	21,506	22,087	-2.7%	-0.4%	-2.7%	11.9%
			Demand (kW)	9.3	10	-3.2%			
Receptacle equipment	x	Electricity	Consumption (kWh)	44,726	10,605	76.3%	25.2%	88.4%	5.7%
			Demand (kW)	14.4	4	69.9%			
IT equipment	x	Electricity	Consumption (kWh)				0.0%	0.0%	0.0%
			Demand (kW)						
Interior lighting - process	x	Electricity	Consumption (kWh)				0.0%	0.0%	0.0%
			Demand (kW)						
Refrigeration equipment	x	Electricity	Consumption (kWh)				0.0%	0.0%	0.0%
			Demand (kW)						
Fans - Kitchen Ventilation	x	Electricity	Consumption (kWh)				0.0%	0.0%	0.0%
			Demand (kW)						

EnergyPlus Input Data idf file

UnititCost:Charge table

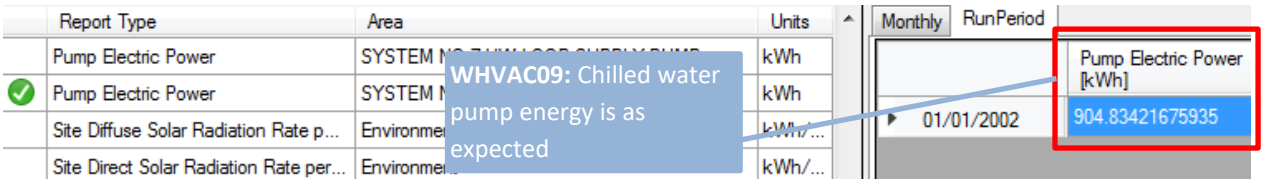
```
UtilityCost:Charge:Block,
   BlockEnergyCharge,                       !- Charge Variable Name
   Block electricity and demand charge,     !- Tariff Name
   totalEnergy,                             !- Source Variable
   Annual,                                  !- Season
   EnergyCharges,                           !- Category Variable Name
   ,                                        !- Remaining Into Variable
   1,                                       !- Block Size Multiplier Value or Variable Name
   20000,                                   !- Block Size 1 Value or Variable Name
   .0474,                                   !- Block 1 Cost per Unit Value or Variable Name
   180000,                                  !- Block Size 2 Value or Variable Name
   .0424,                                   !- Block 2 Cost per Unit Value or Variable Name
   remaining,                               !- Block Size 3 Value or Variable Name
   .0383;                                   !- Block 3 Cost per Unit Value or Variable Name

UtilityCost:Charge:Block,
   BlockDemandCharge,                       !- Charge Variable Name
   Block electricity and demand charge,     !- Tariff Name
   totalDemand,                             !- Source Variable
   Annual,                                  !- Season
   DemandCharges,                           !- Category Variable Name
   ,                                        !- Remaining Into Variable
   1,                                       !- Block Size Multiplier Value or Variable Name
   20,                                      !- Block Size 1 Value or Variable Name
   5.38,                                    !- Block 1 Cost per Unit Value or Variable Name
   80,                                      !- Block Size 2 Value or Variable Name
   4.23,                                    !- Block 2 Cost per Unit Value or Variable Name
   remaining,                               !- Block Size 3 Value or Variable Name
   3.6;                                     !- Block 3 Cost per Unit Value or Variable Name
```

UR03: Utility rate structure. The input for the utility rate used in both the proposed and baseline are displayed in this section

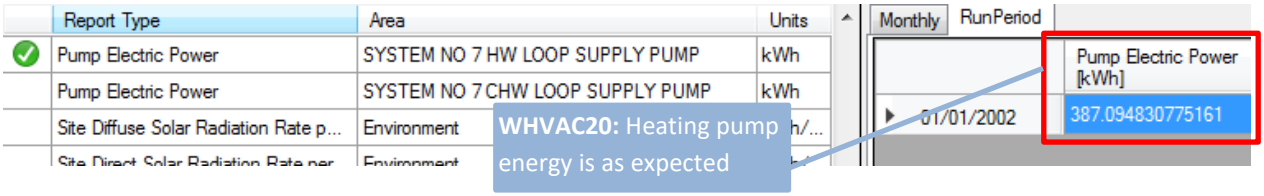
Simulated Results File (eso)

Chilled Water Pump Energy



WHVAC09: Chilled water pump energy is as expected

Heating Pump Energy



WHVAC20: Heating pump energy is as expected

Monthly heating and cooling loads - simultaneous heating and cooling check

	Report Type	Area	Units
	Zone Heating Setpoint Not Met Time	LOWERBLOCK:ZONE1	hr
✓	Zone Air System Sensible Cooling Rate	LOWERBLOCK:ZONE1	kWh
	Zone Cooling Setpoint Not Met While Oc...	LOWERBLOCK:ZONE1	hr
	Zone Cooling Setpoint Not Met Time	LOWERBLOCK:ZONE1	hr
✓	Zone Air System Sensible Heating Rate	LOWERBLOCK:ZONE1	kWh
	Zone Infiltration Sensible Heat Loss Energy	LOWERBLOCK:ZONE1	kWh
	Zone Windows Total Transmitted Solar R...	LOWERBLOCK:ZONE1	kWh
	Zone Interior Windows Total Transmitted ...	LOWERBLOCK:ZONE1	kWh
	Zone Lights Electric Power	LOWERBLOCK:ZONE1	kWh
	Zone Air Relativ	AHVAC31	%
	Zone Mechanic		ach
	Zone Other Equipment Total Heating Rate	LOWERBLOCK:ZONE1	kWh
	Zone Mean Radiant Temperature	LOWERBLOCK:ZONE1	C
	Zone People Sensible Heating Rate	LOWERBLOCK:ZONE1	kWh
	Zone Operative Temperature	LOWERBLOCK:ZONE1	C
	Zone Mean Air Temperature	LOWERBLOCK:ZONE1	C

Monthly | RunPeriod

	Zone Air System Sensible Heating Rate [kWh]	Zone Air System Sensible Cooling Rate [kWh]
01/01/2002	997.453698640376	0.638396465306164
01/02/2002	810.505206523605	0.751900945451373
01/03/2002	491.773445475716	12.4460648328704
01/04/2002	260.722483401388	103.1373118118
01/05/2002	65.7330058899191	371.436963150817
01/06/2002	21.86196978092	486.317375445952
01/07/2002	0.690377659515398	719.253844967048
01/08/2002	5.74455720119424	628.721895944188
01/09/2002	47.6331787687725	340.828732217015
01/10/2002	224.537574439139	117.759066521126
01/11/2002	487.536923901997	11.0828235755798
01/12/2002	947.967048537566	0.604473643690288

EnergyPlus / OpenStudio

Program Version:**EnergyPlus, Version 9.2.0-921312fa1d, YMD=2019.12.10 14:18**

Tabular Output Report in Format: **HTML**

Building: **Building 1**

SG03: Weather File

Environment: **RUN PERIOD 1 ** Chicago Ohare Intl Ap IL USA TMY3 WMO#=725300**

Simulation Timestamp: **2019-12-10 14:19:08**

Annual Building Utility Performance Summary Report

Report: **Annual Building Utility Performance Summary**

For: **Entire Facility**

Timestamp: **2019-12-10 14:19:08**

SG06: Number of hours per year explicitly modeled is as required

Values gathered over 8760.00 hours

SG09: Site Energy Use Intensity (EUI) of the budget (baseline) design does not exceed typical by more than 20%.

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [M
Total Site Energy	1347.66	278.96	330.43
Net Site Energy	427.10	88.41	104.72
Total Source Energy	4268.04	883.48	1046.49
Net Source Energy	1352.63	279.99	331.65

Report: **Input Verification and Results Summary**

For: **Entire Facility**

Timestamp: **2019-12-11 09:58:50**

General

	Value
Program Version and Build	EnergyPlus, Version 9.2.0-921312fa1d, YMD=2019.12.11 09:58
RunPeriod	RUN PERIOD 1
Weather File	Chicago Ohare Intl Ap IL USA TMY3 WMO#=725300
Latitude [deg]	41.98
Longitude [deg]	-87.9
Elevation [m]	201.00
Time Zone	-6.0
North Axis Angle [deg]	0.00
Rotation for Appendix G [deg]	0.00
Hours Simulated [hrs]	8760.00

BE21

ENVELOPE

Window-Wall Ratio

	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 2	West (225 to 315 deg)
Gross Wall Area [m2]	2166.50	817.55	265.70		265.70
Above Ground Wall Area [m2]	2166.50	817.55	265.70	817.55	265.70
Window Opening Area [m2]	649.95	245.26	79.71	245.26	79.71
Gross Window-Wall Ratio [%]	30.00	30.00	30.00	30.00	30.00
Above Ground Window-Wall Ratio [%]	30.00	30.00	30.00	30.00	30.00

BE16

Conditioned Window-Wall Ratio

	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [m2]	1993.70	737.65	259.20	737.65	259.20
Above Ground Wall Area [m2]	1993.70	737.65	259.20	737.65	259.20
Window Opening Area [m2]	598.11	221.30	77.76	221.30	77.76
Gross Window-Wall Ratio [%]	30.00	30.00	30.00	30.00	30.00
Above Ground Window-Wall Ratio [%]	30.00	30.00	30.00	30.00	30.00

Component Sizing Summary Report

AirLoopHVAC

	Sum of Air Terminal Maximum Heating Flow Rates [m3/s]	Sum of Air Terminal Minimum Heating Flow Rates [m3/s]	Sum of Air Terminal Maximum Flow Rates [m3/s]	Adjusted Heating Design Air Flow Rate [m3/s]	Adjusted Cooling Design Air Flow Rate [m3/s]	Adjusted Main Design Air Flow [m3/s]	User Heating Air Flow atio []	Calculated Heating Air Flow Ratio []	Design Supply Air Flow Rate [m3/s]
CAV_BAS	3.81	0.761010	3.81	1.20	3.82	3.82	1.00	0.314487	3.82
DATACENTER_BASEMENT_ZN_6 ZN PSZ-AC DATA CENTER	0.000000	0.000000	18.34	0.000000	18.34	18.34	1.00	0.000000	18.34
DATACENTER_BOT_ZN_6 ZN PSZ-AC DATA CENTER	0.000000	0.000000	0.458429	0.000000	0.458429	0.458429	1.00	0.000000	0.458429

AHVAC04

Initialization Summary Report

ZoneInfiltration Airflow Stats Nominal

	Name	Schedule Name	Zone Name	Zone Floor Area {m2}	# Zone Occupants	Design Volume Flow Rate {m3/s}	Volume Flow Rate/Floor Area {m3/s-m2}	Volume Rate/E Surfac {m3/s-m2}	ACH - Air Changes per Hour	Equation A - Constant Term Coefficient {}	Equation B - Temperature Term Coefficient {1/C}	Equation C - Velocity Term Coefficient {s/m}	Equation D - Velocity Squared Term Coefficient {s2/m2}
1	1_BDRM_1_2 INFILTRATION	ALWAYS ON DISCRETE	1_BDRM_1_2	55.74	1.6	5.292E-003	9.493E-005	2.848E-004	0.11	0.000	0.000	0.224	0.000
2	1_BDRM_1_3 INFILTRATION	ALWAYS ON DISCRETE	1_BDRM_1_3	55.74	1.6	5.292E-003	9.493E-005	2.848E-004	0.112	0.000	0.000	0.224	0.000
3	1_BDRM_1_4 INFILTRATION	ALWAYS ON DISCRETE	1_BDRM_1_4	55.74	1.6	5.292E-003	9.493E-005	7.120E-005	0.112	0.000	0.000	0.224	0.000

BE18

LEED Summary Report

EAp2-2. Advisory Messages

	Data
Number of hours heating loads not met	0.00
Number of hours cooling loads not met	46.17
Number of hours not met	46.17

SG08: Number of hours with unmet heating or cooling load does not exceed 300

Building Area

	Area [m2]
Total Building Area	4830.96
Net Conditioned Building Area	4078.44
Unconditioned Building Area	752.51

SG05: Modeled conditioned floor area is appropriate

Convert to ft2 by multiplying by 10.7639

EAp2-6. Energy Use Summary

	Process Subtotal [GJ]	Total Energy Use [GJ]
Electricity	487.25	1349.26
Natural Gas	0.00	0.00
Total	487.25	1349.26
Additional	0.00	0.00

EAp2-7. Energy Cost Summary

UR03

	Process Subtotal [$]	Total Energy Cost [$]
Electricity	9482.78	26259.01
Natural Gas	0.00	0.00
Other		3321.92
Total	9482.78	29580.93
Additional	0.00	

Process energy cost based on ratio of process to total energy.

RE03

L-1. Renewable Energy Source Summary

	Rated Capacity [kW]	Annual Energy Generated [GJ]
Photovoltaic	0.00	959.08
Wind	0.00	0.00

EAp2-17a. Energy Use Intensity - Electricity

	Electricty [MJ/m2]
Interior Lighting (All)	33.35
Space Heating	8.81
Space Cooling	53.87
Fans (All)	28.08
Service Water Heating	26.38
Receptacle Equipment	100.86
Miscellaneous (All)	279.29
Subtotal	279.29

EAp2-17b. Energy Use Intensity - Natural Gas

	Natural Gas [MJ/m2]
Space Heating	0.00
Service Water Heating	0.00
Miscellaneous (All)	0.00
Subtotal	0.00

Building Envelope Summary Report

Report: **Envelope Summary**

Table of Contents

For: **Entire Facility**

Timestamp: **2019-12-11 09:58:50**

Opaque Exterior

	Construction	Reflectance	U-Factor with Film [W/m2-K]	U-Factor [W/m2-K]	Gross Area [m2]	Net Area [m2]	Azimuth [deg]	Tilt [deg]	Cardinal Direction
FACE 224	TYPICAL INSULATED WOOD FRAMED EXTERIOR WALL R-45.45	0.30	0.125	0.127	18.58	13.01	180.00	90.00	S
FACE 410	TYPICAL INSULATED WOOD FRAMED EXTERIOR WALL R-45.45	0.30	0.125	0.127	18.58	13.01	180.00	90.00	S
FACE 561	TYPICAL INSULATED WOOD FRAMED EXTERIOR WALL R-45.45	0.30	0.125	0.127	18.58	13.01	180.00	90.00	S

BE06

Exterior Fenestration

	Construction	Glass Area [m2]	Frame Area [m2]	Divider Area [m2]	Area of One Opening [m2]	Area of Multiplied Openings [m2]	Glass U-Factor [W/m2-K]	Glass SHGC	Glass Visible Transmittance	Frame Conductance [W/m2-K]	Divider Conductance [W/m2-K]	Shade Control	Parent Surface	Azimuth [deg]	Tilt [deg]	Cardinal Direction
SUB SURFACE 3	U 0.17 SHGC 0.31 SIMPLE GLAZING WINDOW U-0.17 SHGC 0.31	5.57	0.00	0.00	5.57	5.57	1.128	0.313	0.342			No	FACE 224	180.00	90.00	S
SUB SURFACE 17	U 0.17 SHGC 0.31 SIMPLE GLAZING WINDOW U-0.17 SHGC 0.31	5.57	0.00	0.00	5.57	5.57	1.128	0.313	0.342			No	FACE 410	180.00	90.00	S

BE16

...

SUB SURFACE 91	U 0.17 SHGC 0.31 SIMPLE GLAZING WINDOW U-0.17 SHGC 0.31	4.18	0.00	0.00	4.18	4.18	1.128	0.313	0.342			No	FACE 341	0.00	90.00	N
SUB SURFACE 92	U 0.17 SHGC 0.31 SIMPLE GLAZING WINDOW U-0.17 SHGC 0.31	4.18	0.00	0.00	4.18	4.18	1.128	0.313	0.342			No	FACE 494	0.00	90.00	N
Total or Average						649.95	1.128	0.330	0.361							
North Total or Average						245.26	1.128	0.330	0.361							
Non-North Total or Average						404.69	1.128	0.329	0.361							

Lighting Summary Report

Report: **Lighting Summary**

Table of Contents

For: **Entire Facility**

Timestamp: **2019-12-11 09:58:50**

Interior Lighting

	Zone	Lighting Power Density [W/m2]	[illegible]	Total Power [W]	End Use [illegible]tegory	Schedule Name	Scheduled Hours/Week [hr]	Hours/Week > 1% [hr]	Full Load Hours/Week [hr]	Return [illegible]	Conditioned (Y/N)	Consumption [GJ]
RES LIGHTING INTERIOR|BUILDING UNIT 14 1_BDRM_1_2	1_BDRM_1_2	1.9699	55.74	109.81	res lighting interior|Building Unit 14 1_Bdrm_1_2	RES LIGHTING INTERIOR	63.60	168.00	63.60	0.0000	Y	1.31
RES LIGHTING INTERIOR|BUILDING UNIT 29 1_BDRM_1_3	1_BDRM_1_3	1.9699	55.74	109.81	res lighting interior|Building Unit 29 1_Bdrm_1_3	RES LIGHTING INTERIOR	63.60	168.00	63.60	0.0000	Y	1.31
RES LIGHTING INTERIOR|BUILDING UNIT 44 1_BDRM_1_4	1_BDRM_1_4	1.9699	55.74	109.81	res lighting interior|Building Unit 44 1_Bdrm_1_4	RES LIGHTING INTERIOR	63.60	168.00	63.60	0.0000	Y	1.31

...

STAIRWELL_2_3 STAIR LIGHTS	STAIRWELL_2_3	4.3056	27.87	120.00	General	HOTELSMALL BLDG_LIGHT_STAIR_SCH	92.40	168.00	92.40	0.0000	N	2.08
STAIRWELL_2_4 STAIR LIGHTS	STAIRWELL_2_4	4.3056	27.87	120.00	General	HOTELSMALL BLDG_LIGHT_STAIR_SCH	92.40	168.00	92.40	0.0000	N	2.08
Interior Lighting Total		2.6135	4756.64	12431.28								161.09

LI10

Exterior Lighting

LE03 LE06 LE06, LE07

	Total Watts	Astronomical Clock/Schedule	Schedule Name	Scheduled Hours/Week [hr]	Hours/Week > 1% [hr]	Full Load Hours/Week [hr]	Consumption [GJ]
BUILDING FACADES	371.00	AstronomicalClock	-		45.96	45.96	3.20
DRIVE THROUGH WINDOWS	60.00	AstronomicalClock	-		83.62	72.32	0.81
ENTRY CANOPIES	288.00	AstronomicalClock	-		83.62	72.32	3.91
MAIN ENTRIES	168.00	AstronomicalClock	-		83.62	72.32	2.28
OTHER DOORS	548.09	AstronomicalClock	-		83.62	72.32	7.44
PARKING AREAS AND DRIVES	0.00	AstronomicalClock	-		0.00		0.00
Exterior Lighting Total	1435.09						17.65

Equipment Summary Report

Report: **Equipment Summary**

Table of Contents

For: **Entire Facility**

Timestamp: **2019-12-12 10:45:44**

Central Plant

WHVAC02, WHVAC03

WHVAC13, WHVAC14

WHVAC11

	Type	Nominal Capacity [W]	Nominal Efficiency [W/W]	IPLV in SI Units [W/W]	IPLV in IP Units [Btu/W-h]
90.1-2013 WATERCOOLED CENTRIFUGAL CHILLER 0 726TONS 0.6KW/TON	Chiller:Electric:EIR	2348257.78	6.28	7.18	24.51
CENTRIFUGAL FAN CYCLING OPEN COOLING TOWER 40.2 GPM/HP	CoolingTower:SingleSpeed	2177672.44			
HEAT PUMP LOOP CENTRAL TOWER 20.0 GPM/HP	CoolingTower:TwoSpeed	366327.66			
HEAT PUMP LOOP SUPPLEMENTAL BOILER 1486KBTU/HR 0.8 THERMAL EFF	Boiler:HotWater	450801.21	0.80		
BOILER 7072KBTU/HR 0.8 THERMAL EFF	Boiler:HotWater	2099755.97	0.80		

DX Cooling Coils

AHVAC11

	DX Cooling Coil Type	Standard Rated Net Cooling Capacity [W]	Standard Rated Net COP [W/W]	EER [Btu/W-h]	SEER [Btu/W-h]	IEER [Btu/W-h]
CORE_ZN ZN PSZ-AC-1 1SPD DX HP CLG COIL 18KBTU/HR 14.0SEER		5016.1	3.29	11.22	11.74	10.96
PERIMETER_ZN_1 ZN PSZ-AC-2 1SPD DX HP CLG COIL 20KBTU/HR 14.0SEER		5341.5	3.29	11.22	11.74	10.96
PERIMETER_ZN_2 ZN PSZ-AC-3 1SPD DX HP CLG COIL 21KBTU/HR 14.0SEER		5811.6	3.29	11.22	11.74	10.96

Fans

	Type	Total Efficiency [W/W]	Delta Pressure [pa]	Max Air Flow Rate [m3/s]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-s/m3]	Motor Heat I... Fra...	Fan ...	End Use Subcategory	Design Day Name for Fan Sizing Peak	Date/Time for Fan Sizing Peak
CAV_BAS FAN	Fan:ConstantVolume	0.60	1018.77	3.82	6522.74	1709.21	1.00	1.17	CAV System Fans	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 08:20:00
DATACENTER_BASEMENT_ZN_6 ZN PSZ-AC DATA CENTER FAN	Fan:OnOff	0.61	1018.77	18.34	30551.69	1665.62	1.00	1.13	General	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 07:10:00
DATACENTER_BOT_ZN_6 ZN PSZ-AC DATA CENTER FAN	Fan:OnOff	0.56	622.72	0.46	513.67	1120.51	1.00	1.65	General	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 07:10:00
DATACENTER_MID_ZN_6 ZN PSZ-AC DATA CENTER FAN	Fan:OnOff	0.60	1018.77	4.00	6832.31	1709.21	1.00	1.17	General	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 18:40:00
DATACENTER_TOP_ZN_6 ZN PSZ-AC DATA CENTER FAN	Fan:OnOff	0.56	622.72	0.41	456.16	1120.51	1.00	1.71	General	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 18:40:00
VAV_BOT WITH REHEAT FAN	Fan:VariableVolume	0.61	1389.92	11.48	26088.91	2272.40	1.00	1.11	VAV System Fans	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 08:00:00
VAV_MID WITH REHEAT FAN	Fan:VariableVolume	0.62	1389.92	99.86	223826.83	2241.44	1.00	1.09	VAV System Fans	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 08:00:00
VAV_TOP WITH REHEAT FAN	Fan:VariableVolume	0.61	1389.92	10.23	23360.56	2284.54	1.00	1.11	VAV System Fans	CHICAGO OHARE INTL AP ANN CLG .4% CONDNS DB=>MWB	7/21 08:00:00

Pumps

WHVAC07

	Type	Control	Head [pa]	Water Flow [m3/s]	Electric Power [W]	Power Per Water Flow Rate [W-s/m3]	Motor Efficiency [W/W]	End Use Subcategory
CHILLED WATER LOOP SECONDARY PUMP	Pump:VariableSpeed	Intermittent	134508.01	0.099702	18368.92	184237.36	0.94	General
CHILLED WATER LOOP PRIMARY PUMP	Pump:ConstantSpeed	Intermittent	44836.00	0.099702	6249.84	62684.90	0.92	General
CONDENSER WATER LOOP CONSTANT PUMP	Pump:ConstantSpeed	Intermittent	148556.63	0.117234	23728.07	202398.74	0.94	ral
HEAT PUMP LOOP PUMP	Pump:ConstantSpeed	Intermittent	179344.02	0.009960	2558.73	256903.04	0.90	General
HOT WATER LOOP PUMP	Pump:VariableSpeed	Intermittent	179344.02	0.045928	11428.63	248840.07	0.92	General
MAIN SERVICE WATER LOOP CIRCULATOR PUMP	Pump:ConstantSpeed	Intermittent	29891.00	0.000439	24.04	54745.42	0.70	General

WHVAC18

Service Water Heating

SWH05

	Type	Storage Volume [m3]	Input [W]	Thermal Efficiency [W/W]	Recovery Efficiency [W/W]	Energy Factor
RES WH|BUILDING UNIT 1	WaterHeater:Mixed	0.11	11722.84	1.00	7.41	2.71
RES WH|BUILDING UNIT 10	WaterHeater:Mixed	0.11	11722.84	1.00	7.41	2.71
RES WH|BUILDING UNIT 11	WaterHeater:Mixed	0.11	11722.84	1.00	7.41	2.71

Report: **Equipment Summary**

Table of Contents

For: **Entire Facility**

Timestamp: **2019-12-11 09:58:50**

Central Plant

WHVAC02

	Type	Nominal Capacity [W]	Nominal Efficiency [W/W]	IPLV in SI Units [W/W]	IPLV in IP Units [Btu/W-h]
ZE AEDG MULTIFAMILY CHILLER 0 70TONS 1.1KW/TON	Chiller:Electric:EIR	238949.25	3.29	4.41	15.05

Demand End Use Components Summary Report

Report: **Demand End Use Components Summary**

For: **Entire Facility**

Timestamp: **2019-12-11 09:58:50**

End Uses

	Electricity [W]	Natural Gas [W]	Propane [W]	District Cooling [W]	Steam [W]	Water [m3/s]
Time of Peak	04-AUG-13:00	-	-	-	-	01-JAN-05:45
Heating	0.00	0.00	0.00	0.00	0.00	0.00
Cooling	34082.97	0.00	0.00	0.00	0.00	0.00
Interior Lighting	5991.94	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	193128.94	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	5740.74	0.00	0.00	0.00	0.00	0.00
Pumps	2621.74	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	1844.07	0.00	0.00	0.00	0.00	0.00
Water Systems	5306.82	0.00	0.00	0.00	0.00	0.00
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	248717.21	0.00	0.00	0.00	0.00	0.00

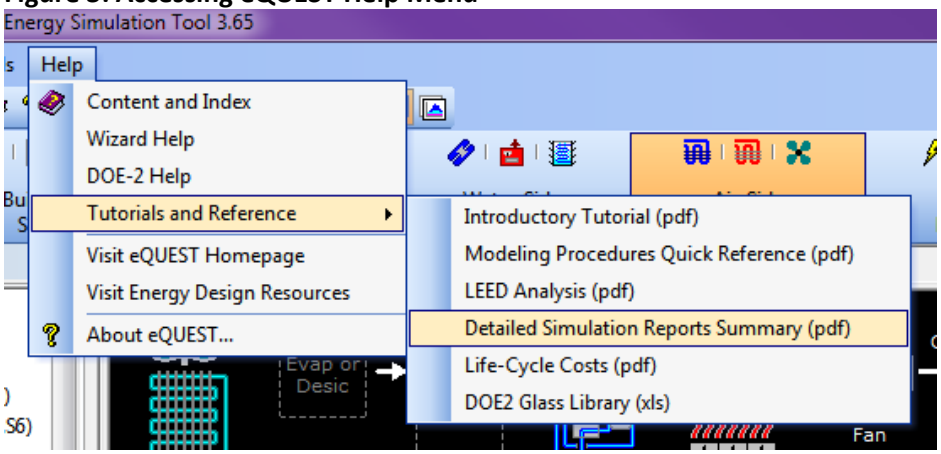
eQUEST

Resources

eQUEST Resources

1. eQUEST is free and can be downloaded from DOE2 website[21].
2. eQUEST download includes extensive reference documentation that can be accessed from eQUEST Help menu (Figure 3). The "Detailed Simulation Reports Summary" is extremely helpful for interpreting eQUEST input and output reports

Figure 3: Accessing eQUEST Help Menu



General

a) Unless noted, the reports below are found in the *.sim files that must be included in the submittal. At least two *.sim files must be included – one for the baseline (budget) and another for the proposed design model.

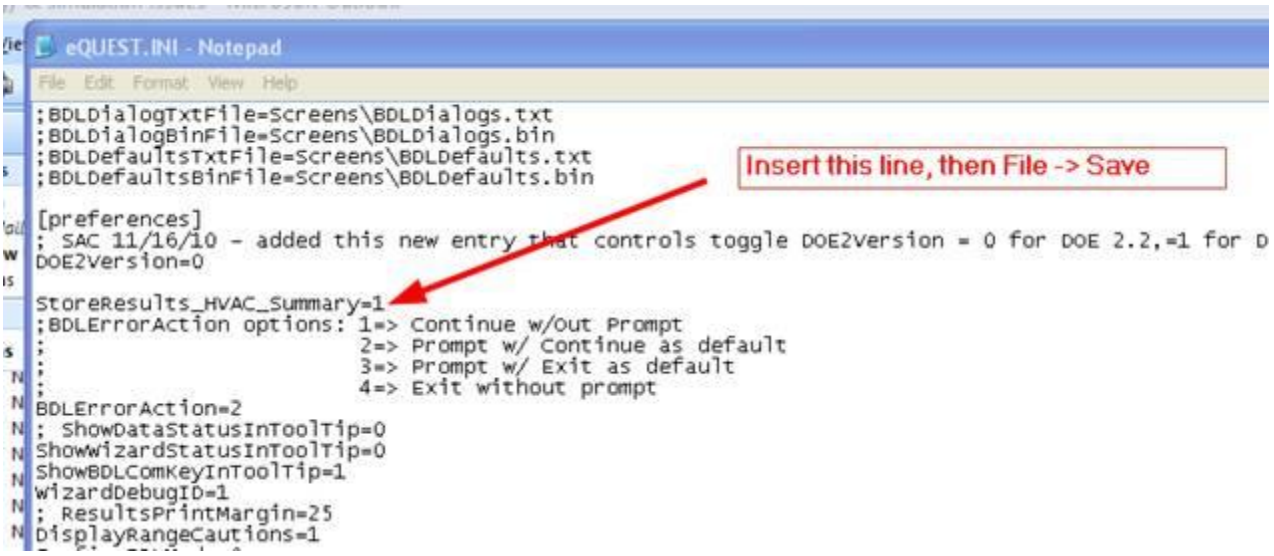
b) The *.sim reports are text files and may be opened in a text editor. SimViewer tool, which is part of the default eQUEST installation, is a better alternative as it simplifies navigation through the numerous available reports.

c) There are separate reports for the baseline (budget) and proposed design model.

d) Some output reports, such as BEPS, report energy use by the end use category. Systems and components that contributing toward each end use are described in the Detailed Simulation Reports Summary.pdf (available from the eQUEST's Help ->Tutorial and References menu), Description of eQUEST/DOE-2.2 End Use Reporting Categories section.

e) eQUEST can generate a handy HVAC Summary file (.csv) automatically with each simulation. To activate the feature, user must open the "eQUEST.INI" file and insert the line, "StoreResults_HVAC_Summary=1" as shown in the screen shot below. The eQUEST.INI file is found in the eQUEST Data directory, which can be located by selecting Tools -> View File Locations -> View eQUEST Data Directory from the main menu. Once you modify, and save the eQUEST.INI file, there will be a "YOUR_PROJECT_NAME – HVAC Summary.csv" file in the project folder after each simulation. The Air-Side System Summaries portion of the file is useful for automating or verifying fan power and EIR calculations for Baseline models.

[21] http://www.doe2.com/equest/



Simulation Reports to Be Submitted

a) <project name B>.SIM and <project name P>.SIM files with the detailed simulation reports for the baseline (budget) and proposed models;

b) Model files including <project name P>.pd2, <project name P>.inp for the proposed design and <project name B>.pd2, <project name B>.inp for the baseline (budget) design. Projects that used eQUEST Parametric Runs must also include the appropriate *.prd file and the appropriate additional *.inp files.

Annotated Reports

BEPS Building Energy Performance

REPORT- BEPS Building Energy Performance — **SG03:** Weather — WEATHER FILE- NEW YORK LAGUARDI NY

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	173.0	231.5	637.0	289.0	261.4	0.0	0.0	132.2	0.0	7.0	0.0	6.7	1737.7
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	33.5	0.0	0.0	0.0	0.0	0.0	0.0	850.0	0.0	883.5
MBTU	173.0	231.5	637.0	322.5	261.4	0.0	0.0	132.2	0.0	7.0	850.0	6.7	2621.2

SG10: Site EUI

TOTAL SITE ENERGY 2621.21 MBTU — 31.1 KBTU/SQFT-YR GROSS-AREA — 31.1 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 6096.65 MBTU — 72.3 KBTU/SQFT-YR GROSS-AREA — 72.3 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 5.30
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 5
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 459

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

SG08: UMLH>300 exceeds the prescribed limit.

BEPU Building Utility Performance

REPORT- BEPU Building Utility Performance — WEATHER FILE- NEW YORK LAGUARDI NY

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY KWH	50677.	67833.	186640.	84677.	76588.	0.	0.	38722.	0.	2045.	0.	1971.	509152.
FM1 NATURAL-GAS THERM	0.	0.	0.	335.	0.	0.	0.	0.	0.	0.	8500.	0.	8835.

LI10, LI11: Annual LI kWh

PPO01, PPO03: Annual ML

SG09

SWH06, SWH07

TOTAL ELECTRICITY	509152. KWH	6.035 KWH	/SQFT-YR GROSS-AREA	6.035 KWH	/SQFT-YR NET-AREA
TOTAL NATURAL-GAS	8835. THERM	0.105 THERM	/SQFT-YR GROSS-AREA	0.105 THERM	/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 5.30
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 5
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 459

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

LE04, LE06: Exterior lighting is often the only end use contributing to this category. However, it may include other direct loads on meter such as fans in un-enclosed parking.

LV-B Summary of Spaces

REPORT- LV-B Summary of Spaces — WEATHER FILE- NEW YORK LAGUARDI NY

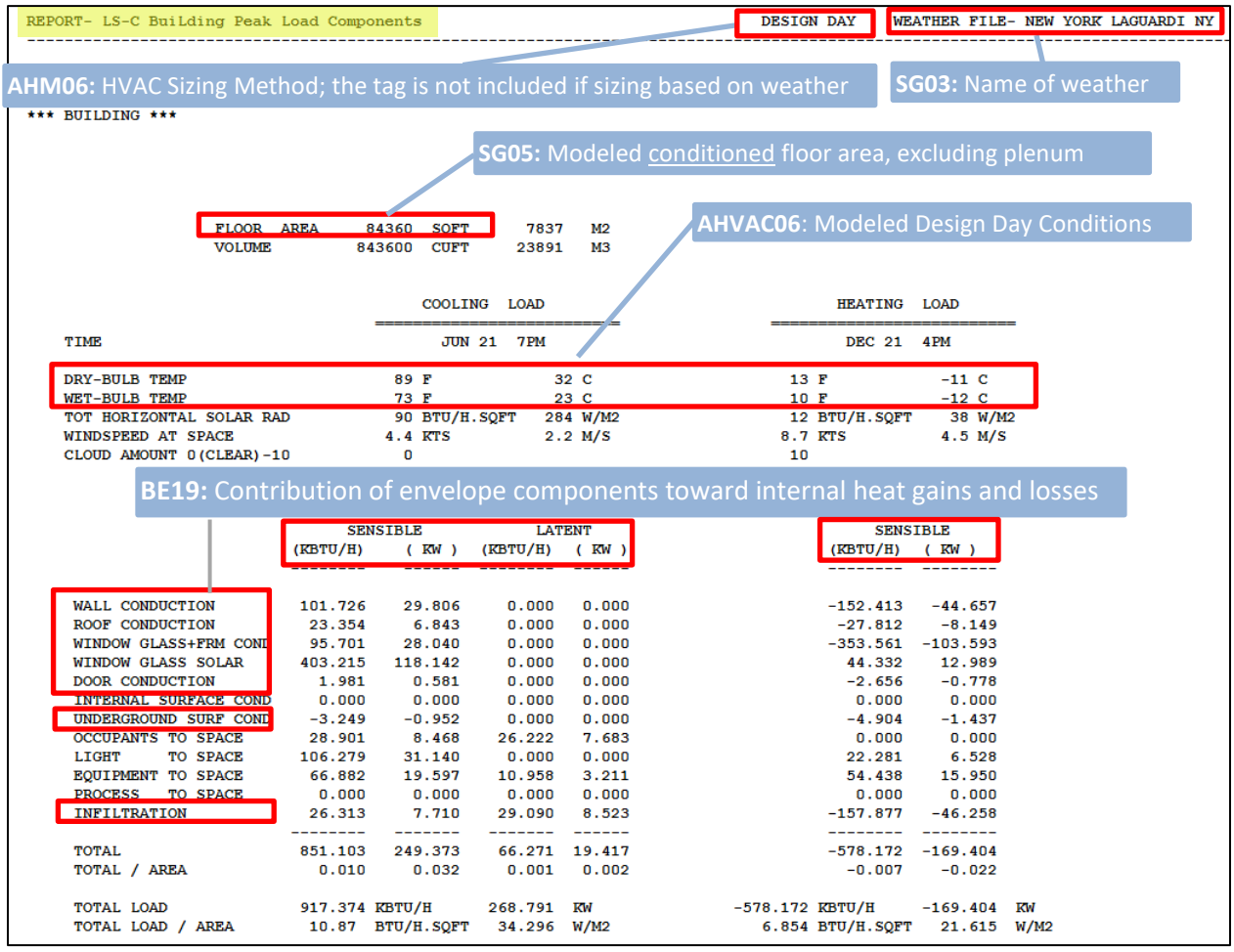
NUMBER OF SPA

BE18: "Air-Change" infiltration modeling method adjusts user-entered infiltration to account for weather, as required by 90.1 Table G3.1 No5 (b).
ACH column shows user-entered infiltration rate expressed as Air Changes per Hour (ACH).

SPACE	SPACE*FLOOR MULTIPLIER	SPACE TYPE	ASIM	LIGHTS (WATT / SQFT)	PEOPLE	EQUIP (WATT / SQFT)	INFILTRATION METHOD	ACH	AREA SQFT)	VOLUME (CUFT)
Spaces on floor: EL1 Ground Flr										
MER	1.0	EXT	0.0	1.50	0.0	0.26	AIR-CHANGE	0.19	950.0	9500.0
Stairwell2	1.0	EXT	0.0	0.60	0.0	0.26	AIR-CHANGE	0.19	950.0	9500.0
Stairwell1	1.0	EXT	0.0	0.60	0.0	0.26	AIR-CHANGE	0.19	950.0	9500.0
Office	1.0	EXT	-90.0	1.10	1.7	0.50	AIR-CHANGE	0.19	950.0	9500.0
EL1 Core Spc (G.C5)	1.0	EXT	0.0	0.50	0.8	0.20	AIR-CHANGE	0.19	836.0	8360.0
EL1 WSW Perim Spc (G.WSW6)	1.0	EXT	90.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
EL1 West Perim Spc (G.W7)	1.0	EXT	180.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
EL1 West Perim Spc (G.W8)	1.0	EXT	180.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
EL1 WNW Perim Spc (G.WNW9)	1.0	EXT	180.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
Spaces on floor: EL1 Mid Flr										
EL1 ESE Perim Spc (M.ESE10)	8.0	EXT	0.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
EL1 East Perim Spc (M.E11)	8.0	EXT	0.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
EL1 East Perim Spc (M.E12)	8.0	EXT	0.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
EL1 ENE Perim Spc (M.ENE13)	8.0	EXT	-90.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0
EL1 Core Spc (M.C14)	8.0	EXT	0.0	0.50	0.8	0.20	AIR-CHANGE	0.19	836.0	8360.0
EL1 WSW Perim Spc (M.WSW15)	8.0	EXT	90.0	1.10	1.7	0.65	AIR-CHANGE	0.19	950.0	9500.0

LI07: The total modeled wattage is the sum of products of Multiplier x LPD x Area. The same information is available in the CSV Space Loads report.

