Pacific Northwest NATIONAL LABORATORY

PNNL-32001

Expanded Energy and Load Management Credits in Energy Codes

Technical Brief

October 2021

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U.S. DEPARTMENT OF ENERGY

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Pacific Northwest National Laboratory
Richland, Washington 99354

Preamble

The Department of Energy (DOE) and Pacific Northwest National Laboratory (PNNL) are developing a series of technical briefs supporting national, state, and local initiatives to update and advance building energy codes. These technical briefs represent specific technologies, measures, or practices that can be incorporated as module-based "plug-ins" via the national model energy codes, such as the International Energy Conservation Code or ASHRAE Standard 90.1 or can be adopted directly by state and local governments pursuing advanced energy savings and greenhouse gas emissions reductions. This collection of briefs is part of a larger effort to provide technical assistance supporting states and local governments and to help them realize their policy goals.

This technical brief provides additional energy efficiency measures that go beyond the current prescriptive commercial energy codes. It demonstrates relative savings for multiple measures and shows a base savings package by building type and climate zone that is cost effective for building owners and tenants. An advanced savings package is also shown. Potential building savings for the base efficiency package for different building types across climate zones range from 4% to 13% of building site energy (weighted average of 7%), while the advanced package building savings range from 7% to 25% (weighted average of 12%). Required renewable and load management measures add 1% to 10% of cost savings (weighted average of 7%). In addition to measure descriptions, this technical brief includes code language that can be adopted by local jurisdictions to implement these measures for new buildings.

Additional assistance may be available from DOE and PNNL to support states and local governments who are interested in adding energy credits and other "stretch" provisions to their building codes. Assistance includes technical guidance, customized analysis of expected impacts (e.g., based on state-specific building stock, climate considerations, or utility prices), and further tailored code language to overlay state building codes or other standards. DOE provides this assistance in response to the Energy Conservation and Production Act, which directs the Secretary of Energy to provide technical assistance "to support implementation of state residential and commercial building energy efficiency codes" (42 USC 6833). PNNL supports this mission by evaluating concepts for future code updates, conducting technical reviews and analysis of potential code changes, and assisting states and local jurisdictions who strive to adopt, comply with, and enforce energy codes. This helps assure successful implementation of building energy codes, as well as a range of advanced technologies and construction practices, and encourages building standards that are proven to be practical, affordable, and efficient.

DOE Building Energy Codes Program

DOE supports the advancement of building energy codes. Modern building codes and standards offer cost-effective solutions, contributing to lower utility bills for homes and businesses and helping mitigate the impacts of climate change. Learn more at energycodes.gov.

Executive Summary

In the 2021 International Energy Conservation Code, energy credit measures were expanded from selecting 1 of 8 alternate options to 15 available energy saving measures that can be flexibly selected to achieve a 2.5% level of energy savings. A similar package of measures has been proposed for ASHRAE Standard 90.1-2022, with 32 energy efficiency, renewable energy, and load management measures available. Building-type-specific targets were developed with a goal of 5% total energy cost savings.

This technical brief includes 37 energy efficiency measures, 1 renewable measure, and 7 load management measures. It builds on the former energy credit approaches with a base goal of around 7% energy savings. The energy efficiency credits here are based on site energy use and each credit represents 1/10 of 1% building energy use. Renewable and load management measures add cost savings based on grid cost impact represented by a time-of-use electric price structure. While measure goals vary by building type and climate zone, a national weighted goal is as follows:

- Base package of cost-effective efficiency measures achieves a weighted national average of 7.0% site energy savings.
- Advanced package of practical efficiency measures achieves a weighted national average of 12.4% site energy savings.
- Base package of cost-effective load management and renewable measures achieves an average of 7.3% utility cost savings.

If these measures are adopted nationally into energy codes, potential national savings for efficiency measures in expected new construction using various metrics would be as shown in Table E.1. The potential impact of load management and renewable measures is shown in Table E.2.

