Technical Guide

New Jersey's Clean Energy Program™

New Construction Program

v1.0

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1 PURPOSE

These Technical Guidelines provide program Partners detailed guidance on technical topics pertaining to projects enrolled in *New Jersey's Clean Energy Program*^{TM} (NJCEP) New Construction Program (NCP). For general program information, please refer to the [Program Guide.]()

Limitations

This document is not legally binding on the New Jersey Board of Public Utilities (Board), the Program Administrator, or the Program. If there is any conflict between this document and a Board Order, the applicable Compliance Filing, any legally binding agreement(s), or any other legally binding document(s), such other document(s) shall take precedence and control over this document.

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NJCEP operates a call center staffed on weekdays between 8 AM and 7 PM EST, excluding State holidays. The phone number is 866-NJSMART (866-657-6278). The call center is trained to answer general questions about the Program and application processes and will direct callers to the appropriate Program Staff as needed.

2 Tools and Resources

Participation in the NCP requires use of the following documents and tools, some of which are provided by the program. Not all documents and tools are required by each program pathway. Please refer to the Program Guide, Appendix B, for details.

Table 2-1. Tools and Resources

Resource	Description	Provided by the Program?
Program Guide (.pdf)	Provides general program information, including eligibility, incentives, and the program process.	Yes
Technical Guide (.pdf) ***[this document]***	Provides detailed information on technical topics related to the program.	Yes
BASIC Workbook (.xls)	Used as primary workbook collecting and summarizing project information, energy efficiency measures, energy savings, and calculating incentives.	Yes
ASHRAE Standard 90.1 Performance Based Compliance Form	Helps the modeler establish simulation inputs for the baseline, budget, and proposed design models. This tool is free and provided by the U.S. Department of Energy.	No
Incentive Estimator (.xls)	Optional workbook that can be used to estimate program incentives based on high-level project information before enrolling in the program.	Yes

Resource	Description	Provided by the Program?
Authorization Form for 3rd party payee (Jotform)	Optional form that allows participants to assign incentive payment to someone other than themselves.	Yes
Photo Template (.doc)	Template to organize and collect project information and photos for the program to complete the Construction Inspection (i.e., open wall inspection).	Yes
Inspection Report Template (Jotform)	Summary report documenting Partner's inspection findings and results.	Yes
Commissioning Plan Template (.doc)	Template to complete a Commissioning Plan.	Yes
License for Ekotrope software	User access for Ekotrope modeling software used for demonstrating energy savings of residential projects participating in the High Performance Proxy pathway.	Yes
License for Sketchbox software	User access for Sketchbox modeling software used for demonstrating energy savings of commercial projects participating in the Streamlined Pathway.	Y
License for modeling software not listed in the Program-provided resources	Projects participating in the High Performance Pathway may use other software to demonstrate energy savings and program compliance.	No

Resource	Description	Provided by the Program?
Energy codes/standards	Current energy code in New Jersey is IECC 2021 (residential) and ASHRAE 90.1-2019 (commercial). Code references and associated user guides will be needed when completing projects. These codes are referenced throughout the guide and various program tools and documents.	No
Proxy certification templates, forms, and documents	Proxy certification organizations, including LEED, ENERGY STAR®, DOE ZERH, Passive House (PHI), and Passive House US (Phius), all provide specific forms, documents, tools, and sometimes software, which must be used to obtain said certification.	No
NJ TRM	Technical Reference Manual	Yes

3 CORE AND SHELL VS. TENANT FIT-OUT

The NCP is unique in that the incentive is calculated based on conditioned square footage rather than for a particular piece of equipment. Although there is a minimum scope of work and/or energy savings thresholds, by design, the NCP is meant to cover all energy efficiency measures within a given building(s). Therefore, NCP projects are required to evaluate the whole building design and submit a project that encompasses all possible energy efficiency components. An exception may apply for projects pursuing Core & Shell separate from Tenant Fit-out improvements as described below.

3.1 Definitions

- ***Tenant Fit-out*** is an area that has components specifically designed for that area based on the tenant's needs and is usually funded by the tenant. For some *Tenant Fit-outs*, components may be limited to lighting and equipment loads if the entire building is served by a central HVAC system (e.g., central plant). For others, equipment may include dedicated HVAC systems that serve the tenant space.
- ***Core & Shell*** are the systems and parts of the building that are not Tenant Fit-out related, and are funded by the developer (or entity other than the tenant, such as the building owner, land owner, or landlord).

3.2 Project Scenario 1- Core & Shell and Tenant Fit-out are Combined

In this scenario, all aspects of the design (whole building) must be included under a single NCP application and treated as a single project. This may apply where:

- Developer is funding and constructing both *Core & Shell* and *Tenant Fit-out*.
- High-performance systems are specified and funded for the Tenant space separate from *Core & Shell*, but the building owner and tenant come to an agreement to include both scopes of work under a single project.

Projects under this scenario will follow all Program Guidelines as typical.

3.3 Project Scenario 2- Core & Shell Separate from Tenant Fit-out

This scenario applies when the *Core & Shell* work is known but the tenant space development is unknown and/or is funded separately. Therefore, the *Core & Shell* is treated as a separate project from the *Tenant Fit-out*.

In this case, a building may apply to an NCP High Performance Pathway for either *Core & Shell* or *Tenant Fit-out(s)*, not both. The determining factor depends on which scope will include the design and construction of the central HVAC system. For example, if the *Core & Shell* scope includes building envelope, common area, and exterior lighting, and central HVAC systems, this project may be eligible to apply for incentives under an NCP High Performance Pathway, in which case:

- NCP incentives will apply to all conditioned square footage of the building serviced by the central HVAC in the project's scope of work.
- The BASIC Workbook should clearly describe *Core & Shell* and Tenant spaces. The space types and areas listed should only reflect the areas associated with the project, per above, to calculate incentives correctly.
- The project scope applying for NCP High Performance Pathway (e.g. *Core & Shell* OR *Tenant Fit-out*) must be able to meet all requirements of that pathway.
- Any *Tenant Fit-out* not included in the NCP High Performance Pathway may seek incentives through the Bundled Pathway for eligible equipment once its scope is known.

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4 BUNDLED PATHWAY

4.1 Overview

Projects applying through the Bundled Pathway must select a minimum of two measures from the list of prescriptive measures set forth in Figure 4-2 and Figure 4-3 for the project's climate zone. The Energy Subcode separates the State into two climates zones as follows:

Zone 4A

Atlantic, Burlington, Camden, Cape May, Cumberland, Essex, Gloucester, Hudson, Middlesex, Monmouth, Ocean, Salem and Union counties

Zone 5A

Bergen, Hunterdon, Mercer, Morris, Passaic, Somerset, Sussex and Warren counties

Figure 4-1. New Jersey Climate Zones

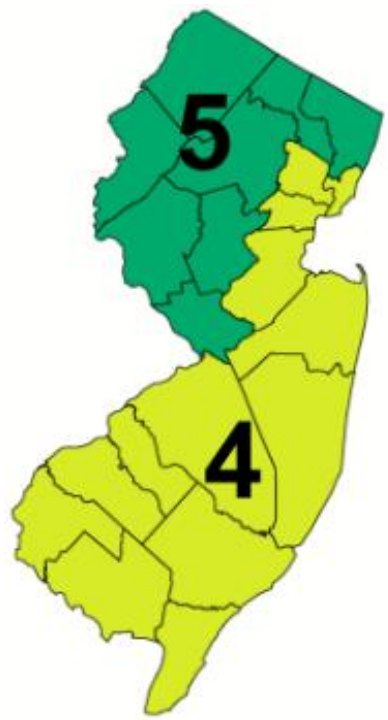

Figure 4-2. Bundled Pathway Credits, Zone 4A

Bundled Pathway Credits, Climate Zone 4A											
Measure ID	Energy Credit Abbreviated Title	Addendum "ap" Section	Dormitory or Retirement	Healthcare	Hotel or Motel	Office	Restaurant	Retail	School or Education	Warehouse or Storage	Other
			Minimum Points Required								
			30	13	12	14	31	24	12	27	13
E02	UA reduction (15%)	C406.2.1.2	24	3	8	7	19	36	4	62	20
E03	Envelope Leakage Reduction	C406.2.1.3	47	6	14	8	24	44	x	77	28
H02	Heating Efficiency *(electric only)*	13.5.2.2.2	4	3	1	2	5	7	2	14	5
H03	Cooling Efficiency	13.5.2.2.3	4	7	7	6	5	7	9	1	5
H05	Ground-Source Heat Pump	13.5.2.2.5	10	11	6	10	13	18	6	x	11
W01	SWH Preheat Recovery	13.5.2.3.1(a)	21	2	7	2	10	7	3	3	7
W02	Heat-Pump Water Heater	13.5.2.3.1(b)	33	1	12	2	8	2	2	1	8
W04	SWH Pipe Insulation	13.5.2.3.2	3	1	2	1	x	x	1	x	2
W05	Point-of-Use Water Heaters	13.5.2.3.3 (a)	x	x	x	3	x	x	2	x	3
W06	Thermostatic Balancing Valves	13.5.2.3.3 (b)	1	1	1	1	1	1	1	1	1
W08	SWH Distribution Sizing	13.5.2.3.5	22	x	8	x	x	x	x	x	x
W09	Shower Drain Heat Recovery	13.5.2.3.6	19	x	6	x	x	x	2	x	9
L06	Light Power Reduction	13.5.2.5.6	2	8	2	8	4	10	9	13	6
Q01	Efficient Elevator Equipment	13.5.2.7.1	5	2	4	5	1	5	6	5	4
Q02	Efficient Kitchen Equipment	13.5.2.7.2	x	x	x	x	27	x	x	x	x

1. Heat pumps providing both space heating and space cooling that meet program requirements may be eligible for credit in both H02 and H03 categories above.
2. "x" indicates that the applicable type of building earns no points for the applicable measure.

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Figure 4-3. Bundled Pathway Credits, Zone 5A

Bundled Pathway Credits, Climate Zone 5A											
Measure ID	Energy Credit Abbreviated Title	Addendum "ap" Section	Dormitory or Retirement	Healthcare	Hotel or Motel	Office	Restaurant	Retail	School or Education	Warehouse or Storage	Other
			Minimum Points Required								
			33	13	11	16	29	22	12	32	15
E02	UA reduction (15%)	C406.2.1.2	30	4	9	10	26	45	3	74	25
E03	Envelope Leakage Reduction	C406.2.1.3	65	7	19	13	33	56	1	92	36
H02	Heating Efficiency *(electric only)*	13.5.2.2.2	5	4	2	5	8	10	3	21	7
H03	Cooling Efficiency	13.5.2.2.3	3	5	5	4	3	4	6	1	3
H05	Ground-Source Heat Pump	13.5.2.2.5	13	11	8	15	14	19	7	x	13
W01	SWH Preheat Recovery	13.5.2.3.1 (a)	22	2	8	2	11	7	3	2	7
W02	Heat-Pump Water Heater	13.5.2.3.1 (b)	36	1	13	2	9	2	2	1	8
W04	SWH Pipe Insulation	13.5.2.3.2	3	1	2	1	x	x	1	x	2
W05	Point-of-Use Water Heaters	13.5.2.3.3 (a)	x	x	x	2	x	x	3	x	3
W06	Thermostatic Balancing Valves	13.5.2.3.3 (b)	1	1	1	1	1	1	1	1	1
W08	SWH Distribution Sizing	13.5.2.3.5	23	x	8	x	x	x	x	x	x
W09	Shower Drain Heat Recovery	13.5.2.3.6	20	x	7	x	x	x	2	x	10
L06	Light Power Reduction	13.5.2.5.6	2	8	2	8	3	8	9	11	6
Q01	Efficient Elevator Equipment	13.5.2.7.1	5	2	4	5	1	5	6	4	4
Q02	Efficient Kitchen Equipment	13.5.2.7.2	x	x	x	x	26	x	x	x	x

1. Heat pumps providing both space heating and space cooling that meet program requirements may be eligible for credit in both H02 and H03 categories above.
2. "x" indicates that the applicable type of building earns no points for the applicable measure.

4.2 Eligible Energy Efficiency Measures ("Credits")

The complete list of energy efficiency measures, or credits, eligible for this pathway can be found in ANSI/ASHRAE/IES Addendum AP to ANSI/ASHRAE/IES Standard 90.1-2019 "Energy Standard for Buildings Except Low-Rise Residential Buildings." Information is reproduced below for convenience.

Note: references to multifamily are not applicable as this building type may not participate in the Bundled Pathway at this time.

- **Measure ID E02 Total UA Envelope Reduction**: Energy credits shall be achieved where the total UA of the building thermal envelope as designed is not less than 15 percent below the total UA of the building thermal envelope in accordance with Section C402.1.5.

- **Measure ID E03 Reduced Air Infiltration**: Energy credits shall be achieved for tested air leakage less than thresholds in either section C406.2.1.3.1, C406.2.1.3.2, or C406.2.1.3.3 where tested in accordance with the following: air infiltration shall be verified by whole-building pressurization testing conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air-leakage rate of the project envelope shall not exceed the required cfm/ft2 (L/s · m2) under a pressure differential of 0.3 inches water column (75 Pa), with the calculated surface area being the sum of the above- and below-grade project envelope. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the code official and the building owner.

- **Measure ID H02 HVAC Heating Performance Improvement:** To achieve this credit, space heating equipment shall exceed the minimum heating efficiency requirements by 5% or more than listed in the tables in Section 6.8.1 of ASHRAE AP.

- **Measure ID H03 HVAC Cooling Performance Improvement:** To achieve this credit, space cooling equipment shall exceed the minimum cooling efficiency requirements by 5% or more than listed in the tables in Section 6.8.1 or Appendix F of ASHRAE AP.
  - For water-cooled chiller plants, heat rejection efficiency shall also exceed the minimum efficiency listed in Table 6.8.1-7 of ASHRAE AP by at least the percentage improvement in the chiller efficiency.

- **Measure ID H05 Ground-Source Heat-Pump System:** To achieve this credit, a ground-source heat pump system shall provide cooling and heating for at least 25% of the gross conditioned building area. The ground-source heat-pump systems shall include building ground-loop HVAC systems coupled with a closed bore ground-heat exchanger, submerged heat exchanger using water-based fluid as a heat transfer medium, groundwater (well), or fluid infrastructure (such as effluent and wastewater), and shall comply with the following:

- Loop pump(s) shall have controls and/or devices that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow and allow turndown to 15% flow. Alternatively, a separate field-loop pump shall be provided, with either a variable-speed building pump or individual pumps for each ground-source heat pump.
- The geothermal-source exchanger shall be sized based on the heating and cooling loads served by the ground-source heat-pump system and shall comply with one of the following:
  - A closed bore field shall have at least 400 lineal feet (120 lineal metres) of bore piping per 12,000 Btu/h (3500 kW) of system cooling or heating capacity, whichever is greater. The system shall not include additional heat rejection or additional devices.
  - The ground source shall be sized such that the loop heat pumps provide 100% of the heating and cooling loads for at least 90% of both the cooling and heating system annual operating hours without requiring any supplemental heating or heat rejection from nonground sources, as demonstrated by an analysis approved by the authority having jurisdiction. Heat rejection shall include a two-speed or variable-speed fan.
- The allowed credits are based on serving 25% of the gross conditioned building area, including dry-cooler partial heat rejection.

- **Measure ID W01 Heat Recovery for Service Hot-Water Preheating:** to achieve this credit, the service water heating system shall have waste heat recovery from service hot water, heat recovery chillers, building equipment, or process equipment that is sized to provide not less than 30% of the annual hot-water requirements or sized to provide not less than 70% of the annual hot-water requirements if the building is required to comply with Section 7.5.3 of ASHRAE AP.

- **Measure ID W02 Heat-Pump Water Heater**: To achieve this credit, air-source heat-pump water heaters shall be installed according to the manufacturer's instructions, and at least 30% of design end-use service water heating requirements shall be met using only heat-pump heating at an ambient condition of 67.5°F (19.7°C) db without supplemental electric resistance or fossil fuel heating. For a hybrid heat-pump water heater, the heat-pump-only capacity shall be deemed at 40% of the first-hour draw. Where the heat-pump only capacity exceeds 50% of the design end-use load, excluding recirculating system losses.

- **Measure ID W04 Service Hot-Water Piping Insulation Increase:** To achieve this credit, where service hot water is provided by a central water heating system, the hot-water pipe insulation thickness shall be at least 1.5 times the thickness required in Table 6.8.3-1 of ASHRAE AP. All service hot-water piping shall be insulated from the hot-water source to the fixture shutoff. Where no more than 50% of hot-water piping does not have increased insulation due to installation in partitions, the credit shall be prorated as a percentage of lineal feet (lineal meters) of piping with increased insulation.

- **Measure ID W05 Point-of-Use Water Heater**: Credits are available for office or school buildings larger than 10,000 ft2 (930 m2). Fixtures requiring hot water shall be supplied from a localized source of hot water with no recirculating system or heat trace piping. Supply piping from the water heater to the termination of the fixture supply pipe shall be insulated to the levels shown in Table 6.8.3-1 of ASHRAE AP without exception. The volume from the water heater to the termination of the fixture supply pipe shall be limited as follows:
    - Nonresidential lavatories: not more than 2 oz (60 mL)
    - All other plumbing fixtures or appliances: not more than 0.25 gal (0.95 L)
        - *Exception to 13.5.2.3.3(a):* Where all remotely located hot-water uses meet the requirements for measure W05, separate water heaters serving commercial kitchens or showers in locker rooms shall be permitted to have a local recirculating system or heat trace piping.

- **Measure ID W06 Thermostatic Balancing Valves:** Credits are available where service water heating is provided centrally and distributed throughout the building. Each recirculating system branch return connection to the main service hot-water supply piping shall have an automatic thermostatic balancing valve set to a minimal return water flow when the branch return temperature is greater than 125°F (52°C).

- **Measure ID W08 Right Sizing the Service Hot-Water Distribution System:** To achieve this credit, where multifamily, dormitory, retirement, or hotel/motel buildings are served by a central service hot-water system, the distribution system serving dwelling units and guest rooms shall be sized using IAPMO/ANSI WE Stand, Appendix C. Plumbing fixtures in residential spaces that are connected to the service water heating system shall have a flow or consumption rating less than or equal to the values shown in Table 13.5.2.3.5 of ASHRAE AP.
    - *Informative Note*: where low water supply pressures are anticipated; user satisfaction may be enhanced if flow restrictors are specified to provide ≥80% of the rated flow at 20 psi (140 kPa). Where the distribution sizing protocol is applied to other than multifamily residential buildings, a variance to the plumbing code may be needed.

- **Measure ID W09 Shower Drain Heat Recovery**: To achieve this credit, cold water serving building showers shall be preheated by shower drain heat recovery units that comply with CSA B55.2. Potable waterside pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. The efficiency of drain heat recovery units shall be 54% or greater measured in accordance with CSA B55.1. Full credits are applicable to the following building use types: health clinic, hospital, hotel, motel, multifamily, retirement facility, dormitory, and schools with more than eight showers. Partial credits are applicable to buildings where all but ground-floor showers are served, where the base energy credit is adjusted by the following factor:

$$EC_{W09\_adj} = EC_{W09\_base} \times \frac{\text{Showers with drain heat recovery}}{\text{Total showers in building}}$$

- **Measure ID L06 Reduce Interior Lighting Power:** To achieve this credit, the installed interior lighting power, less any additional lighting allowed from Section 9.5.2.2, shall be 95% or less than the interior lighting power allowance, less any additional lighting allowed in Section 9.5.2.2 of ASHRAE AP. In multifamily, dormitory, hotel, and motel buildings, the credit is calculated for common areas other than dwelling units and guest rooms. Energy credits shall not be greater than two times the L06 base credit from Section 13.5.3 of ASHRAE AP.

- **Measure ID Q01 Efficient Elevator Equipment:** To achieve this credit, qualifying elevators in the project shall be energy efficiency Class A per ISO 25745-2, Table 7. Elevators with regeneration capability shall have the means to absorb the regenerated electricity by other building loads or be able to export the energy to the utility grid. The electrical system shall not absorb regenerated electricity with electric resistance load banks.

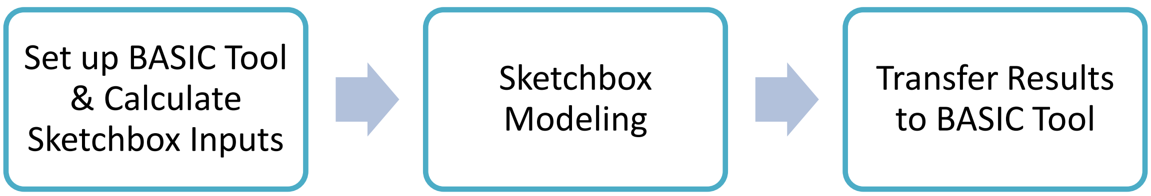
- **Measure ID Q02 Efficient Kitchen Equipment:** To achieve this credit, in projects or facilities that include a commercial kitchen with at least one gas or electric fryer, all fryers, dishwashers, steam cookers, and ovens shall comply with all of the following:
    - Achieve performance levels in accordance with the equipment specifications listed in Tables 13.5.2.6-1 through 13.5.2.6-4 of ASHRAE AP when rated in accordance with the applicable test procedure.
    - Be installed prior to the issuance of the certificate of occupancy.
    - Have associated performance levels listed on the construction documents submitted for permitting. Energy credits for efficient kitchen equipment shall be as stated in Section 13.5.3 of ASHRAE AP.
        - *Informative Note*: Where a commercial kitchen is included in a building where credits for efficient kitchen equipment are excluded, such as a cafeteria in an office building, treat the kitchen and dining area as a restaurant building use type following the weighted-average method in Section 13.5.1(a) of ASHRAE AP.

5 STREAMLINED PATHWAY

5.1 Process Overview

The figure below illustrates the process flow for Streamlined Pathway projects. Detailed descriptions of each step are provided in this document.

Figure 5-1. Streamlined Pathway Process



5.2 BASIC Workbook Inputs for Sketchbox

To set up the BASIC Workbook and calculate Sketchbox inputs for the baseline model and energy efficiency measures, follow these steps:

1. Input project information into all shaded fields on the *General Information* tab of the BASIC Workbook. Select “Streamlined Pathway” as the Performance Pathway.

2. Use the *Sketchbox Calculators* tab(s) of the BASIC Workbook to compute various Sketchbox inputs. These inputs should be used during Sketchbox modeling exactly as they are calculated.

3. External calculators may be needed for certain measures not already provided.

5.3 Sketchbox Modeling

The sections below describe special instructions for Sketchbox modeling under NJ NCP. Unless otherwise specified, Partners should follow the Sketchbox Tutorial.

5.3.1 Project Tab: General

1. Select “NJ BPU New Construction” as the Project Environment.

2. Choose the Nearest City for the project.

    a. **Projects in climate zone 5A should select Newton as the nearest city, even if a different city is geographically closer.** The project’s climate zone is shown on the *General Information* tab of the BASIC Workbook after entering the Project ZIP code.

5.3.2 Project Tab: Financial

Keep all defaults.

5.3.3 Project Tab: Emissions

Keep all defaults.

Note: *For the purpose of program incentive calculation, the amount of GHG reduction (i.e. CO2e) will be calculated within the program's BASIC Workbook. Values shown in Sketchbox are for informational purposes only.*

5.3.4 Design Tab: Shells

Buildings in Sketchbox consist of one or more shells. A shell is a simplified representation of a building geometry with uniform loading, schedule, lighting, and HVAC systems. Each shell consists of at least 5 thermal zones (core + perimeters) and represents all rooms/spaces within that part of the building. Generally, it is not important to accurately represent every geometric detail of the architectural design; aim to accurately represent the gross floor area, number of floors, floor to floor height, exterior surface area (aspect ratio input), and window wall ratio (percentage of glazing) on each façade.

The number of shells should be minimized. Shells should not be used to represent a single room or a type of space such as a corridor. Multiple shells can be combined to form a building with diverse space programming, more complex geometry, or different HVAC configurations. Shells can be attached, which reduces exterior heat transfer and glazing. Shells can be inside other shells to represent unique areas without significant exterior exposure (such as small offices scattered throughout a warehouse).

Unless explicitly approved by the Program, projects should not exceed three building shells in Sketchbox. Building shells are separated based on unique HVAC system types, features, and geometry. Where possible, portions of the building with different HVAC characteristics should be separated into different shells (e.g., HVAC system types, controls, efficiency features such as exhaust air energy recovery, etc.), not to exceed three total shells. If applicable, below-grade portions of the building should be modeled as unique shells.

Components on the Design tab should be entered as specified in design documents according to the guidance below.

5.3.5 Design Tab: HVAC Systems

HVAC Systems should be defined according to the design of the proposed HVAC system type and parameters. The ASHRAE Appendix G baseline definitions for baseline system should not be used for this program pathway.

Many common HVAC configurations are represented in Sketchbox, including both gas and electrically heated systems. Highly specialized systems, hybrid systems, and antiquated systems are not represented; however, reasonable approximations can usually be made with the most similar available system. First select the heating fuel type (gas or electric), then select the appropriate air-side system, then select the appropriate heating/cooling plant equipment (where applicable).

Dedicated outside air (DOAS) systems may be selected for some system types. This should be used when delivery of the ventilation air in the proposed design is decoupled (uses separate equipment and ductwork) from the primary heating and cooling systems. DOAS systems are often used in buildings with certain higher-performing HVAC systems including ground-source heat pump, VRF, etc. A gas-fired and direct-expansion (DX) cooled DOAS system may be selected or the DOAS system can be selected that match the heating/cooling configuration of the primary HVAC system. Selecting "None" for DOAS means that outside ventilation air will be brought in through the primary HVAC system.

The type of domestic hot water selected should align with the type specified in the proposed design.

5.3.6 Sketchbox Calculators

The Sketchbox Calculator tabs in the BASIC Workbook can be used to calculate several of the inputs on the Design Tab of Sketchbox.

1. Aspect Ratio: Enter if known. If unknown, see Building Geometry Calculator - Exterior Wall Area Input.

2. Perimeter Zone Depth: Enter if known. If unknown, see Building Geometry Calculator.

3. Window-to-Wall Ratio (%): Enter if known. If unknown, see Building Geometry Calculator.

5.3.7 Schedules Tab

The schedule defaults come from the ASHRAE Handbook and should be used in most cases. In rare exceptions, the "Simplified" schedule type may be used to set a start and end time for occupancy. One example where the simplified schedule may be appropriate is in a distribution warehouse or call center that operates 2-shifts or 24 hours.

Unless explicitly approved by the Program, projects should use default schedules.