LS-C Building Peak Load Components



REPORT- LS-C BuiLding Peak Load Components — DESIGN DAY — WEATHER FILE- NEW YORK LAGUARDI NY

AHM06: HVAC Sizing Method; the tag is not included if sizing based on weather

SG03: Name of weather

*** BUILDING ***

SG05: Modeled conditioned floor area, excluding plenum

FLOOR AREA	84360	SQFT	7837	M2
VOLUME	843600	CUFT	23891	M3

AHVAC06: Modeled Design Day Conditions

	COOLING LOAD		HEATING LOAD	
TIME	JUN 21 7PM		DEC 21 4PM	
DRY-BULB TEMP	89 F	32 C	13 F	-11 C
WET-BULB TEMP	73 F	23 C	10 F	-12 C
TOT HORIZONTAL SOLAR RAD	90 BTU/H.SQFT	284 W/M2	12 BTU/H.SQFT	38 W/M2
WINDSPEED AT SPACE	4.4 KTS	2.2 M/S	8.7 KTS	4.5 M/S
CLOUD AMOUNT 0(CLEAR)-10	0		10	

BE19: Contribution of envelope components toward internal heat gains and losses

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	SENSIBLE (KBTU/H)	SENSIBLE (KW)
WALL CONDUCTION	101.726	29.806	0.000	0.000	-152.413	-44.657
ROOF CONDUCTION	23.354	6.843	0.000	0.000	-27.812	-8.149
WINDOW GLASS+FRM COND	95.701	28.040	0.000	0.000	-353.561	-103.593
WINDOW GLASS SOLAR	403.215	118.142	0.000	0.000	44.332	12.989
DOOR CONDUCTION	1.981	0.581	0.000	0.000	-2.656	-0.778
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-3.249	-0.952	0.000	0.000	-4.904	-1.437
OCCUPANTS TO SPACE	28.901	8.468	26.222	7.683	0.000	0.000
LIGHT TO SPACE	106.279	31.140	0.000	0.000	22.281	6.528
EQUIPMENT TO SPACE	66.882	19.597	10.958	3.211	54.438	15.950
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	26.313	7.710	29.090	8.523	-157.877	-46.258
TOTAL	851.103	249.373	66.271	19.417	-578.172	-169.404
TOTAL / AREA	0.010	0.032	0.001	0.002	-0.007	-0.022

TOTAL LOAD	917.374	KBTU/H	268.791	KW	-578.172	KBTU/H	-169.404	KW
TOTAL LOAD / AREA	10.87	BTU/H.SQFT	34.296	W/M2	6.854	BTU/H.SQFT	21.615	W/M2

Notes:

1. Heat losses are shown as negative numbers; heat gains are shown as positive numbers. For example, in the report above, conduction heat losses through windows contribute 353.561 kBtu/H toward the heating load; while window solar heat gains reduce peak heating load by 44.332.

LV-D Details of Exterior Surfaces

REPORT- LV-D Details of Exterior Surfaces — WEATHER FILE- NEW YORK LAGUARDI NY

BE1&2: U-values and areas of surfaces adjacent to the ambient conditions or ground for each modeled space
BE3&4: U-value and areas of fenestration area for each modeled space

SURFACE	- - - W I N D O W S - - - U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	- - - - W A L L - - - - U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	-W A L L + W I N D O W S- U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	AZIMUTH
EL1 North Wall (G.ENE4.E5) in space: Office	0.581	79.46	0.118	170.54	0.265	250.00	NORTH
EL1 North Wall (G.C5.E7) in space: EL1 Core Spc (G.C5)	0.531	16.50	0.063	38.50	0.203	55.00	NORTH
EL1 North Wall (G.WNW9.E14) in space: EL1 WNW Perim Spc (G.WNW9)	0.531	75.00	0.063	175.00	0.203	250.00	NORTH
EL1 North Slab (M.ENE13.S19) in space: EL1 ENE Perim Spc (M.ENE13)	0.000	0.00	0.481	100.00	0.481	100.00	NORTH
EL1 North Wall (M.ENE13.E19) in space: EL1 ENE Perim Spc (M.ENE13)	0.531	600.00	0.063	1400.00	0.203	2000.00	NORTH
EL1 North Slab (M.C14.S21) in space: EL1 Core Spc (M.C14)	0.000	0.00	0.481	22.00	0.481	22.00	NORTH

BE07, BE08, BE09, BE10 : The totals for the building by exposure are summarized at the end of the report

: of Exterior Surfaces — WEATHER FILE- NEW YORK LAGUARDI NY (CONTINUED)

	AVERAGE U-VALUE/WINDOWS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+WINDOWS (BTU/HR-SQFT-F)	WINDOW AREA (SQFT)	WALL AREA (SQFT)	WINDOW+WALL AREA (SQFT)
NORTH	0.533	0.090	0.218	1669.46	4130.29	5799.75
EAST	0.531	0.093	0.218	4535.20	11348.80	15884.00
SOUTH	0.533	0.090	0.218	1669.46	4130.29	5799.75
WEST	0.531	0.088	0.215	4535.20	11348.80	15884.00
ROOF	0.000	0.061	0.061	0.00	8436.00	8436.00
ALL WALLS	0.532	0.091	0.217	12409.33	30958.16	43367.50
WALLS+ROOFS	0.532	0.084	0.191	12409.33	39394.16	51803.50
UNDERGRND	0.000	0.038	0.038	0.00	8436.00	8436.00
BUILDING	0.532	0.076	0.170	12409.33	47830.16	60239.50

BE06, BE08: The model has the following area-weighted average U-values: roof U-0.061; exterior walls U-0.091; windows U-0.532

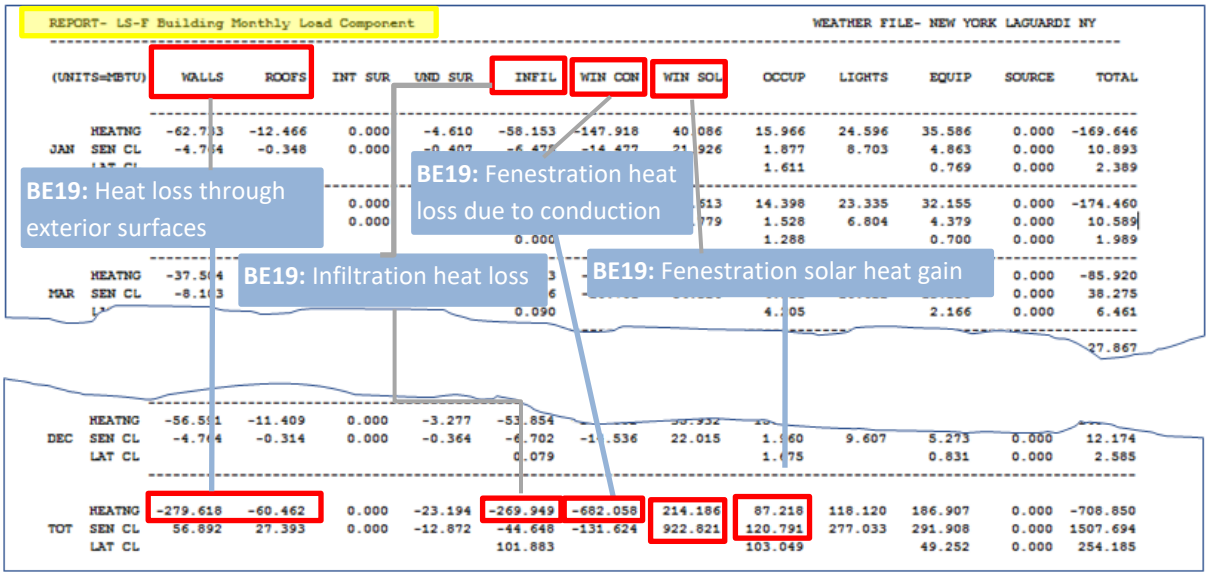
BE06, BE07: The model has the following total surface areas: 12,409 ft^2 windows; 51,804 ft^2 gross exterior wall including windows; 8,436 ft^2 roof area; 8,436 ft^2 below grade walls, floor and slab-on-grade.

BE14: Modeled WWR is 12409/43368=28.6%

Notes:

1. Projects may have exaggerated area of roof or exposed and below grade floors due to common modeling mistake, when exposed horizontal surfaces are sandwiched between the floor that were modeled as different Building Shells when the project was created in the Wizard. If the proposed roof is better insulated than the baseline (budget) and its area is doubled, it's contribution toward the trade-offs will also be exaggerated by the factor of 2.

LS-F Building Monthly Load Components



Notes:

1. Negative numbers indicate heat losses; positive numbers indicate heat gains
2. Jan – Dec values provided in the report indicate that the full annual simulation was completed for 8,760 hours/year.

SS-D Building HVAC Load Summary

REPORT- SS-D Building HVAC Load Summary — WEATHER FILE- NEW YORK LAGUARDI NY

	COOLING					HEATING					ELEC	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	28.56705	11	8	25.F	20.F	257.824	-104.594	25	7	19.F	16.F	-720.587	36969.	129.831
FEB	29.97058	6	8	7.F	5.F	254.431	-103.721	6	8	7.F	5.F	-740.835	35847.	131.865
MAR	25.74771	15	16	69.F	55.F	484.179	-61.423	1	8	37.F	35.F	-604.330	39845.	150.022
APR	39.53304	27	16	78.F	65.F	712.008	-22.636	5	8	46.F	42.F	-330.268	39414.	170.084
MAY	83.86207	25	15	85.F	69.F	858.740	-7.373	20	8	48.F	45.F	-200.396	42753.	188.845
JUN	218.80797	18	17	91.F	77.F	1045.090	-0.906	1	22	60.F	59.F	-70.541	56485.	216.502
JUL	306.24469	8	14	95.F	80.F	1222.826	-0.133	14	22	72.F	70.F	-14.996	65341.	240.500
AUG	280.24261	24	14	91.F	75.F	1074.308	-0.200	19	22	68.F	56.F	-21.934	63048.	219.270
SEP	173.06245	10	14	82.F	74.F	994.159	-2.927	30	22	52.F	48.F	-154.073	50939.	199.313
OCT	80.79825	5	16	79.F	64.F	815.780	-12.397	18	8	44.F	37.F	-270.316	41904.	179.440
NOV	31.42019	4	16	70.F	57.F	612.884	-38.495	27	8	27.F	24.F	-546.697	36531.	158.274
DEC	27.46401	16	12	43.F	37.F	285.190	-87.754	6	8	28.F	27.F	-691.092	38356.	137.048
TOTAL	1325.722						-442.559						547429.	
MAX						1222.826						-740.835		240.500

MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY) 0.000 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE) 0.000 (KBTU)

AHVAC31: Projects with significant simultaneous heating and cooling have high cooling energy use during winter months and high heating energy use during summer months.

SS-E Building HVAC Load Hours

REPORT- SS-E Building HVAC Load Hours — WEATHER FILE- NEW YORK LAGUARDI NY

MONTH	HOURS COOLING LOAD	HOURS HEATING LOAD	HOURS COINCIDENT COOL-HEAT LOAD	HOURS FLOATING	HOURS HEATING AVAIL.	HOURS COOLING AVAIL.	HOURS FANS ON	HOURS FANS CYCLE ON	HOURS NIGHT VENTING	HOURS FLOATING WHEN FANS ON	HEATING LOAD AT COOLING PEAK (KBTU/HR)	ELECTRIC LOAD AT COOLING PEAK (KW)
	NUMBER OF HOURS										COINCIDENT LOADS	
JAN	505	588	504	155	744	744	593	277	0	4	-709.923	82.295
FEB	491	574	486	93	672	672	579	273	0	0	-740.834	66.361
MAR	278	460	272	278	744	744	495	133	0	29	0.000	147.579
APR	187	298	96	331	720	720	440	92	0	51	0.000	167.165
MAY	312	154	65	343	744	744	435	105	0	34	0.000	187.281
JUN	433	58	58	287	720	720	435	87	0	2	0.000	212.929
JUL	477	20	20	267	744	744	477	133	0	0	0.000	240.500
AUG	462	26	26	282	744	744	462	114	0	0	0.000	219.270
SEP	387	113	82	302	720	720	423	89	0	5	0.000	199.313
OCT	264	237	118	361	744	744	405	75	0	22	0.000	178.396
NOV	193	340	155	342	720	720	396	76	0	18	0.000	155.707
DEC	438	543	430	193	744	744	553	219	0	2	-64.518	137.048
ANNUAL	4427	3411	2312	3234	8760	8760	5693	1673	0	167		

AHVAC31: Large hours of simultaneous heating/cooling, especially in summer, may indicate overcooling and excessive reheat.

AHVAC31: Hours when at least one air-side system is running to provide HVAC during occupied hours plus night cycling to maintain setback temperature.

SS-H: System Utility Energy Use

REPORT- SS-H System Utility Energy Use for RTU1 (PVAV) (G) — WEATHER FILE- NEW YORK LAGUARDI NY

MONTH	FAN ELEC FAN ENERGY (KWH)	FAN ELEC MAXIMUM FAN LOAD (KW)	FUEL HEAT GAS OIL ENERGY (MBTU)	FUEL HEAT MAXIMUM GAS OIL LOAD (KBTU/HR)	FUEL COOL GAS OIL ENERGY (MBTU)	FUEL COOL MAXIMUM GAS OIL LOAD (KBTU/HR)	ELEC HEAT ELECTRIC ENERGY (KWH)	ELEC HEAT MAXIMUM ELECTRIC LOAD (KW)	ELEC COOL ELECTRIC ENERGY (KWH)	ELEC COOL MAXIMUM ELECTRIC LOAD (KW)
JAN	1093.	2.744	0.000	0.000	0.000	0.000	0.	0.000	1178.	10.371
FEB	1073.	2.809	0.000	0.000	0.000	0.000	0.	0.000	1187.	10.554
MAR	936.	2.933	0.000	0.000	0.000	0.000	0.	0.000	982.	13.521
APR	891.	4.052	0.000	0.000	0.000	0.000	0.	0.000	1256.	18.646
MAY	907.	4.261	0.000	0.000	0.000	0.000	0.	0.000	2604.	23.345
JUN	1002.	4.284	0.000	0.000	0.000	0.000	0.	0.000	5979.	30.978
JUL	1143.	5.038	0.000	0.000	0.000	0.000	0.	0.000	8506.	37.213
AUG	1164.	4.739	0.000	0.000	0.000	0.000	0.	0.000	7713.	31.434
SEP	983.	4.446	0.000	0.000	0.000	0.000	0.	0.000	4859.	26.681
OCT	913.	4.400	0.000	0.000	0.000	0.000	0.	0.000	2469.	21.777
NOV	789.	3.475	0.000	0.000	0.000	0.000	0.	0.000	1075.	15.813
DEC	1031.	2.811	0.000	0.000	0.000	0.000	0.	0.000	1130.	11.182
TOTAL	11925.		0.000		0.000		0.		38938.	
MAX		5.038		0.000				0.000		37.213

AHVAC19: Fan Peak Demand

SS-L Fan Electric Energy Use

REPORT- SS-L Fan Electric Energy Use for RTU1 (PVAV) (G) WEATHER FILE- NEW YORK LAGUARDI NY

MONTH	FAN ELEC DURING HEATING (KWH)	FAN ELEC DURING COOLING (KWH)	FAN ELEC DURING HEAT & COOL (KWH)	FAN ELEC DURING FLOATING (KWH)	Number of hours within each PART LOAD range 00 10	10 20	20 30	30 40	40 50	50 60	60 70	70 80	80 90	90 100	100 +	TOTAL RUN HOURS
JAN	1084.152	827.287	825.504	7.130	0	0	0	574	19	0	0	0	0	0	0	593
FEB	1058.964	812.834	803.922	5.134	0	0	0	556	22	0	0	0	0	0	0	578
MAR	855.060	507.156	489.272	63.429	0	0	0	454	41	0	0	0	0	0	0	495
APR	539.980	396.757	177.030	131.024	0	0	0	344	87	7	0	0	0	0	0	438
MAY	283.607	662.653	123.588	84.816	0	0	0	329	88	13	0	0	0	0	0	430
JUN	103.750	997.733	103.750	4.412	0	0	0	260	108	60	0	0	0	0	0	428
JUL	36.433	1142.660	36.433	0.000	0	0	0	267	101	90	2	0	0	0	0	460
AUG	47.278	1164.255	47.278	0.000	0	0	0	245	86	121	0	0	0	0	0	452
SEP	212.776	904.918	146.316	11.186	0	0	0	277	80	62	0	0	0	0	0	419
OCT	473.365	613.012	226.470	53.320	0	0	0	260	105	36	0	0	0	0	0	401
NOV	641.018	380.708	266.163	33.020	0	0	0	321	72	2	0	0	0	0	0	395
DEC	1012.801	723.145	710.372	5.347	0	0	0	521	32	0	0	0	0	0	0	553
ANNUAL	6349.336	9133.087	3956.077	398.819	0	0	0	4408	841	391	2	0	0	0	0	5642

BREAKDOWN OF ANNUAL FAN POWER USAGE

FAN TYPE	ANNUAL FAN ELEC (KWH)
SUPPLY	8347.
RETURN	3577.

AHVAC18: Fan in the example has minimum flow of 30% - 40% and never operates above 60% - 70% of the design CFM.

VAV system fans and constant volume systems with cycling fans will have hours with part load <100%.

SS-O Space Temperature Summary

REPORT- SS-O Space Temperature Summary for EL2 North Perim Zn (T.N87) WEATHER FILE- New York CityNY TMY2

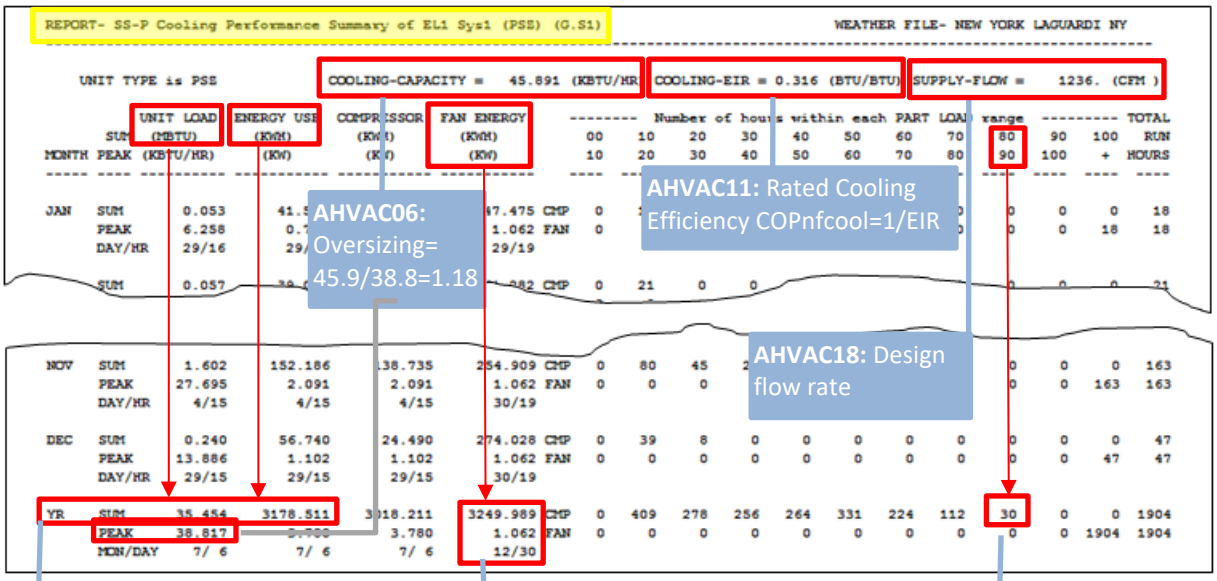
TOTAL HOURS AT TEMPERATURE LEVEL AND TIME OF DAY

HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
ABOVE 85	3	3	3	2	1	2	2	2	2	4	4	6	6	6	6	5	5	5	5	5	4	4	4	3	92
80-85	41	39	35	31	33	34	36	37	46	48	52	53	58	62	64	63	61	59	56	53	52	49	47	42	1151
75-80	65	65	67	68	68	66	66	68	62	59	59	57	56	55	53	53	53	55	58	59	60	62	62	66	1462
70-75	228	223	217	210	203	199	200	255	252	252	249	248	245	242	242	244	246	246	246	248	249	249	251	236	5680
65-70	28	35	43	54	60	64	61	3	3	2	1	1	0	0	0	0	0	0	0	0	0	1	1	18	375
60-65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SG08: The zone is significantly under-cooled, with 80F+ space temperatures for over a thousand hours (see TOTAL column). Temperatures will not be listed for hours when zone is unoccupied and HVAC system is off.

This is a zone-level report. Reports for all modeled zones are included in the *.SIM file.

SS-P – Cooling (Heating) Performance Summary



REPORT- SS-P Cooling Performance Summary of EL1 Sys1 (PSS) (G.S1)

WEATHER FILE- NEW YORK LAGUARDI NY

UNIT TYPE is PSE

COOLING-CAPACITY = 45.891 (KBTU/HR) COOLING-EIR = 0.316 (BTU/BTU) SUPPLY-FLOW = 1236. (CFM)

		UNIT LOAD (MBTU)	ENERGY USE (KWH)	COMPRESSOR (KW)	FAN ENERGY (KWH)		Number of hours within each PART LOAD range 00	10	20	30	40	50	60	70	80	90	100	TOTAL RUN
MONTH	PEAK	(KBTU/HR)	(KW)	(KW)	(KW)		10	20	30	40	50	60	70	80	90	100	+	HOURS
JAN	SUM	0.053	41.5		47.475	CMP	0									0	0	18
	PEAK	6.258	0.7		1.062	FAN	0									0	18	18
	DAY/HR	29/16	29/		29/19													
	SUM	0.057	39.0		382	CMP	0	21	0	0						0	0	21
NOV	SUM	1.602	152.186	138.735	254.909	CMP	0	80	45	2						0	0	163
	PEAK	27.695	2.091	2.091	1.062	FAN	0	0	0							0	163	163
	DAY/HR	4/15	4/15	4/15	30/19													
DEC	SUM	0.240	56.740	24.490	274.028	CMP	0	39	8	0	0	0	0	0	0	0	0	47
	PEAK	13.886	1.102	1.102	1.062	FAN	0	0	0	0	0	0	0	0	0	0	47	47
	DAY/HR	29/15	29/15	29/15	30/19													
YR	SUM	35.454	3178.511	3018.211	3249.989	CMP	0	409	278	256	264	331	224	112	30	0	0	1904
	PEAK	38.817	5.700	3.780	1.062	FAN	0	0	0	0	0	0	0	0	0	0	1904	1904
	MON/DAY	7/ 6	7/ 6	7/ 6	12/30													

AHVAC06: Oversizing= 45.9/38.8=1.18

AHVAC11: Rated Cooling Efficiency COPnfcool=1/EIR

AHVAC18: Design flow rate

AHVAC12: Average realized DX efficiency excluding system supply & return fans: $COP_{nfcooling,avg}$ =35.454*1000/3.412/3178.511=3.269 $EIR_{nfcooling,avg}$ =1/$COP_{nfcooling,avg}$ = 0.305

AHVAC18, AHVAC19: Peak fan demand for all fans of this system is 1.062 KW

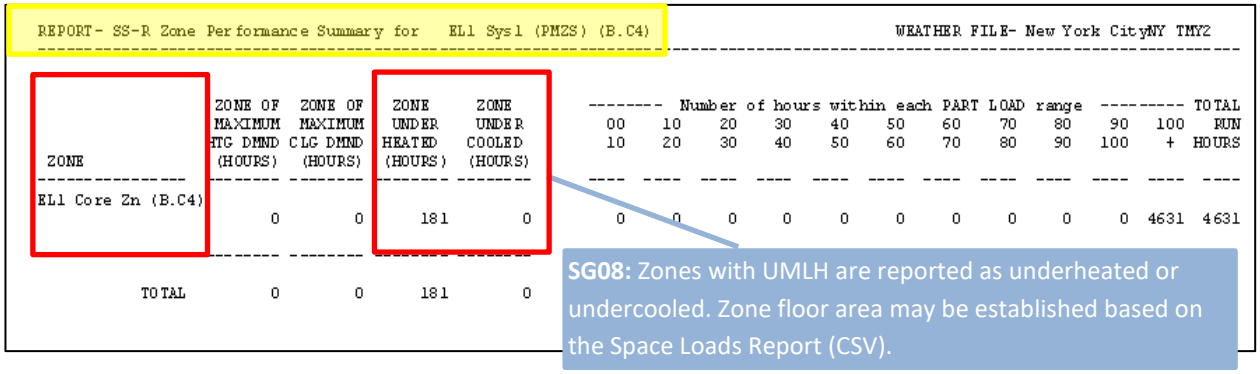
AHM12: Fan system energy 3250 kWh/yr;
EFLH ~ 3250/1.1 = 2955

AHVAC06: Maximum cooling load is 80%-90% cooling capacity; cooling coil is oversized by 10%-20%

Notes:

1. An SS-P report is available for each air-handler.
2. An instance of SS-P report is also generated for each system with DX (heat pump) heating.

SS-R Zone Performance Summary



REPORT- SS-R Zone Performance Summary for EL1 Sys1 (PMZS) (B.C4) WEATHER FILE- New York CityNY TMY2

ZONE	ZONE OF MAXIMUM HTG DMND (HOURS)	ZONE OF MAXIMUM CLG DMND (HOURS)	ZONE UNDER HEATED (HOURS)	ZONE UNDER COOLED (HOURS)	Number of hours within each PART LOAD range 00 10	10 20	20 30	30 40	40 50	50 60	60 70	70 80	80 90	90 100	100 +	TOTAL RUN HOURS
EL1 Core Zn (B.C4)	0	0	181	0	0	0	0	0	0	0	0	0	0	0	4631	4631
TOTAL	0	0	181	0												

SG08: Zones with UMLH are reported as underheated or undercooled. Zone floor area may be established based on the Space Loads Report (CSV).

SV-A System Design Parameters

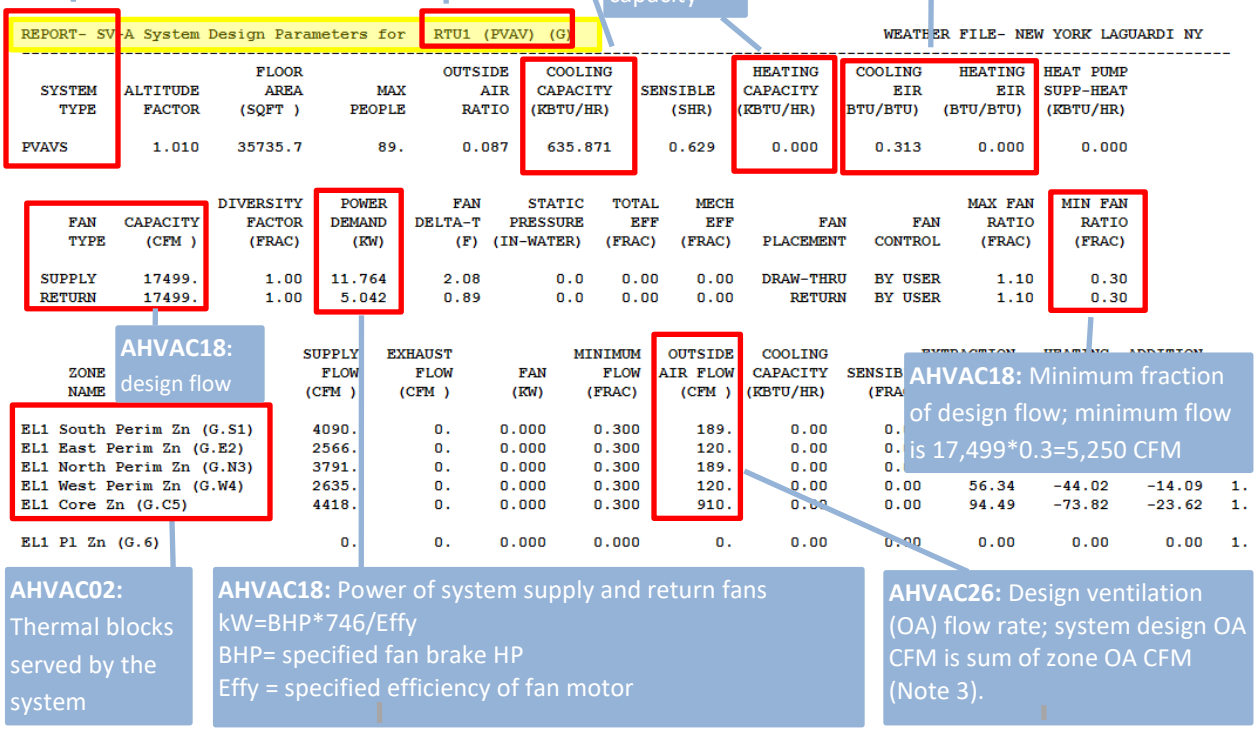
AHVAC06: System type

AHVAC06: System name

AHM4: cooling capacity

AHVAC06: unitary heating capacity

AHVAC11: DX equipment efficiency at AHRI rated conditions excluding system fan power; COP=1/EIR



REPORT- SV-A System Design Parameters for RTU1 (PVAV) (G) WEATHER FILE- NEW YORK LAGUARDI NY

SYSTEM TYPE	ALTITUDE FACTOR	FLOOR AREA (SQFT)	MAX PEOPLE	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR BTU/BTU)	HEATING EIR (BTU/BTU)	HEAT PUMP SUPP-HEAT (KBTU/HR)
PVAVS	1.010	35735.7	89.	0.087	635.871	0.629	0.000	0.313	0.000	0.000

FAN TYPE	CAPACITY (CFM)	DIVERSITY FACTOR (FRAC)	POWER DEMAND (KW)	FAN DELTA-T (F)	STATIC PRESSURE (IN-WATER)	TOTAL EFF (FRAC)	MECH EFF (FRAC)	FAN PLACEMENT	FAN CONTROL	MAX FAN RATIO (FRAC)	MIN FAN RATIO (FRAC)
SUPPLY	17499.	1.00	11.764	2.08	0.0	0.00	0.00	DRAW-THRU	BY USER	1.10	0.30
RETURN	17499.	1.00	5.042	0.89	0.0	0.00	0.00	RETURN	BY USER	1.10	0.30

AHVAC18: design flow

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW (FRAC)	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIB (FRA				
EL1 South Perim Zn (G.S1)	4090.	0.	0.000	0.300	189.	0.00	0.				
EL1 East Perim Zn (G.E2)	2566.	0.	0.000	0.300	120.	0.00	0.				
EL1 North Perim Zn (G.N3)	3791.	0.	0.000	0.300	189.	0.00	0.				
EL1 West Perim Zn (G.W4)	2635.	0.	0.000	0.300	120.	0.00	0.00	56.34	-44.02	-14.09	1.
EL1 Core Zn (G.C5)	4418.	0.	0.000	0.300	910.	0.00	0.00	94.49	-73.82	-23.62	1.
EL1 Pl Zn (G.6)	0.	0.	0.000	0.000	0.	0.00	0.00	0.00	0.00	0.00	1.

AHVAC18: Minimum fraction of design flow; minimum flow is 17,499*0.3=5,250 CFM

AHVAC02: Thermal blocks served by the system

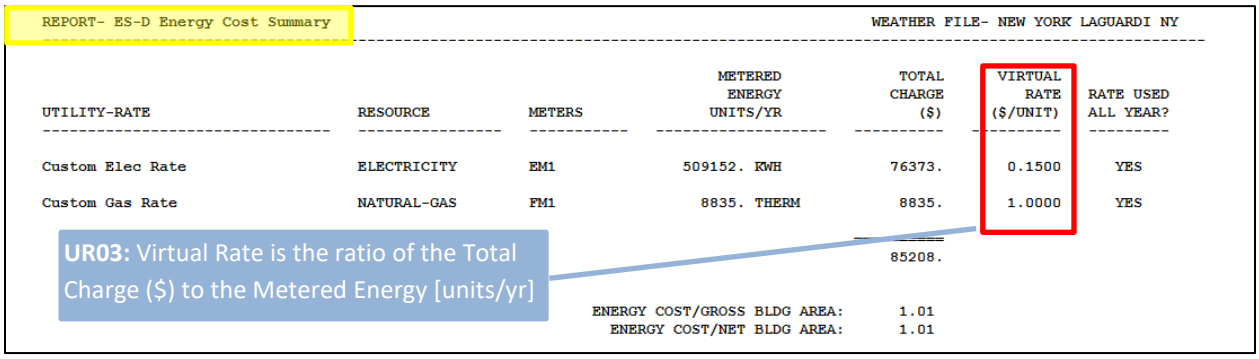
AHVAC18: Power of system supply and return fans
kW=BHP*746/Effy
BHP= specified fan brake HP
Effy = specified efficiency of fan motor

AHVAC26: Design ventilation (OA) flow rate; system design OA CFM is sum of zone OA CFM (Note 3).

Notes:

1. SV-A report is available for each modeled air handler.
2. Refer to eQUEST “Detailed Simulation Reports Summary” p.84 of the pdf for detailed description of other values shown in the SV-A report.
3. Design OA flow in the simulation may be different, based on the entered ventilation schedule.

ES-D Energy Cost Summary



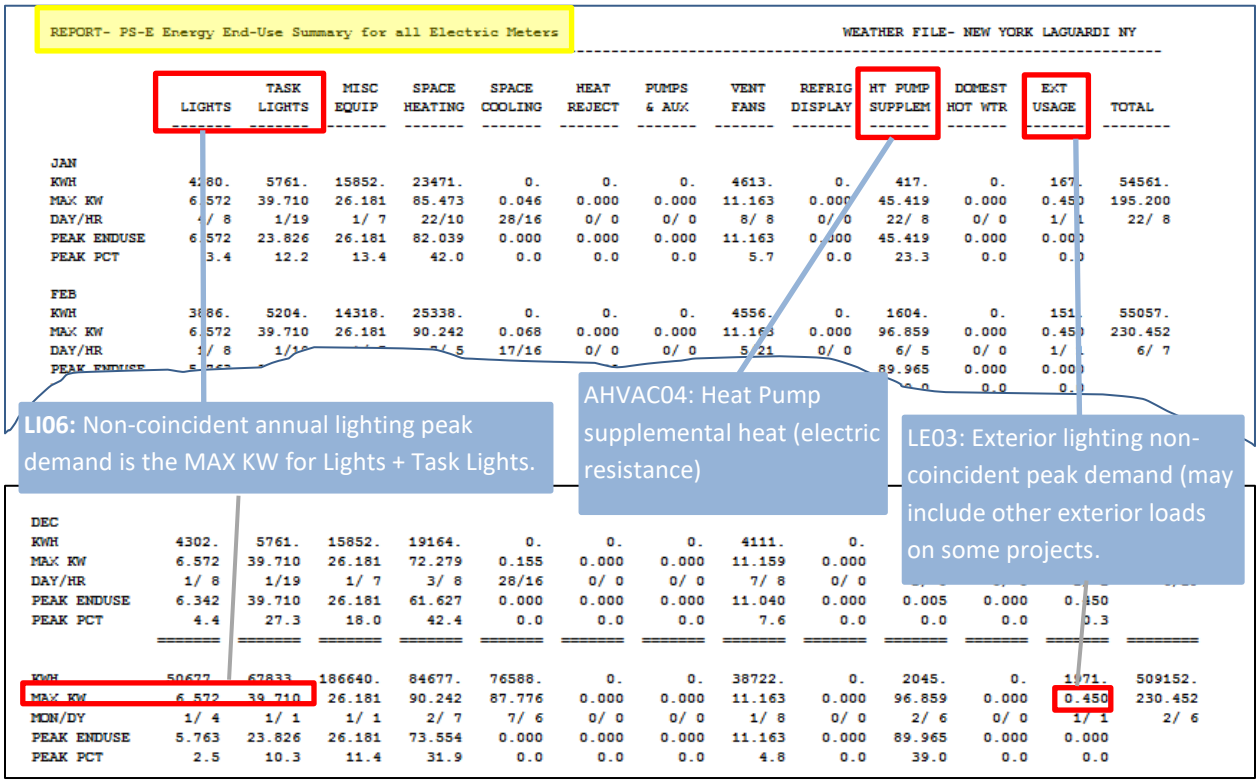
REPORT- ES-D Energy Cost Summary — WEATHER FILE- NEW YORK LAGUARDI NY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
Custom Elec Rate	ELECTRICITY	EM1	509152. KWH	76373.	0.1500	YES
Custom Gas Rate	NATURAL-GAS	FM1	8835. THERM	8835.	1.0000	YES
				85208.		

ENERGY COST/GROSS BLDG AREA: 1.01
ENERGY COST/NET BLDG AREA: 1.01

UR03: Virtual Rate is the ratio of the Total Charge ($) to the Metered Energy [units/yr]

PS-E Energy End Use Summary for all Electric Meters



REPORT- PS-E Energy End-Use Summary for all Electric Meters — WEATHER FILE- NEW YORK LAGUARDI NY

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
JAN													
KWH	4280.	5761.	15852.	23471.	0.	0.	0.	4613.	0.	417.	0.	167.	54561.
MAX KW	6.572	39.710	26.181	85.473	0.046	0.000	0.000	11.163	0.000	45.419	0.000	0.450	195.200
DAY/HR	1/ 8	1/19	1/ 7	22/10	28/16	0/ 0	0/ 0	8/ 8	0/ 0	22/ 8	0/ 0	1/ 1	22/ 8
PEAK ENDUSE	6.572	23.826	26.181	82.039	0.000	0.000	0.000	11.163	0.000	45.419	0.000	0.000	
PEAK PCT	3.4	12.2	13.4	42.0	0.0	0.0	0.0	5.7	0.0	23.3	0.0	0.0	
FEB													
KWH	3886.	5204.	14318.	25338.	0.	0.	0.	4556.	0.	1604.	0.	151.	55057.
MAX KW	6.572	39.710	26.181	90.242	0.068	0.000	0.000	11.163	0.000	96.859	0.000	0.450	230.452
DAY/HR	1/ 8	1/19	1/ 7	3/ 5	17/16	0/ 0	0/ 0	5/21	0/ 0	6/ 5	0/ 0	1/ 1	6/ 7
PEAK ENDUSE	5.763									89.965	0.000	0.000	
PEAK PCT											0.0	0.0	
DEC													
KWH	4302.	5761.	15852.	19164.	0.	0.	0.	4111.	0.				
MAX KW	6.572	39.710	26.181	72.279	0.155	0.000	0.000	11.159	0.000				
DAY/HR	1/ 8	1/19	1/ 7	3/ 8	28/16	0/ 0	0/ 0	7/ 8	0/ 0				
PEAK ENDUSE	6.342	39.710	26.181	61.627	0.000	0.000	0.000	11.040	0.000	0.005	0.000	0.450	
PEAK PCT	4.4	27.3	18.0	42.4	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.3	
KWH	50677	67833	186640.	84677.	76588.	0.	0.	38722.	0.	2045.	0.	1971.	509152.
MAX KW	6.572	39.710	26.181	90.242	87.776	0.000	0.000	11.163	0.000	96.859	0.000	0.450	230.452
MON/DY	1/ 4	1/ 1	1/ 1	2/ 7	7/ 6	0/ 0	0/ 0	1/ 8	0/ 0	2/ 6	0/ 0	1/ 1	2/ 6
PEAK ENDUSE	5.763	23.826	26.181	73.554	0.000	0.000	0.000	11.163	0.000	89.965	0.000	0.000	
PEAK PCT	2.5	10.3	11.4	31.9	0.0	0.0	0.0	4.8	0.0	39.0	0.0	0.0	

LI06: Non-coincident annual lighting peak demand is the MAX KW for Lights + Task Lights.

