

PNNL-34217

Energy Credits Application Guide: ASHRAE Standard 90.1- 2022

July 2023

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PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

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Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Executive Summary

The Standing Standards Project Committee for ASHRAE Standard 90.1 adopted energy credits into ASHRAE Standard 90.1-2022. Energy credits provide additional required prescriptive savings that are more flexible than base prescriptive requirements. The new credit requirement can be met by selecting from 34 available measures that include energy efficiency, renewable energy, and load management options. Building developers select from the available measures to meet a savings target above the base prescriptive requirements. Building-type-specific targets were developed with a goal of achieving an average of 5% total building energy cost savings.

Energy credits have been adopted in other model building energy codes. For example, energy credits were incorporated into the 2018 International Energy Conservation Code (IECC) as a set of eight options, from which one must be selected for compliance. In the 2021 IECC, the energy credit options were expanded to 15 energy saving measures that provides the user with the flexibility to select measures in a combination that achieves at least 2.5% level of energy savings.

The maximum available ASHRAE Standard 90.1 credits from different measure types for each building use type are compared with the 50-point cap on credit requirements in Figure E.1.

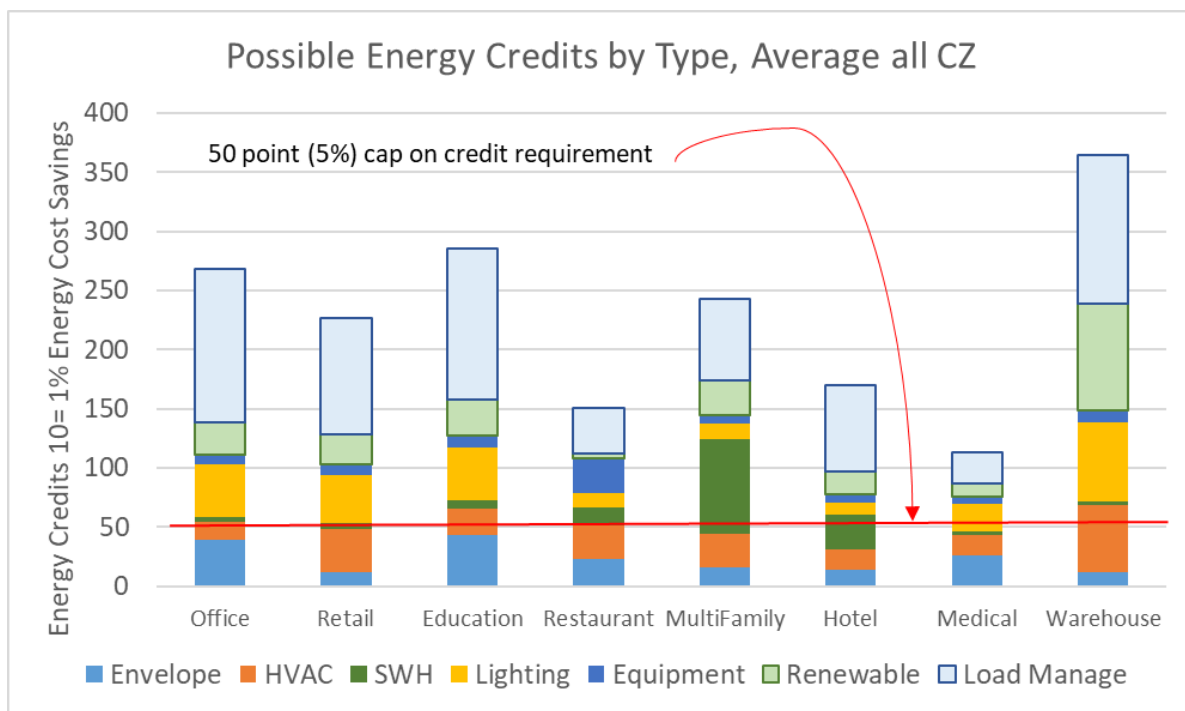


Figure E.1. Available Energy Credits by Building and Measure Type vs. Required Credits

This application guide includes general information about the energy credit requirements in Standard 90.1-2022. Example packages are shown for hot, moderate, and cold climates demonstrating nine alternative ways to meet the energy credit requirements for each building use type. There is also a general description of the energy credit measures, including how they save energy or reduce electric grid costs, and their applicability. The actual code language, credit requirements, and available credits by measure can be found in Standard 90.1-2022.

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1.0 Introduction

The purpose of this document is to assist building designers in complying with the newly adopted energy credit requirements of ASHRAE/ANSI/IES Standard 90.1-2022, *Energy Standard for Sites and Buildings except Low-Rise Residential Buildings* (ASHRAE 2022a), hereafter referred to as Standard 90.1. These new requirements are included in Section 11¹ of Standard 90.1. This document includes the following sections:

- Section 2: “Energy Credit Requirement Development” includes a summary of the rationale behind energy credits, adoption principles, history, and considerations.
- Section 3: “Energy Credit Measures” summarizes the measure types, applicability, and available credits vs. requirements.
- Section 4: “General Energy Credit Provisions and Adjustments” covers which projects are excluded from energy credit requirements and how core and shell projects or mixed occupancy projects are handled. Building use types are also discussed.
- Section 5: “Example Energy Credit Measure Packages” outlines the example packages included in the document with background on the cost-effective, minimum efficiency, and prototype packages. It also reviews, by building type, the energy credit points available for measures with example packages for hot, moderate, and cold climates. This section provides a good starting point for selecting energy credit measures for a user’s building and climate.
- Section 6: “Measures to Achieve Credits” provides more background on the individual measures, including applicability, limitations, and energy saving concepts.

¹ The former Section 11, “Energy Cost Budget Method,” has been moved to Section 12 so that the Energy Credit requirements will be in sequence with other prescriptive requirements.

2.0 Energy Credit Requirement Development

Energy codes have traditionally contained *mandatory* and *prescriptive* requirements. Mandatory requirements must be complied with in all situations while prescriptive requirements can be traded with other efficiency measures by following either a whole-building or discipline-specific performance path. Recent editions of the International Energy Conservation Code (IECC) also include extra efficiency measures, and adequate measures must be selected to satisfy an “additional” efficiency requirement. The efficiency requirement is stated on a point scale, with each measure assigned points relative to the building efficiency improvement. Such a structure is currently employed in Section C406 of the 2021 IECC (ICC 2021) and similar approaches are in several state building codes.

For Standard 90.1-2022, energy credits were adopted through addendum **ap** and are included in the renumbered Section 11 (ASHRAE 2022b). The energy credit approach has the advantage of providing increasing levels of performance, while maintaining flexibility by allowing designers to select the most appropriate technologies and efficiency measures based on the attributes of each particular project.

2.1 Overall Summary

Here we discuss the history and benefits of energy credits, outline the development, and review cost-effectiveness considerations.

2.1.1 History of Energy Credits

Originally, Section C406 appeared in the 2012 IECC as a “select one of three” options approach for additional efficiency. This approach has evolved over the years to include six options in the 2015 IECC and eight options in the 2018 IECC. In the 2021 IECC, energy credit measures were expanded to 15 measures that provides the user with the flexibility to select measures in a combination that achieves at least 10 credit points, which is equivalent to approximately 2.5% energy savings. See Section 1.0 in *90.1 Energy Credits Analysis Documentation* (Hart et al. 2022) for a more complete history.

The credits adopted into ASHRAE Standard 90.1-2022 through addendum **ap** include 34 energy efficiency, renewable energy, and load management measures. Building-type-specific targets were developed with a goal of 5% total building energy cost savings.

2.1.2 Benefits of Energy Credits

The energy credits include 26 energy efficiency measures, 1 renewable measure, and 7 load management measures. The 90.1 credits build on the former energy credit approaches with a base goal of around 5% energy cost savings. The energy efficiency credits in the proposal are based on site energy cost and each credit point represents 1/10 of 1% (i.e., 0.1%) of total building energy cost savings. Load management measures base their cost savings on grid cost impact represented by a time-of-use electric price structure that has been adopted by The Standing Standards Project Committee (SSPC) 90.1 for evaluation of similar measures. The code approach is to add a prescriptive requirement for additional saving measures that can be selected by design teams to meet the requirements for each building use type and climate zone.

Energy codes include mandatory requirements that all buildings must fulfill, prescriptive requirements that can be used without following a performance path, and discipline¹ or whole-building performance paths where equivalent energy performance to the prescriptive path is demonstrated. To fit into the existing code structure, additional energy credits constitute a new prescriptive requirement; however, instead of all measures being required, the building designer is provided the flexibility to select from various options to achieve a defined level of energy performance. To maintain equivalent energy impact, whole-building performance paths must be adjusted to reflect the impact of the required efficiency energy credits. These issues are addressed in the code language through modifications to the Energy Cost Budget in 90.1 Section 12 and a process for modifying building performance factors for Appendix G.

2.1.3 Energy Credit Development

Energy credits have been developed from typical efficiency measures used in green building programs, new construction utility incentive programs, and Advanced Energy Design Guidelines (ASHRAE 2019). More detail is included in Section 1.4 of *90.1 Energy Credits Analysis Documentation* (Hart et al. 2022).

2.1.4 Cost-Effectiveness Considerations

While baseline prescriptive requirements usually undergo individual review for cost-effectiveness, the approach for energy credit measures is different. In general, any measure can be selected for a particular building; however, not all measures are required. Thus, the approach to establish cost effectiveness is to demonstrate that at least one package of measures is cost effective using the ASHRAE Standard 90.1 scalar method. More detail is included in Section 2.2 of *90.1 Energy Credits Analysis Documentation* (Hart et al. 2022).

2.2 Energy Credit Adoption Principles

Energy credits have been used in numerous energy codes, especially the IECC, for more than a decade. A working group on energy credits reporting to ASHRAE's 90.1 SSPC was established in November 2019. Initially, the working group was ad hoc, exploring the energy credit concept, and in April 2020, after presenting initial findings, a chartered working group was established, since this cross-discipline proposal was not appropriate for a single existing subcommittee. As the working group met, the group members moved toward agreement around several options in energy credit development. While the principles here reflect at least a majority opinion of the working group, it is acknowledged that there are some contrary minority opinions. As with all addenda to 90.1, addendum **ap** went through public review. Based on helpful feedback from the process and members of the SSPC as a whole, the proposal was modified to reflect these principles (ASHRAE 2022b). The agreed-to principles for selecting measures and determining credits are listed here and discussed in detail in *90.1 Energy Credits Analysis Documentation* (Hart et al. 2022):

- Calculate energy cost savings relative to prescriptive requirements and general practice.
- Establish energy credits for different building types and climate zones based on prototype analysis and end-use proration; allow for non-simulated building types as well as additions and alterations.

¹ An example of a discipline performance path is the Building Envelope Trade-Off Compliance Path in the envelope discipline of Standard 90.1 that is supported by Appendix C. There are current proposals under public review in Standard 90.1 for discipline performance paths for both lighting and HVAC disciplines.

- Determine credits for measures that are based on approximate energy cost savings equivalency
- Use measure descriptions that are based on prescriptive descriptions and do not require performance analysis.
- Where possible, integrate energy credits with discipline trade-off or performance paths such as the envelope tradeoff, heating, ventilation, and air conditioning (HVAC) performance, or lighting performance methods.
- Establish energy credit requirements by building type and climate zone based on cost-effective demonstration packages of reasonably applicable measures.
- Limit the share of credits from renewables and load management to ensure a balanced portion of credits from energy efficiency.
- Ensure that required energy credits are accounted for in the performance paths by adjusting the Energy Cost Budget formula and including energy credits in the Appendix G Building Performance Factors.
- Review future measures for addition to the measure energy credits based on these criteria.

2.3 General Energy Credit Considerations

How do energy credits compare to what's required in past codes?

Before 2022, Standard 90.1 did not employ energy credit measures. In the 2021 IECC, points for the additional energy efficiency measures are assigned by building type and climate zone rather than all having the same requirements, as is done in the 2018 IECC (ICC 2018). The 2021 IECC required that sufficient measures must be included in the building design until at least 10 points are achieved. That increased building savings by about 2.5% of total building energy cost compared with the base prescriptive path requirements.

Standard 90.1-2022 adds energy credit measures to 90.1 in a similar manner to the 2021 IECC and distinguishes requirements based on building type and climate zone. The energy credit points attributed to individual measures are determined mostly from building simulation prototype analysis. The assigned points for each measure are based on relatively equivalent energy cost savings (credits in the IECC are based on site energy savings). Each efficiency measure credit equals 0.1% of total building energy cost based either on average national energy prices or a composite time of use electric price schedule. For example, a score of 10 credits represents a 1% energy cost reduction for the building as a whole and a score of 50 credits represents a 5% reduction.

What are the benefits of using the energy efficiency credit assignment method?

The extra efficiency credit approach provides compliance flexibility to designers and builders. Project teams select measures that make the most sense for their specific building design, typically considering cost-effectiveness and constructability issues. The approach does require selecting multiple items and adding up points; however, in many cases, credit can be earned for measures that are often included in buildings but not previously accounted for in prescriptive compliance. Expanding the number of measures available for achieving credits makes it possible for buildings to save more, allowing the credit requirements to be set initially with a target of 5% total building cost savings.

What strategies are considered to minimize compliance burdens?

To achieve deeper savings in response to energy and carbon reduction policy goals, energy credits provide a more expedient compliance path than the performance path, which requires developing a custom building model using simulation software. By expanding the number and flexibility of options for achieving energy credits and differentiating credits by building type, additional savings can be achieved with a simplified approach. To streamline its implementation and review, the energy credit measures included in DOE's COMcheck compliance software¹ for the 2021 IECC can be expanded to include the 90.1 measures introduced in Addendum **ap**. While some additional review is required for the building official, it is less complex than the review typically required for a whole building model.

Are there existing codes and standards that take a similar approach?

The outlined approach is an expansion of the structure currently employed in the 2021 IECC for commercial buildings, which has been adopted by several states. The credits approach has been used in the Washington State Energy Code since the 2015 edition, with good results (WSBCC 2015). The Washington State and Seattle energy codes have successfully used the approach to address and balance multiple project considerations, including energy performance, design flexibility, and evolving technologies.

How do load management and renewable measures fit in?

Load management and renewable measures are included in the energy credits even though they do not always save energy, and in some circumstances may increase energy use. These measures are included because they make more flexible and effective use of energy on the grid. Buildings can absorb excess energy when grid-level renewable generation is high or shave peak power when net grid demand is high. This reduces the need for peaking fossil fuel electrical generation and makes better use of renewable energy. Proper grid management helps improve grid resilience and reduce source energy and carbon emissions.

¹ <https://www.energycodes.gov/comcheck>

3.0 Energy Credit Measures

Energy credit measures included in Standard 90.1-2022 are described in detail in Section 6.0. A higher level overview is given here, including the following:

- What general types of measures there are
- How the measures apply to different buildings
- How the credits available compare to the credits required
- The rationale for renewable and load management credits

3.1 Types of Measures

There are two ways to look at measure types: 1) general category and 2) how credit points are determined. The general categories are as follows:

- **Energy efficiency measures** reduce the energy use of the building directly, either by reducing the load on the building or through increased efficiency.
- **Renewable energy measures** offset metered energy use by using solar, wind, or other renewable technologies to generate energy at the building site.¹
- **Load management (LM) measures** help the electric grid by allowing the building to reduce or shift electric demand during times of peak demand. Credits for these measures are based on cost savings in a time of use electric rate schedule. For some load management measures, there may be a small increase in energy use. For others, there may be energy savings in addition to cost savings.

Standard 90.1 sets an upper limit of 60% of required credits for the combined renewable and load management credits. This ensures that at least 40% of the credits produce direct energy savings.

The other category of credits is how credit points are determined with three different approaches. This category is noted as “Adj. Type” in Table 1, using the letter in brackets as a key:

- [T] Credits are taken directly from the tables. This applies to many credits.
- [C] Credits are calculated based on building characteristics. This applies to a few measures, for example, E01 Envelope Improvements and H01 HVAC Performance.
- [A] Table credits are adjusted based on the installed measure characteristics. An example of this is H02, where the table values are based on a 5% improvement in heating efficiency. The table values are multiplied by the actual improvement in efficiency so improvements between 5% and 20% in heating efficiency can be accommodated. Most measures use adjustments to determine credits.

¹ Alternatively, renewable energy can be purchased as a metered energy source with certified renewable energy source through renewable energy certificates. While the flexibility of purchasing renewable credits on a contract basis was not included in the 90.1-2022 published edition, that approach is under development by the committee.

3.2 Measure Applicability to Building Types

Several of the measures may not be applicable in certain building use types. This occurs where the measure may be common practice already, where there are concerns about measure persistence for the particular building use, or where the savings are quite low for that building type. Where measures are not applicable, they are noted with NA in Table 1. The reasons for non-applicability for an entire building use type are included with the measure discussions in Section 6.0. For example, measures may have very low savings or even energy increases in certain climate zones. In this case, the measure non-applicability in a certain climate zone is indicated by an “x” in the measure available credits tables in Section 11 of Standard 90.1.

Table 1. Energy Credit Measure Applicability

Energy Credit ID	Abbreviated Title	Adj. Type	Multifamily	Health-care	Hotel/Motel	Office	Rest-aurant	Retail	Education	Ware-house	Other
E01	Envelope Performance	C	YES	YES	YES	YES	YES	YES	YES	YES	YES
H01	HVAC Performance	C	YES	YES	YES	YES	YES	YES	YES	YES	YES
H02	Heating Efficiency	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
H03	Cooling efficiency	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
H04	Residential HVAC control	T	YES	NA	NA	NA	NA	NA	NA	NA	NA
H05	Ground source heat pump	A	YES	YES	YES	YES	YES	YES	YES	NA	YES
H06	DOAS/fan control	A	NA	YES	NA	YES	NA	YES	YES	NA	YES
H07	Guideline 36 Sequences	T	YES	YES	YES	YES	YES	YES	YES	YES	YES
W01	SHW preheat recovery	T	YES	YES	YES	YES	YES	YES	YES	YES	YES
W02	Heat pump water heater	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
W03	Efficient gas water heater	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
W04	SHW pipe insulation	A	YES	YES	YES	YES	NA	NA	YES	NA	YES
W05	Point of use water heaters	T	NA	NA	NA	YES	NA	NA	YES	NA	YES
W06	Thermostatic balancing valves	T	YES	YES	YES	YES	YES	YES	YES	YES	YES
W07	SHW submeters	T	YES	NA	NA	NA	NA	NA	NA	NA	NA
W08	SHW distribution sizing	T	YES	NA	YES	NA	NA	NA	NA	NA	NA
W09	SHW shower drain HR	A	YES	NA	YES	NA	NA	NA	YES	NA	NA
P01	Energy monitoring	T	YES	YES	YES	YES	YES	YES	YES	YES	YES
L02	Lighting dimming & tuning	A	YES	YES	YES	YES	YES	YES	YES	NA	YES
L03	Increase occupancy sensor	T	NA	YES	YES	YES	YES	YES	YES	YES	YES
L04	Increase daylight area	A	NA	NA	NA	YES	NA	YES	YES	YES	YES
L05	Residential light control	A	YES	NA	NA	NA	NA	NA	NA	NA	NA
L06	Light power reduction	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
R01	Renewable energy	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
Q01	Efficient Elevator	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
Q02	Efficient Kitchen Equipment	T	NA	NA	NA	NA	YES	NA	NA	NA	NA
Q03	Fault detection	T	YES	YES	YES	YES	YES	YES	YES	YES	YES
G01	Lighting load management	A	NA	NA	NA	YES	NA	YES	YES	YES	YES
G02	HVAC load management	T	NA	NA	NA	YES	NA	YES	YES	NA	YES
G03	Shading load management	T	YES	YES	YES	YES	YES	YES	YES	NA	YES
G04	Electric storage	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
G05	Cooling storage	A	YES	YES	YES	YES	YES	YES	YES	YES	YES
G06	SHW storage	T	YES	YES	YES	YES	YES	YES	YES	YES	YES
G07	Bldg. mass / night flush	T	NA	NA	NA	YES	YES	YES	YES	YES	YES

3.2.1 Requirements vs. Potential Savings

As previously discussed, cost effectiveness of the credit requirements was based on a demonstration package of measures applicable to each building type. The requirements based on the demonstration package can be compared to the potential savings from identified measures. For this comparison, mutually exclusive and niche measures were not included. Figure 1 shows the credits that can be achieved with identified measures and illustrates the availability of a range of measure choices to meet a 5% building cost savings requirement. The figure also demonstrates that measures are available for a variety of end uses, so the energy credits do not rely on just one end use to achieve the required credits.

Figure 2 shows the same potential savings organized by climate, with a “warm” group including climate zones 0 to 2, a “moderate” group including climate zones 3 to 5, and a “cold” group including climate zones 6 to 8. This illustrates that adequate credits are available in all climates to meet the requirement. Credit packages are explained in more detail in Section 6.0 of this document.

3.2.2 Renewable and Load Management Credits

Renewable and load management credits do not always save energy directly but focus on making buildings more flexible in terms of load shifting related to electrical grid optimization. These credits can be used to achieve up to 60% of the building type energy credit requirements. One of the packages reviewed uses the full 60% energy credit requirements.

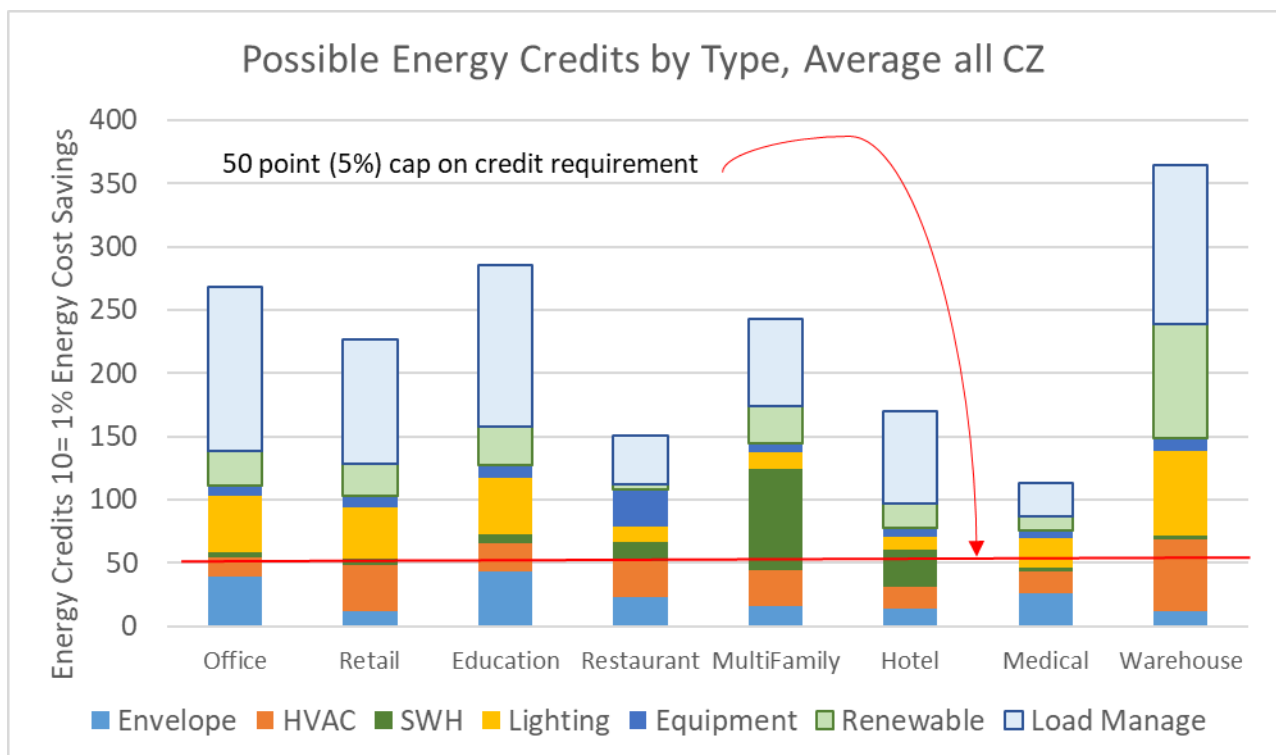


Figure 1. Available Energy Credits by Building and Measure Type vs. Required Credits

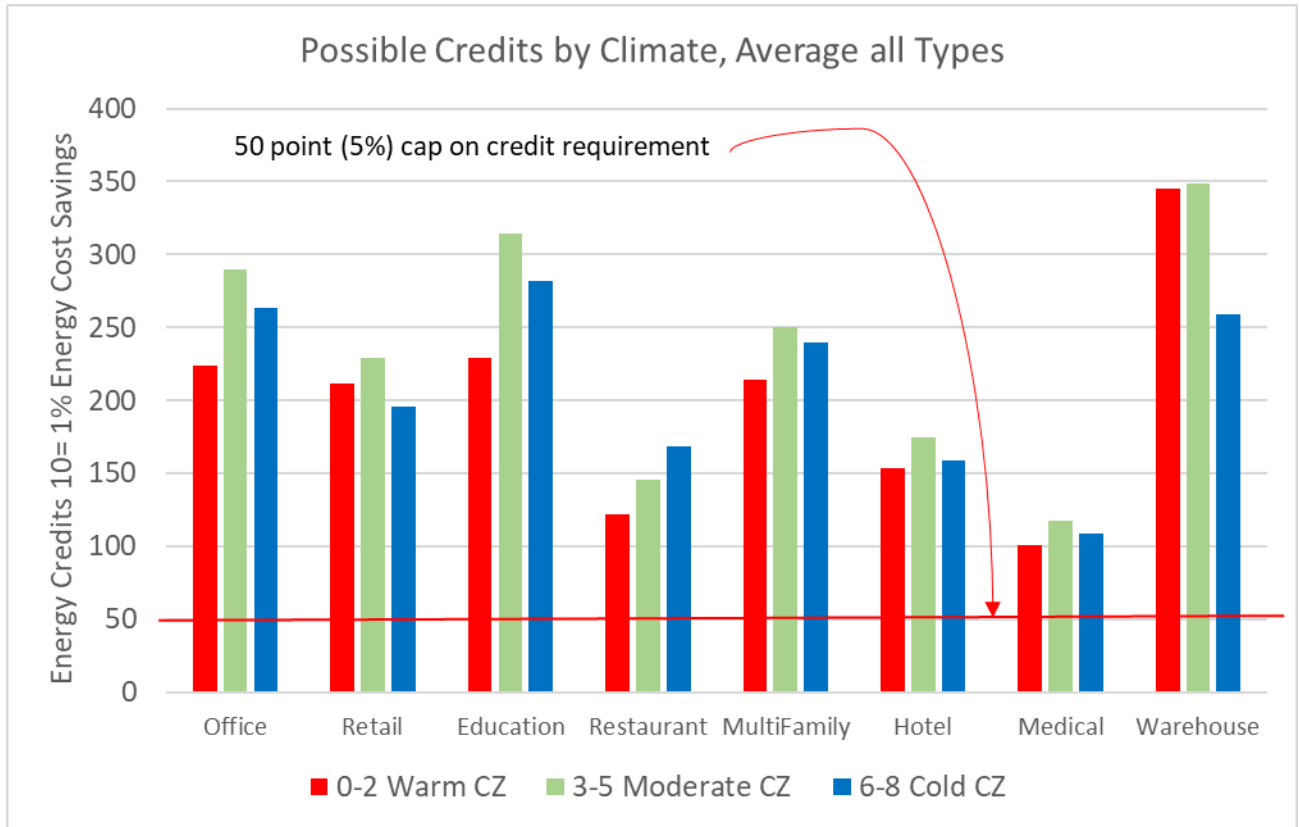


Figure 2. Potential Energy Credit Points by Climate and Building Type vs. Required Credits

4.0 General Energy Credit Provisions and Adjustments

Section 4 of Standard 90.1-2022 requires that the energy credit requirements be applied to all projects by including Section 11 of 90.1-2022 in the higher level compliance requirements. In some cases, Section 11 limits the scope or provides exceptions and adjustments for certain situations. Generally, Figure 3 shows the steps in determining the energy credit requirements and Figure 4 shows the steps in determining the energy credits achieved for the project. The section numbers in Figure 3 refer to sections in this document.