5.3.8 Baseline and Measures Tabs: Baseline and Proposed Design

Parameters of the baseline energy model are established first in the typical Sketchbox workflow, using the Baseline tab. Then the proposed design is represented by applying a series of "Measures" (changes) in the Measures Tab. Most of the relevant baseline information will be populated by default according to the energy code lookups. Unless instructed otherwise below, the baseline values should be left at the defaults.

While baseline values should not be arbitrarily changed, it may be appropriate to modify settings on the "Baseline" tab to accurately reflect the baseline for a project. Some examples of this include:

- Applying existing envelope U-values where existing building envelope is being reused. This will impact related/interactive measures such as HVAC equipment performance.
- Modifying miscellaneous electric or gas loads to match project expectations. Plug and process loads are not code regulated. Reasonable defaults are provided for each building type but these should be modified if better information is available. Be sure to use realistic operational loads (the sum of all installed equipment) and not the total installed electrical capacity.
- Updating Occupant Density to match project details. Use realistic occupancy numbers (that the mechanical engineer would use) and not the higher emergency egress numbers that the architect may use.
- Updating baseline lighting power density or other parameters if the Design tab does not explicitly reflect the building use type. Most building types are represented, but special types (such as car dealerships) may not be represented.
- Updating Ventilation Rate or Humidity Setpoints to match the proposed design. Except as described below, the baseline and proposed ventilation rates should be equal.

Setting Demand Control Ventilation or Energy Recovery Ventilation parameters based on the detailed requirements of the energy code. The energy code has complex criteria to determine whether energy recovery is required for certain systems based on airflow and outside air fraction (among other things), so it is not realistic for Sketchbox to make this determination automatically. Then there are a multitude of exceptions in the code that are employed quite regularly for any given project. Therefore, users should review code requirements and select energy recovery and demand ventilation controls for the baseline where appropriate. The proposed design is generated by applying measures incrementally to the baseline on the Measures tab until the proposed model reflects the project's design parameters. Measures can consist of a single change (such as a lighting power density value) or multiple changes (such as a change in heating efficiency, cooling efficiency, and fan power to represent a piece of equipment). Measures may include similar modifications to multiple shells. Sketchbox runs each measure separately to provide feedback on relative impact. The measures are applied progressively such that when the last measure is applied, the results will reflect the performance of the proposed design (including all measures).

All differences between the baseline and proposed designs should be modeled in Sketchbox, including penalties. Only the measure components listed in the sections below may be modeled. If a component is not listed, no measures shall not be modeled for that component. When multiple shells are modeled, these instructions should be applied to each shell.

Envelope

Proposed building envelope thermal properties must be modeled as shown on architectural drawings. Thermal properties (U-value) of the proposed assemblies shall be calculated in accordance with 90.1 Appendix A. Careful attention must be paid to effective R-values for cavity insulation. For example, the effective R-value for R-21 cavity insulation may be as low as R-7.4 due to frame type, spacing, and depth.

Sketchbox models all exterior walls as above-grade. If significant portions of the building have below-grade walls, users may adjust the wall U-value to reduce heat transfer with the outside air. Below-grade walls shall be modeled with a U-Factor of 0.075 Btu/hr·ft·°F (equivalent to C-value of 0.119 plus four feet of soil using ASHRAE 90.1 Appendix A values). The same values should be used in the baseline and proposed models. Below-grade wall U-values are not permitted to be modeled as a measure.

When whole-building air leakage testing, in accordance with ASTM E779, is specified during design and completed after construction, the proposed infiltration rate shall be modeled based on the total measured air leakage divided by the total building exterior surface area. The infiltration specification modeled shall match testing conditions. Otherwise, the same infiltration rate shall be modeled in the baseline and proposed using the Sketchbox default.

- *Valid measure components: Roof U-value, Wall U-value, Slab F-Factor, Infiltration*

Fenestration

Vertical Fenestration (“Glazing” in Sketchbox)

Proposed fenestration must be modeled as specified and include the whole window assembly (i.e., frames and glazing). Sources for proposed U-value include the window’s NFRC rating and ASHRAE 2014 Fundamentals. If both summer and winter fenestration U-values are available, winter U-value must be used as it reflects the NFRC rating conditions.

- *Valid measure components: Glazing U-Value (by orientation), Glazing Solar Heat Gain Coefficient (by orientation)*

Skylights

Proposed skylights must be modeled as specified and include the whole window assembly (i.e., frames and glazing).

- *Valid measure components: Skylight U-Value, Skylight Solar Heat Gain Coefficient*

Internal Loads

To model savings for efficient miscellaneous electric or gas equipment, including ENERGY STAR® appliances, detailed side calculations must be created and submitted that define Sketchbox inputs for baseline and proposed equipment power density. The NJ Technical Reference Manual (TRM) can be used to determine baseline and proposed values and/or energy savings. Users should be aware that the “Misc and Plug Loads” schedule will be used to modulate the equipment power in the model. Results must be entered into Sketchbox for the baseline (on the Baseline tab) and the proposed design (by way of measures on the Measures tab). If no savings are modeled for miscellaneous equipment, keep the baseline defaults as-is and do not include a measure. Final input and incentives are subject to review.

Exception: Building shells with significant miscellaneous gas equipment (such as commercial kitchens, multiple gas clothes dryers, or industrial process equipment) should model an appropriate BTU/hr·ft² even if savings are not modeled to ensure the proposed model reflects the fuel use of the design.

- *Valid measure components: Miscellaneous Equipment Power, Miscellaneous Equipment Gas*

Heating and Cooling

Heating and cooling equipment capacities and efficiencies must be reported in the Weighted Average Efficiency Calculator on the Sketchbox Calculators tab(s) in the BASIC Workbook, and results must be entered in Sketchbox for the baseline (on the Baseline tab) and the proposed design (by way of measures on the Measures tab).

If claiming savings for system fan power, detailed side calculations must be created (with the baseline established using the method in ASHRAE 90.1 Section 6.5.3.1.1 and Tables 6.5.3.1) and submitted that define Sketchbox inputs for baseline and proposed. Results must be entered in Sketchbox for the baseline (on the Baseline tab) and the proposed design (by way of measures on the Measures tab). If no savings are claimed for fan power, keep the baseline defaults and do not include a measure.

If applicable, the hot water temperature reset control is required to be set to "Yes" on the Baseline tab when the proposed boiler design capacity exceeds 300,000 Btu/h. Otherwise, the hot water temperature reset control field shall be set to "No." The proposed design should be captured, if different than the baseline, through a measure on the Measures tab in Sketchbox.

- *Valid measure components: Average Cooling Equipment Efficiency, Average Heating Equipment Efficiency, DOAS Cooling Efficiency, DOAS Heating Efficiency, Fan Power, DOAS Fan Power, Hot Water Temperature Reset Control*

Lighting

If pursuing credit for interior lighting, fixture counts and wattages must be reported in the Interior Lighting calculator on the Sketchbox Calculator tab(s) in the BASIC Workbook and results must be entered in Sketchbox for the baseline (on the Baseline tab) and the proposed design (by way of a measure on the Measures tab).

To claim savings for interior lighting controls, the project must demonstrate that >=75% of the controlled lighting wattage has controls exceeding mandatory requirements. In this case, the project may apply a 5% reduction to controls. Documentation must be submitted to claim interior lighting control savings.

- *Valid measure components: Interior Lighting Power, Percent Reduction from Interior Lighting Controls*

Domestic Hot Water

If claiming savings for low flow fixtures, the Low-Flow Fixture Calculator must be filled out on the Sketchbox Calculators tab(s) in the BASIC Workbook and results must be entered in Sketchbox for the baseline (on the Baseline tab) and the proposed design (by way of measures on the Measures tab). If no savings are claimed for DHW demand, keep the baseline defaults and do not include a measure.

The proposed water heater's efficiency shall be modeled as specified in the design.

- *Valid measure components: Domestic Hot Water Demand, Domestic Hot Water Heater Efficiency*

Ventilation Rates

Proposed outdoor air ventilation rates shall be consistent with mechanical system design documents.

Baseline outdoor air ventilation rates shall be equal to the proposed design. Sketchbox default values, which originate from ASHRAE Standard 62.1, may be used for early design studies or where specific ventilation rates are not documented on mechanical drawings.

If defaults are not used, documentation must be submitted to justify Sketchbox inputs for the baseline and proposed. The “Ventilation Rate Units” field shall be set to “CFM” on the Baseline tab.

Demand Controlled Ventilation, Air-Side Economizers, and Exhaust Air Energy Recovery

Whenever feasible, portions of the building with DCV, economizers, or exhaust air energy recovery (EAER) should be modeled separately from those without these features (i.e., as separate shells). Since ventilation equipment and controls are on/off type devices in the model, we cannot apply these to only a portion of the spaces in a shell. To apply certain controls strategies to only a portion of a building, users may create two shells, one having the measure and the other not having the measure using relative square feet to proportion the savings.

If separating the building into different shells is impractical due to its geometry or the building shell limit, systems with the same HVAC type may be combined, even if some areas have DCV/economizers/EAER while others do not. In this case, to qualify for DCV/economizer/EAER savings and include these strategies as a measure, at least 75% of the shell floor area must be served by a system that includes these features. The modeled components shall be consistent with the mechanical system design documents. Where applicable, a weighted average exhaust air energy recovery effectiveness should be used.

- *Exception*: If only small portions of the building have DCV and cannot be modeled as a separate shell, the ventilation rate may be modified to account for DCV. Exceptional calculations shall be submitted to demonstrate the reduction in ventilation. Estimate ventilation control savings by coming up with an equivalent reduction in the outside air delivered to the space (CFM per person, CFM, or ACH). Sometimes, the DCV On/Off switch just doesn’t provide reasonable results for ventilation controls. The model is limited in that it’s looking at the occupancy schedule to adjust airflow, and sometimes that’s not the best way to think about ventilation controls. A warehouse or vehicle maintenance bay is a typical example where it’s not really people that are driving the need for outside air. In these cases, an equivalent ventilation rate reduction may be appropriate.

- *Valid measure components: Ventilation Rate, Air-Side Economizer, Demand Control Ventilation, Energy Recovery Ventilation*

Site (Exterior Lighting)

If pursuing credit for exterior lighting, fixture counts, wattages, and applications must be reported in the Exterior Lighting – Baseline and Exterior Lighting – Proposed tab(s) in the BASIC Workbook and results must be entered in Sketchbox for the baseline (on the Baseline Site tab) and the proposed design (by way of a measure on the Measures tab). Exterior lighting control reduction is not a permitted measure; the default reduction from controls shall be modeled in the baseline, and no measure should be modeled.

- *Valid measure components: Exterior Lighting Power*

5.3.9 Reporting

The results from Sketchbox must be entered into the BASIC Workbook for program reporting and incentive calculation. To do so, follow these steps:

1. After running the model, click "Download Results" in the top left of the "Results" tab in Sketchbox. This will generate an Excel file, saved in the computer's Downloads folder.
2. Follow the instructions on the *Streamlined Pathway* tab of the BASIC Workbook to transfer data from the downloaded results into the official reporting template.
3. Follow directions on the *Energy Efficiency Measures* tab of the BASIC Workbook. Any penalties that were modeled should be marked as not exceeding 90.1-2019 prescriptive requirements in the measures table.

5.3.10 Additional Requirements

Exposed Floors

Exposed floors, such as those above a parking garage, cannot be explicitly modeled in Sketchbox. Since thermal properties of exposed floors cannot be evaluated in Sketchbox, projects must meet the minimum performance requirements of 90.1-2019 Section 5.5.3.4 for floors.

Below Grade Walls

Like exposed floors, below-grade walls cannot be explicitly modeled in Sketchbox. Since thermal properties of below-grade walls cannot be evaluated in Sketchbox, projects must meet the minimum performance requirements of 90.1-2019 Section 5.5.3.3 for below-grade walls.

6 High Performance Pathway – PHI/Phius

Projects enrolled in the High Performance Passive House Institute (PHI) or Passive House Institute US (PHIUS) proxy pathways will use the tools and software provided by the respective organization. Specifically, PHI uses PHPP (Passive House Planning Package), and Phius uses a software called WUFI®.

While both organizations evaluate proposed designs through these tools, neither currently requires the development of a corresponding baseline model. This presents a challenge for the New Construction Program (NCP), which is required to report energy savings between the proposed design and a baseline code-compliant building. Therefore, projects participating in the NCP will need to develop a code-compliant baseline building or home using PHPP or WUFI. The Program Administrator is working to establish a standard baseline for single family homes and multifamily buildings, but this is not yet available at the time of this writing.

7 High Performance Pathway – Simulation Guidelines (ASHRAE 90.1 Appendix G)

7.1 Overview

For projects to qualify for incentives under this Program, the Partner must calculate the project's performance rating (or performance score), which must meet or exceed the minimum performance target.

The minimum performance target is 5% site energy savings for commercial and industrial buildings compared to ASHRAE 90.1-2019 based on the 90.1 Appendix G method.

These simulation guidelines are intended to assist the Partner in developing their energy models and are meant to:

1. Facilitate consistent modeling across different modelers
2. Establish modeling protocols for measures
3. Ensure that modeling results are used to drive the energy-efficient design process

The ASHRAE 90.1-2019 standard is referenced throughout these guidelines. If a Partner identifies a discrepancy between the standard and the guidelines here, please contact the program for clarification.

7.2 Software Requirements

Modeling software must satisfy the requirements outlined in ASHRAE 90.1-2019 Appendix G Section G2.2, as modified in these simulation guidelines. Examples of tools that are allowed include eQUEST, HAP, EnergyPlus, and Trane Trace. Approval for use in the LEED and Federal Tax Deductions for Commercial Buildings program may serve as the proxy to demonstrate compliance with the requirement.

Partners or software vendors who believe they have an analytical tool that satisfies the requirements above but is not yet approved for use in the program should discuss with the Program and describe the tool's capabilities and how it complies with the listed program requirements. Particular emphasis must be placed on how the tool meets ASHRAE 90.1 Appendix G Section G2.2 requirements and energy efficiency measure (EEM) modeling. Based on the Program's review, the tool may be accepted for use on one or several pre-approved pilot projects. After successful completion of the pilot project(s), the tool will be included in the approved software list. Projects are not identified as pilot projects prior to preparing the comprehensive energy assessment, and those that utilize software not approved for use in the program will not be accepted.

7.3 Exceptional Calculations[1]

If the approved simulation tool used for the project cannot adequately model a design, material, or device, then the energy savings associated with this component may be calculated using an external (also known as exceptional) calculation, such as custom spreadsheets. Exceptional calculations for systems and components that may be modeled directly in the simulation tool will not be accepted. *If unsure whether a measure can be included through exceptional calculations, please check with the Program prior to submittal.* The resulting savings may then be subtracted from the usage projected by the proposed design model. Spreadsheets may also be used to support simulation inputs. Unless approved by the Program, at no time shall the total exceptional savings constitute more than 50% of the modeled site energy savings of the proposed design.

RETScreen may be used to model savings from solar water heating measures and other renewable energy technologies if these systems are not supported by the simulation tool used for the proposed design. RETScreen is a free tool developed and maintained by Natural Resources Canada. This software can be downloaded at http://www.retscreen.net/ang/home.php. The results must then be integrated into the compliant simulation tool.

Vendor-supplied and proprietary tools that were not / cannot be peer-reviewed cannot be used as external calculations to estimate EEM savings.

Documentation for Exceptional Calculation Methods must include:

1. Copies of all spreadsheets used to perform the calculations are labeled as an Appendix to the BASIC Workbook. PDF calculations will not be accepted.
2. Theoretical or empirical information supporting the method used based on peer-reviewed references.
3. The predicted energy savings by energy type, a narrative explaining the exceptional calculation method, and theoretical or empirical information supporting the accuracy of the

[1] Approach adopted by ASHRAE 90.1-2019 and modified for this document.

method.

4. The calculations shall be performed on a time step basis consistent with the simulation program used.
5. When using exceptional calculation methods, enter data into the Compliance Form Exceptional Calculations Tab.

7.4 General Simulation Requirements

7.4.1 General Description

For any energy efficiency measure (EEM) included in the model that is not addressed in the simulation guidelines, or for any calculations performed outside the modeling software and not specified in the simulation guidelines, Partners must submit a request for Program approval.

The Partner shall model a baseline and proposed building using ASHRAE 90.1-2019 Appendix G (Appendix G). Additional addenda may be used but must be explicitly listed in the submittals. In addition to the ASHRAE Standard 90.1, the ANSI/ASHRAE/IES Standard 90.1- 2019 Performance Rating Method Reference Manual[1] and 90.1 User's Manual are useful references for the interpretation of the Standard.

Appendix G uses a baseline that, starting with ASHRAE 90.1 2016, will remain the same for all future iterations of ASHRAE 90.1 and is roughly equivalent to ASHRAE 90.1-2004.

Baseline Design

- Shall be modeled as described in ASHRAE 90.1-2019 Appendix G;
- Shall not include end uses that do not exist in the proposed design. For example, if the parking lot in the proposed design is not lit, then the parking lot lighting power allowance cannot be added to the baseline energy consumption.

Exception: Cooling must be modeled in some conditioned spaces with no specified cooling, as Appendix G Table G3.1 #1b requires.

Proposed Design

[1] ANSI/ASHRAE/IES Standard 90.1-2019 Performance Rating Method Reference Manual, S Goel, M Rosenberg, C Eley, PNNL 2019

- Must reflect the actual building design components specified;
- Must comply with the mandatory provisions (Sections 5.4, 6.4, 7.4, 9.4 and 10.4) in ASHRAE Standard 90.1-2019, and Table G3.7 or G3.8 in the Appendix G. Compliance with 8.4 is not required by New Jersey State Energy Code (N.J.A.C 5:23-3.18) and will not be required by this program except for Section 8.4.4 Transformers, which is required by EPAct 2005. Receptacle controls required by Section 8.4.2 may be treated as a measure if included in the scope of work.
- Must include all end-use load components, including, but not limited to, exhaust fans, parking garage ventilation fans, snow-melt, and freeze-protection equipment, façade lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration and cooling.
- Where the space classification for a space is unknown in buildings in which energy-related features have yet to be designed, the space shall be categorized as an office space.

7.4.2 Performance Targets and the Performance Energy Index

$$\textbf{Performance Rating} = 100 * (PEIt - PEI)/PEIt$$

$$\textbf{PEI} = PBP/BBP$$

where:

PEI = Performance Energy Index. A project with a PEI=1.0 is as efficient as the baseline (i.e., meets ASHRAE 90.1-2004). A project with a PEI= 0.0 is a net zero building.

PEIt= Performance Energy Index Target

PBP= Proposed Building Performance

Performance shall be determined using the PEIt equation shown below, which deviates from ASHRAE 90.1 2019. These calculations are automated in the BASIC Workbook.

$$PEIt = [BBUE + \Sigma(EUPFi \times BEUEi)]/BBP$$

where:

BBP = Baseline Building Performance

BBREi = Baseline Building Regulated Energy Consumption that is due to *regulated* energy end-use “i”

BBUE = Baseline Building Unregulated Energy Consumption. The portion of the annual energy consumption of a *baseline building design* that is due to *unregulated energy use*.

EUPFi= End Use Performance Factor for regulated end use “i” for the appropriate building type and climate zone. For mixed-use buildings, the EUPFi is calculated as an area-weighted average of the building area types. EUPFs are included in the BASIC Workbook.

Informative Note: The compliance calculations in 90.1 2019 Appendix G require using the Building Performance Factors (BPFs) to measure the difference in stringency between 90.1

2004 (which is the basis of the Appendix G baseline) and 90.1 2019 (NJ state code). Instead of using a whole-building adjustment via the BPF, the program applies adjustment factors to individual end uses. These adjustments are referred to as End Use Performance Factors (EUPF) and are determined using a methodology that is conceptually similar to that used to determine the BPF. Calculating savings on an end-use basis results in more accurate savings relative to code and supports reporting results by fuel.

The BASIC Workbook will calculate a PEIt that is equivalent to ASHRAE 90.1-2019 using EUPFs and will automatically determine project performance.

7.4.3 Building Type Selection

The BASIC Workbook allows for eight (8) building types to be selected. Based on the building type selected, the BASIC Workbook will calculate the minimum Performance Energy Index Target (PEIt) value necessary to comply with ASHRAE 90.1-2019 and meet or exceed the Minimum Performance Target to align with the incentive structure (as noted above).

- Multifamily: Includes all mid-rise and high-rise apartment buildings. It also includes senior living, assisted living, and nursing, assuming the two criteria below are met; otherwise, these should be classified as “all others.”
    - ***Dwelling unit:*** a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.
    - ***Nontransient:*** occupancy of a dwelling unit or sleeping unit for more than 30 days.
- Healthcare/Hospital: Includes outpatient health care and hospitals.
- Hotel/Motel: Includes small and large hotels and motels as well as dormitories.
- Office: Includes administrative, financial, government, and medical buildings as well as data centers (“high intensity users” only).
- Restaurant: Includes fast food and sit-down restaurants.
- Retail: Includes stand-alone retail (non-food), strip malls, malls, and supermarkets.
- School: Includes preschool/day care, primary schools, secondary schools, colleges, and universities.
- Warehouse: Includes non-refrigerated and refrigerated warehouses (“high intensity users” only) as well as distribution centers.
- All Others: Includes manufacturing and process facilities as well as any building type that does not fit into the above categories.

Partners should discuss with the Program if unsure how to classify a building type.

For projects that are mixed use, such as a building that contains a school, retail store, and a multifamily building, each building type and associated area shall be entered in the ‘general info’ tab in the 90.1 Performance-based Compliance Form. If the project has more than three distinct building types, Partners should discuss with the Program on how to proceed.

7.4.4 Unregulated Energy

For 90.1 Appendix G compliance, energy use must be separated into regulated and unregulated components as described below.

Regulated energy use: energy used by building systems and components with requirements prescribed in 90.1 Sections 5 through 10. This includes energy used for HVAC, lighting, service water heating, motors, transformers, vertical transportation, select refrigeration equipment, computer-room cooling equipment, and other building systems, components, and processes.

Unregulated energy use: energy used by building systems and components that are not regulated in Sections 5 through 10, including the following:

1. Lighting is subject to the exceptions 90.1 Section 9.1.1, including emergency lighting that is automatically off during normal building operation, specifically designated as required by a health or life safety statute, ordinance, or regulation, and decorative gas lighting systems.
2. Transformers, except low-voltage dry-type transformers included in Section 8.4.4.
3. Plug-in equipment, including but not limited to consumer and office electronic systems.
4. Industrial process equipment and custom refrigeration systems with no requirements in 90.1.

Miscellaneous plug load density (W/SqFt) shall be determined using COMNET Commercial Buildings Energy Modeling Guidelines and Procedures Appendix C. Plug load hourly schedules shall be determined using COMNET Commercial Buildings Energy Modeling Guidelines and Procedures Appendix B.

All unregulated and process energy must be included in the simulation. Unregulated and process energy must be the same in both the Baseline and Proposed models *unless savings are documented by the Partner with justification for all assumptions and submitted to the Program for approval.*

Unregulated and regulated lighting, refrigeration, and miscellaneous energy must be calculated and entered into the 90.1 Performance-based Compliance Form separately to calculate the PEI target correctly.

7.4.5 Modeling Energy Neutral Systems and Components

If performance credit will not be claimed for a system or component included in the proposed design (e.g., non-qualified lighting or design is not specified), such systems shall be modeled as energy neutral as follows:

- Energy neutral *unregulated* systems and components must be modeled the same in the baseline and proposed design.
- Energy neutral *regulated* systems and components must be modeled as follows:
    - Baseline must be modeled based on the applicable requirements of 90.1 Appendix G and as described in these guidelines. If not prescribed, the baseline must reflect Sections 5 to 10 of 90.1-2019 requirements.
    - Proposed design must be modeled as meeting the applicable requirements of 90.1-2019.

7.4.6 Gut Rehab/Renovation Projects

Renovation projects typically remove and replace all equipment within the space, but sometimes a project may elect to leave and repurpose certain components, such as the envelope or portions of the HVAC. This creates a "hybrid" project that is part new construction and part retrofit. This section outlines the special rules that apply to such projects.

Performance Target Adjustment

Starting from the 2013 edition, Standard 90.1 Appendix G Performance Rating Method (PRM) does not differentiate between new construction (NC) and major renovation (MR) projects, measuring performance of the proposed design relative to the same baseline irrespective of the project type.

ASHRAE 90.1-2019 has several exceptions allowing renovated components to be less efficient than new construction (e.g., 90.1-2019 Section 5.1.3 - Envelope Alterations). Thus, the new PRM approach is more stringent for renovation projects than the prescriptive path of compliance with the energy code. Retrofitting the envelope to meet or exceed the requirements of the current code for new components presents a special challenge and may be cost-prohibitive.

To account for these factors, the EUPFs for the following end uses are unadjusted: interior lighting, exterior lighting, service water heating, refrigeration equipment (regulated), elevators and escalators, and other regulated end uses. While the EUPFs for all other end uses are multiplied by 1.10, which translates into a corresponding reduction in the stringency of the performance target for such projects. This adjustment is incorporated into the BASIC Workbook. Target PEIs will be calculated using an area-weighted average for projects that include new construction and major renovations.

Component Modeling

The table below summarizes the program approach for modeling systems and components in major renovation projects. In summary:

- The baseline model must be the same as for the new construction projects, except as described in Table G3.1 (e.g., fenestration area).

- The proposed model must reflect the project’s design parameters, whether the components are new, renovated/improved, or existing left as-is, EXCEPT the existing systems and components that are left as-is AND exceed 90.1-2019 must be modeled as minimally complying with 90.1-2019.

Table 7-1. New Construction vs Gut Rehab Component Modeling

Component Type	Project and Incentive Impact	Baseline Component Modeling	Proposed Components Modeling	Is Component a Measure?	Examples
New Construction	May be an energy penalty or credit, depending on the proposed design.	ASHRAE 90.1-2019 Appendix G (= ~ ASHRAE 90.1-2004) and as described in Section 7.6 of these guidelines.	As specified by design	Yes, if it exceeds 90.1-2019 prescriptive requirements. *See Section 7.5 for full measure requirements.*	Ground-up new construction project, addition to existing building
Existing Components Being Replaced	Same as New Construction	Same as New Construction	Same as New Construction	Same as New Construction Exception: May use subsections that apply to "alterations" of existing buildings, which may be less stringent (e.g., 90.1-2019, section 5.1.3).	Gut-renovation project with some improvements to the existing envelope
Existing Components Being Left As-Is	Energy neutral if the existing component is better than or equal to the code. Penalty if *worse* than code.	Same as New Construction	If Energy neutral: model as meeting the corresponding prescriptive requirements of 90.1-2019. If penalty: model as-is	No	Gut-renovation project, but the existing chiller to be repurposed. Existing chiller has a rated COP greater than the prescriptive requirements of 90.1-2019, but must be modeled as minimally compliant with 90.1- 2019.