AHVAC04: Heat Pump supplemental heat (electric resistance)

LE03: Exterior lighting non-coincident peak demand (may include other exterior loads on some projects.

PS-C Equipment Loads and Energy Use

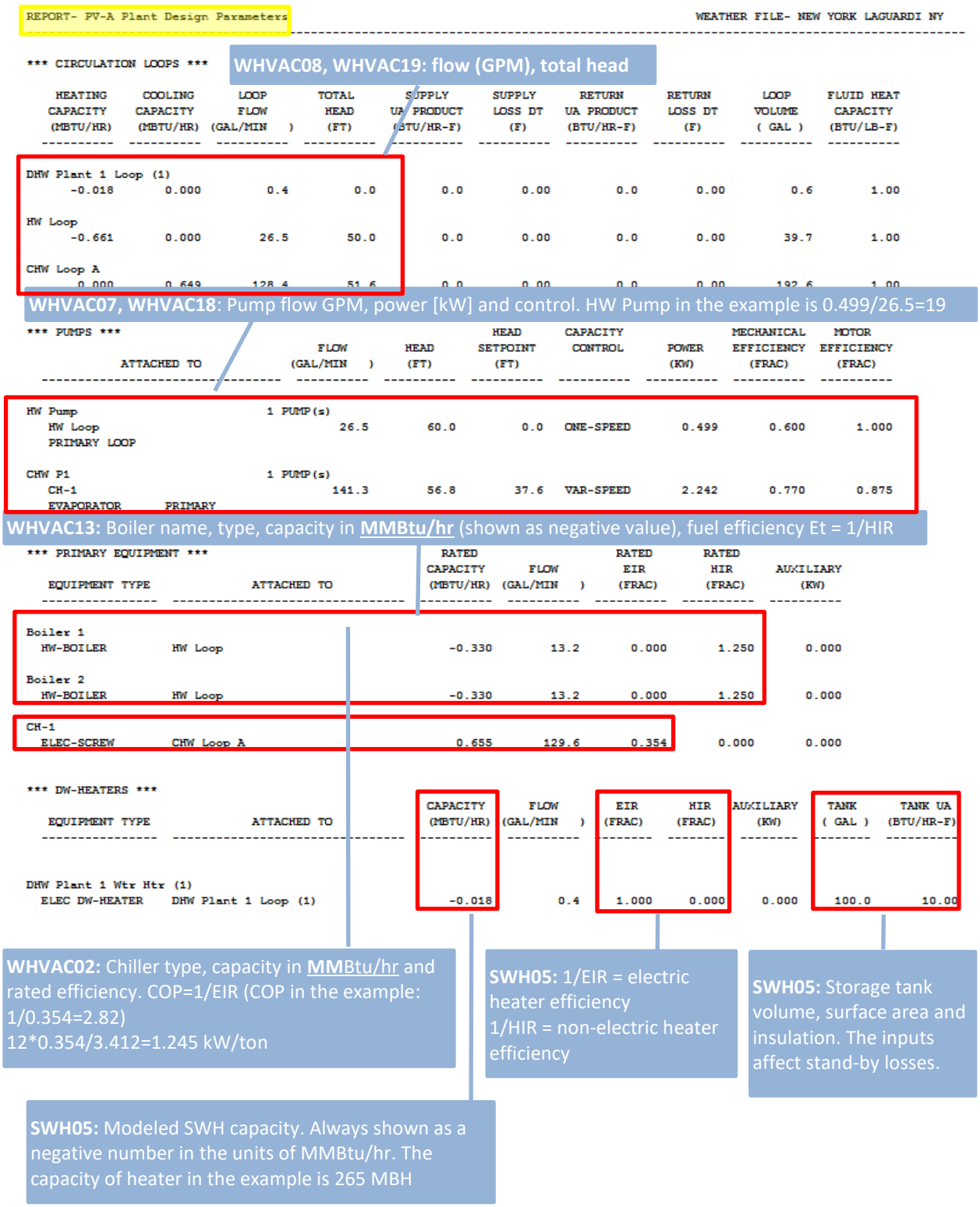
REPORT- PS-C Equipment Loads and Energy Use — WEATHER FILE- NEW YORK LAGUARDI NY

		COOL LOAD	HEAT LOAD	ELEC USE	FUEL USE		Number of hours within each PART LOAD range										TOTAL
	SUM	(MBTU)	(MBTU)	(KWH)	(MBTU)		00	10	20	30	40	50	60	70	80	90	100	RUN
MON	PEAK	(KBTU/HR)	(KBTU/HR)	(KW)	(KBTU/HR)		10	20	30	40	50	60	70	80	90	100	+	HOURS
Boiler 1																		
	SUM		-375.2	0.0	556.2	LOAD	985	623	384	308	222	135	139	96	54	39	31	3016
	PEAK		-568.9	0.0	689.7	ELEC	0	0	0	0	0	0	0	0	0	0	0	0
	MON/DAY		12/13	0/ 0	12/13	FUEL	495	848	476	344	247	199	130	125	73	48	31	3016
Boiler 2																		
	SUM		-63.5	0.0	89.6	LOAD	87	78	37	24	24	26	47	17	6	5	19	370
	PEAK		-570.5	0.0	691.3	ELEC	0	0	0	0	0	0	0	0	0	0	0	0
	MON/DAY		1/12	0/ 0	1/12	FUEL	40	93	51	30	23	27	29	39	12	7	19	370
DHW Plant 1 Wtr Htr (1)																		
	SUM		-38.7	13107.2		LOAD	1271	826	918	535	554	664	500	310	168	163	23	5932
	PEAK		-18.4	5.4		ELEC	3156	1010	680	826	462	569	561	439	250	101	106	8760
	MON/DAY		3/ 1	2/ 1														
HW Pump																		
	SUM			1113.5		FLOW	2212	774	293	101	30	1	0	0	0	0	0	3411
	PEAK			0.5		RPM	0	0	0	0	0	0	0	0	0	0	3411	3411
	MON/DAY			1/ 2		ELEC	0	0	0	0	2754	519	125	13	0	0	0	3411

WHVAC03, WHVAC14: The average realized plant (boiler or chiller) efficiency is the ratio of Heat Load to Fuel Use.
In the example, the average efficiency of the Hot Water Plant (Boiler 1 and Boiler 2 combined) is 68%.

Heat Load =375.2+63.5= 438.7 MMBtu
Fuel Use = 556.2+89.6=645.8
$Effy_{avg}$ = 438.7/645.8=68%

PV-A Plant Design Parameters



REPORT- PV-A Plant Design Parameters — WEATHER FILE- NEW YORK LAGUARDI NY

*** CIRCULATION LOOPS ***

WHVAC08, WHVAC19: flow (GPM), total head

	HEATING CAPACITY (MBTU/HR)	COOLING CAPACITY (MBTU/HR)	LOOP FLOW (GAL/MIN)	TOTAL HEAD (FT)	SUPPLY UA PRODUCT (BTU/HR-F)	SUPPLY LOSS DT (F)	RETURN UA PRODUCT (BTU/HR-F)	RETURN LOSS DT (F)	LOOP VOLUME (GAL)	FLUID HEAT CAPACITY (BTU/LB-F)
DHW Plant 1 Loop (1)	-0.018	0.000	0.4	0.0	0.0	0.00	0.0	0.00	0.6	1.00
HW Loop	-0.661	0.000	26.5	50.0	0.0	0.00	0.0	0.00	39.7	1.00
CHW Loop A	0.000	0.649	128.4	51.6	0.0	0.00	0.0	0.00	192.6	1.00

WHVAC07, WHVAC18: Pump flow GPM, power [kW] and control. HW Pump in the example is 0.499/26.5=19

*** PUMPS ***

	ATTACHED TO		FLOW (GAL/MIN)	HEAD (FT)	HEAD SETPOINT (FT)	CAPACITY CONTROL	POWER (KW)	MECHANICAL EFFICIENCY (FRAC)	MOTOR EFFICIENCY (FRAC)
HW Pump		1 PUMP(s)							
HW Loop			26.5	60.0	0.0	ONE-SPEED	0.499	0.600	1.000
PRIMARY LOOP									
CHW P1		1 PUMP(s)							
CH-1			141.3	56.8	37.6	VAR-SPEED	2.242	0.770	0.875
EVAPORATOR	PRIMARY								

WHVAC13: Boiler name, type, capacity in **MMBtu/hr** (shown as negative value), fuel efficiency Et = 1/HIR

*** PRIMARY EQUIPMENT ***

EQUIPMENT TYPE	ATTACHED TO	RATED CAPACITY (MBTU/HR)	FLOW (GAL/MIN)	RATED EIR (FRAC)	RATED HIR (FRAC)	AUXILIARY (KW)
Boiler 1						
HW-BOILER	HW Loop	-0.330	13.2	0.000	1.250	0.000
Boiler 2						
HW-BOILER	HW Loop	-0.330	13.2	0.000	1.250	0.000
CH-1						
ELEC-SCREW	CHW Loop A	0.655	129.6	0.354	0.000	0.000

*** DW-HEATERS ***

EQUIPMENT TYPE	ATTACHED TO	CAPACITY (MBTU/HR)	FLOW (GAL/MIN)	EIR (FRAC)	HIR (FRAC)	AUXILIARY (KW)	TANK (GAL)	TANK UA (BTU/HR-F)
DHW Plant 1 Wtr Htr (1)								
ELEC DW-HEATER	DHW Plant 1 Loop (1)	-0.018	0.4	1.000	0.000	0.000	100.0	10.00

WHVAC02: Chiller type, capacity in **MM**Btu/hr and rated efficiency. COP=1/EIR (COP in the example: 1/0.354=2.82)
12*0.354/3.412=1.245 kW/ton

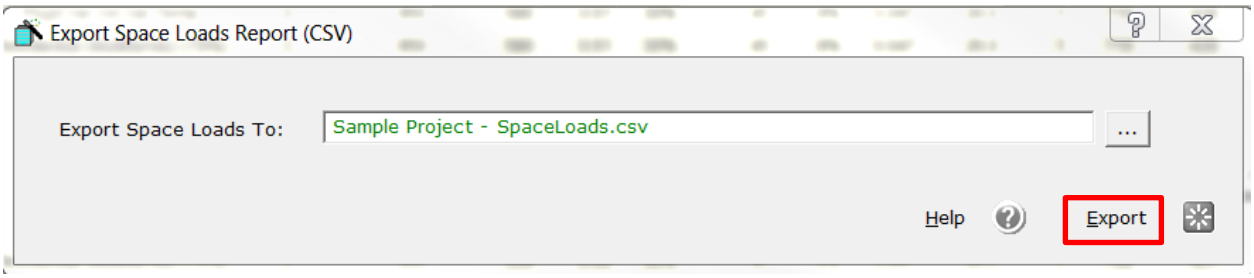
SWH05: 1/EIR = electric heater efficiency
1/HIR = non-electric heater efficiency

SWH05: Storage tank volume, surface area and insulation. The inputs affect stand-by losses.

SWH05: Modeled SWH capacity. Always shown as a negative number in the units of MMBtu/hr. The capacity of heater in the example is 265 MBH

Space Loads Report (CSV)

To generate the report, select File -> Export File -> Space Loads Report (CSV) from the main eQUEST interface and then click Export button.



	A	B	C	D	E	F	G	H	I
4	eQUEST 3.65.7173								
5	Space/Zone Internal Loads Report								
6									
7	Component Names:				Basic Specifications:			Multipliers:	
8	Space	Thermal Zone	Parent Floor	HVAC System	Zone Type	Activity Description	Area	Space	Floor
9									
10	MER	EL1 ESE Perim Zn (G.ESE1)	MER	Unit Heater	Conditioned	Residential (Multifamily	950	1	1
11	Stairw			Heater	Conditioned	Residential (Multifamily	950	1	1
12	Stairw			Heater	Conditioned	Residential (Multifamily	950	1	1
13	Office			er VRF	Conditioned	Residential (Multifamily	950	1	1
14	EL1 Co			dor VRF 1	Conditioned	Corridor	836	1	1
15	EL1 W				Conditioned	Residential (Multifamily	950	1	1
16	EL1 W				Conditioned	Residential (Multifamily	950	1	1
17	EL1 W				Conditioned	Residential (Multifamily	950	1	1
18	EL1 W				Conditioned	Residential (Multifamily	950	1	1
19	EL1 ES				Conditioned	Residential (Multifamily	950	1	8
20	EL1 East Perim Spc (M.E11)	EL1 East Perim Zn (M.E11)	EL1 East Perim Spc (M.E11	VRF10	Conditioned	Residential (Multifamily	950	1	8
21	EL1 East Perim Spc (M.E12)	EL1 East Perim Zn (M.E12)	EL1 East Perim Spc (M.E12	VRF11	Conditioned	Residential (Multifamily	950	1	8
22	EL1 ENE Perim Spc (M.ENE13)	EL1 ENE Perim Zn (M.ENE13)	EL1 ENE Perim Spc (M.ENE	VRF12	Conditioned	Residential (Multifamily	950	1	8
23	EL1 Core Spc (M.C14)	EL1 Core Zn (M.C14)	EL1 Core Spc (M.C14)	Corridor VRF 2	Conditioned	Corridor	836	1	8

SG05: Zone Types may be listed as Conditioned, Unconditioned, or Plenum. For each type, the total floor area is the sum of products of [Area] x [Space Multiplier] x [Floor Multiplier].

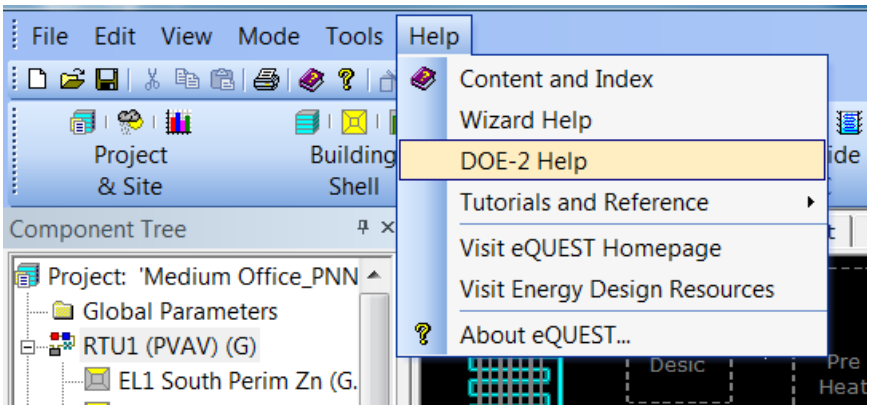
The report includes a detailed list of modeling inputs by space, including but not limited to lighting and equipment power density and full load hours. CSV (Excel) format easily supports data analysis.

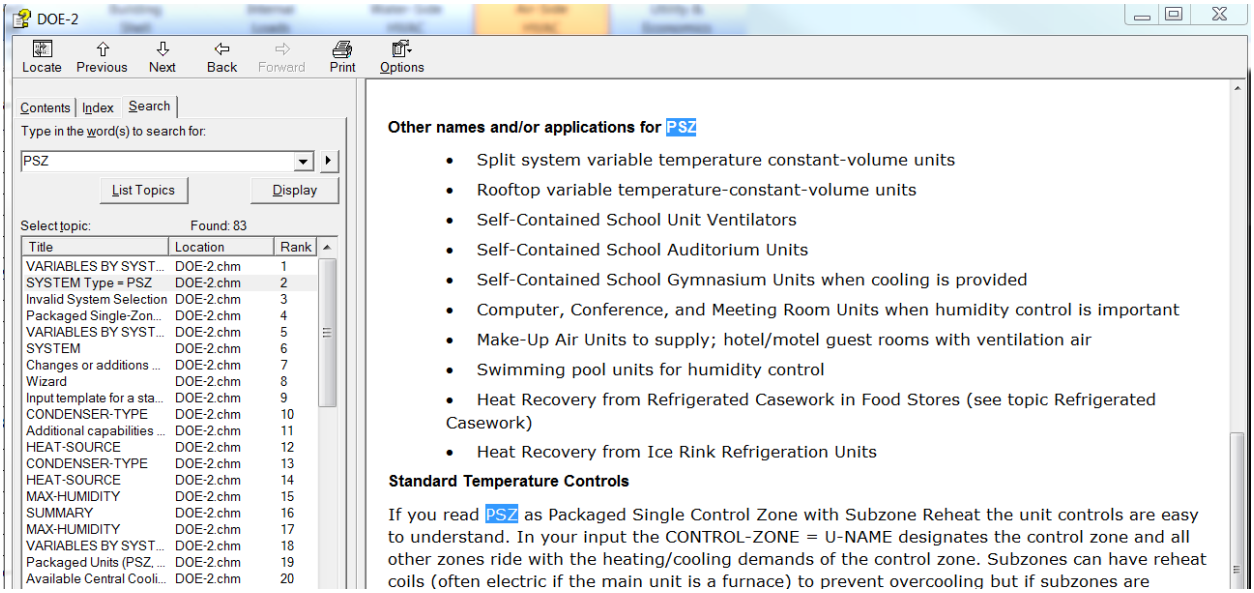
Hourly Results (CSV)

To generate the report, select File -> Export File -> Hourly Results (CSV) from the main eQUEST interface and then click Export button. The values included in the report are specified by the modeler and may differ, however the report will have a value shown for each simulated hour. 8,760 hours indicate that the full hourly simulation was completed.

DOE-2 Help

The help is accessible from within eQUEST interface.


File
Edit
View
Mode
Tools
Help
Content and Index
Wizard Help
DOE-2 Help
Tutorials and Reference
Visit eQUEST Homepage
Visit Energy Design Resources
About eQUEST...
Project & Site
Building Shell
Component Tree
Project: 'Medium Office_PNN
Global Parameters
RTU1 (PVAV) (G)
EL1 South Perim Zn (G.


DOE-2
Locate
Previous
Next
Back
Forward
Print
Options
Contents
Index
Search
Type in the word(s) to search for:
PSZ
List Topics
Display
Select topic:
Found: 83
Title
Location
Rank
VARIABLES BY SYST... DOE-2.chm 1
SYSTEM Type = PSZ DOE-2.chm 2
Invalid System Selection DOE-2.chm 3
Packaged Single-Zon... DOE-2.chm 4
VARIABLES BY SYST... DOE-2.chm 5
SYSTEM DOE-2.chm 6
Changes or additions ... DOE-2.chm 7
Wizard DOE-2.chm 8
Input template for a sta... DOE-2.chm 9
CONDENSER-TYPE DOE-2.chm 10
Additional capabilities ... DOE-2.chm 11
HEAT-SOURCE DOE-2.chm 12
CONDENSER-TYPE DOE-2.chm 13
HEAT-SOURCE DOE-2.chm 14
MAX-HUMIDITY DOE-2.chm 15
SUMMARY DOE-2.chm 16
MAX-HUMIDITY DOE-2.chm 17
VARIABLES BY SYST... DOE-2.chm 18
Packaged Units (PSZ, ... DOE-2.chm 19
Available Central Cooli... DOE-2.chm 20
Other names and/or applications for PSZ
Split system variable temperature constant-volume units
Rooftop variable temperature-constant-volume units
Self-Contained School Unit Ventilators
Self-Contained School Auditorium Units
Self-Contained School Gymnasium Units when cooling is provided
Computer, Conference, and Meeting Room Units when humidity control is important
Make-Up Air Units to supply; hotel/motel guest rooms with ventilation air
Swimming pool units for humidity control
Heat Recovery from Refrigerated Casework in Food Stores (see topic Refrigerated Casework)
Heat Recovery from Ice Rink Refrigeration Units
Standard Temperature Controls
If you read PSZ as Packaged Single Control Zone with Subzone Reheat the unit controls are easy to understand. In your input the CONTROL-ZONE = U-NAME designates the control zone and all other zones ride with the heating/cooling demands of the control zone. Subzones can have reheat coils (often electric if the main unit is a furnace) to prevent overcooling but if subzones are

IESVE Software

Resources

1. Free Software for (AHJ) code reviewers or Utility Incentive Entities. Includes a reviewer-specific help guide.
2. Searchable Help Website: https://help.iesve.com/ve2019/
3. Free Getting Started video: https://www.iesve.com/training/north-america/intro-to-ve-online.
4. Video Library of Specific Topics (E.g. ASHRAE 90.1, Title 24 Compliance, Florida Energy Code Compliance, NECB Compliance, etc: https://www.iesve.com/training/lunch-n-learn
5. Technical Support: +1 617 502 2085 and support@iesve.com
6. GeneralThe reports below are both entered values reports and simulation reports. All reports can be found by going to the Tools Menu in IESVE Software > Content Manager.
7. The reports can be viewed in the Content Manager as a report viewer or exported/opened independently as PDF/DOC/XLS etc. Most commonly, the reports are exported to .pdf files for submittals.

Simulation Reports to be Submitted

AHJ may require that all IESVE reports are submitted. Alternatively, the individual reports listed below may be requested. These reports are utilized in the Review Checks described in the Manual.

Room Loads Report
Zone Loads Report
Space Loads & Ventilation Report
ASHRAE 62.1 Report
Plant Loops & Equipment Report
System Loads Report
Energy Model Output Report
Model Orientation and Rotation Check Report
PRM Compliance Report
ECB Compliance Report
BPRM Report
Unmet Hours Report
Detailed Simulation Report
ASHRAE 55 Thermal Comfort Report

Trane TRACE 3D Plus

Climatic Summary

Overview

Location	La Crosse Municipal Arpt WI USA
Weather File	USA_WI_La.Crosse.Muni.AP.72643(
Weather File Source	TMY3
WMO Station	726430
Latitude	N 43° 52
Longitude	W 91° 15
Time Zone	GMT -6.0 Hours
Elevation	650 ft
Standard Pressure	0.99 Bar
Heating Degree Days (base 65°F)	7,240
Cooling Degree Days (base 50°F)	2,765

SG03: Weather File

Peaks

	Dry Bulb Temp. [F]	Dew Point Temp. [F]
	96.1	82
Date	Jul 17	Jun 26
Minimum	-27	-36
Date	Jan 31	Jan 31

Section 1.3 - Advisory Messages Table EAp2-2 - Advisory Messages

	Baseline 0°	Proposed Design
Number of Unmet Heating Hours	218.00	122.67
Number of Unmet Cooling Hours	20.33	0.00
Total	238.33	122.67

SG08: Unmet

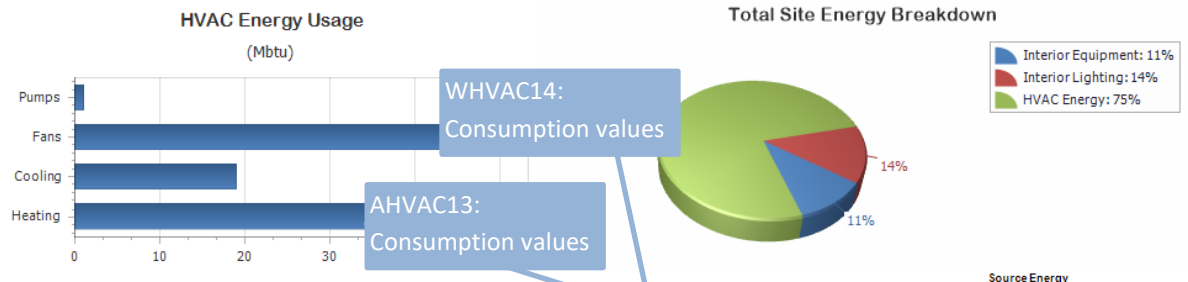
Section 1.2 - Space Summary

Space Name / Building Use (Occupancy Type)	Space Area (m²)	Regularly Occupied Area (m²)	Unconditioned Area (m²)	Typi... O... (hr/wk)
Zn-Room 00-05	400	400	0	95.9
Zn-Room 00-02	400	400	0	95.9
Zn-Room 00-00	400	400	0	95.9
Zn-Room 00-01	400	400	0	95.9
Zn-Room 00-03	400	400	0	95.9
Zn-Room 00-04	400	400	0	95.9
Totals	2400	2400	0	

SG05: Conditioned Floor Area

Site Consumption Summary

Energy Consumption



WHVAC14: Consumption values

AHVAC13: Consumption values

Component	Electricity (kWh)	Gas (Mbtu)	District Cooling (Mbtu)	District Heating (Mbtu)	Other Utilities (Mbtu)	Site Energy (kBtu)	Site Energy Use Intensity (kBtu/ft²)	Source Energy	Source Energy Use Intensity	
Heating	206	48			0	48,670	20.27			
Cooling	5,689	0			0	19,41	8.09			
Fans	12,961	0			0	44,225	18.42	140,061	58.34	0
Pumps	250	0			0	853	0.36	2,702	1.13	0
Heat Rejection	0	0	0	0	0	0	0			
Humidification	0	0	0	0	0	0	0			
Heat Recovery	0	0	0	0	0	0	0			
HVAC	19,106	48	0	0	0	113,160	47.13	258,458	107.66	0
Water Systems	0	0	0	0	0	0	0	0	0	0
Interior Lighting	5,981	0			0	20,407	8.5	64,627	26.92	0
Exterior Lighting	0	0			0	0	0	0	0	0
Interior Equipment	4,822	0	0	0	0	16,454	6.85	52,110		
Exterior Equipment	0	0	0	0	0	0	0	0		
Refrigeration	0	0	0	0	0	0	0	0		
Non-HVAC	10,803	0	0	0	0	36,861	15.35	116,738		
Generators	0	0	0	0	0	0	0	0		
Site Generation	0	0	0	0	0	0	0	0	0	0
Grand Total	29,908	48	0	0	0	150,020	62.49	375,195		

AHVAC12: Consumption values

WHVAC09: pump energy

WHVAC20: pump energy

WHVAC03: Consumption values

PPO04: Miscellaneous equipment EUI

SG09: Site Energy Use Intensity

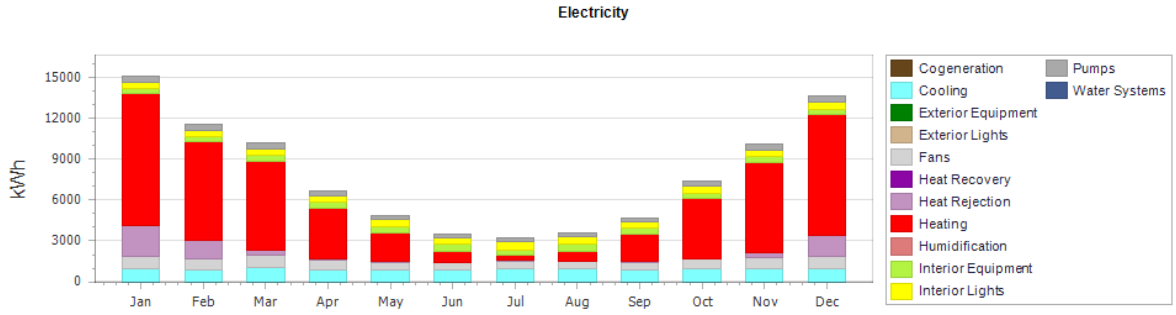
Gross Floor Area: 2,400 ft² Region: Midwest Building Type: Office CBECS Survey Year: 2012

If the region reports as "All US" it means the data for the particular region was withheld because the Relative Standard Error was greater than 50 percent or fewer than

Alternative: Primary-001 **Calculated at: Dec 05, 2019 - 02:26 PM**

File name: Baseline2.mdf TRACE™ 3D Plus 2.04.20.0 Page 5 of 7

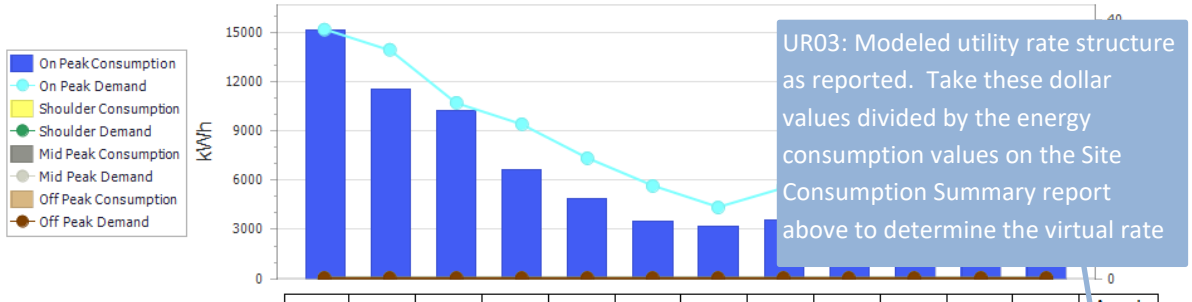
Monthly Energy End Use



	January	February	March	April	May	June	July	August	September	October	November	December	Grand Total
Cogeneration	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooling	959	932	1,089	937	918	945	1,044	1,020	927	992	997	1,021	11,784
Exterior Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0
Exterior Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Fans	925	832	884	681	573	517	528	539	566	738	863	927	8,572
Heat Recovery	0	0	0	0	0	0						0	0
Heat Rejection	2,218	1,204	362	69	19	23						1,441	5,730
Heating	9,707	7,328	6,501	3,728	2,085	816						8,909	53,145
Humidification	0	0	0	0	0	0						0	0
Interior Equipment	405	370	414	396	411	400						407	4,821
Interior Lights	485	457	542	486	523	520						489	5,982
Pumps	459	413	439	338	284	257						160	4,257
Water Systems	0	0	0	0	0	0						0	0
Grand Total	15,158	11,536	10,230	6,636	4,813	3,479						13,653	94,291

UR03: Modeled utility rate structure as reported. Take the dollar values on the Economic and Life Cycle Costs Summary report below divided by these values to determine the virtual rate

Monthly Utility Details



UR03: Modeled utility rate structure as reported. Take these dollar values divided by the energy consumption values on the Site Consumption Summary report above to determine the virtual rate

Electricity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Totals
On Peak Consumption kWh	15,159	11,537	10,231	6,636	4,813	3,479	3,165	3,533	4,656	7,359	10,075	13,654	94,299
On Peak Demand kW	38	35	27	24	19	14	11	14	21	21	27	33	38

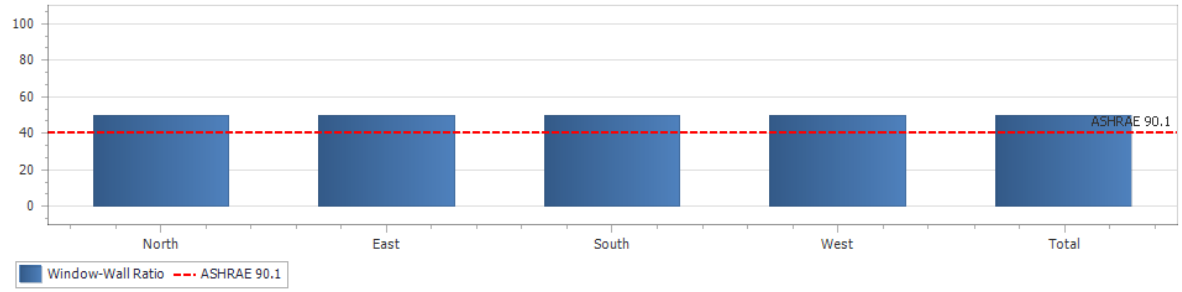
Opaque Exterior

	Construction	Exterior Reflectance	Gross Area (ft²)	U-Factor With Film (BTU/h-ft²-°F)	U-Factor No Film (BTU/h-ft²-°F)	Azimuth	Tilt	Cardinal Direction
Roof 01-01 - [0]	90.1-13 Min Roof Insulation Entirely Above Deck Zone 5	0.3	420	0.032	0.033	180°	0°	
Roof 02-02 - [0]	90.1-13 Min Roof Insulation Entirely Above Deck Zone 5	0.3	420	0.032	0.033	180°	0°	
Roof 03-03 - [0]	90.1-13 Min Roof Insulation Entirely Above Deck Zone 5	0.3	420	0.032	0.033	180°	0°	
Roof 04-04 - [0]	90.1-13 Min Roof Insulation Entirely Above Deck Zone 5	0.3	420	0.032	0.033	180°	0°	
Roof 05-05 - [0]	90.1-13 Min Roof Insulation Entirely Above Deck Zone 5	0.3	420	0.032	0.033	180°	0°	
SLAB 00_0	Slab 00_0_90.1-13 Min Slab On Grade Unheated Floor, R-15 For 24 In., Zone 4-5	1	420	0	0.001		180°	
SLAB 01_0	Slab 01_0_90.1-13 Min Slab On Grade Unheated Floor, R-15 For 24 In., Zone 4-5	1	420	0	0.001		180°	
SLAB 02_0	Slab 02_0_90.1-13 Min Slab On Grade Unheated Floor, R-15 For 24 In., Zone 4-5	1	420	0	0.001		180°	
SLAB 03_0	Slab 03_0_90.1-13 Min Slab On Grade Unheated Floor, R-15 For 24 In., Zone 4-5	1	420	0	0.001		180°	
SLAB 04_0	Slab 04_0_90.1-13 Min Slab On Grade Unheated Floor, R-15 For 24 In., Zone 4-5	1	420	0	0.001		180°	
SLAB 05_0	Slab 05_0_90.1-13 Min Slab On Grade Unheated Floor, R-15 For 24 In., Zone 4-5	1	420	0	0.001		180°	
WALL 00-ROOM 00-00_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	180°	90°	S
WALL 01-ROOM 00-00_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	270°	90°	W
WALL 05-ROOM 00-01_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	180°	90°	S
WALL 07-ROOM 00-02_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	180°	90°	S
WALL 08-ROOM 00-02_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	90°	90°	E
WALL 10-ROOM 00-03_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	0°	90°	N
WALL 11-ROOM 00-03_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	270°	90°	W
WALL 14-ROOM 00-04_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	0°	90°	N
WALL 15-ROOM 00-05_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	90°	90°	E
WALL 16-ROOM 00-05_0	90.1-13 Min Wall, Steel Framed Zone 5	0.3	267	0.055	0.058	0°	90°	N

BE06, BE07, BE08, BE09, BE10: Thermal properties and areas of opaque envelope

BE21: Envelope orientation

Envelope Summary



	North	East	South	West	Total
Gross Window-Wall Ratio	49.93	49.93	49.93	49.93	49.93

Fenestration

	Construction	Area of One Opening (ft²)	Area of Openings (ft²)	U-Factor (BTU/h-ft²-°F)	SHGC	Visible Transmittance	Shade Control	Parent Surface	Azimuth	Cardinal Direction
WINDOW 01 - WALL 11-ROOM 00-03_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 11-ROOM 00-03_0	270°	W
WINDOW 03 - WALL 01-ROOM 00-00_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 01-ROOM 00-00_0	270°	W
WINDOW 02 - WALL 00-ROOM 00-00_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 00-ROOM 00-00_0	180°	S
WINDOW 04 - WALL 05-ROOM 00-01_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 05-ROOM 00-01_0	180°	S
WINDOW 05 - WALL 07-ROOM 00-02_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 07-ROOM 00-02_0	180°	S
WINDOW 00 - WALL 10-ROOM 00-03_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 10-ROOM 00-03_0	0°	N
WINDOW 08 - WALL 16-ROOM 00-05_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 16-ROOM 00-05_0	0°	N
WINDOW 09 - WALL 14-ROOM 00-04_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 14-ROOM 00-04_0	0°	N
WINDOW 06 - WALL 08-ROOM 00-02_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 08-ROOM 00-02_0	90°	E
WINDOW 07 - WALL 15-ROOM 00-05_0	90.1-13 Window Zone 4-6 Metal Oper	133	133	0.501	0.395	0.441	No	WALL 15-ROOM 00-05_0	90°	E
Non-North Total or Average			932	0.501	0.395	0.441				
North Total or Average			399	0.501	0.395	0.441				
Total or Average			1,331	0.501	0.395	0.441				

System Cooling Checksums

VAV RH (30% Min Default) (CW)

	Coil Peak						Fan Peak					
Peak Time (Mo/D/H:M):				7/21/16:00			Peak Time (Mo/D/H:M):			7/21/16:00		
Outside Air (DB/WB/HR):				87.6 / 72.9 / 101.0			Outside Air (DB/WB/HR):			87.6 / 72.9 / 101.0		
	Instant Sensible (Btu/h)	Time Delay Sensible (Btu/h)	Latent (Btu/h)	Total (Btu/h)	Percent of Total (%)	Btu/h per ft²	Instant Sensible (Btu/h)	Time Delay Sensible (Btu/h)	Total Sensible (Btu/h)	Percent of Total (%)	Related Area (ft²)	
Roof	0	7,322	0	7,322	60.3	2.9	0	7,322	7,322	16.0	2,521	
Other Roof	0	0	0	0	0.0	0.0	0	0	0	0.0	2,521	
Glass	9,460	17,944	0	27,404	225.5	20.6	9,460	17,944	27,404	60.0	1,331	
Door	0	0	0	0	0.0	0.0	0	0				
Wall	0	1,861	0	1,861	15.3	0.7	0	1,861				
Below-Grade Wall	0	0	0	0	0.0	0.0	0	0				
Other Wall	0	0	0	0	0.0	0.0	0	0				
Partition	0	502	0	502	4.1	0.1	0	502	502	1.1	3,731	
Exterior Floor	0	0	0	0	0.0	0.0	0	0	0	0.0	0	
Interior Floor	0	0	0	0	0.0	0.0	0	0	0	0.0	0	
Slab	0	-4,074	0	-4,074	-33.5	-1.6	0	-4,074	-4,074	-8.9	2,521	
Other Floor	0	0	0	0	0.0	0.0	0	0	0	0.0	0	
Infiltration	0	0	0	0	0.0	0.0	0	0	0	0.0	2,665	
Envelope Subtotal	9,460	23,555	00	33,015	271.7	-	9,460	23,555	33,015	72.3	-	
People	1,260	1,693	2,399	5,352	44.0	2.2	1,260	1,693	2,953	6.5	2,400	
Lights	2,167	2,960	0	5,126	42.2	3.2	2,167	2,960	5,126	11.2	2,400	
RA Sensible (Lights)	2,243	0	0	2,243	18.5	0.0	-	-	-	-	-	
Miscellaneous Loads	3,095	2,148	0	5,243	43.1	2.2	3,095	2,148	5,243	11.5	2,400	
Internal Subtotal	8,765	6,800	2,399	17,965	147.8	-	6,522	6,800	13,322	29.2	-	
Ventilation	2,855	0	5,151	8,007	65.9	-	-	-	-	-	-	
DOAS Direct to Zone	0	0	0	0	0.0	-			0	0.0	0	
Ceiling	0	0	0	0	0.0	0.0	0	0	0	0.0	0	
Refrigeration	0	0	0	0	0.0	0.0			0	0.0	2,400	
Service Water	0	0	0	0	0.0	0.0			0	0.0	2,400	
HVAC Equipment Losses	0	0	0	0	0.0	0.0			0	0.0	0	
Adj Air Transfer Heat	0	0	0	0	0.0	0.0	0	0	0	0.0	0	
Supply Fan Heat	4,781	0	-	4,781	39.3	-	-	-	-	-	-	
Time Delay Correction	0	-740	-	-740	-6.1	-	0	-740	-740	-1.6	-	
Sizing Factor Correction	0	-	-	0	0.0	-	0	-	0	0.0	-	
Airflow Correction	71	0	33	104	0.9	-	71	-	71	0.2	-	
Grand Total	25,932	29,615	7,584	63,131	100.0		16,052	29,615	45,667	100.0		