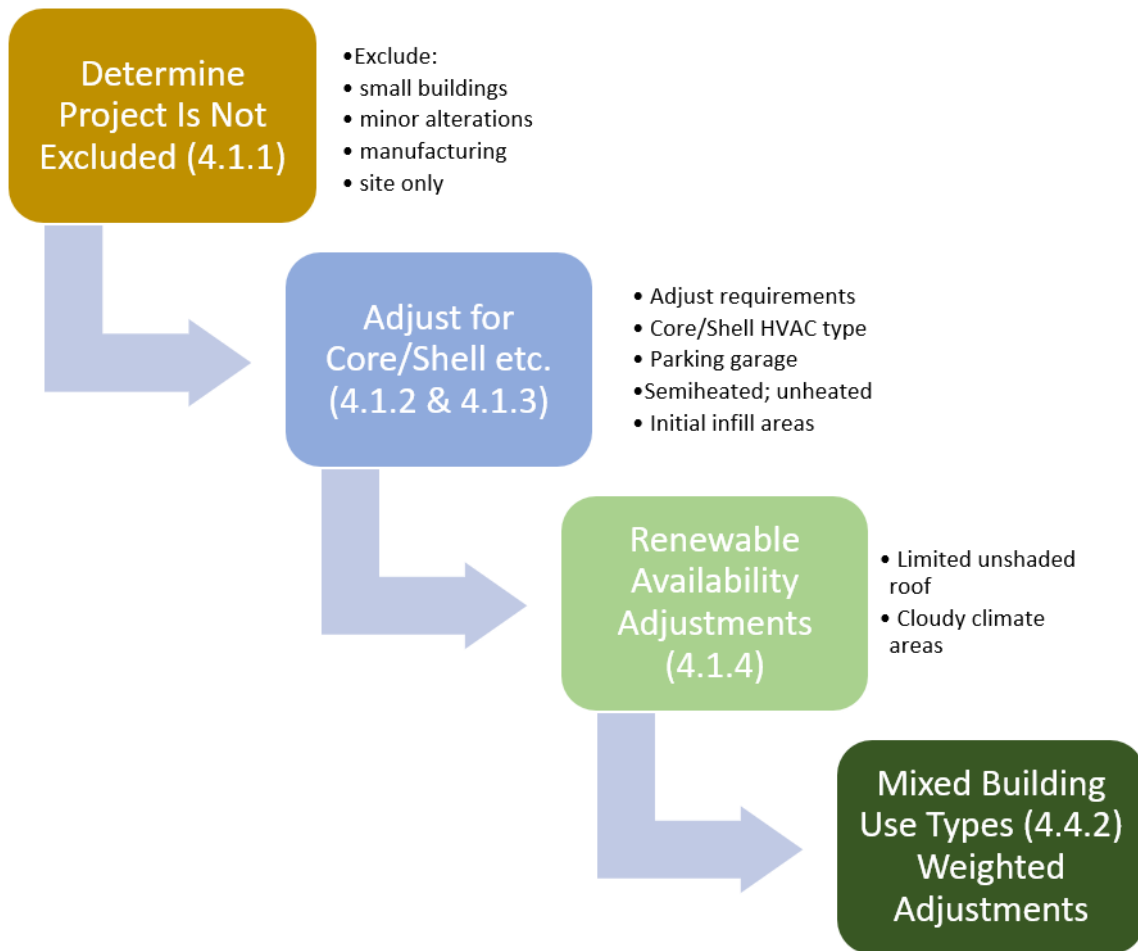


Figure 3. General Approach to Energy Credit Requirement Determination

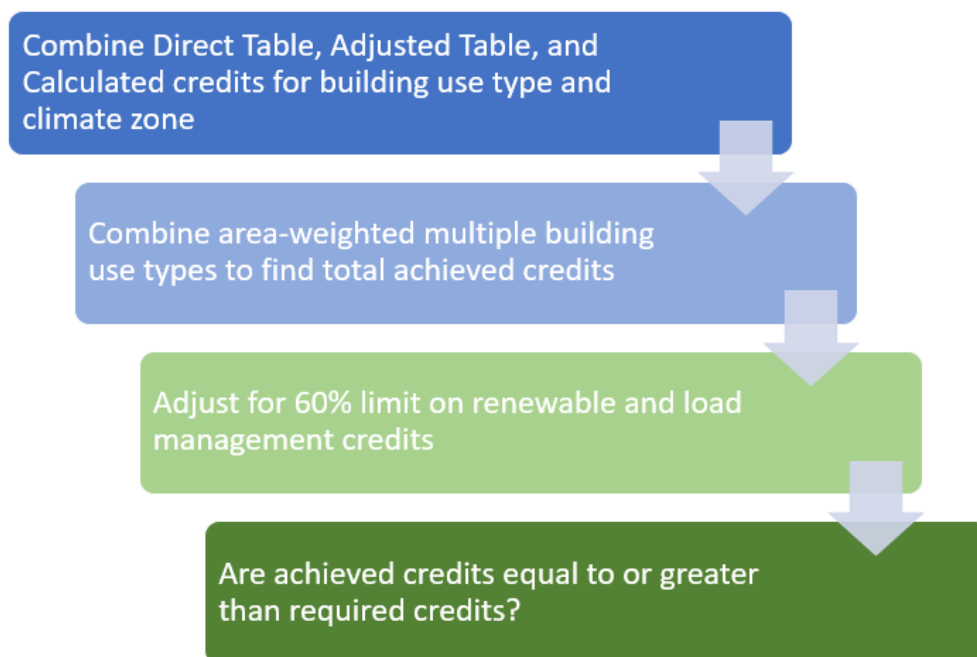


Figure 4. General Approach to Achieved Credit Determination

4.1 Exceptions and Adjustments to Credit Requirements

Exceptions and adjustments are included in Section 11 of Standard 90.1.¹ These cover projects not covered by the scope, core and shell projects, substantial alterations or projects with unconditioned spaces, and projects with multiple building uses. Adjustments are also made where renewable installation is not practical.

4.1.1 Excluded Projects

Some projects are excluded from energy credit requirements by not being included in the scope for buildings, additions, and alterations as described in Sections 11.1.2 through 11.1.4 of Standard 90.1. Projects excluded from energy credit requirements include:

- Performance path projects using the Energy Cost Budget method in Section 12 or the Performance Rating Method in Appendix G. This includes core/shell projects that comply in accordance with Normative Appendix G or Section 12. In these buildings, the initial build-out construction areas do not need to achieve any energy credits. These performance methods have factors included that provide for equivalent savings to the energy credits.
- Site systems and equipment that do not have buildings
- New buildings 2000 ft² or less in gross floor area
- Additions 2000 ft² or less in gross floor area
- Alterations to buildings with an alteration area 5000 ft² or less in gross floor area
- Alterations to buildings that do not include replacement of two or more of the following:

¹ References to tables and section numbers in this section of the document are generally to Standard 90.1 and not this document.

- HVAC systems that account for more than 50% of the capacity serving either the heating or cooling loads of the alteration area. This includes HVAC unitary systems, HVAC terminal units, or components of HVAC central heating or cooling equipment, not including ductwork or piping. HVAC terminal units, for the purposes of this section, can include variable air volume boxes, fan-coil units, variable refrigerant flow room units, or water-loop heat pumps.
- Fifty percent (50%) or more of the luminaires in the alteration area
- Twenty-five percent (25%) or more of the building envelope area of the alteration portion of the building, including new exterior cladding, fenestration, or insulation
- Initial build-out construction of 1000 ft² or less in gross floor area where the initial build-out area did not have final lighting or HVAC systems installed under a prior building permit
- Portions of buildings devoted to manufacturing or industrial use not including office areas

4.1.2 Alterations and Core and Shell Projects

Where separate permits are used for the building core and shell vs. initial build-out construction, the following shall apply:

1. The building core and shell project shall achieve at least 50% of the energy credits required in Table 11.5.1-1 where the core and shell project includes a central HVAC system or service water heating system that includes chillers, boilers, service water heating equipment, or loop pumping systems with heat rejection. Otherwise, the building core and shell project shall achieve at least 33% of the energy credits required in Table 11.5.1-1. The building core and shell permit shall not be eligible for credits from measures involving nonpermanent services in future build-out areas, such as freeze protection and limited lighting.
2. Initial build-out construction, as described in Section 11.1.4.2, shall be deemed to comply with this section where one of the following applies:
 - i. Where the initial build-out project includes HVAC heating and cooling generation equipment, the energy credits achieved under the initial build-out project are not less than 50% of the credits required in Table 11.5.1-1.
 - ii. Where the initial build-out project receives heating and cooling services from the core and shell building—excluding condenser loop water—the energy credits achieved under the initial buildout project are not less than 25% of the credits required in Table 11.5.1-1.
 - iii. The energy credits achieved under the initial build-out project, plus the energy credits achieved under a prior core and shell permit—not including core and shell credits from measures L02, L03, L04, L05, L06, G01, or G02—total at least the credits required in Table 11.5.1-1.

4.1.3 Requirement Adjustments for Certain Projects

- Substantial alterations, as described in Section 11.1.4.1, that are not initial build-out construction shall achieve 50% of the credits required for the building use type in the substantial alteration portion of the building.
- Unconditioned spaces, semiheated spaces, and parking garages shall achieve 50% of the credits required for the “Other” building use type in Table 11.5.1-1.

4.1.4 Renewable and Load Management Credit Adjustments

Renewable credits included in the demonstration packages were a uniform 0.1 W/ft² across building types. In most cases this is easily achievable, and the portion of credits by building use group can be seen in Figure 1. In some cases, due to low insolation in a particular area of the country, roof shading, other uses of the roof, or for a high rise building, there is not the same potential for on-site renewable energy generation. In this case, there is an allowed reduction in required credits. This adjustment is intended to not penalize projects where it is not feasible to install the presumed on-site¹ renewable resource on the roof. There are basically three conditions that could occur:

1. If there is an exception from the baseline renewable requirements in Section 10.5.1.1 this indicates that on-site renewable energy is not feasible at the site, and the full PV_{adj} from Table 11.5.1-2 would be subtracted from the requirement in Table 11.5.1-1.

After the prescriptive on-site renewable requirements in Section 10.5.1, the capability of supporting 0.1 W/ft² of renewable with the remaining roof area (RA_{net}) is assessed using the right half of equation 11.5.1.

$$\left(1 - \frac{RA_{net}}{G_{floor} \times PV_{incl} \times 0.20}\right)$$

2. If that portion of the equation returns a result between 1 and 0 it indicates the roof area is limited relative to the total building area, such that renewables equal to 0.1 Watt per gross square foot of building could not be installed. Then In this case equation 11.5.1 is applied and the energy credit requirement is partially reduced.
3. If that portion of the equation returns a negative result less than 0, it indicates there is adequate roof area to install renewables equal to 0.1 Watt per gross square foot of building area. In this case there is no reduction allowed for the required energy credits in Table 11.5.1-1.

Where on-site renewable capability is limited, related to case 2 above and as defined in Section 11.5.1(e), then the following formula is used for energy requirement credit adjustments:

$$EC_{adj} = EC_{req} - PV_{adj} \times \left(1 - \frac{RA_{net}}{G_{floor} \times PV_{incl} \times 0.20}\right) \tag{11.5.1}$$

where

EC_{adj} = adjusted energy credit requirement used instead of the energy credit requirement from Table 11.5.1-1

EC_{req} = energy credit requirement from Table 11.5.1-1

¹ This adjustment is based on the 90.1-2022 edition that only considers on-site renewable energy. If future changes to 90.1 allow the use of off-site renewable energy to meet renewable energy requirements, then there would likely be significant changes to or elimination of these adjustments.

$PV_{adj} = PV_{adj}$ for building type from Table 11.5.1-2

RA_{net} = horizontal projection of roof area available for renewable energy resources not covered by any combination of equipment other than for on-site renewable energy systems, planters, vegetated space, skylights, or occupied roof deck after meeting requirements of Section 10.5.1

G_{floor} = gross floor area of building, ft²

$PV_{incl} = PV_{incl}$ for building type from Table 11.5.1-2, W/ft²

Table 2 below shows examples that allow for a partial reduction of required credits based on available roof area. In the first case, there is no adjustment as there is plenty of net unshaded roof area (condition 3 above). The formula in this case will show an increase in requirement, but this is ignored as the adjustment formula is not applied when there is adequate unshaded roof space. For the restaurant example, no available roof area is assumed, in which case the full adjustment factor from the table is subtracted and the formula is replaced by a simple subtraction (condition 1 above—also under any exceptions in 10.5.1). The general conclusion is that adjustments are needed only for high rise buildings or cases with very small unshaded and available roof area.

Table 2. Renewable Adjustment of Required Credit Examples

Use Type	Office	Office	Hotel	Multi-family	Warehouse	Restaurant
Climate Zone	4B	4B	3B	3A	3A	2B
Stories	3	20	20	20	20	2
Net unshaded roof area available	25%	25%	20%	20%	20%	0%
Adjusted?	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
ECadj	50.0	46.6	40.5	39.5	37.0	48.0
ECreq	50	50	47	46	47	50
PVadj	9	9	13	13	20	2
RAnet	4,167	625	500	500	500	0
Gfloor	50,000	50,000	50,000	50,000	50,000	10,000
PVincl	0.1	0.1	0.1	0.1	0.1	0.1

4.2 Determining the Appropriate Building Use Type

Building use types are used to identify the general energy character of a building or portion of a building. These are not formally defined like code occupancy groups. Based on the footnotes to Table 11.5.1 in Standard 90.1, there is guidance on assigning the project or portions of the project to the appropriate building use type:

- All building use types include supporting functions such as corridors, break rooms, lobbies, restrooms, mechanical rooms, storage rooms, conference rooms, individual equipment and computer rooms with loads ≤ 10 kW, minor snack and beverage service without a commercial kitchen, and up to 10% of gross floor area of other building use types such as an office area in a nonoffice building use type. Note that any office area with 2000 ft² or more is treated separately as an office building type, even if it is less than 10% of the total building area.

- Multifamily includes apartments, condominiums, dormitories, retirement living facilities, non-transient lodging, and residential portions of institutional care facilities, excluding prisons.
- Healthcare includes buildings within the scope of ASHRAE Standard 170 ventilation requirements that are dedicated to patient care, including related support areas of healthcare facilities, hospitals, nursing facilities, outpatient facilities, and surgery centers.
- Office includes areas for administrative or business use, excluding retail or mercantile, and also include offices or clinics where medical, dental, psychotherapy, physical therapy or other services are provided that are not within the scope of ASHRAE Standard 170 ventilation requirements. While not specifically mentioned in the standard, banks have characteristics more closely related to office use than retail use.
- Restaurants with commercial kitchens and dining areas that are separate buildings or constructed under separate permits shall meet restaurant building use type requirements. Where restaurants are part of a larger building and are not seeking credit for either measure W01, W02, W03, or Q02, their area is permitted to be included with the larger building use type when they constitute 10% or less of the building floor area. If credit for measures W01, W02, W03, or Q02 serving a restaurant or dining area is desired, then the restaurant and dining area needs to be treated separately, even if they constitute 10% or less of the building floor area.
- Education includes schools, lecture halls, gymnasiums, and either educational or municipal libraries.
- Warehouses include only fully conditioned buildings, including storage and distribution buildings, refrigerated warehouses, and storage rental facilities. An unconditioned or semiheated warehouse would fall under the adjustment in Section 11.5.1(d) requiring only 50% of the credits required for the “other” building type. Where a warehouse has a mix of fully conditioned, semiheated, and unconditioned areas, each of which is more than 10% of the building area, it would be treated as a mixed use type building as discussed in Section 4.4.2.
- All other buildings, including any building use not covered in the eight listed building use types of Table 11.5.1 and data centers using Standard 90.4, shall use the energy credits required and available for the “Other” category.

4.3 Blank Energy Credit Form

The form below can be used as a template to create up to three potential packages for a user’s building. Then they can be reviewed to determine which is the best match for the building program and budget. The user should fill out the “table points available” column from the tables in Section 11.5 of the Standard. As discussed in Section 3.1, measures are noted as “T” for direct points from table, “A” for may require adjustment, and “C” for separate calculation. The user may wish to review example packages for their building type in Section 5.0.

Table 3. Blank Energy Credit Form for Package Evaluation

Project:		Points Determined	Table Points from 90.1	Alternative Packages for Project					
Climate Zone	Pack A			Pack B		Pack C			
Required Energy Credits				Notes & Adj	Credits	Notes & Adj	Credits	Notes & Adj	Credits
E01	Improved Envelope	C							
H01	HVAC Performance	C							
H02	Heating Efficiency	A							
H03	Cooling efficiency	A							
H04	Res. HVAC ctrl	T							
H05	Ground source HP	A							
H06	DOAS/fan control.	A							
H07	Guide 36 Sequence	T							
W01	SHW preheat recovery	T							
W02	Heat pump SW heater	A							
W03	Efficient gas SW heater	A							
W04	SHW pipe insulation	A							
W05	Point of use SW heaters	T							
W06	Thermo bal valves	T							
W07	SHW Submeters	T							
W08	SHW distribution sizing	T							
W09	SHW shower drain HR	A							
P01	Energy monitoring	T							
L02	Lighting dim & tuning	A							
L03	Add occup..sensors	T							
L04	Increase daylight area	A							
L05	Residential light control	A							
L06	Light power reduction	A							
R01	Renewable energy	A							
Q01	Efficient Elevator	A							
Q02	Eff kitchen Equip	T							
Q03	Fault detection	T							
G01	Lighting load mgmt.	A							
G02	HVAC load mgmt.	T							
G03	Shading load mgmt.	T							
G04	Electric storage	A							
G05	Cooling storage	A							
G06	SHW storage	T							
G07	Bldg mass / night flush	T							
A: Raw Sum of all Credits Achieved				Pack A		Pack B		Pack C	
B: Renewable (R) + Load Management (G)									
C: R + LM limit: 60% x Required									
Total Credits Achieved (A – B) + { lessor of B , C }									

4.4 Example Package Evaluation

To demonstrate how the previous worksheet can be used, an example is completed for hotels in climate zone 4C. This selection is made because this combination has a higher required-to-available point ratio in Table 10 for the moderate climate. Measures not allowed in hotels in any climate zone are not shown in Table 4. In this example, the three selected credit packages shown in Table 4 all meet the 50-credit requirement and can be used as a starting point for developing the final credit requirements of the project. Example packages by building type are shown in Section 5.0 of this report. For each building type, packages have been developed for three different climate categories and seven different efficiency goals.

Table 4. Example Hotel Evaluation of Three Alternate Packages

Project: Hotel Example		Points Determined	Table Points from 90.1	Alternative Packages for Project					
4C	Climate Zone			Pack A - SHW		Pack B – Control/Des		Pack C: Mix	
Required Energy Credits			50	Notes & Adj	Credits	Notes & Adj	Credits	Notes & Adj	Credits
E01	Improved Envelope	C	Apx C						
H01	HVAC Performance	C	future						
H02	Heating Efficiency	A	x						
H03	Cooling efficiency	A	3					15%/5%	9
H05	Ground source HP	A	4						
H07	Guide 36 Sequence	T	2			In DDC	2		
W01	SHW preheat recovery	T	8						
W02	Heat pump SW heater	A	13	30% load	13				
W03	Efficient gas SW heater	A	10	70% load, 0.6	6				
W04	SHW pipe insulation	A	2						
W06	Thermostatic balancing valves	T	1	Yes	1				
W08	SHW distribution sizing	T	9			Low Flow	9		
W09	SHW shower drain HR	A	7						
P01	Energy monitoring	T	2						
L02	Lighting dim & tuning	A	2			Common	2		
L03	Add occupancy.sensors	T	5			Auto off	5		
L06	Light power reduction	A	3					10%	6
R01	Renewable energy	A	10					0.3 W/sf PV	30
Q01	Efficient Elevator	A	4					all class A	4
Q03	Fault detection	T	2			In DDC	2	In DDC	2
G03	Shading load mgmt.	T	1						
G04	Electric storage	A	11						
G05	Cooling storage	A	12						
G06	SHW storage	T	31	Yes	31	Yes	31		
A:	Raw Sum of all Credits Achieved			Pack A	51	Pack B	51	Pack C	51
B:	Renewable (R) + Load Management (G)				31		31		30
C:	R + LM limit: 60% x Required				30		30		30
Total Credits Achieved (A – B) + {lessor of B, C}					50		50		51

4.4.1 COMcheck Integration

When DOE's COMcheck compliance software is updated to include 90.1-2022, energy credit calculations will be available in the application. Notably, the envelope calculations based on Appendix C will be fully integrated. To review several approaches to energy credits in a project, it may be best to save multiple copies of the COMcheck file with different energy credits selected and compare the results. One advantage of using COMcheck is that several credits that are variable in nature (such as cooling efficiency and lighting power reduction) will be automatically calculated in COMcheck.

4.4.2 Mixed Use Buildings Approach

Under Standard 90.1 Section 11.5.1(a), a building may be required to account for multiple building use types when documenting energy credit selections where the secondary use type accounts for more than 10% of the gross floor area.

Note that where office areas of 2000 ft² or more are associated with a larger building of a different type, such as a data center, warehouse, or hospital, the office area should be separated for energy credit treatment into the office building category, even if the special use was less than 10% of the total project building area.

To help illustrate how to properly account for buildings with multiple use types two examples are included. Both examples include a hotel area, a restaurant area with dining and kitchen, and a retail area adjacent to the hotel lobby. The examples show how different approaches to meeting credit requirements can be developed. Note that if these areas are less than 10% of the total building floor area, they can be combined into the main use; however, some measures can only be achieved if the unique building type is separated out, such as efficient kitchen equipment in a restaurant. In Example A, shown in Table 5, the following measures are included:

- Both the restaurant and hotel are served by a common service hot water (SHW) system, with 30% of load met with heat pump water heaters and the remainder met with condensing gas water heaters or boilers. The retail area has separate electric water heaters.
- All water heaters are heat pump or electric and have a storage- or temperature-based SHW load management system.
- The main hotel area has low flow water fixtures and piping using a reduced sizing design method.
- Guideline 36 control sequences are incorporated into the building control specifications for all three use areas.
- The retail area has tenant spaces that are exempt from specific monitoring in Section 10.4.7. They incorporate tenant metering in accordance with measure P01.