7.4.7 Multiple Building Modeling

If the project involves multiple buildings (with prior program approval), they must be captured in a single energy model. Sometimes projects include several buildings with identical characteristics, in which case a simplified modeling approach may be used with prior approval from the Program. The buildings involved must have *similar envelopes and mechanical systems* as described below:

- Buildings are considered to have similar envelopes if all the following conditions are met:
  - Building geometries are similar
  - Total conditioned building area differs by no more than 20%
  - Percentage of area taken by common spaces differs by no more than 20 percentage points
  - Spaces in buildings are of a similar occupancy type
  - Areas of surfaces of each type (exterior and below grade walls, windows, roof, slab) differ by no more than 20%
  - Thermal properties of envelope components are similar
- Buildings are considered to have similar mechanical systems if *all* the following conditions are met:
  - HVAC or domestic hot water equipment in buildings is of a similar type
  - Overall plant efficiency varies by no more than five percentage points
  - Mechanical ventilation rates are similar

7.4.8 Core and Shell vs. Tenant Fit-Out Modeling

Refer to Section 7.4.1 above for additional guidance. *Core and Shell* and *Tenant Fit-out* projects shall be modeled as follows:

Baseline

The baseline model must be modeled as described in these guidelines.

Proposed Design

- *Core and Shell projects*: The model must reflect the project's design parameters. All unspecified (yet-to-be-designed) systems and components must be modeled as minimally complying with 90.1-2019. Tenant spaces must be included in the whole building model. Miscellaneous plug loads appropriate for the tenant occupancy type must be included in the simulation. Assume office occupancy if the tenant occupancy type is unknown.
- *Tenant Fit-out:* The model must reflect the project's design parameters, EXCEPT
  - The systems and components that are outside of the tenant fit-out area must be

excluded from the scope of the whole building model

- Existing systems and components that are within the tenant fit-out area but outside of the project scope, such as the envelope, must be modeled as described in Table 7-1. New Construction vs Gut Rehab Component Modeling, *Existing Components Left As-Is* row

Table 7-2. Design Scenarios

Design Scenario	Modeling Approach
Developer designed and will construct the envelope and HVAC, as well as lighting in the lobby, corridors, and other common areas, of a future office building (*Core & Shell* scope). Tenants that will lease office spaces are responsible for lighting design and fixture purchase/installation in their spaces (*Tenant Fit-out* scope). *Core & Shell* scope is being submitted to the program.	The *Core & Shell* project must follow the guidelines in this document, with the lighting included in the tenant scope treated as a "future building component." The tenant space must be explicitly modeled. With the Appendix G approach, the baseline lighting must be modeled following the general rules applicable to NC projects. The proposed lighting must be modeled as minimally compliant with 90.1-2019 Section 9.
The developer designed and will construct the building envelope for a future retail strip mall (Core & Shell scope). Tenants are responsible for HVAC and lighting design in their lease areas (*Tenant Fit-out*). Tenant scope is being submitted to the program.	Only the Tenant portion of the building envelope needs to be modeled (if only a part of the total strip mall). With the Appendix G approach, the baseline envelope must be modeled following the general rules (same as for all NC projects). The proposed envelope must be modeled as minimally compliant with 90.1-2019 Section 5. The rest of the Tenant scope (HVAC and Lighting) must follow the guidelines in this document.

7.5 Simulating Measure-Level Savings

7.5.1 General Approach

Energy-efficiency measures must be modeled incrementally. For example, in eQuest, the "parametric runs" function must be used to model all energy reduction measures where possible. In TRACE 700, the "Alternatives" function must be used. Note that TRACE 700 only allows up to four (4) Alternatives; therefore, if modeling more than three (3) measures, Alternative-4 should be 'saved as' Alternative-1 and additional measures modeled as subsequent Alternatives. Model submissions that do not incorporate parametric runs [eQuest], alternatives [TRACE], or an equivalent process will not be accepted.

To account for interactive effects and to allocate them among measures, the measures must first be ordered. The order may be based on the cost-effectiveness of each measure or the sequence in which measures would likely have been implemented had they been implemented individually. The measures are then added sequentially based on the established order as described in the following sections.

The model files submitted to the Program must allow for a review of savings projected from individual measures as described above.

All differences between the Appendix G baseline and the Proposed Design, including energy penalties (see Section 7.5.5), shall be simulated as measures based on the following steps:

Step 1 Add the first measure (M1) to the baseline design to calculate usage of the baseline with measure #1.

Step 2 The savings associated with measure #1 are calculated by comparing the usage of the baseline design to the baseline + M1 model from the previous step.

Step 3 The baseline+M1 model is then modified to include the second measure (measure #2) to obtain the baseline+M1+M2

Step 4 The savings associated with measure #2 are estimated by comparing the baseline +M1 model to baseline+M1+M2 model.

Step 5 Repeat with the remaining measures until the model includes all the measures and is equivalent to the proposed design.

Appendix G baseline is roughly equivalent to ASHRAE 90.1-2004. In the Energy Efficiency Measures tab of the BASIC Workbook, "Measure Exceeds 90.1-2019 Prescriptive Requirements" must be set to "Yes" or "No" depending on whether the measure exceeds the minimum mandatory/prescriptive requirements of 90.1- 2019. This field is used for program reporting purposes.

7.5.2 Measure Granularity

Multiple components or systems may be grouped and reported as a single measure, provided that these components/systems belong to the same end use. Distinct energy efficiency measures should not be combined if individual components have separate baselines, OR if individual components improve efficiency, reduce flow rates, and/or reduce hours of operation. For example, different types of lighting fixtures may be modeled and reported as a single measure, but lighting fixtures and occupancy sensors cannot be combined. Similarly, lighting and HVAC system upgrades cannot be combined. Measure granularity is defined by the available measures in the BASIC Workbook.

7.5.3 Measures Classification

In the 'Energy Efficiency Measures' tab of the BASIC Workbook, Partners must identify if a measure exceeds ASHRAE 90.1-2019 mandatory requirements in Section 5.4, 6.4, 7.4, 8.4.4, 9.4, 10.4 or prescriptive requirements in Sections 5.5, 6.5, 7.5, 8.5, 9.5, and 9.6 by selecting 'Yes' in the 'Measure Exceeds 90.1-2019 Prescriptive Requirements?' column. Select "No" for the following:

Measures that exceed the Appendix G baseline, but do not exceed ASHRAE 90.1-2019 requirements. Measures that result in negative site energy savings. Schedules

Operating and occupancy schedules from one of the following sources shall be used:

- ASHRAE 90.1-2019 User Manual Tables G-5 through G-14
- COMNET Commercial Buildings Energy Modeling Guidelines and Procedures, Appendix C, except for multifamily
- ASHRAE 90.1 Section C3.5.5.3 Schedules and Internal Loads

Schedules must be identical in the baseline and proposed models. Exceptions include:

- Setpoints and schedules for HVAC systems that automatically provide occupant thermal comfort via means other than directly controlling air dry-bulb and wet-bulb temperatures.
- Modeling non-standard energy efficiency measures such as automatic lighting controls, automatic natural ventilation controls, automatic demand control ventilation controls, and automatic controls that reduce service water heating loads. In such cases, documentation including sources must be provided, justifying the assumptions.

Simulated hourly schedule distribution must be realistic, as the Program requires reporting demand savings.

7.5.4 Unmet Load Hours

Unmet load hours shall not exceed 300 hours per year. Exceptions to these limits must be submitted to the Program for approval and will require justification indicating that the accuracy of the simulation is not compromised by these unmet load hours and that there is no significant impact on the project's performance rating.

7.5.5 Energy Penalties

Building components are an *energy penalty* when the proposed component does not result in energy savings compared to the baseline model. Proposed systems that impose energy penalties must be included in the proposed model *as designed*, using separate parametric run(s)/alternative(s) and modeled last, following all other proposed EEMs. They must also be included in the BASIC Workbook and organized in the order modeled (e.g., last).

7.5.6 LEED BD+C Interpretations

LEED interpretations for Energy & Atmosphere credits applicable to LEED BD+C: New Construction contain approaches to claim savings for energy efficient design that exceeds standard practice and is unregulated by ASHRAE 90.1. LEED interpretations and associated calculations to justify model inputs and/or calculate energy savings may be submitted for Program review and approval. When using this approach, measure descriptions in the BASIC Workbook must reference the interpretation identification number, and the ruling must be included as an appendix. LEED interpretations are located at www.usgbc.org/leed-interpretations.

7.6 Component Modeling

7.6.1 Building Envelope: Opaque Assemblies

Proposed Design

The proposed building envelope must be modeled as shown on architectural drawings, except for uninsulated assemblies, which can be averaged with larger adjacent assemblies. Thermal properties (U-value) of the proposed assemblies shall be calculated in accordance with 90.1 Appendix A. Careful attention must be paid to effective R-values for cavity insulation. For example, the effective R-value for R-21 cavity insulation may be as low as R-7.4 due to frame type, spacing, and depth.

To determine that opaque envelopment components exceed ASHRAE 90.1-2019 requirements, proposed opaque assemblies shall exceed the performance listed in Table 5.5-4 and Table 5.5-5. The prescriptive component can be determined as follows:

- Same assembly type as Appendix G (light-weight assemblies)
- Same assembly type as the proposed design. For example, if the proposed design includes a mass wall in climate zone 4a for a residential building, the proposed mass wall U-value must be less than U-0.090 (R-11.4 ci).

For major renovation projects, the proposed design must exceed the requirements of 90.1-2019 Section 5.1.3.

Baseline

Baseline building envelope must be modeled using light-weight assembly types for all above-grade walls, roofs, and floor assemblies using the maximum U-factors in Tables G3.4-1 through G3.4-8 for the building's climate and space type (residential, non-residential, semi-heated).

Gut rehab projects are treated identically to new construction projects. Baseline building envelope shall not be modeled as the existing condition, with the exception of the existing fenestration area.

7.6.2 Building Envelope: Exterior Roof Surfaces

Proposed Design

Performance credit may be claimed for variances in solar reflectance and thermal emittance as long as the proposed performance is clearly documented and tested in accordance with CRRC-1 Standard, Solar Reflectance Index method in ASTM E1890, or equivalent. To determine that the roof surface exceeds ASHRAE 90.1-2019 requirements, the same values as the Appendix G baseline may be used.

Baseline

Baseline exterior roof surfaces shall be modeled using a solar reflectance of 0.30 and thermal emittance of 0.90. The solar reflectance and thermal emittance values may also be used to show compliance with ASHRAE 90.1-2019.

7.6.3 Vertical Fenestration

Proposed Design

Proposed fenestration must be modeled as specified and include the whole window assembly (i.e., frames and glazing). Sources for proposed U-value include the window's NFRC rating and ASHRAE 2014 Fundamentals. If both summer and winter fenestration U-value is available, winter U-value must be used as it reflects the NFRC rating conditions. If software is capable of explicitly modeling framing and glazing separately, this approach may be used if these properties are known. Actual Visible Transmittance (VT) of the specified windows must be modeled to capture interaction with daylighting controls.

To determine that components exceed ASHRAE 90.1-2019 requirements, proposed vertical fenestration shall exceed the performance listed in 90.1-2019 Table 5.5-4 and Table 5.5-5, as applicable based on the project's climate zone. For major renovation projects, the proposed design must exceed the requirements of 90.1-2019 Section 5.1.3.

Exception: If the proposed window area exceeds Table G3.1.1-4 allowances, the additional window area shall be modeled as an energy penalty and separate from the EEM.

Baseline

Per ASHRAE 90.1-2019 Appendix G Table G3.1, vertical fenestration areas for new buildings and additions shall equal that in Table G3.1.1-4 based on gross above-grade exterior wall area. Each type shall use the values in the table for buildings with multiple building area types.

For building areas not shown in Table G3.1.1-4, vertical fenestration areas for new buildings and additions shall equal that in the proposed design or 40% window-to-wall ratio, whichever is less, and shall be distributed on each face of the building in the same proportions as the proposed design.

For gut rehab projects, the fenestration area shall be equal to the existing fenestration area prior to proposed work. It shall be distributed on each face of the building in the same proportions as the existing building.

7.6.4 Skylights and Glazed Smoke Vents

Proposed Design

To determine that components exceed ASHRAE 90.1-2019 requirements, proposed skylights shall exceed the performance listed in Table 5.5-4 and Table 5.5-5. For major renovation projects, the proposed design must exceed the requirements of 90.1-2019 Section 5.1.3.

Baseline

Per ASHRAE 90.1-2019 Appendix G Table G3.1, the skylight area shall be equal to that in the proposed design or 3%, whichever is smaller. If the skylight area of the proposed design is greater than 3%, the baseline skylight area shall be decreased by an identical percentage in all roof components in which skylights are located to reach 3%.

7.6.5 Interior Lighting

Proposed Design

Lighting in the proposed design must include all task and ambient lighting, and a 'space-by-space method' must be employed. Lighting energy savings credit may be claimed only for lighting fixtures compliant with the Program Guidelines.

Baseline

Interior lighting power in the baseline shall be determined using values in Table G3.7 and the methodology described in Sections 9.6.1 and 9.6.2 of ASHRAE 90.1-2019. The building area method shall not be used.

7.6.6 Exterior Lighting

Proposed Design

Performance credit for exterior lighting is only permitted for tradable surfaces based on 90.1-2019 Table 9.4.2-2. Proposed exterior lighting power shall not exceed the baseline allowance prescribed in Table 9.4.2-2, as these requirements are mandatory.

Baseline

Non-tradable exterior lighting shall be modeled identically in the baseline and proposed design.

Exterior Lighting Runtime

Exterior lighting schedules used in the model shall account for the mandatory lighting controls and their schedules as required in ASHRAE 90.1-2019 Section 9.4.1.4. Alternatively, exterior lighting runtime shall not exceed 8 hours per day. Per the baseline column of ASHRAE 90.1-2019 Table G3.1 #4, exterior lighting schedules shall be modeled identically in the baseline and proposed designs. No performance credit shall be claimed for reducing exterior lighting runtime.

7.6.7 Lighting That Does Not Comply with Minimum Performance Standards

Lighting specified must be DLC qualified, as outlined in the Program Guidelines. The following summarizes how to handle scenarios in which spaces or portions of spaces have fixtures that do not meet Program requirements.

a. For entire spaces that do not have lighting fixtures that comply, the lighting shall be modeled as follows:

    i. The baseline lighting power density (LPD) shall be modeled as described in Section 7.6.5.

    ii. The proposed lighting must be based on the maximum LPD in ASHRAE 90.1-2019 Table 9.6.1, complying with Sections 9.6.1, 9.6.2, and 9.6.4, or the specified lighting, whichever is greater. <u>Proposed lighting that does not qualify shall not be modeled as being equal to the Appendix G baseline</u>.

b. For portions of spaces that do not have lighting fixtures that comply with the Minimum Performance Standards, the following approach may be used:

(A) Calculate the total area of the space, [SqFt]

(B) Calculate total wattage of the space, [watts]

(C) Calculate the wattage that does not qualify, [watts]

(D) Calculate the wattage that does qualify, [watts]

(E) Calculate the percentage of lighting power that does not qualify as (C) / (B), [%]

(F) Calculate the area of the space associated with non-qualifying lighting as (A) x (E), [SqFt]

(G) Calculate the lighting power to be used in the proposed design for the portion of the space with non-compliant lighting by using the greater of the value in (C) and the code lighting power density allowance for this area, calculated as described in Section 7.6.5 above x (F) [Watts].

(H) Calculated weighted average proposed LPD as [(G) + (D)] / (A), [W/SqFt]

(I) Calculate baseline LPD as described in 7.6.5 above.

Example: A 1,000 SqFt office space has a lighting design consisting of 200 W of non-qualified lighting and 400 W of qualified lighting. The space Room Cavity Ratio (RCR) of the space is 9 and is calculated as defined in ASHRAE 90.1 Section 9.6.2. The baseline and proposed lighting for the space should be modeled as follows:

(A) Area of space: 1,000 SqFt

(B) Total wattage: 600 W

(C) Wattage that does not qualify: 200 W

(D) Wattage that does qualify: 400 W

(E) Percentage of lighting power that does not qualify: 33.3% (200 W / 600 W)

(F) Area of space associated with non-qualifying lighting: 333 SqFt (1,000 SqFt x 33.3%)

(G) Based on 90.1-2019 Table 9.6.1, the LPD of an enclosed office over 250 SqFt is 0.66 W/SqFt. Since the space RCR>8, the allowance is increased to 0.66*1.20 =0.792 W/SqFt following 90.1 Section 9.6.2.4 and is 333 [SqFt] x 0.792 [W/SqFt] = 263.7 [W]. This is greater than the 200 W specified non-qualifying wattage. Thus, 263.7 [W] must be used for this portion of the space in the proposed design model.

(H) The proposed lighting must be modeled as 400 [W] + 263.7 [W] = 663.7 [W], or 0.66 [W/SqFt].

(I) The baseline LPD is 1.1 W/SqFt per Appendix G Table G3.7

The Program will also allow similar calculations using lumens of qualifying and non-qualifying lighting fixtures in lieu of Watts.

7.6.8 Lighting Controls

Proposed Design – Controls Other than Daylighting

Lighting controls other than daylighting must be modeled by reducing the proposed LPD by the control credit percentages that are automatically calculated in the 90.1 Performance-based Compliance Form based on 90.1-2019 Table G3.7 Occupancy Sensor Reduction column.

The occupancy sensor reduction factor shall be multiplied by 1.25 for manual-on or partial-auto-on occupancy sensors. For occupancy sensors controlling individual workstation lighting, the occupancy sensor reduction factor shall be 30%. These are included in the automated calculations in the 90.1 Performance-based Compliance Form.

To demonstrate that lighting controls meet ASHRAE 90.1-2019 requirements, proposed lighting controls for each space type must:

- Meet all 'REQs' listed in Table 9.6.1
- Include (1) "ADD1" when present in Table 9.6.1
- Include (1) "ADD2" when present in Table 9.6.1

The Program may request a narrative on how mandatory lighting control requirements of Section 9.4 will be met, including the type of control(s) that will be installed in each space type.

Projects participating in the program may also document credit for the following automatic lighting controls included in the proposed design that are not required by Section 9.4.1 and Table 9.6.1:

- Automatic full off (90.1 Section 9.4.1 [i]) when either automatic full off or scheduled shutoff is allowed in 90.1 Table 9.6.1 (ADD2): the occupancy sensor reduction factor may be increased by 5%. Example: enclosed office >250 ft2
- For high end trim or task tuning, the occupancy sensor reduction factor may be increased by 7.5%. The following must be provided to claim this credit:
    - The lighting designer must provide the anticipated degree of turndown that is to be installed in each space with task tuning. This is the basis of savings to be claimed in the energy model. The submission must list what tuning factors are applied to the space LPD. The tuning factor is to be considered in addition to control factors for occupancy sensors and lighting schedules.
- The project construction documents must clearly list the intended light level that the systems are to be tuned to (foot candles as measured below the light at a specific height above the floor).

- The project construction documents must clearly describe lighting controls, commissioning requirements, and methods for implementing task tuning.
- For lighting in dwelling units that have controls meeting all of the following requirements, an occupancy sensor reduction factor of 10% may be used:
    - Each dwelling unit has a main control by the main entrance that turns off all the lights and all switched receptacles in the dwelling unit.
    - The main control may have two controls, one for permanently wired lighting and one for switched receptacles.
    - Where controls are divided, the main controls must be clearly identified as "lights master off" and "outlets master off."

Proposed Design – Daylighting Controls

<u>Daylighting is required for most building types to comply with ASHRAE 90.1-2019 and the NJ State energy code. Partners are encouraged to discuss this requirement with design teams, as this requirement is often overlooked</u>. Daylighting shall be explicitly modeled in the simulation tool if it has the capability (e.g., eQuest). Otherwise, daylighting software or daylighting tools may be used to support model inputs. The software/tool must incorporate the impact of fenestration properties such as visible transmittance (VT). The outputs of the daylighting software/tool shall be used to modify lighting schedules or lighting power density entered in the modeling software tool. The daylighting software tool outputs must be provided and include a discussion on how these results were translated into model inputs.

Baseline

Lighting controls shall be modeled as having occupancy sensors in employee lunch and break rooms, conference/meeting rooms, and classrooms (excluding shop classrooms, laboratory classrooms, and preschool through 12th grade classrooms). No other automatic lighting controls shall be modeled in the baseline building design. Additional interior lighting power for non-mandatory controls allowed in ASHRAE 90.1-2019 Section 9.6.2 shall not be modeled.

7.6.9 Domestic Hot Water

Proposed Design

To demonstrate that components exceed ASHRAE 90.1-2019 requirements, proposed domestic hot water heaters must exceed the performance requirements of Table 7.8. The mandatory requirement shall be determined using the same DHW system type as the proposed design.

When a combination system has been specified to meet both space heating and service water heating loads, the proposed design shall reflect the actual system type using actual component capacities and efficiencies. To demonstrate that components exceed ASHRAE 90.1-2019 requirements, a combination heating and DHW systems shall exceed requirements for boilers listed in Table 6.8.1.6.

For water heater types that reference USDOE minimum efficiencies, please refer to the minimum requirements in ASHRAE 90.1 2019 Appendix F Table F-2.

Baseline

The baseline hot water system type shall be determined using Table G3.1.1-3 which either requires a natural gas storage water heater or electric resistance storage water heater based on the building type. If buildings do not have domestic hot water loads, no heater shall be modeled. If the building will have domestic hot water loads, but a system has not been specified, it shall be modeled identically in the baseline and proposed designs using Table 7.8 of ASHRAE 90.1-2019.

For C&I buildings, where a complete service water-heating system exists or a new service water-heating system has been specified, one central service water heating system shall be modeled for each building area type in the baseline building.

Baseline storage water heaters shall be modeled as insulated to R-12.5.

Combination Heating and DHW Systems: Modeling Approach

For eQuest projects, to simulate an improvement to a combination system, a process load to the space heating boiler should be added, and the baseline DHW system capacity should be set to 0.0001 MMBtu/h. The following equations can be used to convert GPM used as the process flow input of DHW heaters to MMBtu/hr used as the process load input of heating boilers in the proposed design model. In eQuest, DHW consumption entered as a HW boiler process load will appear as a misc. equipment end-use. In the 'Results from eQuest' tab of the BASIC Workbook, the additional misc. equipment end-use compared to the previous run should be subtracted and manually added to the DHW end-use.

$$GPM \times \Delta T \times \frac{lb}{gal} \times \frac{min}{hour} \times \frac{Btu}{lb \cdot {}^{\circ}\mathrm{F}} \times \frac{MMBtu}{Btu} = MMBtu/hr$$

Where:

$$\Delta T = DHW\ outlet\ temp\ ({}^{\circ}\mathrm{F}) - DHW\ inlet\ temp\ ({}^{\circ}\mathrm{F}) \qquad GPM = Process\ Flow\ (gallons\ per\ minute)$$

$$\frac{min}{hour} = 60 \qquad \frac{lb}{gal} = 8.33 \qquad \frac{Btu}{lb \cdot {}^{\circ}\mathrm{F}} = 1 \qquad \frac{MMBtu}{Btu} = 0.000001$$

7.6.10 Hot Water Demand

For commercial buildings, hot water demand shall be based on the ASHRAE 90.1 User Manual Tables G-C through G-M schedules and loads which are automated in Table 5 on the Service Water Heating tab in the Compliance Form. Alternatively, Table 6 from ASHRAE HVAC Applications Handbook 2019 Chapter 51 can be used.

Performance credit associated with reduction may be claimed for low flow faucets and showerheads as well as ENERGY STAR appliances such as clothes washers and dishwashers that result in reduced hot water consumption.

Baseline Design

There are no ASHRAE 90.1-2019 requirements that establish baseline flow rates. Therefore, the maximum flow rates allowed by NJ A5160 for faucets and showerheads must be used for both the Appendix G baseline and establishing the ASHRAE 90.1-2019 baseline when confirming that the component qualifies for incentives. For example:

- Lavatory faucet or a replacement aerator for a lavatory faucet shall not exceed a maximum flow rate of 1.5 gallons per minute at 60 pounds per square inch
- Residential kitchen faucet or replacement aerator for a residential kitchen faucet shall not exceed a maximum flow rate of 1.8 gallons per minute at 60 pounds per square inch, with an optional temporary flow rate of 2.2 gallons per minute, provided the faucet or replacement aerator defaults to a maximum flow rate of 1.8 gallons per minute at 60 pounds per square inch after each use
- Public lavatory faucet or a replacement aerator for a public lavatory faucet shall not exceed a maximum flow rate of 0.5 gallons per minute at 60 pounds per square inch
- Showerhead shall not exceed a maximum flow rate of 2.0 gallons per minute at 80 pounds per square inch

7.6.11 HVAC

Proposed Design

The proposed model shall be consistent with mechanical schedules and drawings, which are included as an Appendix to the BASIC Workbook.

Baseline Design

Change in Baseline System Type

HVAC system types will often vary between proposed and baseline models. If there are no changes to the HVAC system type, only one model shall be submitted, which incorporates all measure runs. In cases where the HVAC system type changes from the baseline to the proposed design, two models may be submitted if necessary. The first model shall reflect the baseline design. The second model shall reflect the change in HVAC system, with each of the measure improvements modeled subsequently as separate parametric runs/alternates. For eQuest projects, the compare documents feature of Microsoft Word or other word processor may be used to compare the *.inp files of the two models to identify any unintended differences.

Conditioned Spaces without Cooling Specified

Heating and cooling shall be modeled in all conditioned spaces, even if no cooling is specified for the project unless spaces are designed with heating only systems serving storage rooms, stairwells, vestibules, electrical/mechanical rooms, and restrooms not exhausting or transferring air from mechanically cooled thermal zones. With proper documentation, the requirement to model cooling may be waived for industrial facilities that do not have a specified cooling system and are unlikely to have cooling installed in the future.