Table E.1. Potential Impact of Energy Efficiency Credit Measures

Metric	Units	Base Package	Advanced Package
National Annual Energy Savings	million site Btu	7,760,000	12,560,000
Consumer Annual Energy Cost Savings	million $US	$154.0m	$223.5m
Annual Emission Reductions, CO_2	metric tons	995,000	1,405,000

Table E.2. Potential Impact of Load Management and Renewable Credit Measures

Metric	Units	Base Package
Consumer Annual Energy Cost Savings	million $US	$158.2m

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1.0 Energy Credit Concept

Energy codes have traditionally contained *mandatory* and *prescriptive* items. Mandatory measures must be complied with in all situations while prescriptive measures can be traded with other efficiency measures by following either a whole-building or discipline 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; similar approaches are in several state building codes, and an energy credit proposal is currently undergoing public review for ASHRAE Standard 90.1 (ICC 2021, ASHRAE 2019a). This approach has the advantage of providing increasing levels of performance, while maintaining flexibility in allowing designers to optimize the most appropriate technologies and efficiency measures based on the attributes of each particular project.

1.1 Overall Summary

We discuss the benefits of energy credits, outline the code approach, review the analysis approach, and review cost effectiveness considerations.

1.1.1 Benefits of Energy Credits

In the 2021 IECC, energy credit measures were expanded from 8 alternate options to 15 measures that can be flexibly selected to achieve a 2.5% level of building energy cost savings. A similar package of measures has been proposed for ASHRAE Standard 90.1-2022, with 32 energy efficiency, renewable energy, and load management measures available. Building-type-specific targets were developed with a goal of 5% total energy cost savings.

This technical brief includes 37 energy efficiency measures, 1 renewable measure, and 7 load management measures. It builds on the former energy credit approaches with a base goal of around 7% energy savings. The energy efficiency credits here are based on site energy use and each credit represents 1/10 of 1% building energy use. Renewable and Load Management measures add cost savings based on grid cost impact represented by a time-of-use electric price structure. While measure goals vary by building type and climate zone, a national weighted goal is as follows:

- Base package of cost effective measures achieves a weighted national average of 7.0% site energy savings
- Advanced package of practical measures achieves a weighted national average of 12.4% site energy savings
- Base package of cost effective load management and renewable measures achieves an average of 7.3% utility cost savings

If these measures were adopted nationally into building codes, potential national savings for full implementation of energy efficiency measures in expected new construction—using various metrics—would be as shown in Table 1 while the cost savings impact of renewable and selected load management measures is shown in Table 2.

Table 1. Potential National Savings of Energy Efficiency Measures

Metric[a]	Units	Base Package	Advanced Package
National Annual Site Energy Savings	million Btu	7,760,000	12,560,000
Consumer Annual Energy Cost Savings	million $US	$154.0m	$223.5m
Annual Emission Reductions, CO_2	metric tons	995,000	1,405,000

(a) The values shown here are based on national average values. Custom results can be generated for states and local jurisdictions to support adoption of advanced code concepts.

Table 2. Potential National Savings of Renewable and Load Management Measures

Metric	Units	Base Package
Consumer Annual Energy Cost Savings	million $US	$158.2m

1.1.2 The Code Approach

Energy codes include mandatory requirements that all buildings must fulfill prescriptive requirements that can be used without following a performance path, and discipline[1] 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 can 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. Also, a parallel requirement for the renewable and load management credits is necessary when performance paths are used. These two issues are addressed in the proposed code language through modifications to Section C407.

1.1.3 Energy Credit Development

Energy credits have been developed from typical measures used in green building programs, new construction utility incentive programs, and Advanced Energy Design Guidelines (ASHRAE 2019b). More detail is included in Section 1.4.

1.1.4 Cost Effectiveness Considerations

While baseline prescriptive requirements usually undergo individual review for cost effectiveness, the approach for energy credit measures is different. Each 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 one package of measures is cost effective. More detail is included in Section 1.7.

[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.