For Example A, the selected measures for the retail and restaurant areas would not meet the energy credit requirements if they were separate buildings; however, the building as a whole does meet the requirement since excess points achieved by the hotel can be applied pro rata to the retail and restaurant areas. The building as a whole meets the energy credit requirement when the results for each area are averaged on a weighted basis.

Table 5. Example A Multiple Building Use Types for Climate Zone 4C

Project: Mixed Use Building		Points Determined	Table Points Htl/Rst/Rtl	Packages for Each Building Use Type in Project					
4C	Climate Zone			Hotel		Restaurant		Retail	
Required Energy Credits			50/50/50	Notes & Adj	Credits	Notes & Adj	Credits	Notes & Adj	Credits
E01	Improved Envelope	C	Apx C						
H01	HVAC Performance	C	future						
H02	Heating Efficiency	A	x / 4 / 5						
H03	Cooling efficiency	A	3 / 1 / 2						
H05	Ground source HP	A	4 / 11 / 16						
H06	DOAS/fan control.	A	x / x / 15						
H07	Guide 36 Sequence	T	2 / 1 / 2	DDC Specs	2	DDC Specs	1	DDC Specs	2
W01	SHW preheat recovery	T	8 / 12 / 8						
W02	Heat pump SW heater	A	13 / 9 / 3	30% load	13	30% load	9		
W03	Efficient gas SW heater	A	10 / 14 / 4	70% load, x 0.6	6	70% load, x 0.6	8		
W04	SHW pipe insulation	A	2 / x / x						
W06	Thermostatic balancing valves	T	1 / 1 / 1						
W07	SHW Submeters	T	x / 1 / x						
W08	SHW distribution sizing	T	9 / x / x	Low Flow	9				
W09	SHW shower drain HR	A	7 / x / x						
P01	Energy monitoring	T	2 / 1 / 6					Tenant Mtr	6
L02	Lighting dim & tuning	A	2 / 3 / 5						
L03	Add occupancy sensors	T	5 / 2 / 5						
L04	Increase daylight area	A	x / x / 9						
L06	Light power reduction	A	3 / 3 / 9						
R01	Renewable energy	A	10 / 2 / 13						
Q01	Efficient Elevator	A	4 / 1 / 5						
Q02	Eff kitchen Equip	T	x / 30 / x						
Q03	Fault detection	T	2 / 1 / 2						
G01	Lighting load mgmt.	A	x / x / 12						
G02	HVAC load mgmt.	T	x / x / 3						
G03	Shading load mgmt.	T	1 / 1 / 2						
G04	Electric storage	A	11 / 3 / 9						
G05	Cooling storage	A	12 / 1 / 9						
G06	SHW storage	T	31 / 19 / 5	SHW DR	31	SHW DR	19	SHW DR	5
G07	Bldg mass / night flush	T	x / 7 / 23						
Total Renewable and Load Management Credits				Hotel	31	Restaurant	19	Retail	5
Total Efficiency Credits					30		18		8
Floor Area			36,700		28,000		3,700		5,000
Use Type Weighting			100.0%		76.3%		10.1%		13.6%
Partial Renewable and LM Credits			26.2		23.7		1.9		0.7
Partial Efficiency Credits			25.8		22.9		1.8		1.1
Limited Renewable and LM Credits			26.2	60%	max is	30.0	Does project meet requirement?		
Total Energy Credits Achieved			52.0	versus	50.0	credit requirement.	TRUE		

Example B takes a different approach, as shown in Table 6. Note that measures not used in either example are removed from this table. By dropping the Guideline 36 sequences and the low flow hot water fixtures and reduced pipe sizing, the hotel area would fall just short of the requirements if evaluated on its own, as the load management credits are limited to 30, resulting in total achieved credits of 49 vs. the requirement of 50. This is made up by adding the following measures in the restaurant and retail areas:

- High-efficiency kitchen equipment is installed in the restaurant.
- The lighting power density (LPD) is reduced 5% in the restaurant and 10% in the retail area.
- The retail area is served by small, packaged HVAC units that do not require multi-speed fans under Section 6. These are set up with on/off control when temperature conditioning is not needed combined with a dedicated outdoor air system (DOAS) unit for ventilation.

Table 6. Example B Multiple Building Use Types for Climate Zone 4C

Project: Mixed Use Building		Points Determined	Table Points Htl/Rst/Rtl	Packages for Each Building Use Type in Project					
				Hotel		Restaurant		Retail	
4C	Climate Zone			Notes & Adj	Credits	Notes & Adj	Credits	Notes & Adj	Credits
Required Energy Credits			50/50/50						
H06	DOAS/fan control.	A	x / x / 15					100% rtl area	15
H07	Guide 36 Sequence	T	2 / 1 / 2						
W02	Heat pump SW heater	A	13 / 9 / 3	30% load	13	30% load	9		
W03	Efficient gas SW heater	A	10 / 14 / 4	70% load, x 0.6	6	70% load, x 0.6	8		
W08	SHW distribution sizing	T	9 / x / x						
P01	Energy monitoring	T	2 / 1 / 6					Tenant Mtr	6
L06	Light power reduction	A	3 / 3 / 9			5% red LPD	3	10% red LPD	18
Q02	Efficient kitchen Equipment	T	x / 30 / x			Eff Fryer	30		
G06	SHW storage	T	31 / 19 / 5	SHW DR	31	SHW DR	19	SHW DR	5
Total Renewable and Load Management Credits				Hotel	31	Restaurant	19	Retail	5
Total Efficiency Credits					19		50		39
Floor Area			36,700		28,000		3,700		5,000
Use Type Weighting			100.0%		76.3%		10.1%		13.6%
Partial Renewable and LM Credits			26.2		23.7		1.9		0.7
Partial Efficiency Credits			24.9		14.5		5.0		5.3
Limited Renewable and LM Credits			26.2	60% max is	30.0	Does project meet requirement?			
Total Energy Credits Achieved			51.1	versus	50.0	credit requirement.			TRUE

To find the credits for a building with multiple spaces requires the following steps as shown at the bottom of each table:

- Determine the credits for each use type separately as if it were a separate building. Keep the totals separate for efficiency and renewable/load management.
- Based on the floor area of each use type, find the percentage of floor area for each use area related to floor area of the building as a whole.

- Multiply each of the use type credits by the floor area percentage to find a partial energy credit.
- Add the partial energy credits to find the total energy credits achieved by the building as a whole.
- If the energy credits required by Section 11.5.1 differ by use type, apply the same area weighting to find the total building credits required.

While Section 11.5.1(a) of Standard 90.1 calls for using the weighted approach in mixed use buildings, it is obvious that if each use type area fully meets the energy credit requirements independently, then the required weighted approach can be presumed to be met.

5.0 Example Energy Credit Measure Packages

To meet the energy credit prescriptive requirements, buildings must include a selection of energy credit measures from Standard 90.1 Section 11 that achieve the total credits required for the building type and climate zone. To illustrate the flexibility allowed by this system, this section provides multiple examples of measure packages that meet the requirements, based on the average of available credits for each building type.

A primary objective of this document is to provide examples of different packages of measures that will meet the energy credit requirement in Section 11 of Standard 90.1. These are organized by building type, and tables with several example packages are presented for each of three climate zone groups: hot (0 to 2), moderate (3 to 5), and cold (6 to 8). This results in 27 example packages per building type or 270 total. Presenting examples for each individual climate zone would have produced an overwhelming amount of data, with 1710 total package examples. The cost effectiveness of these example packages other than the demonstration package have not been analyzed. The cost-effective demonstration package is discussed in Section 5.2.1 of this document.

5.1 Available Credits by Building Type for Discrete Climate Zones

For each building type, a table is provided showing the *nominal* credits available by measure for each climate zone. The availability does not always match the credits listed in the Standard 90.1 Section 11.5.3 tables, since some measures can be adjusted for higher levels of implementation. Following are some examples of implementation levels assumed for specific measures in determining the nominal available credits:

- For Measures H02 and H03 the 90.1 Section 11.5.3 table, credit values are based on a 5% increase in heating or cooling efficiency. Credits can be prorated for higher efficiencies, up to 20%. For the example packages in this section, it is estimated that a 15% efficiency improvement is reasonably achievable for both heating and cooling, resulting in nominal available credits that are three times the credits shown in the 90.1 tables.
- Measure H05 credits in the Standard 90.1 tables are based on 25% of building area being served by a ground source heat pump (GSHP). The nominal available credits are based on the full building area served by a GSHP system, or four times the credits.
- Measure W02 for heat pump water heaters has credits based on a minimum of 30% load met by the heat pump water heaters. The nominal available credits assume full load met or double the table credits, according to the 90.1 rules for scaling the credits for heat pump water heaters.
- Measure L05 credits in the Standard 90.1 tables are based on a 5% LPD reduction, and the nominal available credits are based on the maximum 10% LPD credit option.
- The Standard 90.1 tabulated credits for renewable energy (R01) are based on 0.1 W/ft² of photovoltaics (PV) installed. The nominal available credits are based on 0.5 W/ft².
- The Standard 90.1 tabulated credits for electric storage (G04) are based on 1 Wh/ft² of battery installed. The nominal available credits are based on 2 Wh/ft².
- The Standard 90.1 tabulated credits for cooling energy storage credits (G05) are based on 1 ton-hr/ton of design cooling capacity. The nominal available credits are based on 4 ton-hr/ton.

The table includes a row near the bottom that gives the total available credits. Where subsets of measures are mutually exclusive, total available credits are calculated from the largest value from that subset. This is done for measure sets {W01, W02, W03} and {W05, W06}. The sum of load management and renewable credits is also limited to 60% of the credit requirement as required in Standard 90.1. Also shown is the requirement as a percentage of the available credits.

5.2 Example Credit Package Categories Considered

Several example packages have been developed for each combination of building type and climate zone group. The goal is to demonstrate a range of combinations that can reasonably meet the credit requirements. Descriptions of the example packages are provided below.

5.2.1 Cost-Effective Base Demonstration Package

In a previous analysis by Hart et al. (2022), cost-effective packages of energy credit measures were established for each building type and climate zone. The objective of that analysis was to help guide the determination of energy credit point requirements. Those packages are the basis for the Cost-Effective Base Demonstration Package in the current report. In some cases, there are slight differences due to the grouping of multiple climate zone selections into the hot, moderate, and cold climate groups.

Table 7 provides an overview of measures selected for inclusion in the Cost-Effective Base Demonstration Package. Measures are selected with the goal of 5% savings or 50 credits for this package. Measure selection may be climate zone specific. For example, improved cooling efficiency is only selected in warm climate zones.

5.2.2 Minimum Equipment Efficiency Demonstration Package

The 5.2.2 Minimum Equipment Efficiency Demonstration Package was developed to show a reasonable achievement of the required energy credits without using efficiency improvements for HVAC and service water heating (SWH) equipment subject to The Energy Policy Act (42 USC 6833) minimum federal efficiencies. This package was selected by replacing HVAC and SWH equipment credit selections in the Cost-Effective Base Demonstration Package with energy credit measures that achieve similar savings. Reasonable measures were selected with the same goal of 5% savings, or 50 credits; however, HVAC and service water heating efficiency measures (H02, H03, W02, W03) are not included. Table 8 provides an overview of energy efficiency measures selected for inclusion in this package.

Table 7. Matrix of Cost-Effective Demonstration Package Efficiency Measures^a

ID	Energy Credit Abbreviated Title	Measure Life, yr	Multifamily	Healthcare	Hotel/Motel	Office	Restaurant	Retail	Education	Warehouse
E01	Glazing U & SHGC reduction	40	all CZ	all CZ	all CZ	all CZ	all CZ	CZ 0,3A,3C-4C	all CZ	
H02	Heating efficiency	18	15%, CZ 5A-8	15%, CZ 5A-8	10%, CZ 5B,6-8			10%, CZ 4-8		5%, CZ 5A-8
H03	Cooling efficiency.	15	10%, CZ 0-2A	15%, CZ 0-3B	10%, CZ 0-2	10% CZ 0-1	5%, CZ 0-3B	5%, CZ 0-2	10% CZ 0-2	5% CZ 0-1
H04	Residential HVAC control.	15	all CZ							
W02	Heat pump water heater	13		all CZ (30%)	all CZ (30%)					
W03	Efficient gas water heater	13		all CZ (70%)	all CZ (70%)		all CZ			
W05	Point of use water heaters	15				CZ 0B-5A			CZ 0-4	
L03	Increase occupancy sensor	15		CZ 0-6A	all CZ	all CZ		CZ 0B, 5B, 5C	all CZ	
L04	Increase daylighting area	15						CZ 0-5		CZ 0-5A 10%; 5B-8 5%
L05	Residential Light Control	15	all CZ							
L06	Light power reduction	20	all CZ, 5%	all CZ, 5%	all CZ, 10%	all CZ, 5%	all CZ, 10%	all CZ, 5%	all CZ, 5%	all CZ, 5%
R01	On-site renewable (0.1 W/ft ²)	25	all CZ	all CZ	all CZ	all CZ	all CZ	all CZ	all CZ	all CZ
Q02	Efficient kitchen equipment ^b	15					all CZ			
Q03	Fault detection	15		all CZ				all CZ		
G02	HVAC Load Management	15				all CZ				

^a Percentage values in the table indicate savings applied for the measure in the packages.

^b Dining areas and kitchens in dormitories, hotels, and schools treated as a separate area where efficient kitchen equipment credits apply.

Table 8. Matrix of Minimum Equipment Efficiency Demonstration Package Efficiency Measures^a

ID	Energy Credit Abbreviated Title	Measure Life, yr	Multifamily	Healthcare	Hotel/Motel	Office	Restaurant	Retail	Education	Warehouse
E01	Glazing U & SHGC Reduction		all CZ	all CZ	all CZ	all CZ	all CZ	CZ 0, 3A, 3C-4C, 5A-8	all CZ	
H04	Residential HVAC control.		all CZ							
H06	DOAS + fan control.			CZ 0-2, 25% area				CZ 4C-8, 80% area		
W01	Energy recovery preheat SHW			30% HR	30% HR					
W05	Point of use water heaters					CZ 0B-5A			CZ 0-4	
W08	SWH distribution sizing		all CZ		all CZ					
W09	SHW shower drain heat recovery				CZ 0, 4C, 5C, 7-8					
L03	Increase occupancy sensor				All CZ	CZ 0	CZ 3B, 4C-5C	CZ 0B, 4C, 5B, 5C, 7-8	all CZ	+ all CZ
L04	Increase daylight area						CZ 3B, 4C-5C	CZ 1-5C, +8	+CZ 0-1	CZ 4C,5A, 5C,6A,7,8
L05	Res. Light Control (Ex. # b)		all CZ							
L06	Light power reduction 5%-> 10%		all CZ	most CZ	all CZ,	CZ 0-2A	all CZ	all CZ	CZ 0, 4C, 5C	all CZ
R01	Renewable energy (ex. CZ 4C/5C)		CZ 0-3, 0.1 W/sf	0.2 W/sf All CZ	0.2 W/sf +CZ 0B-3B	all CZ	0.2 W/sf +CZ 0-4B	0.2 W/sf +CZ 8	all CZ	all CZ
Q01	Efficient Elevators		CZ 0A, 6A		CZ 0B-2A, 3C-8					
Q02	Efficient Kitchen Equipment ^b						all CZ			
Q03	Fault detection			all CZ	CZ 0-1			CZ 5C	CZ 0-2A	
G02	HVAC Load Management								CZ 0-3A	
G05	Cooling Storage			CZ 0A/B	CZ 0A	CZ 0A				
G06	SHW Storage						CZ 0-3A, 4C, 5A, 6-8			

^a Percentage values in the table indicate savings applied for the measure in the package. A "+" indicates climate zones in addition to those in the cost-effective package.

^b Dining areas and kitchens in dormitories, hotels, and schools are treated as separate building use type areas where efficient kitchen equipment credits apply.

5.2.3 Prototype Measure Packages

A separate package of measures was developed for each of the prototype models that will be used to capture the impact of the energy credits as part of PNNL's analysis of the savings of Standard 90.1-2022 compared to 90.1-2019. This package of energy credits is based on the cost-effective demonstration package but has several changes that were made to facilitate accurate modeling. The exact measures included in the prototype simulations will be documented in a future 90.1-2022 energy savings analysis technical report.

5.2.4 Alternative Measure Packages

Up to seven additional packages are included for each building type to demonstrate possible ways to meet the prescriptive energy credit requirements. Brief descriptions of these alternative packages are given in Table 9. In general, each package has a focus on the measures related to the theme, but there may be additional unrelated measures needed to meet the total energy credit requirements. Note that not all the alternative packages were applied to every building type.

Table 9. Alternative Measure Packages

Alternative	Focus
Alt. 1. PV	Maximizing renewable PV installation
Alt. 2. SHW	Maximizing service hot water efficiency
Alt. 3. Light	Lighting reductions (warehouse buildings only)
Alt. 3. GSHP	Ground source heat pump implementation (all other building types)
Alt. 4. Ctrl.	Maximizing control improvements
Alt. 5. HVAC	Maximizing HVAC efficiency improvements
Alt. 6. Cl. Stg.	Cooling storage system with improved cooling efficiency (only used for hot and moderate climates)
Alt. 7. Heat	Reduced heating loads with improved heating efficiency (only used for cold climates)

5.2.5 Credit Impact of Discrete Climate Zones

The packages in this report represent averages of multiple climate zones, and the selections were sometimes made such that the total points narrowly meet the requirement. Thus, any climate that has fewer points than the average of its group might fall short of its requirement. If a building in a particular climate zone needs additional points, many of the smaller point measures can be included like Guideline 36 sequences (H07), fault detection (Q03), or other appropriate measures for that particular building.

Table 10 gives some perspective on this variation in climate zone requirements by summarizing the available credits required as a percentage of available credits for each building type in each climate zone. Results are shaded in a heat map format with red cells indicating more measures needed to meet program requirements and green cells indicating fewer measures needed. Each building type row is taken from the last row of the first table in each building type section that follows. The most challenging requirement is in Climate zone 3C for restaurants that must achieve 38% of available credits, while multifamily in Climate Zones 6B and 7 have the easiest requirement with only 17% of available credits required. On average, 25% of available credits are required.

Table 10. Discrete Climate Zone Required Credits vs. Available Credits

Building Use Type	Climate Zone																		Bldg Avg All CZ	
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7		8
Multifamily	22%	23%	24%	23%	24%	24%	21%	23%	23%	18%	21%	19%	18%	19%	20%	16%	17%	17%	16%	20%
Healthcare	30%	25%	34%	25%	25%	28%	29%	29%	26%	26%	27%	27%	29%	29%	25%	27%	27%	26%	27%	27%
Hotel/Motel	25%	27%	30%	28%	31%	33%	32%	32%	30%	32%	35%	37%	30%	31%	34%	27%	29%	26%	26%	30%
Office	24%	24%	26%	24%	26%	27%	26%	27%	28%	24%	26%	26%	22%	25%	26%	20%	22%	21%	21%	25%
Restaurant	26%	28%	30%	28%	30%	33%	29%	30%	38%	25%	28%	29%	25%	25%	26%	22%	23%	20%	20%	27%
Retail	18%	19%	21%	20%	23%	24%	24%	25%	31%	22%	25%	25%	22%	23%	23%	21%	21%	21%	24%	23%
Education	20%	20%	22%	20%	22%	23%	23%	22%	23%	23%	21%	22%	23%	20%	24%	21%	22%	21%	20%	22%
Warehouse	26%	26%	25%	26%	25%	26%	26%	25%	25%	25%	25%	25%	24%	24%	25%	24%	24%	24%	25%	25%
Average by CZ	24%	24%	26%	24%	26%	27%	26%	27%	28%	25%	26%	26%	24%	24%	25%	22%	23%	22%	22%	25%

5.3 Multifamily Building Applicability

Several alternative packages are reviewed for multifamily buildings that include apartments, dormitories, retirement living, and institutional residences. The general package types, tables, and assumed measures are described in Section 5.2, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 11 shows the credits available for applicable measures in multifamily buildings, with higher scoring measures shaded a darker green.¹ Measures are described in detail in Section 6.0.

Table 11. Energy Credits Required and Available for Multifamily

ID	Energy Credit Abbreviated Title	Climate Zone																		
		0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	Building Requirement	50	50	50	50	50	50	46	50	50	48	50	46	50	50	49	50	50	50	50
E01	Improved Envelope	7	6	8	8	9	10	12	12	7	16	16	14	17	18	15	19	19	21	22
H02	Heating Efficiency	x	x	x	x	x	x	3	x	x	12	x	6	15	6	3	18	12	18	27
H03	Cooling efficiency	57	51	42	42	33	27	18	21	9	12	15	6	9	12	6	9	9	6	6
H04	Res. HVAC ctrl	10	11	8	12	10	12	8	9	12	9	11	7	9	11	7	10	10	8	8
H05	Ground source HP	36	32	20	28	16	16	20	16	8	40	20	24	52	36	16	72	52	64	64
H07	Guide 36 Sequence	3	3	3	3	2	2	2	2	1	2	2	1	2	2	1	2	2	2	2
W01	SHW preheat recovery	10	11	13	13	15	16	19	18	23	21	21	24	22	22	25	21	23	23	23
W02	Heat pump SW heater	32	34	40	40	48	50	60	58	72	66	66	78	72	72	82	70	74	74	76
W03	Efficient gas SW heater	12	13	16	15	18	19	23	22	27	25	25	29	26	27	30	26	27	27	27
W04	SHW pipe insulation	2	2	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3
W06	Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W07	SHW submeters	3	4	4	4	5	5	7	6	8	7	7	8	8	8	9	8	8	8	8
W08	SHW distribution sizing	10	11	13	13	16	16	20	19	24	22	22	25	23	23	27	23	24	24	24
W09	SHW shower drain HR	9	9	11	11	13	14	17	16	20	19	19	22	20	23	20	23	21	21	21
P01	Energy monitoring	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
L02	Lighting dim & tuning	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
L05	Residential light control	9	9	10	9	10	10	9	10	11	9	9	10	7	9	10	7	8	8	6
L06	Light power reduction	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2
R01	Renewable energy	60	65	75	70	75	90	80	95	105	65	95	70	55	85	65	60	70	55	45
Q01	Efficient Elevator	4	4	5	5	5	5	5	5	6	5	5	6	5	5	6	5	5	5	5
Q03	Fault detection	3	3	3	3	2	2	2	2	1	2	2	1	2	2	1	2	2	2	2
G03	Shading load mgmt.	11	x	7	18	10	13	4	13	12	x	13	6	8	11	11	x	6	5	14
G04	Electric storage	14	16	18	16	20	18	20	22	28	26	20	26	22	20	26	22	20	22	24
G05	Cooling storage	88	20	108	48	76	72	76	132	40	44	80	36	28	56	32	24	60	4	12
G06	SHW storage	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Multifamily Available Credits		224	218	209	220	210	210	222	217	222	261	235	247	282	265	246	306	287	300	310
% required of available		22%	23%	24%	23%	24%	24%	21%	23%	23%	18%	21%	19%	18%	19%	20%	16%	17%	17%	16%

¹ The credits shown in the table are not limited to the maximum required credits by building type and climate zone so that the table can accommodate stretch codes or future changes in requirements where larger available credits may be desired. The available credits shown here include a reasonable selection within the allowable range as discussed in Section 5.1.

5.3.1 Multifamily Hot Climate Zone Credit Package Examples

Table 12 shows credits achieved for multiple options in a typical hot climate zone for multifamily buildings. The values shown represent the average credits for climate zones 0 through 2. Individual climate zones may require different packages as described in Section 5.2.5. Background information on example packages is found in Section 5.2. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, residential HVAC control, residential light control without stairwell occupancy controls, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, residential HVAC control, SHW piping resizing and flow reduction, residential light control without stairwell occupancy controls, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes a 5% cooling efficiency increase, SHW piping resizing and flow reduction, residential light control, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.2 W/ft² of PV renewables with residential HVAC control, residential light control, and a 5% LPD reduction in common areas.
- Alternative 2, focused on maximizing SHW efficiency, includes heat pump water heaters sized for the full load and SHW piping resizing and flow reduction.
- Alternative 3, focused on a GSHP implementation, includes 100% of building conditioning with GSHP, an integrated heat pump water heater sized for 30% the load, and SHW storage demand management.
- Alternative 4, focused on maximizing control improvements, includes residential HVAC control, Guideline 36 control sequences, SHW submeters, residential light control, efficient elevators, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% cooling efficiency increase and residential HVAC control.
- Alternative 6, focused on a cooling storage system, includes a 5% cooling efficiency increase, efficient elevators, HVAC fault detection controls, and a central cooling storage system sized at 2.2 ton-hours storage per ton cooling design load.