Baseline System Type Selection

All projects in New Jersey are required to use natural gas heating in the baseline. Electric heating shall not be modeled in the baseline design (no exceptions). ASHRAE 90.1-2019 Addendum ab[1] clarified and streamlined the process of determining the baseline HVAC system types. These updated requirements must be followed when documenting performance with the program. Below is a summary of the process based on amended Section G3.1.1.1:

1. Determine the combined gross conditioned and semi-heated floor area for each of the following building area types in the proposed design:
    - residential and residential-associated zones
    - public assembly
    - heating-only storage
    - retail
    - hospitals
    - other nonresidential

[1] https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_ab_20220727.pdf

2. Classify the nonresidential building area type with the largest combined area as the predominant nonresidential building area type. Add the combined area of any remaining nonresidential building area types with less than 20,000 ft^2 to the combined area of the predominant nonresidential building area type.
3. Select a baseline HVAC system type from Table G3.1.1-3 for each of the following building area types included in the proposed design based on the size of the building as a whole and not an individual occupancy: 1. Residential + residential associated 2. Predominant nonresidential 3. Each additional nonresidential building area type with more than 20,000 ft^2 of combined area based on G3.1.1.

The amended section G3.1.1.2 includes requirements for determining additional and adjusted baseline HVAC system types.

Example: Baseline System Type for a Mixed-Use Building

A new construction project involves a 5-story 100,000 ft^2 building with a retail store on the first floor (25,000 ft^2) and hotel on floors 2-5. The retail store includes the sales floor, offices, restrooms and heated-only storage space. Hotel floors include guest rooms, corridors, heated only stairwells, conference rooms and management offices. The baseline HVAC systems are established using a two-step process:

- **Step 1:** Determine the baseline HVAC system types based on building area types following 90.1 addendum ab Section G3.1.1.1

  Based on 90.1 2019 Addendum ab definition, any HVAC zone that primarily includes nonresidential spaces designed to serve occupants of residential spaces on a floor where over 75% of the gross conditioned floor area are residential spaces is considered residential-associated. On floors 2-5, hotel guest rooms account for more than 75% of conditioned and semi heated floor area, and all non-residential spaces on these floors are used for the hotel function. Thus, the residential zones on floors 2-5 shall be modeled with baseline System 1 – PTAC following Table G3.1.1-3 and the residential associated spaces on these floors shall be modeled with System 3 – PSZ- AC following 9.1-2019 Addendum ab G3.1.1.2 (f).

  The entire area of the first floor is considered retail and would map to baseline System 5 – Packaged VAV with reheat following Table G3.1.1-3 based on the number of floors and floor area of the entire building.

- **Step 2:** Determine additional and adjusted baseline HVAC system types following 90.1 addendum ab Section G3.1.1.2

Heated only stairwells on the hotel floors and heated only storage on the retail floor are subject to addendum ab Section G3.1.1.2 Exception(c) and will be modeled with System 9 – Heating and Ventilation.

Economizers in Climate Zone 4a:

Economizers are not required in the baseline for projects in Climate Zone 4a.

Economizers in Climate Zone 5a:

For systems 3, 5, 7, air-side economizers shall be included in the baseline model for projects unless the system serves a computer room, includes gas-phase air cleaning, or impacts refrigerated casework of a supermarket. The exceptions for the latter two only apply if the proposed design does not contain air-side economizers. For system 11, an integrated waterside economizer is required in the baseline that complies with ASHRAE 90.1-2019 Section 6.5.12.

Baseline System Sizing

The baseline systems must be sized based on design day conditions.

Purchased Heat and Chilled Water

Projects with space heating, cooling or service water heating provided by a district plant in lieu of on-site systems must be modeled following the method below, which is based on ASHRAE 90.1-2022 Addendum a. The method eliminates the penalty that has previously existed for such projects.

Sections G3.1.1.1, GG3.1.1.2 and G3.1.1.3 shall be eliminated in their entirety. The HVAC systems in the baseline design for projects served by the district systems shall be modeled the same as for projects with on-site systems.

The proposed designs utilizing purchased thermal energy must be modeled with on-site systems providing hot water, steam, or chilled water as follows:

1. Systems in the proposed design that use purchased hot water or purchased steam for space heating shall be modeled with forced draft boiler(s) that comply with but do not exceed the mandatory and prescriptive requirements of Section 6. The number of boilers and boiler controls shall meet the requirements of Sections G3.2.3.2 through G3.2.3.6 f.
2. Systems in the proposed design that use purchased chilled water shall be modeled with the type and number of chillers determined by following Sections G3.2.3.7 through G3.2.3.11 using equipment efficiency and controls that comply with but not exceed the mandatory and prescriptive requirements of Section 6.

3. Systems in the proposed design that use purchased hot water or purchased steam for service water heating shall be modeled with the same service water heating system type as in the baseline design and shall comply with but not exceed the mandatory and prescriptive requirements of Section 7.

Exception: Proposed systems can be modeled as prescribed in ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1-2020[1] Table C1.2 Proposed Building Performance Column #s1-3, 5 if the following criteria are met:

- The district plant is being designed and constructed contemporaneously with the building.
- The district plant is **not** participating in and receiving incentives from another New Jersey incentive program.

The modeling methodology is subject to program administrator approval. Documentation must be provided to justify all district plant modeling parameters.

Example: A dormitory with proposed purchased chilled water and hot water systems served by an existing district plant would be modeled with System 1, which consists of PTACs with DX cooling served by hot water boilers in the baseline. The baseline hot-water pump distribution power would be modeled as 19 W/GPM as consistent with Appendix G requirements for on-site systems. The number of boilers and boiler controls shall be modeled per the requirements of Sections G3.2.3.2 through G3.2.3.6.

The proposed model would be modeled with as-designed systems, except that instead of modeling purchased hot and chilled water, the systems would be modeled as served by on-site chilled and hot water systems, with the chiller and boiler plants minimally compliant with Section 6. The number of boilers and boiler controls shall meet the requirements of Sections G3.2.3.2 through G3.2.3.6, and the type and number of chillers shall be determined following Sections G3.2.3.7 through G3.2.3.11.

Fan System Operation

Schedules for HVAC fans that provide outdoor air for ventilation shall run continuously whenever spaces are occupied and shall be cycled on and off to meet heating and cooling loads during unoccupied hours. Exceptions include:

- Where no heating and/or cooling system is to be installed. In this scenario, fans shall cycle

[1] https://ashrae.iwrapper.com/ASHRAE_PREVIEW_ONLY_STANDARDS/STD_189.1_2020

on and off to meet heating and cooling loads for all hours.

- Mandated minimum ventilation requirements during unoccupied hours for health and safety.
- HVAC fans serving primarily computer rooms shall remain on during occupied and unoccupied hours.
- Dedicated outdoor air supply fans shall stay off during unoccupied hours.

Fan Power

Additional allowances shall not be modeled for any zonal exhaust fans. Instead, the calculated allowance shall be distributed between supply and exhaust fans in the same proportion as the proposed design. Alternatively, for residential thermal zones, exhaust fans may be excluded from the baseline design, and only supply fans shall be modeled at 0.3 W/CFM.

Baseline fan power for systems 3, 5, 7, 11, and 12 shall be calculated using Table G3.1.2.10 and associated allowances from Section 6.5.3.1.1 of ASHRAE 90.1-2019. Baseline fan motor efficiency shall be calculated using Table G3.9.1. Proposed fan power shall be determined using either the mechanical schedule or manufacturer specifications.

For System 9, baseline fan power shall be modeled as 0.054 W/CFM only if the proposed design includes fans sized and controlled to provide non-mechanical cooling.

Regardless of system type, the fan power allowance calculated reflects the total fan power allowance for supply, return, exhaust, and relief fans (excluding VAV boxes). The calculated fan power must be distributed to the supply, return, exhaust, and relief fans in the same proportion in the proposed design.

Fan power associated with dedicated make-up air systems shall not be included in the baseline, even if it's included in the proposed design.

Improvements in fan power in the proposed design may be grouped with air-side HVAC or cooling EEMs.

Pump Power and Heat-Rejection

Baseline hot water pumps, chilled water pumps, and condenser water pumps shall be modeled per ASHRAE 90.1-2019 Sections G3.1.3.5, 3.1.3.10, and 3.1.3.11, respectively.

ASHRAE 90.1-2019 includes the following requirements for chilled water pumps, condenser water pumps, and heat rejection.

- Chilled-water systems shall be modeled as primary/secondary systems with constant-flow primary loop and a variable flow secondary loop. The baseline 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.

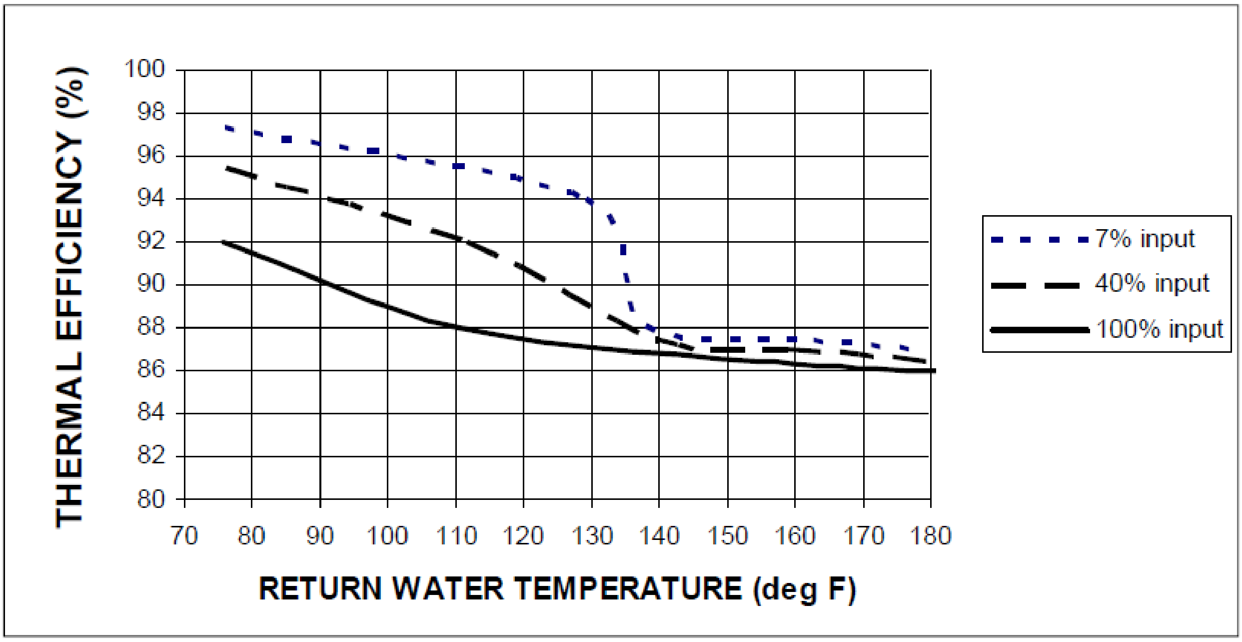
- Baseline condenser-water pumps shall be modeled as constant volume.
- Baseline leaving water temperature for heat-rejection systems shall be equal to 75 °F in climate zone 4A and 70 °F in climate zone 5A.

Improvements in pump power in the proposed design may be grouped with pump control measures such as variable speed drives.

Condensing Boilers

Condensing boiler performance is dependent on return water temperature and variations in load. In general, the efficiency of a condensing boiler increases as return water temperature and part load ratio decreases. Below is a graph that demonstrates typical condensing boiler efficiencies at various return water temperatures and part load ratios. As depicted below, condensing boiler efficiency drops considerably when the return water temperature is greater than 130°F.

Figure 7-1. Condensing Boiler Performance Curves



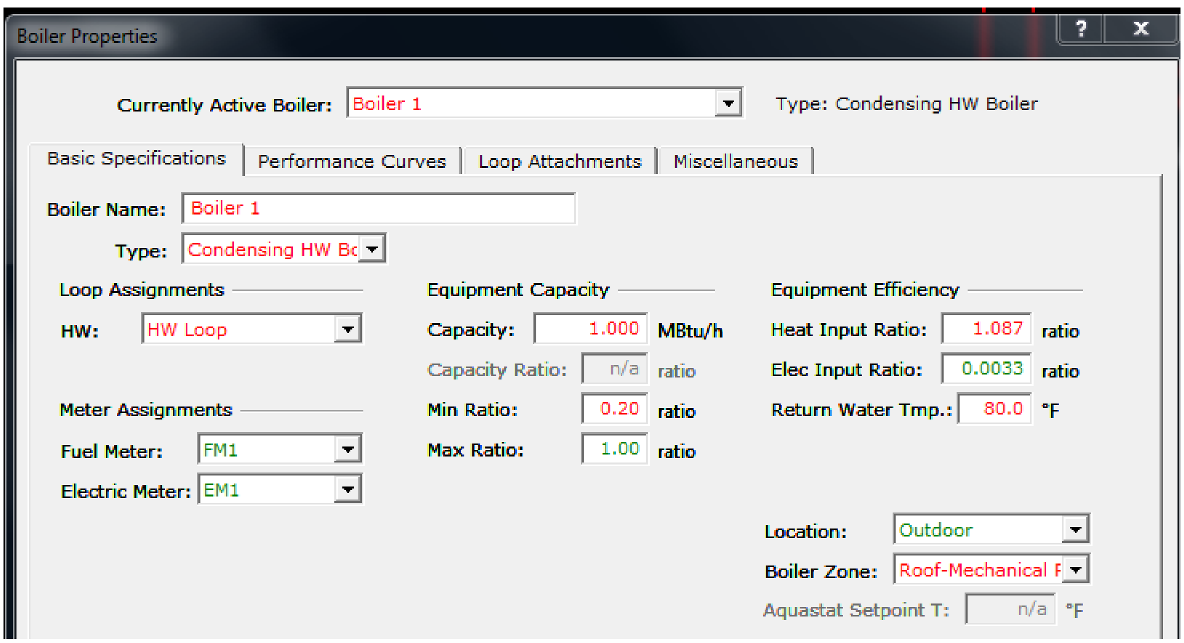
180°F supply and 130°F return water temperature must be modeled in the baseline per Appendix G, if boilers are a baseline requirement. The proposed design must reflect mechanical drawings and should not be modeled identically to the Appendix G baseline.

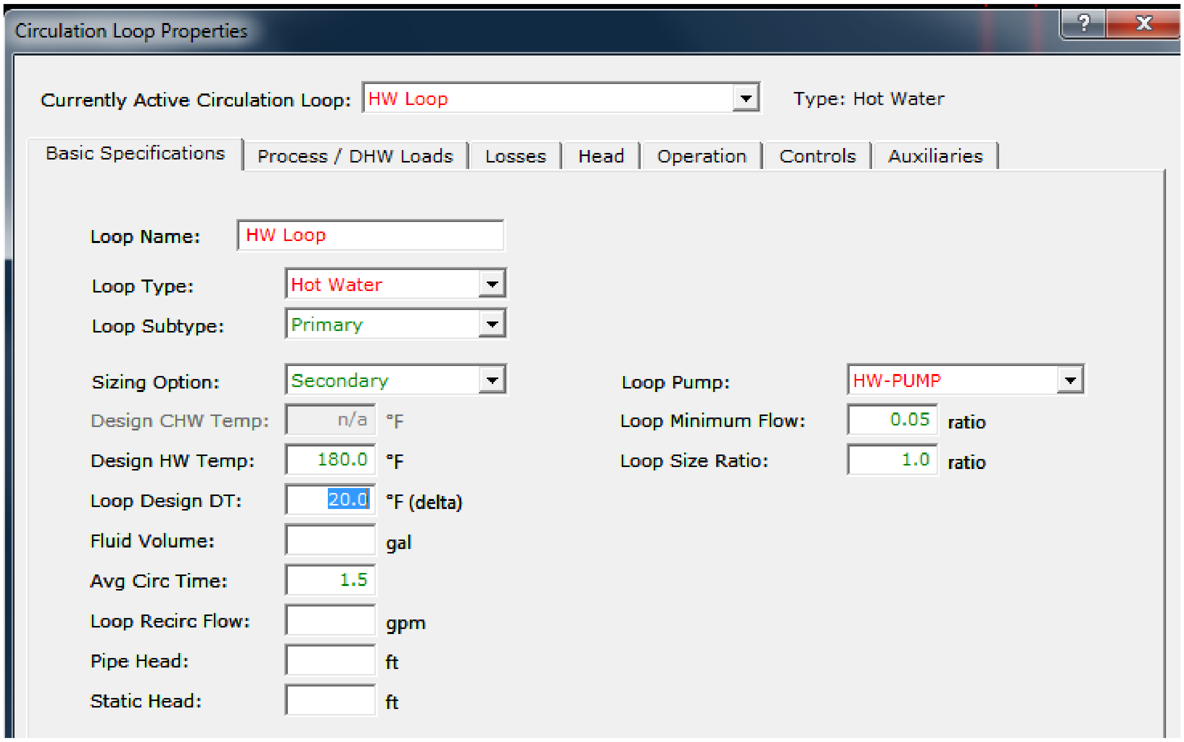
Design supply and return water temperatures must be explicitly entered into the simulation tool if the tool can automatically capture their impact on boiler efficiency (such as eQUEST). If the tool is not capable of automatically adjusting efficiency based on entered loop temperatures (such as TRACE), efficiency entered into the simulation tool must be adjusted manually to reflect the manufacturer's performance data for the boiler at actual operating conditions.

<u>*eQuest Example:*</u> The proposed scope of work includes the installation of a 1,000 MBH condensing boiler, which is rated at 92% thermal efficiency at 80°F return water temperature and at full load (i.e. AHRI rating conditions). Boiler literature states that condensing boilers can achieve efficiencies up to 98% thermal efficiency, which would occur at very low return water temperatures and part load ratios. The current design supply hot water temperature is 180°F, with 20°F design temperature drop.

The heat input ratio (HIR) for the condensing boiler must reflect the return water temperature input and full load capacity. Therefore, HIR of 1.087 (HIR = 1 / 92%) should be used in the simulation tool rather than HIR of 1.02 (HIR = 1 / 98%). When the equipment operates at part load, eQuest will capture boiler efficiency improvements.

Electric Input Ratio (EIR) must be entered to capture electricity usage associated with fans, controls, etc.





eQuest software contains default condensing boiler curves that can be used to simulate the improvement. However, several boiler manufacturers have performance curves readily available for their equipment. Custom performance curves may be simulated in the proposed case if the curves and the curve formula are provided as part of the submission.

Trane TRACE 700 Example: Using the example presented for eQuest, the boiler efficiency at the specified return water temperature per the drawings shall be used. While literature rates equipment up to 98% thermal efficiency, and equipment operates at 92% efficiency at 80°F water temperature, the efficiency corresponding to full load operation and the design return water temperature shall be used. The boiler curve above or manufacturer boiler curves may be submitted to justify proposed efficiency based on return water temperature.

Performance Curves

Table G3.5.2 prescribes full load efficiency (FL) and part load efficiency (IPLV) for the baseline chillers depending on chiller type and capacity. Similarly, construction documents provide FL and IPLV of the specified equipment. Commonly used simulation tools allow entering chiller full load efficiency and performance curves that determine chiller operation at lower loads, but do not the IPLV input.

Previously, performance curves corresponding to the prescribed baseline chiller IPLV were not provided in 90.1. As a result, modelers often used default curves that differed between simulation tools and did not reflect the intended performance of the baseline chillers. The issue was addressed by 90.1 2019 addendum bd,[1] which prescribed the performance curves that must be used for the baseline chillers.

The addendum also requires that, where the performance curves for the chillers specified in the proposed design are not available, the provided default performance curves are used based on the specified chiller type. The addendum also prescribes chiller minimum part-load ratio (ratio of load to available capacity at a given simulation time step) and minimum compressor unloading ratio (part-load ratio below which the chiller capacity cannot be reduced by unloading and chiller is false loaded) of 0.25. Chiller performance must be modeled as required in 90.1 2019 addendum bd[1].

Performance of heating and other cooling systems at part load must be modeled using performance curves for the appropriate system type from the PNNL 90.1 2019 Performance Rating Reference Manual:

- Boilers: page 3.217
- DX systems: Tables –0 - 62

Exception: Custom performance curves may be used in the proposed design based on the manufacturer data. Custom performance curves must be submitted with the supporting calculations and are subject to program approval.

Humidification and Dehumidification Systems

If the proposed design includes humidification, then the baseline building design shall use adiabatic humidification. Exception: if the proposed building humidification system complies with Section 6.5.2.4, then the baseline building design shall use non-adiabatic humidification.

For systems serving computer rooms, the baseline building shall not have reheat for the purpose of dehumidification.

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1 https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_bd_20220531.pdf

If the proposed design HVAC systems have humidistatic controls, the baseline shall use mechanical cooling for dehumidication and shall have reheat available to avoid overcooling. The reheat type shall be the same as the system heating type.

7.6.12 Commercial Refrigeration

Refrigerated Cases

Commercial refrigeration equipment addressed by this section includes the following types:

- Walk-in refrigerators
- Walk-in freezers
- Refrigerated casework and/or display cases

To claim performance credit for refrigerated cases included in the scope of 90.1-2019 Section 6.5.11, baseline energy consumption shall be determined using ASHRAE 90.1-2019 Table G3.10.1 and G3.10.2.

In addition, the refrigerated cases in the proposed design must meet all requirements of ASHRAE 90.1-2019 Section 6.5.11 Refrigeration Systems and be rated according to AHRI 1200.

The modeling inputs used for the baseline shall be based on converting ASHRAE 90.1-2019 Table G3.10.1-2 values into electricity load (Watt or Watt/SF) and schedule inputs. The modeling inputs used for the proposed design shall be based on converting AHRI 1200 rating for the specified equipment into electricity load (Watt or Watt/SF) and schedule inputs.

Per the *Refrigeration Modeling Method* section of the ANSI/ASHRAE/IEC Standard 90.1-2019 Performance Rating Method Reference Manual (2019 PRM RM)[1], two aspects of performance must be accounted for when using the Performance Rating Method:

- Electricity consumption of the refrigeration equipment
- Internal heat gain/removal into the thermal zone for the purposes of HVAC interactivity

Both aspects shall be explicitly captured in the model. The refrigeration system electricity consumption and the HVAC system interactivity should be modeled as two separate values. To

[1] https://www.energycodes.gov/sites/default/files/2023-12/90_1_2019_Appendix_G_PRM_2023.11.pdf

claim credit for commercial refrigeration systems, Partners shall use the Refrigeration Energy Calculator.

AHRI Certificates and Refrigeration Energy Calculator:

- Partners shall gather AHRI 1200 certificates from manufacturers for each refrigeration unit. Each certificate shall mimic the format shown in the AHRI 1200 *Data Format* tab of the Program's Refrigeration Energy Calculator, which is available for download on the Partner Portal.
- Using the Refrigeration Energy Calculator and the AHRI 1200 certificates, Partners shall report each refrigeration unit type as separate columns in the *Ref Data Entry* tab.
- To determine the applicable equipment class geometry (e.g., HZO, SVO, etc.), Partners shall use diagrams of Appendix D of AHRI 1200 for reference.
- The Refrigeration Energy Calculator will automatically calculate baseline kWh/day allowances of each eligible commercial refrigeration unit, which shall be used if measurements were not performed.

Refrigeration Energy Input:

- Refrigeration energy (excluding internal gains/losses) should be modeled as a direct load to the electric meter or assigned to a thermal zone, but with zero sensible and latent heat gains to the space.

HVAC Interactivity Modeling Input

- The Refrigeration Energy Calculator will calculate Q per thermal zone on the Model Inputs tab for the purposes of modeling internal heat gain or removal for each thermal zone to capture HVAC system interactivity.
- Note: Q is the rate of heat removal from the space due to the continuous operation of the refrigeration system (kBtu/h). Q can be positive or negative depending on the condenser location.

Credit for refrigerated cases not regulated by 90.1 may be claimed using exceptional calculation methods and as described in the section below.

Refrigeration Systems Not Regulated by 90.1

As a general rule, refrigeration systems not covered in ASHRAE 90.1-2019 Section 6.5.11 shall be treated as unregulated loads and modeled the same in the baseline and proposed design. The associated energy should be determined based on ANSI/ASHRAE/IEC Standard 90.1-2019 Performance Rating Method Reference Manual or alternative sources as approved by the Program.

Credit for refrigeration systems not regulated by ASHRAE 90.1 may be claimed using Exceptional Calculations (See Section 7.3). Baseline systems and components shall meet or exceed standard practice and be supported by other jurisdictions and/or standards such as USGBC or California Title 24 and as described in Section 7.6.21 of this document. The baseline and exceptional calculations are subject to approval by the Program.

One of the following approaches may be used to simulate unregulated refrigeration systems:

- Model unregulated refrigeration systems using the version of eQuest, EnergyPlus, OpenStudio, or Trane TRACE that support explicit modeling of such systems and their interactions with other building systems and components such as space heating and cooling systems.
- Provide supporting spreadsheet calculations that determine baseline and proposed electricity consumption of refrigeration equipment and internal heat/gain removal into the thermal zone for the purposes of HVAC interactivity. Refrigeration energy (excluding internal gains/losses) should be modeled as a direct load to the electric meter or assigned to a thermal zone. Internal heat gain or removal for each thermal zone shall be modeled to capture HVAC system interactivity.

The following energy modeling guidelines may be used to establish unregulated refrigeration system baseline assumptions for components outside the scope of ASHRAE 90.1-2019: https://www.gcca.org/sites/default/files/protected-docs/protdocs/EnergyGuidelines_2013-12-19.pdf

7.6.13 Distribution Transformers

ASHRAE 90.1-2019, Section 8 includes low voltage dry-type distribution transformers. Distribution transformers can be included as an EEM if the proposed building transformers exceed the efficiency requirements of Table 8.4.4 and meet the characteristics below.

Measure Requirements

A low voltage distribution transformer has the following characteristics:

- Air-cooled,
- Does not use oil as a coolant,
- Has an input voltage ≤ 600 V, and
- Is rated for operation at a frequency of 60 Hz

Key Model Inputs

All inputs should be included for the baseline and proposed design:

- Transformer Capacity (kVA)
- Transformer Efficiency (%)
- Ratio of capacity to peak electrical load

7.6.14 Infiltration

Infiltration shall be modeled using the same methodology and adjustments for weather and building operation in both the baseline and proposed designs. ASHRAE 90.1-2019 Appendix G includes explicit requirements to model infiltration. Below is an example of how to determine infiltration rates using the variables presented in Appendix G for the baseline and proposed models.

Number of stories = 5
Gross floor area = 40,000 SqFt
Gross roof = 8,000 SqFt
Slab on grade floor area = 8,000 SqFt
Total above grade wall area = 17,000 SqFt
Total conditioned volume = 360,000 ft^3

S = 8,000 SqFt + 8,000 SqFt + 17,000 SqFt = 33,000 SqFt I_{75PA} = 0.6 CFM/SqFt in the proposed design and 1.0 CFM/SqFt in the baseline per Table G3.1#5b.