1.2 Requirement Packages

The energy credit path is a prescriptive requirement. To establish requirements for different building types, a package of energy credit measures is selected by building type and climate zone. The packages are selected to demonstrate cost effectiveness. The base package is designed to be achievable across a broad range of building types and situations. The advanced package requires more measures, and consequently has fewer degrees of freedom for the designer.

While the base package is demonstrably cost effective and allows for a wide range of options, the advanced package is more constrained and may require consideration of the social cost of carbon or other non-energy benefits to be considered cost effective across a broad range of conditions. The base package can be adopted as a conservative move to increase energy code savings or be used as the first phase before adopting the advanced package in a later code cycle. In contrast to the base package, adoption of the requirement table values related to the advanced package is appropriate for jurisdictions that are seeking to maximize energy or emission reduction based on policy goals.

1.2.1 Base Package

The base package is selected with a goal of 7% total building energy savings as a weighted average and a 10% cap by building type. For some buildings or climate zones, this goal is not always practical, and the requirement is lower. For buildings with higher energy use, since the goal is a percentage of total building energy use, the result may be a smaller energy credit available for the same measure application and a similar absolute energy savings. Consequently, the credit requirement, based on percentage of building savings, may be smaller in high energy use buildings—typically those in hot and cold climates.

1.2.2 Advanced Package

The advanced package has savings that vary from 7.1% to 25.5% of total building energy use across building types and climate zones. While there are higher savings, there is a trade-off in reduced energy credit selection flexibility, since more measures must be included to get the higher credit result. The high end of the range of savings is based on installation of the same selected package of measures that is applied, even though for the requirement table the savings may be capped at 20% to allow for flexibility. If a jurisdiction wishes to adopt the advanced package, the base code language in Section 3.0 should be modified as described in Appendix A.

1.3 Technical Considerations

How does the proposed measure compare to what's required in current codes?

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). Sufficient measures must be included in the building design until at least 10 points are achieved. This increases building savings by about 2.5% compared with the base prescriptive path requirements.

This tech brief expands the number of measures in the 2021 IECC and distinguishes requirements based on building type and climate zone. The proposed requirements are similar to the energy credit section being considered for ASHRAE Standard 90.1. The energy credit points attributed to individual measures are determined from building simulation prototype analysis. The assigned points for each measure are based on relatively equivalent energy savings. Here the measure credits are based on energy savings rather than cost, as they were for 2021 IECC. Each efficiency measure credit equals 0.1% of total building energy use on a site British thermal unit basis. For example, a score of 10 credits represents a 1% energy reduction and a score of 100 credits represents a 10% reduction. Load management and renewable measure credits are based on cost savings, with a 1% cost reduction being equivalent to 10 credits.

Why is an energy efficiency credit assignment method superior to other approaches?

The extra efficiency credit approach provides compliance flexibility to designers and builders. 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 increased to about 7% savings for the base package. For advanced energy codes, a higher level of savings can be considered, which is reflected in the advanced package option.

In Figure 1, the credits for selected measures in an office building are plotted so the range of savings and resulting credit points for selected measures across climate zones can be seen. Renewable measures are shown for reference, even though they are not included with the code efficiency measures. Again, the y-axis point values are based on 1 energy credit point representing 0.1% savings of total building energy use at the site, so 10 credits equal 1.0% site energy savings. The determination of credits is based on prototype building analysis in the specified climate zone as described in Section 1.6. Figure 2 shows similar results for a multifamily building.