Table 12. Energy Credit Packages for Multifamily Buildings in Hot Climate Zones

Multifamily Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	8	8	8							
H02	Heating Efficiency	x									
H03	Cooling efficiency	42	28		14					42	14
H04	Res. HVAC ctrl	10	10	10		10			10	10	
H05	Ground source HP	24						24			
H07	Guide 36 Sequence	2							2		
W01	SHW preheat recovery	13									
W02	Heat pump SW heater	40					40	20			
W03	Efficient gas SW heater	15									
W04	SHW pipe insulation	2									
W06	Thermo bal valves	1									
W07	SHW submeters	4							4		
W08	SHW distribution sizing	13		13	13		13				
W09	SHW shower drain HR	11									
P01	Energy monitoring	2									
L02	Lighting dim & tuning	1									
L05	Residential light control	9	8	8	9	9			9		
L06	Light power reduction	4	2	2	2	2					
R01	Renewable energy	72	14	14	15	30					
Q01	Efficient Elevator	4							4		4
Q03	Fault detection	2									2
G03	Shading load mgmt.	11									
G04	Electric storage	17									
G05	Cooling storage	68									34
G06	SHW storage	21						7	21		
Renewable + Load Mgmt (limited 60%)			14	14	15	30	0	7	21	0	30
Total Credits Achieved*			71	56	53	51	53	51	50	52	50
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.3.2 Multifamily Moderate Climate Zone Credit Package Examples

Table 13 shows credits achieved for multiple options in a typical moderate climate zone for multifamily buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, residential HVAC control, residential light control without stairwell occupancy controls, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, residential HVAC control, SHW piping resizing and flow reduction, residential light control without stairwell occupancy controls, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes a 5% heating efficiency increase, a 5% cooling efficiency increase, SHW piping resizing and flow reduction, residential light control, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.

- Alternative 1, focused on maximizing renewable PV installation, includes 0.2 W/ft² of PV renewables with residential HVAC control, residential light control, and a 5% LPD reduction in common areas.
- Alternative 2, focused on maximizing SHW efficiency, includes heat pump water heaters sized for 30% of the full load and SHW piping resizing and flow reduction.
- Alternative 3, focused on a GSHP implementation, includes 100% of building conditioning with GSHP and integrated heat pump water heaters sized for 30% of the full load.
- Alternative 4, focused on maximizing control improvements, includes residential HVAC control, Guideline 36 control sequences, SHW submeters, residential light control, efficient elevators, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating and cooling efficiency increase, residential HVAC control, and 0.15 W/ft² of PV renewables.
- Alternative 6, focused on a cooling storage system, includes a central cooling storage system sized at 2.2 ton-hours storage per ton cooling design load and an integrated SHW preheating heat recovery system.
- Alternative 7, focused on reducing heating; heating efficiency is improved with condensing gas technology and envelope improved both in insulation, low U fenestration, and low air leakage. Only applied to cold climates.

Table 13. Energy Credit Packages for Multifamily Buildings in Moderate Climate Zones

Multifamily Buildings		Mod CZ	Alternative Packages for Moderate Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Averages by general climate 3-5		Avg Avail									
Climate Zone											
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	14	14	14							
H02	Heating Efficiency	7			1					7	
H03	Cooling efficiency	12	8		1					12	
H04	Res. HVAC ctrl	9	9	9		9			9	9	
H05	Ground source HP	25						25			
H07	Guide 36 Sequence	1							1		
W01	SHW preheat recovery	21									21
W02	Heat pump SW heater	69					35	35			
W03	Efficient gas SW heater	26									
W04	SHW pipe insulation	3									
W06	Thermo bal valves	1									
W07	SHW submeters	7							7		
W08	SHW distribution sizing	22		22	22		22				
L05	Residential light control	9	8	8	9	9			9		
L06	Light power reduction	4	2	2	2	2					
R01	Renewable energy	79	16	16	16	32				24	
Q01	Efficient Elevator	5							5		
Q03	Fault detection	1									
G03	Shading load mgmt.	9									
G04	Electric storage	23									
G05	Cooling storage	58									32
G06	SHW storage	21							21		
Renewable + Load Mgmt (limited 60%)			16	16	16	30	0	0	21	24	30
Total Credits Achieved*			57	71	51	50	57	60	52	52	51
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.3.3 Multifamily Cold Climate Zone Credit Package Examples

Table 14 shows credits achieved for multiple options in a typical cold climate zone for multifamily buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes improved fenestration, a 15% heating efficiency increase, residential HVAC control, residential light control without stairwell occupancy controls, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, SHW piping resizing and flow reduction, residential light control without stairwell occupancy controls, and a 5% LPD reduction in common areas.
- The package of measures used in the prototype models includes a 5% heating efficiency increase, SHW piping resizing and flow reduction, residential light control, a 5% LPD reduction in common areas, and 0.1 W/ft² of PV renewables.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.25 W/ft² of PV renewables with residential HVAC control, Guideline 36 HVAC sequences, residential light control, a 5% LPD reduction in common areas, and fault detection controls.
- Alternative 2, focused on maximizing SHW efficiency, includes heat pump water heaters sized for 30% of load and SHW piping resizing and flow reduction.
- Alternative 3, focused on a GSHP implementation, includes 100% of building conditioning with GSHP.
- Alternative 4, focused on maximizing control improvements, includes residential HVAC control, Guideline 36 control sequences, SHW submeters, residential light control, efficient elevators, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating and cooling efficiency increase, residential HVAC control and 0.15 W/ft² of PV renewables.
- Alternative 7, focused on reduced heating, includes 15% UA reduction, lowered air leakage, a 15% heating efficiency increase, and residential HVAC control.

Table 14. Energy Credit Packages for Multifamily Buildings in Cold Climate Zones

Multifamily Buildings Averages by general climate 6-8 Climate Zone		Cold CZ Avg Avail	Alternative Packages for Cold Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat
	Requirement	50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	20	20	20							24
H02	Heating Efficiency	18	18		6					18	18
H03	Cooling efficiency	7								7	
H04	Res. HVAC ctrl	9	9			9			9	9	9
H05	Ground source HP	63						63			
H07	Guide 36 Sequence	2				2			2		
W01	SHW preheat recovery	22									
W02	Heat pump SW heater	73					37				
W03	Efficient gas SW heater	26									
W04	SHW pipe insulation	3									
W06	Thermo bal valves	1									
W07	SHW submeters	8							8		
W08	SHW distribution sizing	23		23	23		23				
P01	Energy monitoring	2									
L02	Lighting dim & tuning	1									
L05	Residential light control	7	6	6	7	7			7		
L06	Light power reduction	3	2	2	2	2					
R01	Renewable energy	57	11		11	29				17	
Q01	Efficient Elevator	5							5		
Q03	Fault detection	2			2	2					
G03	Shading load mgmt.	8									
G04	Electric storage	22									
G05	Cooling storage	25									
G06	SHW storage	21							21		
Renewable + Load Mgmt (limited 60%)			11	0	12	29	0	0	21	17	0
Total Credits Achieved*			66	51	51	50	60	63	52	52	51
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.4 Healthcare Building Applicability

Several alternative packages are reviewed for healthcare buildings. The general package types, tables, and assumed measures are described in Section 4.4, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 15 shows the credits available for applicable measures in healthcare buildings, with higher scoring measures shaded a darker green. Measures are described in detail in Section 6.0.

Table 15. Energy Credits Required and Available for Healthcare

ID	Energy Credit Abbreviated Title	Climate Zone																		
		0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	Building Requirement	50	50	50	50	50	50	50	50	50	46	46	50	50	50	50	50	50	50	50
E01	Improved Envelope	9	8	12	11	15	13	20	18	27	26	24	33	24	24	43	23	27	28	28
H02	Heating Efficiency	3	3	3	3	6	6	6	6	6	9	6	9	12	9	12	18	15	21	27
H03	Cooling efficiency	54	48	45	45	42	30	27	24	24	21	18	15	15	15	9	15	12	12	6
H05	Ground source HP	12	56	x	56	56	44	36	40	48	44	40	44	44	40	60	56	56	64	60
H06	DOAS/fan control.	20	19	18	18	17	16	15	15	15	13	15	13	11	14	10	9	9	6	2
H07	Guide 36 Sequence	4	3	3	3	3	3	3	3	2	3	3	2	3	3	2	3	3	3	3
W01	SHW preheat recovery	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
W02	Heat pump SW heater	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
W03	Efficient gas SW heater	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W04	SHW pipe insulation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W06	Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P01	Energy monitoring	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
L02	Lighting dim & tuning	6	6	6	6	6	6	6	6	7	6	7	7	6	7	7	6	6	5	5
L03	Add occup.sensors	1	1	1	1	1	2	2	1	2	2	1	2	2	1	2	1	1	1	1
L06	Light power reduction	14	16	16	16	16	16	18	18	20	16	18	20	16	18	18	14	16	14	12
R01	Renewable energy	25	25	25	25	25	35	30	35	35	25	35	25	20	30	25	25	25	20	15
Q01	Efficient Elevator	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Q03	Fault detection	4	3	3	3	3	3	3	3	2	3	3	2	3	3	2	3	3	3	3
G03	Shading load mgmt.	1	1	1	1	x	x	x	1	x	x	2	x	x	2	x	x	1	1	x
G04	Electric storage	18	20	20	20	20	22	20	22	22	20	22	24	20	22	22	20	20	18	18
G05	Cooling storage	36	8	48	20	36	28	40	56	40	24	32	28	20	28	20	16	32	4	4
G06	SHW storage	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Healthcare Available	167	202	146	201	204	178	175	173	192	180	172	186	175	173	204	187	187	196	186
	% required of available	30%	25%	34%	25%	25%	28%	29%	29%	26%	26%	27%	27%	29%	29%	25%	27%	27%	26%	27%

5.4.1 Healthcare Hot Climate Zone Credit Package Examples

Table 16 shows credits achieved for multiple options in a typical hot climate zone for healthcare buildings. The values shown represent the average credits for climate zones 0 through 2. The following packages are included:

- The demonstration package includes improved fenestration, a 15% cooling efficiency increase, heat pump water heaters sized for 30% load, condensing gas water heaters sized for 70% load, additional occupancy sensors, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The minimum equipment efficiency package includes improved fenestration, DOAS with fan control for patient rooms, a 10% LPD reduction, 0.2 W/ft² of PV renewables (0.3 if needed in some climate zones), efficient elevators, fault detection, and cooling storage where needed.
- The package of measures used in the prototype models includes improved fenestration, a 10% cooling efficiency increase, condensing gas water heaters sized for full load, additional occupancy sensors, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.6 W/ft² of PV renewables with Guideline 36 sequences, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, service water heat recovery, heat pump water heaters sized for the full load, thermostatic balancing valves, SHW piping insulation, a 5% LPD reduction, 0.6 W/ft² of renewables including SHW solar heat, fault detection, and SHW storage.
- Alternative 3, focused on a GSHP implementation, includes Guideline 36 sequences, 100% of building conditioning with GSHP, an integrated heat pump water heater sized for 30% the load, and fault detection.

- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, a 5% LPD reduction, 0.5 W/ft² of renewables, efficient elevators, fault detection, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% cooling efficiency increase, DOAS with fan control for general patient rooms, Guideline 36 control sequences, and fault detection.
- Alternative 6, focused on a cooling storage system, includes a 7% cooling efficiency increase, HVAC fault detection controls, and a central cooling storage system sized at 4.0 ton-hours storage per ton cooling design load.

Table 16. Energy Credit Packages for Healthcare Buildings in Hot Climate Zones

Healthcare Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
	Requirement	47	47	47	47	47	47	47	47	47	47
E01	Improved Envelope	11	11	11	11						
H02	Heating Efficiency	4									
H03	Cooling efficiency	44	44		29					44	21
H05	Ground source HP	44						44			
H07	Guide 36 Sequence	3				3	3	3	3	3	
W01	SHW preheat recovery	1					1				
W02	Heat pump SW heater	2	1				2	1			
W03	Efficient gas SW heater	1	1		1						
W04	SHW pipe insulation	1					1				
W06	Thermo bal valves	1					1				
W09	SHW shower drain HR	x									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	6							6		
L03	Add occup.sensors	1	1		1				1		
L06	Light power reduction	15	8	15	8	15	8		8		
R01	Renewable energy	26	5	13	5	31	31		26		
Q01	Efficient Elevator	2		2			2		2		
Q03	Fault detection	3	3	3	3	3	3	3	3	3	3
G03	Shading load mgmt.	1									
G04	Electric storage	20									
G05	Cooling storage	29		7							29
G06	SHW storage	1					1		1		
Renewable + Load Mgmt (limited 60%)			5	20	5	28	28	0	27	0	28
Total Credits Achieved			74	52	58	50	49	51	50	50	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.4.2 Healthcare Moderate Climate Zone Credit Package Examples

Table 17 shows credits achieved for multiple options in a typical moderate climate zone for healthcare buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, a 10% heating efficiency increase, heat pump water heaters sized for 30% load, condensing gas water heaters sized for 70% load, additional occupancy sensors, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The minimum equipment efficiency package includes improved fenestration, SHW preheat recovery, a 10% LPD reduction, 0.2 W/ft² of PV renewables, and fault detection.
- The package of measures used in the prototype models includes improved fenestration, a 5% cooling efficiency increase, a 5% heating efficiency increase, condensing gas water

heaters sized for full load, additional occupancy sensors, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.

- Alternative 1, focused on maximizing renewable PV installation, includes 0.5 W/ft² of PV renewables with Guideline 36 sequences, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, service water heat recovery, heat pump water heaters sized for the full load, thermostatic balancing valves, SHW piping insulation, a 5% LPD reduction, 0.5 W/ft² of renewables including SHW solar heat, efficient elevator, fault detection, and SHW storage.
- Alternative 3, focused on a GSHP implementation, includes Guideline 36 sequences, 100% of building conditioning with GSHP, an integrated heat pump water heater sized for 30% the load, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, a 5% LPD reduction, 0.5 W/ft² of PV renewables, efficient elevators, fault detection, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, GSHP for 25% of the building, Guideline 36 control sequences, 0.2 W/ft² of PV renewables, and fault detection.
- Alternative 6, focused on a cooling storage system, includes a 15% cooling efficiency increase, SHW preheat, HVAC fault detection controls, and a central cooling storage system sized at 4.0 ton-hours storage per ton cooling design load.

Table 17. Energy Credit Packages for Healthcare Buildings in Moderate Climate Zones

Healthcare Buildings Averages by general climate 3-5 Climate Zone		Mod CZ Avg Avail	Alternative Packages for Moderate Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		49	49	49	49	49	49	49	49	49	49
E01	Improved Envelope	26	26	26	26						
H02	Heating Efficiency	8	5		3					8	
H03	Cooling efficiency	18	12		6					18	18
H05	Ground source HP	44						44		11	
H07	Guide 36 Sequence	2				2	2	2	2	2	
W01	SHW preheat recovery	2		2			2				2
W02	Heat pump SW heater	2	1				2	1			
W03	Efficient gas SW heater	1	1								
W04	SHW pipe insulation	1					1				
W06	Thermo bal valves	1					1				
W09	SHW shower drain HR	x									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	6							6		
L03	Add occup.sensors	1	1						1		
L06	Light power reduction	18	9	18	9	18	9		9		
R01	Renewable energy	28	6	11	6	28	28		28	11	
Q01	Efficient Elevator	2					2		2		
Q03	Fault detection	2	2	2	2	2	2	2	2	2	2
G03	Shading load mgmt.	1									
G04	Electric storage	21									
G05	Cooling storage	32									32
G06	SHW storage	1					1		1		
Renewable + Load Mgmt (limited 60%)			6	11	6	28	29	0	29	11	29
Total Credits Achieved			63	60	52	50	50	49	51	53	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.4.3 Healthcare Cold Climate Zone Credit Package Examples

Table 18 shows credits achieved for multiple options in a typical cold climate zone for healthcare buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes improved fenestration, a 15% heating efficiency increase, heat pump water heaters sized for 30% load, condensing gas water heaters sized for 70% load, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The minimum equipment efficiency package includes improved fenestration, SHW preheat recovery, a 10% LPD reduction, 0.2 W/ft² of PV renewables, and fault detection.
- The package of measures used in the prototype models includes improved fenestration, a 5% heating efficiency increase, 5% cooling efficiency increase, condensing gas water heaters sized for full load, lighting dimming and tuning controls, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.7 W/ft² of PV renewables with Guideline 36 sequences, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, service water heat recovery, heat pump water heaters sized for the full load, thermostatic balancing valves, SHW piping insulation, a 5% LPD reduction, 0.7 W/ft² of renewables including SHW solar heat, fault detection, and SHW storage.
- Alternative 3, focused on a GSHP implementation, includes Guideline 36 sequences, 75% of building conditioning with GSHP, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, a 5% LPD reduction, 0.7 W/ft² of PV renewables, efficient elevators, fault detection, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, GSHP and DOAS with fan control for general patient rooms, Guideline 36 control sequences, and fault detection.
- Alternative 7, focused on reduced heating, includes 15% UA reduction, lowered air leakage, a 15% heating efficiency increase, Guideline 36 control sequences, and fault detection.

Table 18. Energy Credit Packages for Healthcare Buildings in Cold Climate Zones

Healthcare Buildings Averages by general climate 6-8 Climate Zone		Cold CZ Avg Avail	Alternative Packages for Cold Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat
	Requirement	50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	26	26	26	26						24
H02	Heating Efficiency	20	20		7					20	20
H03	Cooling efficiency	11			1					11	
H05	Ground source HP	59						44		15	
H07	Guide 36 Sequence	3				3	3	3	3	3	3
W01	SHW preheat recovery	2		2			2				
W02	Heat pump SW heater	2	1				2				
W03	Efficient gas SW heater	1	1		1						
W04	SHW pipe insulation	1					1				
W06	Thermo bal valves	1					1				
P01	Energy monitoring	3									
L02	Lighting dim & tuning	5			5				5		
L03	Add occup.sensors	1							1		
L06	Light power reduction	14	7	14	7	14	7		7		
R01	Renewable energy	21	4	8	4	29	29		29		
Q01	Efficient Elevator	2					2		2		
Q03	Fault detection	3	3	3	3	3	3	3	3	3	3
G03	Shading load mgmt.	1									
G04	Electric storage	19									
G05	Cooling storage	14									
G06	SHW storage	1					1		1		
Renewable + Load Mgmt (limited 60%)			4	8	4	29	30	0	30	0	0
Total Credits Achieved*			62	54	54	50	51	51	51	52	50
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.5 Hotel/Motel Building Applicability

Several alternative packages are reviewed for hotel/motel buildings. The general package types, tables, and assumed measures are described in Section 4.4, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 19 shows the credits available for applicable measures in hotel/motel buildings, with higher scoring measures shaded a darker green. Measures are described in detail in Section 6.0.

Table 19. Energy Credits Required and Available for Hotel/Motel

ID	Energy Credit Abbreviated Title	Climate Zone																		
		0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	Building Requirement	50	50	50	50	50	50	46	47	50	48	50	50	47	46	47	49	46	50	50
E01	Improved Envelope	7	6	8	8	10	9	12	12	15	14	14	12	12	14	13	13	13	15	16
H02	Heating Efficiency	x	x	x	x	x	x	x	x	x	x	x	x	6	3	x	9	3	9	15
H03	Cooling efficiency	72	66	57	57	45	36	30	30	21	21	21	9	15	15	9	15	12	12	6
H05	Ground source HP	52	40	28	40	28	24	16	20	36	24	16	16	32	24	16	52	36	56	60
H07	Guide 36 Sequence	4	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2
W01	SHW preheat recovery	3	4	4	4	5	5	6	6	7	7	7	8	8	8	9	8	8	8	9
W02	Heat pump SW heater	10	10	14	12	16	16	20	20	22	24	22	26	26	24	28	26	26	28	28
W03	Efficient gas SW heater	4	4	5	5	6	6	8	7	8	9	8	10	10	9	10	10	10	10	10
W04	SHW pipe insulation	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
W06	Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W08	SHW distribution sizing	3	4	4	4	5	6	7	6	7	8	7	9	8	8	9	9	9	9	9
W09	SHW shower drain HR	3	3	4	4	4	5	6	5	6	6	6	7	7	7	8	7	7	8	8
P01	Energy monitoring	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	3	3	3	3
L02	Lighting dim & tuning	1	1	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	2
L03	Add occup.sensors	3	4	4	4	4	5	5	4	5	4	4	5	4	4	5	4	4	4	3
L06	Light power reduction	4	4	4	4	4	4	4	4	6	4	6	6	4	4	6	4	4	4	4
R01	Renewable energy	35	40	45	45	45	60	50	65	65	45	65	50	40	60	45	45	50	40	35
Q01	Efficient Elevator	2	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	3
Q02	Efficient Kitchen Equip	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Fault detection	4	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2
G03	Shading load mgmt.	2	2	2	3	1	2	3	2	4	3	2	1	x	1	3	1	2	x	x
G04	Electric storage	12	14	14	16	14	18	18	24	22	22	18	22	24	22	28	22	20	20	22
G05	Cooling storage	72	20	100	44	76	68	88	132	80	56	76	48	48	64	32	36	76	8	12
G06	SHW storage	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	Hotel/Motel Available	200	184	169	179	161	152	144	145	164	149	142	135	158	147	137	184	158	191	194
	% required of available	25%	27%	30%	28%	31%	33%	32%	32%	30%	32%	35%	37%	30%	31%	34%	27%	29%	26%	26%

5.5.1 Hotel/Motel Hot Climate Zone Credit Package Examples

Table 20 shows credits achieved for multiple options in a typical hot climate zone for hotel/motel buildings. The values shown represent the average credits for climate zones 0 through 2. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, heat pump water heaters sized for 30% load, condensing gas water heaters sized for 70% load, and a 10% LPD reduction.
- The minimum equipment efficiency package includes improved fenestration, Guideline 36 sequences, SHW preheat recovery, a 10% LPD reduction, 0.2 W/ft² of PV renewables, efficient elevators, fault detection, and cooling storage where needed.
- The package of measures used in the prototype models includes improved fenestration, a 5% cooling efficiency increase, condensing gas water heaters sized for full load, SWH distribution sizing in climate zone 0A, lighting tuning where needed, additional occupancy sensors, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.

- Alternative 1, focused on maximizing renewable PV installation, includes 0.3 W/ft² of PV renewables with improved fenestration, Guideline 36 sequences, a 10% LPD reduction, efficient elevators, fault detection, and automatic solar window shading.
- Alternative 2, focused on maximizing SHW efficiency, includes service water heat recovery, heat pump water heaters sized for the full load, thermostatic balancing valves, SHW distribution sizing, a 5% LPD reduction, and SHW storage.
- Alternative 3, focused on a GSHP implementation, includes Guideline 36 sequences, 100% of building conditioning with GSHP, an integrated heat pump water heater sized for 30% the load, a 5% LPD reduction, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, SHW distribution sizing, lighting dimming and tuning controls, additional occupancy sensors, a 10% LPD reduction, efficient elevators, fault detection, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% cooling efficiency increase, Guideline 36 control sequences, and fault detection.
- Alternative 6, focused on a cooling storage system, includes a 5% cooling efficiency increase, HVAC fault detection controls, and a central cooling storage system sized at 2.0 ton-hours storage per ton cooling design load.

Table 20. Energy Credit Packages for Hotel/Motel Buildings in Hot Climate Zones

Hotel/Motel Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		48	48	48	48	48	48	48	48	48	48
E01	Improved Envelope	8	8	8	8	8					
H02	Heating Efficiency	x									
H03	Cooling efficiency	55	37		18					55	18
H05	Ground source HP	35						35			
H07	Guide 36 Sequence	3		3		3		3	3	3	
W01	SHW preheat recovery	4		4			4				
W02	Heat pump SW heater	13	7				13	7			
W03	Efficient gas SW heater	5	3		3						
W04	SHW pipe insulation	1									
W06	Thermo bal valves	1					1				
W08	SHW distribution sizing	4			4		4		4		
W09	SHW shower drain HR	3									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	1			1				1		
L03	Add occup.sensors	4			4				4		
L06	Light power reduction	4	4	4	3	4	2	2	4		
R01	Renewable energy	45	9	18	9	32					
Q01	Efficient Elevator	2		2		2			2		
Q03	Fault detection	3		3	3	3		3	3	3	3
G03	Shading load mgmt.	2				2					
G04	Electric storage	14									
G05	Cooling storage	63		32							32
G06	SHW storage	31					31		31		
Renewable + Load Mgmt (limited 60%)			9	30	9	30	30	0	30	0	30
Total Credits Achieved*			68	54	53	50	54	50	51	61	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.5.2 Hotel/Motel Moderate Climate Zone Credit Package Examples

Table 21 shows credits achieved for multiple options in a typical moderate climate zone for hotel/motel buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes improved fenestration, a 15% heating efficiency increase, heat pump water heaters sized for 30% load, condensing gas water heaters sized for 70% load, additional occupancy sensors, a 10% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, SHW preheat recovery, SHW distribution sizing, a 10% LPD reduction, 0.1 W/ft² of PV renewables, fault detection, and cooling storage.
- The package of measures used in the prototype models includes improved fenestration, condensing gas water heaters sized for full load, SWH distribution sizing, additional occupancy sensors, lighting dimming and tuning, a 5% to 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.3 W/ft² of PV renewables with a 5% cooling efficiency increase, Guideline 36 sequences, SHW distribution sizing, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes heat pump water heaters sized for the full load, SHW distribution sizing, and SHW storage load management.
- Alternative 3, focused on a GSHP implementation, includes a 15% cooling efficiency increase, 100% of building conditioning with GSHP, an integrated heat pump water heater sized for 30% the load, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, SHW distribution sizing, lighting dimming and tuning controls, additional occupancy sensors, a 5% LPD reduction, efficient elevators, fault detection, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, Guideline 36 control sequences, SHW distribution sizing, fault detection, and SHW storage demand management.
- Alternative 6, focused on a cooling storage system, includes a 10% cooling efficiency increase, SHW preheat, HVAC fault detection controls, and a central cooling storage system sized at 2.0 ton-hours storage per ton cooling design load.