Baseline

I_{FLR} = 0.112 x 1.0 CFM/SqFt x 33,000 SqFt / 40,000 SqFt = 0.0924 CFM/SqFt

I_{AGW} = 0.112 x 1.0 CFM/SqFt x 33,000 SqFt / 17,000 SqFt = 0.217 CFM/SqFt

CFM = 0.112 x 1.0 CFM/SqFt x 33,000 SqFt = 3,696 CFM

ACH = 3,696 CFM x 60 min/hr / 360,000 ft^3 = 0.616 ACH

Proposed

I_{FLR} = 0.112 x 0.6 CFM/SqFt x 33,000 SqFt / 40,000 SqFt = 0.055 CFM/SqFt

I_{AGW} = 0.112 x 0.6 CFM/SqFt x 33,000 SqFt / 17,000 SqFt = 0.130 CFM/SqFt

CFM = 0.112 x 0.6 CFM/SqFt x 33,000 SqFt = 2,218 CFM

ACH = 2,218 CFM x 60 min/hr / 360,000 ft^3 = 0.370 ACH

Infiltration rates must be modeled as 0.6 cfm/ft at a fixed building pressure differential of 0.3 in. of water (I_{75Pa}) except when whole-building air leakage testing, in accordance with ASTM E779, is specified during design and completed after construction. In this case, the proposed design air leakage rate of the building envelope shall be as measured and included in the As-Built energy model.

In residential occupancies including hotels, motels and dormitories, infiltration shall be modeled at 100% of the calculated rate (hourly fraction of 1) during all hours. In non-residential spaces, infiltration shall be modeled at 100% (hourly fraction of 1) during unoccupied hours, and at 25% (hourly fraction of 25%) during occupied hours (PNNL Performance Rating Method Reference Manual Section 3.3.5)

7.6.15 Ventilation

Proposed and Baseline Ventilation Rates

Proposed outdoor air ventilation rates shall be consistent with mechanical system design documents. Baseline outdoor air ventilation rates shall be equal to the proposed design, or the rates prescribed by ASHRAE 62.1-2019, whichever is less. Local ventilation codes, if applicable, shall be used in lieu of ASHRAE 62.1-2019 to determine baseline ventilation rates. For laboratory spaces that are prohibited from recirculating return air by code or accreditation standards, the baseline system shall be modeled as 100% outdoor air. The baseline exhaust air energy recovery shall be modeled following G3.1.2.10.

Following 90.1 2019 Addendum i[1], HVAC systems serving laboratory HVAC zones with a total laboratory exhaust volume greater than 15,000 cfm should **not** be modeled with exhaust air energy recovery in the baseline. Prior to the addendum, a proposed laboratory design with variable flow exhaust and energy recovery would be required to model both heat recovery and variable exhaust in the baseline HVAC system, which misrepresents 90.1-2004 requirements.

Performance Credit for Ventilation Design

Performance credit for ventilation design is permitted under the following scenarios:

- Modeling demand-controlled ventilation in the proposed design for systems with outdoor air flow rate less than or equal to 3,000 CFM serving areas with an average occupancy density of 100 people per 1,000 SqFt or less.
- When designing systems in accordance with Standard 62.1, Section 6.2, "Ventilation Rate

[1] ASHRAE 90.1 2019 Addendum I
https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_i_20201030.pdf

Procedure." The baseline zone air distribution effectiveness (E_z) shall be equal to 1.0. Calculations must be provided to take credit for ventilation rate reductions.

Performance Credit for Parking Garage Demand Control Ventilation

The following parameters shall be used to establish the parking garage DCV baseline energy consumption:

- Ventilation rate shall be equal to 0.75 OA CFM/SqFt per ASHRAE 62.1.
- Fan power shall be modeled as 0.3 W/CFM or 0.225 W/SqFt.
- Baseline OA fraction (% OA) shall be equal to 50% when the proposed case OA fraction is less than or equal to 50%.
- Baseline OA fraction shall be equal to 100% when the proposed case OA fraction is greater than 50%.

The following conditions shall be met to claim parking garage DCV as an energy efficiency measure:

- Proposed case ventilation rate and fan power shall be modeled per design.
- Ventilation rates shall meet ASHRAE 62.1 requirements.
- Proposed case ventilation shall be able to maintain at least 0.05 CFM/SqFt at all times.
- Proposed turn-down ratio shall be explicitly modeled.
- Fan performance curves shall be used to determine fan power at part-load ratios.
- Parking garage ventilation profiles shall be provided to justify flow rates and OA fractions.

7.6.16 Elevators

Elevators are a regulated load in ASHRAE 90.1-2019 and have mandatory requirements. The baseline and proposed conditions are incorporated in the 90.1 Compliance Form.

7.6.17 ENERGY STAR Appliances

Performance credit for ENERGY STAR appliances such as refrigerators, clothes washers, clothes dryers, and dishwashers may be claimed. The New Jersey Technical Reference Manual (TRM) can be used to estimate energy savings.

7.6.18 Data Centers

The following energy modeling guidelines may be used to establish unregulated data center IT equipment load assumptions. These guidelines may only be used for unregulated components outside the scope of ASHRAE 90.1-2019:

http://www.calmac.org/publications/2016_PG%26E_Data_Center_Baseline_and_M%26V_Guidelines.pdf

7.6.19 Receptacle Controls

Automatic receptacle controls, such as controls on 15- and 20-amp receptacles in private offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, classrooms, and individual workstations, may be modeled as a measure. The following types of control qualify:

- A scheduled basis using a time-of-day operated control device that turns receptacles off at specific programmed times with an independent program schedule controlling areas of no more than 5000 ft^2 and not more than one floor
- An occupant sensor that turn receptacles off within 20 minutes of all occupants leaving a space, or
- An automated signal from another control or alarm system that turn receptacles off within 20 minutes after determining that the area is unoccupied.

The savings shall be modeled using the methodology and rules in ASHRAE 90.1 2019 Table G3.1 #12 by reducing the hourly receptacle schedule in the proposed design relative to the baseline as follows:

$$RPC = RC \times 10\%$$

Where:

- RPC = Receptacle power credit
- $EPS_{pro} = EPS_{bas} \times (1 - RPC)$
- RC = Percentage of controlled receptacles
- EPS_{bas} = Baseline *equipment* power hourly schedule (fraction)
- EPS_{pro} = Proposed *equipment* power hourly schedule (fraction)

7.6.20 Other Systems Regulated by ASHRAE Standard 90.1-2019

This may include parking garage ventilation; freeze protection and snow/ice melting systems; exhaust air energy recovery for service water heating; kitchen hoods; laboratory fume hoods; swimming pools; all building power distribution systems; exit signs; parking garage lighting; exterior lighting power; and permanently wired electric motors. For all systems regulated by ASHRAE Standard 90.1-2019, the proposed model must reflect actual specified systems. The baseline for projects following Appendix G path must be based on Appendix G. Systems introduced in ASHRAE 90.1-2019 that do not have explicit baseline requirements may be eligible for incentives if their performance exceeds ASHRAE 90.1-2019 requirements.

7.6.21 Other Systems Not Regulated by ASHRAE Standard 90.1-2019

In order to claim performance credit for systems and equipment not regulated by 90.1-2019 or this document, including but not limited to improvements to industrial systems, the baseline shall be established based on one of the following:

- Current requirements of other codes and jurisdictions, such as California Title 24.
- Baseline established by national programs for high performance buildings, such as LEED NC
- Standard practice for new buildings of a similar type and size

In all cases, the baseline and savings calculation methodology are subject to the Program approval

7.6.22 On-Site Renewable Energy

Refer to Program Guide Section 3.1.3

7.6.23 Controlled Environment Horticulture Facilities

Prior to initiating projects, Partners shall discuss project scopes and modeling approach with the Program. ASHRAE 90.1-2019 Appendix G and these Simulation Guidelines shall be followed with the following modifications:

- The following building area type shall be added to Table 4.2.1.1 Building Performance Factors:

Building Area Type	Climate Zone															
	0A and 1A	0B and 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Controlled environmental horticulture	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

- The following requirements shall be added to Section G3.1.1 Baseline HVAC System Type and Description

  For Controlled Environmental Horticulture buildings, use system types 3 or 4. For thermal zones classified as Controlled Environmental Horticulture, portable dehumidification systems shall be modeled in accordance with Table G3.5.7. Portable dehumidification shall not be modeled for any other zone such as office or retail space.

- The first sentence of Section G3.1.2.1 Equipment Efficiencies shall be replaced with:

All HVAC equipment in the baseline building design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with Tables G3.5.1 through G3.5.7[1]*.*

- The following exception shall be added to the Baseline Building Performance column of Table G3.1 5. Building Envelope bullet b (Opaque Assemblies).

  Exception: For controlled environmental horticulture spaces, opaque assemblies used for new buildings, existing buildings, or additions shall match the appropriate maximum U-factors in Tables 5.5-1 through 5.5-8.

- The following exception shall be added to the Baseline Building Performance column of Table G3.1 5. Building Envelope bullet c (Vertical Fenestration Areas).

  Exception: For controlled environmental horticulture spaces, vertical fenestration area for new buildings and additions shall equal that in the proposed design and shall be distributed on each face of the building in the same proportions as the proposed building.

- The following exceptions shall be added to the Baseline Building Performance column of Table G3.1 5. Building Envelope bullet d (Vertical Fenestration Assemblies).

  Exceptions: For indoor growing spaces, fenestration U-factors shall match the appropriate requirements in Tables 5.5-1 through 5.5-8 for U_{all}. For greenhouses, the fenestration U-factor shall be modeled as U-0.7.

- For controlled environmental horticulture spaces, fenestration SHGCs shall match the appropriate requirements in Tables 5.5-1 through 5.5-8 for the SHGCall.

- The following exceptions shall be added to the Baseline Building Performance column of Table G3.1 5. Building Envelope bullet e (Skylights and Glazed Smoke Vents).

[1] For proposed systems rated in terms of ISMRE or ISCOP that exceed ASHRAE 90.1-2019 Table 6.8.1-13 requirements, baseline efficiency in Tables G3.5.1 and G3.5.2 may be derated using the program-approved methodology.

Exception: For controlled environmental horticulture spaces, skylight and non-opaque roof U-factor and SHGCs shall match the appropriate requirements in Tables 5.5-1 through 5.5-8.

- The following exceptions shall be added to the Baseline Building Performance column of Table G3.1 6. Lighting

  Exception: For controlled environmental horticulture spaces, lighting controls shall comply with the requirements of Table 9.6.1.

- For controlled environmental horticulture spaces, exterior lighting in areas identified as "Tradable Surfaces" in Table G3.6 shall be modeled with the baseline lighting power shown in Table 9.4.2-2. Other exterior lighting shall be modeled the same in the baseline building design as in the proposed design.

- The following exception shall be added to Section G3.1.2.6 Economizers:

  Exception: For controlled environmental horticulture buildings, air economizers shall not be included in the baseline.

- The following system types shall be added to Table G.3.1.1-2 Baseline Service Water-Heating System:

***Building* Area Type**	**Baseline Heating Method**
Controlled environmental horticulture	Gas storage *water heater*

- Table G3.5.7 *Performance Rating Method* Portable Dehumidification Systems shall be added[1]:

[1] Projects shall use the program-approved CEH latent load calculation methodology and tool to estimate latent load. Projects shall use the program-approved modeling methodology to account for dehumidification energy consumption and latent loads in the model.

Equipment Type	Size Category	Minimum *Efficiency*	Test Procedure
Portable dehumidifier	*≤ 25 pints per day*	1.3 L/kWh	10 CFR 30
Portable dehumidifier	*> 25 and ≤ 50 pints per day*	1.6 L/kWh	10 CFR 30
Portable dehumidifier	*> 50 pints per day*	2.8 L/kWh	10 CFR 30

- The following common space types shall be added to Table G3.7 *Performance Rating Method Lighting Power Density Allowances and Occupancy Sensor Reductions Using the Space-by-Space Method*[1].

Common *Space* Types[a]	*Lighting Power Density*, W/ft²	*Occupancy Sensor* Reduction[b]
Greenhouse[4]	Proposed PPE ÷ 1.7 x Proposed W/ft²	None
Indoor Growing[5] ≥ 40 kW connected lighting load	Proposed PPE ÷ 1.9 x Proposed W/ft²	None
Indoor Growing[6] < 40 kW connected lighting load	Proposed PPE ÷ 1.7 x Proposed W/ft²	None

[1] Per ASHRAE 90.1-2022 Section 9.4.4.1, luminaires in greenhouse buildings with at least 40 kW of connected load for horticultural lighting shall have a photosynthetic photon efficacy (PPE) of at least 1.7 µmol/J for integrated, non-serviceable luminaires, or a PPE of at least 1.7 µmol/J for lamps in luminaires with removable or serviceable lamps.

Per ASHRAE 90.1-2022 Section 9.4.4.2, for connected lighting loads ≥ 40 kW, luminaires in indoor grow spaces used for horticultural lighting shall have a PPE of at least 1.9 µmol/J for integrated, non-serviceable luminaires, or a PPE of at least 1.9 µmol/J for lamps in luminaires with removable or serviceable lamps. Horticultural lighting in indoor grow spaces shall be controlled by a device that automatically turns off the horticultural lighting at specific programmed times.

Per the Exception of ASHRAE 90.1-2022 Section 9.4.4.2, indoor grow buildings with less than 40 kW of connected load for horticultural lighting shall have a PPE of at least 1.7 µmol/J for integrated, non-serviceable luminaires, or a PPE of at least 1.7 µmol/J for lamps in luminaires with removable or serviceable lamps.

7.7 Energy Conversions in BASIC Workbook

Table 7-3. Energy Conversions

Energy Source	Units	Site Energy kBtu/Unit
Electricity	kWh	3.412
Natural Gas	CCF	102.9
Natural Gas	Therm	100
Propane	Gallon	92
Fuel Oil	Gallon	138

7.8 Documenting Model Inputs

Baseline and proposed model inputs shall be documented in the Compliance Form.

Measure descriptions in the BASIC Workbook shall include proposed equipment details that include, but are not limited to, the following: equipment location, model numbers (where available), equipment capacity/size, equipment efficiency, and any other pertinent information.

Example: DHW: Install Direct-fired Boiler

<u>Description of Energy Efficiency Recommendation</u>

- One central DHW natural gas heater located on the 1st floor;
- 500,000 Btu/hr.
- Storage Tank: 350 gallons
- Thermal Efficiency: 93%
- Energy Factor: 0.89
- Proposed storage tanks have R-12.5 insulation and temperature set point of 120ºF

Additional schedules may be submitted as attachments for measures involving multiple pieces of equipment. For any lighting measures, descriptions must include a schedule of the proposed lighting including fixture types by space, as shown on lighting plans for the project. HVAC measure descriptions should include system type, size, manufacturer/model (if available) and efficiency in the appropriate units.

7.8.1 Modeling File Submittal

Table 7-4 lists modeling files and/or reports that must be submitted as an Appendix with the BASIC Workbook. Reports should be organized in a manner that clearly identifies which reports are for the baseline or proposed design, and which are for each energy efficiency measure. Appendix shall minimally include the files and reports listed below, with reports in the following formats:

- eQuest users shall submit reports using "*.sim" formats.
- DOE-2 users shall submit reports using "*.pdf" or "*.doc" formats.
- TRACE users and other approved software package users shall submit reports in data "*.pdf" format.

Additional files and/or reports may be requested by Program:

Table 7-4. Modeling Documents for Submittal

Software	Modeling Files	Key Output Report (for baseline and each EEM)
DOE-2 (including eQuest)	*.pd2,*.inp, *.prd *(eQuest only)*	Building Energy Performance Summary (BEPS) Building Energy Performance–Utility (BEPU) Energy Cost Summary (ES-D) Summary portion of LV-D report SV-A report PS-C report PS-E report
TRACE	*.TAF	Project Information Energy Cost Budget/ PRM Energy Consumption Summary Monthly Energy Consumption Monthly Equipment Energy Consumption Entered Values Plants Entered Values Systems System Checksums Monthly Utility Costs

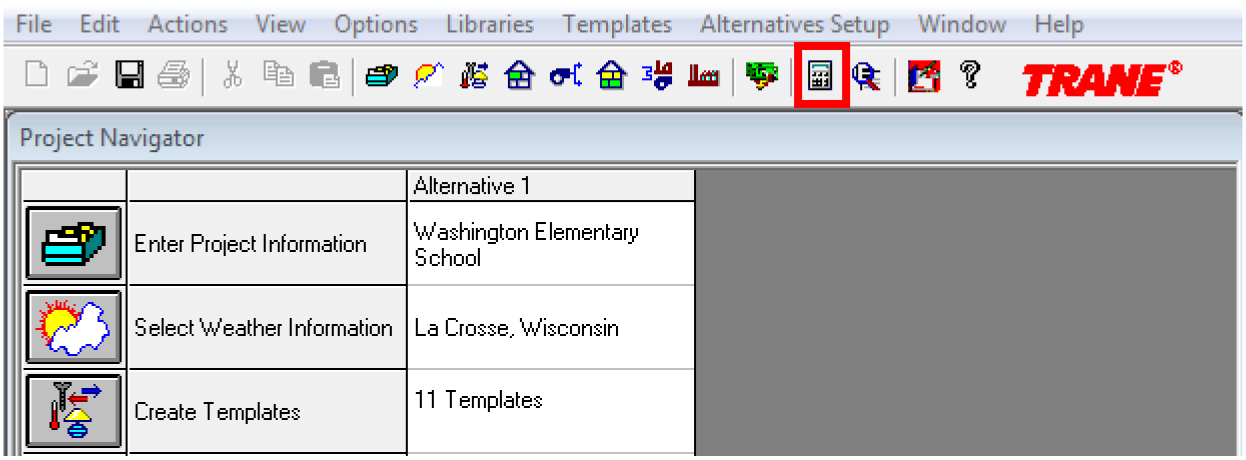
Software	Modeling Files	Key Output Report (for baseline and each EEM)
HAP	HAP file	EA Credit 1 Summary Annual Cost Summary Energy Cost Budget by System Component Zone Temperature Report and Unmet Report (for systems and plants) Monthly Energy Use by Component Monthly Air and System and Plant Simulation Results Air Systems Input Data Boilers Input Data Chilled Water Input Data Chiller Input Data Space Input Data
EnergyPlus	*.idf file for each simulation run	Annual Building Utility Performance Summary LEED Summary METERS.csv Input Verification and Results Summary Demand End Use Components Summary Source Energy End Use Components Summary Climatic Data Summary Equipment Summary Envelope Summary Surface Shadowing Summary Shading Summary Lighting Summary HVAC Sizing Summary System Summary Component Sizing Summary Outside Air Summary Object Count Summary
IES	n/a	General Information Space Summary Advisory Messages Comparison of proposed vs. baseline design energy model inputs Energy Type Summary Exceptional Calculation Measure Summary Performance rating Method Compliance Report
Other		Consult with Program

7.9 BASIC Workbook Hourly Reports Instructions

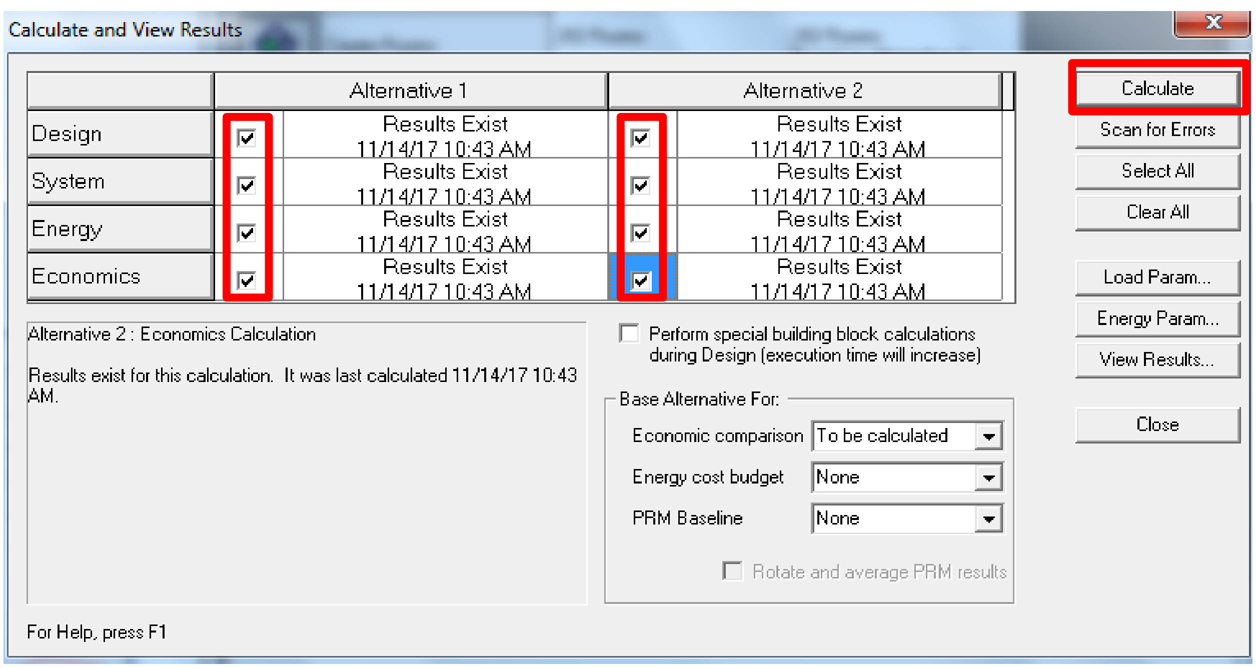
Below instructions are for generating information required for the BASIC Workbook, ‘Hourly Input’ tab, which is required to calculate peak KW savings.

7.9.1 Trace

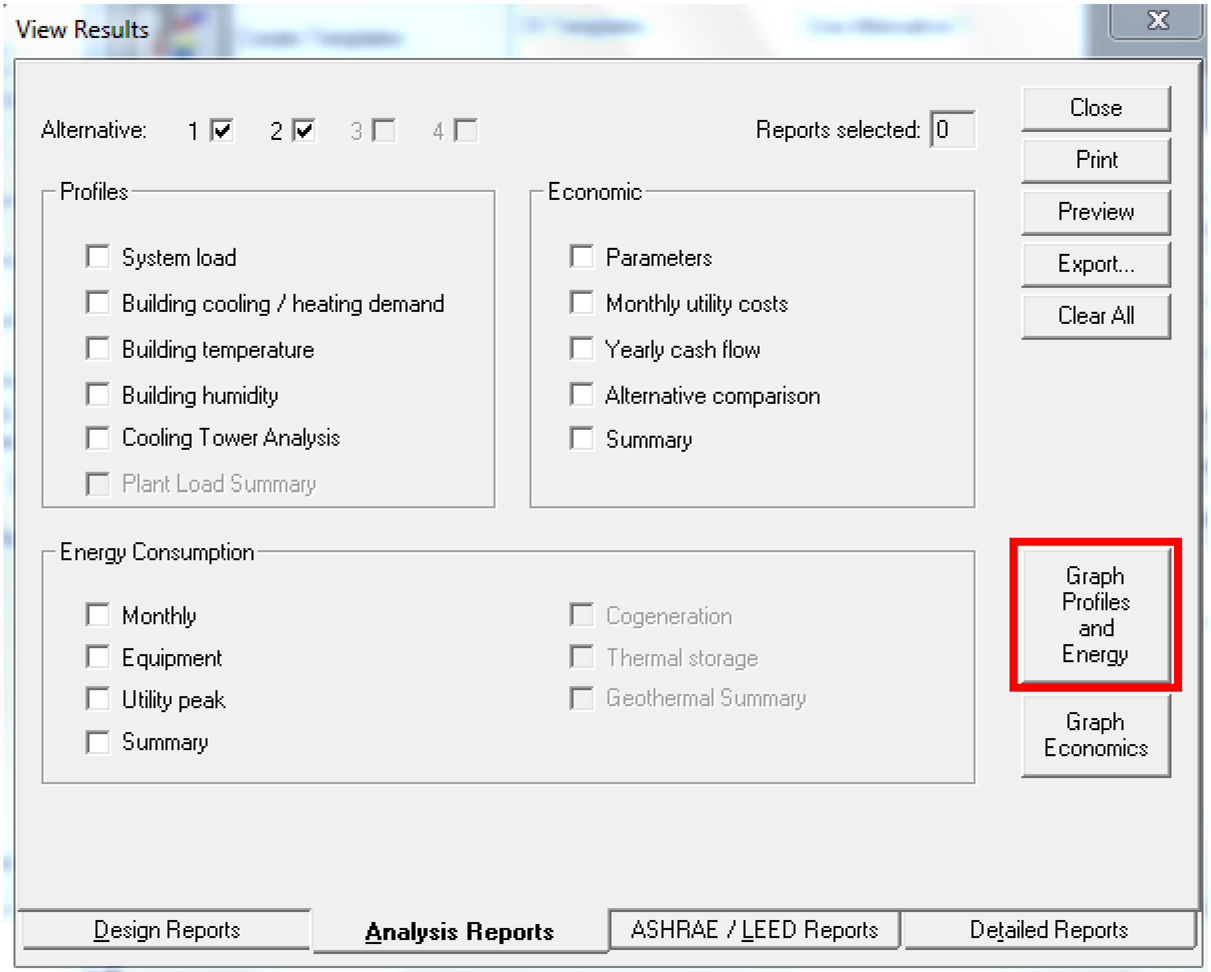
1. Open Trace model.
2. Click the calculate button to generate results.



