Jersey Central Power & Light (JCP&L)

Engineered Solutions & Custom Advantage Program and Technical Guidelines

2026-09-01

v1.0

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Disclaimer

The information provided in these guidelines do not guarantee realization of energy savings. Actual energy savings depend on behavioral factors and other uncontrollable variables, such as changes in operating conditions, occupant behavior, variations in equipment performance and installation, unforeseen circumstances, among other factors. As a result, TRC shall in no event have any liability should actual energy savings vary from projections developed by program allies and reviewed by TRC.

TRC does not warrant or guarantee the performance, reliability, or suitability of any particular technology, equipment, or system. These guidelines do not constitute an endorsement, recommendation, or promotion of any specific product, manufacturer, vendor, contractor, or service provider. By using these guidelines, TRC shall not be held liable for any discrepancies between the estimated and actual energy savings or for any decisions made based on this information. We encourage customers and their representatives to perform their own due diligence and consult with qualified professionals to ensure that selected technologies or measures meet their specific needs and requirements.

Program allies may estimate material and labor costs using RS Means cost manuals, experience at similar facilities, technical resource manuals, or estimates provided by the customer's contractor, when available. Cost estimates often include material and labor pricing associated with one-for-one equipment replacements. Cost estimates may not include demolition, removal, recycling, or disposal of hazardous waste. The actual implementation costs for energy savings projects could be significantly higher based on the specific conditions, labor requirements, and location of site(s). TRC strongly recommends that customers work with their design engineers or contractors to develop actual project costs for your specific scope of work for the installation of high-efficiency equipment. TRC encourages customers to obtain multiple estimates when considering measure installations. Actual installation costs can vary widely based on selected products and installers. TRC does not guarantee cost estimates and shall in no event be held liable should actual installed costs vary from these material and labor estimates.

Incentive values provided in these guidelines are based on current efficiency program offerings. Incentive levels are not guaranteed. Please refer to the relevant efficiency program's terms and conditions. In addition, please review all program incentives and eligibility requirements prior to selecting and installing any energy conservation measures.

The customer and their respective contractor(s) are responsible for implementing energy conservation measures in complete conformance with all applicable local, state, and federal requirements and codes.

Because these are new program offerings, there may be periodic updates and additions to technical guidelines. Prior to beginning a project, please download the latest version of these guidelines or request an update from the Program Manager. Participants should refer to the most recent version of the Program's Incentive Guide for official incentive rates, eligibility criteria, and terms and conditions. Actual incentive eligibility and final incentive values are subject to review and approval by the Program. All incentives are subject to change and are not guaranteed until confirmed through the formal application and review process.

How to Use These Guidelines

These guidelines support energy efficiency project implementation across all project phases. They are intended for Program Allies, auditors, design teams, commissioning authorities, and M&V professionals. Review applicable sections early in the project lifecycle to understand program expectations and minimize rework.

Document Structure

These guidelines are organized into the following sections:

- **General Guidelines:** Program overview, eligibility, incentives, application process, and submission requirements.
- **Pre-Audit Screening:** Initial project eligibility evaluation and savings potential assessment.
- **Auditing:** ASHRAE Level II audit process, data collection, and reporting requirements.
- **Calculation:** Energy savings methodologies, baselines, and technology-specific assumptions.
- **Design:** Engineering design documents and bid process requirements.
- **Construction:** Installation oversight, inspections, and closeout requirements.
- **Commissioning:** Cx planning, testing, reporting, and stakeholder roles.
- **M&V:** Protocols for measuring and verifying post-installation energy savings

Guidelines Updates

Version	Date	Updates
1.0	09/01/2026	▪ Initial Release

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1. General Guidelines

1.1 Introduction

JCP&L's Energy Solutions for Business Program offers commercial and industrial (C&I) customers many pathways to achieve energy savings and qualify for incentives to help offset project costs. The Engineered Solutions and Custom Advantage programs are two of those programs designed to help customers upgrade their equipment with high efficiency options, as well as incorporate measures that optimize the energy use of existing equipment. Emphasis is placed on comprehensive solutions, rather than single measures. Program Allies are leveraged to help customers participate in this program.

This Participation Guide covers eligibility, program requirements, incentive rates, and the application process for Engineered Solutions and Custom Advantage in Triennium II, January 1, 2025 – June 30, 2027. For complete information on all programs in JCP&L's C&I portfolio, please visit the website below.

Parties Involved

- Jersey Central Power & Light (JCP&L)
- TRC a Member of WSP: program implementer
- Customer: JCP&L rate payer and participant of program
- Program Ally: energy efficiency professional assisting customer through program

Program Contact

- Website: https://bizsolutions.energysavenj.com/
- Email: energysaveNJ@trccompanies.com
- Phone: 866-527-5249

1.2 Program Ally Network

The Engineered Solutions and Custom Advantage programs are supported by a network of qualified Program Allies. Program Allies are industry partners who directly support JCP&L's business customers in achieving their energy efficiency goals. Program Allies assist in a variety of program tasks, which may include, but is not limited to: Energy Audit, Engineering Design, Construction Bid, Contract Execution, Construction Administration, Construction Management, Commissioning, and Measurement and Verification (M&V). The projects themselves can include retrofits, end-of-life equipment replacements, tune-ups of existing equipment, controls, and much more.

For Engineered Solutions, Program Allies must be approved by the program, execute a Program Ally Agreement, and receive training prior to submitting project applications.

For Custom Advantage, an approved Program Ally is not required.

1.2.1 How to Apply

Prospective Program Allies must submit an Engineered Solutions Program Ally Application, which can be downloaded from https://bizsolutions.energysavenj.com/become-a-program-ally/. Program Allies are expected to join program trainings, as offered, and quarterly Program Ally calls.

1.2.2 Benefits of Being a Program Ally

- Ability to participate in select JCP&L energy efficiency programs and obtain incentives for customers.
- Opportunities to attract new business or increase project scope.
- Opportunity to list your business information in the Program Ally Directory
- Invitations to Program Ally-only meetings and trainings.
- Program communications to stay current on program updates and training opportunities.
- Program Ally Portal and co-branded Marketing materials to enhance your customer proposals.
- Program Ally JCP&L recognition for performance.

1.2.3 JCP&L Program Ally Portal

Approved Program Allies receive credentials to login to the JCP&L Program Ally Portal. The Program Ally Portal allows for submission of project applications, houses program and project resources, and shows Project and Application status, Incentive Totals, and Energy Savings.

Visit https://jcpl.capturesportal.com/Account/Login to view your dashboard position, access your projects, view Program Ally Resources, or submit an online application.

1.3 Eligibility

The Engineered Solutions and Custom Advantage programs offer distinct support for commercial and industrial customers undertaking large-scale projects:

- **Engineered Solutions** provides comprehensive, program ally-led audits and project guidance from start to finish. Incentives are determined by a six-year buydown on the project payback to no less than three years, and customers can repay remaining costs through a financing plan offered by the National Energy Improvement Fund (NEIF).
- **Custom Advantage** offers a more flexible approach, allowing customers to use a program ally or consultant of their choice and permits acceptance into the program even after the audit or design has been completed. The incentive is calculated based on the energy savings, and customers can repay remaining costs through a financing plan offered by NEIF.

Feature	Engineered Solutions	Custom Advantage
Target Market	MUSH (municipality, university, school, and hospital) customers; C&I and multifamily customers in underserved areas (OZ, UEZ, OBC).	All JCP&L commercial and industrial (C&I) and multifamily customers.
Scope Requirement	Multiple measures with combined minimum annual energy savings of 200,000 kWh	Single or multiple measures with combined minimum annual energy savings of 25,000 kWh. Single measure scope cannot be a prescriptive measure.
Incentive	Six-year buydown on payback to no less than three years, and 100% of audit cost	Incentivized based on energy savings on a $/kW and $/Therm basis capped at 75%* of project cost. *80% for income-eligible multifamily projects.
Engineering Consultant	Approved program ally	Customer can use an approved program ally or consultant of choice
Project Timeline	On average, 1-2 years for construction completion	On average, 6 months - 2 years for construction completion

Table 1. Engineered Solutions and Custom Advantage Comparison

1.3.1 Project Boundary

Generally, each stand-alone building is considered a project for program purposes. Exceptions may be available for a multi-building property or campus of buildings.

1.3.2 Multifamily

The following additional eligibility requirements apply:

- Must be a JCP&L customer with at least one commercial electric account
- Multifamily buildings must contain 3 or more residential units
- The building owner must be the applicant/customer
- Common area and/or in-unit equipment must be owned by the building owner

Multifamily residents with individually metered residential accounts looking to upgrade resident-owned equipment may participate through the Residential programs.

1.3.3 Income Eligibility Criteria

In some cases, income-eligible multifamily buildings are eligible for increased incentives and financing thresholds. A multifamily property will be considered income-eligible if **one** of the following criteria is met:

- **Affordable housing designation:** Any residential building that has an official document identifying the customer as participating in a federal, state, or local affordable housing program (e.g., New Jersey Housing and Mortgage Finance Agency, United States Low Income Housing Tax Credit, United States Housing and Urban Development, housing owned and operated by Public Housing Authorities, Section 8, Section 202, Section 811).
- **Physical location:** A property identified in a physical location classified as a low-income zone:
- **Census tract** — Residences and businesses located within a low- or moderate-income census tract. Census tract confirmation can be verified at FFIEC Geocoding/Mapping System.
- **Overburdened Community (OBC)** — Residences and businesses located within an OBC “Low Income” community will be eligible for enhanced incentives, and their impacts can accumulate towards the LMI/OBC QPIs. Only customers in the following OBC categories, as defined by the New Jersey Department of Environmental Protection (“DEP”), will be tracked and reported:
    - Low Income
    - Low Income and Limited English
    - Low Income and Minority
    - Low Income, Minority, and Limited English
- OBC confirmation can be verified at Overburdened Communities | NJ Environmental Justice Mapping, Assessment and Protection Tool (EJMAP) using these three 2021 Archived Layer List criteria:
    - 2021 Overburdened Communities and Adjacent Block Groups
    - 2021 Municipalities with Overburdened Communities under the NJ Environmental Justice Law
    - 2021 Overburdened Communities by Criteria

- **Opportunity Zone (OZ):** Businesses with a premise within a New Jersey Opportunity Zone may qualify for enhanced incentives. The impacts can accumulate towards the LMI/OBC QPI. OZ confirmation can be verified at **NJ Community Asset Map**.
- **Urban Enterprise Zone (UEZ)** — Businesses with a premise within a UEZ may qualify for enhanced incentives. The impacts can accumulate towards the LMI/OBC QPI. UEZ confirmation can be verified at **Urban Enterprise Zone Business Eligibility Locator**.
- **Alternative income eligibility** If the above criteria are not met, alternative income eligibility—such as active participation in a state income program—will be considered (e.g., food stamps, Temporary Assistance for Needy Families).

Program Allies should consult the Program Manager for guidance on documenting and verifying income eligibility for a specific project.

1.3.4 Eligible and Ineligible Measures

The Engineered Solutions and Custom Advantage program can accommodate a variety of energy saving measures, including, but not limited to the below:

- HVAC upgrades/replacements
- Refrigeration upgrades/replacements
- Lighting upgrades/replacements
- Controls, including lighting controls, HVAC controls, and building-wide systems, and retro-commissioning of existing controls
- Envelope improvements, including air-sealing/weatherization and improved insulation
- Retro-commissioning (RCx) itself cannot be proposed as a standalone recommended measure if no specific details and calculations are provided for individual control strategies. However, measures identified through the RCx process may be eligible for incentives (e.g., hot water supply temperature resets, nighttime setbacks, outdoor air reductions, addition of variable speed drives to one-speed pumps).
- Measures involving a fuel switch from fossil fuel to electric shall be first evaluated under JCP&Ls Decarbonization Program. Systems not covered under that program may be evaluated in Custom Advantage.

The following are generally *ineligible* for the program:

- New Construction, including ground-up new construction and major/gut renovation resulting in change of space use. Incentives for this are offered by the New Jersey’s Clean Energy Program https://cleanenergy.nj.gov/

- Distributed generation, renewables, CHP or fuel cells, energy storage, and battery storage. These technologies may have programs offered by the New Jersey's Clean Energy Program https://cleanenergy.nj.gov/
- Behavioral measures
- Demand response and load shifting measures
- Stand-alone operations and maintenance measures (such as cleaning coils, dampers, sensors, and heat exchangers, routine calibration of systems, and filter replacements).
- UV-C-based measures
- Sub-metering and monitoring equipment.
- Power factor correction equipment.
- Refrigerant additives.
- Emerging/unproven technologies, or measures that have not been historically incentivized in utility prescriptive, custom, and whole building programs. See Section 4.9.
- Individual measures receiving incentives from another BPU or Utility program

Proposed measures must meet or exceed minimum requirements as outlined by ASHRAE 90.1-2019. In cases where ASHRAE 90.1-2019 does not apply, other applicable industry standards will be used, such as the Consortium for Energy Efficiency (CEE), EPA ENERGY STAR, Design Lights Consortium, NEMA, Federal Title 10 or other established resources such as the New Jersey Technical Resource Manual, current New Jersey baseline studies and other market research; the program experience of the Commercial/Industrial Program Manager; experience of the New Jersey utilities; or utility/public program experience from other comparable jurisdictions.

1.4 Incentives & Financing

Engineered Solutions and Custom Advantage offers incentives for both electric and natural gas saving measures. Projects whose energy savings are expected to be predominantly natural gas are advised to apply for incentives through their gas utility programs.

1.4.1 Engineered Solutions Incentive Rates

The Engineered Solution incentive "buys down" the simple payback of the project by up to 6 years, to no less than 3 years.

- **What is "simple payback"?** It's a calculation that determines how many years it takes the project to pay off based on energy cost savings

Example: A whole building projects costs $2,000,000 to implement. The annual energy cost savings that the engineering firm calculates that the customer will see on their bills is expected to be $250,000 each year. The simple payback for this project is 8 years.

$$Simple\ Payback\ (years) = \frac{\$2{,}000{,}000}{\$250{,}000/year} = 8\ years$$

- **How does the incentive come into play?** The incentive ($) reduces the total cost of the project. This means the energy savings will pay for the cost of the project faster. The program will pay an incentive so that the simple payback is 6 years sooner. But, won't bring it to below 3 years.

Example: The project above with 8 year payback gets bought down to 3 years even:

$$Simple\ Payback\ with\ Incentive\ (years) = 3\ years = \frac{\$2{,}000{,}000\ - \boldsymbol{Incentive\ (\$)}}{\$250{,}000/year}$$

Solve for x… Incentive = ***$1,250,000***

Because the incentive is based on the number of years bought down, not a fixed percentage of project cost, the incentive as a percentage of total project cost changes depending on the project's payback before incentives are applied.

The following table shows the relationship between project paybacks of 5 and 25 years (without incentives). Potential incentives are highest, about 67% of project cost, for projects with a 9-year payback before incentives. At that payback, the full 6-year buydown is applied and the resulting payback is 3 years.

Projects with higher capital cost projects, and/or low savings to cost ratio, will have longer project paybacks. Project paybacks may exceed what is shown below, in which case the percent incentive reduces proportionally. These figures show how the incentive works and are not a calculation for any specific project. Actual incentive amounts are determined through program application and engineering review.

Payback Before Incentive	Buydown Applied	Payback After Incentive	% of Project Cost Incentivized
5 yrs	2 yrs	3 yrs	40.0%
6 yrs	3 yrs	3 yrs	50.0%
7 yrs	4 yrs	3 yrs	57.1%
8 yrs	5 yrs	3 yrs	62.5%
9 yrs	**6 yrs**	**3 yrs**	**66.7%**
10 yrs	6 yrs	4 yrs	60.0%
11 yrs	6 yrs	5 yrs	54.5%
12 yrs	6 yrs	6 yrs	50.0%
13 yrs	6 yrs	7 yrs	46.2%
14 yrs	6 yrs	8 yrs	42.9%

Payback Before Incentive	Buydown Applied	Payback After Incentive	% of Project Cost Incentivized
15 yrs	6 yrs	9 yrs	40.0%
16 yrs	6 yrs	10 yrs	37.5%
17 yrs	6 yrs	11 yrs	35.3%
18 yrs	6 yrs	12 yrs	33.3%
19 yrs	6 yrs	13 yrs	31.6%
20 yrs	6 yrs	14 yrs	30.0%
21 yrs	6 yrs	15 yrs	28.6%
22 yrs	6 yrs	16 yrs	27.3%
23 yrs	6 yrs	17 yrs	26.1%
24 yrs	6 yrs	18 yrs	25.0%
25 yrs	6 yrs	19 yrs	24.0%

Table 2. Engineered Solutions Incentives Based on Project Payback

1.4.2 Custom Advantage Incentive Rates

Custom Advantage incentives are based on the project's anticipated energy savings and is capped at (a) the rate-based incentive below; (b) 75% of incremental project cost (80% for income-eligible multifamily buildings); or (c) the amount that buys the project's simple payback down to no less than 2 years.

For Custom Advantage, all incentives are capped at $4,000,000 per entity per Fiscal Year.

Pathway	Annual Savings	Lighting	Electric HVAC*	Electric- Other†	Gas^
Standard	≥ 25,000 kWh and < 200,000 kWh	$0.16 /kWh	$0.30 /kWh	$0.30 /kWh	Up to $3.75/therm
Enhanced	≥ 200,000 kWh	$0.50 /kWh	$2.50 /kWh	$1.00 /kWh	Dependent on partner gas utility offering: **PSE&G:** $15/therm **NJNG:** $20/therm **ETG, SJG:** $10/therm

Table 3. Custom Advantage Incentive Rates

*Applies to equipment that generates heating or cooling capacity, such as packaged RTUs, chillers, and heat pumps. Qualifying systems must be listed in ASHRAE 90.1-2019 Tables 6.8.1-1 through 6.8.1-17 (excluding 6.8.1-11). Exceptions may apply to heating and cooling systems that fall outside the scope of 90.1-2019.

† Applies to all other electric efficiency measures including HVAC controls and improvements to fans and pumps.

^ Note: subject to change at the gas utility discretion

1.4.3 Incentives Processing and Payment

Incentives are processed upon receipt of each deliverable and paid to the Program Ally and/or customer. The structure below allows for up to 5 individual customer payments. Customers who prefer not to receive incremental payments may instead choose to receive the incentives as lump sum payments.

Phase	Program Ally Incentive	Customer Incentive
Audit	Approved Audit Fee (Engineered Solutions projects only)	None
Bid & Contract Execution	None	None
Construction & Commissioning	None	30% paid when construction starts 20% (to up to 50%) paid in up to 2 payments (i.e., 10% each) as work progresses, tied to site inspections and contractor payment requests.
Measurement & Verification	None	Remaining up to 50% paid after construction/commissioning **and** M&V (if required) is complete and all closeout documents are approved. At the program manager's discretion, this payment may be split into a partial payment (e.g., 30%) upon completion, with the balance (e.g., 20%) withheld until M&V is complete.

Table 4. Incentives Processing and Payment

- Customers may choose to receive incentives via the staged payment structure above, or as lump sum payments. When M&V is required, the lump sum payment will be issued after M&V is completed.
- If M&V is not required, remaining incentives are paid at project completion (construction and commissioning).
- If M&V is required, in whole or in part for specific measures, the program reserves the right to withhold or retain a portion of the final incentive payment until M&V is completed.
- Once M&V is completed and results are reviewed, the final incentive payment value will be determined and released.

1.4.4 Program Ally/Technical Assistance Funding

The Engineered Solutions and Custom Advantage Programs offer eligible customers access to technical assistance services throughout the project lifecycle, from initial audit through post-installation M&V. JCP&L will pay the Program Ally directly for eligible technical assistance services as they are completed. **These payments are advanced on the customer's behalf and are deducted from the final incentive payment**, except for the Energy Audit for Engineered Solutions projects.

Program Allies may select which technical service phases to draw upfront funding support from; there is no requirement to participate in every phase. Partial payments are available at key project milestones to support cash flow across longer projects. Customers should discuss technical service scope and funding elections with their Program Ally early in the project, since technical services drawn will reduce the final incentive payment accordingly. Applicants may choose to request lump sum payments or partial payments for the services listed below.

If customer does not work with a Program Ally, and instead chooses to work with a preferred contractor, this funding option may still be available pending contractor vetting by program.

Engineering Service	Milestone	Payment
Energy Study	50% Complete	50% of study cost
	100% Complete	Remaining study balance
Engineering Design and Bid	50% Complete	50% of design cost
	100% Complete / Final Bid Approved / Customer Signs Committed Offer	Remaining design balance
Construction Administration (CA) and Commissioning (Cx)	Project initiation	30% of CA and Cx cost
	First construction inspection	25% of CA and Cx cost
	Second construction inspection	25% of CA and Cx cost
	Final construction inspection	Remaining CA and Cx balance
Measurement and Verification (M&V)	Q1 M&V Report	25% of M&V cost
	Q2 M&V Report	25% of M&V cost
	Q3 M&V Report	25% of M&V cost
	Q4 M&V Report	Remaining M&V balance

Table 5. Technical Assistance Funding

1.4.5 Limited Time Offers

In addition to the incentives above, JCP&L may offer Limited Time Offers to enhance incentives. Please inquire with Program on availability.

1.4.6 Financing

Projects may be able to participate without any up-front funding by combining program incentives with program financing. Interest-free financing may be available for project costs not covered by incentives (if qualified). Learn more here

Who is Eligible?

- Eligible borrowers are any commercial, industrial, non-profit, municipal or multifamily (4+ units) customer that meet NEIF's credit approval standards and are making qualifying improvements.
- Improvements must qualify for and be awarded a program rebate.

What Improvements Qualify?

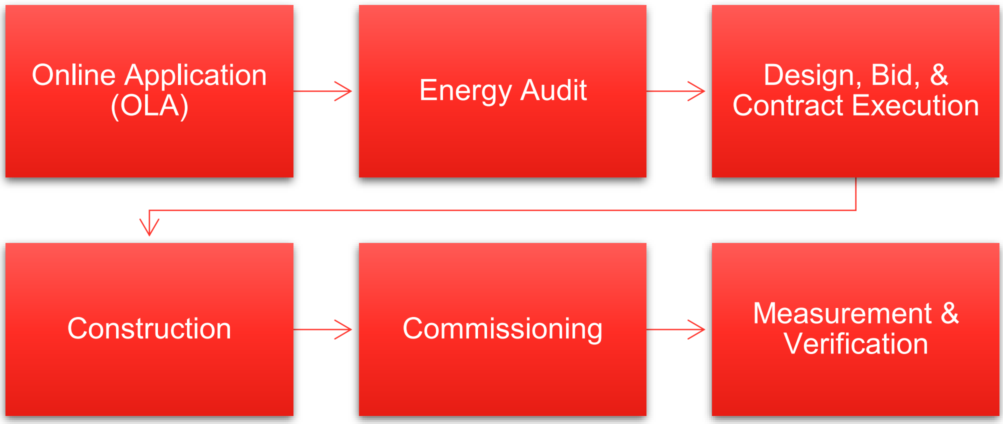
- Work must be performed by a NEIF-Approved Contractor and qualify for a JCP&L program rebate.
- Loan Offer Details:
    - Loan is financed off bill through NEIF for up to 5 years
    - 0% financing is available for financed amounts < $250,000
    - 0% financing is available for 80% of the financed amount over $250,000, with no cap on the financed amount
    - Municipal, University, School, and Hospital (MUSH) customers and customers in Overburdened Communities (OBC) may be eligible for 0% financing for the entire financed amount, regardless if the total loan amount is over $250,000

1.5 Application Process

The image below summarizes the program life cycle of each project.

Projects enrolled in **Custom Advantage** may bypass the energy audit and/or design phase.

Measurement and Verification may be tailored based on scope of work.



1.5.1 Application

The following are required for application submission:

- ☐ Completed online application (OLA)
- ☐ Signed OLA agreement by the customer
- ☐ Customer W-9 Form (dated within 2 years)
- ☐ Payee W-9 Form, if other than Customer (dated within 2 years)
- ☐ Engineered Solutions Project Screening Workbook containing general details of facility (available for download on the OLA)
- ☐ Customer JCP&L Utility Bill (primary account), no more than 2 months old at time of submission
- ☐ Audit Proposal with fees (if applicable)

1.5.2 Energy Audit

The Program Ally or customer's engineering consultant completes an ASHRAE Level II energy audit, and customers receive a comprehensive energy audit that evaluates existing systems, identifies energy efficiency opportunities, and provides actionable insights to support project implementation.

Upon completion of the Audit phase, the following deliverables shall be submitted for review:

- ☐ ASHRAE Level II Energy Audit Report (*not required for Custom Advantage)*
- ☐ Baseline facility energy usage and utility bill analysis with blended utility rates
- ☐ Engineering calculations used to develop estimated energy savings for each ECM, including any supporting documentation (spec sheets, nameplate photos, etc.)
- ☐ Cost Benefit Analysis Tool (CBA)
- ☐ Proposed project costs, including any supporting documentation
- ☐ Draft M&V Plan *(scope dependent)*
- ☐ Estimated Project Schedule

1.5.3 Design & Bid/Contract Execution

The Program Ally or customer's engineering consultant provides comprehensive design services, developing tailored energy efficiency solutions, including specifications and bid-ready documents to ensure optimal performance and seamless integration.

Upon completion of the Design phase, the following deliverables shall be submitted for review:

- ☐ Updated Engineering calculations with supporting documentation
- ☐ CBA Tool with updated project costs, engineering fees, and energy savings as applicable
- ☐ Documentation of cost and energy savings changes including updated savings calculations and written narrative summarizing reasons for changes (Written confirmation of no changes to design/savings to be provided, if not applicable)
- ☐ Signed contracts or POs, with building and measure level breakdown (Values should match CBA)
- ☐ Updated construction schedule, including forecasted start date, 50% completion, and 100% completion date for each measure, current construction status, and % complete of each measure, if applicable
- ☐ M&V plan revised based on design *(scope dependent)*
- ☐ Payment schedule (If project is financed through NEIF, a construction progress payment schedule is required to properly have NEIF release funding)

1.5.4 Construction

The Program Ally or customer's engineering consultant supports the installation phase, providing construction administration to ensure the project is completed on time and meets program standards.

Upon completion of progress inspections during the Construction phase, the following deliverables shall be submitted for review:

- ☐ Construction Inspection Reports, inclusive of photos, any applicable change orders, and contractor payment requests with line-by-line detail (preferably AIA forms)
- ☐ Progress Invoices with building and measure level breakdown

Upon completion of the Construction phase, the following deliverables shall be submitted for review:

- ☐ Updated Engineering calculations with supporting documentation
- ☐ CBA Tool with updated project costs, engineering fees, and energy savings as applicable
- ☐ Documentation of cost and energy savings changes that occurred during construction and written narrative summarizing reasons for changes (Written confirmation of no changes to design/savings to be provided, if not applicable)
- ☐ Final Invoices with building and measure level breakdown (values should match CBA)
- ☐ Final Inspection Report
- ☐ Final M&V plan revised as needed *(scope dependent)*

1.5.4.1 Invoices

Invoices submitted to the program must include at minimum:

- Customer/facility name
- JCP&L utility account number(s)
- Project address
- Date of Invoice
- For TA fees: description of service/phase and dollar amount
- For ECM costs: description of material/labor/work completed and dollar amount.

If the Program Ally is also constructing the ECM’s, they must track ECM invoices separately from engineering services.

If TRC pre-approves a project to be self-installed by the Customer, written documentation shall be provided in lieu of a labor invoice attesting to the start and end dates of the self- installation, totals hours, and internal hourly rate.

1.5.5 Commissioning (Cx)

The Program Ally or customer’s engineering consultant is responsible for system testing and validation to confirm that all installed measures perform as intended and meet the energy efficiency goals, ensuring a smooth transition to operation.

Upon completion of the Cx phase, the following deliverable shall be submitted for review:

☐ Commissioning report and punch list report showing no outstanding issues that impact energy savings for measures in scope

1.5.6 Measurement & Verification (M&V)

The metering and monitoring period must be long enough to accurately represent the annual amount of energy consumed by the affected equipment. Each period will be dependent on measure type, controls, and overall project complexity.

As defined by the M&V plan approved by the Program, the Program Ally monitors post-installation performance to validate energy savings, measure program impact, and provide insights for ongoing improvements.