BE18: Infiltration

Temperatures °F	
Supply	55.0
Return	76.1
Mixed Air	77.2
Fan Heat TD	2.1

Airflows cfm	
Main Fan	2,121
Ventilation	210
Infiltration	0
Min Stop / Reheat	2,110

Engineering Checks	
% OA	9.91
cfm/ft²	.88
Btu/h-ft²	26.32
cfm/ton	403.09
ft²/ton	456.18
People	12
ft²/person	200.00

Areas ft²	
Roof	2,521
Other Roof	2,521
Ceiling	0
Window	1,331
Door	0
Wall	2,665
Below-Grade Wall	0
Other Wall	2,665
Partition	3,731
Exterior Floor	0
Internal Floor	0
Slab	2,521
Other Floor	0

Room Cooling Loads by Component

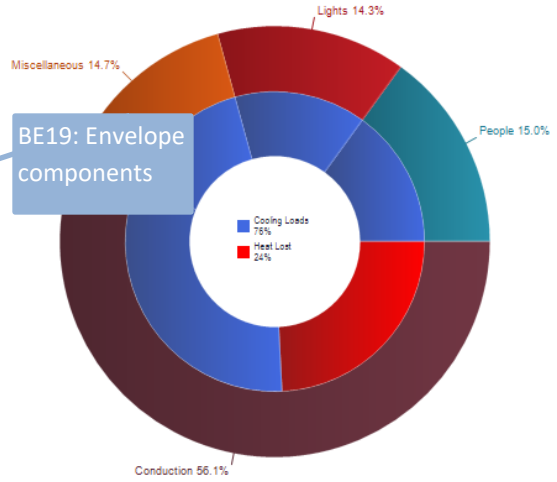
ROOM_Room 00-00 8/21 16:40:00

Conditions at Time of Peak

Outside DB / WB / HR 83.7 °F / 71.7 °F / 100.4 gr/lb Room DB / RH / HR 75.0 °F / 50.3 % / 65.0 gr/lb

	Instant Sensible (Btu/h)	Time Delay Sensible (Btu/h)	Latent (Btu/h)	Total (Btu/h)	Percent of Total (%)
Roof	0	1263	0	1263	10.4
Other Roof	0	0	0	0	0.0
Glass	3001	5782	0	8783	72.4
Door	0	0	0	0	0.0
Wall	0	635	0	635	5.2
Below-Grade Wall	0	0	0	0	0.0
Other Wall	0	0	0	0	0.0
Partition	0	-276	0	-276	-2.3
Exterior Floor	0	0	0	0	0.0
Interior Floor	0	0	0	0	0.0
Slab	0	-1165	0	-1165	-9.6
Other Floor	0	0	0	0	0.0
Infiltration	0	0	0	0	0.0
Envelope Subtotal	3001	6239	0	9240	-
People	210	284	400	894	7.4
Lights	361	488	0	850	7.0
RA Sensible (Lights)	415	0	0	415	0.0
Miscellaneous Loads	516	357	0	873	7.2
Internal Subtotal	1502	1129	400	3031	-
RA (All Other)	0	0	0	0	0.0
DOA Direct to Room	0	0	0	0	0.0
Ceiling	0	0	0	0	0.0
Refrigeration	0	0	0	0	0.0
Service Water	0	0	0	0	0.0
HVAC Equipment Losses	0	0	0	0	0.0
Adj Air Transfer Heat	0	0	0	0	0.0
Sizing Factor Correction	0	0	0	0	0.0
Time Delay Correction	0	-132	0	-132	-1.1
Grand Total	4503	7237	400	12139	100.0

BE19: Envelope components



*Does not reflect Time Delay and Sizing Factor Correction effects

Interior Lighting

LI10: Full load hours (can be multiplied by 52 to get FLH per year)

Zone Name	Zone Lighting Library Entry (Libraries>InternalLoads>Lights)	Schedules (Libraries>Schedules>Lighting)	Lighting Power Density (W/ft²)	P			oad per ek
Zn-Room 00-00	Room 00-00_Light Load #001_Template	Lights - Low-Rise Office - Lighting	0.98	392	0.31	997	48.78
Zn-Room 00-01	Room 00-01_Light Load #001_Template	Lights - Low-Rise Office - Lighting	0.98	392	0.31	997	48.78
Zn-Room 00-02	Room 00-02_Light Load #001_Templ	- Lighting	0.98	392	0.31	997	48.78
Zn-Room 00-03	Room 00-03_Light Load #001_Templ	- Lighting	0.98	392	0.31	997	48.78
Zn-Room 00-04	Room 00-04_Light Load #001_Templ	- Lighting	0.98	392	0.31	997	48.78
Zn-Room 00-05	Room 00-05_Light Load #001_Template	Lights - Low-Rise Office - Lighting	0.98	392	0.31	997	48.78

LI07: Entered lighting power density

Section 1.6 - Performance Rating Method Compliance Report — Table EAp2-4 - Baseline Performance

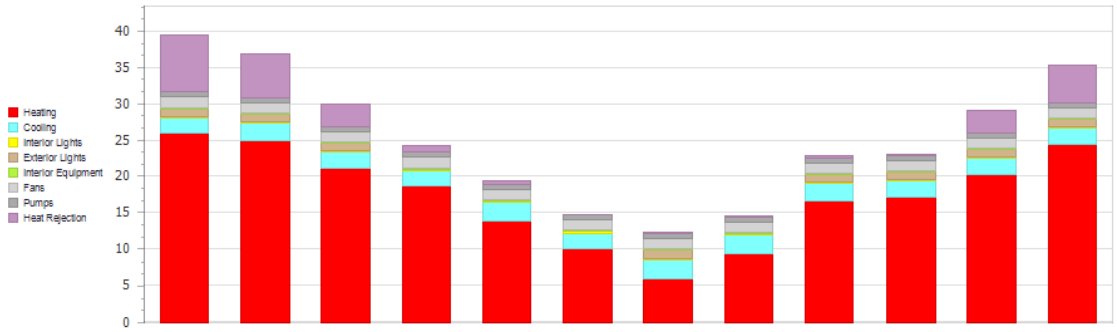
End Use	Process?	Energy Type	Units of Annual Energy Use & Peak Demand		Baseline 0°	Baseline 90°	Baseline 180°	Baseline 270°	Baseline Building Results
Heating -- Boiler	No	Gas	Use	therms	480	477	480	477	478
			Demand	therms/hr	0.8	0.8	0.8	0.8	0.8
Heating -- Boiler Parasitic	No	Electricity	Use	kWh	206	192	206	192	199
			Demand	kW	0.3	0.3	0.3	0.3	0.3
Interior Lighting -- General	No	Electricity	Use	kWh	5981	5981	5981	5981	5981
			Demand	kW	2	2	2	2	2
Interior Equipment -- General	No	Electricity	Use	kWh	4822	4822	4822	4822	4822
			Demand	kW	1.1	1.1	1.1	1.1	1.1
Fans -- General	Yes	Electricity	Use	kWh	12961	14183	12961	14183	13572
			Demand	kW	2.2	2.3	2.2	2.3	2.2
Pumps -- General	Yes	Electricity	Use	kWh	250	267	250	267	258
			Demand	kW	0.1	0.1	0.1	0.1	0.1
Cooling -- Not Subdivided	No	Electricity	Use	kWh	5689	6083	5689	6083	5886
			Demand	kW	5.6	6	5.6	6	5.8
Total Energy Use (MMBtu/year)					150	155	150	155	153
Annual Process Energy (MMBtu/year)					16				

LI11: Interior lighting annual energy use

LI06: Interior lighting peak demand

Utility Peak Demand Summary

Electricity (kW)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peak Facility Demand	39.5	36.7	30	24.2	19.4	14.8	12.2	14.5	22.7	2		
Time of Peak (Day/Hour)	31/05:00	06/05:00	01/05:00	10/05:00	10/05:19	08/05:00	10/19:00	17/05:00	29/05:00	12/0		
Heating	25.9	25	21.1	18.7	13.8	10	6.1	9.4	16.7	1		
Cooling	2.2	2.3	2.3	2.1	2.6	2.2	2.5	2.5	2.3	2		
Interior Lights	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Exterior Lights	1	1	1	0	0	0	1	0	1	1	1	1
Interior Equipment	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Exterior Equipment	0	0	0	0	0	0	0	0	0	0	0	0
Fans	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Pumps	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Heat Rejection	7.9	6	3	0.9	0.5	0.1	0.1	0.1	0.3	0.1	3	5.3
Humidification	0	0	0	0	0	0	0	0	0	0	0	0
Heat Recovery	0	0	0	0	0	0	0	0	0	0	0	0
Water Systems	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0
Generators	0	0	0	0	0	0	0	0	0	0	0	0
Electricity Produced	0	0	0	0	0	0	0	0	0	0	0	0

LE06: Exterior lighting power

Table EAp2-5 - Performance Rating

End Use	Process?	Baseline Energy Type	Baseline Units of Annual Energy Use & Peak Demand			Proposed Energy Type	Proposed Units of Annual Energy Use & Peak Demand			
Heating -- Boiler	No	Gas	Use			Gas	Use	therms		
			Demand				Demand	therms/hr		
Heating -- Boiler Parasitic	No	Electricity	Use			Electricity	Use	kWh		100 %
			Demand	kW	0.3		Demand	kW	0	
Interior Lighting -- General	No	Electricity	Use	kWh	5981	Electricity	Use	kWh	5981	0 %
			Demand	kW	2		Demand	kW	2	
Exterior Lighting -- Exterior Light 00	No	Electricity	Use	kWh	4000	Electricity	Use	kWh	4000	0 %
			Demand	kW	1		Demand	kW	1	
Interior Equipment -- General	No	Electricity	Use	kWh	4822	Electricity	Use	kWh	4822	0 %
			Demand	kW	1.1		Demand	kW	1.1	
Fans -- General	Yes	Electricity	Use	kWh	13572	Electricity	Use	kWh	8572	36.8 %
			Demand	kW	2.2		Demand	kW	1.4	
Pumps -- General	Yes	Electricity	Use	kWh	258	Electricity	Use	kWh	4258	-1548.4 %
			Demand	kW	0.1		Demand	kW	0.7	
Heating -- Other	No	Electricity	Use	kWh	0	Electricity	Use	kWh	53144	NA
			Demand	kW	0		Demand	kW	20.2	
Cooling -- General	No	Electricity	Use	kWh	0	Electricity	Use	kWh	0	NA
			Demand	kW	0		Demand	kW	0	
Heat Rejection -- General	Yes	Electricity	Use	kWh	0	Electricity	Use	kWh	0	NA
			Demand	kW	0		Demand	kW	0	

LE07: Exterior lighting baseline vs proposed

LE06: Exterior lighting EFLH, Divide Use by Demand to get hours

PPO01: Miscellaneous Equipment

AHVAC19: Fan Peak

AHVAC20: Fan EFLH, Divide use by Demand to get hours

System Component Selection Summary

Primary

System Name: VAV RH (30% Min Default) (CW)

System Type: Variable Air Volume (VAV)

Number of Zones: 6

Number of Rooms: 6

AHVAC04: HVAC Systems

AHVAC04: HVAC system type

Component	Quantity
Cooling Coils	1
Heating Coils	7
Fans	1

Cooling Coils

Coil Location			Coil Selection at Design						Airflow Conditions at Design					Water Flow Conditions		
System	Zone	Type	Sizing Method	Time of Peak Mo/D/Hr	Total capacity (tons)	Total capacity (MBh)	Sensible capacity (MBh)	Vent Load (MBh)	Ov/undr sizing (MBh)	Airflow (cfm)	Enter DB (°F)	Enter HR (gr/lb)	Leave DB (°F)	Leave HR (gr/lb)	Flow (gpm)	Enter Temp (°F)	Leave Temp (°F)
SCC-1		Water	Block	7/21 16:00	6.0	72.0	59.3	8.0	11.7	2,121	77.2	68.97	52.9	60.86	14.34	54.0	44.0

*Values do not include effects of plenum loads, heat exchangers such as evaporative cooling devices and similar components.

AHVAC04: HVAC system fuel

AHVAC06: System capacity

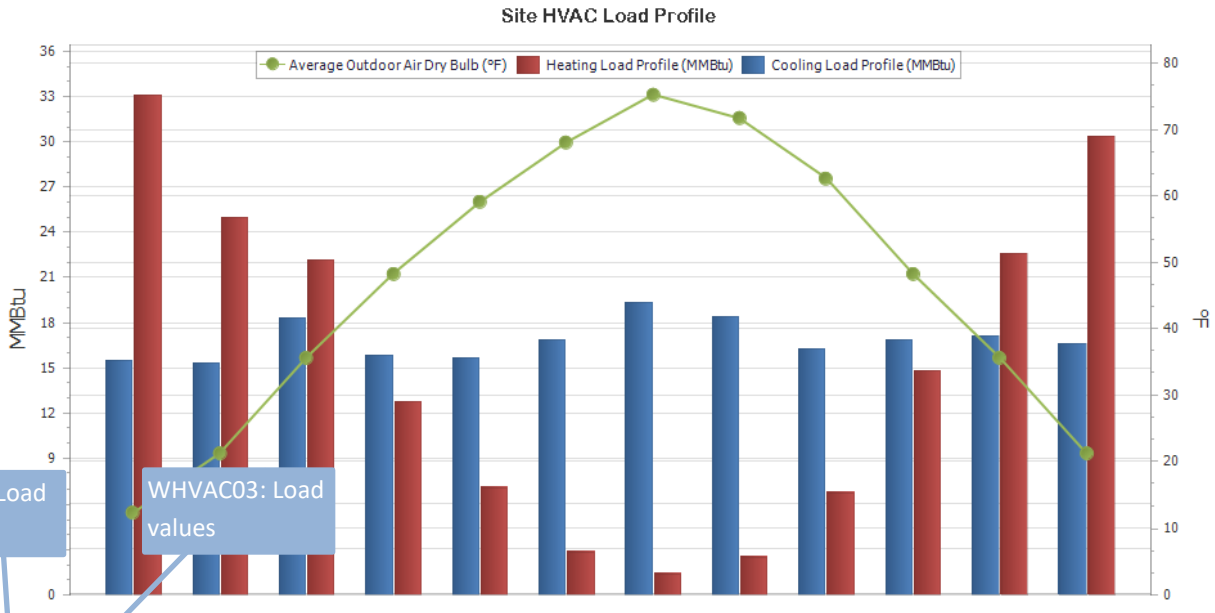
Heating Coils

Coil Location			Coil Selection at Design					Airflow Conditions at Design			Water Flow Conditions		
System	Zone	Type	Sizing Method	Time of Peak Mo/D/Hr	Total capacity (MBh)	Vent Load (MBh)	Ov/undr sizing (MBh)	Airflow (cfm)	Enter DB (°F)	Leave DB (°F)	Flow (gpm)	Enter Temp (°F)	Leave Temp (°F)
SHC-1		Water	Block	2/21 20:00	0.0	7.0	0.0	2,110	95.7	55.0	N/A	90.0	140.0
	VRH-1 Zn-Room 00-00	Electric	Peak	1/21 24:00	17.1	0.0	0.2	403	55.0	95.0	N/A	N/A	N/A
	VRH-1 Zn-Room 00-01	Electric	Peak	1/21 24:00	10.4	0.0	0.1	246	55.0	95.0	N/A	N/A	N/A
	VRH-1 Zn-Room 00-02	Electric	Peak	1/21 24:00	16.8	0.0	0.2	398	55.0	95.0	N/A	N/A	N/A
	VRH-1 Zn-Room 00-03	Electric	Peak	1/21 24:00	17.3	0.0	0.2	409	55.0	95.0	N/A	N/A	N/A
	VRH-1 Zn-Room 00-04	Electric	Peak	1/21 24:00	10.6	0.0	0.1	252	55.0	95.0	N/A	N/A	N/A
	VRH-1 Zn-Room 00-05	Electric	Peak	1/21 24:00	17.1	0.0	0.2	403	55.0	95.0	N/A	N/A	N/A

Plant Equipment

Name	Type	Nominal Capacity (MBh)	Efficiency (%)
Single Boiler CV BO-1	Boiler:HotWater	0.00	82.0

Site Load Profile



AHVAC12: Load values

WHVAC03: Load values

	January	February	March	April	May	June	July	August	September	October	November	December
Cooling Load	0	0	1	3	7	12	15	13	8	2	0	0
Heating Load	14	7	3	1	0	0	0	0	0	1	4	10
Average OADB	12.6	22.1	35.7	48.9	58.8	67.5	74.7	70.9	62.9	48.2	36.3	20.7

AHVAC13: Load values

WHVAC14: Load values

AHVAC26

Outside Air / ASHRAE Standard 62.1 Summary

System Ventilation Requirements

System	Mode	ΣVpz (cfm)	Ps People	ΣPz People	D Ps / ΣPz	Vou (cfm)	Vps (cfm)	Xs	Ev	Vot (cfm)	%OA Vot / Vps
VAV RH (30% Min Default) (CW)	Cooling	7034	11	12	0.95	201	2121	0.095	0.956	210	9.9%
	Heating	2110	11	12	0.95	201	2110	0.095	0.957	210	10.0%

Ventilation Parameters

System Zone	Rp (cfm/p)	Pz People	Ra (cfm/ft²)	Az (ft²)	Vbz (cfm)	Cooling Ez	Cooling Voz (cfm)	Heating Ez	Heating Voz (cfm)
VAV RH (30% Min Default) (CW)	5	12.00	0.06	2400	204		204		204
Zn-Room 00-00	5	2.0000	0.06	400	34	1	34	1	34
Zn-Room 00-01	5	2.0000	0.06	400	34	1	34	1	34
Zn-Room 00-02	5	2.0000	0.06	400	34	1	34	1	34
Zn-Room 00-03	5	2.0000	0.06	400	34	1	34	1	34
Zn-Room 00-04	5	2.0000	0.06	400	34	1	34	1	34
Zn-Room 00-05	5	2.0000	0.06	400	34	1	34	1	34

Ventilation Calculations for Cooling Design

System Zone	Box Type	Vpz (cfm)	Vdz (cfm)	Vpz-min (cfm)	Voz-clg (cfm)	Zpz	Ep	Er	Fa	Fb	Fc	Evz
VAV RH (30% Min Default) (CW)		7034	7034	2110	204							
Zn-Room 00-00	Single Duct VAV Reheat	1344	1344	403	34	0.084	1	0	0	0	0	1.011
Zn-Room 00-01	Single Duct VAV Reheat	819	819	246	34	0.138	1	0	0	0	0	0.956
Zn-Room 00-02	Single Duct VAV Reheat	1325	1325	398	34	0.086	1	0	0	0	0	1.009
Zn-Room 00-03	Single Duct VAV Reheat	1363	1363	409	34	0.083	1	0	0	0	0	1.012
Zn-Room 00-04	Single Duct VAV Reheat	839	839	252	34	0.135	1	0	0	0	0	0.96
Zn-Room 00-05	Single Duct VAV Reheat	1344	1344	403	34	0.084	1	0	0	0	0	1.011

Ventilation Calculations for Heating Design

System Zone	Box Type	Vpz (cfm)	Vdz (cfm)	Vpz-min (cfm)	Voz-htg (cfm)	Zpz	Ep	Er	Fa	Fb	Fc	Evz
VAV RH (30% Min Default) (CW)		2110	2110	2110	204							

AHVAC18: Fan power and full load rate

Fans

System Zone	Type	Efficiency (%)	Static Pressure (in. Wg)	Flow Rate (cfm)	Power (W)	Motor Heat in Air (%)
VAV RH (30% Min Default) (CW) SF-1	System	53.00	3.00	2,119	1,401	100.00

System Cooling Checksums

VAV RH (30% Min Default) (CW)

Coil Peak
Peak Time (Mo/D/H:M): 7/21/16:00
Outside Air (DB/WB/HR): 87.6 / 72.9 / 101.0

	Instant Sensible (Btu/h)	Time Delay Sensible (Btu/h)	Latent (Btu/h)	Total (Btu/h)	Percent of Total (%)	Btu/h per ft²
Roof	0	7,322	0	7,322	60.3	2.9
Other Roof	0	0	0	0	0.0	0.0
Glass	9,460	17,944	0	27,404	225.5	20.6
Door	0	0	0	0	0.0	0.0
Wall	0	1,861	0	1,861	15.3	0.7
Below-Grade Wall	0	0	0	0	0.0	0.0
Other Wall	0	0	0	0	0.0	0.0
Partition	0	502	0	502	4.1	0.1

Fan Peak
Peak Time (Mo/D/H:M): 7/21/16:00
Outside Air (DB/WB/HR): 87.6 / 72.9 / 101.0

	Instant Sensible (Btu/h)	Time Delay Sensible (Btu/h)	Total	Percent of	Related
	0	7,322			
	0	0			
	9,460	17,944			
	0	0			
	0	1,861			
	0	0			
	0	0	0	0.0	2,665
	0	502	502	1.1	3,731

AHVAC18: Minimum flow rate

Temperatures °F	
Supply	55.0
Return	76.1
Mixed Air	77.2
Fan Heat TD	2.1

Airflows cfm	
Main Fan	2,121
Ventilation	210
Infiltration	0
Min Stop / Reheat	2,110

Engineering Checks

WHVAC02

Plant Equipment

Name	Type	Nominal Capacity (tons)	Efficiency (COP)
Single Chiller CV WCH-1	Chiller:Electric:EIR	6.00	5.55

WHVAC05, WHVAC08

Plant Summary

Cooling Plant Summary

	Sizing Method	Peak Time Mo./Day/Time	Capacity (tons)	Flow Rate (gpm)	Percent of Peak Plant Capacity	Coil ΔT (°F)	Plant Temps (°F) Supply	Return
Single Chiller CV	Peak	Sum of Peaks	6	14.35	100 %			
VAV RH (30% Min Default) (CW) SCC-1	Peak	7/21 16:00:00	6	14.34	100 %	10	44.01	54

WHVAC07, WHAVC09

Loop Name: **Single Chiller CV**
Loop Type: Chilled Water Loop
Number of Assigned Coils: 1

Pumps

Name	Type	Contol	Head (psig)	Flow (gpm)	Power (W)	Power per Flow (W/gpm)
Single Chiller CV CHWP-1	Pump:ConstantSpeed	Intermittent	26	14.35	315	22

WHVAC11

Loop Name: **Single Cooling Tower CV**
Loop Type: Condenser Loop
Number of Assigned Coils: 0

Pumps

Name	Type	Contol	Head (psig)	Flow (gpm)	Power (W)	Power per Flow (W/gpm)
Single Cooling Tower CV CWP-1	Pump:ConstantSpeed	Intermittent	26	16.99	374	22

Plant Equipment

Name	Type	Nominal Capacity (tons)	Efficiency (COP)
Single Cooling Tower CV CT-1	Condenser Loop	5.64	0.00

WHVAC16 Hot water plant controls are modeled as reported

WHVAC18 Hot water loop parameters are modeled as reported

Heating Plant Summary

	Sizing Method	Peak Time Mo./Day/Time	Capacity (MBh)	Flow Rate (gpm)	Percent of Peak Plant Capacity	Coil ΔT (°F)	Plant Temps (°F) Supply	Return
Single Boiler CV	Peak	Sum of Peaks	0	0	100 %			
VAV RH (30% Min Default) (CW) SHC-1	Peak	2/21 20:40:00	0	0	0 %	50	180	129.99

WHVAC18 Hot water pumps are modeled as reported

WHVAC20 Annual hot water pump energy is as expected

Loop Name: **Single Boiler CV**
Loop Type: Hot Water Loop
Number of Assigned Coils: 1

Pumps

Name	Type	Contol	Head (psig)	Flow (gpm)	Power (W)	Power per Flow (W/gpm)
Single Boiler CV HWP-1	Pump:ConstantSpeed	Intermittent	23	0.00	0	NaN

Table EAp2-5 - Performance Rating

End Use	Process?	Baseline Energy Type	Baseline Units of Annual Energy Use & Peak Demand		Baseline Building Results	Proposed Energy Type	Proposed Units of Annual Energy Use & Peak Demand		Proposed Building Results	Percent Savings
Heating -- Boiler	No	Gas	Use	therms	478	Gas	Use	therms	0	100 %
			Demand	therms/hr	0.8		Demand	therms/hr	0	
Heating -- Boiler Parasitic	No	Electricity	Use	kWh	199	Electricity	Use	kWh	0	100 %
			Demand	kW	0.3		Demand	kW	0	
Interior Lighting -- General	No	Electricity	Use	kWh	5981	Electricity	Use	kWh	5981	0 %
			Demand	kW	2		Demand	kW	2	
Exterior Lighting -- Exterior Light 00	No	Electricity	Use	kWh	4000	Electricity	Use	kWh	4000	0 %
			Demand	kW	1		Demand	kW	1	
Interior Equipment -- General	No	Electricity	Use	kWh	4822	Electricity	Use	kWh	4822	0 %
			Demand	kW	1.1		Demand	kW	1.1	
Fans -- General	Yes	Electricity	Use	kWh	13572	Electricity	Use	kWh	8572	36.8 %
			Demand	kW	2.2		Demand	kW	1.4	
Pumps -- General	Yes	Electricity	Use	kWh	258	Electricity	Use	kWh	4258	-1548.4 %
			Demand	kW	0.1		Demand	kW	0.7	
Heating -- Other	No	Electricity	Use	kWh	0	Electricity	Use	kWh	53319	NA
			Demand	kW	0		Demand	kW	26.2	
Cooling -- General	No	Electricity	Use	kWh	0	Electricity	Use	kWh	12219	NA
			Demand	kW	0		Demand	kW	3.8	
Heat Rejection -- General	Yes	Electricity	Use	kWh	0	Electricity	Use	kWh	194	NA
			Demand	kW	0		Demand	kW	0.2	

WHVAC22: Heating

SG09: Fans

WHVAC22: Heating

SG09: Cooling

Trane TRACE 700

Resources

4. Searchable database of documentation on various topics22: The database covers topics such as "How do I model ventilation for ASHRAE 90.1/LEED analysis?", "How do I set the ventilation for my proposed and baseline buildings to be identical?", "Input VAV part-load performance for Table G3.1.3.15 for the ASHRAE Standard", "Daylighting on LEED report", "Why do the base utilities report incorrectly on the LEED Report", "Common mistakes in LEED modeling".
5. Free tutorial videos on specific topics 23, such as LEED Guide video.
6. If a TRACE 700 License has been purchased, a User's Manual comes with the software

General

7. The reports below are both entered values reports and simulation reports. The entered values reports can be found by going to View > Entered Values and selecting the appropriate report. The simulation reports can be found by going to Calculate and View Results > View Results and selecting the appropriate report.
8. The reports can be viewed in the report viewer or exported. Most commonly the reports are exported to .pdf files for submittals.

Simulation Reports to be Submitted

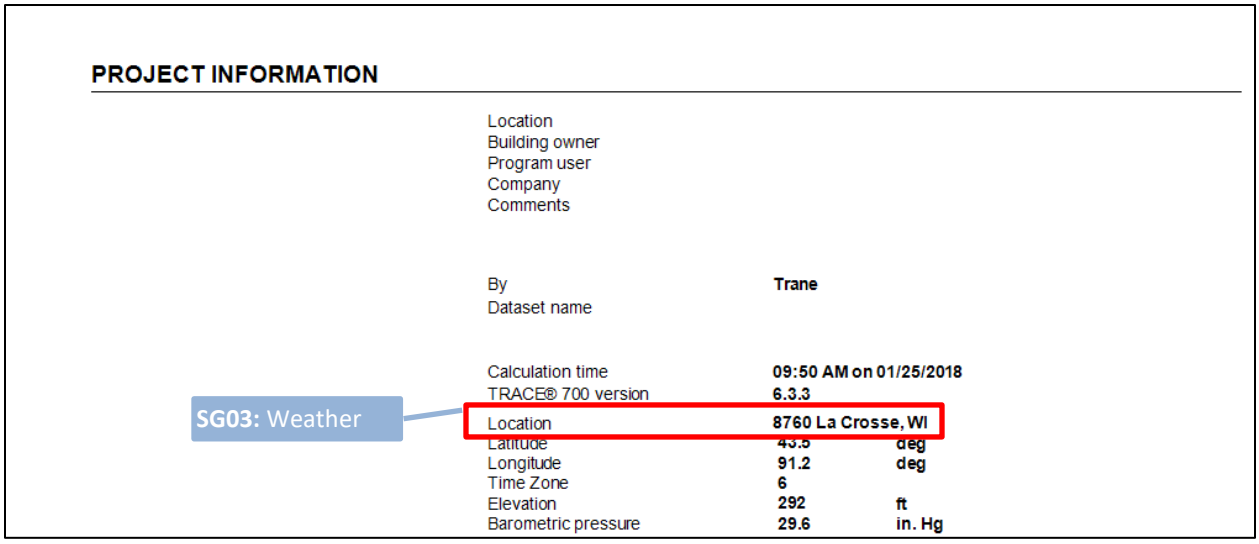
AHJ may require that all TRACE 700 Entered Values and Output reports are submitted. Alternatively, the individual reports listed below may be requested. These reports are utilized in the Review Checks described in the Manual.

5. Title Page Report
6. Project Information Entered Values report
7. Energy Cost Budget/PRM Summary report
8. LEED Summary report
9. Monthly Energy Consumption report
10. Monthly Utility Costs report
11. Library Members Entered Values report
12. Building U-Values report
13. Building Areas report
14. Walls by Direction Entered Values report
15. Walls by Cardinal Direction entered values report
16. Room Information Entered Values report
17. Building Envelope Cooling Loads at Coil Peak
18. Building Envelope Heating Loads at Coil Peak
19. Plant Information Entered Values report
20. Equipment Energy Consumption Report
21. System Entered Values Report
22. System Checksums Report
23. Building Cool/Heat Demand report from the Visualizer

[22] https://irtranecds.custhelp.com/app/answers/list
[23] https://irtranecds.custhelp.com/app/e_learning

Annotated Reports

Title Page Report

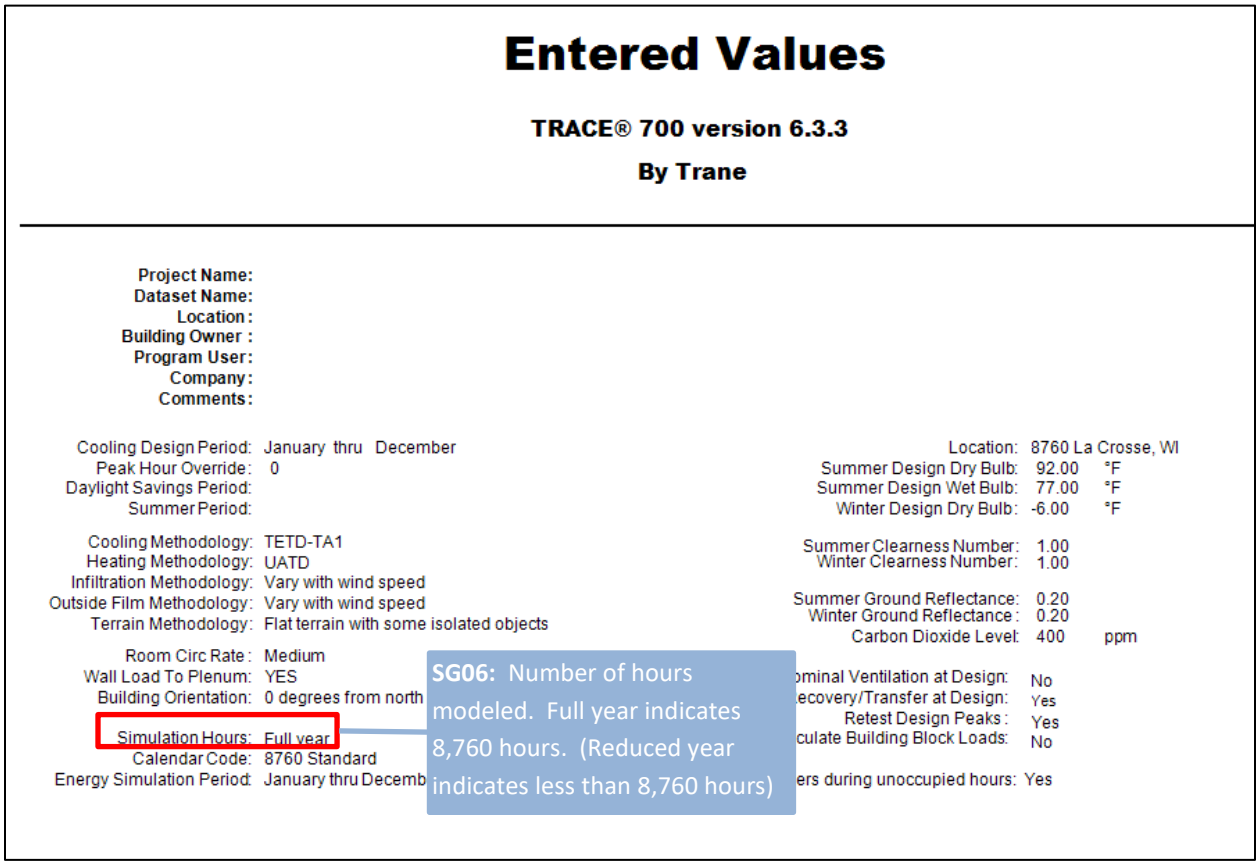


PROJECT INFORMATION

Location		
Building owner		
Program user		
Company		
Comments		
By	**Trane**	
Dataset name		
Calculation time	**09:50 AM on 01/25/2018**	
TRACE® 700 version	**6.3.3**	
Location	**8760 La Crosse, WI**	
Latitude	**43.5**	**deg**
Longitude	**91.2**	**deg**
Time Zone	**6**	
Elevation	**292**	**ft**
Barometric pressure	**29.6**	**in. Hg**

SG03: Weather

Project Information entered values report



Entered Values

TRACE® 700 version 6.3.3

By Trane

Project Name:
Dataset Name:
Location:
Building Owner :
Program User:
Company:
Comments:

Cooling Design Period: January thru December
Peak Hour Override: 0
Daylight Savings Period:
Summer Period:

Cooling Methodology: TETD-TA1
Heating Methodology: UATD
Infiltration Methodology: Vary with wind speed
Outside Film Methodology: Vary with wind speed
Terrain Methodology: Flat terrain with some isolated objects

Room Circ Rate: Medium
Wall Load To Plenum: YES
Building Orientation: 0 degrees from north

Simulation Hours: Full year
Calendar Code: 8760 Standard
Energy Simulation Period: January thru Decemb

Location: 8760 La Crosse, WI
Summer Design Dry Bulb: 92.00 °F
Summer Design Wet Bulb: 77.00 °F
Winter Design Dry Bulb: -6.00 °F

Summer Clearness Number: 1.00
Winter Clearness Number: 1.00

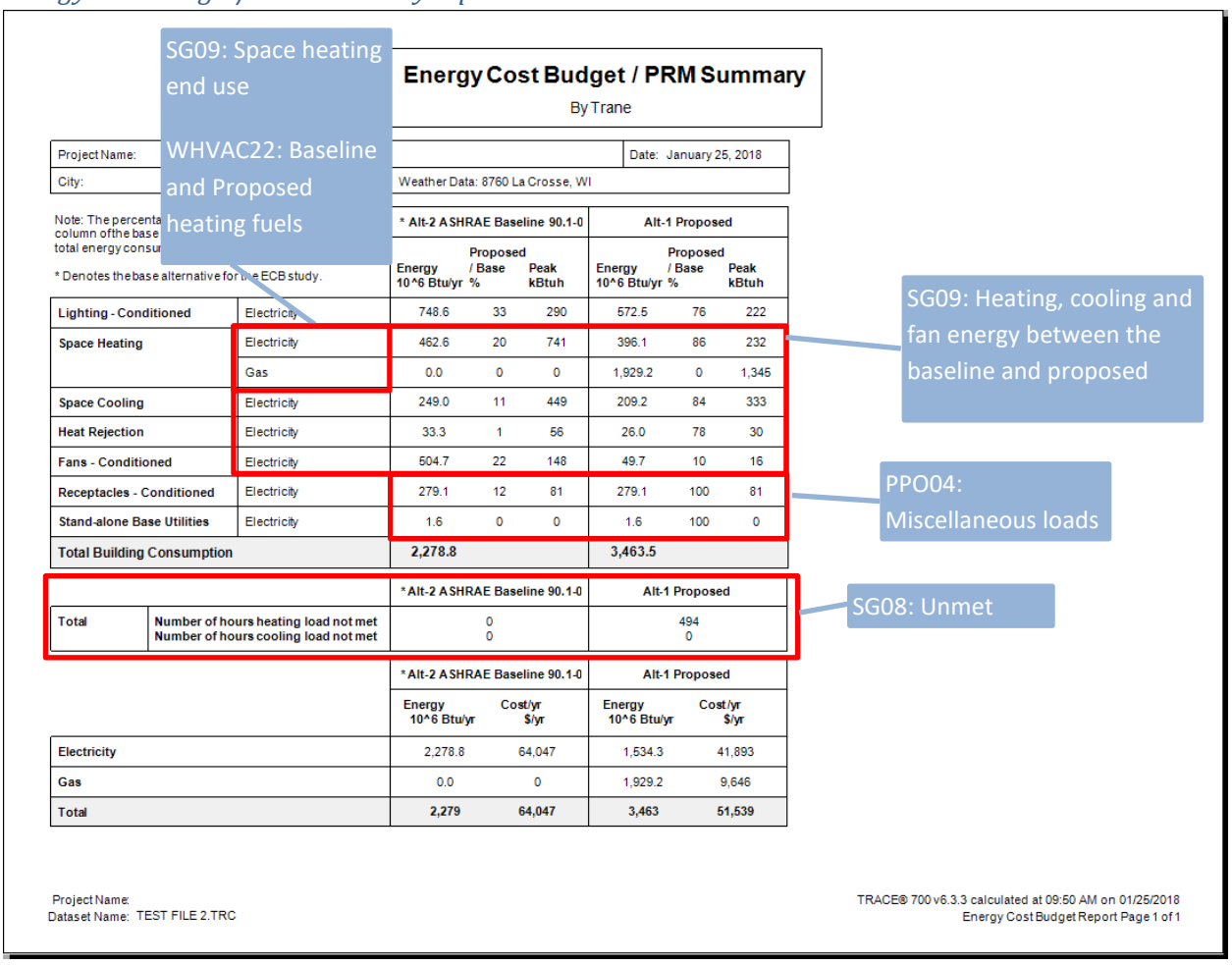
Summer Ground Reflectance: 0.20
Winter Ground Reflectance: 0.20
Carbon Dioxide Level: 400 ppm

ominal Ventilation at Design: No
ecovery/Transfer at Design: Yes
Retest Design Peaks: Yes
culate Building Block Loads: No

ers during unoccupied hours: Yes

SG06: Number of hours modeled. Full year indicates 8,760 hours. (Reduced year indicates less than 8,760 hours)

Energy Cost Budget/PRM Summary report



SG09: Space heating end use

WHVAC22: Baseline and Proposed heating fuels

Energy Cost Budget / PRM Summary

By Trane

Project Name:	Date: January 25, 2018
City:	Weather Data: 8760 La Crosse, WI

Note: The percenta
column of the base
total energy consu

* Denotes the base alternative for the ECB study.