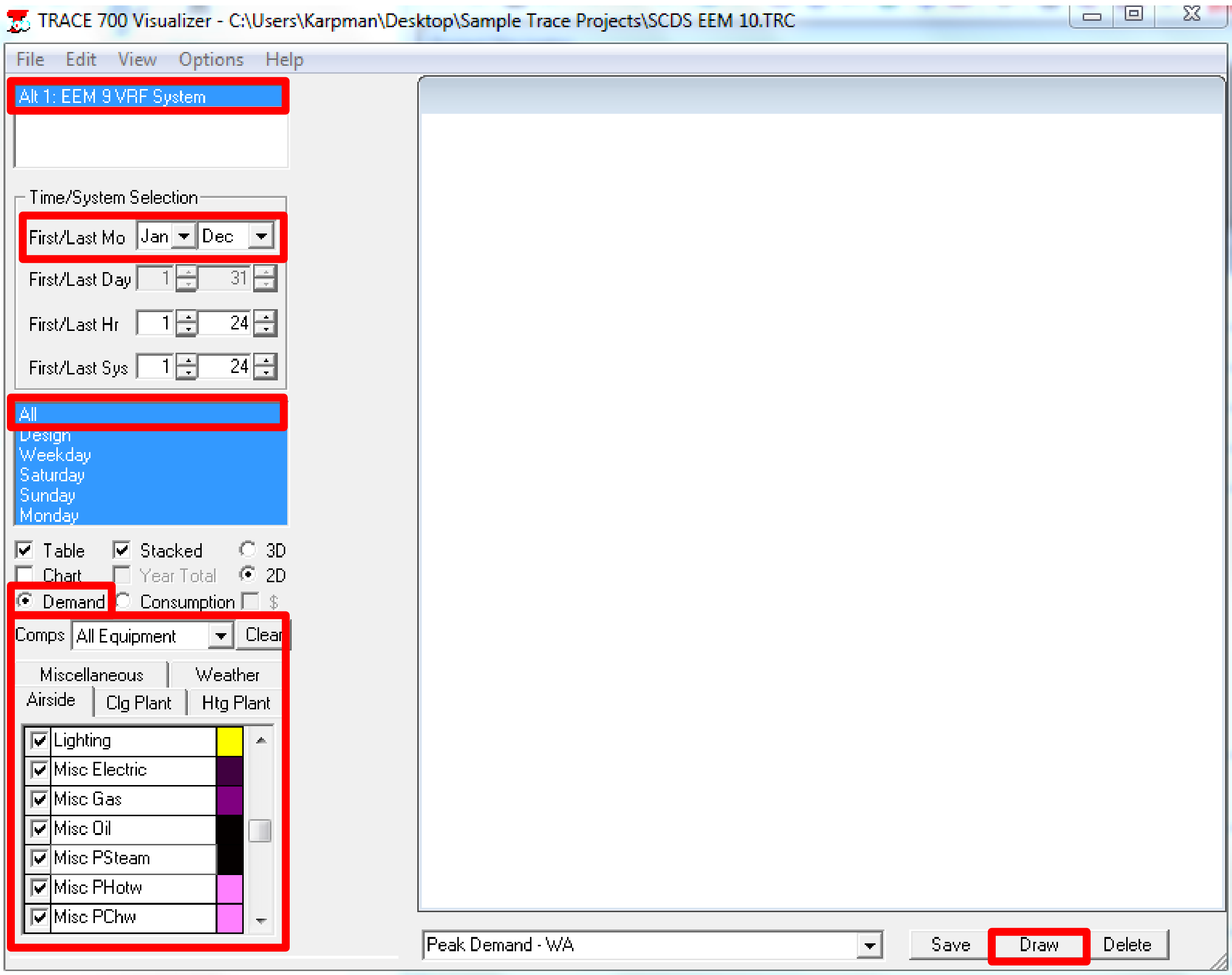
3. Select all applicable alternative check boxes and select “Calculate”.



4. Once the calculation is complete, on the same screen click “View results” on the right. This will bring you to the View Results Screen, below, where you can select the “Graph Profiles and Energy” button.



5. This will bring you to the visualizer. Select the appropriate Alternative, the months to *Jan/Dec*, *All Days*, and *Demand* (as seen below). In the bottom most section, select all reports on all the *Misc, Weather, Airside, Clg plant,* and *Htg plant* tabs (make sure to scroll on some tabs to select all check boxes). Click "Draw" on the bottom of the screen to create the .csv file.



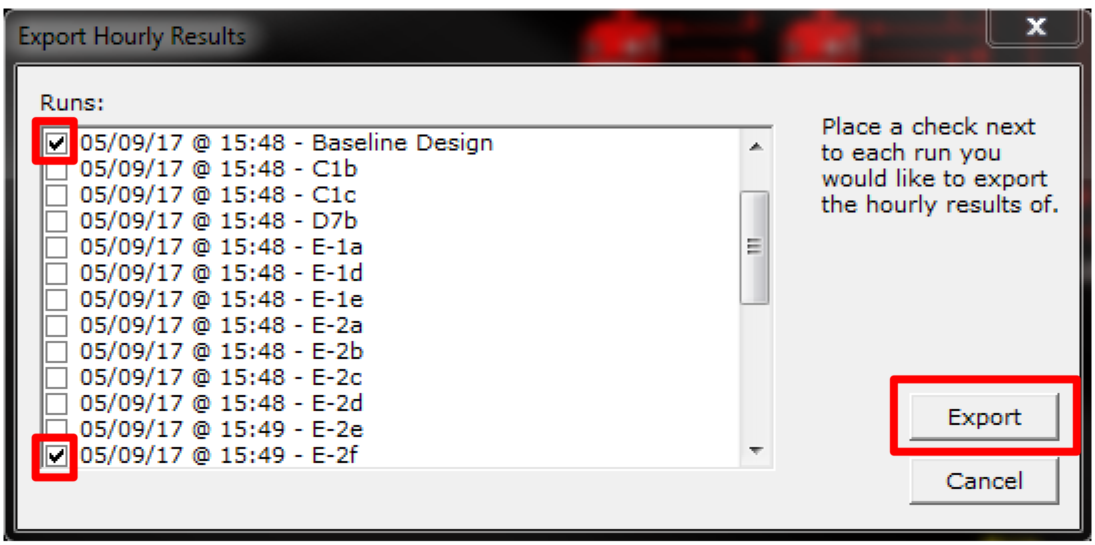
6. Open the folder that contains the project files and open the 'profiles.csv' file. *Note that if this file is open while "drawing", Trace crashes.* Please copy and paste values of the appropriate results into the cells of the BASIC Workbook, 'Hourly Input' tab for both the baseline and proposed results. Please paste each end uses results in the predetermined column in the 'Hourly Input' tab.
7. Once this has been completed, the results can be seen populated on the "High-Performance Pathway" tab.

7.9.2 eQuest

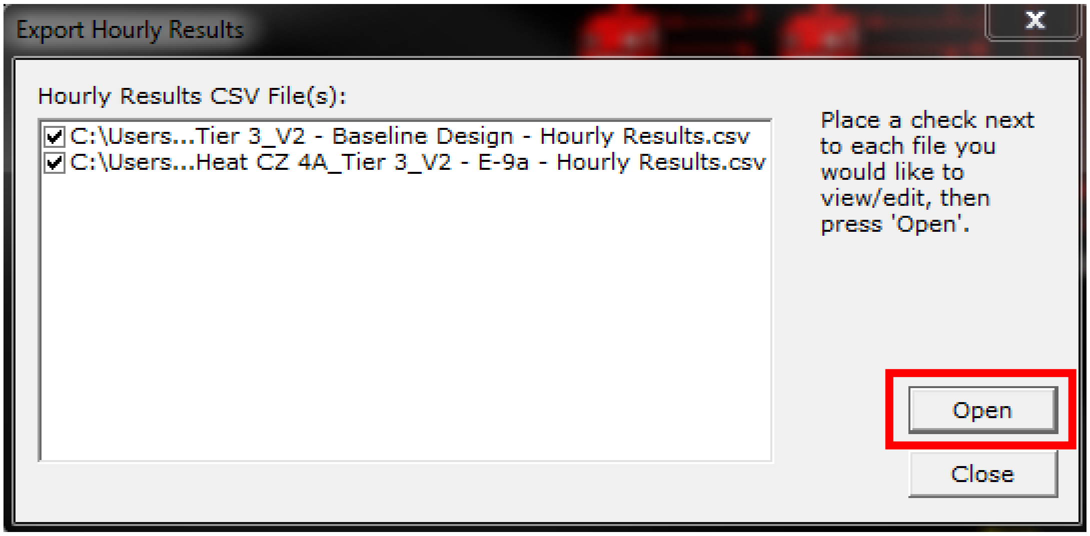
1. Open eQuest model.
2. Simulate all parametric runs in the model to generate results by clicking the 'Perform Simulation' button.

3. After all parametric runs are simulated, click File > Export File > Hourly Results (CSV). An 'Export Hourly Results' dialogue box will appear. Check the Baseline and Proposed (final model) runs and click "Export".

   Please note: If you have two separate models for the Baseline and Proposed, this will need to be done in both model files, once in the Baseline model, and once in the Proposed model.

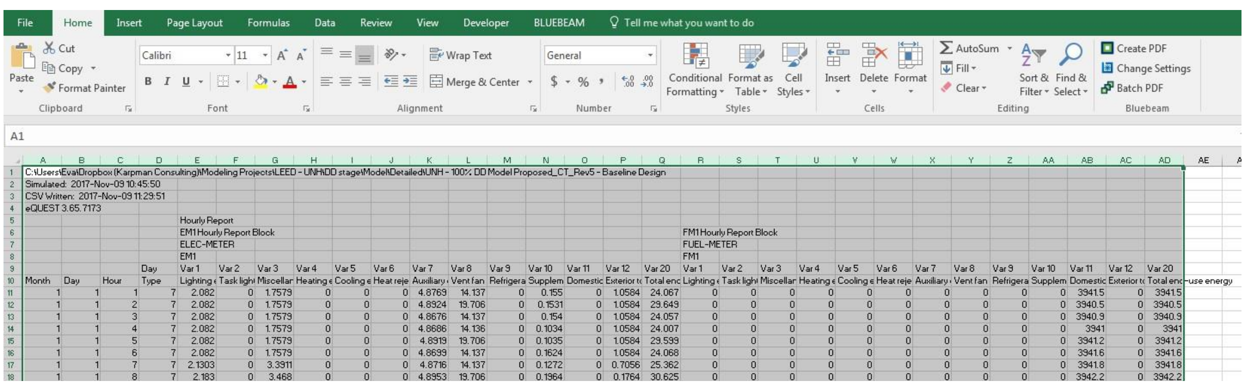


4. Click “Open” in the next screen to open the Excel based Hourly Results.



5. Once the Excel CSV file is open, notice that there are hourly results in columns A:AD. Select all of these columns by clicking the column A heading and dragging the selection to AD, and copy the entire section (CTRL+C).

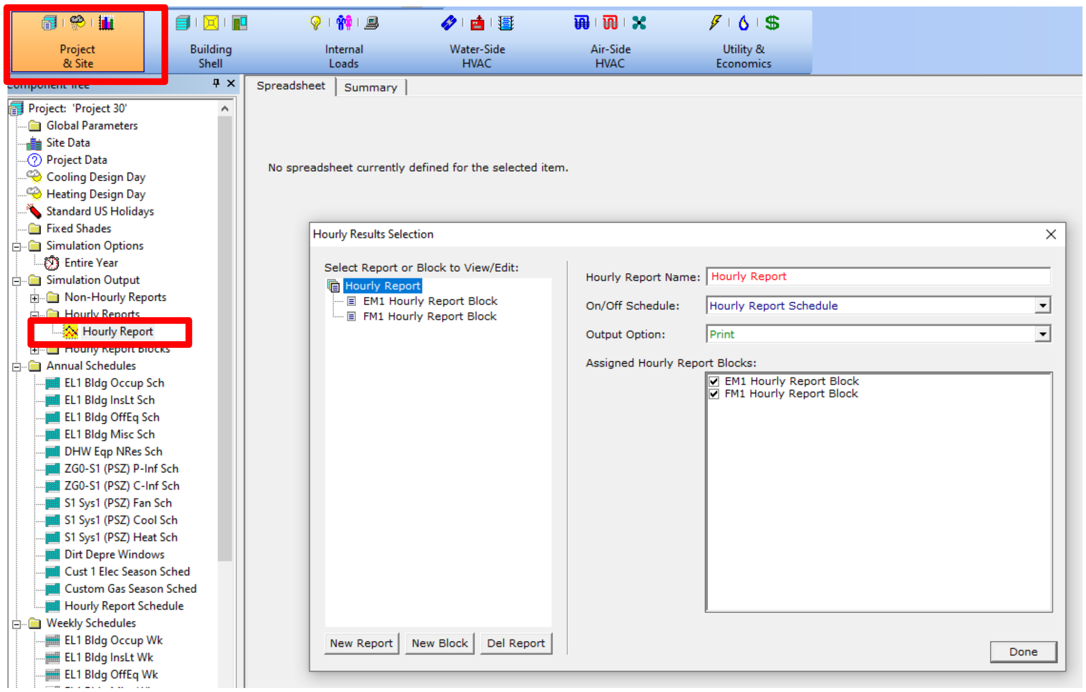
   Please note: If the hourly report(s) generated does not look like the one in the screenshot below it may because the default hourly reports were deleted or modified in eQuest. See next section below for how to restore them.



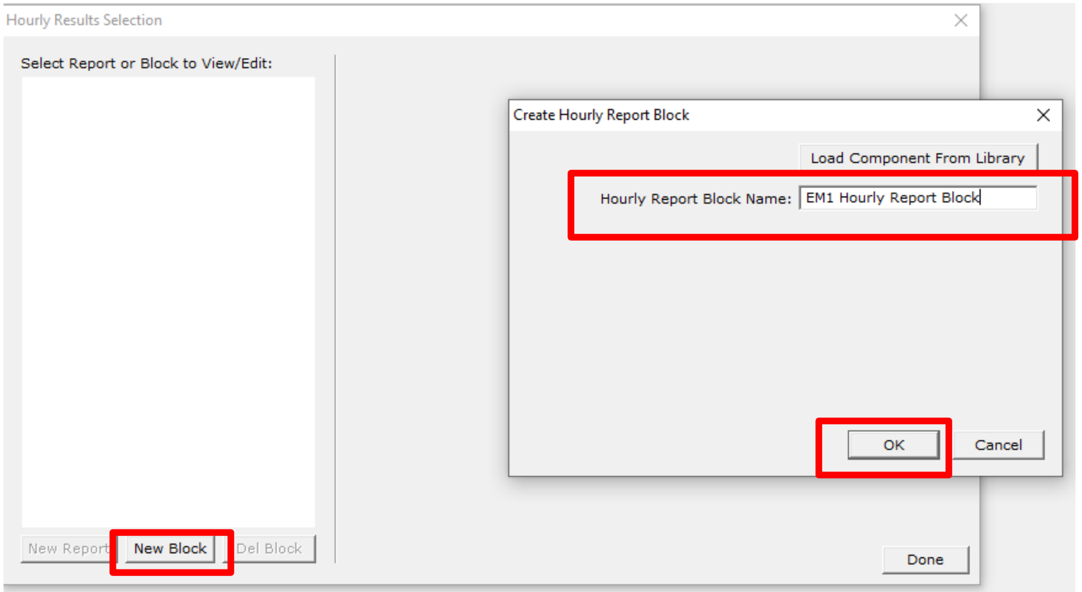
6. The copied selection should then be pasted into the appropriate section of the BASIC Workbook ‘Hrly eQuest Results’ tab. If these are Baseline results, select column ‘A’ in the ‘Hrly eQuest Results’ tab, right click and select Paste Values. If these are Proposed results, do the same in column ‘AF’.
7. Once this has been completed, the results can be seen populated on the ““High-Performance Pathway” tab.

Modifying Hourly Reports in eQuest

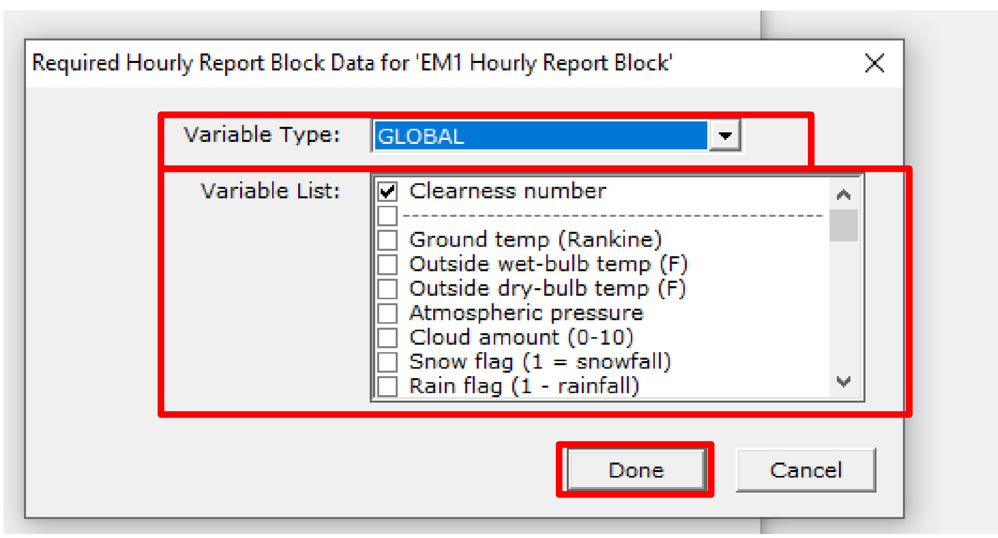
1. In *Detailed Data Edit* mode go the “Project & Site” tab and double click on “Hourly Report” in the component tree as shown below. The default setup is shown below. Follow the remaining instructions to set up your hourly reports the same as the default.



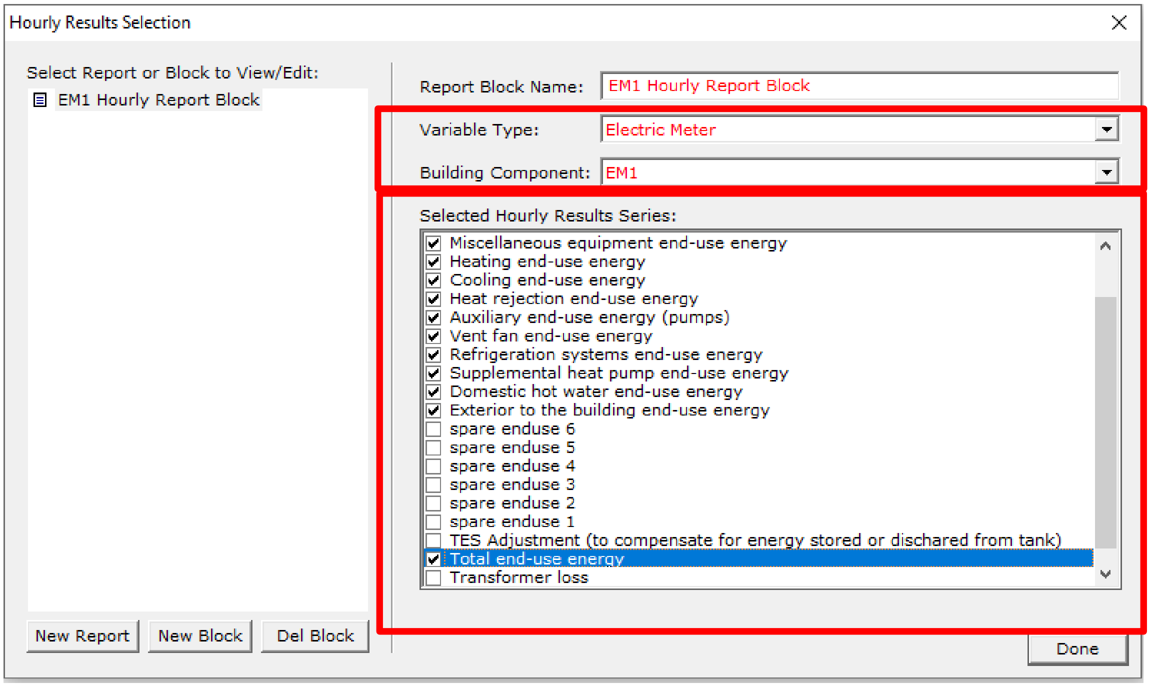
2. Begin by clicking on “New Block” and enter the following name “EM1 Hourly Report Block”. The click “Ok”.



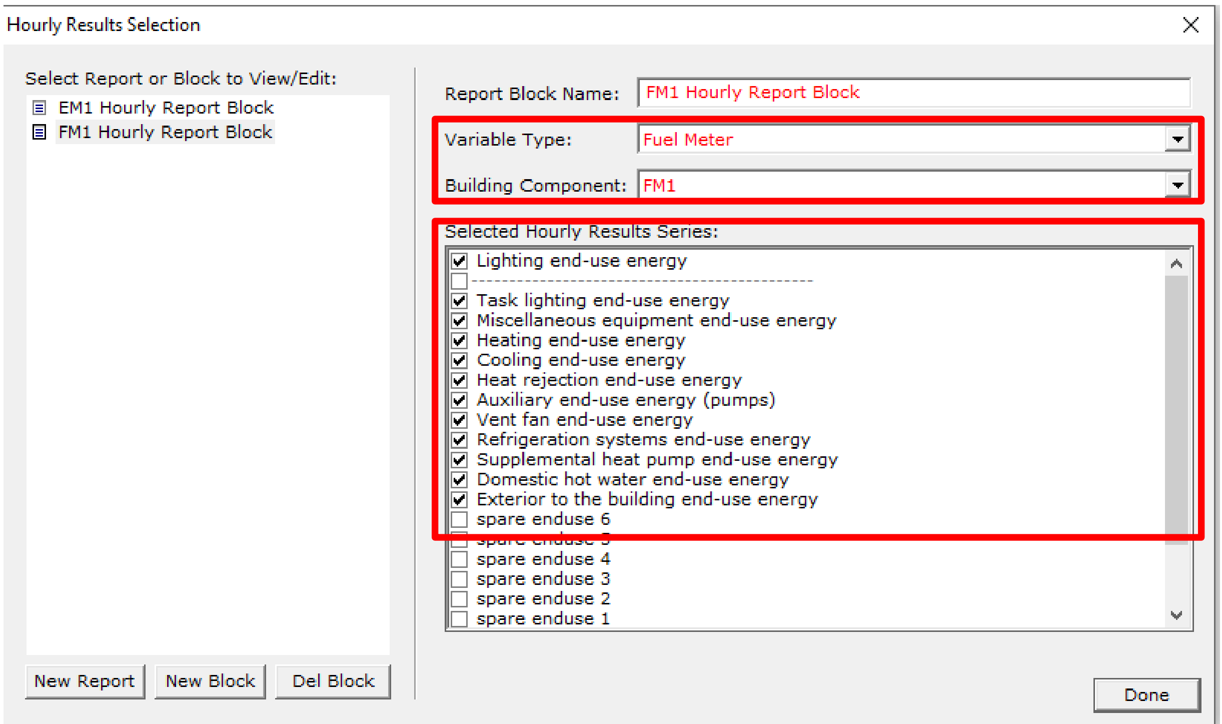
3. In the next dialogue box make the selections shown below (it does not matter what is selected here as it will be changed subsequently). Then click “Done”.



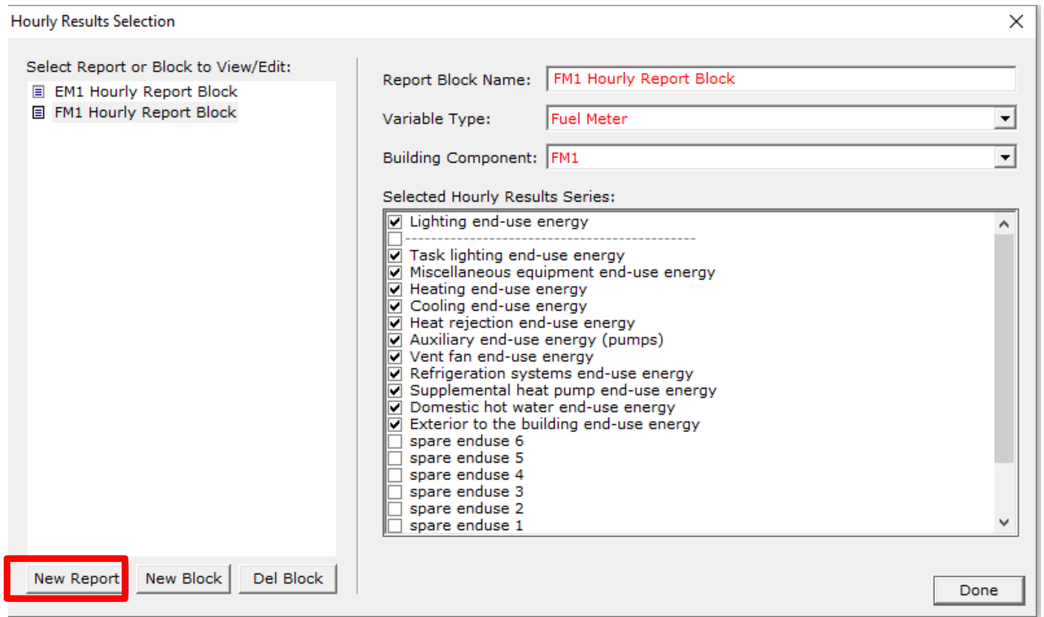
4. Make the selections shown below. Select all items with "…end-use energy" at the end of the name, as well as "Total end-use energy."



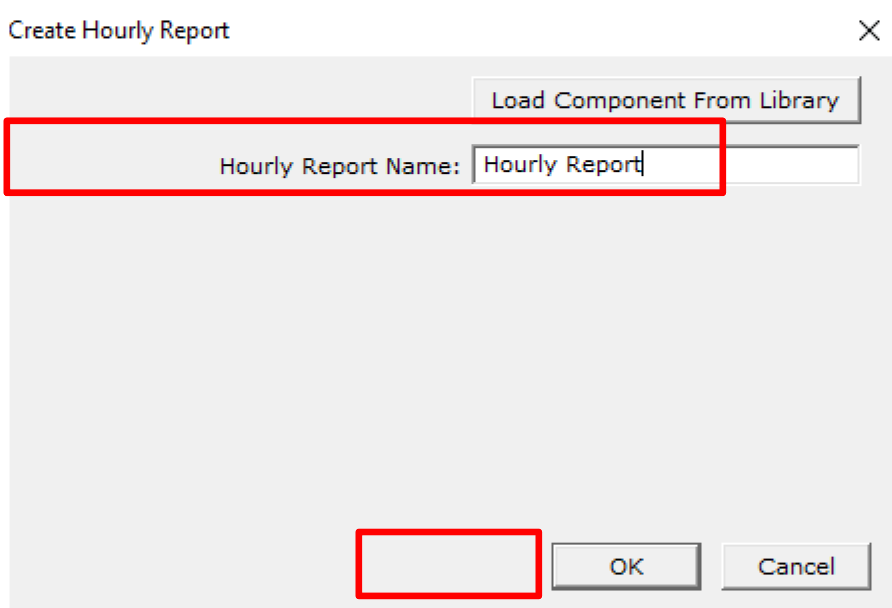
5. Follow the same process and create a block called “FM1 Hourly Report Block” and make the selections shown below once the block is created following steps 2-3 (i.e. select all items with “…end-use energy” at the end, as well as “Total end-use energy”.)



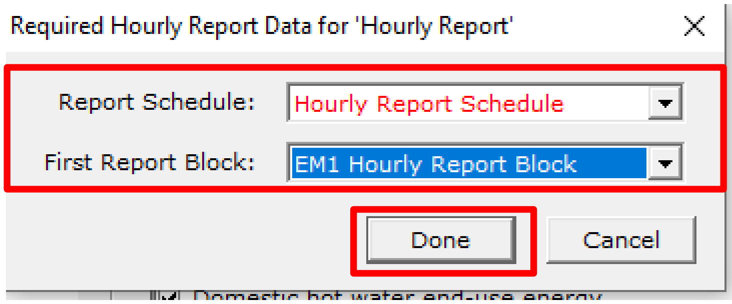
6. Click “New Report”.