Table 21. Energy Credit Packages for Hotel/Motel Buildings in Moderate Climate Zones

Hotel/Motel Buildings Averages by general climate 3-5 Climate Zone		Mod CZ Avg Avail	Alternative Packages for Moderate Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		49	49	49	49	49	49	49	49	49	49
E01	Improved Envelope	13	13	13	13						
H02	Heating Efficiency	4	4							4	
H03	Cooling efficiency	19			6	6		19		19	13
H05	Ground source HP	22						22			
H07	Guide 36 Sequence	2				2			2	2	
W01	SHW preheat recovery	7		7							7
W02	Heat pump SW heater	23	12				23	12			
W03	Efficient gas SW heater	8	5		8						
W04	SHW pipe insulation	2									
W06	Thermo bal valves	1									
W08	SHW distribution sizing	7		7	7	7	7		7	7	
W09	SHW shower drain HR	6									
P01	Energy monitoring	2									
L02	Lighting dim & tuning	1			1				1		
L03	Add occup.sensors	4	2		4				4		
L06	Light power reduction	4	4	4	2	4			2		
R01	Renewable energy	53	11	11	11	32					
Q01	Efficient Elevator	4							4		
Q02	Efficient Kitchen Equip	x									
Q03	Fault detection	2		2	2	2		2	2	2	2
G03	Shading load mgmt.	2									
G04	Electric storage	22									
G05	Cooling storage	69		35							35
G06	SHW storage	31					31		31	31	
Renewable + Load Mgmt (limited 60%)			11	29	11	29	29	0	29	29	29
Total Credits Achieved*			50	63	54	51	60	55	52	64	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.5.3 Hotel/Motel Cold Climate Zone Credit Package Examples

Table 22 shows credits achieved for multiple options in a typical cold climate zone for hotel/motel buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes improved fenestration, a 15% heating efficiency increase, heat pump water heaters sized for 30% load, condensing gas water heaters sized for 70% load, additional occupancy sensors, a 10% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, SHW preheat recovery, SHW distribution sizing, shower drain heat recovery, additional occupancy sensors, a 10% LPD reduction, and 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes improved fenestration, a 5% heating efficiency increase, condensing gas water heaters sized for full load, SHW distribution sizing, lighting dimming and tuning, additional occupancy sensors, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.35 W/ft² of PV renewables with Guideline 36 sequences, SHW distribution sizing, additional occupancy sensors, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes heat pump water heaters sized for the full load, SHW distribution sizing, and SHW storage load management.

- Alternative 3, focused on a GSHP implementation, includes 100% of building conditioning with GSHP.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, SHW distribution sizing, additional occupancy sensors, lighting dimming and tuning controls, efficient elevators, fault detection, and SHW storage demand management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, GSHP for 33% of the building area, Guideline 36 control sequences, SHW distribution sizing, and fault detection.
- Alternative 7, focused on reduced heating, includes a 15% UA reduction, lowered air leakage, a 15% heating efficiency increase, Guideline 36 control sequences, SHW distribution sizing, 0.1 W/ft² of PV renewables, and fault detection.

Table 22. Energy Credit Packages for Hotel/Motel Buildings in Cold Climate Zones

Hotel/Motel Buildings Averages by general climate 6-8 Climate Zone	Cold CZ Avg Avail	Alternative Packages for Cold Climate									
		CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat	
Requirement	49	49	49	49	49	49	49	49	49	49	49
E01 Improved Envelope	14	14	14	14							20
H02 Heating Efficiency	9	9		3					9		9
H03 Cooling efficiency	11								11		
H05 Ground source HP	51						51		17		
H07 Guide 36 Sequence	2				2			2	2		2
W01 SHW preheat recovery	8		8								
W02 Heat pump SW heater	27	14				27					
W03 Efficient gas SW heater	10	6		10							
W04 SHW pipe insulation	2										
W06 Thermo bal valves	1										
W08 SHW distribution sizing	9		9	9	9	9		9	9	9	
W09 SHW shower drain HR	7		7								
P01 Energy monitoring	3										
L02 Lighting dim & tuning	2			2				2			
L03 Add occup.sensors	3	3	3	3	3			3			
L06 Light power reduction	4	4	4	4	4						
R01 Renewable energy	42	8	8	8	29						8
Q01 Efficient Elevator	3							3			
Q03 Fault detection	2			2	2			2	2		2
G03 Shading load mgmt.	1										
G04 Electric storage	21										
G05 Cooling storage	33										
G06 SHW storage	31					31		31			
Renewable + Load Mgmt (limited 60%)		8	8	8	29	30	0	30	0		8
Total Credits Achieved*		58	54	56	50	66	51	51	50		50
Meets Requirement		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE		TRUE

*Totals may not sum due to rounding

5.6 Office Building Applicability

Several alternative packages are reviewed for office buildings. The general package types, tables, and assumed measures are described in Section 4.4, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 23 shows the credits available for applicable measures in office buildings, with higher scoring measures shaded a darker green. Measures are described in detail in Section 6.0.

Table 23. Energy Credits Required and Available for Office

Energy Credit Abbreviated Title	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Building Requirement	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
E01 Improved Envelope	15	15	19	19	23	23	31	31	31	38	38	38	41	41	41	44	44	46	47
H02 Heating Efficiency	x	x	x	x	x	x	3	x	x	6	3	6	15	9	6	21	15	21	30
H03 Cooling efficiency	54	54	45	48	36	30	24	24	21	18	15	9	12	12	6	12	6	9	3
H05 Ground source HP	36	32	20	32	20	16	28	20	8	40	24	28	60	40	32	84	60	76	80
H06 DOAS/fan control.	19	19	17	18	16	16	11	14	12	9	13	8	5	10	7	3	6	3	x
H07 Guide 36 Sequence	3	3	3	3	3	3	2	2	2	2	2	1	2	2	1	2	2	2	2
W01 SHW preheat recovery	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2
W02 Heat pump SW heater	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	4	4
W03 Efficient gas SW heater	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
W04 SHW pipe insulation	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1
W05 Point of use SW heaters	x	4	4	4	4	4	4	3	3	3	2	3	2	1	2	1	1	1	x
W06 Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P01 Energy monitoring	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
L02 Lighting dim & tuning	5	5	6	6	6	6	6	7	7	6	7	7	6	6	7	5	6	5	5
L03 Add occup.sensors	5	6	6	6	7	6	6	6	8	6	6	7	6	6	7	6	6	5	5
L04 Increase daylight area	14	14	16	16	16	16	18	18	20	16	16	18	16	16	16	14	16	16	12
L06 Light power reduction	14	14	16	16	16	18	16	16	18	16	18	18	16	16	18	14	16	14	12
R01 Renewable energy	55	55	70	65	70	80	75	90	95	65	90	70	55	80	65	60	70	60	45
Q01 Efficient Elevator	4	4	4	4	5	5	5	5	6	5	5	6	5	5	6	5	5	5	5
Q03 Fault detection	3	3	3	3	3	3	2	2	2	2	2	1	2	2	1	2	2	2	2
G01 Lighting load mgmt.	5	5	6	6	6	6	7	7	6	6	7	7	6	7	8	6	7	6	6
G02 HVAC load mgmt.	10	10	7	13	8	13	14	12	8	14	15	14	14	17	14	11	17	15	11
G03 Shading load mgmt.	8	13	15	15	14	17	14	15	16	10	16	16	13	15	16	13	15	14	21
G04 Electric storage	38	38	42	42	44	48	54	52	54	54	56	62	52	56	66	44	54	50	46
G05 Cooling storage	88	24	116	52	84	76	88	148	88	52	84	48	48	64	32	36	80	8	12
G06 SHW storage	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
G07 Bldg mass / night flush	4	1	6	3	9	14	12	14	20	11	20	20	19	20	20	16	26	25	12
Office Available	209	209	195	211	191	182	192	184	176	205	189	189	226	204	189	251	223	243	242
% required of available	24%	24%	26%	24%	26%	27%	26%	27%	28%	24%	26%	26%	22%	25%	26%	20%	22%	21%	21%

5.6.1 Office Hot Climate Zone Credit Package Examples

Table 24 shows credits achieved for multiple options in a typical hot climate zone for office buildings. The values shown represent the average credits for climate zones 0 through 2. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, point of use water heaters, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and HVAC load management.
- The minimum equipment efficiency package includes improved fenestration, point of use water heaters, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and cooling storage where needed.
- The package of measures used in the prototype models includes a 5% cooling efficiency increase, lighting dimming and tuning, additional occupancy sensors, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.25 W/ft² of PV renewables with Guideline 36 sequences, a 10% LPD reduction, and fault detection.

- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW pipe insulation, point of use water heaters, a 10% LPD reduction, 0.15 W/ft² of PV renewables fault detection, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes a 7% cooling efficiency increase, Guideline 36 sequences, 100% of building conditioning with GSHP, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, efficient elevators, fault detection, lighting load management, and HVAC load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% cooling efficiency increase, Guideline 36 control sequences, and fault detection.
- Alternative 6, focused on a cooling storage system, includes a 7% cooling efficiency increase, HVAC fault detection controls, and a central cooling storage system sized at 1.5 ton-hours storage per ton cooling design load.

Table 24. Energy Credit Packages for Office Buildings in Hot Climate Zones

Office Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	19	19	19							
H02	Heating Efficiency	x									
H03	Cooling efficiency	44	29		15			21		44	21
H05	Ground source HP	26						26			
H06	DOAS/fan control.	17									
H07	Guide 36 Sequence	3				3	3	3	3	3	
W01	SHW preheat recovery	1									
W02	Heat pump SW heater	2									
W03	Efficient gas SW heater	2									
W04	SHW pipe insulation	1					1				
W05	Point of use SW heaters	4	4	4			4				
W06	Thermo bal valves	1									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	5			5				5		
L03	Add occup.sensors	6			6				6		
L04	Increase daylight area	15							15		
L06	Light power reduction	15	8	15	15	15	15				
R01	Renewable energy	65	13	13	13	33	20				
Q01	Efficient Elevator	4							4		
Q03	Fault detection	3			3	3	3	3	3	3	3
G01	Lighting load mgmt.	5							5		
G02	HVAC load mgmt.	10	10						10		
G03	Shading load mgmt.	13									
G04	Electric storage	42									
G05	Cooling storage	73		27							
G06	SHW storage	7					7				
G07	Bldg mass / night flush	6									
Renewable + Load Mgmt (limited 60%)			23	30	13	30	27	0	15	0	27
Total Credits Achieved*			83	68	57	51	53	53	51	50	51
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.6.2 Office Moderate Climate Zone Credit Package Examples

Table 25 shows credits achieved for multiple options in a typical moderate climate zone for office buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, point of use water heaters, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and HVAC load management.
- The minimum equipment efficiency package includes improved fenestration, point of use water heaters, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes a 5% heating efficiency increase, a 5% cooling efficiency increase, lighting dimming and tuning, additional occupancy sensors, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.2 W/ft² of PV renewables with Guideline 36 sequences, point of use water heaters, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW pipe insulation, point of use water heaters, a 10% LPD reduction, 0.15 W/ft² of PV renewables, fault detection, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes a 15% cooling efficiency increase, 100% of building conditioning with GSHP, Guideline 36 sequences, distributed heat pump water heaters, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, efficient elevators, fault detection, lighting load management, and HVAC load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, fault detection, HVAC load management, and building mass with night flush.
- Alternative 6, focused on a cooling storage system, includes a 10% cooling efficiency increase, integrated heat pump water heaters for 100% of the SHW load, a 5% LPD reduction, HVAC fault detection controls, and a central cooling storage system sized at 2.0 ton-hours storage per ton cooling design load.

Table 25. Energy Credit Packages for Office Buildings in Moderate Climate Zones

Office Buildings Averages by general climate 3-5 Climate Zone		Mod CZ Avg Avail	Alternative Packages for Moderate Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	36	36	36							
H02	Heating Efficiency	6			2					6	
H03	Cooling efficiency	15	10		5				15	15	10
H05	Ground source HP	31						31			
H06	DOAS/fan control.	9									
H07	Guide 36 Sequence	1				1	1	1	1		
W01	SHW preheat recovery	2									
W02	Heat pump SW heater	3						3			3
W03	Efficient gas SW heater	2									
W04	SHW pipe insulation	1					1				
W05	Point of use SW heaters	2	2	2		2	2				
W06	Thermo bal valves	1									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	6			6				6		
L03	Add occup.sensors	6			6				6		
L04	Increase daylight area	17							17		
L06	Light power reduction	16	8	8	16	16	16				8
R01	Renewable energy	76	15	15	15	30	23				
Q01	Efficient Elevator	5							5		
Q03	Fault detection	1			1	1	1	1	1	1	1
G01	Lighting load mgmt.	6							6		
G02	HVAC load mgmt.	13	13						13	13	
G03	Shading load mgmt.	14									
G04	Electric storage	56									
G05	Cooling storage	72									36
G06	SHW storage	7					7				
G07	Bldg mass / night flush	20								20	
Renewable + Load Mgmt (limited 60%)			28	15	15	30	30	0	19	30	30
Total Credits Achieved*			85	62	52	50	51	51	55	52	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.6.3 Office Cold Climate Zone Credit Package Examples

Table 26 shows credits achieved for multiple options in a typical cold climate zone for office buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes improved fenestration, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes a 5% heating efficiency increase, a 5% cooling efficiency increase, lighting dimming and tuning, additional occupancy sensors, a 10% LPD reduction, 0.13 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.25 W/ft² of PV renewables with Guideline 36 sequences, additional occupancy sensors, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW pipe insulation, heat pump water heaters for the full load, a 10% LPD reduction, 0.2 W/ft² of PV renewables, fault detection, and SHW storage for load management.

- Alternative 3, focused on a GSHP implementation, includes 66% of building conditioning with GSHP, Guideline 36 sequences, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, efficient elevators, fault detection, lighting load management, and HVAC load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, fault detection, HVAC load management, and building mass with night flush.
- Alternative 7, focused on reduced heating, includes as needed UA reduction, lowered air leakage, a 15% heating efficiency increase, Guideline 36 control sequences, and fault detection.

Table 26. Energy Credit Packages for Office Buildings in Cold Climate Zones

Office Buildings Averages by general climate 6-8 Climate Zone		Cold CZ Avg Avail	Alternative Packages for Cold Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	45	45	45							26
H02	Heating Efficiency	21			7					21	21
H03	Cooling efficiency	7			2					7	
H05	Ground source HP	75						50			
H06	DOAS/fan control.	4									
H07	Guide 36 Sequence	2				2	2	2	2		2
W01	SHW preheat recovery	2									
W02	Heat pump SW heater	4					4				
W03	Efficient gas SW heater	3									
W04	SHW pipe insulation	1					1				
W05	Point of use SW heaters	1									
W06	Thermo bal valves	1									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	5			5				5		
L03	Add occup.sensors	5			5	5			5		
L04	Increase daylight area	14							14		
L06	Light power reduction	14	7	7	14	14	14				
R01	Renewable energy	58	12	12	15	29	23				
Q01	Efficient Elevator	5							5		
Q03	Fault detection	2			2	2	2	2	2	2	2
G01	Lighting load mgmt.	6							6		
G02	HVAC load mgmt.	13							13	13	
G03	Shading load mgmt.	15									
G04	Electric storage	48									
G05	Cooling storage	34									
G06	SHW storage	7					7				
G07	Bldg mass / night flush	19								19	
Renewable + Load Mgmt (limited 60%)			12	12	12	29	30	0	19	30	0
Total Credits Achieved*			64	64	50	52	53	54	52	60	51
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.7 Restaurant Building Applicability

Several alternative packages are reviewed for restaurant buildings. The general package types, tables, and assumed measures are described in Section 4.4, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 27 shows the credits available for applicable measures in restaurant buildings, with higher scoring measures shaded a darker green. Measures are described in detail in Section 6.0.

Table 27. Energy Credits Required and Available for Restaurant

ID	Energy Credit Abbreviated Title	Climate Zone																		
		0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	Building Requirement	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	9	8	10	10	12	11	16	15	10	22	19	20	23	23	26	26	26	34	38
H02	Heating Efficiency	x	x	x	x	x	x	9	6	3	15	9	12	24	15	15	30	24	39	51
H03	Cooling efficiency	60	54	45	48	39	30	24	21	9	15	12	3	9	9	3	9	6	6	3
H05	Ground source HP	44	36	24	36	28	24	32	32	16	52	44	44	56	60	56	76	68	80	68
H07	Guide 36 Sequence	4	3	3	3	3	2	2	2	1	2	2	1	2	2	1	2	2	3	3
W01	SHW preheat recovery	5	5	7	6	7	8	9	9	11	10	11	12	11	11	12	11	11	11	10
W02	Heat pump SW heater	4	6	6	6	8	10	12	12	14	16	14	18	18	18	20	18	20	20	20
W03	Efficient gas SW heater	6	7	8	8	9	10	11	11	14	13	13	14	13	13	15	13	13	13	12
W06	Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P01	Energy monitoring	3	3	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2
L02	Lighting dim & tuning	3	3	3	3	3	3	3	3	3	3	3	3	2	3	2	2	2	2	2
L03	Add occup.sensors	2	2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1
L06	Light power reduction	8	8	8	8	8	8	8	8	8	8	8	6	6	8	6	6	6	6	4
R01	Renewable energy	10	10	10	10	10	15	10	15	15	10	15	10	10	10	10	10	10	10	5
Q01	Efficient Elevator	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Q02	Eff. Kitchen Equip.	19	21	24	22	24	26	26	27	31	27	28	30	26	27	30	24	26	23	22
Q03	Fault detection	4	3	3	3	3	2	2	2	1	2	2	1	2	2	1	2	2	3	3
G03	Shading load mgmt.	2	2	2	2	2	3	2	2	1	1	2	1	1	1	x	1	1	1	x
G04	Electric storage	6	6	8	8	10	10	8	8	8	6	8	6	6	8	6	6	6	6	4
G05	Cooling storage	16	4	20	8	16	12	16	24	8	8	12	4	4	8	x	4	8	x	x
G06	SHW storage	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
G07	Bldg mass / night flush	2	x	3	1	4	6	4	5	11	3	7	7	4	9	5	3	6	4	1
Restaurant Available		194	180	165	178	166	153	171	165	132	198	177	173	204	203	196	231	218	252	248
% required of available		26%	28%	30%	28%	30%	33%	29%	30%	38%	25%	28%	29%	25%	25%	26%	22%	23%	20%	20%

5.7.1 Restaurant Hot Climate Zone Credit Package Examples

Table 28 shows credits achieved for multiple options in a typical hot climate zone for restaurant buildings. The values shown represent the average credits for climate zones 0 through 2. The following packages are included:

- The demonstration package includes improved fenestration, a 5% cooling efficiency increase, condensing gas water heaters, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and efficient kitchen equipment.
- The minimum equipment efficiency package includes improved fenestration, a 10% LPD reduction, 0.2 W/ft² of PV renewables, efficient kitchen equipment, and SHW storage for load management.

- The package of measures used in the prototype models includes a 5% cooling efficiency increase, condensing gas water heaters, a 10% LPD reduction, efficient kitchen equipment, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 1.0 W/ft² of PV renewables, a 10% LPD reduction, and efficient kitchen equipment.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW heat pump water heater for 30% load, condensing gas water heaters for 70% of the load, thermostatic balancing valves, a 10% LPD reduction, 0.6 W/ft² of PV renewables, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes a 5% cooling efficiency increase, Guideline 36 sequences, 100% of building conditioning with GSHP, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 0.1 W/ft² of PV renewables, efficient kitchen equipment, fault detection, and SHW storage for load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% cooling efficiency increase, Guideline 36 control sequences, and fault detection.
- Alternative 6, focused on a cooling storage system, includes a 12% cooling efficiency increase, HVAC fault detection controls, and a central cooling storage system sized at 4.0 ton-hours storage per ton cooling design load.

Table 28. Energy Credit Packages for Restaurant Buildings in Hot Climate Zones

Restaurant Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	10	7	7							
H02	Heating Efficiency	x									
H03	Cooling efficiency	46	15		15			15		46	37
H05	Ground source HP	32						32			
H07	Guide 36 Sequence	3					3	3	3	3	
W01	SHW preheat recovery	6									
W02	Heat pump SW heater	6					3				
W03	Efficient gas SW heater	8	8		8		5				
W06	Thermo bal valves	1					1				
P01	Energy monitoring	2									
L02	Lighting dim & tuning	3							3		
L03	Add occup.sensors	2							2		
L06	Light power reduction	8	8	8	8	8	8				
R01	Renewable energy	10	2	4		20	12		2		
Q01	Efficient Elevator	1									
Q02	Eff. Kitchen Equip.	22	22	22	22	22			22		
Q03	Fault detection	3			3				3	3	3
G03	Shading load mgmt.	2									
G04	Electric storage	8									
G05	Cooling storage	12									12
G06	SHW storage	19		19			19		19		
G07	Bldg mass / night flush	3									
Renewable + Load Mgmt (limited 60%)			2	23	0	20	30	0	21	0	12
Total Credits Achieved*			63	60	57	50	50	51	54	52	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.7.2 Restaurant Moderate Climate Zone Credit Package Examples

Table 29 shows credits achieved for multiple options in a typical moderate climate zone for restaurant buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, efficient gas water heaters, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and efficient kitchen equipment.
- The minimum equipment efficiency package includes improved fenestration, additional lighting occupancy sensors, a 10% LPD reduction, 0.2 W/ft² of PV renewables, efficient kitchen equipment, and SHW storage for load management.
- The package of measures used in the prototype models includes a 5% heating efficiency increase where needed, a 5% cooling efficiency increase where needed, an efficient gas water heater, a 10% LPD reduction, efficient kitchen equipment, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 1.0 W/ft² of PV renewables with Guideline 36 sequences, efficient kitchen equipment, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW heat pump water heater for 30% load, condensing gas water heaters for 70% of the load, thermostatic balancing valves, a 10% LPD reduction, 0.3 W/ft² of PV renewables, fault detection, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes a 7% cooling efficiency increase, 100% of building conditioning with GSHP, Guideline 36 sequences, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, fault detection, efficient kitchen equipment, and SHW storage for load management.
- Alternative 5, focused on maximizing mechanical efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, Guideline 36 control sequences, SHW heat pump water heater for 30% load, condensing gas water heaters for 70% of the load, thermostatic balancing valves, 0.2 W/ft² of PV renewables, fault detection, and building mass with night flush.
- Alternative 6, focused on a cooling storage system, includes a 7% cooling efficiency increase, integrated heat pump water heaters for 100% of the SHW load, efficient kitchen equipment, HVAC fault detection controls, and a central cooling storage system sized at 4.0 ton-hours storage per ton cooling design load.

Table 29. Energy Credit Packages for Restaurant Buildings in Moderate Climate Zones

Restaurant Buildings Averages by general climate 3-5 Climate Zone	Mod CZ Avg Avail	Alternative Packages for Moderate Climate									
		CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg	
Requirement	50	50	50	50	50	50	50	50	50	50	50
E01 Improved Envelope	19	10	10								
H02 Heating Efficiency	12			4						12	
H03 Cooling efficiency	11	4		4				5		10	5
H04 Res. HVAC ctrl	x										
H05 Ground source HP	43							43			
H07 Guide 36 Sequence	1				1	1		1	1	1	
W01 SHW preheat recovery	10										
W02 Heat pump SW heater	15						8			8	15
W03 Efficient gas SW heater	13	13		13			8			8	
W06 Thermo bal valves	1						1			1	
P01 Energy monitoring	1										
L02 Lighting dim & tuning	2								2		
L03 Add occup.sensors	2		2						2		
L06 Light power reduction	7	7	7	7			7				
R01 Renewable energy	11	2	4		22	7				4	
Q01 Efficient Elevator	1										
Q02 Eff. Kitchen Equip.	28	28	28	28	28				28		28
Q03 Fault detection	1			1	1	1	1	1	1	1	1
G03 Shading load mgmt.	1										
G04 Electric storage	7										
G05 Cooling storage	10										10
G06 SHW storage	19		19				19		19		
G07 Bldg mass / night flush	6									6	
Renewable + Load Mgmt (limited 60%)		2	23	0	22	26	0	19	10	10	
Total Credits Achieved*		64	70	56	51	50	50	52	51	59	
Meets Requirement		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	

*Totals may not sum due to rounding

5.7.3 Restaurant Cold Climate Zone Credit Package Examples

Table 30 shows credits achieved for multiple options in a typical cold climate zone for restaurant buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes improved fenestration, efficient gas water heaters, a 10% LPD reduction, efficient kitchen equipment, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, a 10% LPD reduction, 0.1 W/ft² of PV renewables, efficient kitchen equipment, and SHW storage for load management.
- The package of measures used in the prototype models includes a 5% heating efficiency increase, efficient gas water heaters, a 10% LPD reduction, efficient kitchen equipment, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 1.0 W/ft² of PV renewables with Guideline 36 sequences, thermostatic balancing valves, lighting dimming and tuning, additional occupancy sensors, a 10% LPD reduction, efficient kitchen equipment, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW heat pump water heater for 30% load, condensing gas water heaters for 70% of the load, thermostatic balancing valves, a 10% LPD reduction, 0.4 W/ft² of PV renewables, fault detection, and SHW storage for load management.