		* Alt-2 ASHRAE Baseline 90.1-0			Alt-1 Proposed		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	748.6	33	290	572.5	76	222
Space Heating	Electricity	462.6	20	741	396.1	86	232
	Gas	0.0	0	0	1,929.2	0	1,345
Space Cooling	Electricity	249.0	11	449	209.2	84	333
Heat Rejection	Electricity	33.3	1	56	26.0	78	30
Fans - Conditioned	Electricity	504.7	22	148	49.7	10	16
Receptacles - Conditioned	Electricity	279.1	12	81	279.1	100	81
Stand-alone Base Utilities	Electricity	1.6	0	0	1.6	100	0
Total Building Consumption		**2,278.8**			**3,463.5**		

SG09: Heating, cooling and fan energy between the baseline and proposed

PPO04: Miscellaneous loads

		* Alt-2 ASHRAE Baseline 90.1-0	Alt-1 Proposed
Total	**Number of hours heating load not met**	0	494
	Number of hours cooling load not met	0	0

SG08: Unmet

	* Alt-2 ASHRAE Baseline 90.1-0		Alt-1 Proposed	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	2,278.8	64,047	1,534.3	41,893
Gas	0.0	0	1,929.2	9,646
Total	**2,279**	**64,047**	**3,463**	**51,539**

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Energy Cost Budget Report Page 1 of 1

LEED Summary report

LEED Energy Performance Summary Report

By Trane

Section 1.1 - General Information

Simulation Program:	TRACE™ 700 v6.3.3
Principle Heating Source:	Electric
Energy Code Used:	ASHRAE 90.1-2007
Weather File:	8760 La Crosse, WI (Full Year - 8760)
Climate Zone:	6A
New Construction Percent:	100 %
Existing Renovation Percent:	0 %
Quantity of Floors:	1
Proposed:	Alternative 1 - Proposed
Baseline:	Alternative 2 - ASHRAE Baseline 90.1-07 Climate Zone 6A

SG05: Conditioned Floor

Section 1.2 - Space Summary

Building Use (Occupancy Type)	Space Area (ft^2)	Regularly Occupied Area (ft^2)	Unconditioned Area (ft^2)
Wing 1	10,000.00	10,000.00	0.00
Wing 2	10,000.00	10,000.00	0.00
Wing 3	10,000.00	10,000.00	0.00
Wing 4	10,000.00	10,000.00	0.00
Wing 5	10,000.00	10,000.00	0.00
Total	**50,000.00**	**50,000.00**	**0.00**

Section 1.3 - Advisory Messages

Advisory Messages	Baseline Building (0 deg rotation)	Proposed Building
Number of hours heating load not met:	0	494
Number of hours cooling load not met:	0	0
Total	0	494

SG08: Unmet hours

Project Name :
Dataset Name : TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018

LEED Energy Performance Summary Report

By Trane

Section 1.4 - Comparison of Proposed Design Versus Baseline Design

Input Parameter	Proposed Design Input	Baseline Design Input
Exterior Wall Construction	Frame Wall , No Ins U-factor : 0.438 Btu /h·ft²·°F	90.1-07 Mln Wall Nonres Zone 4-8 U-factor : 0.065 Btu /h·ft²·°F
Roof Construction	4" LW Conc U-factor : 0.214 Btu /h·ft²·°F Reflectivity : 0.10	90.1-07 Mln Roof Nonres Zone 2-8 U-factor : 0.048 Btu /h·ft²·°F Reflectivity : 0.30
Window-to-gross wall ratio	33.8 %	33.8 %
Fenestration Type	Single Clear 1/4" U-factor : 0.950 Btu /h·ft²·°F SHGC : 0.82 Visible Transmissivity : 0.779	90.1 Window Zor U-factor : 0.350 Visible Transmiss
Interior Light Power Density	Lighting Compliance : Space-By-Space Method Daylighting Controls : No Building : 1.30 W/ft²	Lighting Compliance : Space-By-Space Method Daylighting Controls : No Building : 1.70 W/ft²
Interior Light Power Density	Room Type : Wing 1 - 1.30 W/ft² Wing 2 - 1.30 W/ft² Wing 3 - 1.30 W/ft² Wing 4 - 1.30 W/ft² Wing 5 - 1.30 W/ft²	Room Type : Wing 1 - 1.70 W/ft² Wing 2 - 1.70 W/ft² Wing 3 - 1.70 W/ft² Wing 4 - 1.70 W/ft² Wing 5 - 1.70 W/ft²
Receptacle Elec Eq Power Density	0.50 W/ft²	0.50 W/ft²
HVAC System Type	System - 001 Water Source Heat Pump Uses: Heat recov Supply vol : 62792 cfm Fan power : 4.19 kW Dedicated OA Config : Cool/Heat	System - 001 System 3 - 2007 /2010 - Packaged Rooftop Air Conditioner Uses: DB Econ Supply vol : 36845 cfm Fan power : 42.09 kW
Cooling Equipment	Plant : Cooling plant - 004 Type : Default air-cooled unitary Category : Air-cooled unitary Clg Cap : Design Engy Rate : 1 kW/ton	Plant : Cooling plant - 001 Type : Default air-cooled unitary Category : Air-cooled unitary Clg Cap : Design Engy Rate : 1.38 kW/ton
Cooling Equipment	Plant : Cooling plant - 001 Type : Default Water Source HP Category : Water source heat pump Clg Cap : Design Engy Rate : 0.65 kW/ton HR Cap : 10.88 Mbh /ton Engy Rate : 0.05 kW/Mbh	

LI07: Lighting Power Densities for the Space-By-Space Method

AHVAC06: Baseline Equipment Size

Project Name :
Dataset Name : TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018

LEED Energy Performance Summary Report

By Trane

Section 1.4 - Comparison of Proposed Design Versus Baseline Design

Input Parameter	Proposed Design Input	Baseline Design Input
Chilled Water Pump	Type : Cnst vol chill water pump Full load consumption : 0 ft water	
Heat Rejection Parameters	Type : WSHP - Cooling tower HR Type : Cooling tower (DOE) Energy Consumption : 0.066000 kW/ton	Type : Condenser fan for Heat Pump HR Type : Air-cooled condenser Energy Consumption : 0.120000 kW/ton
Heat Rejection Parameters	Type : Condenser fan for Heat Pump HR Type : Air-cooled condenser Energy Consumption : 0.120000 kW/ton	
Heating Equipment	Plant : Heating plant - 003 Type : Default gas -fired heat exchanger Category : Gas -fired heat exchanger Capacity : Design Energy Rate : 90 Percent efficient	Plant : Heating plant - 002 Type : Default electric resistance Category : Electric resistance Capacity : Design Energy Rate : 100 Percent efficient
Heating Equipment	Plant : Heating plant - 002 Type : Default Boiler Category : Boiler Capacity : Design Energy Rate : 95 Percent efficient	
Hot Water Pump	Type : Heating water circ pump Full load consumption : 0 kW	
Base Utility	Type : Parking lot lights Description : Parking lot lights Energy Type : Electricity Hourly Consumption : 0.1 kW Schedule : Parking lot lights	Type : Parking lot lights Description : Parking lot lights Energy Type : Electricity Hourly Consumption : 0.1 kW Schedule : Parking lot lights

AHVAC06: Baseline Equipment

RE03: Renewable Energy

EC02: Exceptional Calculation

LE03: Proposed Exterior Lighting Power

LE03: Baseline Exterior Lighting Power

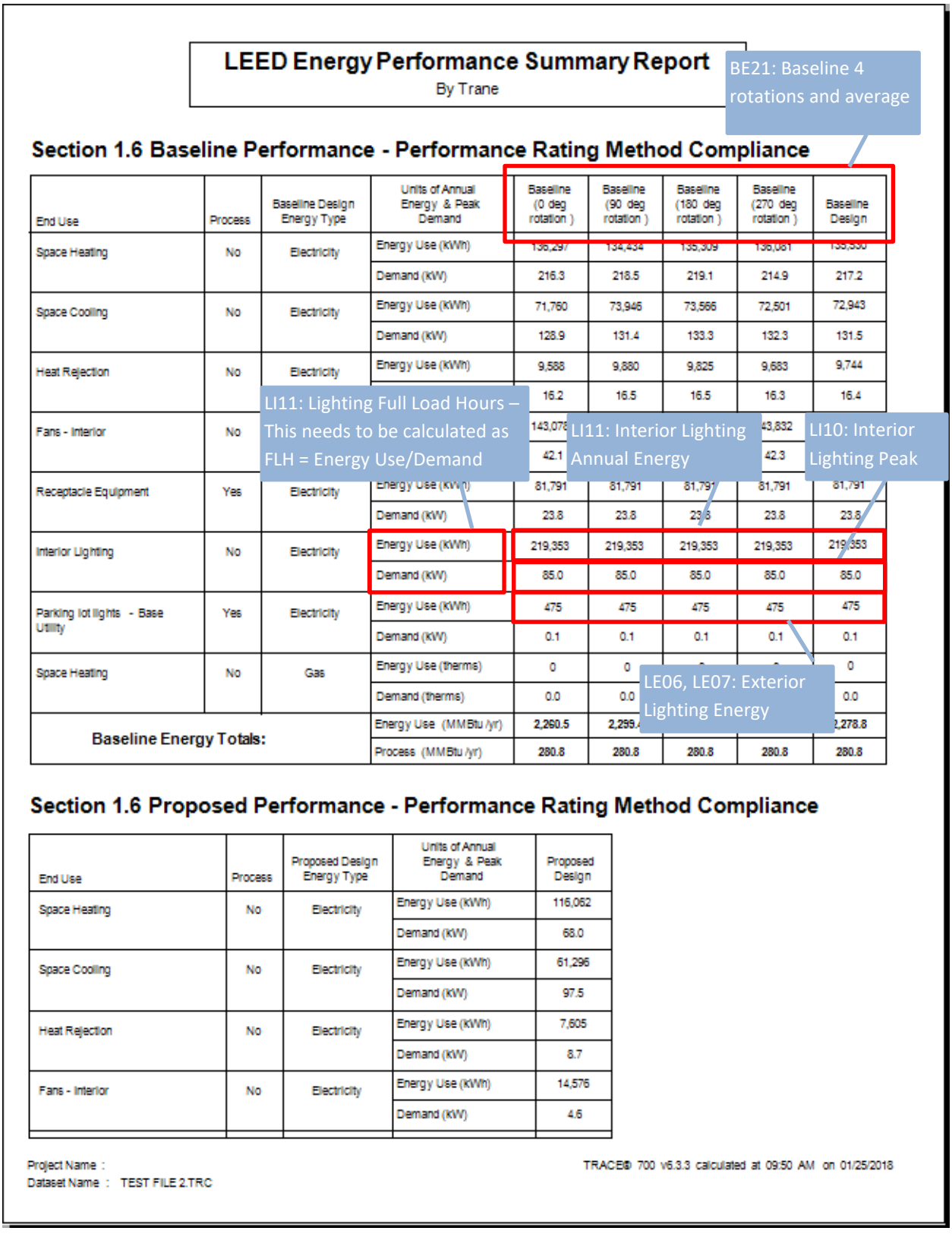
Section 1.5 - Energy Type Summary (Proposed)

Energy Type	Utility Rate Description	Units
Electric Consumption	A sample with all utilities	kWh
Electric Demand	A sample with all utilities	kW
Gas	A sample with all utilities	therms

Project Name :
Dataset Name : TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018

Note: For RE03 and EC02, most renewable energy sources such as solar and wind power cannot be modeled directly in TRACE 700. They must be modeled outside of the program and then input as a negative base utility. A positive base utility consumes energy whereas a negative base utility adds energy. They will appear as separate line items here.



LEED Energy Performance Summary Report

By Trane

BE21: Baseline 4 rotations and average

Section 1.6 Baseline Performance - Performance Rating Method Compliance

End Use	Process	Baseline Design Energy Type	Units of Annual Energy & Peak Demand	Baseline (0 deg rotation)	Baseline (90 deg rotation)	Baseline (180 deg rotation)	Baseline (270 deg rotation)	Baseline Design
Space Heating	No	Electricity	Energy Use (kWh)	136,297	134,434	135,309	136,061	135,500
			Demand (kW)	216.3	218.5	219.1	214.9	217.2
Space Cooling	No	Electricity	Energy Use (kWh)	71,760	73,946	73,566	72,501	72,943
			Demand (kW)	128.9	131.4	133.3	132.3	131.5
Heat Rejection	No	Electricity	Energy Use (kWh)	9,588	9,880	9,825	9,683	9,744
			Demand (kW)	16.2	16.5	16.5	16.3	16.4
Fans - Interior	No			143,078			43,832	
				42.1			42.3	
Receptacle Equipment	Yes	Electricity	Energy Use (kWh)	81,791	81,791	81,791	81,791	81,791
			Demand (kW)	23.8	23.8	23.8	23.8	23.8
Interior Lighting	No	Electricity	Energy Use (kWh)	219,353	219,353	219,353	219,353	219,353
			Demand (kW)	85.0	85.0	85.0	85.0	85.0
Parking lot lights - Base Utility	Yes	Electricity	Energy Use (kWh)	475	475	475	475	475
			Demand (kW)	0.1	0.1	0.1	0.1	0.1
Space Heating	No	Gas	Energy Use (therms)	0	0			0
			Demand (therms)	0.0	0.0			0.0
Baseline Energy Totals:			Energy Use (MMBtu /yr)	2,260.5	2,259.4			2,278.8
			Process (MMBtu /yr)	280.8	280.8	280.8	280.8	280.8

LI11: Lighting Full Load Hours – This needs to be calculated as FLH = Energy Use/Demand

LI11: Interior Lighting Annual Energy

LI10: Interior Lighting Peak

LE06, LE07: Exterior Lighting Energy

Section 1.6 Proposed Performance - Performance Rating Method Compliance

End Use	Process	Proposed Design Energy Type	Units of Annual Energy & Peak Demand	Proposed Design
Space Heating	No	Electricity	Energy Use (kWh)	116,062
			Demand (kW)	68.0
Space Cooling	No	Electricity	Energy Use (kWh)	61,296
			Demand (kW)	97.5
Heat Rejection	No	Electricity	Energy Use (kWh)	7,605
			Demand (kW)	8.7
Fans - Interior	No	Electricity	Energy Use (kWh)	14,576
			Demand (kW)	4.6

Project Name :
Dataset Name : TEST FILE 2.TRC

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LEED Energy Performance Summary Report
By Trane

Section 1.6 Proposed Performance - Performance Rating Method Compliance

End Use	n		Units of A Energy & Dema	
Receptacle E			Energy Use (kWh)	
			Demand (kW)	23.8
Interior Lighting	No	Electricity	Energy Use (kWh)	167,740
			Demand (kW)	65.0
Parking lot lights - Base Utility	Yes	Electricity	Energy Use (kWh)	475
			Demand (kW)	0.1
Space Heating	No	Gas	Energy Use (therms)	19,292
			Demand (	
Proposed Energy Totals:			Energy U	
			Process (MMBtu/yr)	280.77

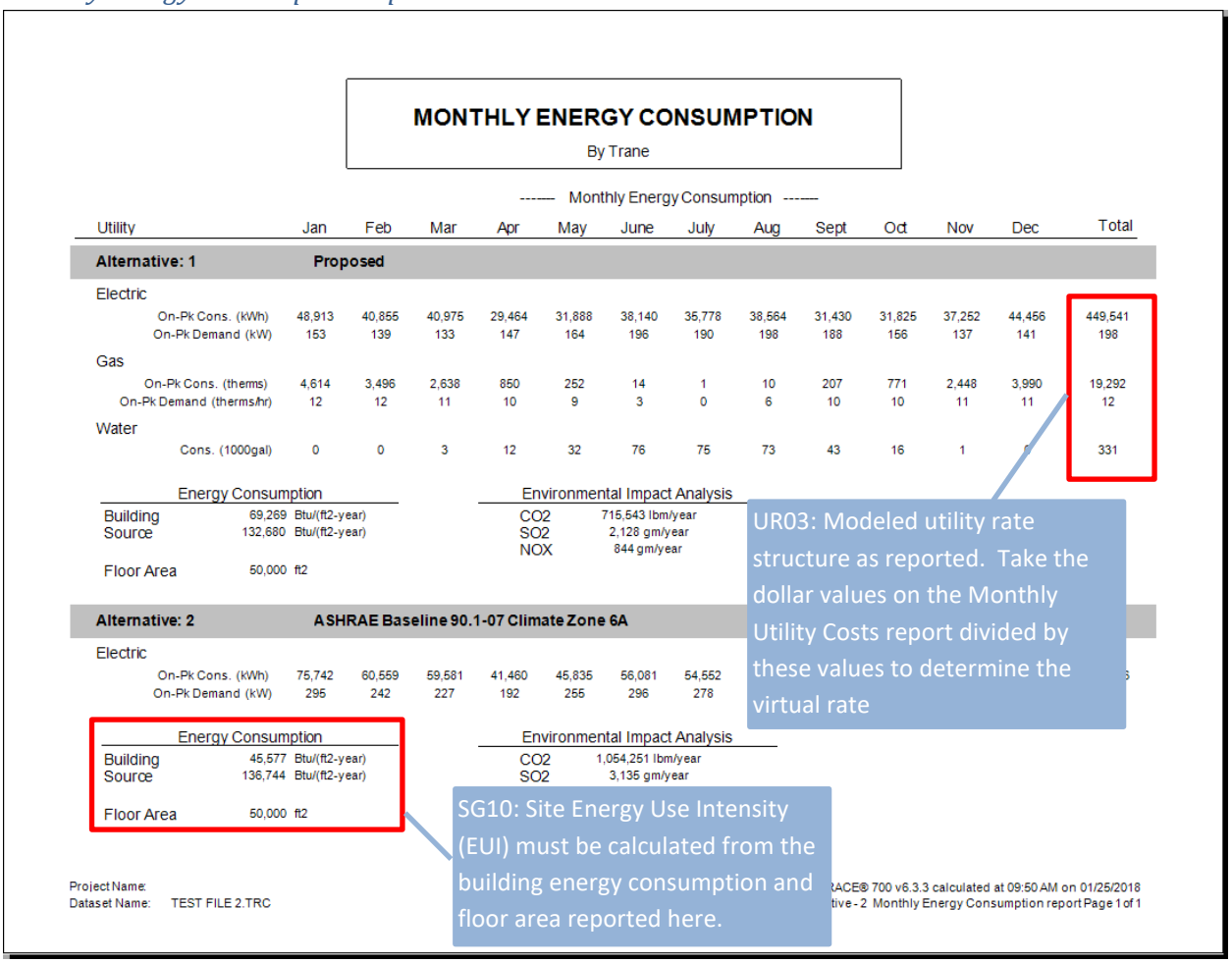
LI10: Lighting Full Load Hours – This needs to be calculated as EFLH = Energy Use/Demand

LI10, LI11: Interior Lighting Annual

LI06: Interior Lighting Peak Demand

LE07: Exterior Lighting Energy

Monthly Energy Consumption report



MONTHLY ENERGY CONSUMPTION

By Trane

------ Monthly Energy Consumption ------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**Proposed**												
Electric													
On-Pk Cons. (kWh)	48,913	40,855	40,975	29,464	31,888	38,140	35,778	38,564	31,430	31,825	37,252	44,456	449,541
On-Pk Demand (kW)	153	139	133	147	164	196	190	198	188	156	137	141	198
Gas													
On-Pk Cons. (therms)	4,614	3,496	2,638	850	252	14	1	10	207	771	2,448	3,990	19,292
On-Pk Demand (therms/hr)	12	12	11	10	9	3	0	6	10	10	11	11	12
Water													
Cons. (1000gal)	0	0	3	12	32	76	75	73	43	16	1		331

Energy Consumption

Building	69,269	Btu/(ft2-year)
Source	132,680	Btu/(ft2-year)
Floor Area	50,000	ft2

Environmental Impact Analysis

CO2	715,543 lbm/year
SO2	2,128 gm/year
NOX	844 gm/year

UR03: Modeled utility rate structure as reported. Take the dollar values on the Monthly Utility Costs report divided by these values to determine the virtual rate

Alternative: 2	**ASHRAE Baseline 90.1-07 Climate Zone 6A**						
Electric							
On-Pk Cons. (kWh)	75,742	60,559	59,581	41,460	45,835	56,081	54,552
On-Pk Demand (kW)	295	242	227	192	255	296	278

Energy Consumption

Building	45,577	Btu/(ft2-year)
Source	136,744	Btu/(ft2-year)
Floor Area	50,000	ft2

Environmental Impact Analysis

CO2	1,054,251 lbm/year
SO2	3,135 gm/year

SG10: Site Energy Use Intensity (EUI) must be calculated from the building energy consumption and floor area reported here.

Project Name:
Dataset Name: TEST FILE 2.TRC

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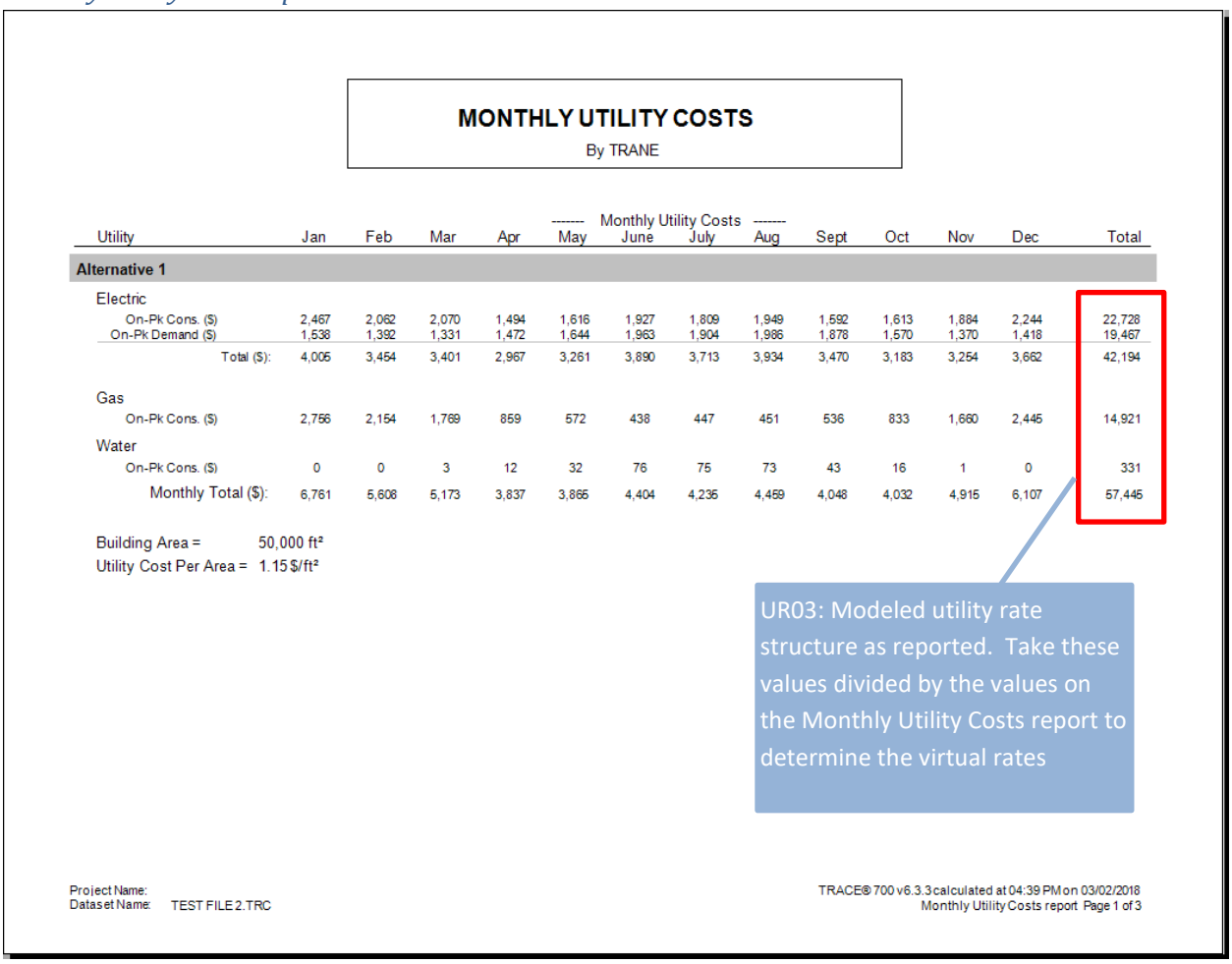
tive - 2 Monthly Energy Consumption report Page 1 of 1

Monthly Utility Costs report



MONTHLY UTILITY COSTS

By TRANE

Monthly Utility Costs

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative 1													
Electric													
On-Pk Cons. ($)	2,467	2,062	2,070	1,494	1,616	1,927	1,809	1,949	1,592	1,613	1,884	2,244	22,728
On-Pk Demand ($)	1,538	1,392	1,331	1,472	1,644	1,963	1,904	1,986	1,878	1,570	1,370	1,418	19,467
Total ($):	4,005	3,454	3,401	2,967	3,261	3,890	3,713	3,934	3,470	3,183	3,254	3,662	42,194
Gas													
On-Pk Cons. ($)	2,756	2,154	1,769	859	572	438	447	451	536	833	1,660	2,445	14,921
Water													
On-Pk Cons. ($)	0	0	3	12	32	76	75	73	43	16	1	0	331
Monthly Total ($):	6,761	5,608	5,173	3,837	3,865	4,404	4,235	4,459	4,048	4,032	4,915	6,107	57,445

Building Area = 50,000 ft²

Utility Cost Per Area = 1.15 $/ft²

UR03: Modeled utility rate structure as reported. Take these values divided by the values on the Monthly Utility Costs report to determine the virtual rates

Project Name:
Dataset Name: TEST FILE 2.TRC

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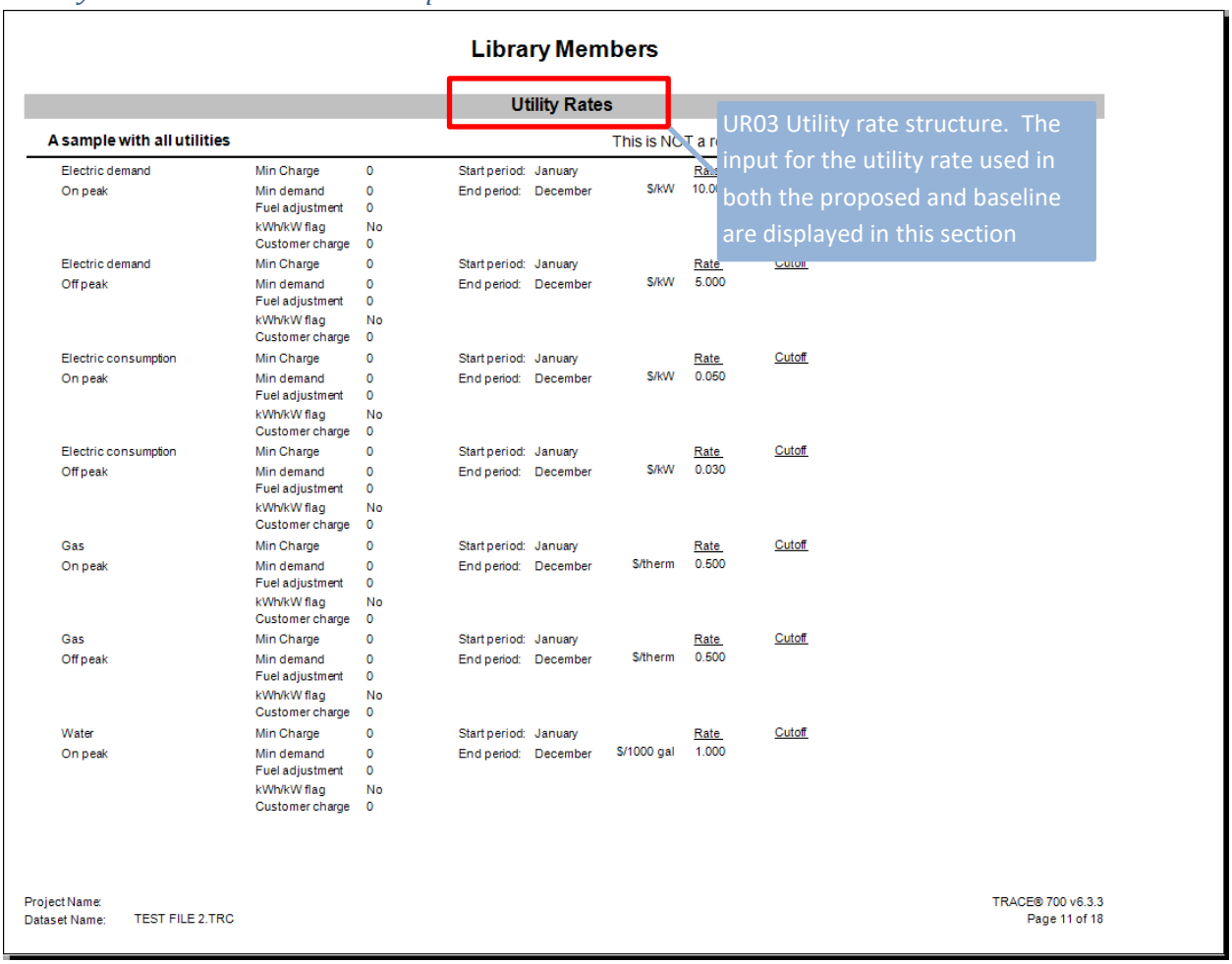
Monthly Utility Costs report Page 1 of 3

Library Members Entered Values report



Library Members

Utility Rates

UR03 Utility rate structure. The input for the utility rate used in both the proposed and baseline are displayed in this section

A sample with all utilities This is NOT a r

Electric demand	Min Charge	0	Start period:	January		Rate	Cutoff
On peak	Min demand	0	End period:	December	$/kW	10.0	
	Fuel adjustment	0					
	kWh/kW flag	No					
	Customer charge	0					
Electric demand	Min Charge	0	Start period:	January		Rate	Cutoff
Off peak	Min demand	0	End period:	December	$/kW	5.000	
	Fuel adjustment	0					
	kWh/kW flag	No					
	Customer charge	0					
Electric consumption	Min Charge	0	Start period:	January		Rate	Cutoff
On peak	Min demand	0	End period:	December	$/kW	0.050	
	Fuel adjustment	0					
	kWh/kW flag	No					
	Customer charge	0					
Electric consumption	Min Charge	0	Start period:	January		Rate	Cutoff
Off peak	Min demand	0	End period:	December	$/kW	0.030	
	Fuel adjustment	0					
	kWh/kW flag	No					
	Customer charge	0					
Gas	Min Charge	0	Start period:	January		Rate	Cutoff
On peak	Min demand	0	End period:	December	$/therm	0.500	
	Fuel adjustment	0					
	kWh/kW flag	No					
	Customer charge	0					
Gas	Min Charge	0	Start period:	January		Rate	Cutoff
Off peak	Min demand	0	End period:	December	$/therm	0.500	
	Fuel adjustment	0					
	kWh/kW flag	No					
	Customer charge	0					
Water	Min Charge	0	Start period:	January		Rate	Cutoff
On peak	Min demand	0	End period:	December	$/1000 gal	1.000	
	Fuel adjustment	0					
	kWh/kW flag	No					
	Customer charge	0					

Project Name:
Dataset Name: TEST FILE 2.TRC

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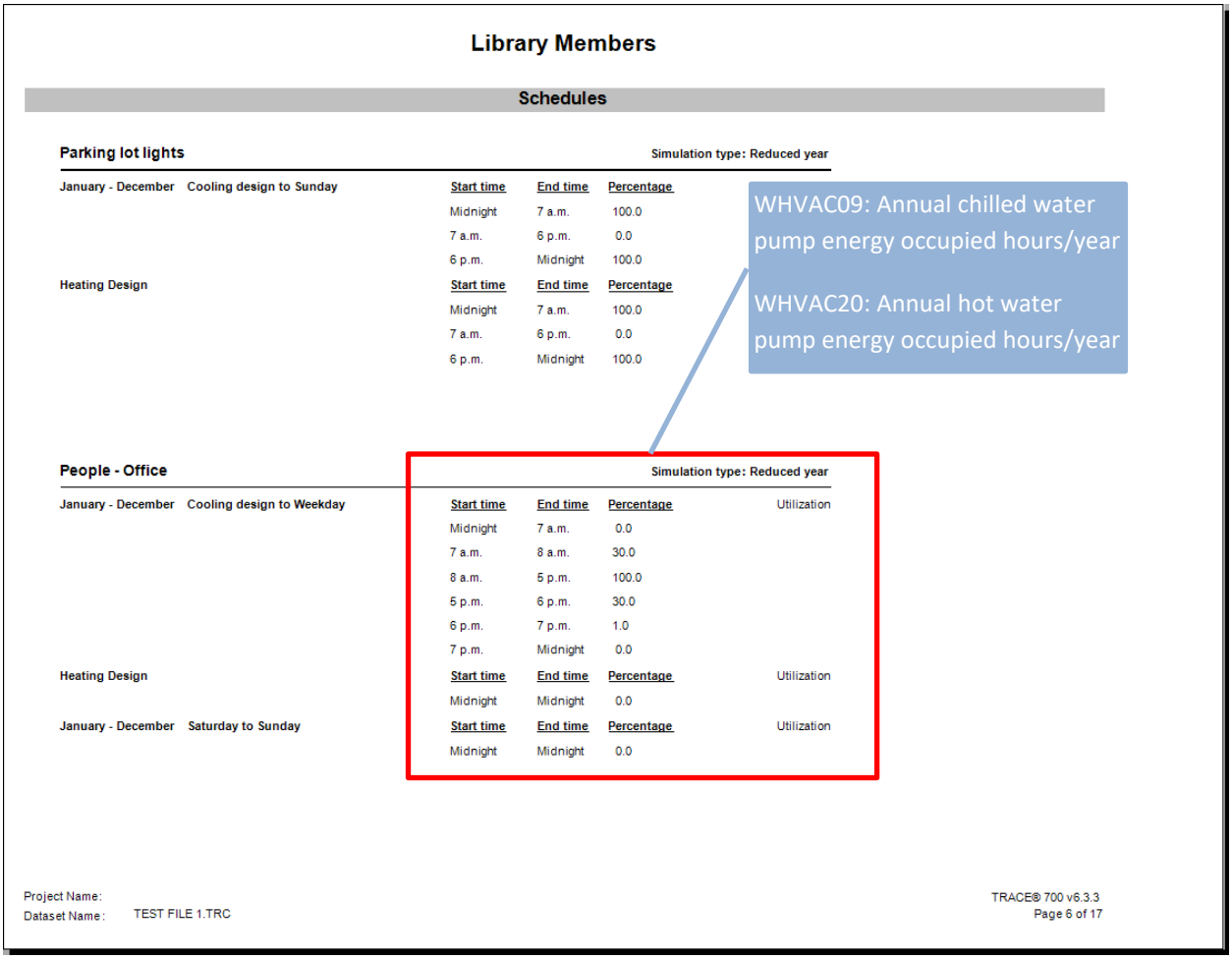

Library Members

Schedules

Parking lot lights — Simulation type: Reduced year

January - December Cooling design to Sunday

Start time	End time	Percentage
Midnight	7 a.m.	100.0
7 a.m.	6 p.m.	0.0
6 p.m.	Midnight	100.0

Heating Design

Start time	End time	Percentage
Midnight	7 a.m.	100.0
7 a.m.	6 p.m.	0.0
6 p.m.	Midnight	100.0

WHVAC09: Annual chilled water pump energy occupied hours/year

WHVAC20: Annual hot water pump energy occupied hours/year

People - Office — Simulation type: Reduced year

January - December Cooling design to Weekday

Start time	End time	Percentage	Utilization
Midnight	7 a.m.	0.0	
7 a.m.	8 a.m.	30.0	
8 a.m.	5 p.m.	100.0	
5 p.m.	6 p.m.	30.0	
6 p.m.	7 p.m.	1.0	
7 p.m.	Midnight	0.0	

Heating Design

Start time	End time	Percentage	Utilization
Midnight	Midnight	0.0	

January - December Saturday to Sunday

Start time	End time	Percentage	Utilization
Midnight	Midnight	0.0	

Project Name:
Dataset Name: TEST FILE 1.TRC

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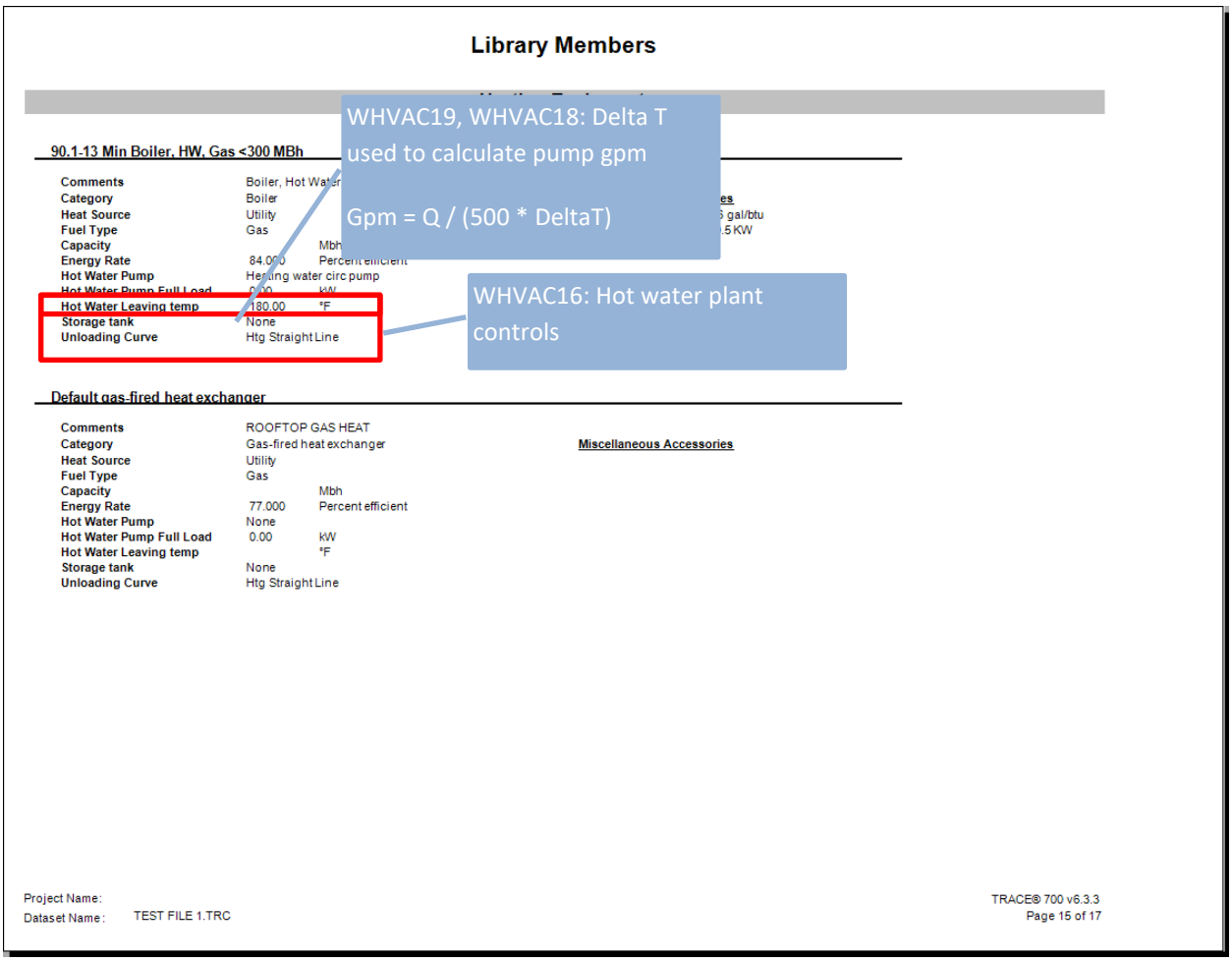
Library Members
WHVAC19, WHVAC18: Delta T used to calculate pump gpm
Gpm = Q / (500 * DeltaT)
WHVAC16: Hot water plant controls
90.1-13 Min Boiler, HW, Gas <300 MBh
Comments Boiler, Hot Water
Category Boiler
Heat Source Utility
Fuel Type Gas
Capacity Mbh
Energy Rate 84.000 Percent efficient
Hot Water Pump Heating water circ pump
Hot Water Pump Full Load 0.00 kW
Hot Water Leaving temp 180.00 °F
Storage tank None
Unloading Curve Htg Straight Line
Default gas-fired heat exchanger
Comments ROOFTOP GAS HEAT
Category Gas-fired heat exchanger
Heat Source Utility
Fuel Type Gas
Capacity Mbh
Energy Rate 77.000 Percent efficient
Hot Water Pump None
Hot Water Pump Full Load 0.00 kW
Hot Water Leaving temp °F
Storage tank None
Unloading Curve Htg Straight Line
Miscellaneous Accessories
Project Name:
Dataset Name: TEST FILE 1.TRC
TRACE® 700 v6.3.3
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Library Members