Upon completion of each period of the M&V phase, the following deliverable shall be submitted for review:

☐ M&V Report(s) based on approved M&V Plan.

1.6 Process Overview

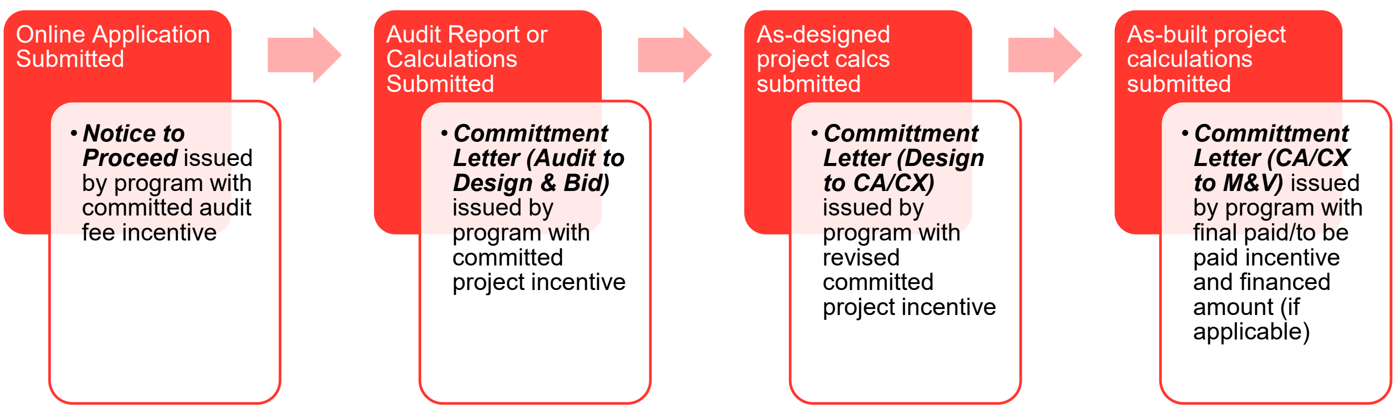
1.6.1 Inspections

All applications are subject to pre- and post-installation inspections to confirm existing site conditions and installed scope of work are aligned with program documentation. Inspections are scheduled with the contact person identified on the application, with the assistance of a Program Ally when necessary.

1.6.2 Pre-Approvals

Program pre-approval is required to move through each phase of the program as illustrated below. Applicants who proceed with the next phase prior to program approval may not be eligible for incentives.

Projects that begin construction or installation before a Commitment Letter is issued may not be eligible for incentives.



1.6.3 Deficient Applications

If an application package is incomplete, information is missing or deemed insufficient by JCP&L or TRC, a Request for Information (RFI) will be sent to the Program Ally or applicant requesting additional information via email. The information or documentation requested must be received by TRC as soon as possible to continue through the process. If the Program Ally or applicant fails to respond to an RFI within 30 days, or request additional time, the application may be cancelled. If an application is cancelled, the Program Ally or applicant may re-apply under the Program Incentives and requirements in place at the time of re-submittal.

1.6.4 W9, ST-4 or ST-5

This form must be provided by the entity receiving incentive payment. Certain private business entities may hold a “Sales Tax Exempt Organization Certificate (Form ST-5).” This form applies solely to purchases of tangible personal property or services.

1.6.5 Expirations and Extensions

Projects are given a custom length of time to complete each phase dependent on the planned project timeline as agreed upon by the Program Manager, Program Ally, and Customer. When a project has expired, the Program Ally or applicant will have 60 days to either submit a request for an extension OR submit final project paperwork. If no response is received within 60 days of expiration, the project may be cancelled.

Extension requests must be in writing from the Program Ally or applicant and include the circumstances that led to the extension request, amount of extension requested, the percentage of the project completed, and an updated timeline for the remainder of the project.

Extension requests will be reviewed and may be granted by JCP&L staff. Please be advised, extension requests are not guaranteed.

1.6.6 Prevailing Wage and Public Works

If the work to be performed by the Program Ally qualifies as a “public work” under the New Jersey State Prevailing Wage Act, N.J.S.A. 34:11-56.25 et seq. (the “Act”), the Program Ally agrees to adhere to and comply with the Act and shall require the same of its subcontractors. These obligations include but are not limited to: 1) workers employed in the performance of work under the Program shall be paid not less than the prevailing wages applicable, and 2) the Program Ally will employ on the site only individuals who have successfully completed all OSHA-certified safety training, if any, required as a prerequisite for the particular work to be performed under the Program. If the work falls under the jurisdiction of the New Jersey Division of Property Management and Construction, the Program Ally agrees to comply with and to require its subcontractors to comply with all requirements of that agency and any related law.

In addition, if a Customer is subject to the Local Public Contracts Law N.J.S.A. 40A:11-1 et seq. (LCPL), Public School Contracts Law N.J.S.A. 18A:18A-1 et seq. (PSCL), the County Colleges Contracting Law 18A:64A-1 et seq. (CCCL), or other bidding requirements or laws not noted above, the customer is responsible for meeting these bid requirements, and the Program Ally will support these requirements.

1.6.7 Program Dispute Resolution

Disputes, concerns, or complaints that arise will be addressed initially by the Program Manager or JCP&L Program Staff at the point of contact. Appeals and disputes must be presented to the Program Manager within 45 days of the Program Manager’s determination regarding the subject of the appeal or dispute.

For contractual disputes between a system owner and installer or registrant, the NJ Division of ConsumerAffairs (DCA) is the point of contact, and the agency has an online complaint form.

The program is designed to allow for participation by any third-party contractor that meets the program requirements. One of the primary responsibilities of the program is to oversee the level of performance of the contractors that participate in the program. There are utility approved contractor remediation procedures that will be followed if a contractor is found to violate program procedures and rules or consistently violates program requirements, which may include being barred from participating in the program.

1.7 Cost Benefit Analysis Tool Requirements

The Cost Benefit Analysis Tool (CBA) is a program provided workbook that summarizes the project's scope, energy savings, and costs in order to calculate the estimated incentive and customer responsibility. The CBA also calculates project payback and NJ Cost Test value. Instructions on how to complete this tool are found within the workbook.

1.7.1 Establishing Baseline

The CBA background calculations vary depending on whether a measure's "Installation Type" is considered new construction, early replacement, or retrofit. Early replacement measures require energy savings to be calculated against both existing conditions and code (i.e. dual baseline).

Type	Description and Requirements	Baseline
New Construction / Normal Replacement	Refers to installation of new equipment where existing equipment did not exist, replacement of existing inoperable equipment, or new equipment installed in an existing building that is not otherwise a retrofit or replacement of existing equipment. Full lighting redesign.	ASHRAE 90.1-2019 code or common market practice if code does not apply (or for low-rise Multifamily, IECC 2021). For lighting, calculate the measure life with the adjusted measure life calculation as defined in the TRM
Early Replacement	Refers to replacement of existing operable equipment before it reaches 2/3 of its equipment useful life (EUL)	Both (1) compared to existing conditions and (2) compared to code baseline.
Extended Life	Refers to replacement of existing operatable equipment after it reaches 2/3 of its EUL. Documentation is required to confirm equipment age and working condition	Both (1) compared to existing conditions and (2) compared to code baseline.
Retrofit / Add-on	Refers to the addition of equipment to an existing system such as HVAC controls or variable frequency drives (VFDs) that enhances performance of existing equipment. Standard lighting replacement work	Existing conditions if they can easily be established and quantified. Otherwise, same as new construction. For lighting, calculate the measure life with the adjusted measure life calculation as defined in the TRM

Table 6. Establishing Baselines

1.7.2 Incremental Costs

The CBA requires entry of both total installation cost and incremental cost for each ECM. Incremental cost is the cost differential between the measure to be installed and its code compliant version.

Please refer to the "*NJIMC_CompleteDatabase_06162025_forDistribution*" file, and associated guidance document for incremental cost data. If the equipment included in the EEM is not listed in this file, then a custom estimate of the incremental costs will need to be developed. Program Ally may estimate costs using cost estimation manuals, vendor quotes, design team calculations, online pricing, or other reasonable methods. Project cost should include, at a minimum, relevant material, and labor/installation costs. Sales tax should be excluded from these figures.

Please follow the directions below to populate costs depending on the "Installation Type" of each measure.

Type	Description
New Construction, Normal Replacement, Early Replacement, Extended Life	Calculate total installation cost of measures, and the incremental cost with the EEM cost as described above.
Retrofit / Add-in	Calculate total installation cost of measures and set the incremental cost equal to that amount.

Table 7. Incremental Cost Methodology

Project costs must reflect only the direct costs associated with the eligible measure(s), including equipment, materials, and labor directly tied to the qualifying installation. The Program Manager reserves the right to determine whether submitted costs are measure-related. Applicants should provide detailed cost breakdowns with clear line-item descriptions to support review.

1.8 Responsibilities

Phase	Program Ally	Program Manager (TRC)	Customer
Application	■ Complete a walkthrough and/or interview of the building(s) to determine savings potential and program eligibility ■ Submit Online Application and all required documents ■ Respond to any review questions from TRC ■ Draft proposal for audit and/or engineering services and provide to Customer ■ Coordinate kick off meeting with TA, Customer, and JCP&L contact(s) if available	■ Conduct a screening call with the TA and customer to vet the projects potential, if needed ■ Application and proposal review and approval ■ Attend project kickoff meeting with TA, Customer, and JCP&L contact(s) if available	■ Join project screening call with TA and TRC staff member, if needed ■ Provide TA with needed information to complete the Online Application or submit application if customer prefers ■ Electronically sign the Customer Agreement when received ■ Sign Audit/ Engineering Proposal ■ Attend kick off meeting
Audit	■ Conduct site visit(s) and collect data ■ Complete site utility analysis ■ Generate energy savings and cost for all ECMs ■ Draft the Audit Report ■ Draft the M&V plan ■ Respond to any technical review questions from TRC in a timely fashion ■ Complete CBA once calculations are approved ■ Lead the Audit review meeting to present the findings to the Customer team	■ Review and approve the Audit Report, M&V Plan, calculations, and CBA ■ Complete Pre-Inspection site visit ■ Attend the Audit review meeting to present the findings to the Customer team ■ Process payment to TA for Audit Completion ■ Draft commitment letter to send to Customer	■ Facilitate site visit(s) access ■ Support data collection ■ Respond to RFI's or question from the TA, as needed, and in a timely fashion ■ Attend Audit review meeting ■ Select energy efficiency measure to proceed to implementation ■ Sign commitment letter to proceed to Design ■ Sign Engineering Proposal
Design	■ Share expected schedule for each engineering phase with TRC, and update as needed ■ Conduct further site visits and collect data, as needed ■ Develop design documents, and follow all code and customer specific design requirements ■ Support Customer in the bid process ■ Support Customer to get contracts signed with Contractor(s)	■ Share planned schedule with JCP&L ■ Review and approve design deliverables ■ Draft revised commitment letter to send to Customer ■ Process 1st Progress Payment to Customer	■ Facilitate site visit(s) access ■ Review and approve Design Documents ■ Sign contracts with Contractor(s) ■ Sign commitment letter ■ Make payment(s) to TA for Design Support

Phase	Program Ally	Program Manager (TRC)	Customer
	■ Submit all deliverables to TRC for review		
Construction	■ Review Contractors submittals and stamp approved submittals ■ Share expected construction schedule with TRC, and update as needed ■ Notify TRC when Customer/Contract or is requesting additional payment ■ Complete on-site progress inspections and submit inspection reports to TRC ■ Coordinate final inspection with Customer, contractor, TRC, and JCP&L ■ Coordinate with Contractor to train facilities staff on operating new equipment ■ Submit all deliverables to TRC for review ■ Respond to any technical review questions from TRC in a timely fashion.	■ Share planned construction schedule with JCP&L ■ Review TA's progress inspection reports ■ Complete Final-Inspection site visit and generate report ■ Verify all equipment in scope was installed ■ Review TA's Final Inspection report, and review and approve all required deliverables. ■ Process Progress Payments to Customer aligning with progress inspections	■ Facilitate site visit(s) access ■ Support Construction Management in house, or hire a CM to manage the project ■ Take part in all inspection walkthroughs, and approve payment requests ■ Provide staff availability to attend Contractor/TA training ■ Make payment(s) to TA for CA Support
Cx	■ Develop Cx Plan ■ Get approval of Cx Plan from Contractor and Customer ■ Complete Cx Activities once Construction is complete ■ Verify all open Cx items are closed out ■ Submit Cx Report to TRC	■ Review Cx Report ■ Follow up with TA on any outstanding Cx items ■ Process Final Progress Payment to Customer	■ Facilitate site visit(s) access ■ Provide facilities staff to support Cx activities as requested by TA ■ Make payment(s) to TA for Cx support
M&V	■ Complete on-site M&V tasks ■ Apply remediation measures, as needed ■ Submit M&V reports to TRC and Customer for review at designated periods based on approved M&V Plan	■ Review and approve M&V reports ■ Submit M&V reports to JCP&L	■ Facilitate site visit(s) access ■ Provide facilities staff to support adjustments to equipment as requested by TA to improve energy savings ■ Review M&V reports ■ Make payment(s) to TA for M&V support

Table 8. Stakeholder Responsibilities

2. Pre-Audit Screening Guidelines

When identifying candidates for energy efficiency projects, Program Allies should apply guidelines and best practices that align with program goals and highlight significant improvement opportunities. This section includes a pre-screening checklist to help Program Allies efficiently evaluate potential projects, identify strong candidates, and maximize energy savings of each project.

2.1 Program Requirements

Program allies shall confirm the customer qualifies as a non-residential or multifamily customer (3+ units) and meets minimum annual peak demand or natural gas load requirements before proceeding.

2.2 Understand the Facility

Program allies shall collect and review prior to or during the audit:

- 12–24 months of utility bills (electricity, gas, other fuels)
- Facility layouts, equipment inventories with specifications and operating schedules
- Maintenance logs, energy management policies, and previously completed audits
- Details on recently completed or planned projects
- Operating hours, seasonal demand variations, and occupant behavioral factors

2.3 Establish Baseline Metrics

Benchmarking and energy cost assessment are critical initial steps in identifying inefficiencies and areas for improvement in a facility's energy performance. By comparing the facility's energy usage to similar buildings, benchmarking highlights opportunities for increased efficiency, while an energy cost assessment quantifies potential savings and justifies investment in energy-saving upgrades. Establishing baseline metrics, such as total energy consumption, costs, and energy use intensity (EUI), provides a foundation for measuring improvements post-audit and ensures the project delivers tangible benefits. As part of this process, Program Allies should assess if projects have the potential to meet minimum savings thresholds required by the program.

2.4 Stakeholder Engagement

Assess customer commitment, decision-making authority, capital availability, and alignment with project goals. Check for recent upgrades that may limit additional savings. Review capital improvement plans for alignment with efficiency opportunities.

2.5 Pre-Screening Checklist

Pre-Screening Checklist
☐ Is the decision maker willing to engage in an energy efficiency project?
☐ Does the customer have capital or financing options to implement the project?
☐ Has the facility undergone significant efficiency upgrades recently?
☐ Are there opportunities for a comprehensive project scope?
☐ What is the age and condition of the building and its systems?
☐ Does the facility have a history of high energy consumption vs. benchmarks?
☐ Does the facility have potential to meet minimum program savings targets?
☐ Is there a capital improvement plan that could support the project?
☐ Are there potential measures with significant gas savings?

Table 9. Pre-Screening Checklist

3. Auditing Guidelines

3.1 General Requirements

Energy audits must meet ASHRAE Level II requirements per ASHRAE Standard 211-2018, including on-site inspection of all major systems, utility bill disaggregation, and quantified recommendations with cost estimates and payback periods. ASHRAE Level III or Investment Grade audits require prior Program Manager approval.

3.2 Pre-Audit Preparation

3.2.1 Pre-Audit Checklist

Pre-Audit Checklist – High Priority Items
☐ Electric utility bills: 24 months, all meters, including supplier bills
☐ Natural gas and other fossil fuel utility bills: 24 months
☐ Mechanical, electrical, and architectural as-built drawings
☐ Asset and equipment lists (HVAC, pumps, fans, lighting, process equipment)
☐ Blank floor plans
☐ Three years of 15-minute interval data (if available from utility)
Pre-Audit Checklist – Optional Items
☐ Previously completed energy audits (including installed measures)
☐ Control sequences for equipment
☐ Building and space operating hours
☐ Maintenance records and combustion reports
☐ Recently completed or ongoing project descriptions

Table 10. Pre-Audit Checklist

3.2.2 Site Access and Scheduling

Before conducting an energy audit, it is important to understand site access limitations and any restrictions that may impact data collection. The following questionnaire provides example questions to ask facility staff regarding access to key areas, security requirements, and potential safety concerns.

Question	Yes?	Response
Will auditors have access to the roof? If no, please confirm that a site representative can collect necessary documentation such as equipment nameplates.	☐	
Will auditors have access to all interior spaces? If no, please confirm which spaces are inaccessible.	☐	
Are there any security checkpoints to access the site? If yes, please explain the requirements.	☐	
Are there any known hazardous materials on-site including asbestos? If yes, please explain.	☐	
Does the facility contain a Building or Energy Management System (BMS/EMS)? If yes, explain if the system has trending and data export capabilities.	☐	
Can auditors take photos of all systems in all spaces?	☐	

Table 11. Site, Space, and System Access Questionnaire

3.2.3 Site Visit Scheduling Questionnaire

To coordinate an efficient site visit, the auditor should confirm scheduling preferences, escort availability, and logistical details with facility staff prior to the visit.

Question	Response
Please provide site visit scheduling preferences, including preferred days of the week and times of day.	
Please confirm the availability of the site escort (full day: 8 hours, half day: 4 hours, or other).	
Please confirm parking location and the meeting point for auditors upon arrival.	

Table 12. Site Visit Scheduling Questionnaire

3.3 Utility Bill Collection

Utility bills must cover a minimum of 24 consecutive months per fuel type, organized by account and meter, and summarized in spreadsheet format. Key requirements:

- Initial and final baseline period readings must be actual (not estimated).
- At least 12 of 24 months must include actual readings.
- Bills must be no more than three years old, with preference for the most recent 12 months.
- Third-party supplier bills must be provided for the same period if applicable.

- Internal software summaries are not acceptable: use actual invoices or utility-provided summaries only.

3.4 Measure Pricing

Acceptable cost documentation: contractor quotes, RS Means (with derivation explanation), or third-party cost estimator reports. Costs must include materials, equipment, installation, permits, inspections, contingencies, disposal, recycling, and refrigerant recovery.

3.5 Audit Report Requirements

An energy audit report provides a detailed assessment of energy consumption patterns, identifies inefficiencies, and offers actionable recommendations for improving energy efficiency. The report should include the following sections:

- Cover Page and Table of Contents
- Introduction
- Facility Description
- Existing Equipment Assessment and Conditions
- Utility Bill Data and Analysis
- Energy Conservation Measures (ECMs)
- Photo Documentation
- Project Schedule
- Appendices

3.5.1 Cover Page and Table of Contents

The cover page should include the report title, the name of the facility or organization, the date of the audit, and the preparer's credentials and contact information. The Table of Contents helps readers navigate the report by listing all sections and subsections with corresponding page numbers.

3.5.2 Introduction

The Introduction shall establish the purpose and scope of the energy audit and provide essential background information about the project. This section should describe the facility's energy challenges or goals, such as minimizing energy costs, achieving sustainability targets, or complying with regulations. It shall outline the audit methodology, including data collection, on-site observations, and analysis techniques, while introducing the audit team. The timeframe and anticipated deliverables should be presented, setting clear expectations for all stakeholders. The project contact list should also be included, covering the owner or owner representative, Program Ally, and other key stakeholders.

3.5.3 Facility Description

The Facility Description section provides an overview of the audited building or site. It should include the facility's type, primary functions, and physical characteristics, such as year of construction, square footage, number of floors, and building configuration. Operating hours, number of occupants, seasonal variations in activity, and typical occupancy patterns shall be outlined to provide context for energy usage. The description should also highlight the major energy-consuming systems and processes, including HVAC, building envelope, service hot water (SHW) and domestic hot water (DHW), lighting, manufacturing equipment, plug loads, and other relevant systems.

3.5.4 Existing Equipment Assessment and Conditions

During the site visit, the audit team will document the physical and operational characteristics of the facility. This includes a comprehensive assessment of all building equipment and systems to identify inefficiencies, maintenance issues, and control settings.

Element	Description
Equipment Inventory	Major systems such as HVAC units, lighting, and process equipment. A complete tabular list of building equipment. Important sequences of operation and operating schedules.
Equipment Condition and Performance	Operational status of equipment. Identified inefficiencies or maintenance concerns. Current control settings.
Behavioral Practices	Energy management protocols. Operational habits affecting energy performance.

Table 13. Building Equipment Assessment

The audit should address the following questions for HVAC systems, where applicable:

Element	Assessment Questions
Temperature Strategies	Does the facility use a zone temperature setup or setback strategy? Is the central supply air temperature fixed, or is a reset strategy used? How is space temperature currently controlled?
System Features	Does the central air system have pre-heat or re-heat? Is free cooling used (e.g., air-side or water-side economizer)?
Air Control	How is outdoor air controlled? What are the design minimum outdoor air requirements?
VAV System Features	Is a supply static pressure reset strategy used? Does the system have automatic shutdown or an optimum start strategy?

Element	Assessment Questions
Energy-Saving Features	Are zone isolation devices used for off-hour operation? Is exhaust air heat recovery implemented?
System Performance	Has the heating and cooling system always met load? If not, under what conditions? Are there issues with humidification or dehumidification?
HVAC Adjustments	What adjustments are made for unoccupied areas (e.g., thermostat changes, HVAC shutdown)? Is HVAC airflow correctly balanced? Are there any equipment sizing issues?

Table 14. HVAC System Assessment Considerations

Key operating parameters for systems comprising over 80% of building energy use should be documented, including:

Element	Description
Operational Set Points	Space heating, cooling, and humidity set points. Space lighting levels. Economizer control parameters. Set points for hot water, steam, chilled water, and condenser water systems. Ventilation level and fan and pump system flow controls. BMS settings.
Operating Schedules	Equipment operating schedules. Occupied and unoccupied hours in controlled zones. Space temperature set point schedules. Warm-up and cool-down periods. Unoccupied override conditions. Lighting occupancy schedules and controls.
Equipment Efficiencies	Steady-state combustion and seasonal boiler efficiency. Cooling equipment efficiency. Heating and cooling distribution efficiency, including motor, pump, and fan efficiencies.

Table 15. Key Building Operating Parameters

3.5.5 Utility Bill Data and Analysis

This section provides a detailed analysis of the facility's historical and current energy usage, focusing on identifying trends and patterns that influence overall consumption. The analysis covers utility data for a minimum of 24 consecutive months (preferably three years) aggregated at the building level by service class.

Data Element	Description
Monthly Utility Data	Rate schedules (standard, time-of-use, block structures, demand charges, power factor charges). Meter number, rate and tariff schedule, and total meters by fuel type. Onsite generation sources and quantities. Monthly energy use (kWh), peak electric demand (kW) for on-peak, mid-peak, and off-peak periods, fuel costs, delivery dates, and number of days in each period.
Monthly Weather Data	Monthly heating and cooling degree days and average outdoor air temperature alongside utility data to identify seasonal trends and support normalization.

Data Element	Description
Delivered Bulk Fuels	Bulk fuel use (therms, gallons, kBtus) with prorated annual amounts based on delivery quantities or inventory changes.
Annual Data	Annual EUI (kBtu/ft2/yr) and Energy Cost Intensity (ECI, $/ft2/yr). Normalization parameters. Total energy consumption breakdown by source in visual format (e.g., pie chart).
End-Use Breakdown	Visual representation of major energy end uses: space heating, space cooling, air distribution, domestic hot water, lighting, motors, plug loads, process loads, refrigeration, cooking, IT, and other. End uses below 5% of annual consumption may be grouped under "Other." For multi-building campuses on a single master meter, justify the breakdown of use between buildings.
Submetering	Description of submetering systems, including metered systems, data recording frequency, and acquisition methods (fixed, portable, or integrated with the BAS).

Table 16. Utility Data Summary

3.5.6 Energy Conservation Measures (ECMs)

The ECM section is the core of the audit report and presents actionable opportunities for energy savings. Each measure should be described in detail, including its purpose, scope, and the system it targets. The report shall quantify energy savings potential, cost savings, implementation costs, and simple payback period for each ECM. Additional financial metrics such as return on investment (ROI) and net present value (NPV) may be included upon customer request.

Capital ECMs involve significant upfront investment and changes to building infrastructure or major systems. Low-cost and no-cost ECMs can be implemented within the facility's existing O&M budget. Items for inclusion shall be determined by the Program Ally based on field observations, and the basis for inclusion shall be stated in the report. Refer to Section 1.3 for a list of measures that do not qualify for incentives.

ECM Element	Description
Description	Describe the existing conditions that provide background for each recommended measure. Describe the recommended measure and the actions required for implementation.
Assumptions	Document all assumptions made in savings calculations and cost estimates, including sources. Assumptions typically pertain to equipment operating hours, energy usage patterns, system performance, and baseline conditions when actual data is unavailable. Base assumptions on industry standards, historical data, or reasonable engineering judgment and note any associated limitations or uncertainties.
Ancillary Impacts	List any non-energy impacts relevant to the customer's decision makers, including maintenance costs, labor, equipment upgrades, compliance costs, and downtime.
Summary and Prioritization	Present a summary table of savings for each measure: annual energy savings by utility, electric demand savings, annual cost savings, implementation cost, measure life, and simple payback in years. Express energy penalties as negative values.

Table 17. ECM Report Elements

3.5.7 Photo Documentation

Photo documentation should support audit findings and recommendations. Photos should capture critical components such as HVAC systems, lighting controls, electrical panels, and other significant machinery. Key nameplate photos must be taken for major plant equipment to document specifications including model numbers, capacities, and energy ratings. Images may be organized and shared through a secure shared drive.

3.5.8 Project Schedule

Audits shall include an initial draft project schedule using the scheduling tool provided in the Executive Summary Excel file, which generates a Gantt chart from milestone start and end dates. The schedule should remain high-level, covering major milestones such as design, construction, and implementation phases, and should account for customer decision-making time between phases. Program Allies should update the schedule as the project progresses.

3.5.9 Appendices

The Appendices shall provide supplemental information and detailed documentation supporting the main report, including equipment specifications, photos, and diagrams from the site visit, detailed energy calculations and modeling outputs, historical utility bills and trend data, any additional data sources or tools used in the analysis, and a glossary of terms and acronyms. Equipment list appendices shall provide complete inventories of building systems.

3.6 Multiple Buildings and CBA Tool

For multi-building projects, submit a single audit report and CBA for the campus, with separate calculation workbooks per building unless otherwise approved.

The CBA tool calculates project cost-effectiveness using the NJ Cost Test. Target score: above 1.0. Program Allies populate the CBA after TRC approves savings calculations. Key inputs: measure descriptions, dual baseline type, load profiles, savings by fuel, measure life, installed and incremental costs, and Program Ally fees. Contact TRC for a tool walkthrough.

4. Calculation Guidelines

This section outlines the calculation requirements and standards including technical guidance on establishing appropriate baselines, applying dual baseline and measure life methodologies, and developing accurate energy savings calculations. The section also includes requirements for modeling, documentation, and technology-specific assumptions to support consistent and transparent energy savings calculations.

4.1 Calculation Requirements

Element	Description
Calculation Methodology	Calculations shall include a detailed explanation of the calculation methods used and use standard engineering methodologies. Aside from inputs used to derive savings, calculations should not contain hard coded values. The analysis shall include energy savings (electricity, gas, and other fuels) as well as peak demand savings for summer peak electric demand (kW) and winter peak natural gas (therms per hour). Vendor-supplied and proprietary tools that were not / cannot be peer-reviewed cannot be used as methods to estimate savings For weather dependent measures, a bin-analysis or hourly analysis (including energy models) shall be provided.
Weather Source	TMY3 or an approved equivalent dataset
Temperature Bins	Minimum of 5°F bin intervals. Must cover the full operating range (e.g., -10°F to 100°F for HVAC applications).
Hourly or Monthly Data	Must include annual bin hours per temperature range. Optionally provide hourly, 15-min, or 5-min intervals for high-resolution analysis.
Format	Excel-based calculations or energy models can be used to estimate savings.