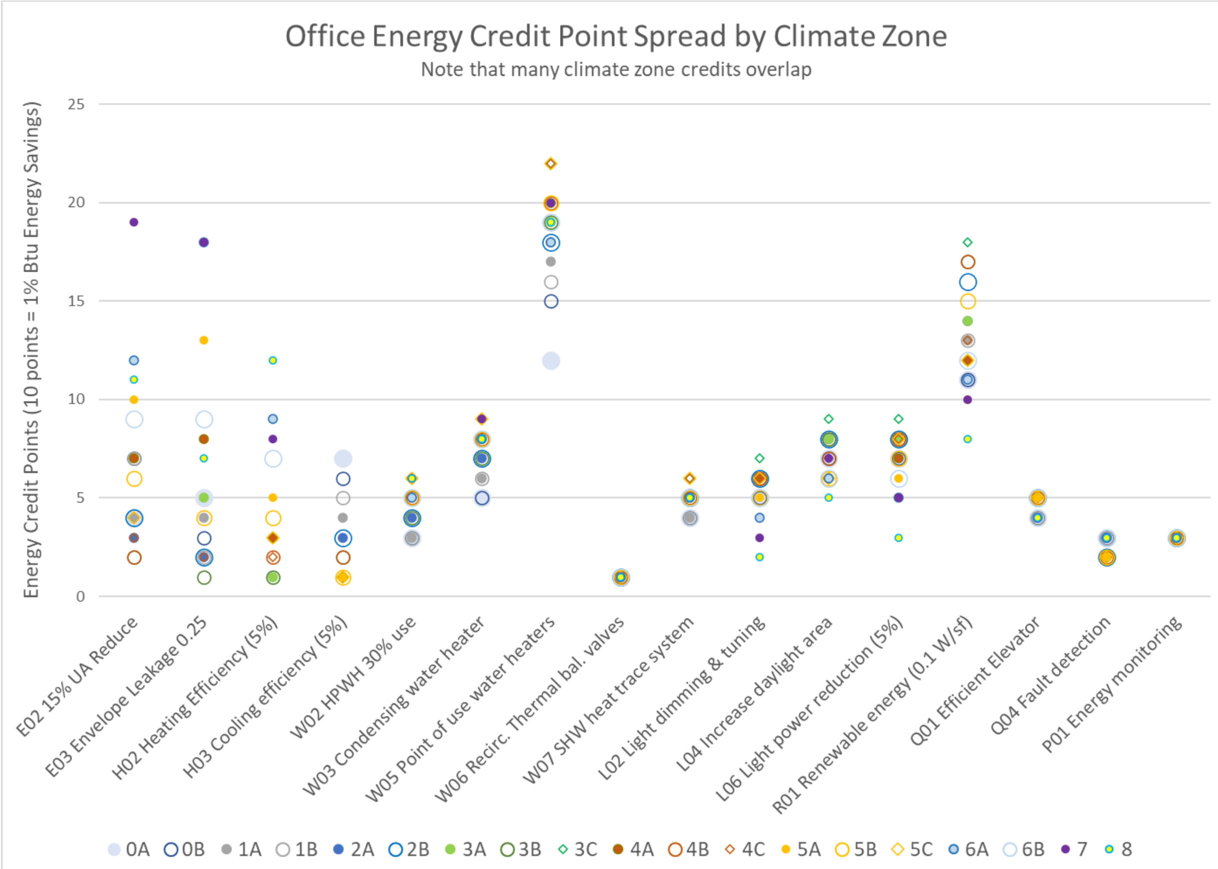

Figure 1. Range of Credit Points for a Sample of Measures for Office Buildings

The measure savings by climate zone has a wide range, especially for building envelope measures. The spread is also broad for lighting reduction, as the reduced lighting heat load must be made up by the heating system in colder climates, while in warmer climates there is added savings in the cooling system. Service hot water (SHW) measures are impacted by different average incoming cold water temperatures. For multifamily buildings, SHW measures provide significant energy credit opportunities.