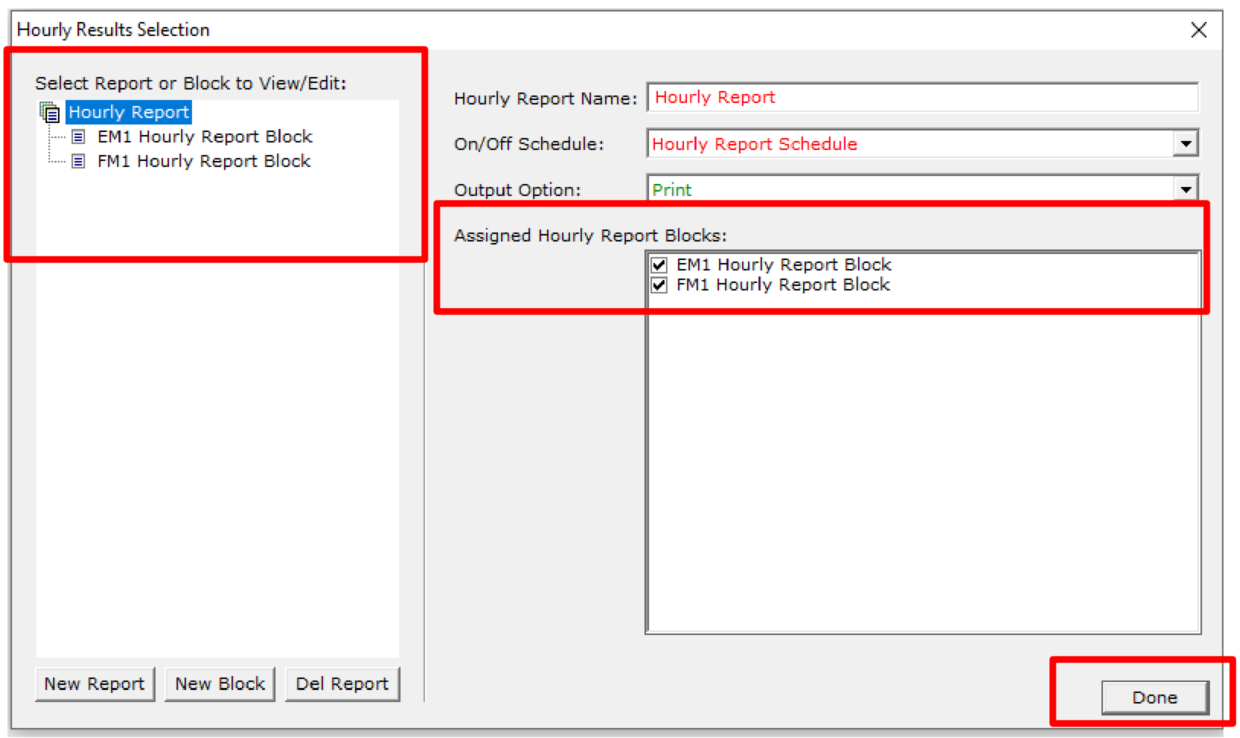
7. Enter the name “Hourly Report” and click “Ok”.



8. Select as shown below and click “Done”.



9. Click on “Hourly Report” on the left and ensure that both “EM1 Hourly Report Block” and “FM1 Hourly Report Block” are clicked in the “Assigned Hourly Report Blocks” section. Also make sure that “Hourly Report” is the first report in the list on the left. Click “Done” and follow the main instructions for eQuest above.



8 As-Built Submission

8.1 Overview

After construction, the As-Built submission will incorporate any changes that occurred during construction from what was originally approved in the proposed submission.

8.2 Incorporating Changes

The Program recognizes that changes to the scope of work may occur during construction. The As-Built submission must verify that the equipment specified and approved by the Program was installed, and identify any deviations in equipment, systems, and/or operating schedules.

Projects in the Streamlined and High Performance Pathway that leverage modeling for energy savings estimation must update the model, as appropriate, to incorporate these changes and obtain revised energy savings estimates. Components in the As-Built model must reflect the actual building components, as verified or measured during inspections. At the completion of the project, these same guidelines can be used to calculate the performance of the As-Built model.

For each measure with significant changes, the As-Built submission must include:

1. Actual equipment specifications and operating conditions
2. Method followed to update building model, or justification that energy savings were not significantly affected
3. As-built energy savings

Changes to the scope of work that deviate from the approved scope in regard to measures installed and square footage will be handled per Table 8-1 below. The project, after changes, must still meet all Program requirements.

Table 8-1. As-Built Project Changes and Incentive Payment Impacts

	Decrease	Increase
As-Built Scope of Work	If the as-built scope of work is reduced (e.g. measure is removed, scaled back, or installed so that it no longer qualifies, etc.), then the As-Built BASIC Workbook must be adjusted accordingly. The final incentive will be reduced based on the As-Built savings.	If the as-built scope of work is increased (e.g. measures added, expanded, etc.), then the As-Built BASIC Workbook must be adjusted accordingly and the final incentive will be increased by no more than 5%, subject to budget availability. Scope changes leading to significantly higher incentives will require review and approval by the Program and potentially the NJ Board of Public Utilities.
As-Built Square Footage	If the as-built square footage is less than that in the approved proposed BASIC Workbook, then the final incentive will be reduced accordingly.	If the as-built square footage is more than was approved in the proposed BASIC Workbook, then the incentive will be increased by no more than 5%, subject to budget availability. Square footage changes leading to significantly higher incentives will require review and approval by the Program Coordinator and potentially the NJ Board of Public Utilities.

8.3 Documenting Measures

Measure descriptions in the BASIC Workbook shall have installed equipment information that includes, but is not limited to, the following: equipment location, model numbers, equipment capacity/size, and equipment efficiency. Additional schedules may be submitted as attachments for measures involving multiple pieces of equipment. For any lighting measures, descriptions must include a schedule of the as-built lighting including fixture types by space, as shown on lighting plans for the project. HVAC measure descriptions should include system type, size, manufacturer/model and efficiency in the appropriate units. **This is necessary for facilitating post-installation inspections.**

Example: DHW: Install Direct-fired Boiler

Description of Energy Efficiency Measure Installed

- One central DHW natural gas heater located on the 1st floor mechanical room
- Bradford White EF100T199E3N33
- 200,000 Btu/hr.
- Storage Tank: 100 gallons
- Thermal Efficiency: 97%

9 HIGH PERFORMANCE PATHWAY – COMMISSIONING GUIDELINES

Project enrolled in one of the High Performance Proxy Pathways (e.g. LEED, ENERGY STAR, etc.) shall follow the Commissioning and/or Testing and Verification procedures outlined by the proxy certification requirements and guidelines.

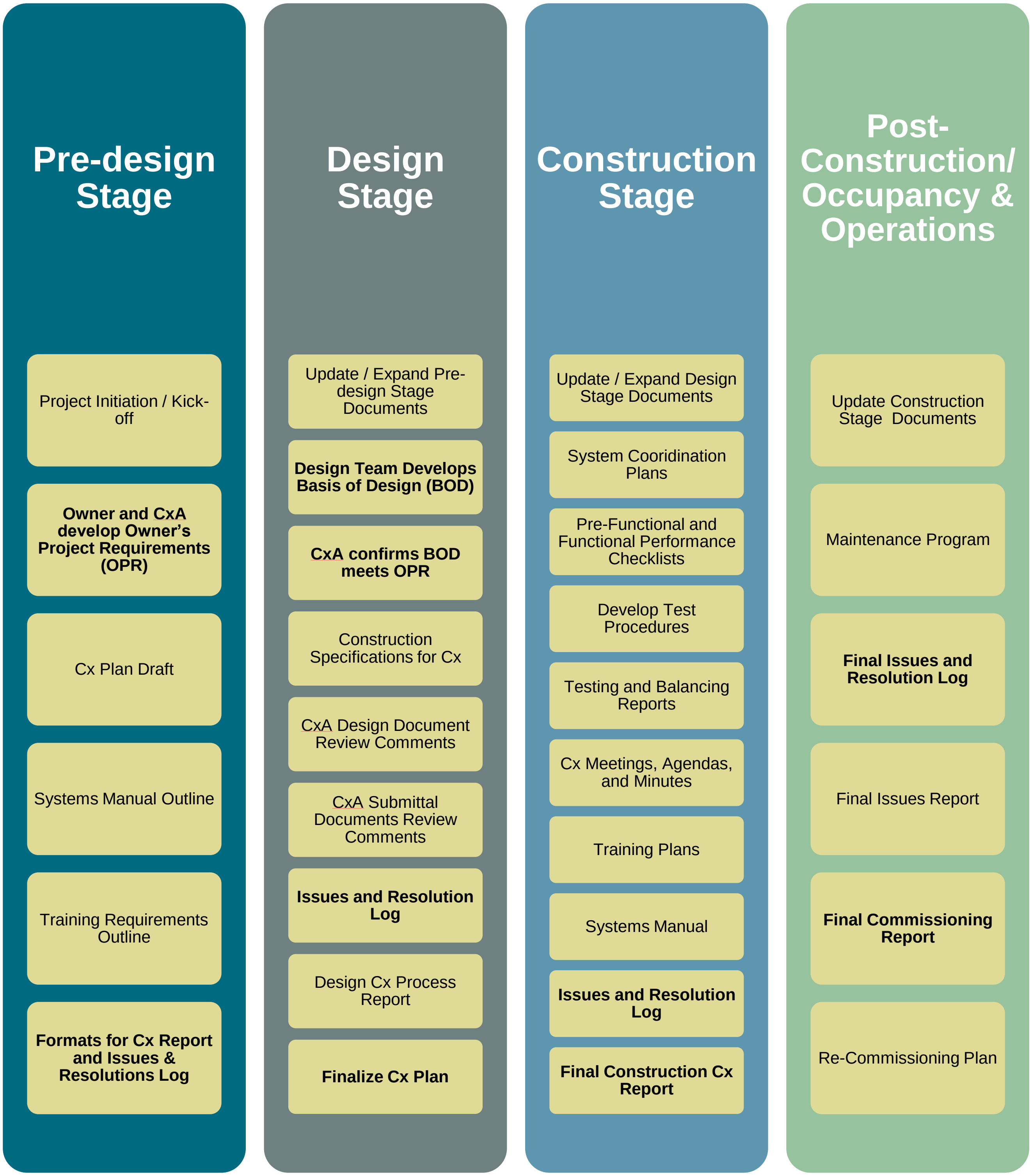
Projects enrolled in the High Performance Non- Proxy Pathway must complete and submit both a Commissioning Plan and Commissioning Report in line with the guidelines written below. A template is also provided by the program for the Commissioning Plan.

Commissioning (Cx) is an ongoing, collaborative quality assurance process involving the owner, design team, contractors, and the Commissioning Authority (CxA). It systematically verifies and documents the performance of building equipment and systems to confirm they meet the owner's project requirements, basis of design, and operational needs. Additionally, Cx validates system performance assumptions documented in the energy audit, supporting the facility in achieving expected energy savings.

An effective Cx process is essential to realizing the full energy efficiency potential of energy efficiency projects. Without it, even well-designed systems may underperform. Cx should span the entire project lifecycle—from pre-design and design through construction, post-occupancy, and ongoing operation—confirming that systems are installed, tested, operated, and maintained according to both owner and program requirements. As a mandatory component of the Program, Cx includes the preparation of a Cx Plan and submission of a Cx report.

The commissioning scope must address all incentivized energy efficiency measures and any new building components and systems that significantly impact projected energy savings and the operational needs of the owner, developer, and occupants. Projects that are not commissioned will not be eligible for program incentives.

Figure 9-1. Commissioning Process



9.1 Commissioning Authority Experience

The CxA is responsible for overseeing the commissioning process, ensuring that building systems are designed, installed, tested, and functioning in alignment with the OPR (if included in the project scope), BOD, and industry best practices. The CxA plays a critical role in verifying system performance and optimizing building efficiency while maintaining independence from the design and construction teams.

The Cx process must be overseen by a qualified CxA with extensive commissioning, building design, and construction experience. The CxA:

- Must be independent from the design and construction teams. Note that the CxA may be part of the same company but on a different team, division, or practice.
- Must possess documented experience commissioning at least two (2) projects of similar technical complexity.
- Must hold recognized industry credentials such as AABC Commissioning Group (ACG) Certified Commissioning Authority (CxA), Association of Energy Engineers (AEE) Certified Building Commissioning Professional (CBCP) or Certified Building Commissioning Firm (CCBF), National Environmental Balancing Bureau (NEBB) Commissioning Technician, or ASHRAE Commissioning Process Management Professional (CPMP). Other industry credentials may be accepted with approval from the Program.
- May be a qualified staff member of the ESSP, a consultant retained by the ESSP, or a consultant engaged by the project Participant.

Roles and responsibilities of the CxA are described in the following table:

Table 9-1. CxA Roles and Responsibilities

Phase	Roles and Responsibilities
Pre-Design Phase	The CxA should be engaged at the onset of the project to integrate Cx into the design process, collaborating with stakeholders to establish Cx requirements in project specifications. Early involvement helps define responsibilities, prevent gaps in accountability, and align Cx activities with the overall project schedule. The CxA also develops the **Cx Plan**, outlining scope, schedule, and verification methods, while ensuring subcontractor contracts include clear commissioning responsibilities.
Design Phase	The CxA reviews drawings and specifications to verify alignment with the **Project Scope** and identify potential deficiencies before construction. The CxA confirms that energy efficiency scope is accurately incorporated into the Cx scope. The CxA also collaborates with project stakeholders to refine the **BOD**.
Construction Phase	During construction, the CxA oversees system installation, conducts site visits, and verifies compliance with design intent. Reviewing submittals, RFIs, and shop drawings ensures alignment with the original specifications. The CxA also maintains an **Issues and Resolution Log** to track discrepancies and corrective actions, ensuring commissioning activities are effectively coordinated throughout the construction process.
Start-up, Testing, and Optimization Phase	The CxA leads **Pre-functional Testing** and **Functional Performance Testing** to confirm that building systems operate as intended. Any deviations from expected performance are identified and resolved with the project team. This phase also includes verifying that energy savings assumptions align with actual system operation, documenting results, and recommending adjustments to optimize performance.
Closeout Phase	To support long-term building operation, the CxA, in conjunction with installation contractors, facilitates training for facility staff on system operation, maintenance, and troubleshooting. The CxA also verifies the completeness and accuracy of O&M manuals, as-built drawings, and system operation guidelines, which will be available for facility personnel for future reference.
Post-Construction (Recommended)	The CxA assists with issue resolution, seasonal testing, and system optimization. The CxA assesses performance under real-world conditions, with recommendations for continuous Cx strategies to sustain energy efficiency and occupant comfort over time.

9.2 Stakeholder Roles and Responsibilities

This section describes the roles and responsibilities of all key stakeholders involved in the commissioning process. It outlines the contributions of the Commissioning Authority (CxA), design team, construction team, and facility operators. Clarifying these roles provides a framework for collaboration and accountability throughout the project lifecycle, from early planning and design through construction and post-occupancy performance. Note that all listed stakeholders may not be involved in every project, but this list details the responsibility for the stakeholders that are typically involved.

Table 9-2. Cx Team Member Roles and Responsibilities

Stakeholder	Responsibility
Owner and/or Partner	Defines project and commissioning (Cx) goals and provides overall support. Grants the Commissioning Authority (CxA) the authority to engage in construction activities within the project boundaries. Makes discretionary decisions based on input from the Cx team and other stakeholders. Establishes communication protocols, ensures the CxA is included in relevant document distribution, and facilitates participation in key project meetings.
Commissioning Authority (CxA)	Oversees and implements the execution of the Cx process by preparing Cx documentation and completing activities relating to construction, measure testing, system modulation, facility staff training, and project closeout.
General Contractor (GC)	Designates a Cx coordinator to actively engage in the Cx process. Supports the implementation of the Cx Plan and its related activities. Manages and ensures the involvement and collaboration of subcontractors while incorporating Cx into the construction, startup, testing, training, and project closeout milestones. Oversees scheduling, preparation, and / or compilation of relevant documentation.
Architect	Responsible for architectural design and approvals. Prepares plans, specs, and reviews submittals and shop drawings. Supports Cx Plan strategies, participates in select tasks, conducts site inspections, prepares punch lists, advises on acceptance, and assists with project closeout.
Mechanical & Electrical Engineers	Responsible for professional engineering design and approvals. Prepares plans, specs, Basis of Design (BOD), and reviews

Stakeholder	Responsibility
	equipment submittals. Coordinates with architects to support Cx Plan strategies, completion of Cx tasks, site inspections, preparation of punch lists, advises on Owner acceptance, and assists with project closeout.
Mechanical & Electrical Contractors	Assist with the Cx process by assigning a Cx coordinator who participates in Cx and related work tasks.
EMS Controls Contractor	Designates a Cx coordinator to be involved in the Cx process. Cx coordinator assists in Cx tasks, primarily preparing EMS data to show system sequences and performance are functioning correctly to advise the CxA on how to proceed with further Cx tasks.
Building Operations and Maintenance Staff	Represents the facility management team that will operate and maintain the building post-construction. Participates in training, testing, and final walkthroughs to ensure a smooth transition from construction to ongoing operations. Provides input on maintainability and system performance.
Owner's Project Manager or Representative	Serves as the Owner's direct representative, overseeing project execution to align with Owner objectives. Coordinates between the CxA, design team, and contractors to align commissioning activities with project goals.

9.3 Commissioning Plan Requirements

The Cx Plan is used to manage and document the commissioning process and provides a systematic approach to verify that systems are operating as designed. The plan defines roles and responsibilities, Cx procedures, testing protocols, and documentation requirements. Following construction, the start-up, testing, optimization, and closeout processes shall begin in accordance with the Cx plan.

Cx plans must be submitted for all projects for review an ESSP d approval. At a minimum, all incentivized ECMs must be included in the Cx scope. They may use the program's Cx Plan template or a template in their own format.

The Cx plan shall contain the following information, in accordance with ASHRAE Guideline 0-2019 and ASHRAE Standard 202-2024:

Table 9-3. Commissioning Report Outline

Section	Content
Introduction	• Purpose and scope of the Commissioning Plan. • Commissioning objectives and goals. • Building description: size, type, occupancy, and use. • Key project dates and major schedule milestones. • Systems and energy efficiency measures (EEMs) to be commissioned. • Applicable codes, standards, and guidelines influencing commissioning.
Cx Team, Roles, and Responsibilities	• List of commissioning team members and organizations. • Summary of roles and responsibilities for each party. • Communication structure: primary contacts, reporting lines, and meeting cadence.
Cx Process and Methodology	• Summary of commissioning activities by project phase: Pre-Design, Design, Construction, Testing, Closeout. • Design review process and coordination efforts. • Construction phase commissioning tasks: site observations, submittal reviews, issue tracking. • Controls and EMS commissioning approach. • Pre-Functional Testing (PFT) scope and checklist development. • Functional Performance Testing (FPT) structure and protocols. • Startup and optimization activities. • Issue resolution process and documentation. • Final deliverables produced at each phase.
Cx Schedule and Milestones	• Commissioning activities mapped to project schedule. • Key Cx milestones such as design review completion, PFTs, FPTs, training sessions, and report deliveries. • Dependencies and critical path commissioning activities
Issues and Resolutions Log	• Active log of identified deficiencies and issues. • Status tracking for each issue (open, in progress, resolved). • Summary of resolutions and final outcomes.

The following table provides an outline of the Cx report appendices that will be provided as part of the Cx Plan.

Table 9-4. Cx Plan Appendices

Commissioning Plan Appendices	
☐	**Owner's Project Requirements** A copy of the most recent OPR at the time of the Cx plan submission.
☐	**Basis of Design** A copy of the most recent BOD at the time of the Cx plan submission.
☐	**Pre-functional Performance Test Forms** Templates used to verify that equipment and systems are properly installed, started up, and prepared for functional testing. PFT forms document the completion of basic installation checks, manufacturer startup procedures, and operational readiness before system-level testing begins.
☐	**Functional Performance Test Forms** Templates used to document the testing of system operation against the design intent and sequences of operation. FPT forms detail test procedures, expected outcomes, and actual results, providing a structured approach for validating integrated system performance during commissioning.
☐	**Training Curriculum** Anticipated training for operations personnel including descriptions of training materials (e.g., manuals, videos), system demonstrations and walkthroughs, and on-going assistance.
☐	**Issues and Resolution Log** Template used to document issues, corrective actions, and responsible parties.

9.4 Integration of Commissioning with Design and Construction

Having a CxA involved in the design phase provides several key benefits that improve project outcomes, energy efficiency, and long-term performance. If design and Cx will be completed by different vendors, **where possible, CxAs should be involved in the design phase, and Cx activities should be integrated into both the design and construction phases.**

Some of the key advantages include integrating Cx with design and construction include:

Table 9-5. Benefits of Integrating Cx with Design and Construction

Element	Description
Early Identification	The CxA can review design documents and identify potential deficiencies, inconsistencies, or areas where performance goals may not be met. Catching these issues early reduces costly rework during construction and post-installation troubleshooting.
Reinforcement of Project Scope and BOD	The CxA ensures that the design aligns with the project scope and BOD, maintaining performance objectives, efficiency targets, and operational expectations. This helps prevent misalignment between the owner's goals and the final constructed systems.
Enhanced Coordination	By engaging in the design phase, the CxA embeds commissioning requirements into project schedules and contract documents. This allows for seamless coordination of functional performance testing, system verification, and quality control measures throughout the construction process.
Improved System Performance and Energy Efficiency	The CxA evaluates equipment selections, control sequences, and system interactions to optimize energy efficiency and operational performance. This proactive approach helps systems operate as designed, reducing unnecessary energy consumption and enhancing occupant comfort.
Clearer Construction and Operation Documentation	The CxA works with designers to refine specifications and ensure that installation, startup, and functional testing requirements are well-defined. Clear documentation minimizes ambiguity for contractors and facilitates smooth system operation and maintenance.
Risk Mitigation & Cost Savings	Addressing issues during design reduces the risk of costly change orders, delays, and post-installation failures. Early involvement also minimizes performance gaps that could lead to higher-than-expected energy costs, warranty claims, or occupant complaints after project completion.
Stronger Collaboration Between Stakeholders	The CxA serves as a bridge between owners, designers, engineers, and contractors, so that all parties remain aligned on system performance expectations. This collaboration fosters better communication, accountability, and problem-solving throughout the project.

9.5 Commissioning Process

The commissioning process is a systematic approach to verify that building systems are designed, installed, and operating according to the project's performance objectives and scope of work. It brings together the owner, design team, contractors, and Commissioning Authority (CxA) in a collaborative effort to review project plans, conduct functional tests, and optimize system performance. Spanning from the pre-design and design stages through construction, start-up, testing, optimization, and into post-occupancy, this process validates that systems operate as intended and deliver anticipated energy efficiency and performance outcomes.

This following table organizes the Cx process into the following phases[1]:

1. Pre-design Phase
2. Design Phase
3. Construction Phase
4. Start-up/Testing and Optimization Phase
5. Closeout Phase

[1] If the design and Cx vendor are the same, the steps below should be completed in conjunction with design.

Table 9-6. Commissioning Process

Phase	Process
Pre-Design Phase	The objectives of the Cx process during the pre-design phase include: ● Developing OPR and BOD ● Delineating ECM interactivity with additional building systems. ● Establishing Cx scope and requirements. ● Selecting and engaging the CxA (if the design firm is not completing the Cx effort).
Design	The objectives of the Cx process during the design phase include: ● Establishing the commissioning process early in project development. ● Integrating Cx requirements into the project specifications and contract documents. ● Aligning design intent with the OPR and BOD ● Reviewing design documents for commissioning feasibility, ease of ongoing maintenance, energy efficiency, and decarbonization. ● Establishing communication protocols and defining team roles and responsibilities. ● Coordinating Cx activity with other quality assurance (QA) and quality control (QC) efforts. ● Developing preliminary commissioning documentation, including the Cx Plan, commissioning specification, and draft Functional Performance Test (FPT) procedures.
Construction Phase Scoping Meeting	The CxA will organize an introductory meeting to ensure alignment with the commissioning process. Topics include: ● Introductions, roles, responsibilities, and expectations. ● Review of the Cx Plan and clarification of scope, interpretation, and key objectives. ● Documentation requirements for pre-testing, testing, and verification. ● Defining functional performance testing responsibilities. ● Establishing key milestones and schedule highlights. ● Obtaining consensus on commissioning strategies and workflows.
Construction Phase Construction Meetings and Site Walkthroughs	The CxA will conduct periodic meetings and site visits to: ● Track commissioning progress and coordinate field activities. ● Observe construction, equipment installation, startup, and testing. ● Verify compliance with the BOD and contract requirements. ● Coordinate Energy Management System (EMS) sequence validation and trend data analysis for system performance verification if applicable.

Phase	Process
Construction Phase Controls and Energy Management Systems Commissioning	The CxA will coordinate periodic control system meetings to track progress for both primary and third-party-furnished controls, including: ● Review of shop drawings, submittals, and final sequences of operation. ● Advanced energy management strategies, including load shedding, peak demand control, and operational flexibility. ● Graphic interface and trend log verification for EMS systems. ● Sensor and device calibration planning. ● Development of pre-functional test (PFT) plans and functional performance test (FPT) plans.
Construction Phase Pre-Functional Testing (PFT)	The General Contractor (GC) will coordinate checklist development with oversight from the CxA. Checklists may include: ● In-house developed PFT checklists. ● Manufacturer-provided startup checklists. ● Technician-furnished startup documentation. The CxA will: ● Review and provide feedback on PFT checklists. ● Organize a comprehensive PFT checklist binder to track equipment readiness.
Construction Phase Functional Performance Testing (FPT)	Functional testing verifies that systems operate per design intent. The CxA will conduct tests to validate: ● EMS communication infrastructure and operator workstations. ● ECM equipment operation. ● System sequencing, scheduling, failure modes, and data logging. The CxA will develop plans that summarize test procedures, expected results, discrepancies, and corrective actions.
Construction Phase Issue Resolution and Reporting	The CxA will document deficiencies found during pre-functional and functional testing. Procedures will address: ● Deficiency reporting and resolution workflows. ● Impact assessments on building performance and compliance. ● Communication protocols with the Owner, Project Team, and Program.
Startup, Testing, and Optimization Phase Pre-functional Start-up and Checkout	The GC will confirm completion of all pre-startup tasks, including: ● Utility services (power, water, gas) readiness. ● Duct and piping pressure testing, cleaning, and treatment completion. ● Equipment manufacturer startup procedures. The CxA will observe startup procedures and: ● Provide real-time feedback. ● Identify and track installation discrepancies.