Element	Description
	Locked workbooks where formulas and references cannot be viewed will not be accepted. Calculations in.pdf format will not be accepted.
Baseline Conditions	Baseline conditions shall describe quantity, manufacturer, model number, capacity, power ratings, flow rates, efficiencies, hours of operation and control settings. Baseline conditions should be supported by site observations, existing equipment schedules and drawings, and specification sheets.
Proposed Conditions	Proposed conditions shall clearly describe how baseline conditions will be modified. Proposed equipment recommendations shall be based on commercially available equipment. Specifications may be requested to justify proposed parameters.
Baseline and Proposed Load Profiles	Load profiles must be provided including **(1)** equipment operation schedules (hourly, daily, or monthly), **(2)** load variation by temperature, and **(3)** system set points, control strategies, and sequences of operation.
Assumptions	Assumptions used in calculations to establish baseline and proposed conditions or used to estimate savings shall be clearly documented. Sources of assumptions shall be provided.
Measure Granularity	Each measure should be clearly defined, including the specific technology or equipment being upgraded or installed. Measures should reflect individual components, systems, and controls. HVAC controls and plant or system upgrades should be treated as separate ECMs, and individual HVAC control strategies should each be reported as distinct ECMs **Example:** Boiler replacement and outdoor air reset controls are two separate ECMs. Setback controls, demand control ventilation, boiler sequencing, and supply air temperature resets are four separate ECMs.
Measure Interactivity	Individual measures aggregated into a single scope of work will often interact with each other. Measure interactivity shall be integrated into the analysis so that the total project savings account for all interactions among individual measures. **Example:** If the project scope includes a condensing boiler replacement and R-40 roof insulation, the baseline efficiency used in roof insulation calculations should be based on the new condensing boiler efficiency.
Measure Impact on HVAC Systems	Individual measures may indirectly impact heating and cooling loads. Such interactions shall be integrated into the analysis.

Element	Description
	Example: A lighting retrofit will likely increase heating load and decrease cooling load. In this case, additional cooling savings and a heating penalty should be included in the analysis.

Table 18. Calculation Requirements Table

4.1.1 Energy Modeling

In lieu of spreadsheet calculations, energy modeling software may be used to estimate savings for very comprehensive and complex projects.

Software platforms complaint with ASHRAE 90.1 Appendix G may be used including Carrier HAP, Design Builder, EnergyPlus / OpenStudio, eQuest, IESVE, Trane TRACE 3D Plus, and Trane TRACE 700. Input and output reports are required for the baseline model, proposed model, and each individual ECM.

Required input and output reports are provided in Appendix A.

4.2 Establishing Baselines

4.2.1 Measure Baselines

Measure baseline, against which energy savings should be assessed, shall be determined in accordance with one of the four options defined in the following table.

All proposed measures must meet or exceed current building codes/appliance standards or common market practice. The applicable building code is New Jersey's current state energy code, which is ASHRAE 90.1-2019. In cases where ASHRAE 90.1-2019 does not apply, other applicable industry standards will be used, such as the Consortium for Energy Efficiency (CEE), EPA ENERGY STAR, Design Lights Consortium, NEMA, Federal Title 10 or other established resources such as utility/public program experience from other comparable jurisdictions.

If applicable industry standards do not apply, common market practice shall be used as the baseline.

Type	Description and Requirements	Baseline	Dual Baseline Required?	Incremental Cost Required?
Normal Replacement / New Construction	Normal replacement is the replacement of equipment that has reached or passed its effective useful life (EUL) and is not classified as extended life replacement.	ASHRAE 90.1-2019 or common market practice if code does not apply	No	Yes

Type	Description and Requirements	Baseline	Dual Baseline Required?	Incremental Cost Required?
	All new construction applications such as new buildings and expansions on existing buildings. New equipment installed in an existing building that is not a retrofit or normal replacement.			
Early Replacement	Replacement of equipment before it reaches 2/3 of EUL. Equipment must be in good condition and operating generally as intended (i.e., no significant defects or on-going maintenance issues). Documentation such as a nameplate must be provided to confirm equipment age. For HVAC systems, existing equipment may be de-rated due to age as described in Section 4.5. **Remaining useful life (RUL) is equal to EUL – age (years).**	Existing conditions if they can easily be established and quantified. Otherwise, same as normal replacement	Yes	No
Extended Life Replacement	Existing systems use significantly more energy than current high efficiency models and have a history of significant repair and/or maintenance. To qualify as extended life, the project must also meet both of the following rules: **Age Based Rule:** Replacement of equipment after it reaches 2/3 of EUL. **Energy Based Rule:** For chillers replacements, existing chillers must use 35% more energy than high efficiency equipment. For all other systems, the existing system must use 20% more energy than high efficiency equipment.1F1F1F[1]	Existing conditions if they can easily be established and quantified. Otherwise, same as normal replacement	Yes	No

Type	Description and Requirements	Baseline	Dual Baseline Required?	Incremental Cost Required?
	Documentation such as a nameplate must be provided to confirm equipment age. Records and/or invoices for service and/or repair work must indicate that the equipment has been regularly serviced or has undergone significant repairs to maintain useful performance. Other forms of documentation, such as a maintenance schedule / logs, recent inspection reports, preliminary measurements/trend data of existing equipment, statement from the building manager regarding viability and continued intent to use the existing equipment, or a summary of past repairs may be accepted at the Program Manager's discretion. For HVAC systems, existing equipment may be de-rated due to age as described in Section 4.5. Remaining useful life (RUL) is equal to 1/3 of the EUL.			
Equipment Add-on / Retrofit	Equipment add-on (or retrofit) refers to the addition of equipment to an existing system such as HVAC controls or variable frequency drives (VFDs) that enhances performance of existing equipment.	Existing conditions if they can easily be established and quantified. Otherwise, same as normal replacement	No	No

Table 19. Measure Baselines

4.2.2 Special Case Scenarios

The following table provides guidance on establishing baselines for special case scenarios. For other scenarios or clarification how to establish baseline on a specific project, please reach out to the program manager for clarification.

Scenario	Baseline Approach
Space Decommissioning	If a space is being decommissioned (e.g., shutting down operations, demolishing a section of a building), energy savings shall not be included in the scope since the energy reduction is not driven by an efficiency improvement but rather by the removal of loads.
System Decommissioning	The same as space decommissioning, with exceptions. In some cases, system decommissioning may be included in the scope of work if building heating and cooling loads are reduced through energy efficiency measures such as weatherization, building envelope improvements, and ventilation optimization, among other similar measures. Similarly, system decommissioning may be permitted if required to optimize equipment performance, lighting levels, sound levels, comfort levels, and outdoor air. The program manager may require additional documentation or justification to include system decommissioning in the scope of work. In all cases, system decommissioning must be associated with an energy efficiency scope of work rather than non-energy efficiency related drivers.
Space Repurposing / Substantial Renovation	If a space is repurposed such as converting an office to a lab or warehouse to a data center, an adjusted baseline may be required, using code or standard practice for the space. If existing systems will be reused, adjustments may still be required for schedules, set points, and hours of operation.

Table 20. Baseline Approach for Special Case Scenarios

4.2.3 Dual Baselines and Lifetime Savings

A dual baseline approach must be applied in early replacement and extended life scenarios, where a measure has two distinct periods of savings calculation.

- **Step 1 (Early Replacement [ER] or Extended Life [EL] Period):** Calculate energy savings relative to existing energy consumption based on existing conditions and equipment derating, if applicable. Savings can be claimed against existing conditions for the equipment's remaining useful life [RUL].
- **Step 2 (Normal Replacement [NR] Period):** Calculate energy savings relative to baseline energy consumption using energy code efficiency requirements (or industry standard practice, if energy code is not applicable). Savings are claimed against the baseline for the remainder of the equipment useful life [EUL] or measure life.

- **Step 3 (Lifetime Savings):** Under normal replacement (NR) and add-on scenarios, calculate lifetime savings as:

$$Lifetime\ Savings\ (NR\ and\ Add-on) = NR\ x\ EUL$$

Under early replacement scenarios, calculate lifetime savings as:

$$Lifetime\ Savings\ (ER) = ER\ x\ (RUL) + NR\ x\ (EUL - RUL)$$

Under extended life scenarios, calculate lifetime savings as:

$$Lifetime\ Savings\ (EL) = EL\ x\ \left(\frac{1}{3}\ x\ EUL\right) + NR\ x\ (\frac{2}{3}\ x\ EUL)$$

Exception: If the existing equipment's efficiency is higher than the energy code or standard practice, the existing equipment efficiency should be used in NR calculations.

- **Step 4 (Calculate Adjusted Measure Life):** Under ER and EL scenarios, calculate effective measure life as:

$$Adjusted\ Measure\ Life = \left(\frac{Lifetime\ Savings}{First\ Year\ Savings}\right)$$

Internal Check: The effective measure life will always be less than or equal to the EUL.

Example

Consider the following early replacement scenario:

- An existing boiler with 75% efficiency is 10 years old and consumes 1,410 MMBtu/yr.
- A code-compliant boiler with 80% efficiency consumes 1,330 MMBtu/yr
- The proposed condensing boiler with 90% efficiency consumes 1,180 MMBtu/yr
- Energy savings relative to existing conditions is 230 MMBtu/yr (1,410 – 1,180 MMBtu/yr)
- Energy savings relative to code is 150 MMBtu/yr (1,330 – 1,180 MMBtu/yr)
- The EUL is 20 years, which means the RUL is 10 years (20 – 10 years)

Lifetime savings is equal to 3,800 MMBtu using the following formula:

$$Lifetime\ Savings\ (ER) = ER\ x\ (RUL) + NR\ x\ (EUL - RUL)$$

$$Lifetime\ Savings\ (ER) = 230\frac{MMBtu}{yr} x\ (10\ years) + 150\frac{MMBtu}{yr}\ x\ (20 - 10\ years)$$

The effective measure life is equal to 16.5 years (must be less than EUL or 20 years).

$$Effective\ Measure\ Life = \left(\frac{Lifetime\ Savings}{First\ Year\ Savings}\right)$$

$$Effective\ Measure\ Life = \left(\frac{3{,}800\ MMBtu}{230\ MMBtu}\right)$$

4.3 Decarbonization

4.3.1 Fuel Switching Methodology

For measures involving fuel switching, decarbonization and energy efficiency savings shall be calculated separately for an individual project. Decarbonization savings will reflect the source energy savings from replacing fossil fuel equipment with code compliant or industry standard electric baseline equipment. Energy efficiency savings will reflect the kWh energy savings from installing high efficiency electric equipment compared to code compliant or industry standard electric baseline equipment.

- **Step 1 (Establish Fossil Fuel Baseline):** Establish the baseline system type per Section 4.2.1, and calculate baseline therms and site MMBtu consumption (e.g., 10 therms = 1 MMBtu). The baseline system type shall be a fossil fuel system. If existing conditions cannot be established, the baseline shall meet state or local energy code requirements. Industry standard fossil fuel systems may be used if energy code is not applicable.
- **Step 2 (Establish Electric Baseline):** Establish the electric baseline system using energy code or industry standard practice corresponding to the proposed electric system. For example, if the proposed case includes variable refrigerant flow or ground source heat pumps, the baseline is an ASHRAE 90.1 code compliant air source heat pump. Calculate electric kWh and site MMBtu consumption of the electric baseline system. For the purposes of converting kWh to Btus, 1 kWh = 3,412 Btu.
- **Step 3 (Calculate Site Energy Savings):** Calculate the net impact on fossil fuel (e.g., therms), electricity (kWh), and site MMBtu. For many measures, the net impact will be positive fossil fuel savings, electric penalty (negative kWh savings), and positive MMBtu savings. Exceptions apply such as a heat pump replacement that results in slightly positive electric savings as well due to exceptional part load cooling performance.
- **Step 4 (Calculate Source Energy Savings):** Calculate source energy savings per the methodology in Section 4.3.
- **Step 5 (Calculate Proposed Electric Consumption):** Calculate proposed kWh of the replacement system.
- **Step 6 (Calculate Energy Efficiency Savings):** Calculate energy savings (kWh) as the difference between baseline electric kWh consumption in Step 2 and proposed electric kWh consumption in Step 5 (identical to a normal replacement scenario).

The following table provides examples of electrification measures that may be included in scopes of work. Energy savings shall be calculated in accordance with the previous section (4.2.3). Electric resistance heating such as electric baseboards or radiant heating as an alternative to gas heating is not eligible for incentives.

Proposed Equipment Type	Existing Equipment Type(s)
Commercial Food Service	▪ Gas griddles, fryers, and steamers
Electric Chillers including centrifugal, screw scroll, and air-cooled	▪ Steam absorption and turbine chillers ▪ Gas-engine driven chiller ▪ Gas absorption chiller
Electric-powered Manufacturing Equipment	▪ Gas or oil-fired manufacturing equipment
Ground Source Heat Pumps	▪ Fossil fuel heating and/or cooling systems
Heat Pumps Including air-source, water-source, variable refrigerant flow	▪ Fossil fuel heating and/or cooling systems
Heat Pump Dryers	▪ Gas-fired dryers in C&I applications
Heat Pump Water Heaters	▪ Gas or oil-fired water heaters
Induction Cooktops and Electric Ovens	▪ Gas stoves
Industrial Process Cooling Electrification including electric infrared, microwave, or induction heating	▪ Steam absorption and turbine chillers ▪ Gas-engine driven chiller ▪ Gas absorption chiller ▪ Other fossil fuel based cooling systems
Industrial Process Heating Electrification including electric infrared, microwave, or induction heating	▪ Gas or oil-fired process heating
Packaged Terminal Heat Pumps	▪ Packaged terminal air conditioners with fossil fuel heat

Table 21. Electrification Measure Examples

4.3.2 Source Energy Savings

The program requires calculation of source energy savings, which will be calculated by TRC or TRC-supplied tools. Source energy consumption and savings in MMBtu will be calculated using the following equation:

$$
\begin{aligned}
&Source\ Energy\ Savings\ (MMBtu) \\
&\quad = [MMBtu_{FF,B}\ \ x\ SSR_{Fuel} + MMBtu_{Elec,B}\ \ x\ SSR_{Elec} + MMBtu_{Renew,B}] \\
&\quad - [MMBtu_{FF,P}\ \ x\ SSR_{Fuel} + MMBtu_{Elec,P}\ \ x\ SSR_{Elec} + MMBtu_{Renew,P}\ ]
\end{aligned}
$$

Where MMBtu is site energy for fossil fuel (FF), electricity (elec), and on-site renewable systems (renew) and the site to source ratio (SSR) is derived from the following two tables.

Per NJBPU Board Order 8C, electric site to source ratios (SSR) from the following table shall be used in source energy calculations.[2] On-site electricity generation such as solar or wind shall use an SSR of 1.0.

Year	SSR	Year	SSR	Year	SSR	Year	SSR
2022	2.54	2032	2.28	2042	2.02	2052	1.76
2023	2.51	2033	2.25	2043	2	2053	1.74
2024	2.48	2034	2.23	2044	1.97	2054	1.71
2025	2.46	2035	2.2	2045	1.94	2055	1.69
2026	2.43	2036	2.18	2046	1.92	2056	1.66
2027	2.41	2037	2.15	2047	1.89	2057	1.64
2028	2.38	2038	2.12	2048	1.87	2058	1.61
2029	2.36	2039	2.1	2049	1.84	2059	1.58
2030	2.33	2040	2.07	2050	1.82	2060	1.56
2031	2.3	2041	2.05	2051	1.79		

Table 22. Electric Site to Source Ratios

The following SSRs for fossil fuels shall be used in source energy calculations.[3]

Fuel	SSR
Natural Gas	1.05
Fuel Oil	1.01

Fuel	SSR
Propane	1.01
Wood / Coal	1.00
Steam	1.20
Chilled Water	1.05

Table 23. Fossil Fuel Site to Source Ratios

4.4 Whole Building Calibration

4.4.1 Allowed Adjustments to Utility Bills

If one or more utility bills in the baseline period correspond to irregular events (e.g., one-time repairs) or represent faulty or estimated readings, adjustments may be made to utility bill consumption. Any modified or excluded bills must be justified in the audit and are subject to approval by the Program Manager. No more than 25% of the actual billing data can be modified or excluded. Further, adjustments cannot be applied to the first or last monthly billing period of the baseline period. The bill preceding the first and the last bill of the baseline period must be based on actual rather than estimated readings.

- **One-Time Events**: If an irregular bill is due to a specific event (e.g., repairs or seasonal equipment use), adjust the bill by normalizing consumption for the impacted period. This could involve applying average consumption patterns from prior or subsequent months as a proxy.
- **Adjust for Irregular Deliveries**: If fuel deliveries are irregular or atypical (e.g., one large delivery in a short period), adjust for this in the utility bill analysis by prorating fuel usage over time. For instance, if a large delivery occurred at the start of the period, break it down into smaller monthly increments based on historical usage patterns. If a delivery has been mistakenly recorded or is inconsistent with typical consumption, correct the data by recalculating expected fuel usage based on past delivery trends or facility demand.

Any adjustments or exclusions made to utility bills should be well-documented in the energy audit report with a clear justification for why a bill was excluded or adjusted and the methodology used. All adjustments and exclusions are subject to approval by the Program Manager.

4.5 New Jersey TRM

Program allies shall leverage the New Jersey Technical Reference Manual (NJ TRM) corresponding to the program year in which the application for a project is submitted. The NJ TRM shall be used for calculation methodologies and/or assumptions for projects with energy savings measures that are included in the TRM. The New Jersey TRM will take precedence over other jurisdictions' TRMs. If updates to the NJ TRM are issued following publication of these guidelines, the latest version of the NJ TRM shall be used.

4.6 Peak Demand Calculations

Per Section 1.9.1 of the NJ TRM, peak coincident demand savings should be calculated as the average reduction between the hours ending 3pm and 6pm, Monday through Friday, from June 1 through August 31, excluding holidays such as Fourth of July. The NJ TRM does not define the methodology to calculate winter peak and annual peak demand.

The following table clarifies how to estimate summer peak demand, winter peak demand, and annual peak demand.

Proposed Equipment Type	Existing Equipment Type(s)
Summer Peak Demand (kW)	Average peak demand during weekdays, June 1 -- September 30, 3pm - 6pm, excluding holidays
Winter Peak Demand (kW) including centrifugal, screw scroll, and air-cooled	Average peak demand during weekdays, December 15 – March 15, 7am – 9am, excluding holidays
Annual Peak Demand (kW)	Maximum of summer and winter peak demand values above

Table 24. Peak Demand Definitions

If an 8,760 analysis is not performed, baseline and proposed coincident peak demand may be approximated as the average demand per the peak defined above. Alternatively, NJ TRM coincidence factors corresponding to the measure that best aligns with the custom measure may be used.

4.7 Peak Day Natural Gas

For non-weather sensitive measures, peak day natural gas (therms/day) should be calculated as the product of annual therm savings and peak day factor (PDF) from Table 10-6 (Peak Day Factors for Commercial and Industrial Buildings Using the Day Per Year Ratio) of the NJ TRM.

For weather sensitive measures, peak day natural gas (therms/day) should be calculated as the product of annual therm savings and peak day factor (PDF) from one of the two tables:

- **Small Commercial Buildings**: Table 10-9 Small Commercial Building PDFs using the Full Load Hour Method,
- **Large Commercial Buildings**: Table 10-10 Large Commercial Building PDFs using the Full Load Hour Method

4.8 Emerging Technology Evaluation

New and emerging technologies have potential to provide customers with significant energy savings, but there is often a high degree of savings uncertainty due to equipment novelty and lack of available data to substantiate savings claims. These technologies are defined as commercially available equipment, controls, and technologies that are either new to the market, have low customer adoption rates, and/or have limited acceptance in energy efficiency programs. Due to these risks, additional screening is required when evaluating new and emerging technologies, including pre-installation and/or post-installation measurement and verification (M&V).

For technologies outside the scope of measures described in New Jersey's TRM, TRMs in other jurisdictions, and projects TRC has previously evaluated under Custom C&I programs, Program Allies shall submit the following documentation for review:

- Manufacturer product literature including potential energy savings, technology overview, and clear description how the product reduces energy consumption.
- Laboratory test results.
- Third party evaluation studies and results confirming manufacturer claims.
- Documentation confirming the technology does not void equipment warranties.
- Documentation confirming the technology has been incentivized in other jurisdictions (such as other utilities or state energy offices). Documentation should include a complete project file (energy savings analysis, unprocessed and analyzed M&V, report narrative, specification sheets, and approval letter).
- Project case studies with back-up raw trended and analyzed M&V data.

TRC will perform an initial screening of the documentation, and if acceptable, TRC will request details to support M&V of the technology including:

- Proposed M&V plan including details of all metering points and timing/duration of metering.
- For weather-dependent technologies, the M&V plan must include extended pre- and post-metering period over a representative range of weather conditions and loads.
- For weather-independent technologies, the M&V period shall be long enough to confirm the equipment load profile and no shorter than one week.
- Spot measurements will be encouraged to support savings claims but cannot be used as a stand-alone method to confirm energy savings.
- Calculation methodology to determine savings from M&V data.

Following TRC review of the M&V plan, TRC will submit a recommendation and associated documentation for JCP&L and third-party evaluator review and approval prior to pre-installation M&V activities and project pre-approval. The Program Ally is responsible for implementing the M&V plan and provided required documentation and data at each project milestone.

4.9 Building Envelope Specific Requirements

4.9.1 Opaque Assemblies

Energy savings from insulating opaque surfaces, such as roofs, walls, floors, and other assemblies separating conditioned from unconditioned or exterior spaces, depend on the following key factors:

- The existing thermal performance of the assembly prior to retrofit
- The rated R-value/in, thickness, framing, and installation method of the new insulation
- The total area of the insulated surface

These three factors must be clearly documented as part of the project documentation. If energy modeling or bin-based analysis is not used, calculations must be developed in accordance with the latest version of the TRM.

For assemblies with varying construction cross-sections (e.g., areas with different framing or cavity materials), the overall effective R-value must be calculated by first determining the U-value of each distinct cross-section and then area-weighting the U-values based on their proportional surface area. Where appropriate, construction libraries from approved simulation tools may be used to support these calculations, provided the assemblies represent combined thermal properties of framing and cavity components.

For metal-framed constructions, effective R-values must be based on **ASHRAE Standard 90.1-2019 Appendix A**. If existing or proposed insulation levels fall between those listed in Appendix A, interpolation between listed values is permitted. For example, if cavity insulation is rated at R-20, but the appendix only lists effective R-values for R-19 and R-21, the average of those two values may be used to estimate the effective R-value for R-20.

If existing roof R-values cannot be established, the following defaults shall be used.

Building Type	Baseline R-value
Hospital	13.5
Hotel	13.5
Large Office	13.5
Light Industrial	12
Multi-family high-rise	13.5
Multi-family low-rise	13.5
Motel	13.5
Multi Story Retail	13.5
Primary School	13.5

Building Type	Baseline R-value
Religious	13.5
Secondary School	13.5
Small Office	13.5
Small Retail	13.5
University	13.5
Warehouse	12

Table 25. Default Baseline Roof Insulation R-values

4.9.2 Fenestration

For projects involving window replacement, baseline performance characteristics must be based on **ASHRAE 90.1-2019 Appendix A** unless actual building-specific data (e.g., original specifications, as-built drawings, or verified field observations) are available and well-documented.

The following information must be provided for each window-related measure:

- **Pre- and post-retrofit number of panes** (e.g., single-pane, double-pane, triple-pane, or glass block)
- **Pre- and post-retrofit frame type** (e.g., wood, vinyl, fiberglass, aluminum, thermally broken aluminum, or other)
- Pre- and post-retrofit U-value
- Pre- and post-retrofit Solar Heat Gain Coefficient (SHGC)
- Quantity and size of windows affected, provided in a format sufficient to determine the total improved fenestration area in square feet (e.g., twenty (20) 5’ x 3’ windows)

All window measures must clearly document both the baseline and proposed conditions. Supporting product specifications, manufacturer data sheets, and NFRC ratings should be included to verify claimed performance values. Area-weighted averages may be used if multiple window types are included in a single measure.

If existing window U-values and SHGC values cannot be established, the following table shall be used.

		Unlabeled *Vertical Fenestration*					
		Clear Glass			***Tinted* Glass**		
Frame Type	**Glazing Type**	***U-Factor***	***SHGC***	***VT***	***U-Factor***	***SHGC***	***VT***
All frame types	Single glazing	1.25	0.82	0.76	1.25	0.70	0.58
	Glass block	0.60	0.56	0.56	NA	NA	NA
Wood, vinyl, or fiberglass frames	Double glazing	0.60	0.59	0.64	0.60	0.42	0.39
	Triple glazing	0.45	0.52	0.57	0.45	0.34	0.21
Metal and other frame types	Double glazing	0.90	0.68	0.66	0.90	0.50	0.40
	Triple glazing	0.70	0.60	0.59	0.70	0.42	0.22

Table 26. Default Baseline Window U-values and SHGC Values

4.9.3 Airsealing and Infiltration

Component	Requirements
Baseline Infiltration Rate	▪ **Site-specific:** Use actual results from a blower door test (conducted per ASHRAE 90.1-2019 Section 5.4.3.1.1). ▪ **Default:** If no test is available, assume 0.40 CFM75/SF (building envelope area).
Proposed Infiltration (Post-Retrofit)	▪ **Site-specific settings:** Use blower door test results following air-sealing work. ▪ **Default assumption:** If post-retrofit testing isn’t available, assume 0.25 CFM75/SF.
Occupied vs. Unoccupied Infiltration Schedule	Apply infiltration schedules reflecting building operation: ▪ **Occupied periods:** 25% of peak infiltration ▪ **Unoccupied periods:** 100% of peak infiltration This approach aligns with common commercial modeling practices (e.g., EnergyPlus default schedules use 0.25 when HVAC fan is on and 1.0 when off)

Component	Requirements
Projects Without Air-Sealing Measures	If air-sealing isn't part of the scope, use baseline infiltration values (site-specific or 0.40 CFM75/SF default) for both pre- and post-retrofit.
Air-Sealing Scope of Work Requirements	Provide a detailed, itemized air-sealing scope, including: ▪ All affected components (e.g., penetrations, joints, access doors) ▪ Impacted areas and lengths (in linear feet) ▪ Systems or zones involved ▪ Sealing materials and methods ▪ Before-and-after description of envelope continuity

Table 27. Air sealing and Infiltration Requirements

4.10 Domestic Hot Water Specific Requirements

4.10.1 Low Flow Fixtures

Measurements of a representative sample of fixtures may be conducted to establish baseline flow rate. Specification sheets or measurements of installed fixtures may be used to establish proposed rate. If pre- or post-retrofit flow rates are not measured or manufacturer specs are not provided, the following default values must be used:

Fixture Type	Location	GPM_b	GPM_p	$T_{operating}$ (°F)
Faucet aerator	Kitchen	1.8	1.5	93
	Public restroom	0.5	0.5	86
	Private restroom	1.5	1.0	86
Showerhead	Any	2.0	1.5	105

Table 28. Baseline and Proposed Default DHW Fixture Flow Rates

Unless measurements are performed to establish a load profile, energy savings calculations shall comply with the TRM.

4.11 HVAC Specific Requirements

4.11.1 HVAC Equipment Derating

When determining the existing efficiency for existing equipment, derating may be used to represent the decrease in efficiency of equipment over time. Efficiency of existing equipment affected by retrofit may be de-rated as follows due to age:

$$Efficiency_{Derated} = Efficiency_{Original}\ x\ (1 - M)^{Age}$$

Where:

- $Efficiency_{Orginal}$ = Existing HVAC or DHW equipment efficiency:
- Nameplate photos or specification sheets shall be used to justify $Efficiency_{Orginal}$ when possible.
- For equipment in which nameplate or specification sheet efficiency is unavailable, vintage versions of ASHRAE 90.1 shall be used as a proxy. The version of ASHRAE 90.1 must correspond to the energy code in place at the time of equipment manufacture.
- If electrical efficiency is calculated based on nameplate electric specifications (e.g., volts, amps, phase, power factor), assumed power factor shall not exceed 0.75.
- Age = equipment age or the equipment measure life in years per the NJ TRM, whichever is less.
- M = maintenance factor:
- M_a = Maintenance factor for equipment that received annual professional maintenance
- M_b = Maintenance factor for equipment that was seldom or never maintained

HVAC Maintenance Factors	M_a	M_b
Air conditioners and heat pumps	0.0050	0.0100
DHW heaters, *electric*	0.0050	0.0075
DHW heaters, *fossil fuel*	0.0025	0.0050
Chillers	0.0025	0.0050
Furnaces and boilers, *gas*	0.0025	0.0050
Furnaces and boilers, *oil*	0.0050	0.0075

Table 29. HVAC Maintenance Factors[4]

Example: A 22-year-old, 10 EER air conditioner received annual professional maintenance.