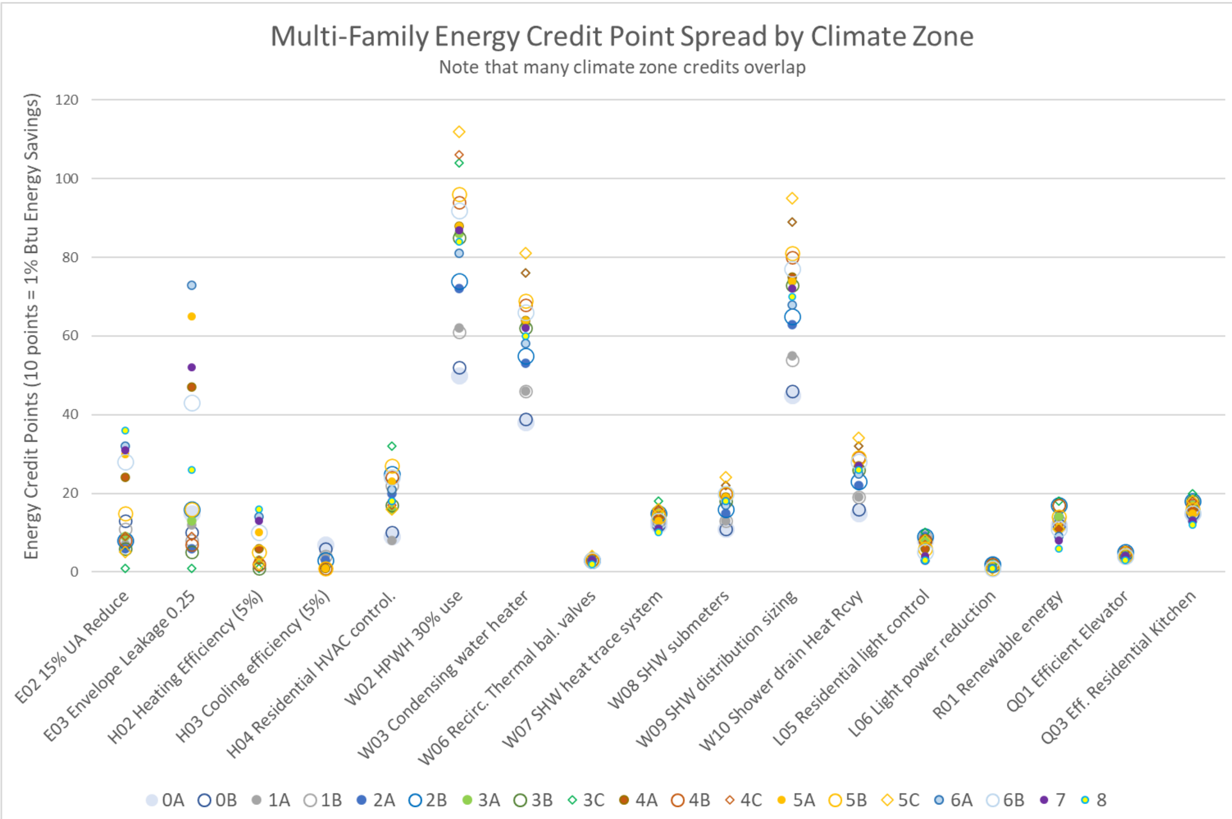

Figure 2. Range of Credit Points for a Sample of Measures for Multifamily Buildings

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. 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 the COMcheck program for the 2021 IECC can be expanded for to include the new measures introduced in this amendment. While there is some additional review required for the building official, it is less complex than review typically required for a whole building model.

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

The outlined approach is a simple 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 approach is also similar to packages of measures used in both residential and commercial energy codes, particularly in the Pacific Northwest. 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.

1.4 Energy Credit Development

This tech brief covers multiple measure types:

- 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 waste heat recovery or energy generation, such as photovoltaic electrical generation systems that offset local building energy use.

- Load management measures that shift building electrical loads and support the utilization of renewable and low carbon generation sources.

In the proposed code language energy efficiency requirements have been separated from renewable and load management requirements to avoid diluting the impact of energy efficiency measures.

1.4.1 Energy Efficiency Measures

The credit energy efficiency measures considered in the analysis were identified from lists of energy saving measures recognized as being effective for new construction and major renovation projects. The big 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. At certain limits, low SHGC glazing products may have inventory or supply issues in some styles. As a result, there is a low-value threshold adhered to for the baseline prescriptive requirement in order to still meet the supply needs of the construction industry. 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 2019b), 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 3 lists the energy efficiency measures included in this technical brief and shows how they relate to measures in the 2021 IECC Section C406.