Heat Rejection

Condenser fan for MZ rooftop

Comments	Multizone packaged rooftop cond fan	
Capacity	100.00	Percent
Energy consumption	0.08	kW/ton
Low speed consumpt	0.00	Percent full load
Fluid type	Water	
Condenser type	Air-cooled condenser	
Number of cells	1	
% Air at low Speed	0.00	
Approach Temp	5.56	°C
Temp Range	5.56	°C
Wet bulb Temp	25.56	°C
Design water flow rate	3.00	gpm/ton
Makeup water flow rate	0.00	gal/ton-hr
Hourly Amb WB Offset		°C
Unloading curve	C-Tower on/off	

Coil load assignmen
+Main
Direct evaporator
+Indirect evaporator
+Auxiliary
+Optional ventilation
+Misc cooling load

Cooling tower for Cent. Chillers

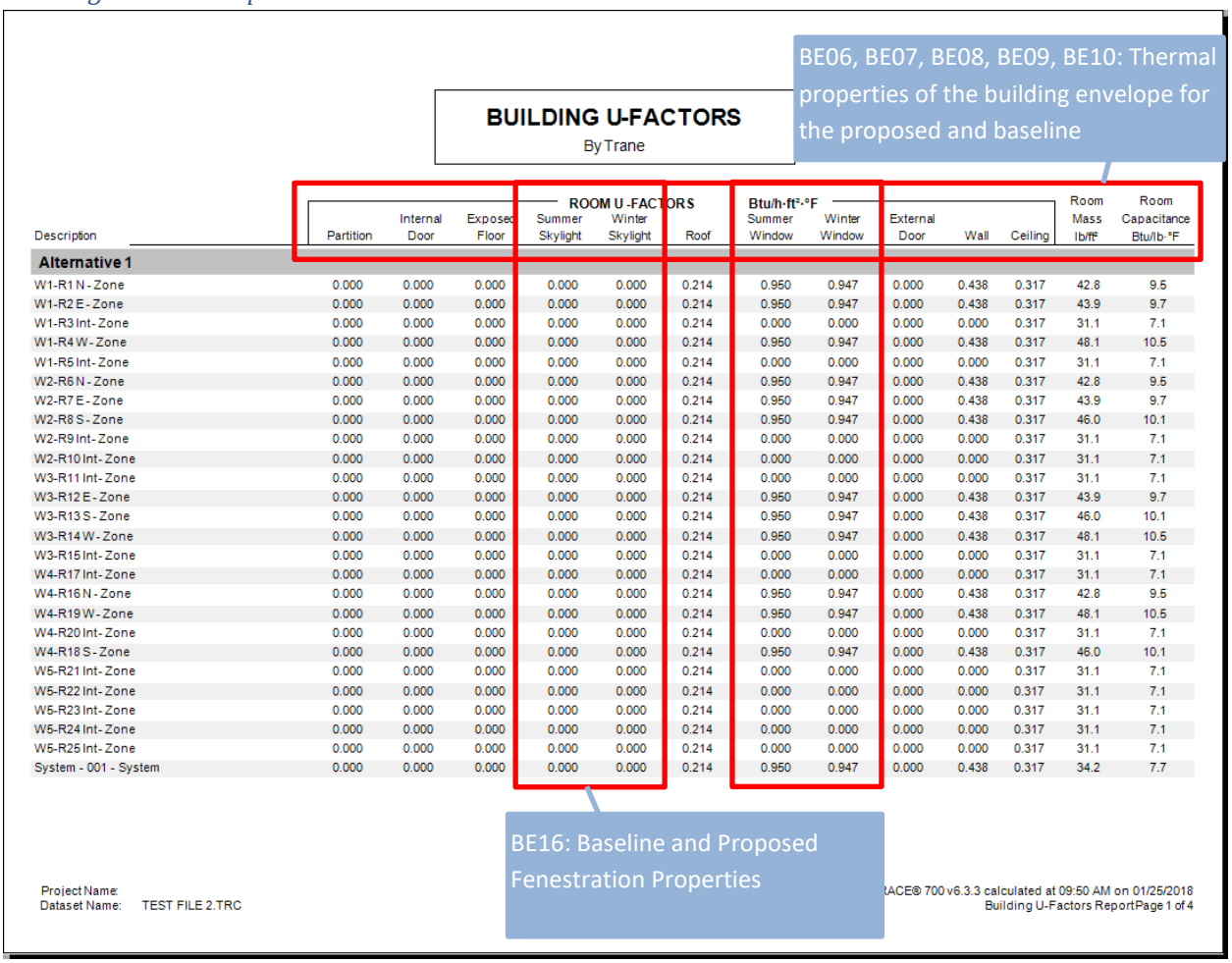
Comments	For Centrifugal Chillers.	
Capacity	100.00	Percent
Energy consumption	0.07	kW/ton
Low speed consumpt	0.00	Percent full load
Fluid type	Water	
Condenser type	Cooling tower (DOE)	
Number of cells	1	
% Air at low Speed	0.00	
Approach Temp	7.00	°F
Temp Range	10.00	°F
Wet bulb Temp	78.00	°F
Design water flow rate	3.00	gpm/ton
Makeup water flow rate	3.20	gal/ton-hr
Hourly Amb WB Offset		°F
Unloading curve	C-Tower on/off	

Coil load assignmen
+Main
Direct evaporator
+Indirect evaporator
+Auxiliary
+Optional ventilation
+Misc cooling load

WHVAC11: Heat Rejection System

Heat Recovery

Building U-Values report



BE06, BE07, BE08, BE09, BE10: Thermal properties of the building envelope for the proposed and baseline

BUILDING U-FACTORS
By Trane

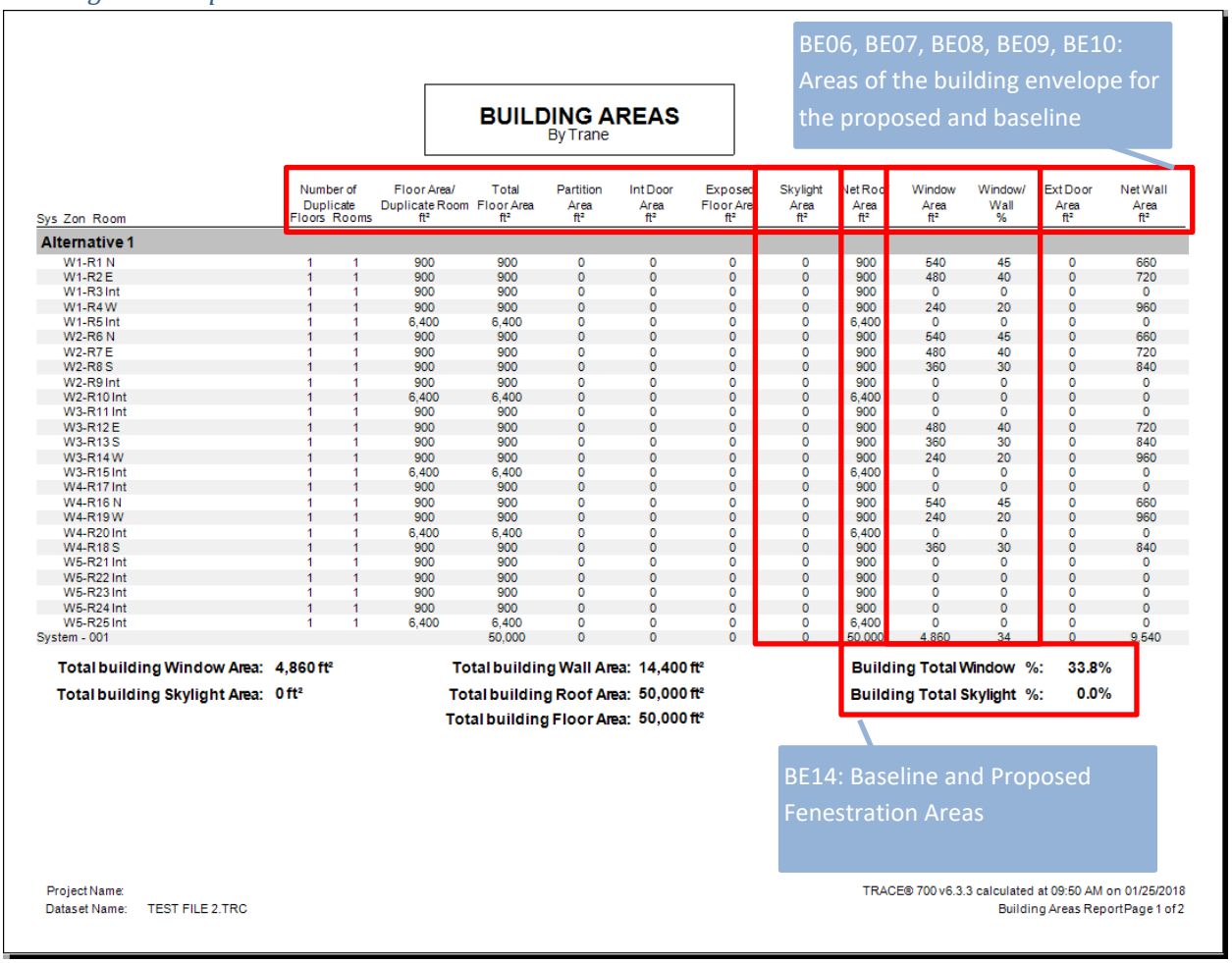
Description	ROOM U-FACTORS Btu/h·ft²·°F											Room Mass lb/ft²	Room Capacitance Btu/lb·°F
	Partition	Internal Door	Exposed Floor	Summer Skylight	Winter Skylight	Roof	Summer Window	Winter Window	External Door	Wall	Ceiling		
Alternative 1													
W1-R1 N - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	42.8	9.5
W1-R2 E - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	43.9	9.7
W1-R3 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W1-R4 W - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	48.1	10.5
W1-R5 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W2-R6 N - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	42.8	9.5
W2-R7 E - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	43.9	9.7
W2-R8 S - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	46.0	10.1
W2-R9 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W2-R10 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W3-R11 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W3-R12 E - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	43.9	9.7
W3-R13 S - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	46.0	10.1
W3-R14 W - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	48.1	10.5
W3-R15 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W4-R17 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W4-R16 N - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	42.8	9.5
W4-R19 W - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	48.1	10.5
W4-R20 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W4-R18 S - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	46.0	10.1
W5-R21 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W5-R22 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W5-R23 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W5-R24 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
W5-R25 Int - Zone	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.317	31.1	7.1
System - 001 - System	0.000	0.000	0.000	0.000	0.000	0.214	0.950	0.947	0.000	0.438	0.317	34.2	7.7

BE16: Baseline and Proposed Fenestration Properties

Project Name:
Dataset Name: TEST FILE 2.TRC

ACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Building U-Factors Report Page 1 of 4

Building Areas report



BE06, BE07, BE08, BE09, BE10: Areas of the building envelope for the proposed and baseline

BUILDING AREAS
By Trane

Sys Zon Room	Number of Duplicate Floors	Number of Duplicate Rooms	Floor Area/ Duplicate Room ft²	Total Floor Area ft²	Partition Area ft²	Int Door Area ft²	Exposed Floor Area ft²	Skylight Area ft²	Net Roof Area ft²	Window Area ft²	Window/ Wall %	Ext Door Area ft²	Net Wall Area ft²
Alternative 1													
W1-R1 N	1	1	900	900	0	0	0	0	900	540	45	0	660
W1-R2 E	1	1	900	900	0	0	0	0	900	480	40	0	720
W1-R3 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W1-R4 W	1	1	900	900	0	0	0	0	900	240	20	0	960
W1-R5 Int	1	1	6,400	6,400	0	0	0	0	6,400	0	0	0	0
W2-R6 N	1	1	900	900	0	0	0	0	900	540	45	0	660
W2-R7 E	1	1	900	900	0	0	0	0	900	480	40	0	720
W2-R8 S	1	1	900	900	0	0	0	0	900	360	30	0	840
W2-R9 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W2-R10 Int	1	1	6,400	6,400	0	0	0	0	6,400	0	0	0	0
W3-R11 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W3-R12 E	1	1	900	900	0	0	0	0	900	480	40	0	720
W3-R13 S	1	1	900	900	0	0	0	0	900	360	30	0	840
W3-R14 W	1	1	900	900	0	0	0	0	900	240	20	0	960
W3-R15 Int	1	1	6,400	6,400	0	0	0	0	6,400	0	0	0	0
W4-R17 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W4-R16 N	1	1	900	900	0	0	0	0	900	540	45	0	660
W4-R19 W	1	1	900	900	0	0	0	0	900	240	20	0	960
W4-R20 Int	1	1	6,400	6,400	0	0	0	0	6,400	0	0	0	0
W4-R18 S	1	1	900	900	0	0	0	0	900	360	30	0	840
W5-R21 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W5-R22 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W5-R23 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W5-R24 Int	1	1	900	900	0	0	0	0	900	0	0	0	0
W5-R25 Int	1	1	6,400	6,400	0	0	0	0	6,400	0	0	0	0
System - 001				50,000	0	0	0	0	50,000	4,860	34	0	9,540

Total building Window Area: 4,860 ft²
Total building Skylight Area: 0 ft²
Total building Wall Area: 14,400 ft²
Total building Roof Area: 50,000 ft²
Total building Floor Area: 50,000 ft²
Building Total Window %: 33.8%
Building Total Skylight %: 0.0%

BE14: Baseline and Proposed Fenestration Areas

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Building Areas ReportPage 1 of 2

Walls by Direction Entered Values report

ENTERED VALUES
Walls by Direction
By Trane

Alternative 1

North (0 degrees)

Room Description	Wall Description	Area	Tilt	Const Type	U Value Btu/h·ft²·°F	Alpha	Type	Glass Area ft²	Glass SHGC	Glass U Value Btu/h·ft²·°F	External Shading	Internal Shading
W1-R1 N	N Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	540.0	0.82	0.9500	Overhang - None	None
W2-R6 N	N Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	540.0	0.82	0.9500	Overhang - None	None
W4-R16 N	N Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	540.0	0.82	0.9500	Overhang - None	None
		3,600.0			**0.4376**			**1,620.0**	**0.82**	**0.9500**		

BE14: Baseline and Proposed Fenestration Areas

East (90 degrees)

Room Description	Wall Description	Area	Tilt	Const Type	U Value Btu/h·ft²·°F	Alpha	Type	Glass Area ft²	Glass SHGC	Glass U Value Btu/h·ft²·°F	External Shading	Internal Shading
W1-R2 E	E Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	480.0	0.82	0.9500	Overhang - None	None
W2-R7 E	E Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	480.0	0.82	0.9500	Overhang - None	None
W3-R12 E	E Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1						Clear 1/4*	480.0	0.82	0.9500	Overhang - None	None
		3,600.0			**0.4376**			**1,440.0**	**0.82**	**0.9500**		

BE16: Baseline and Proposed Fenestration Properties

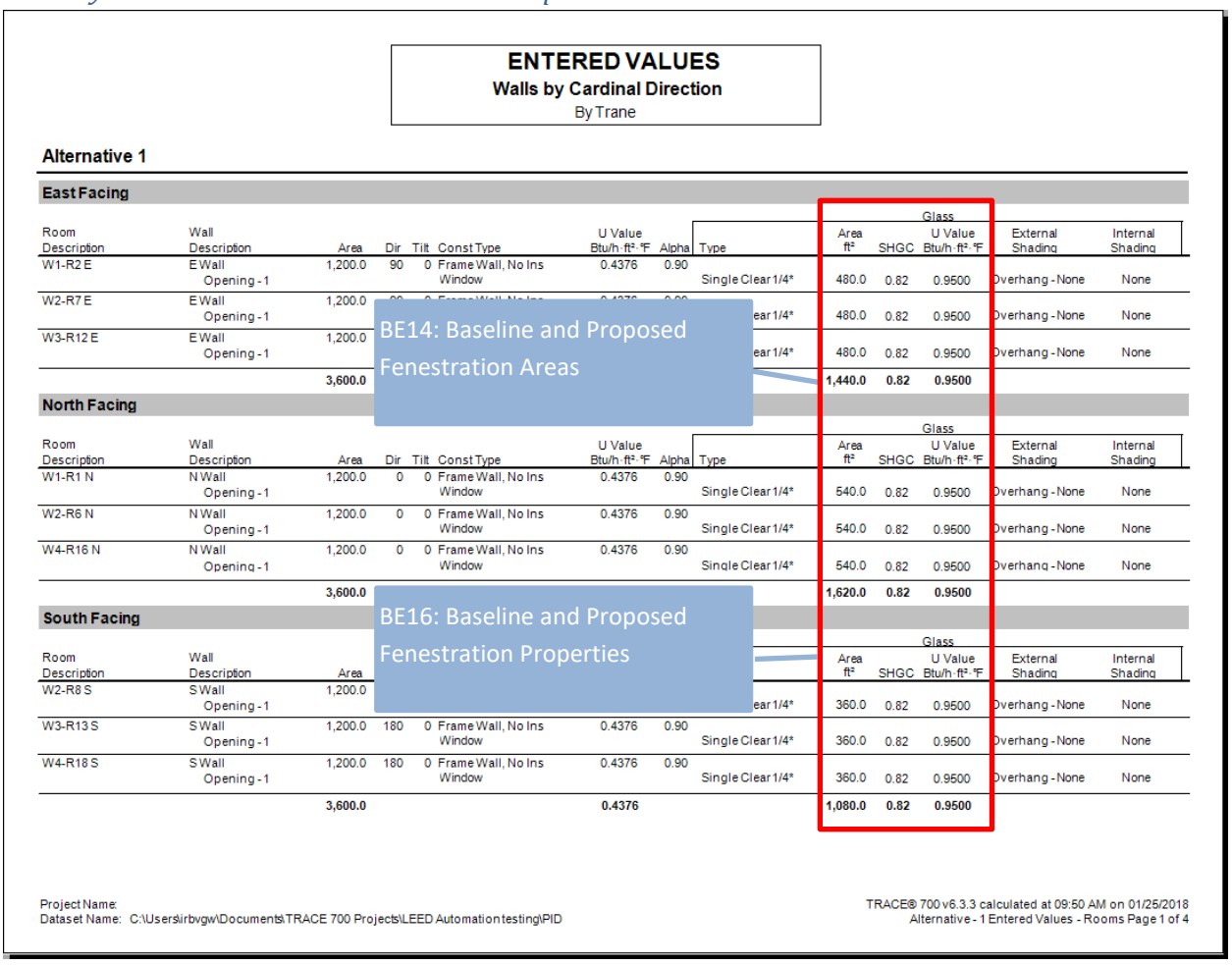
South (180 degrees)

Room Description	Wall Description	Area	Tilt	Const Type	U Value Btu/h·ft²·°F	Alpha	Type	Glass Area ft²	Glass SHGC	Glass U Value Btu/h·ft²·°F	External Shading	Internal Shading
W2-R8 S	S Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	360.0	0.82	0.9500	Overhang - None	None
W3-R13 S	S Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	360.0	0.82	0.9500	Overhang - None	None
W4-R18 S	S Wall	1,200.0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1			Window			Single Clear 1/4*	360.0	0.82	0.9500	Overhang - None	None
		3,600.0			**0.4376**			**1,080.0**	**0.82**	**0.9500**		

Project Name:
Dataset Name: C:\Users\irbvgw\Documents\TRACE 700 Projects\LEED Automation testing\PID

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Alternative - 1 Entered Values - Rooms Page 1 of 4

Walls by Cardinal Direction entered values report



ENTERED VALUES
Walls by Cardinal Direction
By Trane

Alternative 1

East Facing

Room Description	Wall Description	Area	Dir	Tilt	Const Type	U Value Btu/h·ft²·°F	Alpha	Type	Glass Area ft²	Glass SHGC	Glass U Value Btu/h·ft²·°F	External Shading	Internal Shading
W1-R2 E	E Wall	1,200.0	90	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1				Window			Single Clear 1/4*	480.0	0.82	0.9500	Overhang - None	None
W2-R7 E	E Wall	1,200.0											
	Opening - 1							ear 1/4*	480.0	0.82	0.9500	Overhang - None	None
W3-R12 E	E Wall	1,200.0											
	Opening - 1							ear 1/4*	480.0	0.82	0.9500	Overhang - None	None
		3,600.0							**1,440.0**	**0.82**	**0.9500**		

North Facing

Room Description	Wall Description	Area	Dir	Tilt	Const Type	U Value Btu/h·ft²·°F	Alpha	Type	Glass Area ft²	Glass SHGC	Glass U Value Btu/h·ft²·°F	External Shading	Internal Shading
W1-R1 N	N Wall	1,200.0	0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1				Window			Single Clear 1/4*	540.0	0.82	0.9500	Overhang - None	None
W2-R6 N	N Wall	1,200.0	0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1				Window			Single Clear 1/4*	540.0	0.82	0.9500	Overhang - None	None
W4-R16 N	N Wall	1,200.0	0	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1				Window			Single Clear 1/4*	540.0	0.82	0.9500	Overhang - None	None
		3,600.0							**1,620.0**	**0.82**	**0.9500**		

South Facing

Room Description	Wall Description	Area	Dir	Tilt	Const Type	U Value Btu/h·ft²·°F	Alpha	Type	Glass Area ft²	Glass SHGC	Glass U Value Btu/h·ft²·°F	External Shading	Internal Shading
W2-R8 S	S Wall	1,200.0											
	Opening - 1							ear 1/4*	360.0	0.82	0.9500	Overhang - None	None
W3-R13 S	S Wall	1,200.0	180	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1				Window			Single Clear 1/4*	360.0	0.82	0.9500	Overhang - None	None
W4-R18 S	S Wall	1,200.0	180	0	Frame Wall, No Ins	0.4376	0.90						
	Opening - 1				Window			Single Clear 1/4*	360.0	0.82	0.9500	Overhang - None	None
		3,600.0				**0.4376**			**1,080.0**	**0.82**	**0.9500**		

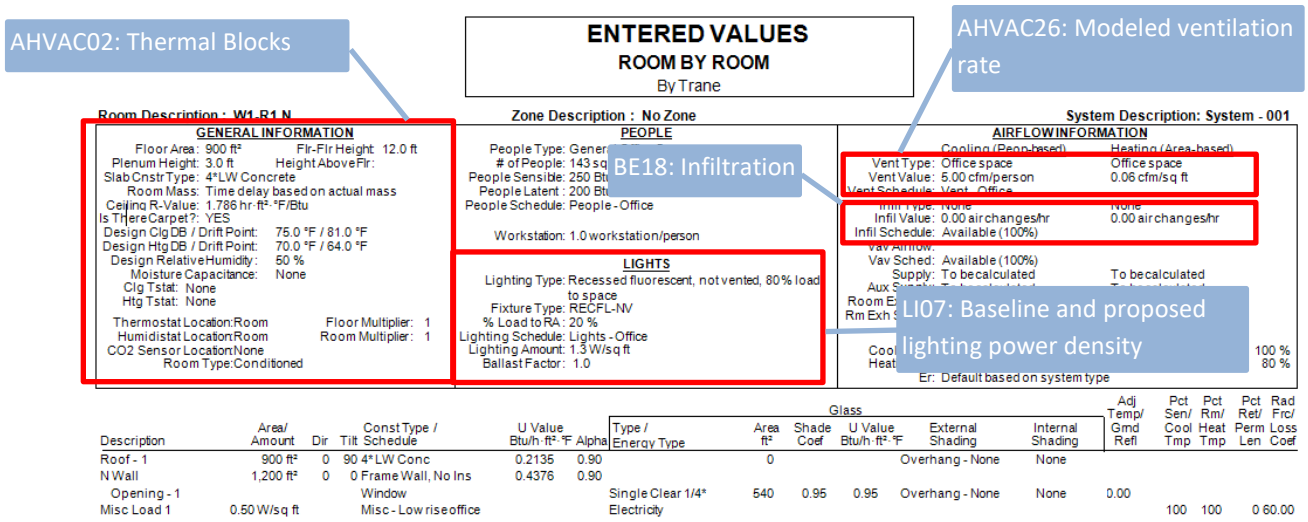
BE14: Baseline and Proposed Fenestration Areas

BE16: Baseline and Proposed Fenestration Properties

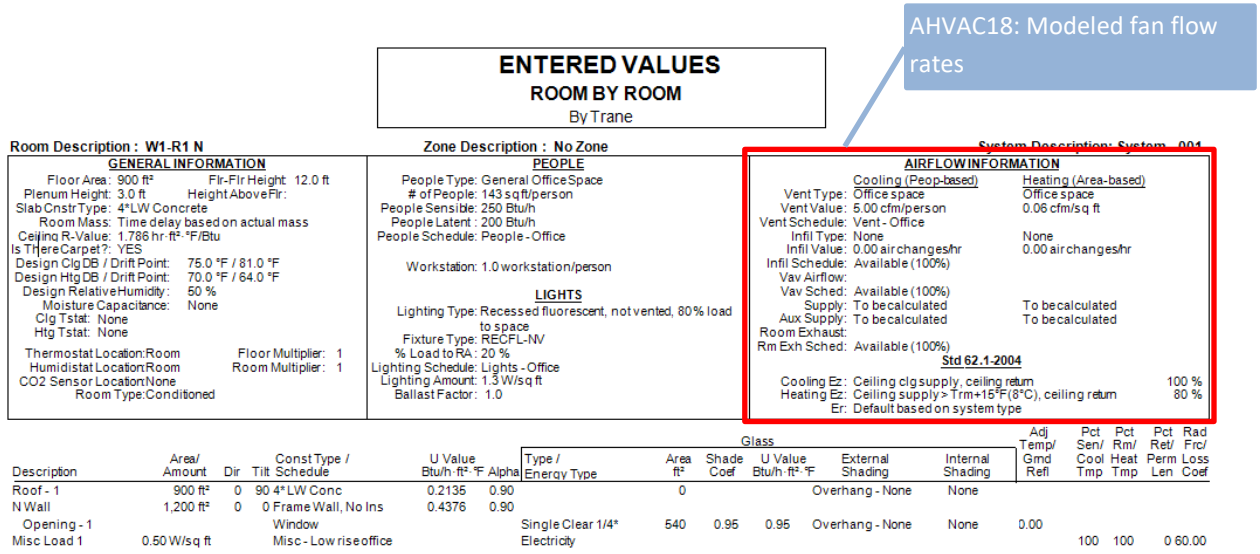
Project Name:
Dataset Name: C:\Users\irbvgw\Documents\TRACE 700 Projects\LEED Automation testing\PID

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Alternative - 1 Entered Values - Rooms Page 1 of 4

Room Information entered values report



Note: Alternative 1 rooms are displayed first. Alternative 2 rooms are displayed later in the report.



Building Envelope Cooling Loads at Coil Peak

BUILDING ENVELOPE COOLING LOADS
at Coil Peak
By Trane

Alternative 1

System Zone Room		WALL Plenum Load Btu/h	WALL Plenum CLTD °F	WALL Space Load Btu/h	WALL Space CLTD °F	WINDOW Space Solar Btu/h	WINDOW Plenum Solar Btu/h	WINDOW Solar CLF	WINDOW Space Conduction Btu/h	WINDOW Space CLTD °F	WINDOW Plenum Conduction Btu/h	WINDOW Plenum CLTD °F
W1-R1 N	Zn Tot/Ave	2,441	18.6	4,362	27.7	18,086	0	0.955	9,342	18.2	0	0.0
W1-R2 E	Zn Tot/Ave	8,232	62.7	11,906	64.8	91,065	0	0.945	2,375	5.2	0	0.0
W1-R3 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W1-R4 W	Zn Tot/Ave	9,419	71.7	23,420	81.1	46,043	0	0.944	3,427	15.0	0	0.0
W1-R5 Int	Zn Tot/Ave	0	0.0	0	0.0						0	0.0
W2-R6 N	Zn Tot/Ave	2,441	18.6	4,362	27.7						0	0.0
W2-R7 E	Zn Tot/Ave	8,232	62.7	11,906	64.8						0	0.0
W2-R8 S	Zn Tot/Ave	8,793	67.0	17,130	72.5						0	0.0
W2-R9 Int	Zn Tot/Ave	0	0.0	0	0.0						0	0.0
W2-R10 Int	Zn Tot/Ave	0	0.0	0	0.0						0	0.0
W3-R11 Int	Zn Tot/Ave	0	0.0	0	0.0						0	0.0
W3-R12 E	Zn Tot/Ave	8,232	62.7	11,906	64.8						0	0.0
W3-R13 S	Zn Tot/Ave	8,793	67.0	17,130	72.5						0	0.0
W3-R14 W	Zn Tot/Ave	9,419	71.7	23,420	81.1	46,043	0	0.944	3,427	15.0	0	0.0
W3-R15 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W4-R17 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W4-R16 N	Zn Tot/Ave	2,441	18.6	4,362	27.7	18,086	0	0.955	9,342	18.2	0	0.0
W4-R19 W	Zn Tot/Ave	9,419	71.7	23,420	81.1	46,043	0	0.944	3,427	15.0	0	0.0
W4-R20 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W4-R18 S	Zn Tot/Ave	8,793	67.0	17,130	72.5	68,138	0	0.966	2,336	6.8	0	0.0
W5-R21 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R22 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R23 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R24 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R25 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
System - 001	Sys Tot/Ave	86,651	55.0	170,449	65.6	669,995	0	0.952	52,441	11.4	0	0.0
System - 001	Sys Block	60,577	38.5	127,309	49.0	271,611	0	0.438	78,731	17.1	0	0.0

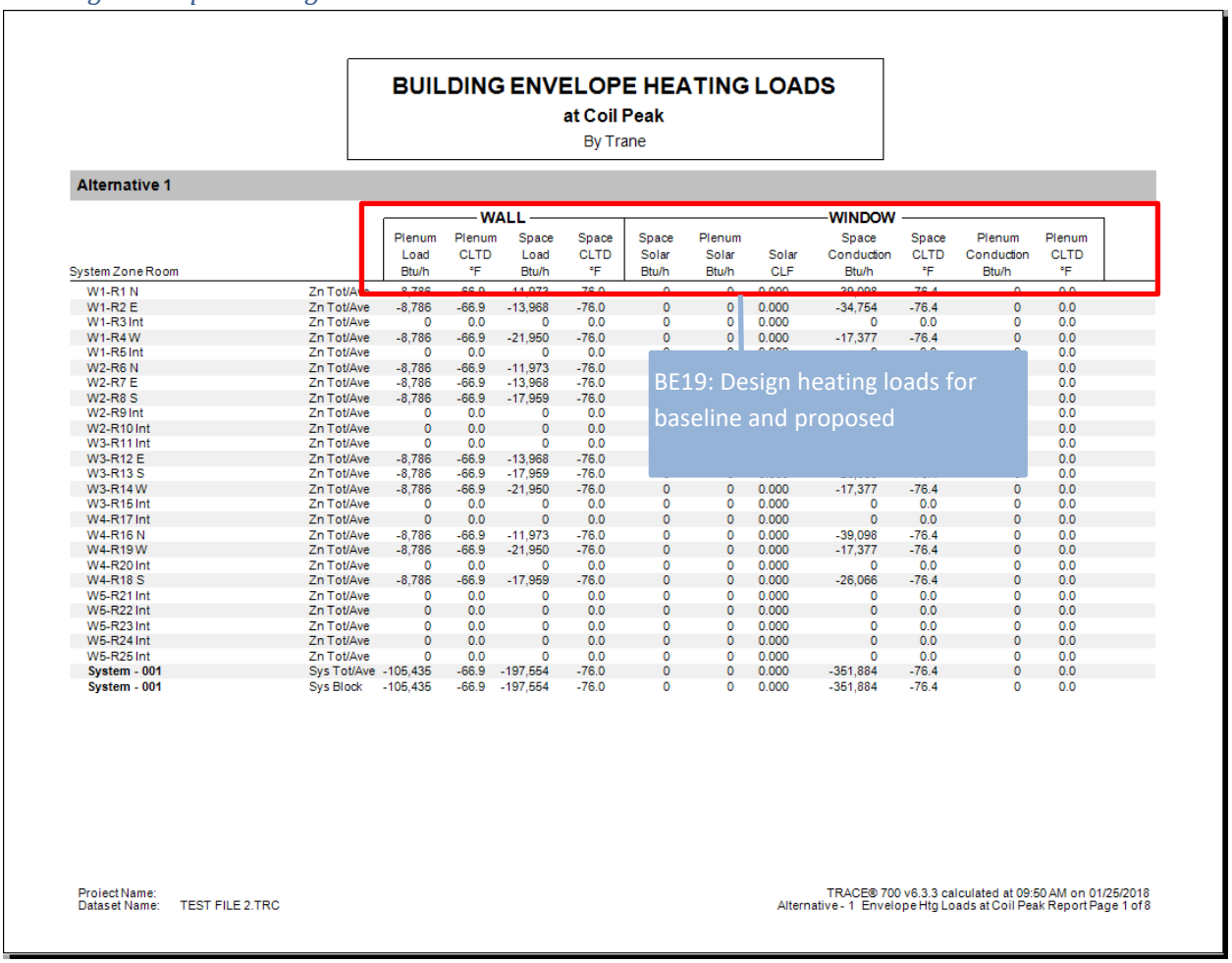
BE19: Design cooling loads for baseline and proposed

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Alternative - 1 Envelope Loads at Coil Peak Report Page 1 of 8

Note: Alternative 1 loads are displayed first, alternative 2 loads are later in the report.

Building Envelope Heating Loads at Coil Peak



BUILDING ENVELOPE HEATING LOADS
at Coil Peak
By Trane

Alternative 1

System Zone Room		WALL Plenum Load Btu/h	WALL Plenum CLTD °F	WALL Space Load Btu/h	WALL Space CLTD °F	WINDOW Space Solar Btu/h	WINDOW Plenum Solar Btu/h	WINDOW Solar CLF	WINDOW Space Conduction Btu/h	WINDOW Space CLTD °F	WINDOW Plenum Conduction Btu/h	WINDOW Plenum CLTD °F
W1-R1 N	Zn Tot/Ave	-8,786	-66.9	-11,973	-76.0	0	0	0.000	-39,098	-76.4	0	0.0
W1-R2 E	Zn Tot/Ave	-8,786	-66.9	-13,968	-76.0	0	0	0.000	-34,754	-76.4	0	0.0
W1-R3 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W1-R4 W	Zn Tot/Ave	-8,786	-66.9	-21,950	-76.0	0	0	0.000	-17,377	-76.4	0	0.0
W1-R5 Int	Zn Tot/Ave	0	0.0	0	0.0							0.0
W2-R6 N	Zn Tot/Ave	-8,786	-66.9	-11,973	-76.0							0.0
W2-R7 E	Zn Tot/Ave	-8,786	-66.9	-13,968	-76.0							0.0
W2-R8 S	Zn Tot/Ave	-8,786	-66.9	-17,959	-76.0							0.0
W2-R9 Int	Zn Tot/Ave	0	0.0	0	0.0							0.0
W2-R10 Int	Zn Tot/Ave	0	0.0	0	0.0							0.0
W3-R11 Int	Zn Tot/Ave	0	0.0	0	0.0							0.0
W3-R12 E	Zn Tot/Ave	-8,786	-66.9	-13,968	-76.0							0.0
W3-R13 S	Zn Tot/Ave	-8,786	-66.9	-17,959	-76.0							0.0
W3-R14 W	Zn Tot/Ave	-8,786	-66.9	-21,950	-76.0	0	0	0.000	-17,377	-76.4	0	0.0
W3-R15 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W4-R17 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W4-R16 N	Zn Tot/Ave	-8,786	-66.9	-11,973	-76.0	0	0	0.000	-39,098	-76.4	0	0.0
W4-R19 W	Zn Tot/Ave	-8,786	-66.9	-21,950	-76.0	0	0	0.000	-17,377	-76.4	0	0.0
W4-R20 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W4-R18 S	Zn Tot/Ave	-8,786	-66.9	-17,959	-76.0	0	0	0.000	-26,066	-76.4	0	0.0
W5-R21 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R22 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R23 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R24 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
W5-R25 Int	Zn Tot/Ave	0	0.0	0	0.0	0	0	0.000	0	0.0	0	0.0
System - 001	Sys Tot/Ave	-105,435	-66.9	-197,554	-76.0	0	0	0.000	-351,884	-76.4	0	0.0
System - 001	Sys Block	-105,435	-66.9	-197,554	-76.0	0	0	0.000	-351,884	-76.4	0	0.0

BE19: Design heating loads for baseline and proposed

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Alternative - 1 Envelope Htg Loads at Coil Peak Report Page 1 of 8

Note: Alternative 1 loads are displayed first, alternative 2 loads are later in the report.