- $\text{Efficiency}_{\text{Derated}}$ = $\text{Efficiency}_{\text{Orginal}}$ $*(1\text{-M})^{\text{Age}}$ = 10 EER * (1 – 0.005) $^{\text{minimum of (22 years old, 15-year lifetime)}}$
- $\text{Efficiency}_{\text{Derated}}$ = 9.3 EER (rather than 9.0 EER since measure life [15 years] < equipment age [22 years])

Note that derating should not be applied in cases where the customer or their contractor has provided industry standard performance testing results in support of their equipment's existing efficiency. Derating can only be applied to early replacement, extended life and add-on scenarios. It shall not be applied to normal replacement and new construction scenarios. $\text{Efficiency}_{\text{Derated}}$ represents the maximum allowable derating in energy savings calculations. Adjustments may be required to appropriately calibrate calculated baseline energy consumption to utility bills.

4.11.2 Performance Curves

For equipment operating under variable load conditions, energy savings calculations must account for part-load performance. Performance curves should be used to reflect how efficiency or input power varies with load. These curves are essential for accurately estimating energy use and savings, particularly for equipment such as chillers, variable speed pumps and fans, and staged or modulating HVAC units.

Requirements for performance curves include:

- Performance curves must reflect the equipment type and control strategy.
- Curves may be sourced from manufacturer data, approved industry references, or standard libraries such as those provided by ASHRAE or modeling software. Manufacturer curves should be used when possible.
- The selected curve should match the equipment's type (e.g., air-cooled vs. water-cooled chillers) and configuration (e.g., variable speed vs. constant speed).

Documentation requirements include:

- Clearly identify the curve used, its source, and justify its applicability to the equipment modeled.
- Include a copy of the curve (graph or equation) and any parameters used.
- For custom curves, provide a description of how the curve was derived and any validation steps.

4.11.3 SEER/SEER2, HSPF/HSPF2, and EER/EER2 Conversions

Per Section 8.1 of the NJ TRM, the following table can be used to convert units of efficiency between SEER / SEER2 and HSPF / HSPF2.

SEER2	SEER	HSPF2	HSPF
13.4	14	6.7	8.0
14.3	15	7.1	8.5
15.2	16	7.5	8.8
16	17	7.8	9.2
17	18	8	9.5
18	19	8.4	10
19	20	8.5	10.2
20	21	8.9	10.8
21	22	9.1	11
22	23	9.3	11.3
23	24	9.7	11.9
		10	12.4

Table 30. SEER2/SEER and HSPF2/HSPF Conversions

Per Section 8.1 of the NJ TRM, the following table can be used to convert units of efficiency between SEER / SEER2 and EER / EER2.

Equipment Type	SEER	SEER2	EER	EER2	EER2/EER
Split system Air conditioner	14	13.4	11.3	10.8	0.96
Split system heat pump	15	14.3	12.1	11.5	0.95

Table 31. EER/EER 2 Conversions

4.11.4 Extracting Supply Fan Power from Efficiency Ratings

For air-side heating and cooling systems—such as packaged terminal air conditioners (PTACs), rooftop units (RTUs), and packaged heat pumps—electric efficiency must be calculated and modeled separately from AHRI-rated efficiency (e.g., EER, SEER, COP, HSPF) to isolate supply fan power.

This adjustment is required for both baseline and proposed systems in projects where savings are claimed in modeling-based projects and in cases where savings are being claimed for both cooling and ventilation measures, in order to avoid double-counting supply fan energy savings.

- If equipment is derated, the adjusted efficiency must be used in the fan power separation calculations.

- The following equations, adapted from ASHRAE 90.1-2019, are used to extract cooling and heating efficiencies without supply fan power (COPnf) from manufacturer-rated data:

$$COP_{nf,cooling} = 7.84 \times 10^{-8} \times EER \times Q + 0.338 \times EER$$

$$COP_{nf,cooling} = -0.0076 \times SEER^2 + 0.3796 \times SEER$$

$$COP_{nf,heating} *= 1.48 \times 10^{-7} \times COP47 \times Q + 1.062 \times COP47$$

$$COP_{nf,heating} = -0.0296 \times HSPF^2 + 0.7134 \times HSPF$$

Definitions of variables include

- $COP_{nf,cooling}$ and $COP_{nf,heating}$: Cooling and heating efficiency excluding supply fan power (to be used in modeling).
- EER, SEER, COP47, HSPF: Manufacturer-rated efficiencies at AHRI test conditions.
- Q: AHRI-rated cooling capacity, in Btu/h.

When using eQUEST or similar energy modeling tools, the Energy Input Ratio (EIR) must be based on the adjusted efficiency:

$$EIR = \frac{1}{COP_{nf}}$$

4.11.5 Establishing Existing Fossil Fuel System Efficiency

Calculations should clearly describe existing boiler type, age, and fuel source. Typical efficiencies of various boiler types are provided in the following table for reference:

Boiler Type	Typical Efficiencies
Standard gas-fired boiler (older)	75-80%
Standard gas-fired boiler (newer)	80-85%
Atmospheric gas boiler	75-80%

Boiler Type	Typical Efficiencies
Condensing boiler	87-95% (if condensing properly)
Oil-fired boiler	80-85%
Gas-fired furnace	78-80%
Oil-fired furnace	78-80%
Gas-fired unit heater	80%
Oil-fired unit heater	80%

Table 32. Typical Fossil Fuel System Efficiencies

Existing fossil fuel system efficiency may be established using one of the following methods

- Combustion tests (boilers only)
- Nameplate data
- Specification sheets
- Vintage code efficiency

With the exception of combustion efficiency test method, efficiency may be derated using the methodology described in Section 4.12.1.

Distribution losses should be excluded from efficiency calculations and accounted for separately.

4.11.6 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 return water temperature is greater than 130°F.

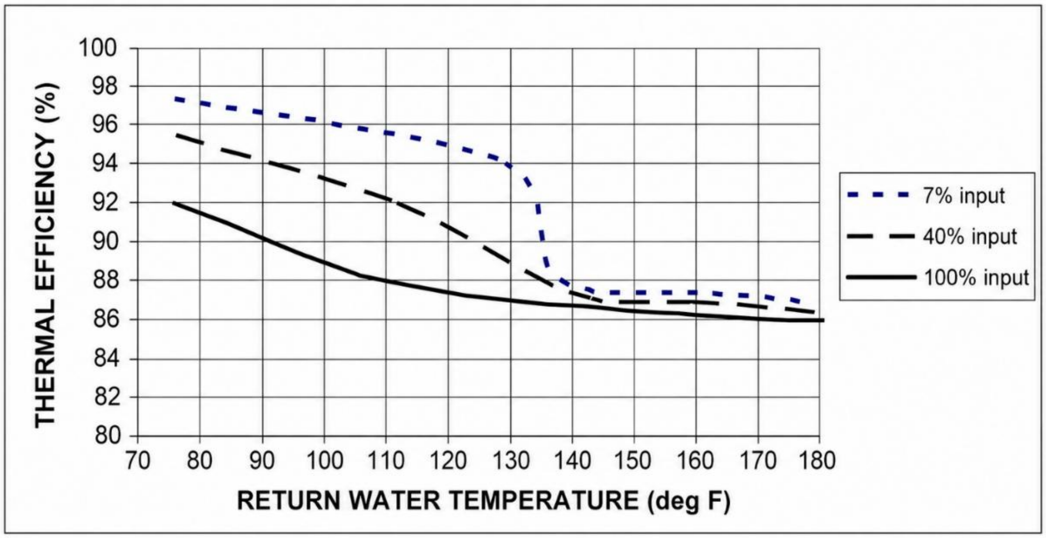


Figure 1. Example Boiler Performance Curve

Condenser boiler efficiency shall be based on verified supply and return water temperature and account for variations in efficiency due to return water temperature and load. Program Allies should provide supplemental documentation to confirm these temperatures.

If supplemental documentation is not provided, condensing boiler efficiency shall reflect conditions at 150°F (87% efficiency).

4.11.7 Low Power Fans

For fans with nameplate electrical input power less than 180 W, or a motor nameplate horsepower less than 1/12 hp, the minimum fan efficacies from the following table shall be used if nameplate or specification sheet efficacy values are unavailable.

System Type	Minimum Fan Efficacy (cfm/W)
HRV, ERV, or other system with exhaust air energy recovery	1.2
Transfer fans; in-line supply or exhaust fans	3.8
Other exhaust fan, <90 cfm	2.8
Other exhaust fan, ≥90 cfm and ≤200 cfm	3.5
Other exhaust fan, >200 cfm	4.0

Table 33. Low Power Fans Baseline Efficacy Requirements

4.11.8 Destratification Fans

To model energy savings from destratification fans, the primary method should be to adjust the heating thermostat setpoint to reflect improved air mixing in the space. Savings are based on a reduction in thermal stratification, which should be quantified through temperature measurements taken before the retrofit. These measurements should capture temperatures at both the ceiling and occupant level. If measurements are not performed, the following table shall be used, which assumes an existing stratification rate of 0.4°F per foot above 5 ft.

Ceiling Height (ft)	Estimated ΔT	Assumed Floor Temp	Estimated Ceiling Temp
10	2°F	70°F	72°F
15	4°F	70°F	74°F
20	6°F	70°F	76°F
25	8°F	70°F	78°F
30	10°F	70°F	80°F
35	12°F	70°F	82°F

Table 34. Destratification Assumptions

Stratification of 3°F shall be assumed in the proposed case.

For example, if the pre-retrofit ceiling temperature is 80°F and the floor temperature is 70°F, the average space temperature without destratification is calculated as (80 + 70) / 2 = 75°F, which can be modeled as the average setpoint of the space. If the installed fans reduce the stratification to 3°F, resulting in a 73°F ceiling and 70°F floor, the new average temperature becomes (73 + 70) / 2 = 71.5°F. The adjusted setpoint of 71.5°F can then be used in the post-retrofit model to reflect reduced heating energy requirements.

If other measures impact space temperature set points and setbacks, destratification fan savings shall be calculated after those measures.

In addition, the energy consumed by the destratification fans must be incorporated into calculations. Fan specifications, operating hours, power consumption, and calculation methodology must be provided as part of the model submission.

4.12 HVAC Controls Specific Requirements

4.12.1 General Best Practices

The following table provides best practices when calculating savings from HVAC controls.

Component	Best Practices
Baseline Conditions	▪ Establish existing equipment schedules, setpoints, and control strategies. ▪ Identify any inefficiencies, like constant volume operation, simultaneous heating and cooling, or lack of setback scheduling. ▪ If trend data is available pre-installation, use it to quantify existing conditions. ▪ If trend data is not available, compare modeled consumption to utility bill consumption
Proposed Conditions	▪ Document specific control strategies being implemented (e.g., optimized start/stop, temperature resets, demand-based ventilation). ▪ Clearly define changes to baseline conditions to simulate proposed conditions ▪ Include assumptions for improved scheduling and setpoints in the calculations. ▪ Where possible, calculate energy savings for each control strategy individually ▪ Account for interactivity among individual control strategies ▪ Validate modeled proposed energy consumption using post-installation BMS data ▪ Do not use rules of thumb to estimate savings from controls.

Table 35. HVAC Control Calculations Best Practices

4.12.2 Ventilation Schedule

For measures involving ventilation fan shutdown or reduced outdoor air during unoccupied periods, baseline and proposed schedules must be clearly documented. When available, on-site verification of the existing ventilation schedule (e.g., trend data, timeclock settings, or BMS screenshots) should be used to establish baseline operation.

If no site data are provided, assumptions for proposed schedule reductions must follow these limits:

- **Weekdays:** No more than 8 hours of ventilation reduction per day
- **Weekends:** No more than 16 hours of ventilation reduction per day

Ventilation schedules must remain aligned with space occupancy. Fans may only be assumed to shut off when spaces are unoccupied, and ventilation must resume prior to occupancy as needed to meet indoor air quality standards. Complete elimination of ventilation during the workday or occupied hours is not permitted unless supported by verified controls or occupancy data.

All assumptions must be documented and justified, including any staggered start times, cycling, or reduced flow periods.

4.12.3 Demand Control Ventilation

For measures involving demand control ventilation (DCV), calculations must reflect how outdoor air is reduced in response to real-time occupancy or CO_2 levels. DCV savings should not be based on arbitrary percentage reductions or simplified hourly offsets.

Instead, calculations should reflect:

- Design ventilation rate at full occupancy
- Minimum ventilation rate allowed under DCV (not less than ASHRAE 62.1-2016 requirements)
- Estimated occupancy patterns or CO_2 control setpoints (e.g., modulation between 100% and 30% of design flow based on zone demand)

Acceptable calculation methods include:

- Spreadsheet calculations using weighted average flow rates across time bins or operating hours
- Engineering estimates based on expected occupancy profiles and equipment capabilities
- Manufacturer data showing control logic or minimum turndown ratios

If no site-specific data are available, minimum airflow should not be assumed to drop below 30% of design ventilation during low-occupancy periods. All assumptions, control logic, and supporting references must be clearly documented.

4.12.4 Hot Water Supply Reset

If a hot water supply temperature (HWST) reset schedule has not been established, the following default schedule shall be used based on **outdoor dry-bulb temperature**:

- 150°F at 50°F and above
- 180°F at 20°F and below
- Ramped linearly between 180°F and 150°F at temperatures between 20°F and 50°F

This reset strategy reduces heating system energy use during milder conditions while maintaining occupant comfort. The above schedule may be modified if site-specific data are available, such as measured hot water supply and return temperatures or documented control logic.

4.12.5 Chilled Water Supply Reset

f a chilled water supply temperature (CHWST) reset schedule has not been established, the following default schedule shall be used based on **outdoor dry-bulb temperature**::

- 44°F at 80°F and above
- 54°F at 60°F and below
- Ramped linearly between 44°F and 54°F at temperatures between 80°F and 60°F

This reset strategy reduces overcooling and compressor energy use during mild weather conditions. The above schedule may be modified if site-specific data are available, such as measured chilled water supply and return temperatures or documented control sequences.

4.12.6 Condenser Water Supply Reset

If a condenser water supply temperature (CWST) reset schedule has not been established, the following default schedule shall be used to reset CWST based on the **outdoor wet-bulb temperature**:

- 75°F CWST at 75°F wet-bulb and above
- 65°F CWST at 55°F wet-bulb and below
- Ramp linearly between 75°F and 65°F CWST for wet-bulb temperatures between 75°F and 55°F

This schedule assumes a control strategy that resets CWST downward as outdoor conditions improve, reducing lift on the chiller and improving system efficiency.

The above reset schedule may be modified if site-specific data is available, including:

1. Measured condenser water supply and return temperatures
2. Documented BMS or plant control sequences
3. Manufacturer-recommended reset strategies

4.12.7 Thermostat Nighttime Setbacks

Nighttime temperature setbacks can be applied to heating and cooling systems during unoccupied periods. The following table provides limits on the setbacks that can be claimed in energy savings calculations. Exceptions may be permitted by the Program Manager with appropriate documentation.

Building Type	Heating Setback (°F) Limit	Cooling Setback (°F) Limit	Notes
Grocery	65°F	75°F	Refrigeration loads may limit cooling setback.
Medical – Clinic	70°F	75°F	Limited setbacks due to patient comfort.
Multifamily – Common Areas	65°F	80°F	Depends on resident usage patterns and tenant comfort
Medical - Hospital	No Setback	No Setback	24/7 operation; strict temperature controls.
Multifamily – In-Unit	No Setback	No Setback	Resident preferences vary considerably.
Office – Small	60°F	80°F	Typical unoccupied hours: nights and weekends.
Office – Large	60°F	80°F	Typical unoccupied hours: nights & weekends.
College/University – Cafeteria	65°F	80°F	Kitchens may require separate ventilation controls.
College/University – Classrooms	60°F	80°F	Setbacks applied outside of class hours.
College/University – Dormitory – Common Area	65°F	80°F	Depends on resident usage patterns and tenant comfort
College/University – Dormitory – Living Area	No Setback	No Setback	Resident preferences vary considerably.
Religious Building	55°F	85°F	Often used intermittently, allowing deeper setbacks.
Nursing Home	No Setback	No Setback	No / minimal setbacks to maintain patient comfort.
Retail – Small	60°F	80°F	Setbacks depend on occupancy patterns.
Retail – Large	60°F	80°F	Similar to small retail but may have more 24/7 equipment loads.
School	60°F	80°F	Setbacks applied on nights, weekends, and holidays.
Warehouse – Large C&I	55°F	85°F	Heating setback depends on material storage needs.
Warehouse – Small	55°F	85°F	Heating setback depends on material storage needs.

Table 36. Typical Thermostat Nighttime Setbacks

4.12.8 Thermostat Daytime / Occupied Period Setbacks

Savings may be claimed for measures that reduce space temperatures during occupied periods if on-site measurements of existing temperatures is performed. The post-retrofit temperature during occupied periods may not be less than **72°F** for heating and no higher than **75°F** for cooling. If measurements are not performed to verify existing space temperatures, credit cannot be claimed for this measure and schedule adjustments should be limited to nighttime setbacks.

4.12.9 Supply Air Temperature Reset

If the supply air temperature reset schedule has not been established, the air temperature for cooling shall be set no higher than 5°F under the minimum cooling load conditions.

4.13 Lighting Specific Requirements

For LED projects where the product is qualified by either Design Lights Consortium® (DLC) or ENERGY STAR but the qualification category is not presently offered through the Prescriptive Program the following additional information should be included with this application:

- Confirmation of existing fixture wattage (ballast/lamp or other system documentation)
- Documentation supporting existing and proposed lighting run hours
- LED to LED replacements must reduce wattage and result in measurable savings.

All Prescriptive LED equipment requirements apply. Pre-approval and pre-inspections will be required.

4.13.1 Energy Code Trigger for Lighting Retrofits

Projects that include comprehensive interior lighting retrofits in the scope of work must install lighting controls per ASHRAE 90.1-2019 Section 9 requirements to comply the New Jersey Administrative Code and its Uniform Construction Code. Depending on the nature of the retrofit, mandatory lighting control requirements will vary.

Similarly, projects that include exterior lighting retrofits in the scope of work must install lighting controls per ASHRAE 90.1-2019 Section 9 requirements

It is the responsibility of the Program Ally to verify that all projects enrolled in the program comply with all local, state, and federal codes.

4.13.2 Hours of Operation

The following table provides equivalent full load lighting hours (EFLH) for various C&I building types. Supplemental documentation such as site measurements or documentation that actual hours of operation exceed NJ TRM prototype hours of operation must be provided if calculated EFLH exceeds EFLH in the table by more than 15%.

Building Type	Hours	Building Type	Hours
Grocery	7,134	Parking Garage	8,678
Medical – Clinic	3,909	Multifamily – Common Areas	5,950
Medical - Hospital	8,760	Multifamily – In-Unit	679

Building Type	Hours	Building Type	Hours
Office – Small	2,969	Multifamily –Exterior	3,338
Office – Large	2,950	College/University – Cafeteria	2,713
Other	See below	College/University – Classes	2,586
Retail – Small	4,920	College/University – Dormitory	3,066
Retail – Large	4,926	Religious Building	1,955
School	2,575	Nursing Home	5,840
Warehouse – Large C&I	4,116	Restaurant - Dine-In	4,182
Warehouse – Small	3,799	Restaurant - Fast food	6,456
Outside/Outdoor Area	3,604	Museum	3,748

Table 37. Lighting Hours of Operation

4.13.3 Hours of Operation – "Other" Building Type

For building types outside the scope of Table 54 annual lighting hours, excluding impact of lighting controls, shall not exceed the sum of the following:

- (Weekday hours per week open) x 50.6 weeks x 90%
- (Weekday hours per week closed) x 50.6 weeks x 5% + 9.6 hours
- (Weekend hours per week open) x 52 weeks x 90%
- (Weekend hours per week closed) x 52 weeks x 5%

For example, if a library is open 9-6pm Monday through Friday, open 9-1pm on Saturday, and closed on Sunday, annual lighting hours shall not exceed 2,550, which is calculated as the sum of the following:

- (45 hours per week open on weekdays) x 50.6 weeks x 90% = 2,049 hours
- (75 hours per week closed on Weekdays) x 50.6 weeks x 5% + 9.6 = 200 hours
- (4 hours per week open on weekends) x 52 weeks x 90% = 187 hours
- (44 hours per week closed on weekends) x 52 weeks x 5% = 114 hours

4.13.4 Lighting Control Savings Factors

The following lighting control factors (SVG) may be used to account for adjustments to hours of operation due to lighting controls. If existing lighting is served by lighting controls, lighting control factors shall be applied to baseline hours of operation.

For example, if existing hours of lighting operation of an office space is 2,950 and daylighting controls are present, 2,124 hours should be used in the analysis (2,950 hours x [1 – 0.28 LCF]).

Control Type	Lighting Control Factor (SVG)
Networked lighting controls (NLC)	0.49
Luminaire-level lighting controls (LLLC) – Networked & Commissioned	0.49
Integrated fixture with room-based controls	0.38
Dual occupancy and daylight sensors	0.38
Combination of high-end trim and daylight dimming	0.35
Combination of high-end trim and occupancy sensors	0.33
Daylight dimming	0.28
Occupancy sensors	0.24
No lighting controls	0.00

Table 38. Lighting Control Factors

4.14 Motors and Drives Specific Requirements

4.14.1 Fan Performance Curves

The following fan performance table should be used to estimate fan power at various part load ratios. **For example**, for a VFD with duct SP controls operating at 50% of full design air flow, the fan power should be equal to 21% of the design fan power.

VFD performance accounts for VFD efficiency. Therefore, calculations should not include an additional penalty to account for VFD efficiency (such as increasing power consumption by 1 / VFD eff).

Fan Type	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Control or Bypass Damper	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Discharge Dampers	46%	55%	63%	70%	77%	83%	88%	93%	97%	100%
Outlet Damper, BI & Airfoil Fans	53%	53%	57%	64%	72%	80%	89%	96%	102%	105%
Inlet Damper Box	56%	60%	62%	64%	66%	69%	74%	81%	92%	107%
Inlet Guide Vane, BI & Airfoil Fans	53%	56%	57%	59%	60%	62%	67%	74%	85%	100%
Inlet Vane Dampers	38%	40%	42%	44%	48%	53%	60%	70%	83%	99%
Outlet Damper, FC Fans	22%	26%	30%	37%	45%	54%	65%	77%	91%	106%
Eddy Current Drives	17%	20%	25%	32%	41%	51%	63%	76%	90%	104%
Inlet Guide Vane, FC Fans	21%	22%	23%	26%	31%	39%	49%	63%	81%	104%
VFD with duct SP controls	10%	11%	12%	16%	21%	30%	42%	58%	78%	103%
VFD with low/no duct SP	6%	7%	10%	13%	19%	28%	40%	56%	77%	102%

Table 39. Fan Performance (Fan Power as a Function of Part Load Ratio)

Using the values in the above table, the following table provides fan curve coefficients to streamline energy savings calculations. The coefficients shall be used in the following equation

$$FPLR = A + B\ x\ PLR + C\ x\ \ PLR^2 +\ D\ x\ \ PLR^3$$

Where:

- PLR is the ratio of operating flow to design flow rate (i.e., part load ratio)
- FPLR is the ratio of fan power to design fan power
- Design fan power x FPLR is equivalent to the actual fan power at a specific part load ratio

Fan Type	A	B	C	D
No Control or Bypass Damper	1	0	0	0.0000
Discharge Dampers	0.3670	0.9750	-0.3409	0.0000
Outlet Damper, BI & Airfoil Fans	0.5627	-0.5893	2.5093	-1.4336
Inlet Damper Box	0.5010	0.7303	-1.4883	1.3267
Inlet Guide Vane, BI & Airfoil Fans	0.4797	0.6371	-1.4779	1.3617
Inlet Vane Dampers	0.3587	0.2589	-0.4499	0.8236
Outlet Damper, FC Fans	0.2013	0.1241	0.7407	-0.0058
Eddy Current Drives	0.1673	-0.0953	1.3427	-0.3730
Inlet Guide Vane, FC Fans	0.2090	0.0168	-0.0629	0.8761
VFD with duct SP controls	0.1072	-0.0705	0.1413	0.8518
VFD with low/no duct SP	0.0475	0.0804	-0.0707	0.9637

Table 40. Fan Performance Curve Coefficients

4.14.2 Pump Performance Curves

the following table provides pump curve coefficients to streamline energy savings calculations. The coefficients shall be used in the following equation

$$FPLR = A + B\ x\ PLR + C\ x\ \ PLR^2 +\ D\ x\ \ PLR^3$$

Where:

- PLR is the ratio of operating flow to design flow rate (i.e., part load ratio)
- FPLR is the ratio of fan power to design fan power
- Design fan power x FPLR is equivalent to the actual fan power at a specific part load ratio

Control Type	A	B	C	D
One-Speed	1	0	0	0
Throttle Valve	0.55218	0.63701	-0.18996	0
Variable Speed	0.219762	-0.874784	1.652597	0
DP Reset	0	0.0205	0.4101	0.5753

Table 41. Pump Curve Coefficients

4.14.3 Affinity Law Factor

For simple fan applications or all pump applications, for measures involving variable frequency drives, if performance curves are not used, the affinity law exponent, η, in the equation below shall not exceed 2.3.

$$kW_{new} = kW_{old}\ x\ (\frac{Flow_{new}}{Flow_{old}})^{\eta}$$

4.14.4 Motor Load Factor

Unless supported by site observations and supplemental documentation, motor load factor assumed in calculations shall be equal to 0.75 for motors ≥ 1 HP and 0.90 for motors < 1 HP.

4.14.5 Motor Efficiency

Unless supported by site observations such as photos of equipment nameplates, the analysis shall assume NEMA premium efficiencies as described in ASHRAE 90.1-2019 Tables 10.8.1 through 10.8.5.

4.14.6 Minimum Speed Ratios

If unknown, the following minimum turndown speed ratios shall be used in fan and pump power calculations.

Control Type	Minimum Turndown Speed
No Control or Bypass Damper	100%
Two-Speed	50%

Control Type	Minimum Turndown Speed
Discharge Dampers	50%
Outlet Damper, BI & Airfoil Fans	50%
Inlet Damper Box	50%
Inlet Guide Vane, BI & Airfoil Fans	30%
Inlet Vane Dampers	30%
Outlet Damper, FC Fans	20%
Eddy Current Drives	20%
Inlet Guide Vane, FC Fans	20%
VFD with Duct SP controls	20%
VFD with Low/No Duct SP	20%

Table 42. Minimum Turndown Speeds, Fans

Control Type	Minimum Turndown Speed
One-Speed	100%
Two-Speed	50%
Throttle Valve	20%
Variable Speed	20%
Differential Pressure Reset	20%

Table 43. Minimum Turndown Speeds, Pumps

4.15 Plug and Process Load Specific Requirements

4.15.1 Plug Load Control Savings Factors

Plug load controls can eliminate or reduce idle or standby power consumption of connected equipment. Plug load control types include:

- **Load sensing controls** monitors a specific devices power state and de-energizes connected auxiliary units when the monitored devise enters a low power state.
- **Occupancy sensing controls** automatically de-energize devices when no user is present for a set period of time.
- **Scheduled timer controls** allow users to set a schedule to energize and de-energize devices based on the devices' usage pattern and space schedule.

The following energy savings factors (ESFs) may be used to claim savings for plug load controls. ESFs may only be applied to equipment that is directly impacted by the plug load control.