Phase	Process
Startup, Testing, and Optimization Phase Functional Performance Testing Execution	The CxA will perform testing using structured, progressive approach including: ● Component-level verification ● Subsystem validation ● Full-system integration testing ● Inter-system connectivity, including life safety interactions ● Manual observation and testing ● EMS trend log analysis to validate long-term performance
Closeout Phase Closeout Meeting	The CxA will lead a closeout meeting at or near project completion to finalize commissioning activities. Key topics: ● Verification of completed functional performance testing (unless exceptions are agreed upon). ● Review and acceptance of record documentation.
Closeout Phase Training and Knowledge Transfer	The CxA and GC will fulfill all training requirements. Training will cover: ● Operational best practices, continuous commissioning strategies, and energy management techniques. ● System troubleshooting and maintenance procedures. Training documentation will include: ● Schedules ● Attendee lists ● Recorded sessions ● Reference materials.
Closeout Phase Warranty Management	The CxA will compile warranty information, covering: ● Coverage period, inclusions/exclusions, and escalation procedures. ● Owner responsibilities for compliance.
Closeout Phase Final Commissioning Report	The CxA will aggregate and document all commissioning activities, including: ● Testing results, discrepancies, corrective actions, and final system performance evaluation. ● Long-term operational recommendations for facility staff.

9.6 Commissioning Schedule

The Cx Plans and Reports shall include a comprehensive schedule outlining all Cx process activities. At the Cx planning stage, the schedule serves as a roadmap for design, construction, and post-construction activities of the project. Standard construction and Cx schedules are typically highly detailed, often including multiple sub-milestones, dependencies, and timelines. However, the level of detail required for developing a Cx Plan for this program is not as robust.

The following table provides a detailed project schedule with timeframes for individual tasks under each phase. Schedules in simpler formats are acceptable based on the project and scope.

Minimally, all schedules must include start and end dates of each phase. Schedules in other formats such as Gantt charts are also acceptable.

Table 9-7. Design, Construction, and Commissioning Schedule Example

#	Phase	Tasks	Start Date	End Date	Duration (Days)
1	**Design**	Complete Draft of OPR	1/1/2025	1/15/2025	15
2	**Design**	Design Review	1/16/2025	2/15/2025	31
3	**Design**	Cx Kick-off Meeting (Design)	2/20/2025	2/20/2025	1
4	**Design**	Develop Draft of Commissioning Plan	2/21/2025	3/5/2025	13
5	**Design**	CxA Schematic Design Review	3/6/2025	3/20/2025	15
5	**Design**	Complete Schematic Design	3/21/2025	3/21/2025	1
6	**Design**	Develop Draft of BOD	3/22/2025	4/5/2025	15
7	**Design**	CxA Design Development Review	4/6/2025	4/20/2025	15
7	**Design**	Complete Design Development	4/21/2025	4/21/2025	1
8	**Design**	Complete Construction Documents	5/1/2025	6/30/2025	61
9	**Construction**	Pre-bid Meeting	7/5/2025	7/5/2025	1
10	**Construction**	Finalize Construction Contracts	7/6/2025	7/20/2025	15
11	**Construction**	Pre-construction Meeting	7/25/2025	7/25/2025	1
11	**Construction**	Start Construction	8/1/2025	8/1/2025	1
12	**Construction**	Review and Approve All Submittals	8/1/2025	9/30/2025	61
13	**Construction**	Cx Kick-off Meeting (Construction)	8/10/2025	8/10/2025	1
14	**Construction**	Construction Inspections	8/15/2025	1/27/2026	166
15	**Startup, Testing, and Optimization Phase**	Complete Construction / Pre-Functional Testing Checklists	1/28/2026	2/15/2026	19
16	**Startup, Testing, and Optimization Phase**	Complete Functional Performance Testing	2/16/2026	3/31/2026	45
17	**Close Out**	Complete O&M and Systems Manual	3/1/2026	4/15/2026	46
18	**Close Out**	Complete Training Manual	3/1/2026	4/15/2026	46
19	**Close Out**	Conduct Maintenance Staff Training	4/16/2026	4/22/2026	7
20	**Close Out**	Project Completion	4/30/2026	4/30/2026	1
21	**Close Out**	Address All Outstanding Issues and Discrepancies	5/1/2026	5/31/2026	31
22	**Close Out**	Warranty Review	11/1/2026	11/15/2026	15
23	**Close Out**	Finalize Cx Report	6/1/2026	6/30/2026	30

9.7 Sampling Requirements

Sampling is a critical component of the commissioning (Cx) process to help validate that systems and equipment are properly installed, function correctly, and meet the owner's project requirements. Quality-based sampling should be performed based on project size, system complexity, and historical performance data. Factors that influence sampling rates include:

- System type (HVAC, lighting, domestic hot water, etc.)
- Quantity and uniformity of installed equipment
- Historical reliability of similar installations
- Risk assessment of system failure
- Owner and project-specific requirements

The sampling procedure should be described in the Cx Plan and Report. Cx sampling should be conducted using a *minimum* of 80% confidence with 20% precision. Exceptions are permitted with justification.

The following table provides guidance on minimum sample sizes based on the number of similar components and systems (such as lighting fixtures in a room and VAV boxes).

Table 9-8. Cx Sampling Requirements

Number of Components or Systems	Minimum Sample Size (#)	Minimum Sample Size (%)
1	1	100%
2	2	100%
3	3	100%
4 – 6	4	67%
6 – 10	5	50%
11 – 15	6	40%
16 – 20	7	35%
21 – 40	8	20%
41 – 99	9	9%
100+	10	5%

Actual sampling should be based on owner and project specific requirements, deficiency trends, and criticality of systems. For example, sampling rates should be increased based on the following criteria:

- **Critical Systems:** 100% of systems classified as critical must be commissioned. Examples include plant equipment, air handling units, emergency generators, uninterruptible power supplies, large refrigeration systems, laboratory systems, and data center equipment, among many others.

- **Deficiency Trends:** If multiple failures occur within an initial sample, expand sampling up to 100% of all systems
- **Project Requirements:** Higher sampling percentage rates may be needed to satisfy other program requirements such as LEED.
- **Owner Requirements:** Custom sampling plans may be required based on owner expectations and risk tolerance

The program may request documentation to justify sampling rates if they appear to be low.

Appendix N Quality-Based Sampling Examples of ASHRAE Guideline 0 provides best practices for equipment sampling, which may be referenced in development of sampling requirements.

9.8 Issues and Resolution Log

The issues and resolution log serves as a centralized record for tracking and managing Cx-related issues that arise throughout the project. This log facilitates clear communication among project stakeholders, documents identified deficiencies, and tracks corrective actions to support project completion in alignment with the OPR, BOD, and design intent.

The program requires that a complete issues and resolution log is included in the final Cx report, including descriptions of issues and actions taken to resolve them. All significant issues impacting building energy performance must be resolved prior to the approval of the commissioning report.

The following figure provides an example of an acceptable issues and resolution log to be included in Cx reports. Formats can vary, but the pertinent content should be included.

Table 9-9. Example Issue Record

Issue ID		Location	Building name, space type, room number, etc.	
Date Identified		**Resolution Date**		
System ID		**System Description**	Description of the affected system or equipment	
Manufacturer		**Model Number**		
Description of Issues	A clear, concise explanation of the problem, including observed performance deficiencies, deviations from specifications, or installation errors			
Phase	**Root Cause**	**Priority Level**	**Responsible Party**	**Current Status**
☐ Design ☐ Inspection ☐ Pre-Functional ☐ Functional Testing ☐ Start-up ☐ Walkthrough	☐ Design Error ☐ Installation ☐ Programming ☐ Malfunction ☐ <Other>	☐ 1 – Very High ☐ 2 – High ☐ 3 – Medium ☐ 4 – Low ☐ 5 – Very Low	☐ Design Team ☐ CxA ☐ Owner ☐ Contractor ☐ <Other>	☐ Open ☐ In Progress ☐ Escalated ☐ Closed
Recommended Resolution	The proposed corrective action(s) to resolve the issue.			
Solution	Corrective actions implemented, including method of verification			
Notes				
Verified By:	Name, Title, Company			**Date:**
Approved By:	Name, Title, Company			**Date:**

9.9 Commissioning Report Requirements

This section outlines the requirements for the Commissioning Report, which documents all activities, test results, and performance evaluations conducted during the commissioning process. The report serves as a comprehensive record of how building systems operate relative to design intent and project requirements. It details inspection outcomes, functional testing results, and corrective actions taken, while offering recommendations for long-term operational performance and maintenance. The report also includes guidelines for functionality to achieve ongoing energy savings and addresses any additional operational and maintenance requirements. This complete package, along with system maintenance manuals and warranties, should be provided to the building owner for future reference and support.

The goals of commissioning and the Cx report include:

1. ECMs are implemented as originally planned or deliver equivalent or greater energy savings compared to initial projections.
2. Equipment nameplate data (model number, size, power rating, energy efficiency rating, etc.) matches the project design specifications.
3. Actual energy consumption or equipment output corresponds with the assumptions used in the energy savings model and calculations.

4. Control systems are properly configured and operate in accordance with the assumptions applied in the energy savings calculations.
5. Operator training for all relevant equipment is completed.
6. A comprehensive deficiency log is maintained, detailing the impact on energy savings and corrective actions implemented to resolve issues.
7. ECMs perform at or above expected levels; if performance falls short, all reasonable corrective actions are implemented, and final savings are recalculated accurately.

The Cx report shall contain the following information, in accordance with ASHRAE Guideline 0-2019 and ASHRAE Standard 202-2024:

Table 9-10. Commissioning Report Outline

Section	Content
Executive Summary	• Overview of commissioning process • Summary of findings • General performance of systems • High-level recommendations
Project Information	• Project name and address • Owner and key project team members • Brief project description (size, type, systems commissioned)
Cx Scope and Objectives	• Systems and equipment commissioned • Scope of Cx activities • Specific owner goals (e.g., energy efficiency, indoor air quality, decarbonization)
Cx Process Overview	• Phases and activities performed (Pre-Design, Design, Construction, Startup, Closeout) • Summary of Cx Plan execution • Key milestones and timelines
Systems Commissioned	• List of systems and subsystems commissioned (e.g., HVAC, BAS, domestic hot water, lighting controls) • Summary of system functionality
Summary of Issues and Resolutions	• Overview of deficiencies identified • How issues were resolved (or if open items remain) • Impact of issues on project goals (e.g., performance, schedule)
Testing and Verification Results	• Summary of functional performance testing (FPT) outcomes • Verification of sequence of operations • Control system performance (trend log analysis, sensor calibration)

Section	Content
Outstanding Issues and Recommendations	• Unresolved deficiencies (if any) • Long-term operational and maintenance recommendations • Suggested energy-saving opportunities • Opportunities for continuous commissioning (ongoing monitoring)
Warranty and post-construction	• Key warranty information • Post-construction commissioning plans (if applicable) • Lessons learned / recommendations for seasonal testing

The following table provides an outline of the Cx report appendices that will be provided as part of the Cx Report.

Table 9-11. Cx Report Appendices

	Commissioning Report Appendices
☐	**Owner's Project Requirements** Final version of OPR
☐	**Basis of Design** Final version of the BOD
☐	**Cx Plan** Final version of the Cx Plan
☐	**Pre-functional Performance Test Forms** Completed forms used to verify that equipment and systems are properly installed, started up, and prepared for functional testing.
☐	**Functional Performance Test Forms** Completed forms used to document the testing of system operation against the design intent and sequences of operation.
☐	**Contractor Start-up Reports** Start-up documentation provided by contractors
☐	**Building Envelope Cx Reports** Summarizes testing and verification of opaque assemblies (e.g., walls, roof, floors) and fenestration (e.g., windows, skylights).
☐	**Field Reports and Meeting Minutes** CxA site visit reports, meetings, and communications.
☐	**Issues and Resolution Log** Tracks all Cx deficiencies and corrective actions
☐	**Training Curriculum** Completed training for operations personnel including descriptions of training materials (e.g., manuals, videos), system demonstrations and walkthroughs, and on-going assistance.
☐	**Equipment Warranties** Warranty documentation and terms for major mechanical systems and ECMs.
☐	**Trend Log and EMS Screenshots (Optional)** BAS/EMS data used to verify system operation.

9.10 Owner's Project Requirements (Recommended)

The Owner's Project Requirements (OPR) is not required for this program but is a recommended best practice for larger and more complex projects. Any references to OPR in these guidelines should be treated as optional.

The OPR document serves as the foundation for the project's design, construction, occupancy, and operation. The OPR helps establish clear performance goals, operational expectations, and sustainability targets at the beginning of a project. By defining efficiency benchmarks, indoor environmental quality (IEQ) parameters, and system performance criteria, the OPR provides a structured framework that aligns design, construction, and commissioning efforts with the Owner's objectives. It helps minimize scope misalignment, improve accountability, and facilitate informed decision-making throughout the project lifecycle.

The OPR also guides the development of the Cx plan and schedule and is expected to evolve throughout the project. Following the energy audit phase and ideally prior to the design phase, the design team and CxA should facilitate development of an OPR document with the owner and project team.

9.10.1 Gathering OPR Input

To develop a comprehensive OPR, building owner, engineer and operator input is required. The process for obtaining this information should facilitate interaction among the various stakeholders to capture diverse perspectives and operational needs. Methods such as nominal group technique workshops, interviews, and surveys can be used to collect this input, with each approach offering varying levels of direct engagement. Workshops provide the highest level of interaction, followed by interviews, while surveys offer the least direct engagement.

Common stakeholder engagement methods are described in the following table:

Table 9-12. Stakeholder Engagement Methods

Method	Description
Workshops	A highly interactive method that facilitates group discussions, prioritization of project needs, and consensus-building. These workshops encourage open dialogue and collaborative decision-making among stakeholders. Workshops can be conducted virtually or in-person
Interviews	One-on-one discussions with key personnel to gather in-depth insights on operational requirements and system preferences. This method allows for targeted feedback but may lack broader consensus.

Method	Description
Surveys	A structured approach to collecting input from a larger group with minimal interaction. While surveys provide quantitative data, they may not fully capture nuanced operational concerns.

Best practices for OPR development include:

- Engaging stakeholders early to ensure their requirements are incorporated into the project from the outset.
- Using structured facilitation techniques to balance input from various user groups and prevent dominant voices from skewing outcomes.
- Clearly documenting all collected information to establish a traceable and validated OPR that serves as a reference throughout design, construction, and commissioning.
- Maintaining transparency in the decision-making process by communicating findings and allowing for iterative feedback as the project evolves.

ASHRAE Guideline 0 -2019 Appendix I *Owner's Project Requirements Workshop Guidance* provides an example of the format, process, and documentation of a well-structured OPR workshop.

9.10.2 OPR Document

Contents of the OPR document may include the following items for commissioned systems:

- Facility objectives, size, location, user requirements, and Owner directives
- Environmental, sustainability, and efficiency goals and benchmarks
- Indoor environment requirements, including temperature, humidity, and ventilation
- Space use and occupancy and operations schedules
- Clearly defined Cx scope and requirements
- Cx scope and requirements where required by Owner or by code
- Equipment, systems and assembly requirements, expectations, and warranty provisions
- Maintainability, access, and operational performance requirements
- Installation evaluation and testing requirements
- Project documentation, Cx Progress Reports, Preliminary Cx Report, Final Cx Report, Systems Manual requirements and formats
- Training requirements for Owner's operations and maintenance (O&M) personnel, emergency response personnel and occupants, including level of training required, qualifications of trainers, and documentation requirements
- Basis of Design (BOD) milestone submission requirements
- Project schedules
- Special project requirements

- The content, organization, and milestones of BOD submittals for the design and construction process
- The number, format, and scheduling of design and submittal reviews
- Sampling procedures, if permitted, for all reviews, evaluations, and testing

The following table provides an outline of recommended OPR contents. Contents will vary based on project type, complexity, and owner needs.

Table 9-13. Owner's Project Requirements Outline

Section	Component	Description
Section 1: Introduction	Project Overview	Project name, location, and description Purpose and scope of the project Owner's vision and key objectives
	Purpose of the OPR	Role of the OPR in guiding design, construction, and operation Relationship to the Basis of Design (BOD) and Commissioning Process
	OPR Development and Updates	Stakeholder involvement and approval process Method for revising and updating the document
Section 2: Facility Objectives and Requirements	Facility Type and Function	Intended building use and occupancy Special functional or operational need
	Performance Goals	Energy efficiency, sustainability, and environmental impact targets Indoor environmental quality expectations (e.g., air quality, thermal comfort, acoustics, lighting)
Section 3: Cx Scope and Requirements	Cx Goals	Project-specific Cx objectives Owner's expectations for system performance verification
	Cx Scope	Systems and assemblies subject to commissioning (e.g., HVAC, lighting, controls, envelope) Integration with existing systems and controls (if applicable)
Section 4: Indoor Environmental Quality (IEQ) Requirements	Thermal Comfort	Temperature and humidity setpoints and control ranges Seasonal variations and zoning strategies
	Ventilation and Air Quality	Outdoor air intake and filtration requirements Compliance with ASHRAE 62.1 and/or other applicable standards

Section	Component	Description
	Acoustics and Lighting	Noise criteria (NC) levels for different spaces Daylighting and artificial lighting expectations
Section 5: Energy and Sustainability Goals	Energy Performance Requirements	Energy Use Intensity (EUI) targets Renewable energy integration and efficiency strategies
	Sustainability and Green Building	LEED, WELL, ENERGY STAR, or other program participation Material and resource efficiency considerations
	Water Use Conservation	Plumbing fixture efficiency standards Irrigation and stormwater management requirements
	Decarbonization	Greenhouse gas emission (GHG) targets and reduction goals Electrical capacity requirements
Section 6: Operation and Maintenance Requirements	Maintainability and accessibility	Access to mechanical, electrical, and plumbing (MEP) systems Design features that facilitate maintenance
	System Reliability and Resilience	Backup power and redundancy expectations Disaster recovery and emergency response considerations
	Training and Documentation	Training requirements for Owner's operations staff System manuals, as-built documentation, and Cx reports
Section 7: Basis of Design	Codes and Standards and Regulatory Requirements	Applicable building codes and jurisdictional requirements Compliance with ASHRAE, NFPA, NEC, and other relevant standards Specific utility or incentive program participation
	Coordination and Review Process	Requirements for BOD submissions at design milestones Process for reviewing design compliance with OPR Stakeholder involvement in BOD validation
	Milestones	Major project phases and key deadlines Cx milestones (e.g., design review, construction, functional testing, post-construction) Owner's involvement and approval checkpoints
	Special Project Considerations	Unique requirements based on location, climate, process, or project type Specific security, accessibility, or technology integration needs

9.11 Basis of Design (Required)

The Basis of Design (BOD) is a written document that outlines the Design Team's approach to meeting the OPR. It serves to clarify design decisions, enhance the Owner's understanding of key issues, and secure approval of critical design elements. The design team is responsible for developing, updating, and expanding the BOD throughout the design and construction phases as the project evolves. The BOD should:

- Define the building systems and assemblies proposed to fulfill the OPR for Owner approval.
- Detail the technical approach to each Owner requirement relevant to the Commissioning (Cx) scope.
- Serve as a reference for reviewing design progress and modifications.
- Ensure coordination with applicable technical and code requirements.

The BOD will vary depending on project complexity and scope of work, but should generally include the following details:

- Specific codes, standards, and guidelines considered during design of the facility and designer interpretations of such requirements
- Information regarding ambient conditions (climatic, geologic, structural, existing construction) used during design.
- Assumptions regarding use of the facility
- Expectations regarding system O&M
- Performance criteria that the system was designed to meet (linked to the OPR if developed)
- Specific design methods, techniques, and software used in design
- A narrative statement of design that describes how the designer intends to meet the OPR (if applicable)
- A narrative statement of operation that details how the facility is expected to operate under various situations (such as normal operation, extreme event, emergency)
- A listing of specific manufacturer models used as the basis of drawings and specifications

The following table provides an outline of recommended BOD contents. Contents will vary based on project type, complexity, and owner needs.

Table 9-14. Basis of Design Outline

Section	Component	Description
Section 1: Introduction	Project Overview	Project name, location, and description Purpose and scope of the project Owner's vision and key objectives Summary of major systems and scope of design
	Purpose of the BOD	Define the Design Team's approach to meeting the OPR Document key design decisions, assumptions, and performance criteria Serve as a reference for the Owner, Commissioning (Cx) Team, and project stakeholders
	Relationship to the OPR	Explanation of how the design aligns with the OPR Summary of any Owner-directed modifications or deviations Performance criteria that the system was designed to meet, linked to the OPR
	BOD Development and Updates	Stakeholder involvement and approval process Method for revising and updating the document
	Codes, Standards and Guidelines	Specific codes, standards, and guidelines considered during design (e.g., ASHRAE, NFPA, NEC, LEED) Designer interpretations of such requirements and rationale for key decisions
Section 2: Facility and Environmental Considerations	Climatic Conditions	Climatic conditions (temperature, humidity, wind loads, sun exposure) Geologic and structural considerations (seismic activity, soil conditions) Existing building conditions (if applicable)
	Assumptions Regarding Facility Use	Expected occupancy patterns and operational schedules Space function and flexibility considerations
	Expectations for System Operation and Maintenance	Long-term O&M expectations for major systems Design decisions that impact serviceability, accessibility, and lifespan

Section	Component	Description
Section 3: Building Systems and Assemblies	Architectural Design (if applicable)	Building orientation, envelope performance, and material selections Integration of daylighting, thermal insulation, and acoustic treatments
	Structural Design (if applicable)	Structural system selection and design criteria Load considerations and coordination with building systems
	Mechanical Design	System types, capacity calculations, and efficiency targets exceeding ASHRAE 90.1 requirements Ventilation strategies and compliance with ASHRAE 62.1 Assumed internal loads and environmental conditions
	Electrical Design	Power distribution and load requirements Emergency and backup power expectations Lighting system design and control strategies Electrical capacity review and upsizing requirements (if applicable)
	Plumbing Design	Domestic water supply, distribution, and heating Wastewater and stormwater management strategies
Section 4: Design Methodology and Approach	Narrative Statement of Design	Detailed narrative describing how the design meets the OPR Design team's rationale for key technical and engineering decisions
	Specific Design Methods, Techniques, and Software	Engineering methodologies used for system sizing and performance analysis Software tools for modeling, simulations, and calculations
	Manufacturer Specific Basis of Design	List of specific manufacturer models used as the basis of drawings and specifications
Section 5: Indoor Environmental Quality (IEQ) Requirements	Thermal Comfort	Temperature and humidity setpoints and control ranges Seasonal variations and zoning strategies
	Ventilation and Air Quality	Outdoor air intake and filtration requirements Compliance with ASHRAE 62.1 and/or other applicable standards

Section	Component	Description
	Acoustics and Noise Control	Noise criteria (NC) levels for different spaces Vibration isolation for mechanical equipment
	Lighting and Daylighting	Lighting levels and control strategies Integration of daylighting with artificial lighting
Section 6: Energy and Sustainability Goals	Energy Performance Requirements	Energy Use Intensity (EUI) targets Renewable energy integration and efficiency strategies
	Sustainability and Green Building	LEED, WELL, ENERGY STAR, or other program participation Material and resource efficiency considerations
	Water Use Conservation	Plumbing fixture efficiency standards Irrigation and stormwater management requirements
	Decarbonization	Greenhouse gas emission (GHG) targets and reduction goals Electrical capacity requirements
Section 7: Operation and Maintenance Requirements	Narrative Statement of Operations	Description of how the facility is expected to operate under various situations: • Normal operation • Extreme events (e.g., weather-related conditions) • Emergency operation and recovery
	Maintainability and Accessibility	Access to mechanical, electrical, and plumbing (MEP) systems Design features that facilitate maintenance
	System Reliability and Resilience	Backup power and redundancy expectations Disaster recovery and emergency response considerations
	Training and Documentation	Training requirements for Owner's operations staff System manuals, as-built documentation, and Cx reports
Section 8: Design and Approval Process	Milestones	Required submissions at key project phases (e.g., schematic design, design development, construction documents) Format and level of detail for each submission Commissioning schedule and integration into construction timeline

Section	Component	Description
		Owner review and approval checkpoints
	Design Coordination and Stakeholder Involvement	Process for Owner and Cx Team review of design documents Approach for addressing feedback and revisions
	Change Management and Design Modifications	Procedures for documenting and approving design changes Coordination with the OPR when modifications occur
	Special Project Considerations	Unique requirements based on location, climate, process, or project type Specific security, accessibility, or technology integration needs

9.12 Additional Commissioning Resources

In addition to these guidelines, the following resources best practices, templates, examples, and technical information related to the Cx process. These materials can support Cx professionals in developing and implementing effective Cx plans. This list is provided for reference only and does not imply endorsement of any specific organization, standard, or publication. Other references may available beyond those listed here. Users should evaluate each resource based on the specific project needs and applicable program requirement. References in red contain hyperlinks

- ASHRAE Commissioning Stakeholders' Guide
- ASHRAE Strategic Guide to Commissioning
- ASHRAE Standard 202-2024 – The Commissioning Process Requirements for New Buildings and New Systems
- ASHRAE Standard 230-2022 – Commissioning Process for Existing Buildings and Systems
- ASHRAE Guideline 0-2019 – The Commissioning Process
- ASHRAE Guideline 1.3-2018 – Building Operations and Maintenance Training for the HVAC&R Commissioning Process
- ASHRAE Guideline 1.4-2019 – Preparing System Manuals for Facilities
- ASHRAE Guideline 1.5-2017 -- The Commissioning Process for Smoke Control Systems
- ASHRAE Guideline 4-2019, Preparation of Operating and Maintenance Documentation for HVAC&R Systems
- ASHRAE Guideline 41-2023, Design, Installation, and Commissioning of Variable Refrigerant Flow (VRF) System

- ASHRAE Commissioning Definitions and Terminology for the Building Industry: A Common Overview
- Building Commissioning Authority Best Practices
- Building Commissioning Authority Samples and Templates
- Building Commissioning Authority Owner Resources (including OPR templates and examples)
- California Building Commissioning Guide
- NEBB ANSI/NEBB S110-2019, May 1, 2019 Second Edition - Whole Building Technical Commissioning of New Construction
- NEBB Design Phase Commissioning Handbook

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