Table 3. Energy Credit Measures

ID	New C406	Measure Name	IECC 2021	Compare to 2021
E01	C406.2.1.1	Envelope performance (90.1 Appendix C basis)		New
E02	C406.2.1.2	UA reduction (15%)	C406.8	Same
E03	C406.2.1.3	Envelope leakage reduction	C406.9	Same
E04	C406.2.1.4	Add R-5 Roof Insulation	C406.8 sim	New
E05	C406.2.1.4	Add R-10 Roof Insulation	C406.8 sim	New
E06	C406.2.1.5	Add R-2.5ci Wall Insulation	C406.8 sim	New
E07	C406.2.1.5	Add R-5.0ci Wall Insulation	C406.8 sim	New
E08	C406.2.1.6	Fenestration U-0.26/0.38 SHGC	C406.8 sim	New
E09	C406.2.1.6	Fenestration U-0.33/0.36 SHGC	C406.8 sim	New
E10	C406.2.1.6	Fenestration U-0.31/0.23 SHGC	C406.8 sim	New
E11	C406.2.1.6	Fenestration U-0.45/0.21 SHGC	C406.8 sim	New
H01	C406.2.2.1	HVAC performance (TSPR)		New
H02	C406.2.2.2	Heating efficiency	C406.2.1	Expanded
	in above	5-20% Heat efficiency by formula	C406.2.3	in H02
H03	C406.2.2.3	Cooling efficiency	C406.2.2	Expanded
	in above	5-20% Cool efficiency by formula	C406.2.4	in H03
H04	C406.2.2.4	Residential HVAC control		New
H05	C406.2.2.5	DOAS/fan control	C406.6	Modified
W01	C406.2.3.1 a	SHW preheat recovery	C406.7.2	Same
W02	C406.2.3.1 b	Heat pump water heater	C406.7.4	Modified
W03	C406.2.3.1 c	Efficient gas water heater	C406.7.3	Same
W04	C406.2.3.2	SHW pipe insulation		New
W05	C406.2.3.3 a	Point of use water heaters		New
W06	C406.2.3.3 b	Thermostatic balancing valves		New
W07	C406.2.3.3 c	SHW heat trace system		New
W08	C406.2.3.4	SHW submeters		New
W09	C406.2.3.5	SHW distribution sizing		New
W10	C406.2.3.6	SHW shower drain heat recovery		New
P01	C406.2.4	Energy monitoring	C406.10	Same
L01	C406.2.5.1	Lighting performance		*Future*
L02	C406.2.5.2	Lighting dimming & tuning	C406.4	Expanded
L03	C406.2.5.3	Increase occupancy sensor		New
L04	C406.2.5.4	Increase daylight area		New
L05	C406.2.5.5	Residential light control		New
L06	C406.2.5.6	Lighting power reduction	C406.3.1	Expanded
	in above	*20% LPA reduction*	C406.3.2	in L06
	in above	Residential lamp efficacy	C406.3.3	in L06
Q01	C406.2.7.1	Efficient elevators		New
Q02	C406.2.7.2	Efficient commercial kitchen equipment	C406.12	Same
Q03	C406.2.7.3	Efficient residential kitchen equipment		New
Q04	C406.2.7.4	Fault detection and diagnosis (FDD)	C406.11	Same

1.4.2 Renewable and Load Management Measures

There are several load management measures added in this proposal, which are listed in Sections 2.7 and 2.8. The renewable measure was previously included with the IECC credit measures; however, the load management measures are new. Renewable and load management measures include:

- R01: On-Site Renewable Energy (2021 IECC Section C406.5)
- G01: Lighting load management
- G02: HVAC load management
- G03: Automated shading
- G04: Electric energy storage
- G05: Cooling energy storage
- G06: SHW energy storage
- G07: Building thermal mass

1.5 Savings and Emission Reductions from Efficiency Measures

Energy credits can increase the energy savings beyond prescriptive efficiency requirements. They provide a flexible array of energy saving options that do not have to work for all buildings. Based on the sample code language, adopting the base code option in Section 3.0 will increase the savings compared to various versions of ASHRAE Standard 90.1 and the IECC. The sample code language is based on the 2021 IECC and will require adaptation if used with other energy codes. If there are no current energy credit requirements in the current local code, savings from the base or advanced option will increase by about 2.5% compared to the 2021 IECC.