Control Type	Energy Savings Factor
Load sensing control, workstations	0.04
Load sensing control, print rooms	0.32
Schedule timer control, workstations	0.25
Schedule timer control, print rooms	0.50
Schedule timer control, break rooms	0.46
Occupancy sensor controls, all	0.21
All other controls	0.10

Table 44. Plug Load Control Factors

4.16 Controlled Environment Horticulture

Cannabis grow facilities and other buildings dedicated to plant production (controlled environment horticulture, or CEH) fall outside the scope of local and state energy codes. As a result, baseline efficiency requirements for lighting, HVAC, dehumidification, and other loads are not established through the standard code-reference baseline used elsewhere in these guidelines. This subsection defines CEH-specific terms, baseline HVAC/dehumidification (HVAC/D) system types, and baseline efficiency requirements for Custom program projects involving CEH spaces.

Two ASHRAE baseline tracks are provided throughout this subsection: ASHRAE 90.1-2019 and ASHRAE 90.1-2022. Use the track that corresponds to the energy code baseline in effect for the project at the time of application submission, unless program guidance directs otherwise.

4.16.1 Definitions

The following definitions apply to CEH buildings and spaces and are referenced throughout this subsection.

- **Controlled Environment Horticulture (CEH) Space:** a building space dedicated to plant production by manipulating indoor environmental conditions (electric lighting, irrigation, mechanical heating, mechanical cooling, or dehumidification). Does not include space where plants are grown solely to decorate that same space. Greenhouse and indoor growing spaces are both types of CEH space.
- **Desiccant Dehumidification System:** a mechanical dehumidification technology that uses a solid or liquid material to remove moisture from the air.
- **Greenhouse:** a CEH space that maintains a sunlit environment for horticultural production, with a Skylight Roof Ratio of 50% or more above the growing area, erected for a period of 180 days or more.
- **Greenhouse, Conditioned:** a greenhouse with heating capacity exceeding 10 Btu/hr-ft² or mechanical cooling capacity exceeding 5 Btu/hr-ft².
- **Horticultural Lighting:** luminaires used for plant growth and maintenance, with either plug-in or hard-wired power connections.
- **Indoor Growing:** a CEH space used exclusively for horticultural production with a Skylight Roof Ratio of less than 50% above the growing area — for example, growing plants in a warehouse with or without skylights.
- **Integrated HVAC/D System:** a system designed to handle both sensible and latent heat removal, which may include systems with a sensible heat ratio of 0.65 or less capable of providing cooling, dedicated outdoor air systems, single packaged units with hot-gas reheat, and modified portable dehumidifiers with external heat rejection.
- **Photosynthetic Photon Efficacy (PPE):** photosynthetic photon flux divided by input electric power, in micromoles per second per watt (or micromoles per joule), as defined by ANSI/ASABE S640.
- **Skylight Roof Ratio:** the ratio of skylight area to gross exterior roof area.

4.16.2 Baseline HVAC/D System Types

The proposed baseline for Custom projects must correspond to one of the following four system types.

4.16.2.1 System Type 1: Packaged Dehumidifiers

Packaged dehumidifiers control humidity in the grow area using a DX refrigeration coil, with the sole purpose of dehumidifying air; heat is added to the space by the dehumidifiers, and external HVAC systems handle the full space sensible cooling load. Baseline dehumidifier and HVAC efficiencies are selected from the table in §1.1.1. If the proposed HVAC system type is not represented in the table, the baseline defaults to an air-cooled air conditioner (cooling mode).

4.16.2.2 System Type 2: Integrated HVAC/D Systems

HVAC/D systems handle both sensible and latent heat removal — air is cooled by a DX coil for conditioning and dehumidification, then reheated to the design supply air temperature. At least 75% of the annual electric reheat energy must come from on-site heat recovery; if the proposed design uses 100% hot gas reheat, savings may be claimed for 25% of the baseline annual electric reheat energy. Baseline efficiencies come from §1.1.1, defaulting to an air-cooled air conditioner (cooling mode) if the proposed type isn’t represented.

4.16.2.3 System Type 3: Chilled Water System

Dehumidification uses chilled water-cooling coils to condense moisture from recirculated air, which is then reheated to the design supply air temperature. The same 75% on-site heat recovery requirement and 25% hot-gas-reheat savings allowance from System Type 2 apply. Baseline chiller efficiency is selected from the appropriate size range and fuel type in §1.1.1; for electric chillers, the baseline may be air-cooled or water-cooled.

4.16.2.4 System Type 4: Solid or Liquid Desiccant Dehumidification

Desiccant dehumidifiers remove moisture from recirculated room air, with heat added to regenerate the desiccant once moisture is removed. This system type applies where a space dew point of 50°F or less is required. At least 75% of the heat added by the desiccant system must be removed by a heat exchanger with energy recovery.

4.16.3 Baseline System Type Selection

There are two options for establishing the baseline HVAC/D system type on Custom projects.

4.16.3.1 Option 1 (Simplified Approach)

- Select the baseline HVAC/D system type from §4.16.2 that best corresponds to the proposed configuration.
- Use baseline efficiencies and parameters from §1.1.1 based on the proposed equipment scope.
- Calculate proposed energy consumption per design; it must be lower than baseline consumption to be incentive-eligible.

4.16.3.2 Option 2 (Complex Approach)

- Select any HVAC/D system type option from §4.16.2 to establish baseline.

- Calculate baseline energy consumption using efficiencies and parameters from §1.1.1.
- Calculate proposed-system-type energy consumption using §1.1.1; if claiming savings from a system type change, establish baseline consumption for each system type under consideration.
- Calculate proposed design energy consumption, distinguishing savings from system type changes versus efficiency improvements. Proposed consumption must be less than both baselines to be incentive-eligible.

For both options: the baseline heating system type must match the proposed case heating system type, and the baseline fuel type must match the proposed system's fuel type.

4.16.4 CEH Baseline Efficiency Requirements

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
Lighting[5,6]						
Indoor Grow Spaces	Indoor Lighting (Overhead)	< 40 kW connected lighting load		PPE ≥ 1.6 μmol/J	PPE ≥ 1.7 μmol/J	ASHRAE 90.1-2022 §9.4.4.2 exception; NJ Program Year 5 TRM §3.7.6
Indoor Grow Spaces	Indoor Lighting (Overhead)	≥ 40 kW connected lighting load		PPE ≥ 1.6 μmol/J	PPE ≥ 1.9 μmol/J	ASHRAE 90.1-2022 §9.4.4.2
Greenhouse	Indoor Lighting (Overhead)	All		PPE ≥ 1.6 μmol/J	PPE ≥ 1.7 μmol/J	ASHRAE 90.1-2022 §9.4.4.1
Indoor Grow / Greenhouse	Under-Canopy Lighting	Supplemental horticultural fixtures mounted under primary canopy	See §4.17.5 for full methodology	*[(EE fixture PPF × # of EE fixtures) / BL PPE] × 1.2458 × (1 / 1,000)* Baseline efficacy no less than required by DLC v3.0 for equivalent overhead fixtures, stepping to DLC v4.0 upon adoption of v5.0 See §4.17.5 for full methodology		Program-developed methodology; DLC v3.0/v4.0 Qualified Products List.

[5] Horticultural lighting baseline requirements (Indoor Grow Spaces and Greenhouse rows) are new to ASHRAE 90.1-2022 — there is no 90.1-2019 equivalent, since CEH lighting was not addressed prior to the 2022 edition.
[6] Total Baseline kW = Total Proposed PPF / Baseline PPE

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
Envelope[7]						
All	Opaque Wall	Steel-framed		U-0.064 (CZ 4A) / U-0.055 (CZ 5A) / U-0.049 (CZ 6A)	Same as 90.1-2019	ASHRAE 90.1 Table 5.5
All	Opaque Roof	Insulation entirely above deck		U-0.032 (CZ 4A–6A)	Same as 90.1-2019	ASHRAE 90.1 Table 5.5
Conditioned Greenhouse[8]	Non-Opaque Wall			U-0.7	Same as 90.1-2019	2021 IECC C402.1.1.1
Conditioned Greenhouse[8]	Non-Opaque Roof			U-0.5	Same as 90.1-2019	2021 IECC C402.1.1.1
All	Vertical Fenestration, 0%–40% of wall		Fixed	U-0.36 (CZ 4A–5A) U-0.34 (CZ 6A) SHGC-0.36 (CZ 4A) SHGC-0.38 (CZ 5A–6A)	Same as 90.1-2019	ASHRAE 90.1 Table 5.5
All	Vertical Fenestration, 0%–40% of wall		Entrance door	U-0.63 (CZ 4A–6A) SHGC-0.33 (4A–5A) SHGC-0.34 (6A)	Same as 90.1-2019	ASHRAE 90.1 Table 5.5

[7] Note: IECC does not provide a required SHGC for greenhouse envelopes. Therefore, the baseline SHGC for a non-opaque wall or roof shall be modeled equally to the proposed SHGC. Alternatively, credit may be taken for SHGC improvements as long as the applicant provides appropriate documentation of the baseline SHGC for an industry-standard greenhouse envelope construction.

[8] Two or more glazings separated by air or gas fill. The U-factor for a roof shall be for the roof assembly or a roof that includes the assembly and an internal curtain system.

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
All	Skylight		All types	U-0.50 (CZ 4A–5A) U-0.47 (6A) SHGC-0.40 (CZ 4A–6A)	Same as 90.1-2019	ASHRAE 90.1 Table 5.5
Cooling and Dehumidification Systems — Direct Expansion[9,10]						
All	Air-cooled air conditioner (cooling mode)	< 65,000 Btu/h	Code-compliant split system and single package	13.4 SEER2; 10.8 EER2	Same as 90.1-2019	ASHRAE 90.1-2019 Table 6.8.1-1.
		≥ 65,000 and < 135,000 Btu/h		11.0 EER; 14.6 IEER	Same as 90.1-2019	
		≥ 135,000 and < 240,000 Btu/h		10.8 EER; 14.0 IEER	Same as 90.1-2019	
		≥ 240,000 and < 760,000 Btu/h		9.8 EER; 13.0 IEER	Same as 90.1-2019	
		≥ 760,000 Btu/h		9.5 EER; 12.3 IEER	Same as 90.1-2019	
		< 65,000 Btu/h	Code-compliant air	14.3 SEER2; 11.5 EER2 (split system); 13.4 SEER2; 10.8	Same as 90.1-2019	ASHRAE 90.1-2019 Table 6.8.1-2

[9] For projects involving cooling and dehumidification equipment, equipment loads shall be calculated based on internal heat / humidity loads rather than nominal equipment tonnage
[10] For proposed systems rated in ISMRE or ISCOP that exceed the ASHRAE 90.1-2019 Table 6.8.1-13 requirement, baseline efficiency in Tables G3.5.1 and G3.5.2 may be derated using the program-approved methodology.

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
	Air source heat pump (cooling mode)		source heat pump	EER2 (single package)		
		≥ 65,000 and < 135,000 Btu/h		10.8 EER; 13.9 IEER	Same as 90.1-2019	
		≥ 135,000 and < 240,000 Btu/h		10.4 EER; 13.3 IEER	Same as 90.1-2019	
		≥ 240,000 Btu/h		9.3 EER; 12.3 IEER	Same as 90.1-2019	
	DOAS unit, air-cooled	De-humidification mode	Code-compliant DX DOAS unit without energy recovery	4.0 ISMRE; 3.8 ISMRE2	Same as 90.1-2019	ASHRAE 90.1 Table 6.8.1-13
Cooling and Dehumidification Systems — Chilled Water						
All	Air-cooled chiller	< 150 tons	Code-compliant air-cooled chiller without heat recovery	10.1 EER (Full Load); 13.7 EER (IPLV)	Same as 90.1-2019	ASHRAE 90.1 Table 6.8.1-3.
		≥ 150 tons		10.1 EER (Full Load); 14.0 EER (IPLV)	Same as 90.1-2019	
	Water-cooled chiller	< 75 tons	Code-compliant water-cooled	0.75 kW/ton (Full Load); 0.60 kW/ton (IPLV)	Same as 90.1-2019	

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
		≥ 75 and < 150 tons	chiller without heat recovery	0.72 kW/ton (Full Load); 0.56 kW/ton (IPLV)	Same as 90.1-2019	
		≥ 150 and < 300 tons		0.66 kW/ton (Full Load); 0.54 kW/ton (IPLV)	Same as 90.1-2019	
		≥ 300 and < 600 tons		0.61 kW/ton (Full Load); 0.52 kW/ton (IPLV)	Same as 90.1-2019	
		≥ 600 tons		0.56 kW/ton (Full Load); 0.50 kW/ton (IPLV)	Same as 90.1-2019	
	Absorption double effect (indirect or direct fired)	All capacities	Code-compliant absorption chiller	≥ 1.000 COP (Full Load and IPLV)	Same as 90.1-2019	ASHRAE 90.1 Table 6.8.1-3
	DOAS unit, water-cooled	De-humidification mode	Code-compliant chilled-water DOAS without energy recovery	4.9 ISMRE; 4.7 ISMRE2	Same as 90.1-2019	ASHRAE 90.1 Table 6.8.1-13
Heating Systems						

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
All	Gas-fired furnace	All capacities	Code-compliant furnace	81% AFUE or 81% Et	Same as 90.1-2019	ASHRAE 90.1 Table 6.8.1-5 and Table 6.8.1-6
	Gas-fired hot water boiler	< 300 MBH	Code-compliant gas-fired boiler	82% AFUE	Same as 90.1-2019	
		≥ 300 and ≤ 2,500 MBH		80% Et	Same as 90.1-2019	
		> 2,500 MBH		82% Ec	Same as 90.1-2019	
	Air source heat pump	< 65,000 Btu/h (cooling capacity)	Code-compliant air-cooled heat pump	7.5 HSPF2 (split system); 6.7 HSPF2 (single package)	Same as 90.1-2019	ASHRAE 90.1 Table 6.8.1-2.
		≥ 65,000 and < 135,000 Btu/h		3.4 COP_h at 47°F db/43°F wb; 2.25 COP_h at 17°F db/15°F wb	Same as 90.1-2019	
		≥ 135,000 and < 240,000 Btu/h		3.3 COP_h at 47°F db/43°F wb; 2.05 COP_h at 17°F db/15°F wb	Same as 90.1-2019	
		≥ 240,000 Btu/h		3.2 COP_h at 47°F db/43°F wb; 2.05	Same as 90.1-2019	

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
				COP_h at 17°F db/15°F wb		
	DOAS unit, air source heat pump (heating mode)		Code-compliant DOAS without energy recovery	2.7 ISCOP; 2.05 ISCOP	Same as 90.1-2019	ASHRAE 90.1 Table 6.8.1-13
Dehumidification Systems						
All	Stand-alone (non-ducted) dehumidifier	≤ 25 pints/day		1.30 L/kWh	Same as 90.1-2019	10 CFR 430
		> 25 and ≤ 50 pints/day		1.60 L/kWh	Same as 90.1-2019	
		> 50 pints/day		2.80 L/kWh	Same as 90.1-2019	
	Ducted dehumidifier	Product case volume ≤ 8 ft^3		1.77 L/kWh	Same as 90.1-2019	
		Product case volume > 8 ft^3		2.41 L/kWh	Same as 90.1-2019	
Heat Recovery						

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
All	Integrated HVAC/D System	Heat recovery		75% of the annual energy used for dehumidification reheat	Same as 90.1-2019	ASHRAE 90.1 §6.5.2.1 Exception 4
	Chilled Water System	Heat recovery		75% of the annual energy used for dehumidification reheat	Same as 90.1-2019	ASHRAE 90.1 §6.5.2.1 Exception 4
	Desiccant System	Heat recovery		75% of heat added by the desiccant system is removed by a heat exchanger with energy recovery	Same as 90.1-2019	ASHRAE 90.1 §6.5.2.3
Pumps						
All	Chilled Water Pump	Pump Efficacy	Constant-volume	9 W/GPM	Same as 90.1-2019	ASHRAE 90.1 Appendix G §G3.1.3.10.
		Pump Efficacy	Variable-volume	13 W/GPM	Same as 90.1-2019	
	Hot Water Pump	Pump Efficacy	All hot water pumps	19 W/GPM	Same as 90.1-2019	ASHRAE 90.1 §G3.1.3.5
	Condenser Water Pump	Pump Efficacy	All condenser water pumps	19 W/GPM	Same as 90.1-2019	ASHRAE 90.1 §G3.1.3.11

Building Type	Building Component	Subcategory / Rating Condition	Baseline Description	ASHRAE 90.1-2019 Baseline Efficiency	ASHRAE 90.1-2022 Baseline Efficiency	Sources/Notes
	Chilled / Hot Water System	Pump Controls	Variable-flow chilled or heating-water system controls	Controls limiting pump motor demand to no more than 30% of design wattage at 50% of design flow	Same as 90.1-2019	ASHRAE 90.1 §6.5.4.2
	Condenser Water System		Constant-volume condenser water system	Constant volume	Same as 90.1-2019	ASHRAE 90.1 §G3.1.3.11
Ventilation Fans[11]						
All	Constant Volume Fan System	Constant Volume Fan Power	Maximum allowable motor power	Pf = bhp × 746 / fan efficiency, where bhp = cfms × 0.00094 + Σ(PD × cfmD / 4,131)	Same as 90.1-2019	ASHRAE 90.1 Table 6.5.3.1-1
	Variable Volume Fan System	Variable Volume Fan Power	Maximum allowable motor power	Pf = bhp × 746 / fan efficiency, where bhp = cfms × 0.0013 + Σ(PD × cfmD / 4,131)	Same as 90.1-2019	

Table 45. CEH Baseline Efficiency Requirements

[11] See ASHRAE 90.1 Table 6.5.3.1-2 for applicable pressure drop (PD) in terms of in. of water. CFMD is the design airflow through each applicable device from Table 6.5.3.1-2 in CFM. A = Σ (PD x cfmD / 4,131).

4.16.5 Under-Canopy Lighting Calculation Methodology

Under-canopy horticultural lighting supplements the primary canopy lighting layer. The following methodology and formulas apply when calculating savings for under-canopy lighting retrofits.

Assumptions

- Hours of operation remain the same between baseline (BL) and proposed (efficient case) configurations, based on the under-canopy lighting configuration.
- Minimum efficacy requirements for the baseline case shall be no less than required by DLC v3.0 for equivalent overhead fixtures. This minimum steps up to DLC v4.0 if/when DLC v5.0 is adopted.
- A Waste Heat Factor (WHF), crediting the efficient case for adding less sensible cooling load to the HVAC system, may be applied by multiplying final kWh savings by no more than 1.141 (source: Pennsylvania TRM).
- An efficiency factor of 1.2458 (a 24.58% increase in efficiency of under-canopy lighting versus traditional lighting) is sourced from peer-reviewed research on subcanopy and inter-canopy supplemental lighting in medicinal cannabis cultivation.

Formulas

Efficient case power (kW):

Efficient case power kW = (EE fixture W × # of EE fixtures) / 1,000

Baseline power (kW):

BL power kW = [(EE fixture PPF × # of EE fixtures) / BL PPE] × 1.2458 × (1 / 1,000)

Where PPF is photosynthetic photon flux and PPE is photosynthetic photon efficacy of the baseline fixture, both consistent with the definitions in §4.17.1.

Garrido, J.; Corral, C.; García-Valverde, M.T.; Hidalgo-García, J.; Ferreiro-Vera, C.; Martínez-Quesada, J.J. Subcanopy and Inter-Canopy Supplemental Light Enhances and Standardizes Yields in Medicinal Cannabis (Cannabis sativa L.). Plants 2025, 14, 1469.

5. Design Guidelines

Engineering design is a collaborative and systematic process involving the owner, design team, and other project stakeholders. This process addresses existing building conditions and applies engineering standards, operational requirements, and performance objectives to develop a design that aligns with the owner's project goals, applicable codes, and long-term facility needs, with optimizing energy use as one of the primary objectives. It also validates existing system capacities and field conditions identified during the audit, supporting the project in achieving targeted improvements in energy efficiency, system reliability, and occupant comfort.

An effective design process is essential to realizing the full performance potential of energy efficiency projects. Without a coordinated approach, even well-intended ECMs may underperform or create operational challenges. Engineering design should span the entire project lifecycle, from pre-design through construction, commissioning, and post-occupancy operation.

Disclaimer: The intent of submitting design documents to TRC is to review the proposed design from an administrative perspective to align with program goals and general compliance requirements. The Program Ally is fully responsible for the accuracy and functionality of the design and associated documents. TRC will review and may offer guidance on technical viability, but TRC is not responsible for the design. As a result, JCP&L and TRC are not liable if estimated savings or economics are not achieved. In no event will JCP&L or TRC be liable for failure to achieve a specified amount of energy savings, performance, the operation of customer facilities, or any incidental or consequential damages in connection with this report, design, or the installation or operation of recommended measures. The customer and their respective contractors are responsible for implementing energy conservation measures in complete conformance with all applicable local, state, and federal requirements.

5.1 Basis of Design

The Basis of Design (BOD) is a written document that outlines the Design Team's approach to meeting the Customer's requirements and the defined design scope. 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 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:

- Specific codes, standards, and guidelines considered during design, 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 operation and maintenance.
- Performance criteria that the system was designed to meet.
- Specific design methods, techniques, and software used in design.
- A narrative statement of design describing how the designer intends to meet the Customer's requirements.
- A narrative statement of operation detailing how the facility is expected to operate under various situations (normal operation, extreme events, emergency).
- A listing of specific manufacturer models used as the basis of drawings and specifications.

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

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 design intent. Document key design decisions, assumptions, and performance criteria. Serve as a reference for the Owner, Cx Team, and project stakeholders.
	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 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. Existing building conditions (if applicable).

Section	Component	Description
	Assumptions Regarding Facility Use	Expected occupancy patterns and operational schedules. Space function and flexibility considerations.
	System O&M Expectations	Long-term O&M expectations for major systems. Design decisions that impact serviceability, accessibility, and lifespan.
Section 3: Building Systems and Assemblies	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).
	Architectural and Structural Design (if applicable)	Building orientation, envelope performance, and material selections. Structural system selection and design criteria. Load considerations and coordination with building systems.
	Plumbing Design	Domestic water supply, distribution, and heating. Wastewater and stormwater management strategies.
Section 4: Design Methodology	Narrative Statement of Design	Design team's rationale for key technical and engineering decisions.
	Design Methods, Techniques, and Software	Engineering methodologies for system sizing and performance analysis. Software tools for modeling, simulations, and calculations.
	Manufacturer Basis of Design	List of specific manufacturer models used as the basis of drawings and specifications.
Section 5: Indoor Environmental Quality	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 applicable standards.
	Acoustics, Noise, and Lighting	Noise criteria (NC) levels for different spaces. Vibration isolation for mechanical equipment. Lighting levels, control strategies, and daylighting integration.
Section 6: Energy and Sustainability Goals	Energy Performance	Energy Use Intensity (EUI) targets. Renewable energy integration and efficiency strategies.
	Sustainability and Decarbonization	LEED, WELL, ENERGY STAR, or other program participation. GHG emission targets and reduction goals. Electrical capacity requirements.
	Water Conservation	Plumbing fixture efficiency standards. Irrigation and stormwater management requirements.

Section	Component	Description
Section 7: Operation and Maintenance	Narrative Statement of Operations	Description of how the facility is expected to operate under normal conditions, extreme events, and emergency situations.
	Maintainability and Reliability	Access to MEP systems. Design features that facilitate maintenance. Backup power and redundancy expectations.
	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 and Submissions	Required submissions at key project phases (schematic design, design development, construction documents). Owner review and approval checkpoints. Commissioning schedule and integration into construction timeline.
	Change Management	Procedures for documenting and approving design changes. Process for addressing Owner and Cx Team feedback.
	Special Project Considerations	Unique requirements based on location, climate, process, or project type. Specific security, accessibility, or technology integration needs.

Table 46. Basis of Design Outline

5.2 Engineering Design

The Program Ally is responsible for developing construction documents, including design building plans, specifications, basis of design, and bidding instructions required for the installation and construction of the ECMs identified in the final approved energy audit. The Program Ally shall follow the most current version of the Construction Specifications Institute (CSI) MasterFormat Standard or the customer's specific design standards. All construction documents, revisions, and addenda shall be provided to both the customer and TRC in a suitable electronic format.

The Program Ally is also responsible for:

- Delivering calculations that support energy savings, the Executive Summary/CBA tool, and an explanation of changes to scope, energy savings, or cost from audit to design completion to TRC for review after engineering design is completed and prior to bidding.
- Assisting the customer through the bid process and contracts, and delivering updated calculations, Executive Summary/CBA tool, and final Supplement 1 to TRC for approval after bidding and before the contract is awarded.

5.2.1 Bidding

The Program Ally shall assist the customer in the bidding process between the Customer and prospective Construction Contractors. The customer will determine the extent of support needed. The Program Ally shall be engaged to assist in identifying and qualifying prospective contractors, addressing Requests for Information (RFIs), attending bidding conferences, and reviewing, descoping, and levelizing final bids.

The Program Ally shall:

- Coordinate the preparation and distribution of invitations to bidders.
- Coordinate all Requests for Information (RFIs) during the bid process.
- Advise all bid participants that communication shall be in writing (electronic mail is acceptable) and that all relevant information will be distributed to all bidders.
- Advise all bidders that construction contracts are either Guaranteed Maximum Price (GMP) or fixed price. All allowances and contingencies must be identified in contractor bids and may only be utilized through the 3-signature change order process, requiring approval from the engineer, Customer, and Construction Contractor. The engineer shall maintain a change order log and provide updates to TRC as change orders are processed.
- Notify bidders that the American Institute of Architects (AIA) Application and Certification of Payment form should be used to request payments throughout construction.
- Notify bidders that bids must include prevailing wages. If the customer requests union labor requirements, relay these to contractors ahead of and during the pre-bid meeting.
- Arrange and coordinate a pre-bid meeting at the Customer's facility. If an alternate location is selected, ensure all bidders have access to the facility for walkthroughs and inspections as needed.
- Monitor and ensure timely progress throughout the bid process.
- Receive all proposals and review them for: (1) completeness of all required information; (2) accuracy; (3) conformance with the construction documents; and (4) references and other quality checks.
- Notify any bidders who submitted deficient proposals and allow them a reasonable time to re-submit.
- Prior to contract award, meet with one or more bidders to descope the bid and confirm sufficient qualifications and resources to complete the project.
- Review proposals for cost, accuracy, and adequacy to ECM designs, and recommend a bidder to the Customer.

- Communicate the customer's final bid selection to the selected bidder(s) and confirm any outstanding documentation. Compile and transmit the complete set of proposals to TRC electronically.
- Provide TRC with Supplement 1, which identifies and documents any changes in ECM cost, quantity, or energy savings relative to the Final Energy Audit report.

5.2.2 Contract Award

The Program Ally is responsible for drafting and facilitating execution of contracts with each Construction Contractor and providing copies to TRC. Contracts shall be executed and dated by both the Customer and Construction Contractor, and shall follow the American Institute of Architects (AIA) format unless otherwise required by the customer.

The Program Ally is responsible for obtaining and providing the following to TRC:

- Preliminary construction and implementation schedules for each ECM, including a project start date (such as mobilization date). Schedules should account for facility constraints that may impact construction availability, and should highlight potential delays (e.g., installing boilers during the heating season) or extraordinary conditions that might change the duration, cost, or anticipated energy savings.
- A list identifying any anticipated building permits and inspections.

6. Construction Administration Guidelines

The customer is responsible for hiring or operating as the Construction Manager for construction at the project site. The Program Ally is responsible for managing the project to align with the design and energy savings expectations, providing clear communication with the Customer, Contractor, and TRC throughout the process. This task includes technical engineering submittal reviews, on-site inspections, and updating deliverables for final closeout.

Disclaimer: TRC is performing an administrative function to quality control the deliverables for implementation of this incentive program. The Program Ally is responsible for the accuracy and functionality of their audit, design, Cx, and operation of the design. As a result, JCP&L and TRC are not liable if estimated savings ranges or economics are not actually achieved. In no event will JCP&L or TRC be liable for the failure of the customer to achieve a specified amount of energy savings, performance, the operation of customer facilities, or any incidental or consequential damages in connection with this report, design, or the installation or operation of recommended measures. The customer and their respective contractors are responsible for implementing energy conservation measures in complete conformance with all applicable local, state, and federal requirements.