- Alternative 3, focused on a GSHP implementation, includes 66% of building conditioning with GSHP, Guideline 36 sequences, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, efficient elevators, efficient kitchen equipment, fault detection, SHW storage for load management, and 0.1 W/ft² of PV renewables.
- Alternative 5, focused on maximizing mechanical efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, Guideline 36 control sequences, and condensing gas water heaters.
- Alternative 7, focused on reduced heating, includes as needed UA reduction, lowered air leakage, a 15% heating efficiency increase, Guideline 36 control sequences, and fault detection.

Table 30. Energy Credit Packages for Restaurant Buildings in Cold Climate Zones

Restaurant Buildings Averages by general climate 6-8 Climate Zone		Cold CZ Avg Avail	Alternative Packages for Cold Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	31	16	16							12
H02	Heating Efficiency	36			12					36	36
H03	Cooling efficiency	6								6	
H04	Res. HVAC ctrl	x									
H05	Ground source HP	73						48			
H07	Guide 36 Sequence	2				2	2	2	2	2	2
W01	SHW preheat recovery	10									
W02	Heat pump SW heater	19					10				
W03	Efficient gas SW heater	12	12		12		7			12	
W06	Thermo bal valves	1				1	1				
P01	Energy monitoring	2									
L02	Lighting dim & tuning	2				2			2		
L03	Add occup.sensors	1				1			1		
L06	Light power reduction	5	5	5	5	5	5				
R01	Renewable energy	8	2	2		16	6		2		
Q01	Efficient Elevator	1							1		
Q02	Eff. Kitchen Equip.	23	23	23	23	23			23		
Q03	Fault detection	2			2	2	2	2	2		2
G03	Shading load mgmt.	1									
G04	Electric storage	5									
G05	Cooling storage	6									
G06	SHW storage	19		19			19		19		
G07	Bldg. mass / night flush	3									
Renewable + Load Mgmt (limited 60%)			2	21	0	16	25	0	21	0	0
Total Credits Achieved*			58	65	54	50	51	51	50	56	50
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.8 Retail Building Applicability

Several alternative packages are reviewed for retail buildings. The general package types, tables, and assumed measures are described in Section 4.4, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 31 shows the credits available for applicable measures in retail buildings, with higher scoring measures shaded a darker green. Measures are described in detail in Section 6.0.

Table 31. Energy Credits Required and Available for Retail

ID	Energy Credit Abbreviated Title	Climate Zone																		
		0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	Building Requirement	50	50	50	50	50	50	50	50	50	50	50	50	49	50	47	48	45	42	46
E01	Improved Envelope	5	5	6	6	6	6	7	7	7	8	8	8	9	9	9	10	10	10	10
H02	Heating Efficiency	x	x	x	x	x	x	9	3	x	21	6	15	30	18	18	36	27	27	39
H03	Cooling efficiency	78	72	63	66	54	45	33	33	15	21	21	6	12	15	3	12	9	9	3
H05	Ground source HP	64	52	36	52	32	28	40	32	8	72	44	64	76	72	76	92	80	72	60
H06	DOAS/fan control.	29	30	26	28	24	25	18	23	23	12	22	15	7	17	13	3	10	5	2
H07	Guide 36 Sequence	5	5	4	4	4	3	3	3	2	3	3	2	3	3	2	3	3	3	4
W01	SHW preheat recovery	4	4	5	4	6	6	7	7	8	7	7	8	7	7	8	6	7	7	6
W02	Heat pump SW heater	2	2	2	2	4	4	4	4	6	4	4	6	4	4	6	4	4	4	4
W03	Efficient gas SW heater	2	2	3	2	3	3	4	4	4	4	4	4	4	4	4	3	4	4	3
W06	Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P01	Energy monitoring	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
L02	Lighting dim & tuning	6	6	6	6	6	6	5	6	6	4	5	5	3	4	4	3	3	2	2
L03	Add occup.sensors	6	6	6	6	6	6	5	6	6	4	5	5	3	4	4	3	4	2	2
L04	Increase daylight area	14	14	16	14	14	14	12	14	14	8	12	10	8	10	8	6	8	8	6
L06	Light power reduction	22	22	24	24	24	24	22	24	28	20	22	18	16	16	18	16	16	14	12
R01	Renewable energy	45	45	55	55	65	80	70	90	95	60	85	65	50	75	60	50	60	50	35
Q01	Efficient Elevator	3	3	4	4	4	5	5	5	6	5	5	5	5	5	5	4	4	4	4
Q03	Fault detection	5	5	4	4	4	3	3	3	2	3	3	2	3	3	2	3	3	3	4
G01	Lighting load mgmt.	9	8	10	10	11	11	11	12	12	10	12	12	11	11	12	11	11	9	8
G02	HVAC load mgmt.	14	13	14	14	12	10	10	7	5	7	1	3	6	x	x	7	4	6	1
G03	Shading load mgmt.	2	4	6	3	6	4	2	x	8	x	1	2	2	x	x	x	x	3	1
G04	Electric storage	10	16	12	14	18	20	20	18	22	20	16	18	16	20	18	18	14	16	12
G05	Cooling storage	96	24	140	60	104	92	112	160	72	60	92	36	40	64	12	32	64	8	8
G06	SHW storage	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
G07	Bldg mass / night flush	4	1	6	2	8	14	11	14	32	9	20	20	16	20	18	13	23	21	10
Retail Available		277	260	236	254	221	208	206	203	162	225	200	200	218	220	205	233	218	198	189
% required of available		18%	19%	21%	20%	23%	24%	24%	25%	31%	22%	25%	25%	22%	23%	23%	21%	21%	21%	24%

5.8.1 Retail Hot Climate Zone Credit Package Examples

Table 32 shows credits achieved for multiple options in a typical hot climate zone for retail buildings. The values shown represent the average credits for climate zones 0 through 2. The following packages are included:

- The demonstration package includes improved fenestration, a 5% cooling efficiency increase, condensing gas water heaters, 5% increased daylight area, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The minimum equipment efficiency package includes improved fenestration, 5% to 10% increased daylight area, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The package of measures used in the prototype models includes improved fenestration where needed, a 5% cooling efficiency increase, lighting dimming and tuning, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.

- Alternative 1, focused on maximizing renewable PV installation, includes 0.25 W/ft² of PV renewables with Guideline 36 sequences, a 5% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, heat pump water heaters for 100% of the load, a 10% LPD reduction, 0.1 W/ft² of PV renewables, fault detection, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes Guideline 36 sequences, 100% of building conditioning with GSHP, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, fault detection, lighting load management, and HVAC load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 10% cooling efficiency increase, Guideline 36 control sequences, and fault detection.
- Alternative 6, focused on a cooling storage system, includes a 5% cooling efficiency increase, HVAC fault detection controls, and a central cooling storage system sized at 1.5 ton-hours storage per ton cooling design load.

Table 32. Energy Credit Packages for Retail Buildings in Hot Climate Zones

Retail Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 CI Stg
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	5	5	5	2						
H02	Heating Efficiency	x									
H03	Cooling efficiency	63	21		21					42	21
H05	Ground source HP	44						44			
H06	DOAS/fan control.	27									
H07	Guide 36 Sequence	4				4	4	4	4	4	
W01	SHW preheat recovery	4									
W02	Heat pump SW heater	2					2				
W03	Efficient gas SW heater	2	2								
W06	Thermo bal valves	1									
P01	Energy monitoring	5									
L02	Lighting dim & tuning	6			6				6		
L03	Add occup.sensors	6							6		
L04	Increase daylight area	14	7	9					14		
L06	Light power reduction	23	12	23	12	12	23				
R01	Renewable energy	57	11	11	11	29	11				
Q01	Efficient Elevator	3									
Q03	Fault detection	4	4	4	4	4	4	4	4	4	4
G01	Lighting load mgmt.	9							9		
G02	HVAC load mgmt.	12							12		
G03	Shading load mgmt.	4									
G04	Electric storage	15									
G05	Cooling storage	86									32
G06	SHW storage	5					5				
G07	Bldg mass / night flush	5									
Renewable + Load Mgmt (limited 60%)			11	11	11	29	16	0	21	0	30
Total Credits Achieved*			62	53	56	48	50	52	55	50	55
Meets Requirement			TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.8.2 Retail Moderate Climate Zone Credit Package Examples

Table 33 shows credits achieved for multiple options in a typical moderate climate zone for retail buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes improved fenestration, a 5% heating efficiency increase, Guideline 36 sequences, condensing gas water heaters, a 5% increased daylit area, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The minimum equipment efficiency package includes improved fenestration, 5% to 10% increased daylit area, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The package of measures used in the prototype models includes improved fenestration, a 5% heating efficiency increase, a 5% cooling efficiency increase, lighting dimming and tuning, additional occupancy sensors where needed, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.2 W/ft² of PV renewables with Guideline 36 sequences, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, heat pump water heaters for 100% of the load, added occupancy sensors, a 10% LPD reduction, 0.1 W/ft² of PV renewables, fault detection, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes 100% of building conditioning with GSHP.
- Alternative 4, focused on maximizing control improvements, includes lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, fault detection, lighting load management, and building mass with night flush.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, fault detection, HVAC load management, and building mass with night flush.
- Alternative 6, focused on a cooling storage system, includes a 5% cooling efficiency increase, integrated heat pump water heaters for 100% of the SHW load, a 5% LPD reduction, fault detection controls, and a central cooling storage system sized at 2.0 ton-hours storage per ton cooling design load.

Table 33. Energy Credit Packages for Retail Buildings in Moderate Climate Zones

Retail Buildings Averages by general climate 3-5 Climate Zone	Mod CZ Avg Avail	Alternative Packages for Moderate Climate									
		CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg	
Requirement	50	50	50	50	50	50	50	50	50	50	50
E01 Improved Envelope	8	8	8	8							
H02 Heating Efficiency	15	5		5					15		
H03 Cooling efficiency	17			6					17	6	
H05 Ground source HP	53							53			
H06 DOAS/fan control.	16										
H07 Guide 36 Sequence	2	2			2	2					
W01 SHW preheat recovery	7										
W02 Heat pump SW heater	4					4				4	
W03 Efficient gas SW heater	4	4									
W06 Thermo bal valves	1										
P01 Energy monitoring	6										
L02 Lighting dim & tuning	4			4				4			
L03 Add occup.sensors	4			2		4		4			
L04 Increase daylight area	10	5	7					10			
L06 Light power reduction	20	10	20	10	20	20				10	
R01 Renewable energy	72	14	14	14	29	14					
Q01 Efficient Elevator	5										
Q03 Fault detection	2	2	2	2	2	2		2	2	2	
G01 Lighting load mgmt.	11							11			
G02 HVAC load mgmt.	5								5		
G03 Shading load mgmt.	3										
G04 Electric storage	18										
G05 Cooling storage	72										36
G06 SHW storage	5					5					
G07 Bldg mass / night flush	19							19	19		
Renewable + Load Mgmt (limited 60%)		14	14	14	29	19	0	30	24	30	
Total Credits Achieved*		51	52	52	53	52	53	50	58	52	
Meets Requirement		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	

*Totals may not sum due to rounding

5.8.3 Retail Cold Climate Zone Credit Package Examples

Table 34 shows credits achieved for multiple options in a typical cold climate zone for retail buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes improved fenestration, a 10% heating efficiency increase, condensing gas water heater, 5% more building area with daylight controls, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, DOAS improvement with fan control, additional occupancy sensors, 10% more building area with daylight controls, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- The package of measures used in the prototype models includes improved fenestration where needed, a 10% heating efficiency increase, lighting dimming and tuning, additional occupancy sensors, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.3 W/ft² of PV renewables with Guideline 36 sequences, additional occupancy sensors, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, heat pump water heaters for 100% of the load, thermostatic balancing valves, additional

occupancy sensors, a 10% LPD reduction, 0.2 W/ft² of PV renewables, fault detection, and SHW storage for load management.

- Alternative 3, focused on a GSHP implementation, includes 66% of building conditioning with GSHP, Guideline 36 sequences, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, efficient elevators, fault detection, lighting load management, SHW storage for load management, and building mass with night flush.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, Guideline 36 control sequences, 0.1 W/ft² of PV renewables, fault detection, lighting load management, and HVAC load management.
- Alternative 7, focused on reduced heating, includes as needed UA reduction and lowered air leakage, a 15% heating efficiency increase, Guideline 36 control sequences, and fault detection.

Table 34. Energy Credit Packages for Retail Buildings in Cold Climate Zones

Retail Buildings Averages by general climate 6-8 Climate Zone		Cold CZ Avg Avail	Alternative Packages for Cold Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat
	Requirement	46	46	46	46	46	46	46	46	46	46
E01	Improved Envelope	10	10	10	3						12
H02	Heating Efficiency	32	21		21					32	32
H03	Cooling efficiency	8								8	
H05	Ground source HP	76						50			
H06	DOAS/fan control.	5		5							
H07	Guide 36 Sequence	3				3	3	3	3	3	3
W01	SHW preheat recovery	6									
W02	Heat pump SW heater	4					4				
W03	Efficient gas SW heater	3	3								
W06	Thermo bal valves	1					1				
P01	Energy monitoring	6									
L02	Lighting dim & tuning	2			2				2		
L03	Add occup.sensors	2		2	2	2	2		2		
L04	Increase daylight area	7	4	7					7		
L06	Light power reduction	14	7	14	7	14	14				
R01	Renewable energy	48	10	10	10	29	19			10	
Q01	Efficient Elevator	4							4		
Q03	Fault detection	3		3	3	3	3	3	3	3	3
G01	Lighting load mgmt.	9							9	9	
G02	HVAC load mgmt.	4								4	
G03	Shading load mgmt.	2									
G04	Electric storage	15									
G05	Cooling storage	28									
G06	SHW storage	5					5		5		
G07	Bldg mass / night flush	16							16		
Renewable + Load Mgmt (limited 60%)			10	10	10	29	24	0	30	23	0
Total Credits Achieved*			55	51	49	51	52	57	51	69	50
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.9 Education Building Applicability

Several alternative packages are reviewed for education buildings. The general package types, tables, and assumed measures are described in Section 4.4, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 35 shows the credits available for applicable measures in education buildings, with higher scoring measures shaded a darker green. Measures are described in detail in Section 6.0.

Table 35. Energy Credits Required and Available for Education

ID	Energy Credit Abbreviated Title	Climate Zone																		
		0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	Building Requirement	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	46
E01	Improved Envelope	13	14	19	18	23	24	33	35	34	43	45	44	48	48	48	50	50	51	50
H02	Heating Efficiency	x	x	x	x	x	x	x	3	x	3	6	9	9	12	6	15	12	21	33
H03	Cooling efficiency	72	69	57	63	54	45	36	36	30	27	27	15	18	21	9	18	15	15	6
H05	Ground source HP	52	48	32	48	32	28	24	32	20	24	36	44	28	52	24	48	36	48	48
H06	DOAS/fan control.	28	27	25	26	23	23	19	21	19	17	19	13	14	14	13	11	13	9	2
H07	Guide 36 Sequence	5	4	4	4	4	3	3	3	2	3	3	2	3	3	2	3	3	3	3
W01	SHW preheat recovery	1	1	2	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
W02	Heat pump SW heater	2	2	2	2	2	2	2	2	4	4	4	4	4	4	6	6	6	6	6
W03	Efficient gas SW heater	1	1	2	2	2	2	3	3	3	3	3	4	4	4	4	3	4	4	4
W04	SHW pipe insulation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W05	Point of use SW heaters	1	2	2	2	2	2	2	2	3	2	3	3	3	3	3	2	3	2	2
W06	Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W09	Add occup.sensors	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
P01	Energy monitoring	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3
L02	Lighting dim & tuning	5	5	6	6	6	7	6	7	8	7	7	8	7	7	7	6	6	6	5
L03	Add occup.sensors	4	4	5	5	6	6	6	7	7	7	7	6	6	6	7	5	6	5	4
L04	Increase daylight area	12	14	16	14	14	16	16	18	20	16	16	18	16	16	18	14	16	16	12
L06	Light power reduction	14	14	16	16	16	18	18	20	22	18	18	20	18	18	20	16	18	16	14
R01	Renewable energy	50	55	65	60	70	90	80	100	105	75	105	80	65	95	75	70	80	65	50
Q01	Efficient Elevator	3	4	4	4	5	5	5	6	6	6	6	6	6	6	7	6	6	6	5
Q03	Fault detection	5	4	4	4	4	3	3	3	2	3	3	2	3	3	2	3	3	3	3
G01	Lighting load mgmt.	2	3	3	3	3	4	3	4	3	3	4	4	2	4	5	4	3	3	3
G02	HVAC load mgmt.	6	5	8	6	6	8	6	6	5	6	8	6	5	8	3	4	7	4	2
G03	Shading load mgmt.	9	13	16	12	18	17	16	18	13	11	17	16	10	15	14	12	10	15	15
G04	Electric storage	24	24	26	26	28	32	32	34	40	32	36	36	34	36	36	30	34	30	28
G05	Cooling storage	104	28	148	68	120	112	144	160	152	92	148	88	80	112	52	64	128	12	16
G06	SHW storage	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
G07	Bldg mass / night flush	4	1	6	2	8	14	11	14	20	10	20	20	19	30	19	16	20	20	10
	Education Available	252	247	228	248	227	217	213	232	213	216	236	230	219	249	208	239	229	243	227
	% required of available	20%	20%	22%	20%	22%	23%	23%	22%	23%	23%	21%	22%	23%	20%	24%	21%	22%	21%	20%

5.9.1 Education Hot Climate Zone Credit Package Examples

Table 36 shows credits achieved for multiple options in a typical hot climate zone for education buildings. The values shown represent the average credits for climate zones 0 through 2. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, point of use water heaters, additional occupancy sensors, a 5% LPD reduction, and 0.1 W/ft² of PV renewables
- The minimum equipment efficiency package includes improved fenestration, point of use water heaters, additional occupancy sensors, 5% more building area with daylight controls, a 5% LPD reduction, 0.1 W/ft² of PV renewables, fault detection, and HVAC load management.

- The package of measures used in the prototype models includes a 5% cooling efficiency increase, lighting dimming and tuning, additional occupancy sensors, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.25 W/ft² of PV renewables with Guideline 36 sequences, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW pipe insulation, point of use water heaters, a 10% LPD reduction, 0.15 W/ft² of PV renewables, fault detection, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes Guideline 36 sequences, 100% of building conditioning with GSHP, fault detection, and HVAC load management.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, efficient elevators, fault detection, lighting load management, HVAC load management, and SHW storage for load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 12% cooling efficiency increase, Guideline 36 control sequences, and fault detection.
- Alternative 6, focused on a cooling storage system, includes a 5% cooling efficiency increase, HVAC fault detection controls, and a central cooling storage system sized at 1.5 ton-hours storage per ton cooling design load.

Table 36. Energy Credit Packages for Education Buildings in Hot Climate Zones

Education Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	18	9	9							
H02	Heating Efficiency	x									
H03	Cooling efficiency	60	40		20					48	20
H05	Ground source HP	40						40			
H06	DOAS/fan control.	25									
H07	Guide 36 Sequence	4				4	4	4	4	4	
W01	SHW preheat recovery	1									
W02	Heat pump SW heater	2									
W03	Efficient gas SW heater	1									
W04	SHW pipe insulation	1					1				
W05	Point of use SW heaters	1	1	1			1				
W06	Thermo bal valves	1									
W09	Add occup.sensors	1									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	5			5				5		
L03	Add occup.sensors	5	5	5	5				5		
L04	Increase daylight area	14		7					14		
L06	Light power reduction	15	8	8	8	15	15				
R01	Renewable energy	65	13	13	13	33	20				
Q01	Efficient Elevator	4							4		
Q03	Fault detection	4		4	4	4	4	4	4	4	4
G01	Lighting load mgmt.	3							3		
G02	HVAC load mgmt.	6		6				6	6		
G03	Shading load mgmt.	14									
G04	Electric storage	26									
G05	Cooling storage	96									36
G06	SHW storage	8					8		8		
G07	Bldg mass / night flush	5									
Renewable + Load Mgmt (limited 60%)			13	19	13	30	28	6	17	0	30
Total Credits Achieved*			76	53	55	53	53	54	53	56	54
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.9.2 Education Moderate Climate Zone Credit Package Examples

Table 37 shows credits achieved for multiple options in a typical moderate climate zone for education buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes improved fenestration, a 10% cooling efficiency increase, point of use water heaters, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and HVAC load management.
- The minimum equipment efficiency package includes improved fenestration, point of use water heaters, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and HVAC load management.
- The package of measures used in the prototype models includes a 5% heating efficiency increase where needed, a 5% cooling efficiency increase where needed, lighting dimming and tuning, additional occupancy sensors, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.2 W/ft² of PV renewables with Guideline 36 sequences, point of use water heaters, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, heat pump water heaters for full load, SHW pipe insulation, thermostatic balancing valves, a 10% LPD reduction, 0.1 W/ft² of PV renewables, fault detection, and SHW storage for load management.
- Alternative 3, focused on a GSHP implementation, includes an 8% heating and cooling efficiency increase, 100% of building conditioning with GSHP, Guideline 36 sequences, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, fault detection, lighting load management, HVAC load management, and SHW storage for load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, fault detection, HVAC load management, and building mass with night flush.
- Alternative 6, focused on a cooling storage system, includes a 10% cooling efficiency increase, heat pump water heaters for full load, fault detection controls, HVAC load management, and a central cooling storage system sized at 1.0 ton-hours storage per ton cooling design load.

Table 37. Energy Credit Packages for Education Buildings in Moderate Climate Zones

Education Buildings Averages by general climate 3-5 Climate Zone		Mod CZ Avg Avail	Alternative Packages for Moderate Climate								
			CE Demo	Min Eff	Proto- type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 CI Stg
	Requirement	50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	42	21	21							
H02	Heating Efficiency	6			2			3		6	
H03	Cooling efficiency	24	16		5			13		24	16
H05	Ground source HP	31						31			
H06	DOAS/fan control.	16									
H07	Guide 36 Sequence	2				2	2	2	2		
W01	SHW preheat recovery	2									
W02	Heat pump SW heater	3					3				3
W03	Efficient gas SW heater	3									
W04	SHW pipe insulation	1					1				
W05	Point of use SW heaters	2	2	2		2					
W06	Thermo bal valves	1					1				
W09	Add occup.sensors	2									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	7			7				7		
L03	Add occup.sensors	6		6	6				6		
L04	Increase daylight area	17							17		
L06	Light power reduction	19	10	10	19	19	19				
R01	Renewable energy	86	17	17	17	34	17				
Q01	Efficient Elevator	6									
Q03	Fault detection	2			2	2	2	2	2	2	2
G01	Lighting load mgmt.	3							3		
G02	HVAC load mgmt.	5	5	5					5	5	5
G03	Shading load mgmt.	14									
G04	Electric storage	35									
G05	Cooling storage	114									29
G06	SHW storage	8					8		8		
G07	Bldg mass / night flush	20								20	
Renewable + Load Mgmt (limited 60%)			22	22	17	30	25	0	16	25	30
Total Credits Achieved*			71	61	58	55	54	51	50	57	51
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.9.3 Education Cold Climate Zone Credit Package Examples

Table 38 shows credits achieved for multiple options in a typical cold climate zone for education buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes improved fenestration, additional occupancy sensors, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes improved fenestration, a 5% LPD reduction, 0.1 W/ft² of PV renewables, and HVAC load management.
- The package of measures used in the prototype models includes a 5% heating efficiency increase, a 5% cooling efficiency increase, lighting dimming and tuning, additional occupancy sensors, a 10% LPD reduction, 0.1 W/ft² of PV renewables, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.25 W/ft² of PV renewables with Guideline 36 sequences, additional occupancy sensors, a 10% LPD reduction, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, SHW pipe insulation, heat pump water heaters for the full load, SHW pipe insulation,

thermostatic balancing valves, a 5% LPD reduction, 0.15 W/ft² of PV renewables, fault detection, and SHW storage for load management.

- Alternative 3, focused on a GSHP implementation, includes 100% of building conditioning with GSHP, Guideline 36 sequences, and fault detection.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, lighting dimming and tuning controls, additional occupancy sensors, 10% more building area with daylight controls, fault detection, lighting load management, HVAC load management, and building mass with night flush.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% heating efficiency increase, a 15% cooling efficiency increase, Guideline 36 control sequences, fault detection, HVAC load management, and building mass with night flush.
- Alternative 7, focused on reduced heating, includes as needed UA reduction and lowered air leakage, a 15% heating efficiency increase, Guideline 36 control sequences, and fault detection.