Plant Information entered values report

ENTERED VALUES
PLANTS
By TRANE

Cooling Plant: Cooling plant - 001

Sizing method: Peak
Heat rejection type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Off (0%)

Geothermal Loop
TLoop Ent Bldg: None
TLoop schedule: None
Flow rate: 100.00% of condenser flow rate
Loop pump None
Pump F.L. rate: 0.00ft water
Flow scheme: Fully mixed
Loop fluid glycol: 0%
Heat exchanger approach: 0°F

Equipment tag: Water source heat pump - 001 Cooling Type: Default Water Source HP — Cooling plant - 001

Operating Mode	Capacity	Energy Rate
Cooling:		0.6500 kW/ton
Heat recovery:	10.9 Mbh/ton	0.0500 kW/Mbh
Tank charging:		
Tank charging & heat recovery:		

Pumps Type
Chilled water: Cnst vol chill water pump
Condenser water: None
Heat recovery or aux cond: None
Free cooling: None

Full Load Consumption
0.00 Ft Water

Heat Rejection and Thermal Storage
Heat rejection type: WSHP - Cooling tower
Thermal storage type: Heat pump loop no storage
T-storage capacity: 12 gal/ton
T-storage schedule: Heatpump

Sequencing type: Single
Demand lim priority:
Dsn chilled water delta T: 10 °F
Dsn cond water delta T: 10 °F

Equipment Options
Free clg type: None
Fluid cooler type: None
Load shed econ: no
Evap precooling: no
Hot gas reheat No

Energy source: Heating plant - 002
Reject cond heat: Heat Reject.Equip
Cond. heat to plant:
Equip schedule: Available (100%)

Reset Based On	Reset Curve	Max Reset TD
Chilled Water:	None	0°F
Condenser Water:	None	0°F

Cooling Plant: Cooling plant - 004

Sizing method: Peak
Heat rejection type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Off (0%)

Geothermal Loop
ow rate
Pump F.L. rate: 0.00ft water
Flow scheme: Fully mixed
Loop fluid glycol: 0%
Heat exchanger approach: 0°F

AHVAC11: DX cooling efficiencies

Equipment tag: Air-cooled unitary - 002 Cooling Type: Default air-cooled unitary — Cooling plant - 004

Operating Mode	Capacity	Energy Rate
Cooling:		1.0000 kW/ton
Heat recovery:		
Tank charging:		
Tank charging & heat recovery:		

Pumps Type
Chilled water: None
Condenser water: None
Heat recovery or aux cond: None
Free cooling: None

Full Load Consumption

Heat Rejection and Thermal Storage
Heat rejection type: Condenser fan for Heat Pump
Thermal storage type: None
T-storage capacity: 0 ton-hr
T-storage schedule: Storage

Sequencing type: Single
Demand lim priority:
Dsn chilled water delta T: 10 °F
Dsn cond water delta T: 10 °F

Equipment Options
Free clg type: None
Fluid cooler type: None
Load shed econ: no
Evap precooling: no
Hot gas reheat No

Energy source:
Reject cond heat: Heat Reject.Equip
Cond. heat to plant:
Equip schedule: Available (100%)

Reset Based On	Reset Curve	Max Reset TD

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 04:39 PM on 03/02/2018
Alternative - 1 Entered Values - Plants Page 1 of 5

ENTERED VALUES
PLANTS
By Trane

Chilled Water: None — None — 0°F
Condenser Water: None — None — 0°F

Heating Plant: Heating plant - 002

Sizing method: Peak
Cogeneration type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr

Equipment tag: Boiler - 001 — Heating Type: Default Boiler — Heating plant - 002

Heating capacity:
Energy rate: 95.00 % Effic.
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Storage
Hot water pump type: Heating water circ pump
Hot water pump cons: 0.00 kW
Equipment schedule: Available (100%)
Demand limiting priority:

Heating Plant: Heating plant - 003

Sizing method: Peak
Cogeneration type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr

Equipment tag: Gas-fired heat exchanger - 002 — Heating Type: Default gas-fired heat exchanger — Heating plant - 003

Heating capacity:
Energy rate: 90.00 % Effic.
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Storage
Equipment schedule: Available (100%)
Demand limiting priority:

Base Utilities

Plant assigned to: Stand-alone — Description: Parking lot lights — Schedule: Parking lot lights
Type: Parking lot lights — Demand limiting priority: — Hourly demand: 0.10 kW

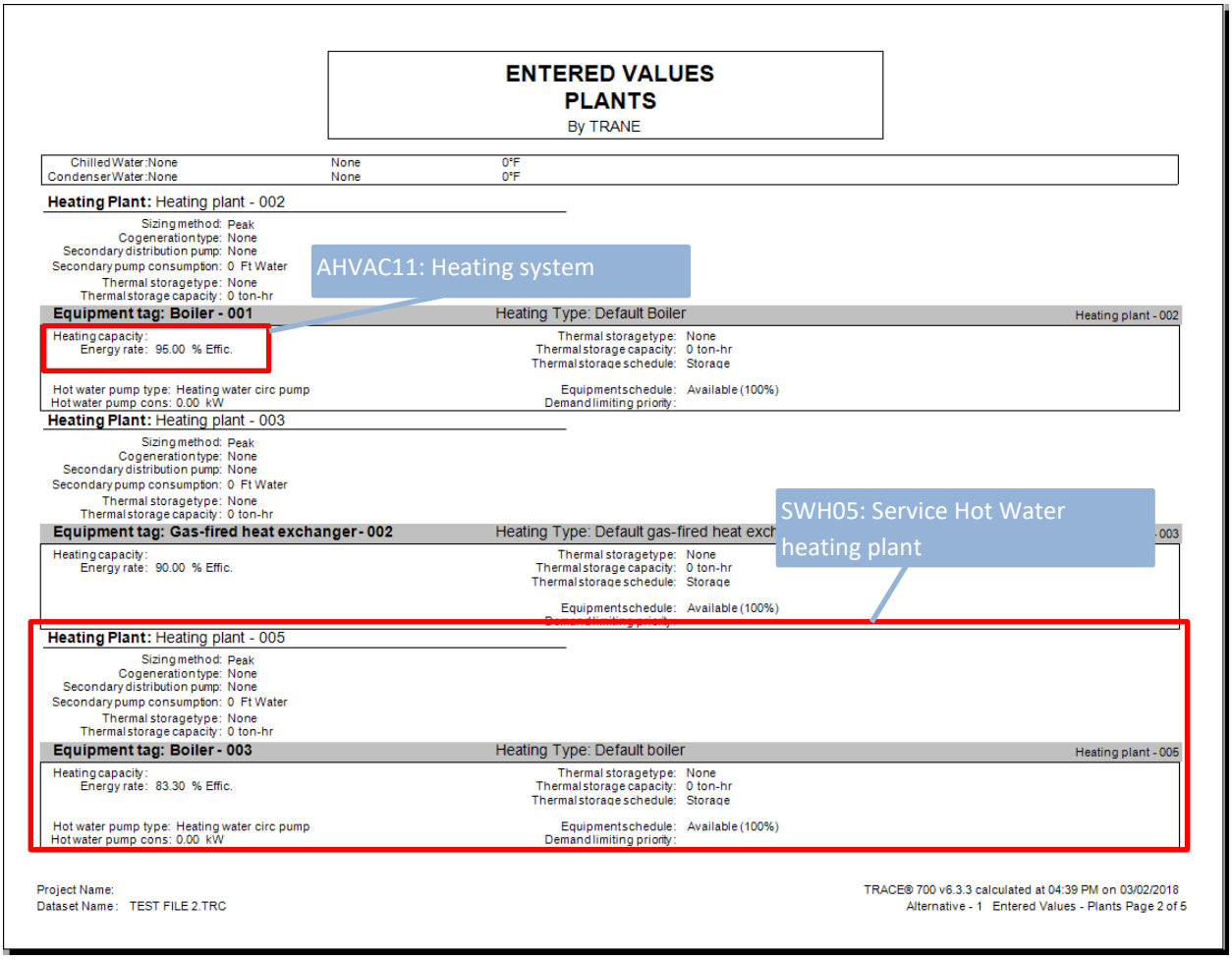
Miscellaneous accessories

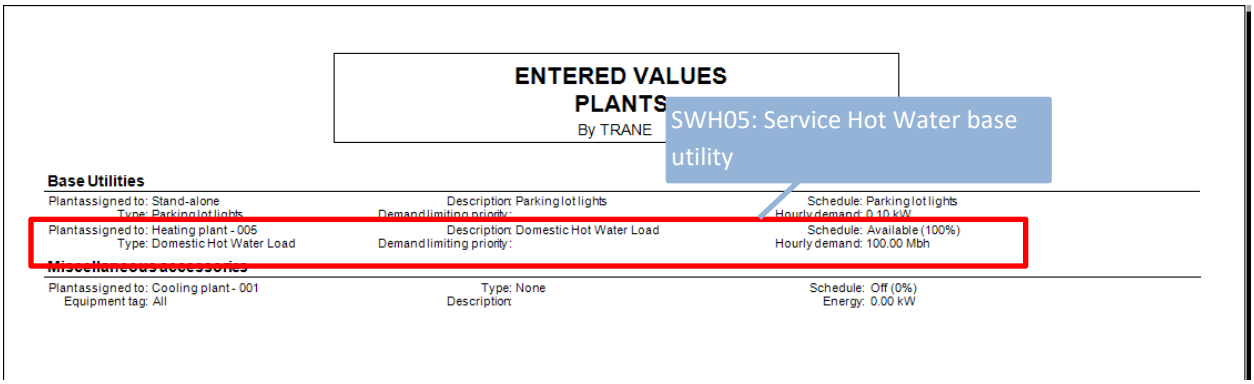
Plant assigned to: Cooling plant - 001 — Type: None — Schedule: Off (0%)
Equipment tag: All — Description: — Energy: 0.00 kW

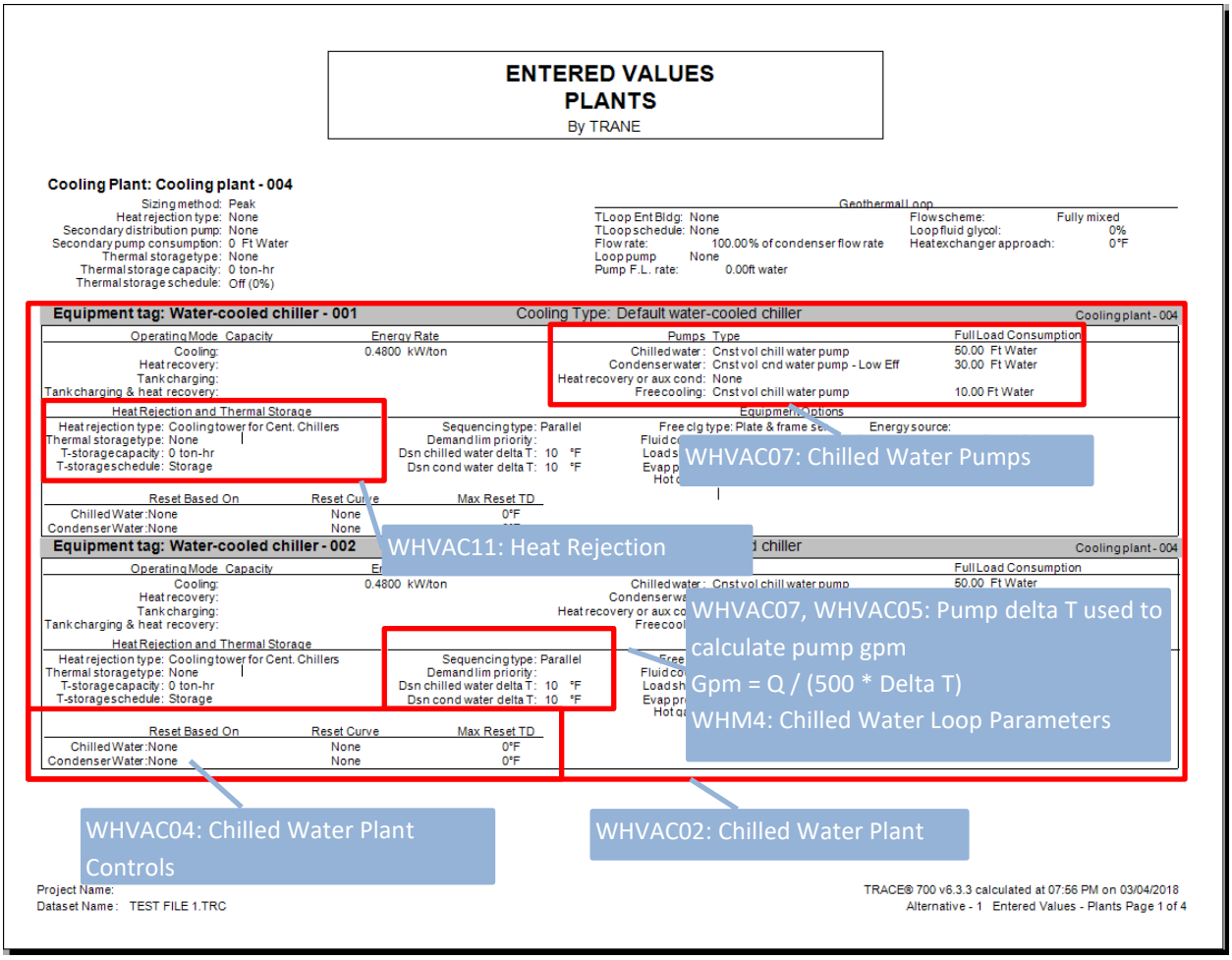
LE03: Exterior Lighting Entered Lighting Power

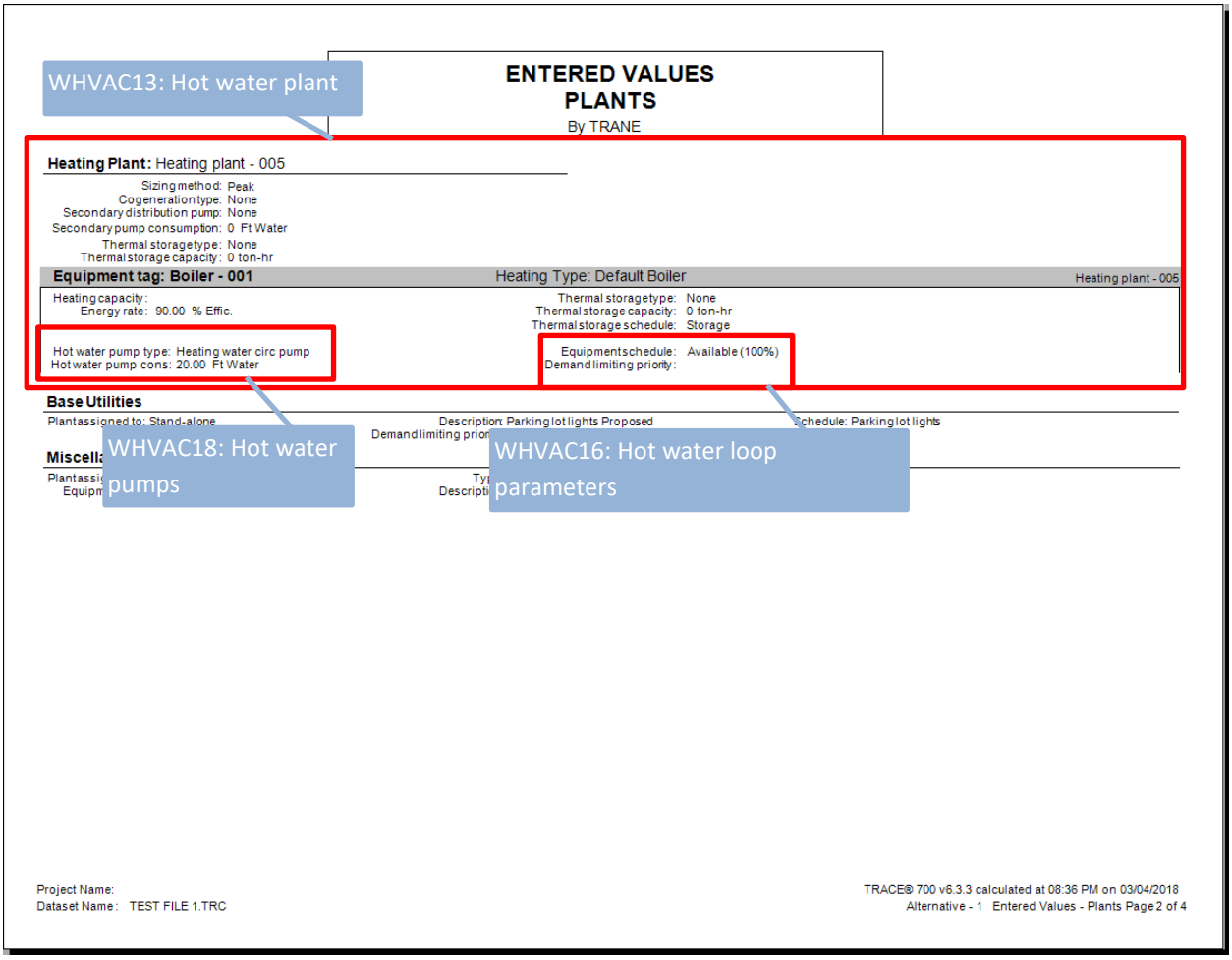
Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 09:50 AM on 01/25/2018
Alternative - 1 Entered Values - Plants Page 2 of 4


ENTERED VALUES
PLANTS
By TRANE
Chilled Water:None None 0°F
Condenser Water:None None 0°F
Heating Plant: Heating plant - 002
Sizing method: Peak
Cogeneration type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
AHVAC11: Heating system
Equipment tag: Boiler - 001
Heating Type: Default Boiler
Heating plant - 002
Heating capacity:
Energy rate: 95.00 % Effic.
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Storage
Hot water pump type: Heating water circ pump
Hot water pump cons: 0.00 kW
Equipment schedule: Available (100%)
Demand limiting priority:
Heating Plant: Heating plant - 003
Sizing method: Peak
Cogeneration type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
SWH05: Service Hot Water heating plant
Equipment tag: Gas-fired heat exchanger - 002
Heating Type: Default gas-fired heat exch
Heating capacity:
Energy rate: 90.00 % Effic.
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Storage
Equipment schedule: Available (100%)
Heating Plant: Heating plant - 005
Sizing method: Peak
Cogeneration type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Equipment tag: Boiler - 003
Heating Type: Default boiler
Heating plant - 005
Heating capacity:
Energy rate: 83.30 % Effic.
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Storage
Hot water pump type: Heating water circ pump
Hot water pump cons: 0.00 kW
Equipment schedule: Available (100%)
Demand limiting priority:
Project Name:
Dataset Name: TEST FILE 2.TRC
TRACE® 700 v6.3.3 calculated at 04:39 PM on 03/02/2018
Alternative - 1 Entered Values - Plants Page 2 of 5


ENTERED VALUES
PLANTS
By TRANE
SWH05: Service Hot Water base utility
Base Utilities
Plant assigned to: Stand-alone
Description: Parking lot lights
Schedule: Parking lot lights
Type: Parking lot lights
Demand limiting priority:
Hourly demand: 0.10 kW
Plant assigned to: Heating plant - 005
Description: Domestic Hot Water Load
Schedule: Available (100%)
Type: Domestic Hot Water Load
Demand limiting priority:
Hourly demand: 100.00 Mbh
Miscellaneous accessories
Plant assigned to: Cooling plant - 001
Type: None
Schedule: Off (0%)
Equipment tag: All
Description:
Energy: 0.00 kW


ENTERED VALUES
PLANTS
By TRANE
Cooling Plant: Cooling plant - 004
Sizing method: Peak
Heat rejection type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Off (0%)
Geothermal Loop
TLoop Ent Bldg: None
TLoop schedule: None
Flow rate: 100.00 % of condenser flow rate
Loop pump None
Pump F.L. rate: 0.00ft water
Flow scheme: Fully mixed
Loop fluid glycol: 0%
Heat exchanger approach: 0°F
Equipment tag: Water-cooled chiller - 001
Cooling Type: Default water-cooled chiller
Cooling plant - 004
Operating Mode Capacity
Energy Rate
Cooling: 0.4800 kW/ton
Heat recovery:
Tank charging:
Tank charging & heat recovery:
Pumps Type
Full Load Consumption
Chilled water: Cnst vol chill water pump 50.00 Ft Water
Condenser water: Cnst vol cnd water pump - Low Eff 30.00 Ft Water
Heat recovery or aux cond: None
Free cooling: Cnst vol chill water pump 10.00 Ft Water
Heat Rejection and Thermal Storage
Heat rejection type: Cooling tower for Cent. Chillers
Thermal storage type: None
T-storage capacity: 0 ton-hr
T-storage schedule: Storage
Sequencing type: Parallel
Demand lim priority:
Dsn chilled water delta T: 10 °F
Dsn cond water delta T: 10 °F
Equipment Options
Free clg type: Plate & frame s...
Energy source:
Reset Based On
Reset Curve
Max Reset TD
Chilled Water: None
None
0°F
Condenser Water: None
None
WHVAC07: Chilled Water Pumps
WHVAC11: Heat Rejection
Equipment tag: Water-cooled chiller - 002
Cooling plant - 004
Operating Mode Capacity
Cooling: 0.4800 kW/ton
Heat recovery:
Tank charging:
Tank charging & heat recovery:
Full Load Consumption
50.00 Ft Water
Heat Rejection and Thermal Storage
Heat rejection type: Cooling tower for Cent. Chillers
Thermal storage type: None
T-storage capacity: 0 ton-hr
T-storage schedule: Storage
Sequencing type: Parallel
Demand lim priority:
Dsn chilled water delta T: 10 °F
Dsn cond water delta T: 10 °F
Reset Based On
Reset Curve
Max Reset TD
Chilled Water: None
None
0°F
Condenser Water: None
None
0°F
WHVAC07, WHVAC05: Pump delta T used to calculate pump gpm
Gpm = Q / (500 * Delta T)
WHM4: Chilled Water Loop Parameters
WHVAC04: Chilled Water Plant Controls
WHVAC02: Chilled Water Plant
Project Name:
Dataset Name: TEST FILE 1.TRC
TRACE® 700 v6.3.3 calculated at 07:56 PM on 03/04/2018
Alternative - 1 Entered Values - Plants Page 1 of 4


WHVAC13: Hot water plant
ENTERED VALUES
PLANTS
By TRANE
Heating Plant: Heating plant - 005
Sizing method: Peak
Cogeneration type: None
Secondary distribution pump: None
Secondary pump consumption: 0 Ft Water
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Equipment tag: Boiler - 001
Heating Type: Default Boiler
Heating plant - 005
Heating capacity:
Energy rate: 90.00 % Effic.
Thermal storage type: None
Thermal storage capacity: 0 ton-hr
Thermal storage schedule: Storage
Hot water pump type: Heating water circ pump
Hot water pump cons: 20.00 Ft Water
Equipment schedule: Available (100%)
Demand limiting priority:
Base Utilities
Plant assigned to: Stand-alone
Description: Parking lot lights Proposed
Schedule: Parking lot lights
WHVAC18: Hot water pumps
WHVAC16: Hot water loop parameters
Project Name:
Dataset Name: TEST FILE 1.TRC
TRACE® 700 v6.3.3 calculated at 08:36 PM on 03/04/2018
Alternative - 1 Entered Values - Plants Page 2 of 4

Equipment Energy Consumption Report

EQUIPMENT ENERGY CONSUMPTION
By TRANE

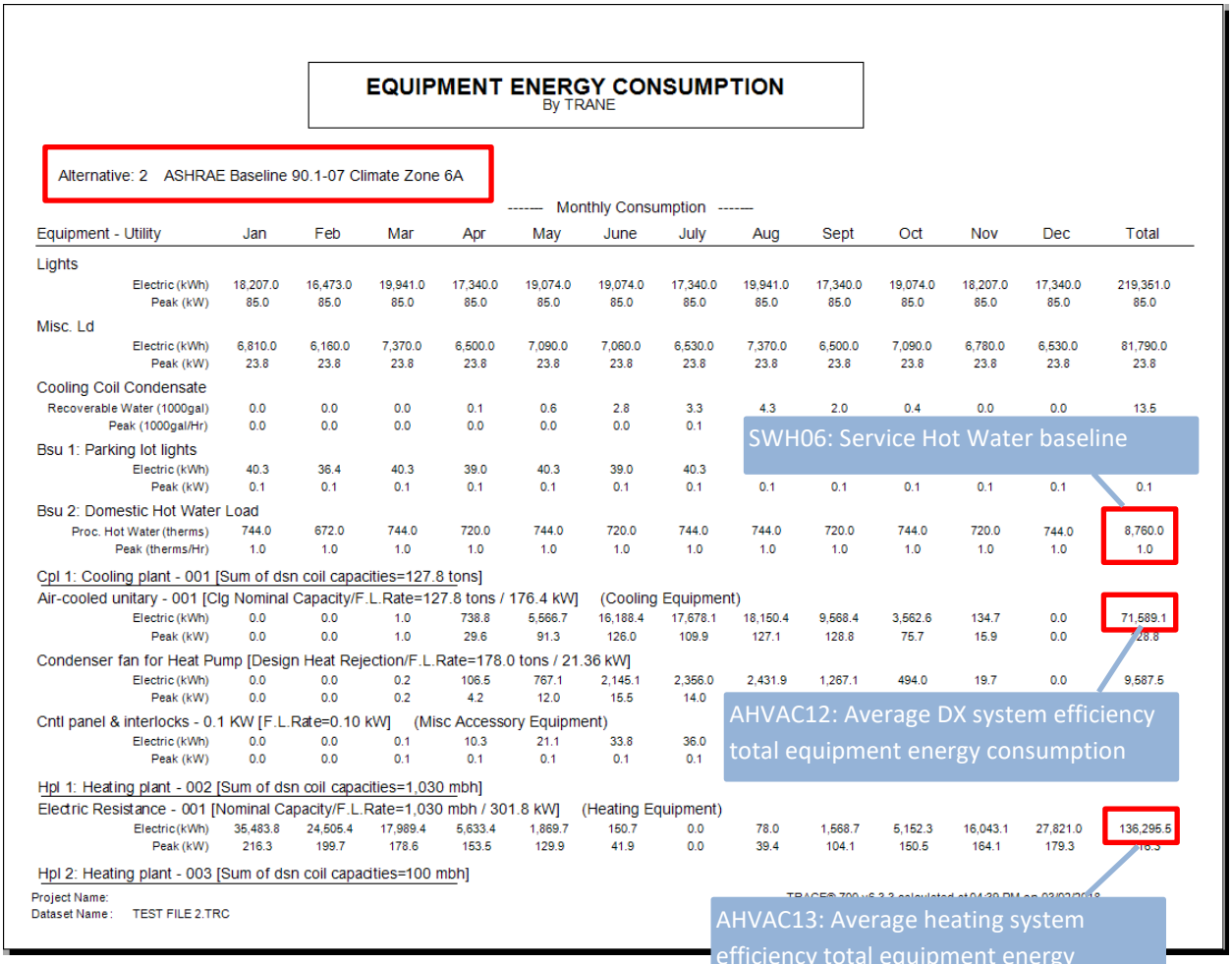
Alternative: 1 Proposed

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	------ Monthly Consumption ------												
Lights													
Electric (kWh)	13,923.0	12,597.0	15,249.0	13,260.0	14,586.0	14,586.0	13,260.0	15,249.0	13,260.0	14,586.0	13,923.0	13,260.0	167,739.0
Peak (kW)	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
Misc. Ld													
Electric (kWh)	6,810.0	6,160.0	7,370.0	6,500.0	7,090.0	7,060.0	6,530.0	7,370.0	6,500.0	7,090.0	6,780.0	6,530.0	81,790.0
Peak (kW)	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8
Cooling Coil Condensate													
Recoverable Water (1000gal)	0.0	0.0	0.0	0.1	0.4	1.8							
Peak (1000gal/Hr)	0.0	0.0	0.0	0.0	0.0	0.0							
Bsu 1: Parking lot lights													
Electric (kWh)	40.3	36.4	40.3	39.0	40.3	39.0							
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bsu 2: Domestic Hot Water Load													
Proc. Hot Water (therms)	744.0	672.0	744.0	720.0	744.0	720.0	744.0	744.0	720.0	744.0	720.0	744.0	8,760.0
Peak (therms/Hr)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cpl 1: Cooling plant - 001 [Sum of dsn coil capacities=182.7 tons]													
Water source heat pump - 001 [Clg Nominal Capacity/F.L.Rate=182.7 tons / 118.7 kW] (Cooling Equipment - Cooling Mode)													
Electric (kWh)	113.6	244.2	887.8	2,509.5	5,986.4	13,137.7	12,871.0	12,713.2	7,662.9	3,191.0	501.3	105.4	59,923.8
Peak (kW)	4.9	7.8	32.9	50.7	64.0	88.8	86.1	91.7	82.6	58.7	24.2	4.7	91.7
Water source heat pump - 001 [Htg Nominal Capacity/F.L.Rate=1,987 mbh / 99.4 kW] (Cooling Equipment - Heating Mode)													
Electric (kWh)	25,055.5	19,317.7	14,802.1	5,152.8	2,023.3	293.0	31.0	220.1	1,639.4	4,754.3	13,590.2	21,775.4	108,654.6
Peak (kW)	66.1	66.1	63.3	57.1	51.8	37.0	10.1	45.7	54.3	55.8	63.4	64.3	66.1
WSHP - Cooling tower [Design Heat Rejection/F.L.Rate=216.4 tons / 14.28 kW]													
Electric (kWh)	0.0	0.0	135.0	426.5	773.9	1,517.9	1,647.2	1,447.2	956.5	423.2	83.5	0.0	7,410.9
Peak (kW)	0.0	0.0	3.5	3.9	5.1	7.2	6.4	7.4	7.8	4.5	3.4	0.0	7.8
WSHP - Cooling tower													
Make Up Water (1000gal)	0.0	0.0	2.6	12.0	32.0	75.7	74.9	73.4	42.6	16.1	1.4	0.0	330.5
Peak (1000gal/Hr)	0.0	0.0	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.3	0.1	0.0	0.5

SWH07: Service Hot Water full load hours,
SWH06: Service Hot Water proposed

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 04:39 PM on 03/02/2018
Alternative - 1 Equipment Energy Consumption report page 1 of 5



EQUIPMENT ENERGY CONSUMPTION
By TRANE

Alternative: 2 ASHRAE Baseline 90.1-07 Climate Zone 6A

------ Monthly Consumption ------

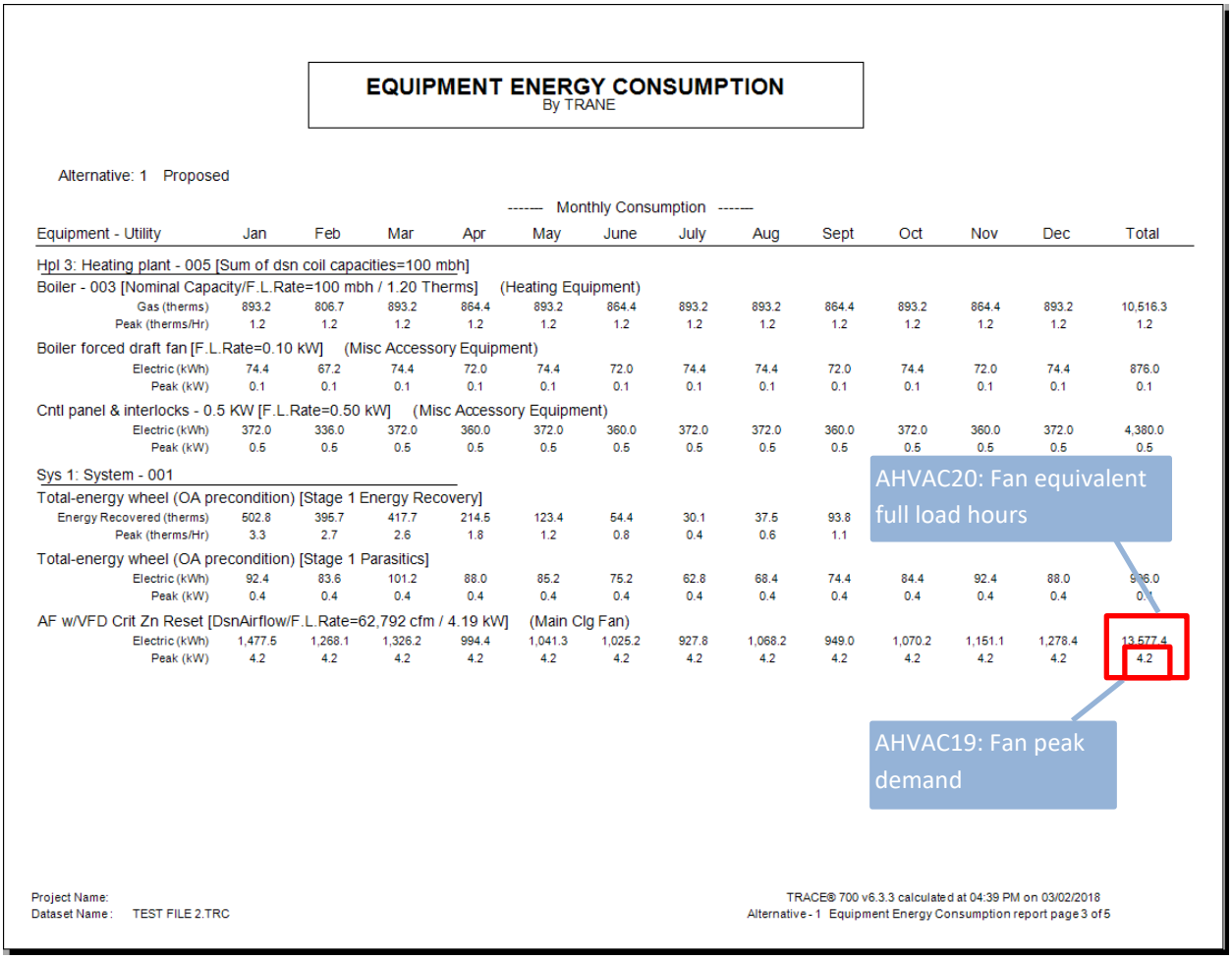
Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Lights													
Electric (kWh)	18,207.0	16,473.0	19,941.0	17,340.0	19,074.0	19,074.0	17,340.0	19,941.0	17,340.0	19,074.0	18,207.0	17,340.0	219,351.0
Peak (kW)	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0
Misc. Ld													
Electric (kWh)	6,810.0	6,160.0	7,370.0	6,500.0	7,090.0	7,060.0	6,530.0	7,370.0	6,500.0	7,090.0	6,780.0	6,530.0	81,790.0
Peak (kW)	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8
Cooling Coil Condensate													
Recoverable Water (1000gal)	0.0	0.0	0.0	0.1	0.6	2.8	3.3	4.3	2.0	0.4	0.0	0.0	13.5
Peak (1000gal/Hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.1						
Bsu 1: Parking lot lights													
Electric (kWh)	40.3	36.4	40.3	39.0	40.3	39.0	40.3						
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bsu 2: Domestic Hot Water Load													
Proc. Hot Water (therms)	744.0	672.0	744.0	720.0	744.0	720.0	744.0	744.0	720.0	744.0	720.0	744.0	8,760.0
Peak (therms/Hr)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cpl 1: Cooling plant - 001 [Sum of dsn coil capacities=127.8 tons]													
Air-cooled unitary - 001 [Clg Nominal Capacity/F.L.Rate=127.8 tons / 176.4 kW] (Cooling Equipment)													
Electric (kWh)	0.0	0.0	1.0	738.8	5,566.7	16,188.4	17,678.1	18,150.4	9,568.4	3,562.6	134.7	0.0	71,589.1
Peak (kW)	0.0	0.0	1.0	29.6	91.3	126.0	109.9	127.1	128.8	75.7	15.9	0.0	128.8
Condenser fan for Heat Pump [Design Heat Rejection/F.L.Rate=178.0 tons / 21.36 kW]													
Electric (kWh)	0.0	0.0	0.2	106.5	767.1	2,145.1	2,356.0	2,431.9	1,267.1	494.0	19.7	0.0	9,587.5
Peak (kW)	0.0	0.0	0.2	4.2	12.0	15.5	14.0						
Cntl panel & interlocks - 0.1 KW [F.L.Rate=0.10 kW] (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	0.1	10.3	21.1	33.8	36.0						
Peak (kW)	0.0	0.0	0.1	0.1	0.1	0.1	0.1						
Hpl 1: Heating plant - 002 [Sum of dsn coil capacities=1,030 mbh]													
Electric Resistance - 001 [Nominal Capacity/F.L.Rate=1,030 mbh / 301.8 kW] (Heating Equipment)													
Electric (kWh)	35,483.8	24,505.4	17,989.4	5,633.4	1,869.7	150.7	0.0	78.0	1,568.7	5,152.3	16,043.1	27,821.0	136,295.5
Peak (kW)	216.3	199.7	178.6	153.5	129.9	41.9	0.0	39.4	104.1	150.5	164.1	179.3	216.3
Hpl 2: Heating plant - 003 [Sum of dsn coil capacities=100 mbh]													

Project Name:
Dataset Name: TEST FILE 2.TRC

SWH06: Service Hot Water baseline

AHVAC12: Average DX system efficiency total equipment energy consumption

AHVAC13: Average heating system efficiency total equipment energy consumption



EQUIPMENT ENERGY CONSUMPTION
By TRANE

Alternative: 1 Proposed

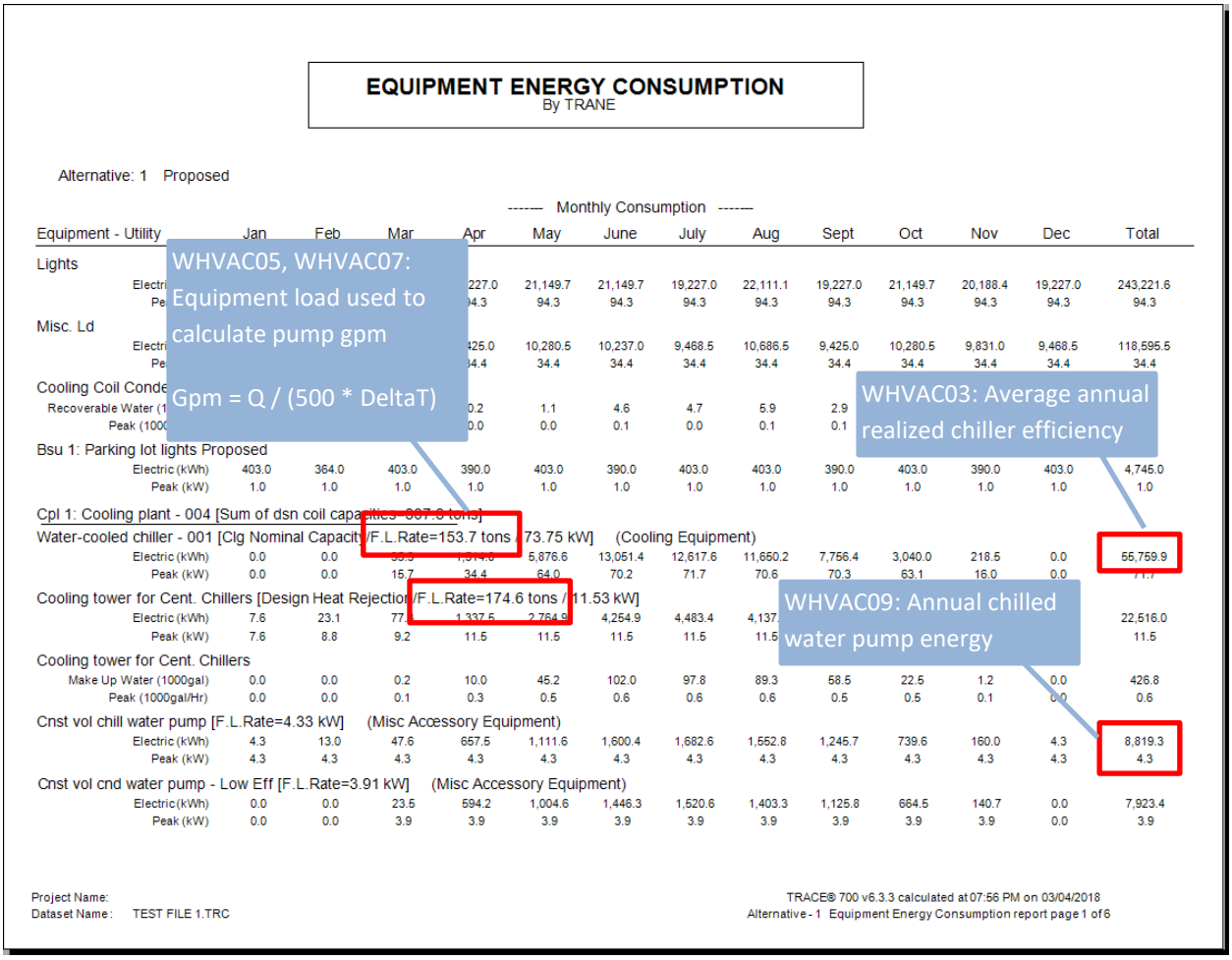
Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	------ Monthly Consumption ------												
Hpl 3: Heating plant - 005 [Sum of dsn coil capacities=100 mbh]													
Boiler - 003 [Nominal Capacity/F.L.Rate=100 mbh / 1.20 Therms] (Heating Equipment)													
Gas (therms)	893.2	806.7	893.2	864.4	893.2	864.4	893.2	893.2	864.4	893.2	864.4	893.2	10,516.3
Peak (therms/Hr)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Boiler forced draft fan [F.L.Rate=0.10 kW] (Misc Accessory Equipment)													
Electric (kWh)	74.4	67.2	74.4	72.0	74.4	72.0	74.4	74.4	72.0	74.4	72.0	74.4	876.0
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cntl panel & interlocks - 0.5 KW [F.L.Rate=0.50 kW] (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	360.0	372.0	360.0	372.0	372.0	360.0	372.0	360.0	372.0	4,380.0
Peak (kW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sys 1: System - 001													
Total-energy wheel (OA precondition) [Stage 1 Energy Recovery]													
Energy Recovered (therms)	502.8	395.7	417.7	214.5	123.4	54.4	30.1	37.5	93.8				
Peak (therms/Hr)	3.3	2.7	2.6	1.8	1.2	0.8	0.4	0.6	1.1				
Total-energy wheel (OA precondition) [Stage 1 Parasitics]													
Electric (kWh)	92.4	83.6	101.2	88.0	85.2	75.2	62.8	68.4	74.4	84.4	92.4	88.0	936.0
Peak (kW)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
AF w/VFD Crit Zn Reset [DsnAirflow/F.L.Rate=62,792 cfm / 4.19 kW] (Main Clg Fan)													
Electric (kWh)	1,477.5	1,268.1	1,326.2	994.4	1,041.3	1,025.2	927.8	1,068.2	949.0	1,070.2	1,151.1	1,278.4	13,577.4
Peak (kW)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2