6.1 Construction Phase

The Program Ally is responsible for ensuring that the ECMs are installed and constructed in accordance with the construction design documents, construction schedule, approved funding plan, and any approved change orders. The Program Ally shall:

- Attend all key construction meetings at an appropriate interval to maintain current knowledge of implementation progress (monthly at minimum, unless otherwise agreed upon in writing with TRC).
- Observe and report on the construction progress of the ECM installation, including the approval of payment requests from the prime Construction Contractor, along with scheduling updates and any impediments to progress.
- Perform on-site inspections (with TRC included) to report customer requests for milestone payments. Inspection reports shall include: the Program Ally's letterhead or equivalent identification; the date of inspection and the funding amount requested or percent of construction completed; a list of attendees; a brief description of progress, observations, and any issues to be addressed; a table summarizing the estimate of completion by ECM; and photo documentation supporting the project progress.

- Provide copies of all invoices, requests for payment, and other payment-related documentation to TRC. Payment requests must be signed by the contractor, customer, and Program Ally confirming the work noted in the request was confirmed on site.
- Maintain a list of outstanding energy efficiency-related project issues to be completed by the Construction Contractor throughout the course of the project.
- Review all construction documentation and respond to submittals, shop drawings, and RFIs to ensure conformance with construction design. Any change orders resulting in changes to energy savings or project costs shall be reported in writing to TRC.
- Maintain a count of equipment quantities per ECM.

6.2 Final Inspection

At project completion, the Program Ally will conduct a Final Inspection of the project. The Program Ally shall:

- Coordinate the final inspection with TRC.
- Perform an on-site final inspection of all ECMs installed as part of the project.
- Document final equipment quantities per ECM.
- Provide a Final Inspection Report meeting all requirements described in the construction submission requirements section. The Final Inspection Report shall be submitted within seven days of the final inspection, or within seven days of the observed punch list items being addressed.

7. Commissioning Guidelines

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 (OPR), Basis of Design (BOD), 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 potential of energy efficiency projects. Without it, even well-designed systems may underperform. Cx spans the entire project lifecycle, from pre-design through post-occupancy operation, and includes the preparation of a Cx Plan and Cx Report, both mandatory program deliverables.

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.

Disclaimer: TRC is performing an administrative function to quality control the deliverables for implementation of this incentive program. The Program Ally is responsible for the accuracy and functionality of their audit, design, Cx, and operation of the design. As a result, the supporting utility and TRC are not liable if estimated savings ranges or economics are not actually achieved. In no event will the supporting utility or TRC be liable for the failure of the customer to achieve a specified amount of energy savings, performance, the operation of customer facilities, or any incidental or consequential damages in connection with this report, design, or the installation or operation of recommended measures. The customer and their respective contractors are responsible for implementing energy conservation measures in complete conformance with all applicable local, state, and federal requirements.

7.1 Commissioning Authority Experience

The CxA oversees the commissioning process, ensuring that building systems are designed, installed, tested, and functioning in alignment with the BOD, design intent, and industry best practices, 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 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), or ASHRAE Commissioning Process Management Professional (CPMP). Other industry credentials may be accepted with approval from the Program Manager.
- May be a qualified staff member of the Program Ally, a consultant retained by the Program Ally, or a consultant engaged by the project participant.

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

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 and 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 (PFT) and Functional Performance Testing (FPT) 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.

Table 47. CxA Roles and Responsibilities

7.2 Stakeholder Roles and Responsibilities

This section describes the roles and responsibilities of all key stakeholders involved in the commissioning process. Note that all listed stakeholders may not be involved in every project, but this list details the responsibilities for stakeholders that are typically involved.

Stakeholder	Responsibility
Owner and/or Partner	Defines project and commissioning (Cx) goals and provides overall support. Grants the CxA the authority to engage in construction activities within the project boundaries. Makes discretionary decisions based on input from the Cx team. 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 related activities. Manages and ensures the involvement and collaboration of subcontractors while incorporating Cx into construction, startup, testing, training, and closeout milestones. Oversees scheduling, preparation, and 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 and Electrical Engineers	Responsible for professional engineering design and approvals. Prepares plans, specs, BOD, and reviews equipment submittals. Coordinates with architects to support Cx Plan strategies, site inspections, punch lists, Owner acceptance, and project closeout.
Mechanical and 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. The coordinator assists in Cx tasks, primarily preparing EMS data to confirm system sequences and performance are functioning correctly.
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.

Table 48. Commissioning Stakeholder Responsibilities

7.3 Commissioning Plan Requirements

The Cx Plan manages and documents the commissioning process, defining roles and responsibilities, Cx procedures, testing protocols, and documentation requirements. Following construction, start-up, testing, optimization, and closeout shall proceed in accordance with the Cx Plan.

Cx Plans must be submitted for all projects for review and approval. At minimum, all incentivized ECMs must be included in the Cx scope. Program Allies 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:

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 ECMs to be commissioned. Applicable codes, standards, and guidelines.
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. Construction phase Cx tasks: site observations, submittal reviews, issue tracking. Controls and EMS commissioning approach. PFT scope and checklist development. 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 the 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 Resolution Log	Active log of identified deficiencies and issues. Status tracking for each issue (open, in progress, resolved). Summary of resolutions and final outcomes.

Table 49. Commissioning Plan Outline

The following appendices are recommended as part of the Cx Plan:

Cx Plan Appendices
☐ Owner's Project Requirements: A copy of the most recent OPR at the time of the Cx Plan submission, if applicable.
☐ Basis of Design: A copy of the most recent BOD at the time of the Cx Plan submission.
☐ Pre-functional Performance Test Forms: Templates to verify equipment and systems are properly installed, started up, and prepared for functional testing.
☐ Functional Performance Test Forms: Templates to document system operation testing against the design intent and sequences of operation.

Cx Plan Appendices
☐ Training Curriculum: Anticipated training for operations personnel, including descriptions of training materials, system demonstrations, and ongoing assistance.
☐ Issues and Resolution Log: Template to document issues, corrective actions, and responsible parties.

Table 50. Commissioning Plan Appendices

7.4 Integration of Commissioning with Design and Construction

CxAs should be involved in the design phase whenever possible. Early involvement is strongly recommended, particularly when design and Cx will be completed by different vendors.

Key advantages of integrating Cx with design and construction include:

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, allowing for seamless coordination of functional performance testing, system verification, and quality control throughout construction.
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 and reduces unnecessary energy consumption.
Risk Mitigation and 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 or occupant complaints after project completion.

Table 51. Benefits of Integrating Cx with Design

7.5 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 CxA in a collaborative effort to review project plans, conduct functional tests, and optimize system performance.

Phase	Process
Pre-Design Phase	Develop BOD. Delineate ECM interactivity with additional building systems. Establish Cx scope and requirements. Select and engage the CxA if the design firm is not completing the Cx effort.
Design Phase	Establish the commissioning process early in project development. Integrate Cx requirements into project specifications and contract documents. Align design intent with the BOD. Review design documents for commissioning feasibility, ease of ongoing maintenance, energy efficiency, and decarbonization. Establish communication protocols and define team roles and responsibilities. Coordinate Cx activity with other QA and QC efforts. Develop preliminary Cx documentation including the Cx Plan, commissioning specification, and draft FPT procedures.
Construction Phase: Scoping Meeting	The CxA will organize an introductory meeting to ensure alignment with the commissioning process. Topics include introductions and roles, review of the Cx Plan and scope, documentation requirements, functional performance testing responsibilities, key milestones, and consensus on commissioning strategies.
Construction Phase: Meetings and Site Walkthroughs	The CxA will conduct periodic meetings and site visits to track commissioning progress, observe construction and equipment installation, verify compliance with the BOD, and coordinate EMS sequence validation and trend data analysis.
Construction Phase: Controls and EMS 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 and sequences of operation, advanced energy management strategies, graphic interface and trend log verification, sensor calibration planning, and PFT and FPT plan development.
Construction Phase: Pre-Functional Testing (PFT)	The General Contractor (GC) will coordinate checklist development with CxA oversight. Checklists may include in-house developed PFT checklists, manufacturer startup checklists, and technician startup documentation. The CxA will review and provide feedback on PFT checklists and organize a comprehensive PFT 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, ECM equipment operation, and system sequencing, scheduling, failure modes, and data logging. The CxA will develop test plans summarizing procedures, expected results, discrepancies, and corrective actions.
Construction Phase: Issue Resolution	The CxA will document deficiencies found during pre-functional and functional testing. Procedures will address deficiency reporting workflows, impact assessments on building performance, and communication protocols with the Owner, Project Team, and Program Manager.
Startup, Testing, and Optimization: Pre-functional Start-up	The GC will confirm completion of all pre-startup tasks, including utility readiness, duct and piping testing, and manufacturer startup procedures. The

Phase	Process
	CxA will observe startup and provide real-time feedback while identifying and tracking installation discrepancies.
Startup, Testing, and Optimization: FPT Execution	The CxA will perform testing using a structured, progressive approach: component-level verification, subsystem validation, full-system integration testing, inter-system connectivity including life safety interactions, manual observation and testing, and EMS trend log analysis to validate long-term performance.
Closeout Phase	The CxA will lead a closeout meeting to finalize commissioning activities, verify completed functional performance testing, and review and accept record documentation. The CxA and GC will fulfill all training requirements covering operational best practices, troubleshooting, and maintenance procedures. The CxA will compile warranty information and aggregate all commissioning activities in the Final Commissioning Report.

Table 52. Commissioning Process

7.6 Commissioning Schedule

The Cx Plans and Reports shall include a comprehensive schedule outlining all Cx process activities. At a minimum, all schedules must include start and end dates for each phase. Schedules in other formats such as Gantt charts are also acceptable.

Phase	Tasks	Duration
Design	Design Review; Cx Kick-off Meeting; Develop Draft Cx Plan; CxA Schematic and Design Development Review; Complete Construction Documents	~31–61 days
Construction	Pre-bid Meeting; Finalize Contracts; Pre-construction Meeting; Review and Approve Submittals; Cx Kick-off Meeting; Construction Inspections	~61–166 days
Startup, Testing, and Optimization	Complete Construction / Pre-Functional Testing Checklists; Complete Functional Performance Testing	~19–45 days
Closeout	Complete O&M and Systems Manual; Conduct Training; Address Outstanding Issues; Warranty Review; Finalize Cx Report	~30–46 days

Table 53. Commissioning Schedule

7.7 Sampling Requirements

Sampling validates that systems and equipment are properly installed, function correctly, and meet the owner's requirements. Sampling rates should reflect project size, system complexity, and historical performance data.

The sampling procedure shall 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.

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

Table 54. Cx Sampling Requirements

Actual sampling should be based on owner and project-specific requirements, deficiency trends, and criticality of systems. 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.
- **Deficiency Trends:** If multiple failures occur within an initial sample, expand sampling up to 100% of all systems.
- **Project Requirements:** Higher sampling percentages 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.

7.8 Issues and Resolution Log

The Issues and Resolution Log is a centralized record for tracking Cx-related issues throughout the project. A complete log must be included in the final Cx Report. All significant issues impacting energy performance must be resolved prior to Cx Report approval.

The log shall track the following for each issue: issue ID, location (building name, space type, room number), date identified, resolution date, system ID and description, manufacturer and model, description of the issue, phase when identified, root cause, priority level, responsible party, current status, recommended resolution, solution implemented, and verification sign-off by name, title, and company.

7.9 Commissioning Report Requirements

The Cx Report documents all commissioning activities, test results, and performance evaluations, and serves as the comprehensive record of system performance relative to design intent. The report shall be prepared in accordance with ASHRAE Guideline 0-2019 and ASHRAE Standard 202-2024.

The goals of commissioning and the Cx Report include confirming that:

- ECMs are implemented as originally planned or deliver equivalent or greater energy savings compared to initial projections.
- Equipment nameplate data matches the project design specifications.
- Actual energy consumption or equipment output corresponds with assumptions used in energy savings calculations.
- Control systems are properly configured and operate in accordance with assumptions applied in energy savings calculations.
- Operator training for all relevant equipment is completed.
- A comprehensive deficiency log is maintained, detailing the impact on energy savings and corrective actions implemented.
- 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 include the following sections:

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).

Section	Content
Cx Scope and Objectives	Systems and equipment commissioned. Scope of Cx activities. Specific owner goals (energy efficiency, indoor air quality, decarbonization).
Cx Process Overview	Phases and activities performed. Summary of Cx Plan execution. Key milestones and timelines.
Systems Commissioned	List of systems and subsystems commissioned. 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.
Testing and Verification Results	Summary of FPT outcomes. Verification of sequence of operations. Control system performance (trend log analysis, sensor calibration).
Outstanding Issues and Recommendations	Unresolved deficiencies (if any). Long-term operational and maintenance recommendations. Suggested energy-saving opportunities. Opportunities for continuous commissioning.
Warranty and Post-Construction	Key warranty information. Post-construction commissioning plans (if applicable). Lessons learned and recommendations for seasonal testing.

Table 55. Commissioning Report Outline

The following appendices shall be provided as part of the Cx Report:

Cx Report Appendices
☐ Basis of Design: Final version of the BOD.
☐ Cx Plan: Final version of the Cx Plan.
☐ Pre-functional Performance Test Forms: Completed forms verifying equipment installation and readiness.
☐ Functional Performance Test Forms: Completed forms documenting system operation testing.
☐ Contractor Start-up Reports: Start-up documentation provided by contractors.
☐ Building Envelope Cx Reports: Summarizes testing and verification of opaque assemblies and fenestration.
☐ 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.
☐ 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.

Table 56. Commissioning Report Appendices

7.10 Additional Commissioning Resources

The following resources provide best practices, templates, examples, and technical information related to the Cx process. This list is provided for reference only and does not imply endorsement of any specific organization or publication. Users should evaluate each resource based on specific project needs and applicable program requirements.

- ASHRAE Guideline 0-2019: The Commissioning Process
- ASHRAE Standard 202-2024: Commissioning Process Requirements for New Buildings and New Systems
- ASHRAE Standard 230-2022: Commissioning Process for Existing Buildings and Systems
- 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 4-2019: Preparation of Operating and Maintenance Documentation for HVAC&R Systems
- Building Commissioning Authority (BCxA) Best Practices and Sample Templates: bcxa.org
- California Building Commissioning Guide (CEC)
- NEBB ANSI/NEBB S110-2019: Whole Building Technical Commissioning of New Construction

8. Measurement and Verification Guidelines

Measurement and Verification (M&V) quantifies energy savings achieved through efficiency projects by comparing pre- and post-installation energy use while accounting for external factors. M&V validates reported savings in accordance with established protocols such as the International Performance Measurement and Verification Protocol (IPMVP).

Disclaimer: The intent of submitting M&V documents to TRC is to review the proposed plan from an administrative perspective to align with program goals and general compliance requirements. The Program Ally is fully responsible for the accuracy and functionality of M&V plans and reports. As a result, JCP&L and TRC are not liable if estimated savings ranges or economics are not actually achieved. In no event will JCP&L or TRC be liable for the failure of the customer to achieve a specified amount of energy savings, performance, the operation of customer facilities, or any incidental or consequential damages in connection with this report, design, or the installation or operation of recommended measures. The customer and their respective contractors are responsible for implementing energy conservation measures in complete conformance with all applicable local, state, and federal requirements.

M&V Applicability

M&V is required for a project when any of the following conditions apply:

- Projected savings for the entire project exceed 500,000 kWh/year.
- The facility is a manufacturing or processing facility, and measure savings are associated with process-based improvements.
- The project involves new or emerging technology or measures with a high degree of savings uncertainty such as BMS controls or compressed air leak repair or involve technologies in which established methodologies are limited.
- The engineering analysis uses assumptions or savings factors that are not supported by site specific conditions, specification sheets, TRMs, or other reference manuals and technical studies.

M&V requirements may be waived for individual measures that meet one or more of the following requirements:

- Individual measure savings are less than 50,000 kWh/yr.
- Individual measure savings are calculated in accordance with the current version of the NJ TRM (or TRMs from other jurisdictions with prior approval from the utility and/or evaluator).

The Program Manager reserves the right to waive or enforce M&V requirements on a project-specific basis.

If the program ally performs M&V and verified savings are lower than the initial estimate, TRC will evaluate the results to determine the cause of the discrepancy. Differences attributable to external factors outside the project scope (e.g., changes in occupancy, operations, weather, or other unrelated facility changes) would not necessarily warrant an adjustment to the incentive. However, if the discrepancy is determined to be due to incorrect installation, failure to implement the approved measure, or material differences between the approved scope and actual implementation, the program may adjust the claimed savings and associated incentive accordingly.

8.1 M&V Experience

A qualified M&V professional plays a key role in verifying energy savings and supporting program success. This individual or firm should have demonstrated experience in developing and implementing M&V plans using recognized industry standards, such as IPMVP.

Key qualifications and responsibilities include:

- Experience establishing baseline energy use and tracking savings over time.
- Familiarity with tools such as Building Management Systems (BMS), utility meters, and data loggers.
- Ability to apply weather normalization, modeling, and statistical analysis techniques.
- Proven track record preparing M&V reports that meet utility, contractual, or regulatory requirements.

8.2 M&V Planning Process

The M&V planning process establishes a consistent framework for defining, measuring, and verifying energy savings. A well-defined plan increases transparency, supports accountability, and ensures credible results.

Step	Description
Step 1. Assemble the M&V Team	Identify project stakeholders, assign roles, and designate the M&V lead.
Step 2. Understand the Project Scope	Review the site and ECM details, including expected implementation timelines.
Step 3. Define M&V Requirements	Clarify performance goals, accuracy needs, and any third-party verification requirements.
Step 4. Establish a Preliminary Budget	Set a high-level budget to guide selection of the M&V approach.

Step	Description
Step 5. Select M&V Approach	Choose the appropriate option (e.g., IPMVP Option A, B, C, or D), define boundaries, key variables, and operating conditions.
Step 6. Define Methods	Specify measurement points, data collection methods, and calculation approaches.
Step 7. Develop Tasks and Timelines	Outline required activities, assign responsibilities, and set key milestones.
Step 8. Refine the Budget	Update the M&V budget based on finalized scope, equipment needs, and timeline.
Step 9. Review and Adjust	Confirm alignment with objectives and adjust the plan or budget as needed.
Step 10. Finalize M&V Plan	Document the full plan and obtain approvals prior to ECM implementation.

Table 57. M&V Planning Process

8.3 IPMVP Options

The following table provides descriptions, calculation methodologies, and example applications for each IPMVP option. The Program may require a specific IPMVP Option, such as Option A or B, rather than Option C to reduce potential impact of variables outside of project scope.

IPMVP Option	Description	Calculation Methodology	Example Applications
Option A (Partially Measured Retrofit Isolation)	Savings are predicted using engineering or statistical methods involving short-term to continuous measurement frequencies. Parameters that are not directly measured are estimated using manufacturer specifications, historical data, technical resource manuals, or engineering judgment. Documentation of the source or justification is required and subject to program approval.	Combination of short-term or continuous measurements of key parameters and deemed values. Routine and non-routine adjustments as required.	Lighting retrofit where lighting power is calculated using DLC certifications and hours of operation are measured for a two-to-four-week period.
Option B (Retrofit Isolation)	Savings are predicted using engineering or statistical methods involving short-term to continuous measurement frequencies. All key parameters are directly measured.	Short-term or continuous measurements of key parameters for the baseline and reporting period.	Variable frequency drives serving a chilled water pump. In the baseline, a kW meter confirms constant loading over a one-week period. In the reporting period, the kW meter confirms variations in power over a three-week period.

IPMVP Option	Description	Calculation Methodology	Example Applications
Option C (Whole Facility)	Savings are calculated by (1) comparing monthly billing data recorded for the whole building or project site before and after installation, and (2) analyzing that data to account for variables such as weather or occupancy levels.	Analysis of whole facility baseline and reporting period utility data. Routine adjustments as required, using techniques such as simple comparison or regression analysis. Non-routine adjustments as required.	Comprehensive energy savings project with multiple measures that interact with one another. Typical whole building savings exceed 10% of annual consumption.
Option D (Calibrated Simulation)	Savings are calculated using modeling software to create a simulated model of a building based on drawings and site surveys. The model is calibrated using utility data and metered equipment data.	Energy simulation, calibrated with hourly or monthly utility billing data using a tool compliant with ASHRAE 90.1 Appendix G. Supplemental equipment metering is used to refine model inputs.	Comprehensive energy savings project with multiple interacting measures. Utility data is unavailable or unreliable for the baseline or reporting period.

Table 58. IPMVP Options

8.4 M&V Plan Requirements

Program participants should complete the TRC M&V plan template in its entirety. Alternatively, participants may provide their own M&V plan as long as the plan:

- Reflects the entire scope of a project.
- Minimally includes all data included in the TRC M&V plan template.
- Clearly identifies and justifies the IPMVP option.
- Describes baseline data collection procedures and energy consumption calculation methodology.
- Describes reporting period data collection procedures and energy consumption calculation methodology.
- Describes the relationship between baseline and reporting period consumption.
- Incorporates factors and variables that impact consumption under baseline and reporting period conditions, such as outdoor and indoor air temperature, humidity, occupancy, and operating hours.
- Describes how these factors and variables will be measured and used to normalize consumption due to changes in weather, occupancy, and other factors unrelated to the energy efficiency project.

- Includes details of the calculation methodology used to calculate and extrapolate annual energy savings.
- Provides documentation of all assumptions, sources of data, and anticipated routine and non-routine adjustments.

All M&V plans must comply with these guidelines and the IPMVP. The IPMVP option selected should be appropriate based on unique project characteristics. The following table provides guidance for determining the most appropriate option.

Project Characteristics	A	B	C	D
Only one measure is included in the scope	✓	✓		
The project includes multiple measures with little or no interaction	✓	✓		
The project includes multiple measures with easily estimated interaction impacts	✓			✓
The project has a comprehensive work scope that impacts most energy end-uses			✓	✓
The stipulation of parameters is less costly than measurement	✓			✓
Interaction impacts are difficult to estimate or measure			✓	✓
The project includes behavioral, operations, or maintenance-type measures			✓	
The cost to assess measures individually is inexpensive	✓	✓		
The cost to assess measures individually is expensive				✓
Total facility performance needs to be addressed			✓	✓
Expected savings are less than 10% of the utility meter	✓	✓		
The significance of some energy-driving variables is unclear		✓		
Correlations exist between energy use and independent variables			✓	
A long-term performance assessment is needed	✓		✓	
Baseline or post-retrofit data is not available or is unreliable				✓
Stipulated parameters will not significantly impact overall savings	✓			
Submeters exist to isolate the energy use of systems		✓		

Table 59. IPMVP Option Selection Criteria

8.5 Additional M&V Plan Requirements

The following additional requirements shall be addressed depending on the IPMVP option selected.

8.5.1 Option A

Justification of Estimates: The M&V Plan should identify estimated variables in savings calculations, their sources, and their impact on uncertainty. Best practice includes reporting the range of possible savings based on parameter variations.

Periodic Inspections: The plan should outline periodic inspections during the reporting period to confirm that equipment remains in place and operates as expected. These inspections may include measuring key parameters and validating estimated values to ensure their continued accuracy.

8.5.2 Option C

Meters: All fuel sources within the measurement boundary must be accounted for in the analysis. Any exclusions should be justified.

Software Identification: The M&V Plan should specify the name and version of any software or data analysis tool used for savings calculations.

Energy and Independent Variable Data: The plan must detail the sources of all energy and independent variable data, along with the processes for data collection and management. All relevant data should be reported, with raw data archived and available as needed. This includes interval data, utility invoices, weather data, and other independent variables.

Model Fit Metrics: The plan should include key goodness-of-fit statistics for the selected model, such as confidence level, standard error, CV(RMSE), R squared, net mean bias error, and t-statistics for independent variables. It should also specify the criteria required for the baseline energy model to be considered valid based on expected savings, and define the range of independent variables covered by the model and the acceptable range for its validity during the reporting period.

8.5.3 Option D

Software Identification: The M&V Plan must specify the name and version of the simulation software used for savings calculations.

Input and Output Data: The plan should provide copies of all input files, output files, reports, and weather files used in the simulation. It should also detail any post-processing methods or calculations used for data presentation and analysis.

Measured Data: The M&V Plan should outline the process for obtaining measured data, specifying which input parameters were directly measured and which were estimated. The actual measured data should be reported, with raw data archived and available as needed.

Model Calibration: The plan should define the energy and operating data used for calibration, including the required accuracy levels (CV(RMSE), MBE) and how well the simulation results must align with actual facility conditions. Supporting data should be provided at intervals of at least one billing cycle (monthly), though higher resolution is preferred. M&V Reports must present model calibration results.

Justification of Estimates: The M&V Plan must identify all estimated variables used in savings calculations and assess their impact on uncertainty. This includes reporting actual values, sources of estimates, and when possible, the range of potential savings based on plausible variations in these estimates.

8.6 M&V Plan Contents

Program Allies may use the TRC M&V plan template or submit M&V plans in their own format. The following table provides a list of contents that should be included.

Section	Contents
Introduction	Purpose (why the M&V Plan is being developed). Scope (systems and spaces included). Overview of the facility and project.
Measure Descriptions	Baseline description (existing equipment/system types, sizes, controls, performance characteristics). Proposed description (selected equipment/system types, sizes, controls, performance characteristics). Controls and operational strategies implemented. Expected energy performance improvements (e.g., efficiency increase, demand reduction).
IPMVP Option and Measurement Boundary	IPMVP option and measurement boundary (selected protocol and physical/virtual boundaries). Interactive effects (consideration of interactions between measures).
Pre-installation Reporting	Establishing baseline energy consumption (methodology for baseline per measure). Sampling approach during baseline. Energy-influencing parameters (variables affecting baseline energy). Non-metered data points (handling data not directly metered).
Post-installation Reporting	Reporting period (post-installation data collection timeframe). Establishing post-installation energy consumption. Sampling approach post-installation. Non-metered data points post-installation.
Basis for Adjustment	Routine adjustments (planned operational or environmental changes). Non-routine adjustments (unplanned or one-time events).
Savings Calculation Methodology	Analysis approach (statistical and analytical techniques). Key equations (formulas used for savings calculations). Independent variables (inputs for savings models). Dependent variables (measured outputs). Statistical metrics (metrics for evaluating results).
Meter Specification and Data Collection	Meter inventory (list and specs of meters used). Additional procedures and notes (supplementary metering and data collection instructions).

Section	Contents
Expected Accuracy and Uncertainty	Expected accuracy (accuracy targets or thresholds). Confidence and precision levels (statistical confidence aims). Expected uncertainties (potential uncertainty sources).
M&V Report Format	Outline and structure of the final M&V report.
Owner Acknowledgement	Confirmation of owner understanding and approval of the M&V Plan.

Table 60. M&V Plan Contents

8.7 M&V Reporting Requirements

Periodic M&V Reports are used to document and communicate the results of measurement and verification activities, following the procedures outlined in the M&V Plan. The required frequency and format of these reports must be specified in the M&V Plan. Savings verification may be conducted by the project developer or a third party, provided that appropriate quality assurance oversight is in place. At minimum, each report should include the following:

Item	Description
Overview of M&V Report	Purpose of the M&V Report (project scope, ECMs evaluated). Reference to M&V Plan (date or version). Entities involved in M&V activities. Summary of QA/QC procedures and relevant findings.
Project Background	Description of implemented ECMs. IPMVP Option and Measurement Boundary. Reporting period (start and end dates).
M&V Data Collection Activities	Measurement period (dates and durations). Energy data and key influencing variables collected. Independent variables, static factors, and assumptions. Summary of site inspection and operational verification activities.
Savings Calculations and Methodology	Data analysis and calculation methodology. Assumptions and sources used in calculations. Baseline and post-installation adjustments (routine and non-routine).
Verified Savings	Energy and demand savings (electric, gas, etc.). Cost savings (if applicable). Comparison to expected savings. Summary of sources of uncertainty and confidence level (if evaluated).
Additional Information	Additional requirements from M&V Plan. Notes on data gaps, anomalies, or site-specific issues.