Table 38. Energy Credit Packages for Education Buildings in Cold Climate Zones

Education Buildings Averages by general climate 6-8 Climate Zone		Cold CZ Avg Avail	Alternative Packages for Cold Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 GSHP	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat
	Requirement	49	49	49	49	49	49	49	49	49	49
E01	Improved Envelope	50	25	25							24
H02	Heating Efficiency	20			7					20	20
H03	Cooling efficiency	13			4					13	
H05	Ground source HP	45						45			
H06	DOAS/fan control.	8									
H07	Guide 36 Sequence	3				3	3	3	3	3	3
W01	SHW preheat recovery	3									
W02	Heat pump SW heater	6					6				
W03	Efficient gas SW heater	3									
W04	SHW pipe insulation	1					1				
W05	Point of use SW heaters	2									
W06	Thermo bal valves	1					1				
W09	Add occup.sensors	2									
P01	Energy monitoring	3									
L02	Lighting dim & tuning	5			5				5		
L03	Add occup.sensors	5	5		5	5			5		
L04	Increase daylight area	14							14		
L06	Light power reduction	16	8	8	16	16	8				
R01	Renewable energy	66	13	13	13	33	20				
Q01	Efficient Elevator	5									
Q03	Fault detection	3			3	3	3	3	3	3	3
G01	Lighting load mgmt.	3							3		
G02	HVAC load mgmt.	4		4					4	4	
G03	Shading load mgmt.	13									
G04	Electric storage	30									
G05	Cooling storage	55									
G06	SHW storage	8					8				
G07	Bldg mass / night flush	18							18	18	
Renewable + Load Mgmt (limited 60%)			13	17	13	30	28	0	25	22	0
Total Credits Achieved*			52	51	54	57	50	51	55	61	50
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
*Totals may not sum due to rounding											

5.10 Warehouse Building Applicability

Several alternative packages are reviewed for warehouse buildings. The general package types, tables, and assumed measures are described in Section 4.4, with narrative package descriptions included along with a scoring table for hot, moderate, and cold climate zones. Table 39 shows the credits available for applicable measures in warehouse buildings, with higher scoring measures shaded a darker green. Measures are described in detail in Section 6.0.

Table 39. Energy Credits Required and Available for Warehouse

ID	Energy Credit Abbreviated Title	Climate Zone																		
		0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
	Building Requirement	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	12	12	13	13	14	16	16	17	20	16	18	18	17	18	18	15	17	15	14
H02	Heating Efficiency	x	x	x	x	x	x	15	3	x	42	18	24	63	39	21	72	54	69	72
H03	Cooling efficiency	39	39	27	30	21	18	9	12	3	3	6	x	3	3	x	x	x	x	x
H07	Guide 36 Sequence	3	3	2	3	2	2	2	2	1	3	2	2	4	3	2	4	3	4	4
W01	SHW preheat recovery	2	2	3	2	3	3	3	3	4	3	3	3	2	3	3	2	2	2	2
W02	Heat pump SW heater	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
W03	Efficient gas SW heater	1	1	1	1	2	2	2	2	2	1	2	2	1	2	2	1	1	1	1
W06	Thermo bal valves	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P01	Energy monitoring	5	5	6	6	6	6	6	6	6	5	6	6	5	6	6	6	6	6	6
L03	Add occup.sensors	6	6	7	6	7	7	7	7	9	6	7	7	5	6	8	5	6	5	4
L04	Increase daylight area	60	56	72	64	72	72	68	72	84	56	68	68	48	60	68	44	56	48	40
L06	Light power reduction	28	28	34	32	34	34	32	36	38	26	32	34	22	28	34	22	28	22	20
R01	Renewable energy	132	123	162	147	168	186	156	201	216	114	192	135	84	147	126	72	99	72	57
Q01	Efficient Elevator	5	4	5	5	6	5	5	6	6	5	5	6	4	5	6	3	4	3	3
Q03	Fault detection	3	3	2	3	2	2	2	2	1	3	2	2	4	3	2	4	3	4	4
G01	Lighting load mgmt.	6	7	8	7	8	9	8	9	9	6	8	9	6	7	9	5	7	5	5
G04	Electric storage	66	68	80	70	82	78	80	86	98	68	80	84	58	68	84	44	56	46	48
G05	Cooling storage	160	60	160	128	160	160	128	160	68	48	104	16	20	48	4	12	28	x	x
G06	SHW storage	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
G07	Bldg mass / night flush	4	1	6	3	9	15	12	14	20	9	20	20	14	20	19	10	20	15	6
	Warehouse Available	194	189	202	195	198	196	196	197	203	199	198	201	208	205	199	208	210	209	200
	% required of available	26%	26%	25%	26%	25%	26%	26%	25%	25%	25%	25%	25%	24%	24%	25%	24%	24%	24%	25%

5.10.1 Warehouse Hot Climate Zone Credit Package Examples

Table 40 shows credits achieved for multiple options in a typical hot climate zone for warehouse buildings. The values shown represent the average credits for climate zones 0 through 2. The following packages are included:

- The demonstration package includes a 5% cooling efficiency increase, 10% more building area with daylight controls, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes additional occupancy sensors, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes a 10% cooling efficiency increase, additional occupancy sensors, a 10% LPD reduction, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.1 W/ft² of PV renewables with Guideline 36 sequences, 5% more building area with daylight controls, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, heat pump water heaters for 100% of load, thermostatic balancing valves, 5% more building

area with daylight controls, a 5% LPD reduction, fault detection, lighting load management, and SHW storage for load management.

- Alternative 3, focused on lighting implementation, includes additional occupancy sensors, 7% more building area with daylight controls, a 5% LPD reduction, and lighting load management.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, additional occupancy sensors, 7% more building area with daylight controls, efficient elevators, fault detection, lighting load management, and SHW storage for load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes improved envelope, a 15% cooling efficiency increase, Guideline 36 control sequences, fault detection, and SHW storage for load management.
- Alternative 6, focused on a cooling storage system, includes a 10% cooling efficiency increase, HVAC fault detection controls, and a central cooling storage system sized at 1.0 ton-hours storage per ton cooling design load.

Table 40. Energy Credit Packages for Warehouse Buildings in Hot Climate Zones

Warehouse Buildings Averages by general climate 0-2 Climate Zone		Hot CZ Avg Avail	Alternative Packages for Hot Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 Light	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	13								13	
H02	Heating Efficiency	x									
H03	Cooling efficiency	29	10		19					29	19
H07	Guide 36 Sequence	2				2	2		2	2	
W01	SHW preheat recovery	2									
W02	Heat pump SW heater	2					2				
W03	Efficient gas SW heater	1									
W06	Thermo bal valves	1					1				
P01	Energy monitoring	5									
L03	Add occup.sensors	6		6	6			6	6		
L04	Increase daylight area	66	33			17	17	23	23		
L06	Light power reduction	31	16	16	31		16	16			
R01	Renewable energy	153	31	31		31					
Q01	Efficient Elevator	5							5		
Q03	Fault detection	2			2	2	2		2	2	2
G01	Lighting load mgmt.	7					7	7	7		
G04	Electric storage	74									
G05	Cooling storage	138									35
G06	SHW storage	4					4		4	4	
G07	Bldg mass / night flush	6									
Renewable + Load Mgmt (limited 60%)			30	30	0	30	11	7	11	4	30
Total Credits Achieved*			89	52	59	51	50	52	50	50	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
*Totals may not sum due to rounding											

5.10.2 Warehouse Moderate Climate Zone Credit Package Examples

Table 41 shows credits achieved for multiple options in a typical moderate climate zone for warehouse buildings. The values shown represent the average credits for climate zones 3 through 5. The following packages are included:

- The demonstration package includes a 5% heating efficiency increase where needed, 10% more building area with daylight controls, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes additional occupancy sensors, a 5% LPD reduction, and a 5% increase in daylight area or 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes a 5% to 10% heating efficiency increase where needed, a 10% cooling efficiency increase, additional occupancy sensors, a 10% LPD reduction, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.1 W/ft² of PV renewables with Guideline 36 sequences, 5% more building area with daylight controls, and fault detection.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, heat pump water heaters for 100% of load, thermostatic balancing valves, 5% more building area with daylight controls, a 5% LPD reduction, fault detection, lighting load management, and SHW storage for load management.
- Alternative 3, focused on lighting implementation, includes additional occupancy sensors, 7% more building area with daylight controls, a 5% LPD reduction, and lighting load management.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, additional occupancy sensors, 10% more building area with daylight controls, fault detection, lighting load management, and SHW storage for load management.
- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 15% cooling and heating efficiency increase, fault detection, and building mass with night flush.
- Alternative 6, focused on a cooling storage system, includes a 10% cooling efficiency increase, 5% more building area with daylight controls, fault detection controls, and a central cooling storage system sized at 2.0 ton-hours storage per ton cooling design load.

Table 41. Energy Credit Packages for Warehouse Buildings in Moderate Climate Zones

Warehouse Buildings Averages by general climate 3-5 Climate Zone		Mod CZ Avg Avail	Alternative Packages for Moderate Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 Light	Alt 4 Ctrl	Alt 5 HVAC	Alt 6 Cl Stg
	Requirement	50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	17									
H02	Heating Efficiency	28	9		10					28	
H03	Cooling efficiency	5			2					5	3
H07	Guide 36 Sequence	2				2	2		2		
W01	SHW preheat recovery	3									
W02	Heat pump SW heater	2					2				
W03	Efficient gas SW heater	1									
W06	Thermo bal valves	1					1				
P01	Energy monitoring	5									
L03	Add occup.sensors	6		6	6			6	6		
L04	Increase daylight area	65	33	16		16	16	23	33		16
L06	Light power reduction	31	16	16	31		16	16			
R01	Renewable energy	152	30	30		30					
Q01	Efficient Elevator	5									
Q03	Fault detection	2			2	2	2		2	2	2
G01	Lighting load mgmt.	7					7	7	7		
G04	Electric storage	78									
G05	Cooling storage	66									33
G06	SHW storage	4					4		4		
G07	Bldg mass / night flush	19								19	
Renewable + Load Mgmt (limited 60%)			30	30	0	30	11	7	11	19	30
Total Credits Achieved*			88	68	51	51	50	52	54	54	52
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.10.3 Warehouse Cold Climate Zone Credit Package Examples

Table 42 shows credits achieved for multiple options in a typical cold climate zone for warehouse buildings. The values shown represent the average credits for climate zones 6 through 8. The following packages are included:

- The demonstration package includes a 5% heating efficiency increase where needed, 5% more building area with daylight controls, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The minimum equipment efficiency package includes additional occupancy sensors, 5% to 10% more building area with daylight controls, a 5% LPD reduction, and 0.1 W/ft² of PV renewables.
- The package of measures used in the prototype models includes a 5% heating efficiency increase, additional occupancy sensors, a 10% LPD reduction, and fault detection.
- Alternative 1, focused on maximizing renewable PV installation, includes 0.2 W/ft² of PV renewables with 10% more building area with daylight controls.
- Alternative 2, focused on maximizing SHW efficiency, includes Guideline 36 sequences, heat pump water heaters for 100% of load, thermostatic balancing valves, 16% more building area with daylight controls, fault detection, and SHW storage for load management.
- Alternative 3, focused on lighting implementation, includes additional occupancy sensors, about 7% more building area with daylight controls, a 10% LPD reduction, and lighting load management.
- Alternative 4, focused on maximizing control improvements, includes Guideline 36 control sequences, additional occupancy sensors, about 8% more building area with daylight

controls, fault detection, lighting load management, SHW storage for load management, and building mass with night flush.

- Alternative 5, focused on maximizing HVAC efficiency improvements, includes a 10% heating efficiency increase, Guideline 36 control sequences, and fault detection.
- Alternative 7, focused on reduced heating, includes as needed UA reduction and lowered air leakage, a 10% heating efficiency increase, and fault detection.

Table 42. Energy Credit Packages for Warehouse Buildings in Cold Climate Zones

Warehouse Buildings Averages by general climate 6-8 Climate Zone		Cold CZ Avg Avail	Alternative Packages for Cold Climate								
			CE Demo	Min Eff	Proto-type	Alt 1 PV	Alt 2 SHW	Alt 3 Light	Alt 4 Ctrl	Alt 5 HVAC	Alt 7 Heat
Requirement		50	50	50	50	50	50	50	50	50	50
E01	Improved Envelope	15									8
H02	Heating Efficiency	66	22		22					44	44
H03	Cooling efficiency	x									
H07	Guide 36 Sequence	3					3		3	3	
W01	SHW preheat recovery	2									
W02	Heat pump SW heater	2					2				
W03	Efficient gas SW heater	1									
W06	Thermo bal valves	1					1				
P01	Energy monitoring	6									
L03	Add occup.sensors	5		5	5			5	5		
L04	Increase daylight area	47	12	18		24	38	16	19		
L06	Light power reduction	23	12	12	23			23			
R01	Renewable energy	75	15	15		30					
Q01	Efficient Elevator	3									
Q03	Fault detection	3			3		3		3	3	3
G01	Lighting load mgmt.	5						5	5		
G04	Electric storage	48									
G05	Cooling storage	20									
G06	SHW storage	4					4		4		
G07	Bldg mass / night flush	12							12		
Renewable + Load Mgmt (limited 60%)			15	15	0	30	4	5	21	0	0
Total Credits Achieved*			61	50	53	54	51	50	51	50	55
Meets Requirement			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

*Totals may not sum due to rounding

5.11 Other Building Applicability

Other buildings not previously discussed have a reduced requirement of 50% of the average energy credits required for the named building types. Their available credits are the full average of other building type credits. Select measures appropriate for the building type.

6.0 Measures to Achieve Credits

Each of the energy credit measures included in Standard 90.1-2022 is described with the following information:

- The modifications to the building required to achieve the credit
- In some cases, the limitations on the measure
- How the measure saves energy compared to the prescriptive baseline
- What the measure applicability is to different buildings
- How the measure relates to the measures included in C406 of the 2021 IECC

6.1 Energy Credit Measure Types

Multiple measure types are included in Standard 90.1-2022 Section 11:

- Energy efficiency measures that directly reduce the energy use of a building through reduced loads, improved efficiency, improved system configuration, or improved controls.
- Renewable energy measures that reduce the energy impact of the building through local energy generation, such as PV electrical generation systems or solar water heating systems that offset local building energy use.
- Load management measures that shift building electrical loads and support the effective utilization of renewable and low carbon generation sources on the electric grid.

In the requirements, renewable and load management credits are limited in their use to meet requirements to avoid diluting the impact of energy efficiency measures.

6.1.1 Energy Efficiency Measures

The credit energy efficiency measures included in Standard 90.1 were identified from lists of energy saving measures recognized as being effective for new construction and major renovation projects. The major difference between baseline prescriptive requirements and energy credit measures is that baseline requirements must be applicable to almost all buildings. As a result, there is a limit on the level of energy efficiency that can be achieved. Because the selection of energy credit measures is flexible, the credit approach supports achieving deeper energy savings. For example, lower solar heat gain coefficient (SHGC) glass reduces solar heat gain in commercial buildings, saving cooling energy. Prescriptive SHGC requirements may be set higher than cost effective to allow for flexibility in building design. As a result, there is a limit to how low SHGC requirements are set for the baseline prescriptive requirement. This allows for flexibility in design. Since there are lower SHGC products available, energy credits can account for their use; however, if a particular design includes the baseline prescriptive SHGC product, the designer can choose some other energy credit measure, like increased cooling efficiency or added insulation in exterior walls, to achieve similar savings.

Energy efficiency credits were sourced from advanced building guidelines like the Advanced Energy Design Guidelines (ASHRAE 2019), prescriptive energy code requirements in general, measures in utility new construction programs, green building programs, and other building industry documentation to arrive a list of potential measures. The measures build on existing measures that were previously developed (Hart et al. 2019) and include measures considered

by other code development groups including the State of Washington technical review committee. Table 43 lists the energy efficiency measures included in Standard 90.1 and shows how they relate to measures in the 2021 IECC Section C406.

Table 43. Energy Efficiency Credit Measures

ID	90.1 Section	Measure Name	IECC 2021
E01	11.5.2. 1	Envelope performance (90.1 Appendix C basis)	
H01	(11.5.2.2.1)	HVAC performance (TSPR) [Future]	
H02	11.5.2.2.2	Heating efficiency	C406.2.1-3
H03	11.5.2.2.3	Cooling efficiency	C406.2.2-4
H04	11.5.2.2.4	Residential HVAC control	
H05	11.5.2.2.5	DOAS/fan control	C406.6
W01	11.5.2.2.6	SHW preheat recovery	C406.7.2
W02	11.5.2.3.1 a	Heat pump water heater	C406.7.4
W03	11.5.2.3.1 b	Efficient gas water heater	C406.7.3
W04	11.5.2.3.1 c	SHW pipe insulation	
W05	11.5.2.3.2	Point of use water heaters	
W06	11.5.2.3.3 a	Thermostatic balancing valves	
W07	11.5.2.3.3 b	SHW submeters	
W08	11.5.2.3.4	SHW distribution sizing	
W09	11.5.2.3.5	SHW shower drain heat recovery	
P01	11.5.2.3.6	Energy monitoring	C406.10
L01		Lighting performance	
L02	11.5.2.5.2	Lighting dimming & tuning	C406.4
L03	11.5.2.5.3	Increase occupancy sensor	
L04	11.5.2.5.4	Increase daylight area	
L05	11.5.2.5.5	Residential light control	
L06	11.5.2.5.6	Lighting power reduction	C406.3.1-2-3
Q01	11.5.2.7.1	Efficient elevators	
Q02	11.5.2.7.2	Efficient commercial kitchen equipment	C406.12
Q03	11.5.2.7.3	Fault detection and diagnosis	C406.11

6.1.2 Renewable and Load Management Credit Measures

There are several load management measures in this proposal, which are listed in Sections 3.8 and 3.9. For reference, in the IECC, the renewable measure was previously included with the 2021 IECC credit measures; however, the load management measures are not included in the 2021 IECC. Renewable and load management measures included in Standard 90.1 include:

- R01: On-Site Renewable Energy (2021 IECC Section C406.5; 90.1 Section 11.5.2.6)
- G01: Lighting load management (90.1 Section 11.5.2.8.1)
- G02: HVAC load management (90.1 Section 11.5.2.8.2)
- G03: Automated shading (90.1 Section 11.5.2.8.3)
- G04: Electric energy storage (90.1 Section 11.5.2.8.4)
- G05: Cooling energy storage (90.1 Section 11.5.2.8.5)

- G06: SHW energy storage (90.1 Section 11.5.2.8.6)
- G07: Building thermal mass (90.1 Section 11.5.2.8.7)

6.2 Building Envelope Energy Measures

Improvements to the building envelope can achieve energy credits through the envelope performance (E01).

6.2.1 E01: Envelope Performance (90.1 Appendix C)

Envelope performance captures savings from multiple improvements in the building envelope:

- Increased insulation reduces heat loss and gain, reducing HVAC energy use.
- Improved glazing reduces energy use through any of the following:
 - Lower U-factor results in less heat transfer, reducing HVAC energy.
 - Lower SHGC reduces heat gain, saving cooling.
 - Increased glazing visual transmittance allows more daylight, reducing lighting where there are daylight controls.
 - A reduced window area generally provides savings.
- Lower reflectivity reduces cooling loads in warm climates.
- Better air barriers reduce outdoor air leakage into the building, reducing HVAC energy.

While these general improvements usually save energy, in some cases they may not. All of these impacts can be modeled in the Standard 90.1 Appendix C methodology that is accessible in COMcheck. The input to model these changes is the same as needed to verify compliance with the prescriptive requirements. There are two advantage to using that model for envelope changes:

- It accounts for the different internal loads of different occupancy types.
- It is already used in COMcheck if there are envelope tradeoffs.

This measure is applicable to all building use types. Compared to the 2021 IECC, this is a new measure and an alternative to the UA reduction and air leakage reduction energy credits in the IECC.

6.3 HVAC Energy Measures

Improvements to the building HVAC system can achieve energy credits either through the HVAC performance measure (H01) or a combination of other HVAC measures (H02-H03 and H05). The residential HVAC control (H04) and DOAS (H05) measures can be completed independently or in conjunction with other HVAC measures.

6.3.1 H01: HVAC Performance (TSPR) (Reserved¹)

Measure H01 requires the installation of HVAC equipment efficiency improvements and distribution system design upgrades that match the inputs to the HVAC performance analysis. It is flexible and credits can be achieved when the total system performance ratio (TSPR) of the proposed HVAC system is greater than the TSPR of a target system. This measure relies on Normative Appendix J in Standard, that includes the TSPR methodology. Multiple HVAC system changes can be included, including the following:

- Improved heating or cooling equipment efficiency, including packaged units, chillers, heat rejection, and boilers
- Reduced fan energy due to better ductwork design, better fan selection or fan drive and motor efficiency, and improved fan controls
- Reduced pumping energy due to better piping design, better hydronic configuration, better pump selection or pump motor and drive efficiency, and improved pump controls
- Separate management of ventilation air including energy recovery, low DOAS fan power, demand controlled ventilation, energy recovery bypass, or improved delivery effectiveness
- Improved energy recovery opportunities, including ground loop systems and other energy recovery systems

Measure H01 saves energy by increasing the overall delivered heating and cooling relative to the total energy input to the HVAC system, when compared to a target HVAC system that is selected from available prescriptive systems.

This measure is applicable to all building use types for which TSPR capability has been developed. These include multifamily, hotel/motel, office, retail, and education. To avoid duplicate credits, measure H01 cannot be used in combination with measures H02, H03, H05, or H06 since savings from those measures can be included in measure H01. H02: Heating Efficiency

6.3.2 H02: Heating Efficiency

Measure H02 requires the installation of more efficient heating equipment than required by the minimum HVAC efficiency requirements. Examples of such improvements include:

- Replacing a standard furnace or boiler with a condensing furnace or boiler
- Including a heat pump with a higher heating seasonal performance factor or heating coefficient of performance than the minimum heat pump heating efficiency requirements

Measure H02 does not provide credit for system type or fuel switches, such as from a furnace to a heat pump or from electric resistance heat to a heat pump. For such system comparisons,

¹ Measure H01 uses the alternative HVAC system performance path added to Appendix L of Standard 90.1-2022; however the measure is not included in the 2022 edition of Standard 90.1. At the time of this publication, the addition of measure was out for public review consideration and could become part of Standard 90.1 through continuous maintenance.

H01 (TSPR) can be used (when available) or H05 for the specific case of a ground source heat pump. In H01, the proposed system is compared to a preset target system for the building type.

Measure H02 saves energy by increasing the overall delivered heating relative to the heating energy input to the HVAC system, when compared to the minimum heating efficiency required in the prescriptive energy code for the proposed heating equipment.

This measure is applicable to all building use types. Compared to the 2021 IECC, this matches existing measures with some modification. For H02, the credits are based on a minimum efficiency improvement of 5% and credits can be adjusted to reflect an efficiency improvement of up to 20%. This replaces both the 5% and 10% heating efficiency improvement measures in the 2021 IECC. H02 will be an alternative to the HVAC performance (H01) energy credits when available.

6.3.3 H03: Cooling Efficiency

Measure H03 requires the installation of cooling or heat rejection equipment that is more efficient than the minimum HVAC efficiency requirements. Examples of such improvements include:

- Replacing a standard AC unit or chiller (including heat rejection equipment with water-cooled chillers) with a higher efficiency AC unit or chiller plus heat rejection equipment
- Including an evaporative assist device for air-cooled equipment where the efficiency improvement of the cooling equipment efficiency can be documented seasonally.
- Measure H03 does not provide credit for system type switches, such as from an air-cooled chiller to a water-cooled chiller, or from packaged units to variable air volume hydronic units. For such system comparisons, H01 (TSPR) can be used instead, when available. In H01, the proposed system is compared to a preset target system for the building type.

Measure H03 saves energy by increasing the overall delivered cooling relative to the cooling energy input to the HVAC system, when compared to the minimum cooling efficiency required in the prescriptive energy code for the proposed cooling equipment.

This measure is applicable to all building use types. Compared to the 2021 IECC, this matches existing measures with some modification. For H03, the credits are based on a minimum efficiency improvement of 5% and credits can be adjusted to reflect an efficiency improvement of up to 20%. This replaces both the 5% and 10% cooling efficiency improvement measures in the 2021 IECC. It will be an alternative to the HVAC performance (H01) energy credits when available.

6.3.4 H04: Residential HVAC Control

Measure H04 requires the installation of a centralized HVAC setback control in multifamily buildings. The controls will relax temperature setpoints when occupants are away from their apartments. Alternative approaches to such controls include:

- A main manual control by each dwelling unit main entrance that initiates setback and non-ventilation mode for all HVAC units serving the dwelling unit and is clearly identified as “Heating/Cooling Master Setback.”

- Occupancy sensors in each room of the dwelling unit combined with a door switch to initiate setback and non-ventilation mode for all HVAC units in the dwelling within 20 minutes of a door switch operation, followed by all spaces being vacant. Where separate room HVAC units are used, individual occupancy sensors are adequate.
- An advanced learning thermostat that senses occupant presence, automatically creates a schedule for occupancy, and provides a dynamic setback schedule based on when the spaces are generally unoccupied. Where ventilation is provided by a separate system, it shall also have occupancy sensor control.

Measure H04 saves energy by reducing the temperature difference between interior HVAC setpoint and outdoor conditions, resulting in reduced heating and cooling system operation. In addition, ventilation outdoor air is curtailed when the space is unoccupied, resulting in less heating and cooling of outdoor air.

This measure is applicable only to the multifamily building use type. Compared to the 2021 IECC, this is a new measure. It is allowed in conjunction with either the HVAC performance (H01) energy credits or other HVAC credits (H02, H03, H05).