AHVAC20: Fan equivalent full load hours

AHVAC19: Fan peak demand

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 04:39 PM on 03/02/2018
Alternative - 1 Equipment Energy Consumption report page 3 of 5



EQUIPMENT ENERGY CONSUMPTION
By TRANE

Alternative: 1 Proposed

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
------ Monthly Consumption ------													
Lights													
Electri				227.0	21,149.7	21,149.7	19,227.0	22,111.1	19,227.0	21,149.7	20,188.4	19,227.0	243,221.6
Pe				94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3
Misc. Ld													
Electri				425.0	10,280.5	10,237.0	9,468.5	10,686.5	9,425.0	10,280.5	9,831.0	9,468.5	118,595.5
Pe				34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4
Cooling Coil Conde													
Recoverable Water (1				0.2	1.1	4.6	4.7	5.9	2.9				
Peak (1000				0.0	0.0	0.1	0.0	0.1	0.1				
Bsu 1: Parking lot lights Proposed													
Electric (kWh)	403.0	364.0	403.0	390.0	403.0	390.0	403.0	403.0	390.0	403.0	390.0	403.0	4,745.0
Peak (kW)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cpl 1: Cooling plant - 004 [Sum of dsn coil capacities=607.8 tons]													
Water-cooled chiller - 001 [Clg Nominal Capacity/F.L.Rate=153.7 tons / 73.75 kW] (Cooling Equipment)													
Electric (kWh)	0.0	0.0	33.6	1,514.6	5,876.6	13,051.4	12,617.6	11,650.2	7,756.4	3,040.0	218.5	0.0	55,759.9
Peak (kW)	0.0	0.0	15.7	34.4	64.0	70.2	71.7	70.6	70.3	63.1	16.0	0.0	71.7
Cooling tower for Cent. Chillers [Design Heat Rejection/F.L.Rate=174.6 tons / 11.53 kW]													
Electric (kWh)	7.6	23.1	77.	1,337.5	2,764.9	4,254.9	4,483.4	4,137.					22,516.0
Peak (kW)	7.6	8.8	9.2	11.5	11.5	11.5	11.5	11.5					11.5
Cooling tower for Cent. Chillers													
Make Up Water (1000gal)	0.0	0.0	0.2	10.0	45.2	102.0	97.8	89.3	58.5	22.5	1.2	0.0	426.8
Peak (1000gal/Hr)	0.0	0.0	0.1	0.3	0.5	0.6	0.6	0.6	0.5	0.5	0.1	0.0	0.6
Cnst vol chill water pump [F.L.Rate=4.33 kW] (Misc Accessory Equipment)													
Electric (kWh)	4.3	13.0	47.6	657.5	1,111.6	1,600.4	1,682.6	1,552.8	1,245.7	739.6	160.0	4.3	8,819.3
Peak (kW)	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Cnst vol cnd water pump - Low Eff [F.L.Rate=3.91 kW] (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	23.5	594.2	1,004.6	1,446.3	1,520.6	1,403.3	1,125.8	664.5	140.7	0.0	7,923.4
Peak (kW)	0.0	0.0	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	0.0	3.9

WHVAC05, WHVAC07: Equipment load used to calculate pump gpm

Gpm = Q / (500 * DeltaT)

WHVAC03: Average annual realized chiller efficiency

WHVAC09: Annual chilled water pump energy

Project Name:
Dataset Name: TEST FILE 1.TRC

TRACE® 700 v6.3.3 calculated at 07:56 PM on 03/04/2018
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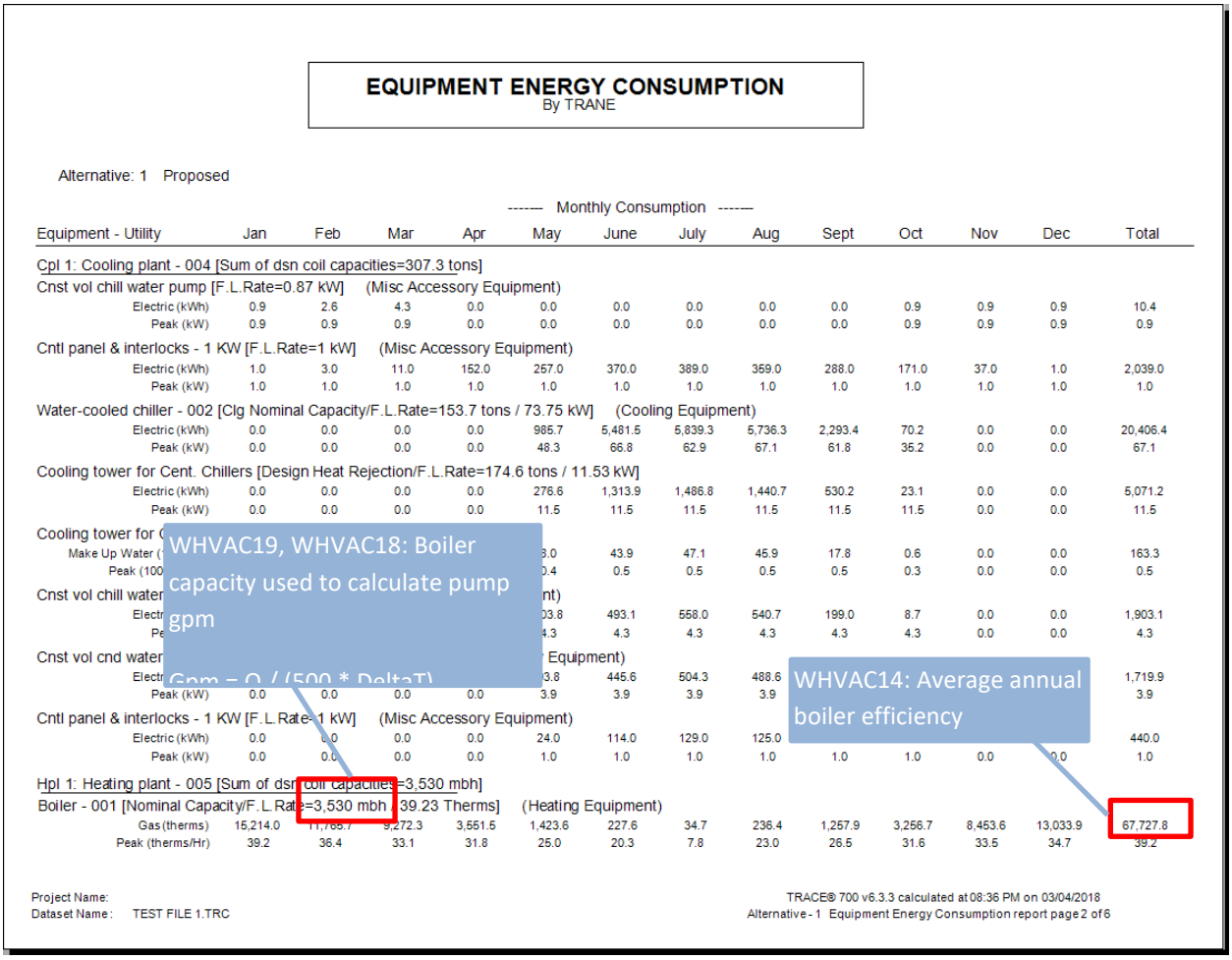


EQUIPMENT ENERGY CONSUMPTION
By TRANE

Alternative: 1 Proposed

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------ Monthly Consumption ------								
Cpl 1: Cooling plant - 004 [Sum of dsn coil capacities=307.3 tons]													
Cnst vol chill water pump [F.L.Rate=0.87 kW] (Misc Accessory Equipment)													
Electric (kWh)	0.9	2.6	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.9	10.4
Peak (kW)	0.9	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.9	0.9
Cntl panel & interlocks - 1 KW [F.L.Rate=1 kW] (Misc Accessory Equipment)													
Electric (kWh)	1.0	3.0	11.0	152.0	257.0	370.0	389.0	359.0	288.0	171.0	37.0	1.0	2,039.0
Peak (kW)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Water-cooled chiller - 002 [Clg Nominal Capacity/F.L.Rate=153.7 tons / 73.75 kW] (Cooling Equipment)													
Electric (kWh)	0.0	0.0	0.0	0.0	985.7	5,481.5	5,839.3	5,736.3	2,293.4	70.2	0.0	0.0	20,406.4
Peak (kW)	0.0	0.0	0.0	0.0	48.3	66.8	62.9	67.1	61.8	35.2	0.0	0.0	67.1
Cooling tower for Cent. Chillers [Design Heat Rejection/F.L.Rate=174.6 tons / 11.53 kW]													
Electric (kWh)	0.0	0.0	0.0	0.0	276.6	1,313.9	1,486.8	1,440.7	530.2	23.1	0.0	0.0	5,071.2
Peak (kW)	0.0	0.0	0.0	0.0	11.5	11.5	11.5	11.5	11.5	11.5	0.0	0.0	11.5
Cooling tower for C													
Make Up Water (						3.0	43.9	47.1	45.9	17.8	0.6	0.0	0.0	163.3
Peak (100						0.4	0.5	0.5	0.5	0.5	0.3	0.0	0.0	0.5
Cnst vol chill water							nt)							
Electr						03.8	493.1	558.0	540.7	199.0	8.7	0.0	0.0	1,903.1
Pe						4.3	4.3	4.3	4.3	4.3	4.3	0.0	0.0	4.3
Cnst vol cnd water							Equipment)							
Electr						3.8	445.6	504.3	488.6					1,719.9
Peak (kW)	0.0	0.0	0.0	0.0	3.9	3.9	3.9	3.9						3.9
Cntl panel & interlocks - 1 KW [F.L.Rate=1 kW] (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	0.0	0.0	24.0	114.0	129.0	125.0						440.0
Peak (kW)	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0		1.0
Hpl 1: Heating plant - 005 [Sum of dsn coil capacities=3,530 mbh]													
Boiler - 001 [Nominal Capacity/F.L.Rate=3,530 mbh / 39.23 Therms] (Heating Equipment)													
Gas (therms)	15,214.0	11,765.7	9,272.3	3,551.5	1,423.6	227.6	34.7	236.4	1,257.9	3,256.7	8,453.6	13,033.9	67,727.8
Peak (therms/Hr)	39.2	36.4	33.1	31.8	25.0	20.3	7.8	23.0	26.5	31.6	33.5	34.7	39.2

WHVAC19, WHVAC18: Boiler capacity used to calculate pump gpm

Gpm = Q / (500 * DeltaT)

WHVAC14: Average annual boiler efficiency

Project Name:
Dataset Name: TEST FILE 1.TRC

TRACE® 700 v6.3.3 calculated at 08:36 PM on 03/04/2018
Alternative - 1 Equipment Energy Consumption report page 2 of 6

EQUIPMENT ENERGY CONSUMPTION
By TRANE

Alternative: 1 Proposed

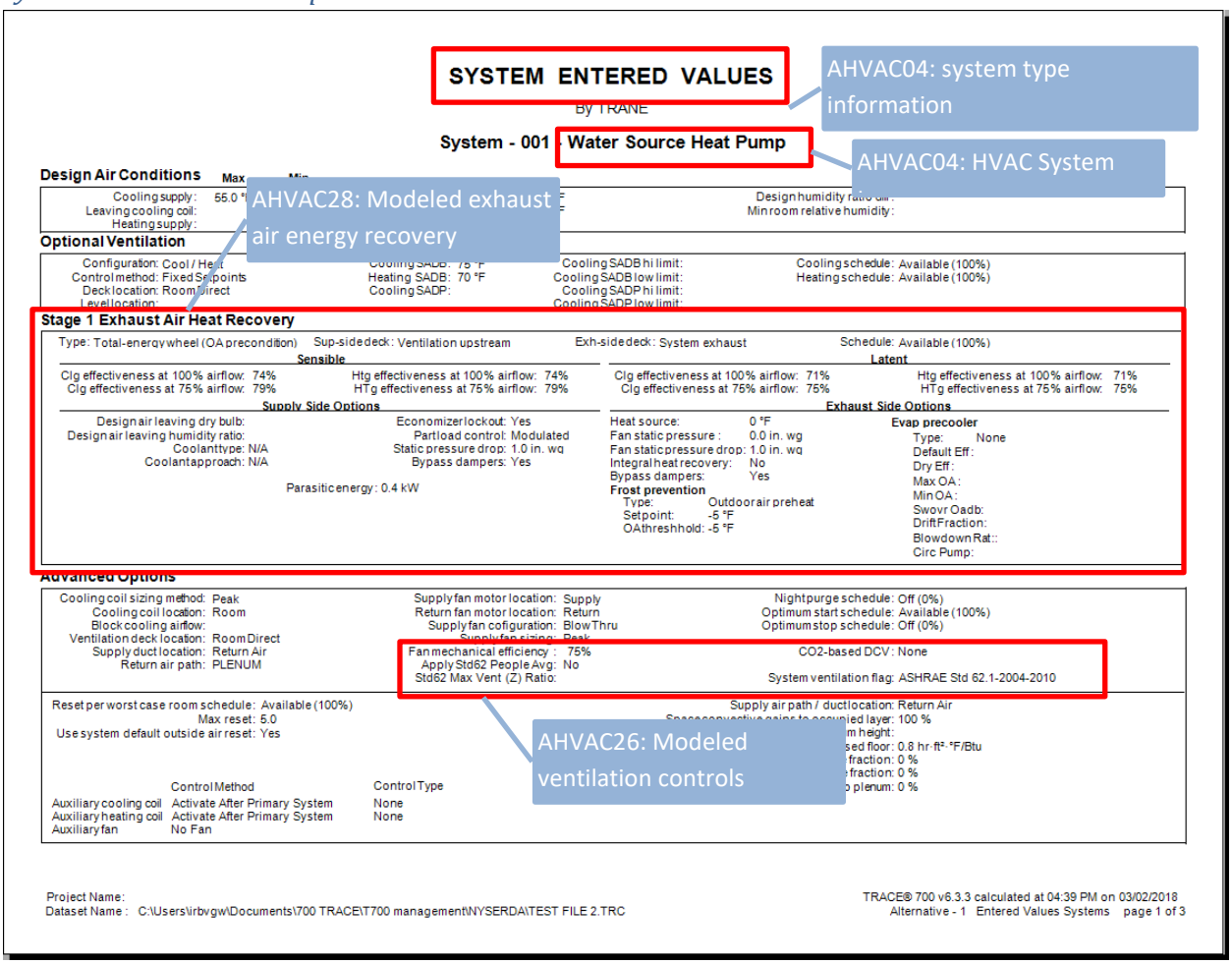
Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	------ Monthly Consumption ------												
Hpl 1: Heating plant - 005 [Sum of dsn coil capacities=3,530 mbh]													
Heating water circ pump [F.L.Rate=1.62 kW] (Misc Accessory Equipment)													
Electric (kWh)	1,180.6	1,057.2	1,128.7	805.5	540.8	168.9	112.1	211.1	490.4	844.5	1,101.1	1,179.0	8,819.8
Peak (kW)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Boiler forced draft fan [F.L.Rate=3.53 kW] (Misc Accessory Equipment)													
Electric (kWh)	2,566.6	2,298.3	2,453.6	1,751.1	1,175.6	367.2	243.6	459.0	1,066.2	1,835.8	2,393.6	2,563.1	19,173.7
Peak (kW)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Cntl panel & interlocks - 0.5 KW [F.L.Rate=0.50 kW] (Misc Accessory Equipment)													
Electric (kWh)	363.5	325.5	347.5	248.0	166.5	52.0	34.5	65.0	151.0	260.0	339.0	363.0	2,715.5
Peak (kW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sys 1: VAV System 1st Floor													
Total-energy wheel (OA precondition) [Stage 1 Energy Recovery]													
Energy Recovered (therms)	646.6	415.8	315.0	33.9	4.2	31.6	24.0	22.2	27.0	22.2	241.4	480.3	2,264.3
Peak (therms/Hr)	4.9	4.0	3.9	2.0	0.3	1.0	0.5	0.8	1.0	1.4	3.1	3.8	4.9
Total-energy wheel (OA precondition) [Stage 1 Parasitics]													
Electric (kWh)	92.4	82.8	85.2	27.6	26.0	63.6	82.4	94.4	42.8	39.6	68.0	88.0	792.8
Peak (kW)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
AF w/VFD Crit Zn Reset [DsnAirflow/F.L.Rate=24,966 cfm / 13.32 kW] (Main Clg Fan)													
Electric (kWh)	447.8	399.0	427.9	339.0	657.2	1,453.9	1,407.7	1,466.4	820.9	442.6	352.6	392.0	8,606.8
Peak (kW)	2.2	2.6	2.5	5.5	10.7	13.3	13.3	13.3	13.3	7.4	2.5	2.1	13.3
Sys 2: RTU Single Zone													
Total-energy wheel (OA precondition) [Stage 1 Energy Recovery]													
Energy Recovered (therms)	18.6	6.9	4.3	4.8	3.2	7.1	5.7	4.9					74.3
Peak (therms/Hr)	1.0	0.5	0.3	0.5	0.4	0.2	0.1	0.2					1.0
Total-energy wheel (OA precondition) [Stage 1 Parasitics]													
Electric (kWh)	43.6	28.4	21.6	7.6	10.4	46.4	62.0	56.0	26.8	7.2	17.2	21.6	358.8
Peak (kW)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
AF Centrifugal const vol [DsnAirflow/F.L.Rate=18,545 cfm / 12.36 kW] (Main Clg Fan)													
Electric (kWh)	3,996.8	3,328.3	3,258.7	2,166.1	2,171.9	2,572.0	2,558.6	2,721.8	2,199.9	2,327.8	2,993.1	3,614.1	33,909.0
Peak (kW)	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4

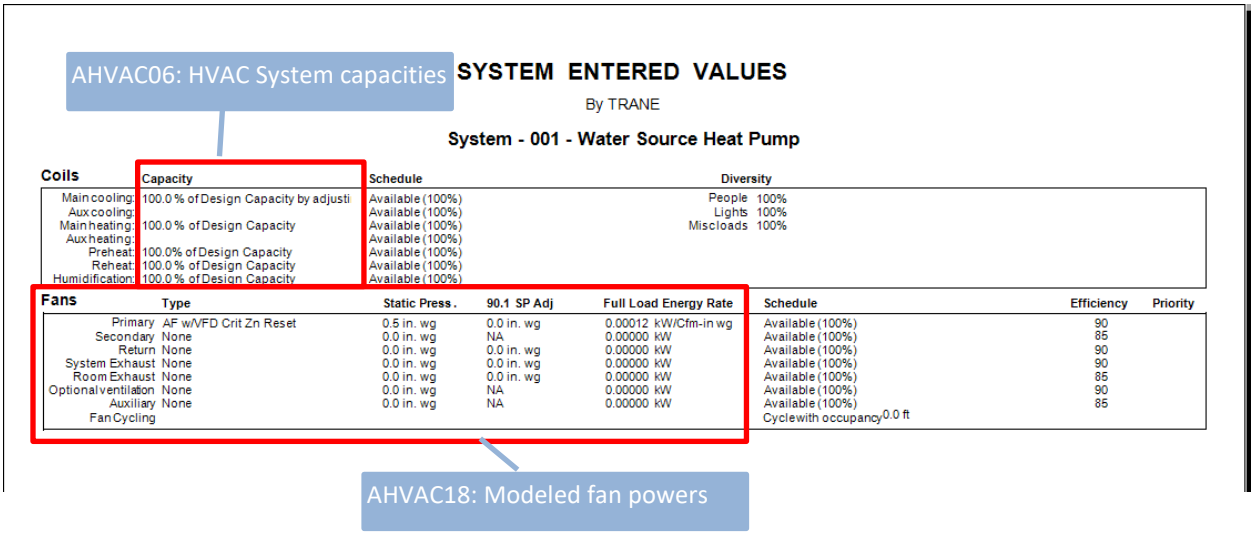
WHVAC20: Annual hot water pump energy

Project Name:
Dataset Name: TEST FILE 1.TRC

TRACE® 700 v6.3.3 calculated at 08:36 PM on 03/04/2018
Alternative - 1 Equipment Energy Consumption report page 3 of 6

System Entered Values Report





System Checksums Report

System Checksums

By TRANE

System - 001

System 3 - 2007/2010 - Packaged Rooftop Air Conditioner

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 15
Outside Air: OADB/WB/HR: 92 / 78 / 123

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)
Envelope Loads				
Skylite Solar	0	0	0	0
Skylite Cond	0	0	0	0
Roof Cond	0	104,790	104,790	8
Glass Solar	329,894	0	329,894	25
Glass/Door Cond	18,667	0	18,667	1
Wall Cond	15,257	8,311	23,568	2
Partition/Door	0		0	0
Floor	0		0	0
Adjacent Floor	0.00	0.00	0.00	0.00
Infiltration	0		0	0
Sub Total ==>	363,818	113,101	476,919	36
Internal Loads				
Lights	231,040	57,760	288,800	22
People	156,572	0	156,572	12
Misc	74,325	0	74,325	6
Sub Total ==>	461,936	57,760	519,696	39
Ceiling Load	47,363	-47,363	0	0
Ventilation Load	0	0	345,949	26
Adj Air Trans Heat	0		0	0
Dehumid. Ov Sizing			0	0
Ov/Undr Sizing	0		0	0
Exhaust Heat		-19,575	-19,575	-1
Sup. Fan Heat			10,917	1
Ret. Fan Heat		0	0	0
Duct Heat Pkup		0	0	0
Underflr Sup Ht Pkup			0	0
Supply Air Leakage		0	0	0
Grand Total ==>	873,117	103,923	1,333,906	100.00

CLG SPACE PEAK

Mo/Hr: 8 / 11
OADB: 82

	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads		
Skylite Solar	0	0
Skylite Cond	0	0
Roof Cond	0	0
Glass Solar	345,369	42
Glass/Door Cond	13,230	2
Wall Cond	14,445	2
Partition/Door	0	0
Floor	0.00	0
Adjacent Floor	0.00	0.00
Infiltration	0	0
Sub Total ==>	373,044	46
Internal Loads		
Lights	231,040	28
People	86,642	11
Misc	79,815	10
Sub Total ==>	397,496	49
Ceiling Load	42,538	5
Ventilation Load	0	0
Adj Air Trans Heat	0	0
Ov/Undr Sizing		
Exhaust Heat	0	0
OA Preheat Diff.		
RA Preheat Diff.		
Additional Reheat		
Underflr Sup Ht Pkup		
Supply Air Leakage		
Grand Total ==>	813,078	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design
OADB: -6

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-172,925	20.99
Glass Solar	0	0	0.00
Glass/Door Cond	-129,410	-129,410	15.70
Wall Cond	-29,160	-46,052	5.59
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0.00	0.00	0.00
Infiltration	0	0	0.00
Sub Total ==>	-158,571	-348,388	42.28
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-53,228	0	0.00
Ventilation Load	0	-497,643	60.39
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		22,000	-2.67
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat			
Underflr Sup Ht Pkup			
Supply Air Leakage			
Grand Total ==>	-211		

TEMPERATURES

	Cooling	Heating
SADB	55.0	75.2
Ra Plenum	78.0	66.6
Return	77.7	66.6
Ret/OA	80.0	54.9
Fn MtrTD	0.0	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.2	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	36,845	36,845
Terminal	36,845	36,845
Main Fan	36,845	36,845
Sec Fan	0	0
Nom Vent	5,935	5,935
AHU Vent	5,935	5,935
Infil	0	0
Min Stop/Rh	0	0
Return	36,845	36,845
Exhaust	5,935	5,935
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating

AHVAC28: Modeled exhaust air energy recovery airflows

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	127.8	1,534.0	1,021.5	36,845	80.0	65.0	69.4	54.7	50.9	49.8
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	127.8	1,534.0								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	50,000		
Part	0		
Int Door	0		
ExFlr	0		
Roof	50,000	0	0
Wall	14,400	4,860	34
Ext Door	0	0	0

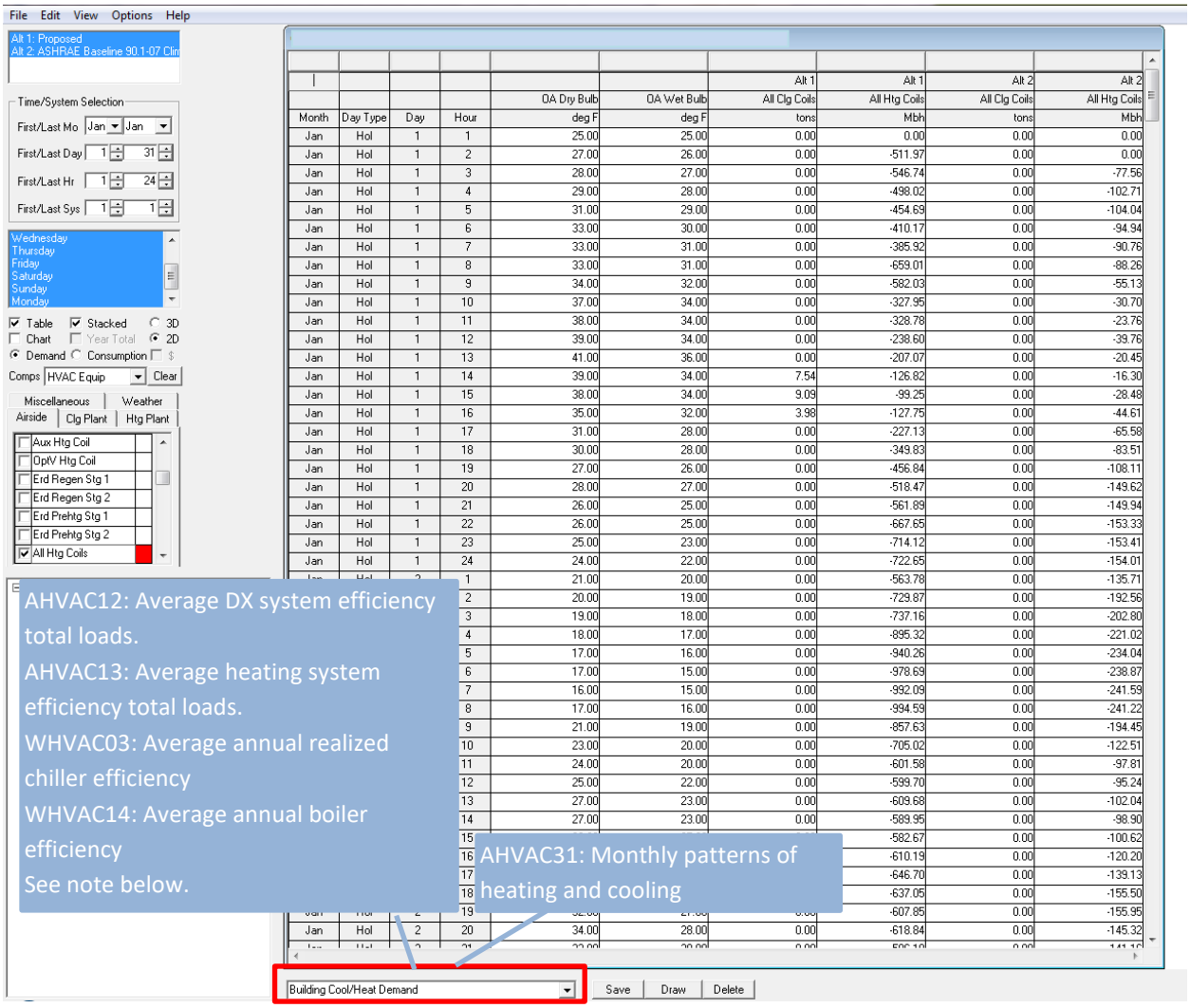
HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-1,030.0	36,845	54.9	75.2
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-1,030.0			

Project Name:
Dataset Name: TEST FILE 2.TRC

TRACE® 700 v6.3.3 calculated at 04:39 PM on 03/02/2018
Alternative - 2 System Checksums Report Page 2 of 2

Building Cool/Heat Demand report from the Visualizer



						Alt 1	Alt 1	Alt 2	Alt 2
				OA Dry Bulb	OA Wet Bulb	All Clg Coils	All Htg Coils	All Clg Coils	All Htg Coils
Month	Day Type	Day	Hour	deg F	deg F	tons	Mbh	tons	Mbh
Jan	Hol	1	1	25.00	25.00	0.00	0.00	0.00	0.00
Jan	Hol	1	2	27.00	26.00	0.00	-511.97	0.00	0.00
Jan	Hol	1	3	28.00	27.00	0.00	-546.74	0.00	-77.56
Jan	Hol	1	4	29.00	28.00	0.00	-498.02	0.00	-102.71
Jan	Hol	1	5	31.00	29.00	0.00	-454.69	0.00	-104.04
Jan	Hol	1	6	33.00	30.00	0.00	-410.17	0.00	-94.94
Jan	Hol	1	7	33.00	31.00	0.00	-385.92	0.00	-90.76
Jan	Hol	1	8	33.00	31.00	0.00	-659.01	0.00	-88.26
Jan	Hol	1	9	34.00	32.00	0.00	-582.03	0.00	-55.13
Jan	Hol	1	10	37.00	34.00	0.00	-327.95	0.00	-30.70
Jan	Hol	1	11	38.00	34.00	0.00	-328.78	0.00	-23.76
Jan	Hol	1	12	39.00	34.00	0.00	-238.60	0.00	-39.76
Jan	Hol	1	13	41.00	36.00	0.00	-207.07	0.00	-20.45
Jan	Hol	1	14	39.00	34.00	7.54	-126.82	0.00	-16.30
Jan	Hol	1	15	38.00	34.00	9.09	-99.25	0.00	-28.48
Jan	Hol	1	16	35.00	32.00	3.98	-127.75	0.00	-44.61
Jan	Hol	1	17	31.00	28.00	0.00	-227.13	0.00	-65.58
Jan	Hol	1	18	30.00	28.00	0.00	-349.83	0.00	-83.51
Jan	Hol	1	19	27.00	26.00	0.00	-456.84	0.00	-108.11
Jan	Hol	1	20	28.00	27.00	0.00	-518.47	0.00	-149.62
Jan	Hol	1	21	26.00	25.00	0.00	-561.89	0.00	-149.94
Jan	Hol	1	22	26.00	25.00	0.00	-667.65	0.00	-153.33
Jan	Hol	1	23	25.00	23.00	0.00	-714.12	0.00	-153.41
Jan	Hol	1	24	24.00	22.00	0.00	-722.65	0.00	-154.01
			1	21.00	20.00	0.00	-563.78	0.00	-135.71
			2	20.00	19.00	0.00	-729.87	0.00	-192.56
			3	19.00	18.00	0.00	-737.16	0.00	-202.80
			4	18.00	17.00	0.00	-895.32	0.00	-221.02
			5	17.00	16.00	0.00	-940.26	0.00	-234.04
			6	17.00	15.00	0.00	-978.69	0.00	-238.87
			7	16.00	15.00	0.00	-992.09	0.00	-241.59
			8	17.00	16.00	0.00	-994.59	0.00	-241.22
			9	21.00	19.00	0.00	-857.63	0.00	-194.45
			10	23.00	20.00	0.00	-705.02	0.00	-122.51
			11	24.00	20.00	0.00	-601.58	0.00	-97.81
			12	25.00	22.00	0.00	-599.70	0.00	-95.24
			13	27.00	23.00	0.00	-609.68	0.00	-102.04
			14	27.00	23.00	0.00	-589.95	0.00	-98.90
			15				-582.67	0.00	-100.62
			16				-610.19	0.00	-120.20
			17				-646.70	0.00	-139.13
			18				-637.05	0.00	-155.50
			19				-607.85	0.00	-155.95
Jan	Hol	2	20	34.00	28.00	0.00	-618.84	0.00	-145.32

Note: The Visualizer is accessed by clicking the Graph Profiles and Energy button on the Analysis Reports tab of View Results. The Building Cool/Heat Demand report is selected from the dropdown at the bottom. The controls on the left are used to specify months, day types, etc. The Draw button is used to export the data to excel. For AHVAC12, AHVAC13, WHVAC03 and WHVAC14, it will be easiest to export this data to Excel to sum the hourly loads to determine the total loads for the year. If there are multiple systems assigned to different plants, this will need to be done separately for each system. The system data displayed can be changed by using the First/Last Sys inputs.

Appendix A: Recommended Minimum Energy Modeler Qualifications

The Energy Modeler is a professional responsible for completing the Compliance Form and performing energy modeling on projects following ASHRAE Standard 90.1 Section 11 and Appendix G. The Energy Modeler responsibilities include the following:

1. Documenting specified systems and components in the Compliance Form based on the design documents.
2. Establishing configuration of the budget/baseline systems and components following the rules of ASHRAE Standard 90.1 Section 11 and Appendix G and documenting them in the Compliance Form.
3. Performing energy simulations for the baseline/budget and proposed design based on the parameters reported in the Compliance Form and following requirements of ASHRAE Standard 90.1 Section 11 and Appendix G.
4. Establishing compliance outcome based on the simulation results and as required in ASHRAE Standard 90.1 Section 11 and Appendix G.
5. Performing quality control of the information included in the Compliance Form to ensure that it is complete and consistent with the design documents and 90.1 requirements.
6. Performing quality control of the energy simulations to ensure that they are error free and aligned with the information provided in the Compliance Form.
7. Responding to comments from submittal reviewer and implementing all required corrective actions.

The Energy Modeler or the individual supervising the work of the Energy Modeler should meet the following minimum qualifications:

1. One of the following professional certifications:
    a. ASHRAE Building Energy Modeling Professional (BEMP)
    b. Association of Energy Engineer's Building Energy Simulation Analyst (BESA)
2. Three years of full-time equivalent modeling experience with whole building energy simulation of commercial buildings and multifamily buildings of four or more stories.
3. Successful completion of at least three projects modeled following ASHRAE Standard 90.1 Section 11 or Appendix G.
4. Complete trainings on ASHRAE Standard 90.1 Section 11 or Appendix G

To following documentation should be used to demonstrate compliance with the minimum qualification requirements:

    a. BEMP or BESA certificates.
    b. Resume highlighting the required experience.
    c. Training completion certificates

Appendix B: Recommended Minimum Submittal Reviewer Qualifications

The Submittal Reviewer is a professional responsible for reviewing the compliance documentation on behalf of the authority having jurisdiction or rating authority for projects following ASHRAE Standard 90.1 Section 11 and Appendix G. The Submittal Reviewer responsibilities include the following:

1. Verifying that submittal meets ASHRAE Standard 90.1 Section 11 or Appendix G reporting requirements, including that the Compliance Form and other required documentation is submitted and complete.
2. Verifying that the specified systems and components reported in the Compliance Form reflect design documents.
3. Verifying that the budget/baseline systems and components are established correctly following the rules of ASHRAE Standard 90.1 Section 11 and Appendix G.
4. Verify that project meets general simulation requirements of ASHRAE Standard 90.1 Section 11 and Appendix G.
5. Verify that the simulation inputs for the budget/baseline and proposed design reflect information reported in the compliance form.
6. Communicating uncovered deficiencies and requested corrective actions to the Energy Modeler.
7. Review Energy Modeler responses to confirm that the deficiencies are resolved.
8. Approve the submittal once it is demonstrated that the compliance outcome is established correctly.

The Submittal Reviewer or the individual supervising the work of the Submittal Reviewer should meet the following minimum qualifications:

1. One years of full-time equivalent modeling experience with whole building energy simulation of commercial buildings and multifamily buildings of four or more stories.
2. Successful completion of submittal review on at least ten projects modeled following ASHRAE Standard 90.1 Section 11 or Appendix G.
3. Complete trainings on ASHRAE Standard 90.1 Section 11 or Appendix G.
4. Complete trainings on submittal review for projects following ASHRAE Standard 90.1 Section 11 or Appendix G

To following documentation should be used to demonstrate compliance with the minimum qualification requirements:

   a. Resume highlighting the required experience.
   b. Training completion certificates

Appendix C: Typical Building Operating Schedules

TBD

Appendix D: Overview of the Prototype Models Used as Energy Performance Benchmarks

References

[1] ANSI/ASHRAE/IES (2016) ANSI/ASHRAE/IES 90.1-2016, Energy Standard for Buildings Except Low Rise Residential Buildings. American Society of Heating, Refrigerating and Air-Conditioning Engineers
[2] ANSI/ASHRAE/IES (2016) ANSI/ASHRAE/IES 90.1-2016, 90.1 2016 User's Manual
[3] PNNL-26917, ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual, Richland, WA. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26917.pdf
[4] U.S. Green Building Council, ADVANCED ENERGY MODELING FOR LEED Technical Manual v2.0 September 2011 Edition, Washington, DC.
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[6] International Code Council, 2015 International Building Code (3rd Printing as adopted by New York State), Washington, DC.
[7] Methodology for Compliance with The Oregon Energy Efficiency Specialty Code Using the Whole Building Approach, by M.I. Rosenberg
[8] Whole Building Approach Instructions October 1, 2014 (v1.1), State of Oregon Building Codes Division
[8] LEED v4_Minimum Energy Performance Calculator
[9] Pacific Northwest National Lab,