Table 61. M&V Report Contents

8.8 Sampling Requirements

M&V plans that address multiple systems and components should describe the equipment sampling that will be conducted. Sample size must meet the following requirements:

- The sample size must meet the confidence and precision required by the program (80% confidence with plus or minus 20% precision).
- Equipment or systems that operate similarly should be grouped together.
- The sample size must consider the operation of all equipment, even if that equipment is similar. Similar systems with different operating schedules should be grouped separately.
- Sampling should focus on the systems that contribute to the largest amount of energy savings and/or incentives.

The following table provides general guidance for sampling requirements based on 80% confidence with plus or minus 20% precision. If M&V plans cannot meet desired sample sizes, please discuss an alternate plan with the Program Manager.

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

Table 62. M&V Sampling Requirements

8.9 Weather-Normalization Assumptions

Performance of many efficiency measures is weather-dependent. M&V plans must detail the weather normalization methodology used, including all weather-normalization assumptions:

- Weather station (name and ID).
- Weather data source (name of source and link).

- HDD and/or CDD reference temperature(s).
- Weather normalization time period, including specific years included in the analysis.
- Discussion of how inaccuracies and/or inconsistencies in weather data will be handled.

8.10 Expected Accuracy and Uncertainty

The M&V Plan shall define the expected accuracy of reported savings and identify all potential sources of uncertainty, including measurement, sampling, modeling, and data analysis. The assessment should incorporate qualitative and, where feasible, quantitative evaluations. For each uncertainty source, document its origin, anticipated direction of influence, and estimated magnitude of impact.

8.11 Analysis Methods

M&V plans must specify the analysis method used to calculate energy savings. Degree-day analyses are appropriate for residential, multifamily, and small commercial projects with strong temperature-energy correlations. For other project types, use outdoor air temperature bins (bin analysis) or hourly analysis.

8.12 M&V Duration

The metering and monitoring period must be long enough to accurately represent the annual amount of energy consumed by the affected equipment. Each period will be dependent on measure type, controls, and overall project complexity. For example, projects involving cooling systems such as chillers must be metered during the cooling season for a long enough period to capture performance over a wide range of outdoor air temperatures. In many cases, chiller projects undergo metering and monitoring from May through September. Other measures such as compressed air optimization may only require two weeks of trend data.

8.13 Facility Baseline Variables

Energy use often depends on factors unrelated to building components. In addition to outdoor temperature, common baseline variables include:

- Building occupancy (e.g., number of guests in a hotel, types of tenants).
- Production volumes (e.g., number of items produced at an industrial facility).
- Hours of operation (e.g., number of shifts, hours open).

These key baseline variables may vary between the baseline and post-retrofit periods and must be recorded in as much detail as possible. Any changes in these variables will need to be adjusted for in consultation with the Program Manager. The most impactful baseline variables for different building types are typically reflected in EPA's ENERGY STAR Portfolio Manager. The following are examples of why and how baselines could be adjusted:

- **Changes in occupancy:** Baseline occupancy levels must be documented. If significant changes in future occupancy are expected and predictable (e.g., hotel, multifamily), details of these changes should be included, along with defined procedures for addressing them.
- **Changes in hours of operation:** Baseline hours of operation must be documented, along with any known or predictable future changes.
- **Tenant changes or improvements:** Program Allies do not need to provide detailed calculation methods for every possible scenario, but the baseline should include information on each tenant, including business type, hours of operation, and major energy-consuming equipment. Changes in operating hours, conditioned space, or equipment outside the approved scope will not be counted toward savings and must be adjusted for during post-retrofit verification.
- **Changes in process loads:** For facility types such as wastewater treatment plants and manufacturing facilities, energy consumption is primarily influenced by process loads. The baseline should detail the type of process load and its unit of measurement. Procedures for addressing process changes should be defined to account for them in post-retrofit savings verification.
- **New or unexpected loads:** This includes changes such as the addition or removal of equipment outside the project scope, unexpected construction, and other modifications. Adjustments should be made where possible, leveraging information from site representatives.

8.14 Additional M&V Resources

The following resources provide best practices, templates, examples, and technical information related to the M&V process. This list is provided for reference only and does not imply endorsement of any specific organization or publication. Users should evaluate each resource based on specific project needs and applicable program requirements.

- IPMVP Core Concepts
- IPMVP Application Guide for Non-Routine Events and Adjustments
- IPMVP Application Guide for Energy Efficiency, Renewable Energy, and Water Efficiency Projects
- IPMVP Statistical Uncertainty Guide
- IPMVP Volume I: Concepts and Options for Determining Energy and Water Savings
- ASHRAE Guideline 14: Measurement of Energy, Demand, and Water Savings
- Federal Energy Management Program (FEMP) M&V Guidelines
- ISO 50015:2014: Energy Management - Measurement and Verification of Energy Performance

Appendix A – Energy Input and Output Reports

The following table identifies required input and output reports for each approved modeling software platform. Reports must clearly identify the baseline model, proposed model, and each individual ECM.

Software	Required Input and Output Reports
Carrier HAP	Building-level: LEED Summary, Energy Budget by System and Energy Type, Monthly Energy Use, Billing Details. Plant-level: Monthly Simulation Results. Air-side: Monthly/Hourly Simulation Results, Sizing Summaries. Input Data: Building, Plant, Air System, Weather, Space, Wall/Roof/Window, Chiller, Cooling Tower, Boiler, Rates.
DesignBuilder / OpenStudio / EnergyPlus	EnergyPlus summary output (.html); input (.idf) files; simulated results (.eso).
eQuest	Input (.inp), parametric run (.prd), interface (.pd2), and output (.sim) files.
IESVE	Room/Zone Loads, Space Loads and Ventilation, Thermal Template, ASHRAE 62.1, Plant Loops and Equipment, System Loads, Energy Model Output, ASHRAE 90.1 PRM Compliance, Unmet Hours, Detailed Simulation Report.
Trane TRACE 700	Project Information, Energy Cost Budget/PRM Summary, Monthly Energy Consumption and Utility Costs, Building Envelope, Plant Information, Equipment Energy Consumption, System Checksums, Demand Report from Visualizer.
Trane TRACE 3D Plus	Climatic Summary, Space Summary, Site Consumption Summary, Monthly Energy End Use and Utility Details, Opaque/Fenestration, System Checksums, Room Loads by Component, Interior Lighting, Utility Peak Demand, System Component Selection, Plant Summaries.

Table 63. Energy Model Input and Output Reports

Appendix B – Technology Specific M&V Guidance

This appendix provides one-page M&V reference cards for each major measure category. Each card identifies the recommended IPMVP option, metering requirements, critical data points, required documentation, meter accuracy, analysis methodology, and additional notes.

The measure-level guidance in this appendix represents recommended approaches based on common project configurations and standard industry practice. Actual project characteristics including system complexity, facility constraints, budget considerations, and available metering infrastructure may warrant different M&V approaches, metering durations, data collection intervals, instrumentation types, or accuracy requirements than those described here. Alternative methodologies, sampling strategies, and equipment configurations are acceptable provided they are technically defensible and consistent with IPMVP principles.

Program Allies are strongly encouraged to discuss the proposed M&V approach with the Program Manager prior to developing the M&V Plan. Early engagement allows for alignment on methodology, identification of project-specific requirements, and avoidance of rework during the review process. Deviations from the guidance in this appendix do not require formal approval but should be documented and justified in the M&V Plan.

Lighting Upgrades

APPLICABLE MEASURES	
LED fixture and lamp replacements	Occupancy sensors and daylight harvesting controls
Dimming controls, scheduling systems, and LLLC	Lighting layout and fixture count optimization

IPMVP OPTION
Option A: fixture power is measured or taken from DLC certifications; operating hours are stipulated from schedules or metered with runtime loggers

METERING PARAMETERS	
Baseline Duration	1–2 weeks pre-installation spot metering; DLC-certified wattage acceptable in lieu of measurement
Reporting Period	2–4 weeks post-installation covering weekdays and weekends; extend to 4–8 weeks if occupancy sensors or controls are included
Data Interval	15-minute intervals
Weather Data	Not required for interior lighting. For outdoor lighting, document annual photoperiod hours by location.

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Fixture input power (W or kW) per circuit or fixture type	Pre-retrofit lighting inventory (fixture type, wattage, quantity, operating hours)	Power meter: ±1%–2% of reading
Installed fixture count by type and space	DLC qualification certificates or manufacturer spec sheets for proposed fixtures	CTs: ±1%
Lighting levels (fc) pre- and post-installation for quality verification	Baseline runtime data (utility bills, submetering, or runtime logger data)	Light level meter: ±5% of reading
Operating hours from runtime loggers, schedules, or occupancy sensor data	Post-installation control sequences and schedules	
Control system setpoints and schedule documentation		

ANALYSIS METHODOLOGY
Calculate baseline energy from measured or DLC-certified fixture power multiplied by fixture count and annual operating hours. Apply Lighting Control Factors (LCFs) per program guidelines to proposed operating hours when controls are installed — LCFs apply to proposed hours, not baseline hours. Calculate energy savings (kWh), demand reduction (kW), and cost savings.

ADDITIONAL NOTES	
LCFs from Section 4.14.4 reduce proposed operating hours only; do not apply LCFs to baseline hours, as this double-counts savings.	Operating hours must be supported by runtime logger data, documented schedules, or occupancy sensor logs; assumed hours require Program Manager approval for controls projects.
DLC qualification must be current at time of application submission.	Ballast factor (typically 0.85–0.95) should be applied to nameplate wattage when characterizing fluorescent baseline systems.

Air Conditioners and Heat Pumps

APPLICABLE MEASURES	
Replacement of split, packaged, or PTAC units with high-efficiency models	Air source heat pump installations and replacements
Mini-split and variable refrigerant flow (VRF) system installations	Optimization of controls and defrost cycle programming
IPMVP OPTION	
Option A or B: Option A where runtime and efficiency are well-documented; Option B where variable loading or equipment configuration warrants direct metering	
METERING PARAMETERS	
Baseline Duration	1–2 weeks pre-installation spot metering of power and runtime during representative load conditions
Reporting Period	2–4 weeks in each of heating and cooling seasons to capture seasonal efficiency variation
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb temperature via weather station, BMS, or on-site data logger

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Unit input power (kW)	Equipment nameplate data and spec sheets (baseline and proposed)	Power meter: ±2% of reading
Supply and return air dry-bulb temperature (°F)	AHRI ratings: SEER2, EER2, HSPF2 for proposed equipment; original SEER/EER/HSPF for pre-2023 baseline	Temperature sensor: ±0.5°F
Outdoor air dry-bulb temperature (°F)	Pre- and post-retrofit nameplate photos	CTs: ±1%
Runtime hours	Description of existing and upgraded control sequences	
Voltage and current (if kW metering unavailable)	Operating schedules	

ANALYSIS METHODOLOGY
Convert efficiency ratings to SEER2/EER2/HSPF2 per NJ TRM Section 8.1. Note that SEER2 and original SEER use different external static pressure test conditions and must not be mixed in the same calculation. Extract supply fan power from AHRI-rated efficiency using COPnf methodology (Section 4.12.4) when fan savings are also being claimed. Develop annual bin-hour profiles using TMY weather data. Calculate heating and cooling season savings separately.

ADDITIONAL NOTES	
SEER2/EER2 ratings reflect higher external static pressure test conditions than original SEER/EER; do not mix rating systems in the same calculation.	Supply fan power must be extracted per Section 4.12.4 when fan savings are claimed alongside HVAC savings; failure to do so overstates total savings.
For equipment without nameplate efficiency, use ASHRAE 90.1 vintage baseline for the installation year and apply age-derating per Section 4.12.1.	VRF systems require COP data at multiple load levels; single-point rated COP should not be applied across all operating conditions.

Electric Chiller Plant Upgrades

APPLICABLE MEASURES	
High-efficiency electric chiller replacements	Chiller plant sequencing and optimization controls
VFD retrofits on chilled water or condenser water pumps	CHW supply temperature reset, condenser water reset, or water-side economizer controls

IPMVP OPTION
Option B: all key parameters directly measured; chiller performance is load- and weather-dependent and cannot be reliably stipulated

METERING PARAMETERS	
Baseline Duration	2–4 weeks pre-installation at representative cooling load conditions; capture a range of loads, not just peak or minimum
Reporting Period	Full cooling season (May–September); minimum 8 weeks if full season is not achievable, spanning a representative range of outdoor temperatures
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb (°F) and wet-bulb (°F) or relative humidity at 15-minute intervals coincident with plant metering

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Chiller compressor input power (kW)	Chiller nameplate, spec sheets, and AHRI certification	Power meter: ±2% of reading
CHW supply and return temperature (°F)	CHW pump, CW pump, and cooling tower fan nameplates	Flow meter: ±3% of reading (ultrasonic or magnetic preferred)
CHW flow rate (GPM)	Existing and proposed control sequences for CHW and CW setpoints	Temperature sensor: ±0.3°F (use matched pairs for CHW delta-T measurement)
CHW pump input power (kW)	Operating schedules	If kW metering unavailable: V × A × PF with CT accuracy ±1%
CW supply and return temperature (°F)	P&ID diagrams	
CW flow rate (GPM)		
CW pump input power (kW)		
Cooling tower fan power (kW)		

ANALYSIS METHODOLOGY
Calculate instantaneous cooling load (tons) = GPM × ΔT × 500 / 12,000. Calculate chiller efficiency (kW/ton) from compressor power and cooling load. Develop a performance relationship between kW/ton, part-load ratio, and condenser entering water temperature from measured data. Apply this relationship to the annual bin-hour cooling load profile to extrapolate annual chiller energy. Calculate pump and tower fan energy separately. Sum all component savings.

ADDITIONAL NOTES	
Use matched temperature sensor pairs calibrated against a common reference for CHW supply/return measurement; individual ±0.5°F sensors can introduce significant error in delta-T-based load calculations.	Chiller kW/ton varies with both part-load ratio and condenser entering water temperature; metering must capture both dimensions across a representative range.
Report chiller, CHW pump, CW pump, and cooling tower fan savings as separate line items.	Controls-only ECMs (CHW reset, sequencing) must each have individual baseline setpoint documentation and separate savings calculations.

Gas Chiller Upgrades

APPLICABLE MEASURES	
Direct-fired or indirect-fired absorption chiller replacements	Absorption chiller controls optimization (sequencing, temperature resets)
Replacement of absorption chillers with electric alternatives (fuel switching)	

IPMVP OPTION
Option B: all key parameters directly measured; thermal COP varies significantly with load and generator temperature

METERING PARAMETERS	
Baseline Duration	2–4 weeks pre-installation at representative cooling load and hot water supply temperature conditions
Reporting Period	Full cooling season (May–September)
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb and wet-bulb temperature

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Gas input rate (therms/hr) from a dedicated gas submeter	Chiller nameplate and manufacturer performance data at multiple operating conditions	Gas meter: ±2% of reading
Hot water supply temperature to chiller generator (°F)	CHW pump, CW pump, and cooling tower nameplates	Flow meter: ±3% of reading
CHW supply and return temperature (°F)	Existing and proposed control sequences and temperature setpoints	Temperature sensor: ±0.3°F (matched pairs for CHW differential)
CHW flow rate (GPM)	Operating schedules	
CW supply and return temperature (°F)		
Cooling capacity (tons) calculated from CHW temperatures and flow		

ANALYSIS METHODOLOGY
Calculate instantaneous cooling load (tons) from CHW temperatures and flow. Calculate thermal COP from gas input rate and cooling load. Develop a COP performance relationship as a function of part-load ratio and hot water supply temperature. Apply to annual bin-hour cooling load profile using TMY data to extrapolate annual gas consumption.

ADDITIONAL NOTES	
Absorption chiller COP is highly sensitive to hot water supply temperature; metering must capture the actual operating range, not just design conditions.	A dedicated gas submeter is required to isolate chiller gas consumption from other building loads sharing the same meter.
For fuel-switching projects, compare proposed electric alternative to a code-minimum electric baseline; do not compare directly against existing gas chiller consumption.	

Boiler Upgrades

APPLICABLE MEASURES	
High-efficiency non-condensing boiler replacements	Condensing boiler replacements (AFUE ≥ 90%)
Modulating burner retrofits	Boiler plant sequencing and lead-lag controls
Outdoor air reset (OAR) controls for hot water supply temperature	

IPMVP OPTION
Option A where combustion efficiency is verified by flue gas analysis and gas consumption is stipulated; Option B where gas consumption is directly submetered

METERING PARAMETERS	
Baseline Duration	4–8 weeks during the heating season at representative load conditions (30–70% of design load preferred)
Reporting Period	4–8 weeks during the heating season; include a range of outdoor temperatures to validate efficiency across the operating range
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb temperature at 15-minute intervals

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Gas input rate (therms/hr or SCFH)	Boiler nameplate and combustion efficiency ratings at multiple fire rates	Gas meter: ±2% of reading
Stack temperature (°F) and O_2 or CO_2 content (%) from flue gas analysis	Flue gas analysis reports (baseline and post-installation)	Flue gas analyzer: ±0.2% O_2 or ±0.5% CO_2
Combustion efficiency (%) from flue gas analysis	Piping diagrams and system schematics	Temperature sensor: ±0.5°F
Hot water supply and return temperature (°F)	Operating schedules	Flow meter: ±5% of reading
Hot water flow rate (GPM)	Description of existing and upgraded controls and sequences	
Runtime hours		

ANALYSIS METHODOLOGY
Determine baseline efficiency from flue gas analysis (Siegert method) or nameplate data derated per Section 4.12.1. For condensing boilers, apply part-load efficiency adjustment using the manufacturer performance curve — condensing mode is only achieved when return water temperature is below approximately 130°F, so do not apply peak condensing efficiency across all load conditions. Develop annual heating load profile using HDD bin analysis. Extrapolate annual gas savings.

ADDITIONAL NOTES	
Condensing boiler efficiency is only achieved when return water temperature is below approximately 130°F; at higher return water temperatures, efficiency reverts to non-condensing range. Savings calculations must reflect actual return water temperature distribution across the heating season.	Boiler cycling losses at low fire rates can reduce effective seasonal efficiency below steady-state combustion test results; account for on/off cycling frequency in the analysis.
Distribution losses must be excluded from boiler savings and quantified separately if pipe insulation is also in scope.	Each control strategy (OAR, sequencing, setback) must be a separate ECM with individual baseline documentation.

Rooftop Units (Gas-Fired)

APPLICABLE MEASURES	
High-efficiency gas-fired RTU replacements	Variable-speed RTU replacements with integrated controls
RTU controls optimization: DCV, economizers, and scheduling	

IPMVP OPTION
Option A: gas heating efficiency stipulated from flue gas analysis or AHRI ratings; electric cooling savings calculated from SEER2/EER2 ratings and measured runtime

METERING PARAMETERS	
Baseline Duration	2–4 weeks during the heating season; additional 1–2 weeks during cooling season if electric cooling savings are claimed
Reporting Period	4–8 weeks spanning representative heating and cooling conditions
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb temperature; wet-bulb or RH required if economizer savings are claimed

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Gas input rate (BTU/hr) during heating operation	RTU nameplate: gas input rating (BTU/hr), cooling capacity (tons), SEER2/EER2, AFUE or thermal efficiency	Gas meter or BTU meter: ±2% of reading
Supply and return air temperature (°F)	AHRI certified ratings for proposed equipment	Power meter (electric): ±2% of reading
Outdoor air temperature (°F) and damper position (% open)	Description of existing and proposed controls (economizer type, DCV strategy)	Temperature sensor: ±0.5°F
Electric input power (kW) for cooling mode	Operating schedules	
Runtime hours (compressor and heat stages)		

ANALYSIS METHODOLOGY
For gas heating: apply flue gas combustion efficiency or AFUE to the calculated heat load using HDD bin analysis. For two-stage or modulating units, apply part-load efficiency at representative operating conditions. For electric cooling: apply SEER2/EER2 with bin-hour analysis using TMY weather data. Report gas heat savings and electric cooling savings as separate line items. Extract supply fan power per Section 4.12.4 if fan savings are also claimed.

ADDITIONAL NOTES	
RTU supply fan power is typically 15–25% of total unit power; fan savings must be extracted from total unit power before calculating compressor savings to avoid double-counting.	Two-stage and modulating RTUs must use part-load efficiency data; applying full-load AFUE at all conditions overstates savings.
DCV and economizer savings must be calculated as separate ECMs with individual baseline documentation.	

Fans, Pumps, and High-Efficiency Motors

<table>
<tr><th colspan="6">APPLICABLE MEASURES</th></tr>
<tr><td colspan="3">High-efficiency fan or pump replacements</td><td colspan="3">Variable frequency drive (VFD) installations on fans or pumps</td></tr>
<tr><td colspan="3">NEMA Premium Efficiency motor replacements</td><td colspan="3">Control sequence optimization: static pressure reset, differential pressure reset</td></tr>
<tr><th colspan="6">IPMVP OPTION</th></tr>
<tr><td colspan="6">Option A where motor load factor and annual hours are well-documented; Option B where variable loading requires direct power measurement</td></tr>
<tr><th colspan="6">METERING PARAMETERS</th></tr>
<tr><td>Baseline Duration</td><td colspan="5">1–2 weeks at representative operating conditions; capture both high-load and low-load periods for variable systems</td></tr>
<tr><td>Reporting Period</td><td colspan="5">2–4 weeks for constant-load systems; full operating season for variable systems with significant load variation</td></tr>
<tr><td>Data Interval</td><td colspan="5">15-minute intervals</td></tr>
<tr><td>Weather Data</td><td colspan="5">Not required for most applications; include OAT for HVAC-coupled systems</td></tr>
<tr><th colspan="2">CRITICAL DATA POINTS</th><th colspan="2">REQUIRED DOCUMENTATION</th><th colspan="2">METER ACCURACY</th></tr>
<tr><td colspan="2">Motor input power (kW)</td><td colspan="2">Motor and fan/pump nameplate and spec sheets (baseline and proposed)</td><td colspan="2">Power meter: ±2% of reading</td></tr>
<tr><td colspan="2">Flow rate (CFM for fans; GPM for pumps)</td><td colspan="2">Pre- and post-retrofit nameplate photos</td><td colspan="2">Flow meter: ±5% of reading</td></tr>
<tr><td colspan="2">Static pressure (in. WC) or differential pressure (ft or psi)</td><td colspan="2">Load profile description and control strategy documentation</td><td colspan="2">Pressure sensor: ±2% of full-scale</td></tr>
<tr><td colspan="2">Motor speed (RPM) or VFD output frequency (Hz)</td><td colspan="2">Operating schedules</td><td colspan="2">CTs: ±1%</td></tr>
<tr><td colspan="2">Voltage, current, and power factor</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Runtime hours</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><th colspan="6">ANALYSIS METHODOLOGY</th></tr>
<tr><td colspan="6">For constant-speed motor replacements, calculate savings from efficiency improvement at the measured load factor. For VFD applications, use measured power at multiple speed setpoints to develop an empirical power-speed curve; do not assume ideal cube law savings, as real systems deviate due to static pressure and mechanical losses. Apply minimum turndown speeds per Section 4.15.6. Extrapolate annual savings using the operating schedule and load profile.</td></tr>
<tr><th colspan="6">ADDITIONAL NOTES</th></tr>
<tr><td colspan="3">The affinity law (power $\propto$ speed^3) is a theoretical maximum; real systems often deviate due to system static pressure. Where possible, use measured power at multiple speeds rather than calculated affinity law projections.</td><td colspan="3">Motor load factor default of 0.75 applies when site data is unavailable; site measurements are preferred and should be used when metering is practical.</td></tr>
<tr><td colspan="3">VFD efficiency losses (typically 2–4% of output) are incorporated in program performance curves; do not apply an additional VFD efficiency deduction.</td><td colspan="3">Motor-only replacements without VFDs typically yield small savings (<5% efficiency gain); verify cost-effectiveness before proposing as a standalone ECM.</td></tr>
</table>

CAV to VAV Conversion

APPLICABLE MEASURES	
Converting constant air volume (CAV) air handling units to variable air volume (VAV)	Installing VFDs on supply and return fans
Adding pressure-independent VAV terminal units with DDC controls	Installing duct static pressure sensors and implementing static pressure reset

IPMVP OPTION
Option B: fan power, zone airflow, and reheat energy must be directly measured; savings are highly system-specific and cannot be reliably stipulated

METERING PARAMETERS	
Baseline Duration	2–4 weeks during representative heating and cooling conditions at normal occupancy
Reporting Period	Minimum 6 weeks spanning both heating and cooling seasons; full heating and cooling seasons preferred
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb and wet-bulb temperature at 15-minute intervals

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Supply and return fan input power (kW)	Pre- and post-conversion air balance reports	Power meter: ±2% of reading
Supply fan speed (%) or VFD output frequency (Hz)	AHU schematics showing fan configuration and VAV box locations	Airflow (flow station or balometer): ±5% of reading
Duct static pressure at control sensor location (in. WC)	VFD nameplate and programming documentation	Temperature sensor: ±0.5°F
Zone airflow (CFM) at a representative sample of VAV boxes	VAV box specifications including minimum flow setpoints	Pressure sensor: ±2% of full-scale
Reheat coil energy (BTU/hr for HW reheat; kW for electric reheat)	Static pressure reset sequence and sensor location documentation	
Supply air temperature (°F)	BMS trend data confirming VAV sequences are active post-installation	

ANALYSIS METHODOLOGY
Establish CAV baseline from measured constant-speed fan power and annual operating hours. Calculate post-conversion fan energy from measured power at multiple VFD speed setpoints applied to an annual load duration curve. Subtract net reheat energy increase from gross fan savings to determine net energy savings. Where possible, use measured empirical power-speed data rather than ideal cube law projections.

ADDITIONAL NOTES	
Reheat energy increase is the most commonly underestimated cost of CAV-to-VAV conversion; in systems with high minimum airflow setpoints, reheat can offset a substantial portion of fan savings. Metering must cover the full heating season.	Static pressure reset must be active and verified through BMS trend logs before final savings are reported.
Minimum zone airflow rates must comply with ASHRAE 62.1 ventilation minimums; reductions below code minimums require approval from the mechanical engineer of record.	Both supply and return fan savings should be included in the analysis.

Heat Recovery and Energy Recovery Ventilators (ERVs)

APPLICABLE MEASURES	
Energy recovery ventilators (ERVs) with enthalpy wheels or membrane exchangers	Heat recovery ventilators (HRVs) with sensible-only plate exchangers
Run-around coil heat recovery systems	Waste heat recovery from process or kitchen exhaust streams
Heat recovery chillers for simultaneous heating and cooling	

IPMVP OPTION
Option B: heat recovery effectiveness must be field-verified; manufacturer ratings reflect laboratory conditions and typically overstate field performance

METERING PARAMETERS	
Baseline Duration	2–4 weeks during representative heating or cooling conditions; document pre-installation ventilation energy as the baseline
Reporting Period	Full heating and cooling seasons to capture annual recovery potential
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb and wet-bulb temperature (or dew point) at 15-minute intervals; required for latent recovery calculations

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Supply air temperature entering and leaving HX (°F)	ERV/HRV spec sheets with rated sensible and total effectiveness (%)	Airflow meter: ±5% of reading
Exhaust air temperature entering and leaving HX (°F)	Pre- and post-installation air balance data	Temperature sensor: ±0.3°F (matched pairs recommended for HX differential)
Outdoor air temperature (°F) and relative humidity (%)	Wheel or media condition documentation	Relative humidity sensor: ±3% RH
Supply and exhaust airflow rates (CFM)	Control sequences including bypass logic and defrost cycle	
Differential pressure across HX (in. WC) on supply and exhaust sides	Operating schedules	
Bypass damper position and frequency of bypass activation		
Runtime hours		

ANALYSIS METHODOLOGY
Calculate sensible effectiveness from supply and exhaust air temperature measurements across the HX. For enthalpy wheels, calculate total effectiveness using measured temperature and humidity values. Apply measured effectiveness (not manufacturer ratings) to annual bin-hour outdoor conditions using TMY data. Subtract any incremental fan energy from gross thermal savings. Report sensible and latent recovery separately where both are significant.

ADDITIONAL NOTES	
Field-measured ERV effectiveness is typically 65–80% of manufacturer-rated values due to wheel degradation, seal leakage, and non-ideal airflow balance; use measured effectiveness in annual savings calculations.	Bypass mode must be documented from BMS trend data and excluded from savings hours; bypass typically activates during mild weather or economizer operation.
For enthalpy wheels, latent recovery depends on moisture differential between exhaust and outdoor air; measure humidity at both inlet points, not temperature alone.	Wheel purge sectors reduce effective supply airflow by 3–5%; account for this in net supply airflow calculations.