6.3.5 H05: Ground Source Heat Pump

Measure H05 requires installation of a ground source loop or other water source loop to serve individual zone water-to-air heat pumps that provide heating and cooling. To match typical system design approaches, the simulated bore field is sized to handle the cooling load for about 90% of the operating hours that typically provides half the peak cooling load. When cooling loads are higher, a dry fluid cooler is used to reject heat.

Measure H06 saves energy primarily by using a moderately high efficiency zone cooling device that rejects heat to an earth ground sink. In addition, there are savings through reduced fan energy use with a distributed zone fan system that has relatively short duct runs.

This measure is applicable to all building use types except warehouse, as GSHPs are rarely used in warehouses. Compared to the 2021 IECC, this is a new measure. It is allowed in conjunction with other HVAC credits (H02, H03, H06).

6.3.6 H06: DOAS/Fan Control

Measure H06 requires the installation of local zone or central DOAS sized to provide the minimum outdoor air ventilation requirements. The DOAS is equipped with an energy recovery device providing a 65% enthalpy recovery ratio. An energy recovery bypass is required for a DOAS serving multiple zones.

Measure H05 does not provide credit for zone heating and cooling system type switches, such as from a packaged terminal air conditioner to a fan coil or from packaged units to variable air volume hydronic units. For such system comparisons, use H01, TSPR, instead. In H01, the proposed system is compared to a preset target system for the building type.

Measure H05 saves energy primarily by reducing the fan energy use of the zone heating and cooling system, since it can be shut down in the deadband when neither heating nor cooling is required. In addition, there are savings through use of energy recovery to preheat or precool outside air.

This measure is applicable to health, office, retail, and education building use types. It is not applicable to the following building types: (1) multifamily, as their fans are typically in cycling mode; (2) lodging, as guest room HVAC shutoff controls are already required; (3) restaurant, as the measure is superseded by transfer air used for exhaust; and (3) warehouse, as ventilation requirements are too low and fans are typically set in cycling mode.

Compared to the 2021 IECC, this is a modification of an existing measure. The modifications include a specified energy recovery specification in addition to zone unit fan control not required in the existing measure. It is an alternative to the HVAC performance (H01) energy credits.

6.3.7 H07: Guideline 36 Sequence of Operations

Measure H07 requires the specified HVAC controls sequence of operations be in accordance with ASHRAE Guideline 36, *High-Performance Sequences of Operation for HVAC Systems*.

Measure H07 saves energy in two ways: First, the sequences are more integrated with an eye toward energy efficient operation. Second, because they are based on a common industry-wide guideline, the sequences are more likely to be applied and previously quality checked in multiple installations, resulting in better interlocks and more robust operation.

Measure H07 is applicable only in HVAC systems that include at least one of the following: a variable air volume air handler serving at least five zone terminals, a chilled-water plant with at least two chillers, or a hot-water plant with at least two boilers or heat pumps.

This measure is unique in 90.1 and is not currently included in the IECC.

6.4 Service Hot Water Energy Measures

SHW energy use can be reduced through a combination of measures. These include more efficient hot water generation, energy recovery, reducing hot water use, reducing the heat loss in hot water distribution systems, and metering multifamily hot water use. The energy credits allowed vary with the typical hot water use patterns of the different building types. The first three efficiency improvement credits (W01, W02, and W03) improve SHW generation efficiency. For systems with recirculation, there is a choice of W05 or W06. Other measures have specific building applications.

6.4.1 W01: SHW Preheat Recovery

Measure W01 requires the installation of SHW preheat recovery devices that recover heat from chiller system heat rejection, kitchen drain water, site-based renewable systems, refrigeration systems, or some other heat source. The system preheats entering cold water and reduces the use of non-renewable energy sources for annual SHW heating by between 30% and 80%.

Measure W01 saves energy primarily by reducing the electric or fossil fuel used to heat SHW by using waste or renewable heat to preheat the cold water entering the system.

This measure is applicable to all building use types, although it is usually practical only where a chiller is used. Compared to the 2021 IECC, this is a modification of an existing measure. It can be combined with other SHW efficiency (W02 or W03) energy credits. It can be combined with appropriate minimum equipment efficiency SHW (W04 through W09) energy credits.

6.4.2 W02: Heat Pump Water Heater

Measure W02 requires the installation of an air-source heat pump water heater system sized to meet 50% of the design water heating requirement. The system includes either an integrated or separate hot water storage tank with a pump. In recirculating hot water distribution systems, there is typically a separate gas or resistance electric heater to reheat the circulated water for temperature maintenance in periods of low demand.

Measure W02 saves energy primarily by using a more efficient heat pump system rather than electric resistance or combustion heating. The system heats entering cold water and reduces the use of non-renewable energy sources for annual SHW heating by between 30% and 80%.

This measure is applicable to all building use types. Compared to the 2021 IECC, this is a modification of an existing measure. It can be combined with other SHW efficiency (W01 or W03) energy credits. It can be combined with appropriate minimum equipment efficiency SHW (W04 through W09) energy credits.

6.4.3 W03: Efficient Gas Water Heater

Measure W03 requires the installation of a gas water heater with higher efficiency than the minimum prescriptively required. A condensing water heater is required to meet the efficiency increase to 95%.

Measure W03 saves energy primarily by reducing the gas energy used to provide the same water heating. Using a condensing water-heating coil, the exhaust gas temperature is lower than a conventional gas water heater, transferring that additional heat to the heated water.

This measure is applicable to all building use types. Compared to the 2021 IECC, this is a modification of an existing measure. It can be combined with other SHW efficiency (W01 or W02) energy credits. It can be combined with appropriate minimum equipment efficiency SHW (W04 through W09) energy credits.

6.4.4 W04: SHW Pipe Insulation

Measure W04 requires the installation of additional pipe insulation beyond the minimum required prescriptively.

Measure W04 saves energy primarily by reducing the heat loss from piping delivering the SHW or recirculating the SHW for temperature maintenance.

This measure is applicable to office, health, multifamily, lodging, and education building use types that typically have extensive hot water distribution systems. The other building types typically do not have recirculation systems and savings are quite limited. Compared to the 2021 IECC, this is a new measure. It is allowed in combination with other SHW efficiency (W02 and W03) energy credits.

6.4.5 W05: Point of Use Water Heaters

Measure W05 requires the installation of point of use water heaters with reduced piping lengths in buildings that typically use recirculation systems and a central water heater. An example of good application of a point of use water heater is a small electric water heater that serves a

cluster of restrooms. Exceptions are provided for showers and kitchens that have local water heaters that require recirculation for temperature maintenance.

Measure W05 saves energy primarily by reducing the heat lost from SHW piping in two ways:

- Recirculation piping for temperature maintenance along with its heat loss is eliminated.
- Supply piping length is reduced, along with a reduction in heat loss.

This measure is only applicable to office and education building use types where hot water use is relatively low and there are extensive distribution systems to deliver hot water to remote restrooms. Compared to the 2021 IECC, this is a new measure. It is one option that can be selected from the SHW distribution temperature maintenance energy credits (W05 and W06).

6.4.6 W06: Thermostatic Balancing Valves

Measure W06 requires the installation of thermostatic balancing valves for a recirculation system rather than manually adjusted or fixed-flow balancing valves. The valves are required to minimize the return water flow when the branch return temperature is greater than 120°F. These valves reduce the balancing labor compared with manual valves as they are self-balancing.

Measure W06 saves energy primarily by reducing the recirculation pipe temperature and associated heat loss. This is because actual temperature is measured rather than a constant flow delivered regardless of primary supply temperature or an estimate of flow required to maintain the desired temperature.

This measure is applicable to all building use types where there are recirculation systems. Compared to the 2021 IECC, this is a new measure. It is one option that can be selected from the SHW distribution temperature maintenance energy credits (W05, W06, and W07).

6.4.7 W07: SHW Submeters

Measure W07 requires the installation of separate dwelling unit SHW meters in multifamily buildings served by a central water heating system. A data collection and reporting system is also required.

Measure W08 saves energy primarily by allowing centrally heated SHW to be reported or billed to individual tenants, providing an incentive to reduce hot water use.

This measure is only applicable to multifamily building use types where there is some possibility of affecting hot water use behavior. Compared to the 2021 IECC, this is a new measure. It is allowed in combination with any other SHW efficiency energy credits.

6.4.8 W08: SHW Distribution Sizing

Measure W08¹ requires the installation of reduced flow sink, lavatory, and showerhead fixtures in buildings with residential occupancies. The hot water distribution system must also be sized

¹ As of May, 2023, this measure is undergoing revision to change the shower flow reduction requirement in response to base plumbing code changes. The revised measure would also eliminate the requirement for hot water distribution downsizing, so it could be applicable to buildings that have separate water heaters for each dwelling unit.

in accordance with IAPMO/ANSI, *WE•Stand – 2017 Water Efficiency and Sanitation Standard for the Built Environment* (IAPMO 2017) Appendix C. This standard is an alternative path for sizing multifamily SHW systems and is recognized in some plumbing codes. Using this method for hotel guest room hot water piping would require a plumbing variance.

Measure W08 saves energy primarily by reducing the SHW end use and by reducing the piping size, and therefore heat loss, of the SHW distribution piping.

This measure is applicable to multifamily and lodging building use types that have a large number of dwelling units or sleeping units. Compared to the 2021 IECC, this is a new measure. It is allowed in combination with any other SHW efficiency energy credits.

6.4.9 W09: SHW Shower Drain Heat Recovery

Measure W09 requires the installation of shower drain heat recovery devices used to preheat the cold water serving showers.

Measure W09 saves energy primarily by reducing the volume of hot water used for showering, since the cold water is warmer and less hot water is required to achieve the same mixed shower water temperature.

This measure is applicable to multifamily, lodging, and schools. Other buildings do not have enough shower use to provide adequate savings. Compared to the 2021 IECC, this is a new measure. It is allowed in combination with any other SHW efficiency energy credits.

6.5 Power

The power energy credit measure acknowledges the potential for improved operation for energy monitoring where not required prescriptively.

6.5.1 P01: Energy Monitoring

Section 10 of Standard 90.1 requires energy monitoring in non-residential buildings 25,000 ft² and larger. Measure P01 provides an energy credit where similar electrical monitoring is installed in smaller buildings. This equipment is much less expensive to install in new construction than to retrofit into existing buildings.

Measure P01 empowers tenants and operating staff to save energy by providing detailed energy use information so they can note excess energy use at times when the building is unoccupied and should have low energy use or where there is increased energy use over time due to degradation of energy system controls or equipment.

This measure is applicable to all building use types where it is not already required by Section 10.4.7 of Standard 90.1., P01 is essentially the same as an existing measure in the 2021 IECC.

6.6 Lighting Energy Measures

Lighting energy credit measures either reduce lighting power installed or improve the controls compared to prescriptive requirements.

6.6.1 L01: Lighting Performance (Reserved)

Measure L01¹ is an alternative lighting performance path that is under development. The method combines lighting power reduction and lighting controls into a comprehensive interior lighting approach that considers interaction of all possibilities. When available, it would provide a more comprehensive performance alternative to L02, L03, L04, and L06.

The measure would be applicable to all building types included in the lighting performance path. This measure is not in the 2021 IECC.

6.6.2 L02: Lighting Dimming & Tuning

Measure L02 requires the installation of dimming lighting systems with central and zonal controls and an intentional high-end trim adjustment commissioning process for at least half the building floor area or lighting power.

Measure L02 saves energy by tuning the light levels in different spaces more specifically to the tasks performed in those spaces. This reduces the initial maximum light output to best match the visual needs in the task space. Additionally, lighting is often designed for higher initial lighting levels to compensate for luminaire output depreciation over time. The capability to manually or automatically tune lighting output over time to maintain task level illumination allows the added depreciation compensation power to be saved.

This measure is applicable to all building types except warehouses that are unlikely to have dimming systems. Compared to the 2021 IECC, this is a modification of an existing measure. It can be applied in conjunction with other lighting energy credits, excluding L03 and possibly the future lighting performance credit (L01), depending on how the final implementation of the lighting performance measure related to zonal tuning is established. This measure is more stringent than the current measure through the addition of tuning that provides reliable energy savings.

6.6.3 L03: Increase Occupancy Sensor Control Area

Measure L03 requires the installation of full off occupancy sensor controls where time controls are allowed by the prescriptive path. This allows the lighting system to respond to actual occupancy rather than time control that is often set for the most expansive scheduled use of the space. Time controls require manual intervention to turn lighting on outside of scheduled times or to schedule special events, which frequently result in extended “on” periods.

Measure L03 saves energy by reducing lighting operation when lighting is not required, since the spaces are unoccupied. A prime example of this is custodial work performed after hours, where often the entire building or multiple floors are lit up via the time-scheduled controls, even though the work is occurring in a small area. A time control, or even a bypass switch, illuminates large areas of the building, whereas occupancy sensors control a small area where the work is actually occurring.

This measure is applicable to all building types except multifamily buildings, which have very few areas where occupancy sensors are suitable and are not already required. Compared to the

¹ L01 is not included as a measure in 90.1-2022 and will require a future addendum to be included with energy credits.

2021 IECC, this replaces and expands the enhanced digital lighting control measure. It can be applied in conjunction with some other lighting energy credits, including L04, L05, and L06.

6.6.4 L04: Increase Daylight Area

Measure L04 requires the installation of daylight responsive controls in space types beyond where they are typically required by current energy codes. So, if the building is arranged to provide more daylight area than typical, or controls are added to areas where the low wattage would otherwise exempt the area from daylight responsive controls, then credit is provided for increased daylight area.

Measure L04 saves energy by increasing the area where electrical lighting reductions can be achieved with daylight availability at satisfactory levels of illuminance required to perform visual tasks. This reduces the energy used for lighting and also reduces the energy used for cooling.

This measure is applicable to office, retail, warehouse, and education building use types. It is not applicable to multifamily and lodging buildings, as it is not suitable for apartments or guest rooms. Healthcare buildings and restaurants are not suitable for additional daylighting areas.

Compared to the 2021 IECC, this is a new measure. It can be applied in conjunction with other lighting energy credits, excluding the future lighting performance credit (L01).

6.6.5 L05: Lighting Control for Multifamily Buildings

Measure L05 requires the installation of a centralized master switch near apartment (dwelling unit) exits that can turn off the entire lighting in the unit with one or two switch operations. This can be achieved by wiring the lighting circuits through a central switch at the unit entrance. There is an additional requirement that there be two clearly identified switched receptacles in each room connected to the unit exit control. It is anticipated that these receptacles would be used for floor lamps or other task lighting. As a master switch, this does not require three-way or four-way switching. The measure can be implemented with traditional wiring or with wireless remote-control methods.

Measure L05 saves energy by making it easy for apartment occupants to turn off all lighting in an apartment when exiting the unit. This reduces lighting operation and also reduces cooling energy use, although it may increase heating energy use in colder climates.

This measure is applicable to multifamily building use types only. Transient lodging already has requirements for guest room lighting controls. Compared to the 2021 IECC, this is a new measure. It can be applied in conjunction with other lighting energy credits, possibly excluding the future lighting performance credit (L01).

6.6.6 L06: Lighting Power Reduction

Measure L06 requires that the LPD of the installed lighting system be at least 5% lower than the prescriptive lighting power allowance. This can be achieved through selection of higher efficacy luminaires or a better match of design fixture layout to space lighting requirements.

Measure L06 saves energy by reducing the lighting power required to meet minimum lighting levels.

This measure is applicable to all building use types. Compared to the 2021 IECC, this is a modification of two existing measures. Rather than listing separate 10% and 20% reductions, L06 is based on a 5% LPD reduction and can be adjusted up to a 10% LPD reduction (limited to two times the L06 base credit). It will be an alternative to the future lighting performance (L01) energy credits and may be replaced by that performance approach.

6.7 Equipment Energy Measures

This section includes measures for more efficient elevators and commercial kitchen equipment and improved fault detection.

6.7.1 Q01: Efficient Elevator

Measure Q01 requires the installation of higher efficiency elevator equipment than is typical. The requirement is for class A elevators based on ISO 25745-2. The level of efficiency according to this standard is required to be documented in Standard 90.1-2019, although there are no IECC requirements.

Measure Q01 saves energy by providing an increase in elevator energy efficiency, based on an international standard. The savings come through improved motor and traction efficiency, along with regeneration in some cases.

This measure is applicable to all building use types. Compared to the 2021 IECC, this is a new measure. It can be applied in conjunction with other energy credits.

6.7.2 Q02: Efficient Commercial Kitchen Equipment

Measure Q02 requires the installation of higher efficiency fryers and ovens that meet Energy Star specifications in commercial kitchens. In addition, other kitchen equipment installed before the occupancy permit is required to be more efficient in line with Energy Star specifications. When claiming this credit, other kitchen equipment is also required to be high efficiency.

Measure Q02 saves energy by reducing the energy used by kitchen equipment, primarily by reducing standby losses.

This measure is applicable to restaurants. Other buildings with commercial kitchens like schools or dormitories can receive credits for this measure by treating the dining and kitchen areas separately and using a weighted average of the separate building use credits. Compared to the 2021 IECC, this is an existing measure. It can be applied in conjunction with other energy credits.

6.7.3 Q03: Fault Detection

Measure Q03 requires the installation of a fault detection and diagnosis system. This system detects failures in HVAC system equipment and controls and reports them automatically to building operators.

Measure Q03 saves energy by noting where controls have failed and alerting building maintenance staff to the problem.

This measure is applicable to all building use types. Compared to the 2021 IECC, this is an existing measure. It can be applied in conjunction with other energy credits.

6.8 Renewable Energy Credit Measures

Site-based renewable energy is usually incorporated into a building with PV panels that produce electrical energy that is used by the building. In the hours when more electrical energy is produced than can be used in the building, the excess energy is typically transferred to the electrical grid through a net-metering arrangement or stored in batteries. The credit can also be achieved by installing other renewable measures, such as solar water heating panels that provide SHW or space heating. Wind power or geothermal sources that capture high-temperature telluric thermal energy can also be used.

6.8.1 R01: Renewable Energy

Measure R01 requires the installation of site-based renewable systems—typically PV panels—that use site-available solar energy sources to offset imported metered energy into the building. The measure can also be achieved through solar heating of pool or service hot water or other renewable energy technologies, like small wind power. The credit is provided for site-based renewable systems that exceed any other baseline onsite prescriptive requirements in Section 10.5.1 or other uses of site-based renewable energy to meet 90.1 exceptions to other provisions.¹

Measure R01 saves net energy (i.e., energy provided to the building by the grid) by using renewable energy to offset grid purchased energy.

This measure is applicable to all building use types. Compared to the 2021 IECC, this is a minor modification of an existing measure. Rather than being fixed at an installation requirement of 0.25 W/ft² of building area and having a separate measure to accommodate larger renewable installations, this measure starts at a minimum of 0.10 W/ft² of building area and allows linear expansion if a larger system is installed. The alternative annual savings method that is an option in the current IECC—which required a detailed analysis and review by the building official—is abandoned for 90.1 to reduce complexity.

6.9 Load Management Measures

Load management measures work in conjunction with an energy-efficient building to support grid reliability, use of low emission electricity generation, building owner cost savings, and occupant needs and preferences.

The electric grid is transitioning from being centralized, fossil fuel based, and relatively predictable to being more distributed and dynamic due to increasing levels of generation being contributed by variable, non-controllable distributed renewable energy resources. Load management measures provide behind-the-meter demand flexibility in support of a clean, reliant grid. Automated load management controls can be activated in response to an input signal based on demand response, dynamic price, time of use price, or building peak demand

¹ Modification to the baseline prescriptive renewable requirements is under consideration at the time of this publication. If adopted, there would likely be an additional renewable measure that provides credit for off-site renewable energy and further coordination with any modified baseline prescriptive requirements. Any such changes or additional measures would be adopted under continuous maintenance.

monitoring to reduce or shift electric demand and decrease electricity costs. Typically, such communication interfaces also support value-added cloud-based services that improve building operation through smart analytics, occupant comfort, room scheduling, and optimized space utilization.

Load management measures apply to building equipment and systems capable of storing energy or shifting building loads. These measures reduce building electric load during periods of high electric demand and high peak demand prices. They also help maximize the utilization of on-site renewable energy generation. Load management credit requirements address capabilities for load flexibility, controls, and operation sequences.

6.9.1 G01: Lighting Load Management

Measure G01 reduces electrical charges by directly reducing lighting levels and power by 20% using dimming during peak price or demand periods. It has been shown that occupants rarely notice light reduction levels up to 20% as long as they are dimmed gradually. Also, circadian rhythm impacts from lighting are not significant when this reduction occurs later in the afternoon, when price signals and building demand are generally high. LED technology has made dimming much less costly than it was for fluorescent fixtures. The lighting dimming control sequence requires integration with automated controls that interface with utility signals or local building demand monitoring software.

This measure is applicable to office, retail, warehouse, and education building use types. It is not applicable to multifamily and lodging buildings as it is not suitable for apartments or guest rooms. Healthcare buildings and restaurants are also not suitable for lighting adjustment in most areas.

6.9.2 G02: HVAC Load Management

Measure G02 requires that building-wide thermostats be reset during peak price periods, with heating reset during winter peak periods and cooling reset during summer peak periods. Preheating is engaged for the winter peaks that occur in the early morning, but cooling does not use pre-cooling. The thermostat setpoints are reset gradually by 3 °F (5 °C) over the peak period. Research has shown that rather than a fixed full step up in temperature, better peak reduction can be achieved with a gradual increase of about 2/3 of the setpoint shift over the first 1/3 of the peak period, with the remaining increase gradually over the last 2/3 of the peak period (Lee and Braun 2008). The HVAC setpoint adjustment control sequence requires integration with automated controls that interface with utility signals or local building demand monitoring software.

For systems serving multiple zones that also have an outdoor air ventilation requirement less than 70% of supply air, additional savings can be achieved by over-ventilating just before the summer peak period and then reducing ventilation during that peak period. This type of average ventilation is allowed under Standard 62.1. This ventilation shaving is not required for single zone packaged units or DOASs, and the controls cannot readily handle such a sequence.

This measure is applicable to office, retail, and education building use types. It is not applicable to multifamily and lodging buildings as it is not suitable to apartments or guest rooms. Healthcare buildings and restaurants are not suitable for temperature adjustment. Warehouses typically already have thermostat setpoints at the limit of the acceptable range.

6.9.3 G03: Automated Shading Load Management

Measure G03 provides automated external shades to reduce solar gain through fenestration during peak price hours. This credit can be met by exterior roller, movable blind, or movable shutter shading devices; however, fixed overhang, screen, or shutter shading will not meet the requirement. Roller shades that reject solar gain but still allow a view are credited as long as they provide an effective 50% reduction in net solar gain. Interior shading devices will not meet the requirement. In addition to automated shading devices, electrochromatic windows that achieve 50% of SHGC would qualify. This reduces the solar gain into the enclosed space, consequently reducing cooling loads and cooling equipment energy use during peak price periods. The automated shading devices require integration with automated controls that interface with utility signals or local building demand monitoring software.

This measure is applicable to all building use types except warehouses, which typically have a small window area and would not receive much benefit.

6.9.4 G04: Electric Energy Storage

Measure G04 requires installation of batteries, flywheels, or other electric storage devices. The storage devices require integration with automated controls that interface with utility signals or local building demand monitoring software. Electricity sourced either from renewable generation or from the grid during off-peak times is stored for release during the on-peak pricing periods.

This measure is applicable to all building use types.

6.9.5 G05: Cooling Energy Storage

Measure G05 requires either ice or chilled water cooling energy storage to be installed. Such storage allows generation of stored cooling medium at night when chilled water or ice is more efficiently produced. In addition, during peak price periods, stored cooling can be used rather than electrical cooling systems, reducing building electrical demand. An additional benefit of a cooling storage system is that the cooling plant size can be reduced, resulting in lower cost. The cooling storage system requires integration with automated controls that interface with utility signals or local building demand monitoring software.

This measure is applicable to all building use types, although it is more suited for larger buildings with chillers and chilled water systems.

6.9.6 G06: SWH Energy Storage

Measure G06 can be achieved with two alternate approaches:

- Provide additional hot water storage so that peak service water-heating requirements can be met without loading electrical hot water generation equipment.
- Preheat SHW above the required temperature and then shut off SHW electric generation equipment during peak price periods. This approach requires reliable automatic temperature mixing valves to assure that water delivered to building fixtures is at a safe temperature.

The SHW storage system requires integration with automated controls that interface with utility signals or local building demand monitoring software.

This measure is applicable to all building use types.

6.9.7 G07: Building Thermal Mass

Measure G07 requires two complementary components:

- Provide additional building mass exposed to the interior space so that peak cooling requirements can be met with less reliance on electrical cooling generation equipment.
- Include night flush logic to pre-cool the building at night when unoccupied. Such logic needs to avoid overcooling the building, resulting in morning heating, only operate fans when the outside air is cold enough to provide a net benefit, and operate at a lower fan speed to reduce fan energy use.

This measure saves energy more passively by extracting heat from the building at night during the unoccupied period using mass storage, and then removing heat from the building during the day when there are internal and solar heat loads. There is no actual OpenADR protocol required because the cooling loads are naturally reduced during peak price hours.

This measure is applicable to office, restaurant, retail, education, and warehouse building use types. It is not applicable to multifamily and lodging buildings as it is not adaptable to apartments or guest rooms. Healthcare buildings typically do not have unoccupied hours.

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