Demand Control Ventilation (DCV) and Kitchen Ventilation

APPLICABLE MEASURES	
CO_2-based DCV for densely occupied spaces (assembly, dining, conference rooms)	Occupancy sensor-based ventilation reduction for intermittently occupied zones
Demand-controlled kitchen exhaust systems with variable-speed hoods	Minimum OA setpoint optimization for multi-zone VAV systems with DCV capability

IPMVP OPTION
Option A: ventilation airflow reduction is the primary variable; heating and cooling energy savings are calculated using stipulated system efficiencies

METERING PARAMETERS	
Baseline Duration	2–4 weeks during representative occupancy; capture both peak and unoccupied periods with CO_2 logging at sensor locations
Reporting Period	2–4 weeks post-installation under comparable occupancy conditions
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb and wet-bulb temperature at 15-minute intervals; required to calculate heating and cooling energy savings from reduced OA

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Ventilation airflow rate (CFM) at design occupancy and at minimum setpoint	ASHRAE 62.1 ventilation rate calculations confirming proposed minimum OA does not violate code minimums	Airflow meter: ±5% of reading
CO_2 concentration (ppm) at zone sensor locations	CO_2 sensor specifications and most recent calibration records	CO_2 sensor: ±50 ppm or ±3% of reading (NDIR type preferred)
OA damper position (%) correlated with CO_2 or occupancy signal	Control sequences for DCV logic including CO_2 setpoints and minimum OA limits	Power meter: ±2% of reading
Supply fan power (kW) and speed (%)	Kitchen: hood manufacturer performance data and demand-control algorithm description	Temperature sensor: ±0.5°F
Supply air temperature (°F)	BMS trend data confirming DCV sequence is active post-installation	
Occupancy counts or BMS schedule data		
For kitchen DCV: hood exhaust CFM at high, medium, and low demand setpoints		

ANALYSIS METHODOLOGY
Calculate baseline ventilation energy from design OA CFM applied to the annual occupancy schedule. Calculate proposed ventilation energy from CO_2-based demand profile or occupancy-weighted average OA fraction. Calculate heating and cooling energy reduction from reduced OA using system-specific HVAC efficiencies. For kitchen DCV: calculate baseline exhaust energy at design CFM and extrapolate savings from measured demand-speed profile. Apply TMY weather data for annual extrapolation.

ADDITIONAL NOTES	
CO_2 control setpoints should not exceed approximately 1,100 ppm (700 ppm above outdoor ambient); more aggressive setpoints risk IAQ compliance and should be reviewed against ASHRAE 62.1.	DCV savings must be derived from occupancy profiles or CO_2 trend data; assumed percentage reductions in OA without supporting data are not acceptable.
CO_2 sensors require periodic calibration (at least annually); document calibration records and note that sensor drift can affect both control accuracy and savings verification.	Kitchen DCV reductions must comply with local health code minimum exhaust rates; confirm with AHJ before reducing below design CFM.

HVAC Controls (Resets, Setbacks, and Schedule Optimization)

<table>
<tr><th colspan="6">APPLICABLE MEASURES</th></tr>
<tr><td colspan="3">Hot water supply temperature outdoor air reset (OAR)</td><td colspan="3">Chilled water supply temperature reset (CHWST reset)</td></tr>
<tr><td colspan="3">Condenser water supply temperature reset (CWST reset)</td><td colspan="3">Supply air temperature reset (SATR) and duct static pressure reset (DSPR)</td></tr>
<tr><td colspan="3">Occupied/unoccupied temperature setbacks</td><td colspan="3"></td></tr>
<tr><th colspan="6">IPMVP OPTION</th></tr>
<tr><td colspan="6">Option A: each control strategy has stable, verifiable parameters confirmable through BMS trend data and short-term metering</td></tr>
<tr><th colspan="6">METERING PARAMETERS</th></tr>
<tr><td>Baseline Duration</td><td colspan="5">2–4 weeks with BMS trend logging of temperatures, flows, and setpoints to document actual baseline operating conditions</td></tr>
<tr><td>Reporting Period</td><td colspan="5">4–8 weeks post-installation spanning representative weather and occupancy; BMS trend data must confirm setpoints are active</td></tr>
<tr><td>Data Interval</td><td colspan="5">15-minute intervals; 5-minute intervals preferred for BMS trend data</td></tr>
<tr><td>Weather Data</td><td colspan="5">Outdoor air dry-bulb at 15-minute intervals; wet-bulb required for CWST reset</td></tr>
<tr><th colspan="2">CRITICAL DATA POINTS</th><th colspan="2">REQUIRED DOCUMENTATION</th><th colspan="2">METER ACCURACY</th></tr>
<tr><td colspan="2">System supply and return temperatures (°F) for the affected system (HW, CHW, CW, or supply air)</td><td colspan="2">BMS control sequences: baseline (as-found) and proposed (as-left) for each strategy</td><td colspan="2">Power meter: ±2% of reading</td></tr>
<tr><td colspan="2">Flow rates (GPM or CFM) for the affected system</td><td colspan="2">BMS trend data export covering baseline and reporting periods</td><td colspan="2">Temperature sensor: ±0.5°F</td></tr>
<tr><td colspan="2">System energy input (kW or therms/hr)</td><td colspan="2">Setpoint documentation: reset schedule curves, setback temperatures, and schedule tables</td><td colspan="2">Flow meter: ±5% of reading</td></tr>
<tr><td colspan="2">BMS trend data showing setpoint changes as a function of OAT or occupancy signal</td><td colspan="2">Operating schedules</td><td colspan="2"></td></tr>
<tr><td colspan="2">Fan or pump speed (%) for VFD-driven systems</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Space temperatures (for setback strategies)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><th colspan="6">ANALYSIS METHODOLOGY</th></tr>
<tr><td colspan="6">Establish baseline setpoints and operating patterns from BMS trend data. For each reset strategy, calculate the energy reduction as a function of OAT using bin analysis or regression. Apply the energy-OAT relationship to the annual TMY bin-hour profile to extrapolate annual savings. Account for interactive effects between multiple strategies. Report savings for each strategy individually before summing.</td></tr>
<tr><th colspan="6">ADDITIONAL NOTES</th></tr>
<tr><td colspan="3">Rules of thumb (e.g., 1% savings per °F of reset) are not acceptable; calculate savings from system performance characteristics and bin analysis.</td><td colspan="3">Each control strategy must be a separate ECM; bundling multiple strategies into a single calculation obscures individual contributions and complicates verification.</td></tr>
<tr><td colspan="3">BMS trend data must confirm setpoints are active and stable during the reporting period; setpoints that are regularly overridden require investigation before savings are accepted.</td><td colspan="3">If BMS trend data is unavailable, calibrate calculated savings against utility billing data before submission.</td></tr>
</table>

Economizers (Air-Side and Water-Side)

APPLICABLE MEASURES	
Air-side economizer addition or upgrade (modulating dampers, enthalpy controls)	Air-side economizer high-limit setpoint optimization
Water-side economizer (plate heat exchanger in bypass around chiller)	Integrated water-side economizer (simultaneous free cooling and mechanical cooling)

IPMVP OPTION
Option B: economizer savings are weather-dependent and require measurement of both mechanical cooling and free cooling modes across representative outdoor conditions

METERING PARAMETERS	
Baseline Duration	2–4 weeks spanning economizer-eligible outdoor conditions; document mechanical cooling operation at comparable outdoor temperatures if no prior economizer exists
Reporting Period	Full economizer season: September–May for air-side; October–April for water-side (NJ climate)
Data Interval	15-minute intervals
Weather Data	Outdoor air dry-bulb and wet-bulb temperature at 15-minute intervals; required for economizer activation condition verification

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Air-side: OAT (°F), OA wet-bulb (°F), OA damper position (%), return air temp (°F), supply fan power (kW)	Economizer specifications, control diagrams, and high-limit controller settings	Power meter: ±2% of reading
Water-side: chiller compressor power (kW), HX supply and return temps (°F) on both sides, CHW flow (GPM), tower fan power (kW), bypass valve position (%)	Plate heat exchanger specifications and design performance data (water-side)	Temperature sensor: ±0.5°F
Economizer activation status and control mode from BMS	Cooling tower capacity and approach temperature documentation	Flow meter: ±5% of reading
Mechanical cooling energy during economizer-eligible hours (to quantify displacement)	BMS sequences showing economizer enable/disable logic	Humidity sensor: ±3% RH (for enthalpy control verification)
	Operating schedules	

ANALYSIS METHODOLOGY
Air-side: identify economizer-eligible hours from TMY data using the applicable high-limit type (dry-bulb, dew-point, or enthalpy). Calculate mechanical cooling reduction as the difference between metered chiller energy with and without economizer at each outdoor condition. Water-side: calculate free cooling capacity from HX performance at each ambient condition. Determine annual hours of full and partial free cooling using tower approach temperature. Calculate annual chiller kWh displaced.

ADDITIONAL NOTES	
Damper leakage in air-side economizers can significantly reduce savings; verify damper closes tightly before baseline metering and document leakage if present.	Water-side free cooling capacity drops as outdoor temperatures rise and cooling tower leaving water temperature approaches CHW supply setpoint; do not assume full free cooling capacity at all economizer-eligible hours.
In humid climates like New Jersey, enthalpy control reduces economizer-eligible hours by 15–30% compared to dry-bulb-only control; use the appropriate high-limit type for the installed equipment.	Economizer operation must be verified through BMS trend logs; assumed operation without verification is not acceptable.

Water Heater Replacements (Gas)

APPLICABLE MEASURES	
High-efficiency storage gas water heaters	Condensing gas water heaters or tankless condensing units
Gas-fired boilers serving domestic hot water via indirect storage tank	Combination space heating and DHW systems (combi-systems)

IPMVP OPTION
Option A: gas efficiency stipulated from UEF/EF ratings and flue gas analysis; hot water demand measured or derived from occupancy profiles

METERING PARAMETERS	
Baseline Duration	5–7 days of hot water consumption and gas use logging; avoid holiday periods or weeks with atypical occupancy
Reporting Period	5–7 days post-installation under comparable occupancy conditions
Data Interval	15-minute intervals
Weather Data	Cold water inlet temperature (°F); may be measured or stipulated from ASHRAE groundwater temperature data for the project location

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Gas input rate (BTU/hr or therms/hr)	Water heater nameplate: input rating (BTU/hr), storage volume (gallons), UEF or EF rating	Gas meter: ±2% of reading
Hot water outlet temperature (°F)	Current UEF or EF certification	Water flow meter: ±5% of reading
Cold water inlet temperature (°F)	Hot water usage schedule or occupancy data	Temperature sensor: ±0.5°F
Hot water flow rate (GPM) and estimated daily volume (gallons/day)	Operating schedules and setpoint temperatures	
Runtime hours and firing cycle frequency		

ANALYSIS METHODOLOGY
Calculate daily hot water consumption from metered flow data or TRM default profiles (Section 4.11.1). Calculate baseline gas consumption using measured inlet water temperature, outlet setpoint, and baseline EF/UEF. Calculate proposed gas consumption using proposed UEF and the same demand profile. For condensing units, apply part-load efficiency adjustment — condensing efficiency is only achieved when cold water inlet temperature is below approximately 125°F for natural gas. Extrapolate annual savings adjusted for seasonal inlet temperature variation.

ADDITIONAL NOTES	
UEF replaced EF as the federal test standard; do not compare UEF of proposed equipment to EF of baseline equipment without applying a conversion factor (EF ≈ UEF × 0.92 for storage units).	Condensing water heater efficiency is only achieved when inlet water temperature is sufficiently low; in recirculation systems with warm return water, condensing mode may not be reliably achieved.
Distribution losses (pipe heat loss, recirculation pump energy) should be quantified separately, particularly in large buildings where distribution losses can be comparable to water heater standby losses.	Low-flow fixture savings require a separate ECM with individual flow reduction metering.

Water Heater Replacements (Electric / Heat Pump)

APPLICABLE MEASURES	
Replacement of electric resistance water heaters with ENERGY STAR-certified HPWHs	Replacement of gas water heaters with HPWHs (fuel switching)
Commercial heat pump water heaters for multifamily or light commercial DHW	

IPMVP OPTION
Option A: COP stipulated from UEF rating adjusted for site ambient temperature; hot water demand measured or derived from occupancy data

METERING PARAMETERS	
Baseline Duration	5–7 days of hot water consumption and electric power logging covering both weekday and weekend days
Reporting Period	5–7 days post-installation under comparable occupancy; measure during a period with ambient temperatures below 60°F to verify heat pump vs. resistance operation
Data Interval	15-minute intervals
Weather Data	Ambient air temperature (°F) at the water heater installation location; basement or mechanical room temperature may differ significantly from outdoor temperature

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Total electric input power (kW) including compressor and resistance backup elements	HPWH nameplate: UEF, rated COP, storage volume	Power meter: ±2% of reading
Hot water outlet temperature (°F)	ENERGY STAR certification or manufacturer performance data showing COP vs. ambient temperature	Water flow meter: ±5% of reading
Cold water inlet temperature (°F)	Installation documentation: location and available air volume	Temperature sensor: ±0.5°F
Hot water flow rate (GPM) and daily volume (gallons/day)	Hot water demand schedule and occupancy data	
Ambient air temperature at HPWH intake (°F)		
Runtime in heat pump mode vs. resistance mode (where accessible from unit controls)		

ANALYSIS METHODOLOGY
Calculate daily hot water demand from metered flow data. Adjust rated UEF or COP for actual average ambient temperature using manufacturer performance data; HPWH COP degrades significantly below 50°F ambient. Estimate proportion of heat pump vs. resistance operation from ambient temperature profile and manufacturer specifications. For fuel-switching, use the New Construction baseline per Section 4.3 (compare to code-minimum HPWH, not to existing gas equipment). Extrapolate annual savings.

ADDITIONAL NOTES	
HPWH COP degrades from approximately 3.5 at 70°F ambient to 1.5–2.0 at 40°F ambient; resistance backup engages below approximately 45°F. Annual savings must reflect seasonal ambient conditions at the installation location, not rated COP alone.	HPWHs extract heat from surrounding air, which increases space heating load in winter. This interactive effect should be included in the net savings calculation, particularly in smaller mechanical rooms.
Minimum surrounding air volume (typically 1,000 cu ft per manufacturer guidance) must be verified; inadequate air volume causes the unit to operate primarily in resistance mode, eliminating most heat pump savings.	For fuel-switching, the baseline is code-minimum HPWH efficiency (UEF 2.0 for ≤55-gallon units), not the existing gas water heater; savings represent the efficiency gain above code.

Building Envelope Improvements

APPLICABLE MEASURES	
Roof and attic insulation upgrades	Above-grade wall insulation (exterior continuous or cavity fill)
High-performance window replacements	Air sealing and infiltration reduction
Below-grade wall and slab insulation	

IPMVP OPTION
Option A for isolated measures with directly calculable thermal savings; Option D (calibrated simulation) for comprehensive projects or where interactive HVAC effects are significant

METERING PARAMETERS	
Baseline Duration	Blower door test pre-installation (for air sealing); thermal imaging survey during heating season recommended to identify deficiencies; HVAC energy logging 2–4 weeks
Reporting Period	Full heating and cooling seasons; minimum 6 months of post-installation HVAC energy data for Option D calibration
Data Interval	15-minute intervals for HVAC energy; monthly utility data acceptable for Option D
Weather Data	Outdoor dry-bulb temperature (hourly); solar radiation data recommended for window SHGC calculations

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Indoor and outdoor temperature (°F) at 15-minute intervals	Thermal properties of baseline assemblies (from drawings, investigation, or ASHRAE 90.1 defaults)	Thermal performance: ±5%–10% (inherent uncertainty in envelope modeling)
HVAC heating and cooling energy (kWh and therms)	Proposed assembly specifications: R-value, insulation continuity, and thermal bridge treatment	Blower door: ±3% per ASTM E779
Blower door test results: CFM50 and CFM75 pre- and post-installation (air sealing)	NFRC window certifications	Power meter (HVAC): ±2% of reading
Window U-value and SHGC from NFRC label or field measurement	Blower door test reports per ASTM E779 (air sealing)	
Installed R-value and assembly U-value for modified assemblies	Building area takeoffs by assembly type and orientation	

ANALYSIS METHODOLOGY
Calculate heat transfer reduction using U × A × HDD for heating and U × A × CDD for cooling for opaque assemblies. For metal-framed assemblies, apply ASHRAE 90.1 Appendix A correction for thermal bridging — do not use nominal cavity R-value alone. For windows: calculate conductive savings from U-value improvement; account for SHGC change by orientation (reduced SHGC increases cooling savings but may add a heating penalty for south-facing windows). For air sealing: convert blower door results to annual infiltration energy using ASHRAE simplified method or engineering calculation.

ADDITIONAL NOTES	
Effective R-value for metal-framed assemblies is typically 30–50% lower than cavity insulation R-value due to thermal bridging; use ASHRAE 90.1 Appendix A correction factors.	Window SHGC changes have orientation-dependent effects; south-facing windows with reduced SHGC may have reduced net savings in winter due to lower passive solar gains. Analyze savings by orientation.
For air sealing projects, post-installation blower door testing is required to verify the claimed reduction in air leakage.	Envelope savings interact with HVAC system performance; reduced load on a condensing boiler system, for example, lowers return water temperatures and can increase condensing efficiency as a secondary benefit.

District and Campus Energy Systems

APPLICABLE MEASURES	
District steam: high-efficiency boilers, condensate return upgrades, steam trap replacement	District hot water: high-efficiency generators, distribution pipe insulation, variable flow pumping
District chilled water: high-efficiency chillers, VFDs on pumps, sequencing controls	

IPMVP OPTION
Option B for plant-level equipment upgrades; Option C may be appropriate where multiple interacting measures make individual isolation impractical

METERING PARAMETERS	
Baseline Duration	4–6 weeks during peak season at representative load (steam/HW: heating season; CHW: cooling season)
Reporting Period	Steam/HW: full heating season (October–April minimum). CHW: full cooling season (May–September). Year-round systems require both.
Data Interval	15-minute intervals
Weather Data	Outdoor dry-bulb and wet-bulb temperature at 15-minute intervals

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Steam: boiler gas input (BTU/hr), steam mass flow (lb/hr), steam pressure (psig), condensate return rate (%), makeup water flow (GPM)	Campus utility map showing distribution pipe routing, sizes, and insulation condition	Gas meter: ±2% of reading
Hot water: generator input (BTU/hr or kW), HW supply and return temp (°F), flow (GPM), distribution supply/return temps at end-of-line buildings	Equipment nameplates and efficiency certifications	Power meter: ±2% of reading
Chilled water: chiller kW per machine, CHW/CW supply/return temps (°F), CHW/CW flows (GPM), cooling tower fan kW	Steam trap inventory: type, size, age, and last inspection date	Steam flow meter: ±3% of reading (vortex or differential pressure type preferred)
Distribution system temperature drop from plant to representative end-of-line buildings	Condensate return system documentation and historical return rates	Water flow meter: ±3% of reading
	Control sequences for plant staging, reset strategies, and distribution controls	Temperature sensor: ±0.5°F; ±0.3°F for distribution loss calculations
	Operating schedules	Pressure sensor: ±2% of full-scale

ANALYSIS METHODOLOGY
Steam: calculate system efficiency from fuel input and useful steam delivered; include condensate return credit. Quantify distribution losses from supply/return temperature measurements. Hot water: assess generator efficiency and calculate distribution heat loss from supply/return measurements at plant and end-of-line. CHW: follow Section B.3 methodology. Report plant efficiency improvement and distribution loss reduction as separate line items. Extrapolate annual savings from seasonal load profiles.

ADDITIONAL NOTES	
Steam trap survey is typically among the highest-value district steam measures; failed-open traps can waste significant steam and should be quantified from the survey before claiming savings from replacement.	Condensate return rate directly affects boiler efficiency; a 10% improvement in return rate reduces fuel consumption by approximately 3% through reduced makeup water heating and blowdown.
Distribution losses in older campus steam systems can represent 20–40% of total plant output; insulation repair and steam trap replacement often yield larger savings than equipment upgrades.	For campus CHW systems, individual chiller metering is required; aggregate plant power alone does not allow attribution of savings to specific equipment.

Geothermal Heat Pump Systems

APPLICABLE MEASURES	
Vertical closed-loop ground-source heat pump (GSHP) system installations	Horizontal closed-loop GSHP installations
Open-loop (groundwater) heat pump systems	Ground loop flow and temperature optimization controls

IPMVP OPTION
Option B: system COP varies with ground loop entering water temperature and must be directly measured; manufacturer COP ratings are not representative of field performance

METERING PARAMETERS	
Baseline Duration	For replacements: 2–4 weeks in each season. For new installations: establish baseline from pre-installation HVAC energy data or ASHRAE 90.1 code-minimum baseline.
Reporting Period	Minimum 6 months spanning both heating and cooling seasons; 12 months preferred for large projects where ground loop temperature stabilization is a concern
Data Interval	15-minute intervals
Weather Data	Outdoor dry-bulb and wet-bulb temperature

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Heat pump compressor input power (kW)	Ground loop design documentation: bore depth, configuration, and loop length	Power meter: ±2% of reading
Ground loop entering water temperature (EWT, °F)	Heat pump manufacturer performance data: COP and capacity vs. entering water temperature	Flow meter: ±3% of reading (magnetic type recommended for antifreeze solutions)
Ground loop leaving water temperature (LWT, °F)	Antifreeze type and concentration for closed-loop systems	Temperature sensor: ±0.3°F (matched pairs for EWT-LWT differential)
Ground loop flow rate (GPM)	Existing HVAC system documentation (replacements) or ASHRAE baseline (new installations)	
Supply air or hot water temperature and flow at building side	Operating schedules	
Ground loop and distribution circulation pump power (kW)		

ANALYSIS METHODOLOGY
Calculate heat pump COP from measured compressor power and calculated heat output. Develop a COP vs. entering water temperature relationship from measured data. Apply this relationship to the annual load profile, accounting for seasonal variation in ground loop EWT. Subtract ground loop and distribution circulation pump energy from gross savings. For new installations, calculate savings relative to ASHRAE 90.1 baseline equipment at code-minimum efficiency.

ADDITIONAL NOTES	
Field GSHP COP is typically 15–25% below manufacturer rated values due to pump losses, antifreeze heat transfer reduction, and part-load operation; field verification is essential.	Ground loop EWT warms over the cooling season and cools over the heating season; in improperly sized systems, multi-year ground temperature migration can progressively reduce performance. Note this in the M&V plan for larger projects.
Circulation pump energy (ground loop and distribution) typically represents 10–20% of total system energy and must be included in the net savings calculation.	For open-loop systems, document groundwater temperature, flow rate, and discharge approach; regulatory requirements for groundwater withdrawal may affect operating hours.

Air Compressors

APPLICABLE MEASURES	
Replacement of reciprocating or rotary screw compressors with high-efficiency models	Variable speed drive (VSD) retrofits on fixed-speed compressors
System pressure setpoint reduction	Compressed air leak detection and repair (CALD) programs
Heat of compression recovery for space or process heating	

IPMVP OPTION
Option B: compressor energy varies significantly with production demand and system pressure; direct measurement of all key parameters is required

METERING PARAMETERS	
Baseline Duration	2–4 weeks capturing at least three distinct production demand levels including weekday production, weekend or standby, and a production surge if applicable
Reporting Period	4–8 weeks covering the same production schedule range as the baseline period
Data Interval	15-minute intervals; 5-minute preferred to capture compressor loading and unloading cycles
Weather Data	Intake air temperature and humidity at the compressor location; not outdoor weather unless compressor draws from outside

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Compressor input power (kW)	Compressor nameplate and CAGI data sheet showing specific power (kW/100 SCFM)	Power meter: ±1%–2% of reading
System discharge pressure (psig) at compressor outlet	System pressure profile at supply, distribution, and point-of-use locations	Compressed air flow meter: ±2%–3% of reading (thermal mass type)
Compressed air flow rate (SCFM) from thermal mass flow meter	Ultrasonic leak survey report with leak locations and estimated flow rates	Pressure sensor: ±1% of full-scale
Compressor operating mode: loaded, unloaded, or off	Pneumatic end-use inventory with pressure requirements	CTs: ±1%
Intake air temperature (°F) and relative humidity (%)	Piping schematic	
Air leak rate (SCFM) from ultrasonic survey		

ANALYSIS METHODOLOGY
Calculate baseline specific power (kW/100 SCFM) at multiple demand levels to develop a power-flow curve. Quantify air leak load as a fraction of total system flow. Calculate savings from: (1) compressor efficiency improvement at equivalent demand; (2) pressure reduction; (3) leak repair reducing total demand. Apply the power-flow curve to the annual production demand profile to extrapolate annual kWh. For VSD applications, use measured power at multiple speed setpoints; do not assume proportional savings below 40–50% speed due to compressor unloading behavior.

ADDITIONAL NOTES	
Fixed-speed compressors operating unloaded (typically at 20–40% of full-load power) represent wasted energy; quantify unloaded operating hours in the baseline — VSD retrofits can eliminate most of this waste.	System pressure reduction of 2 psi reduces compressor energy by approximately 0.5–1.0%; use this as a sanity check on calculated savings, not as the primary calculation method.
Heat of compression recovery can capture 80–90% of input power as usable heat for space or process heating; consider this as a companion measure where a heat sink is available.	Leak repair savings degrade over time as new leaks develop; document the re-survey schedule in the M&V plan and note expected savings degradation.

Industrial Process Loads (Gas and Electric)

APPLICABLE MEASURES	
High-efficiency process heating equipment: furnaces, ovens, kilns, and dryers	Process cooling system improvements and refrigeration efficiency
Motor-driven process equipment upgrades with VFDs	Process heat recovery: recuperators, regenerators, and exhaust economizers
Batch process optimization: scheduling, insulation, and cycle time reduction	

IPMVP OPTION
Option A where process-normalized savings can be stipulated from engineering calculations and spot measurements; Option B where process variability warrants direct metering

METERING PARAMETERS	
Baseline Duration	Minimum 3 production cycles covering the full range of operating modes including peak production and standby; contact Program Manager for processes with non-standard cycles
Reporting Period	Minimum 3 production cycles post-installation under equivalent production conditions
Data Interval	15-minute intervals for continuous processes; 5-minute intervals for batch processes
Weather Data	Required only if process load is temperature-dependent; document temperature sensitivity in the M&V plan

CRITICAL DATA POINTS	REQUIRED DOCUMENTATION	METER ACCURACY
Energy input (kW or therms/hr) at multiple production rates including full load and idle	Process description: inputs, outputs, and major energy-consuming equipment	Gas meter: ±2% of reading
Production output metric (units/hr, tons/hr, or batch size) coincident with energy metering	Equipment nameplate data and efficiency specifications	Power meter: ±2% of reading
Process temperature setpoint and actual (°F)	Historical production records for at least 12 months prior to baseline	Flow meter: ±5% of reading
Specific energy consumption (kWh/unit or therms/unit)	Process flow diagram	Production measurement: ±2%–5% as applicable
Runtime hours by operating mode: production, standby, idle, and scheduled off	Load profiles and production schedules	

ANALYSIS METHODOLOGY
Establish an energy-production relationship from baseline metering: $E = a \times P + b$, where E is energy input, P is production output, a is the variable production coefficient, and b is the fixed (idle/standby) load. Verify the goodness of fit ($R^2 \geq 0.85$ recommended) before accepting the regression. Apply the baseline and proposed energy-production relationships to equivalent production volumes to calculate savings. Report savings as both absolute (kWh or therms) and normalized (kWh/unit or therms/unit).

ADDITIONAL NOTES	
Production normalization is required for process M&V; raw energy reduction without coincident production data cannot be accepted as verified savings.	A regression analysis requires sufficient data points across the production range (minimum 20 data points recommended); a single operating point at full load is not sufficient.
Idle and standby loads can represent 20–50% of full-production energy consumption; efficiency measures targeting idle losses must track this separately from production-mode savings.	Contact the Program Manager at least 60 days before baseline metering begins for complex or novel industrial processes; site-specific M&V plan approval may be required.