1.5.1 Energy Savings Potential

Energy savings can be characterized based on site energy savings, cost savings, or source energy savings. National savings are annual estimates based on construction weights for climate zones located in the United States. For the packages of selected measures, savings are given in Table 4.

Table 4. Energy Savings Impact of Energy Efficiency Credit Measures

Metric[(a)]	Units	Base Package	Advanced Package
National Annual Electric Savings	GWH	1,300	2,400
National Annual Natural Gas Savings	million therm	40.9	70.5
National Annual Site Energy Savings	million Btu	8,515,000	15,310,000
Consumer Annual Energy Cost Savings	million $US	$185.5m	$335.0m

(a) The results shown here are based on national average values. Custom results can be generated for states and local jurisdictions to support adoption of advanced code concepts.

1.5.2 Energy Credit Metric

There are several ways to evaluate energy savings in a building. Among them are:

- Energy cost savings, based on local or national average prices

- Site energy savings, based on delivered (metered) energy measured in a consistent conversion to a common metric such as British thermal units (Btu) or gigajoules (GJ)
- Source energy savings, which include adjustments to site energy savings to reflect the conversion efficiency of electrical generation and drilling and distribution losses for natural gas
- Emission savings, usually expressed as carbon equivalent (CO_2e), which may be based on a national conversion rate, regional electric conversion rates, or various streams of future emission impact resulting in a range of possible results

For this analysis, the energy credits are based on site energy conversions. This approach results in a consistent result that does not change based on region or serving utility considerations. For specific applications, customized measure energy credits and energy credit requirements can be determined based on local jurisdiction policy.

Note that currently, different jurisdictions use different metrics:

- The 2021 IECC uses a cost basis, based on national average energy prices.
- A proposal undergoing review for Standard 90.1-2022 uses a cost basis, based on national average energy prices.
- The State of Washington and City of Seattle use a carbon basis, based on local carbon conversion factors.
- This amendment analysis uses a site energy basis for efficiency measures, with industry standard conversion factors for electricity and gas that do not vary by region or policy. Load management and renewable measure credits are based on utility cost.

1.5.3 Carbon Emission Reductions

Carbon emissions resulting from the base and advanced requirement packages are based on the energy consumption on a national scale. Carbon emission metrics are provided by the U.S. Environmental Protection Agency Greenhouse Gas Equivalencies Calculator.[1] Table 5 summarizes the carbon emission factors and Table 6 provides the annual national emission reductions if the credit packages were adopted nationwide in the U.S.

Table 5. Carbon Emission Factors by Fuel Type

Energy Source	Carbon Emission Factor[1]
Electricity	7.07×10^{-4} metric tons CO_2/kWh
Natural Gas	0.0053 metric tons CO_2/therm

Table 6. Emission Savings Impact of Energy Credit Measures

Metric	Units	Base Package	Advanced Package
National Annual Electric Savings	GWH	1,300	2,400
National Annual Natural Gas Savings	million therm	40.9	70.5
Annual Emission Reductions, CO_2	metric tons	1,135,000	2,085,000

[1] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator accessed March 21, 2021.

1.6 Energy Savings Analysis

To estimate energy savings for this project, PNNL used prototype buildings from the ASHRAE Standard 90.1 model code analysis process (PNNL 2020) to analyze savings for each measure. The baseline used was ASHRAE Standard 90.1-2019. This baseline is somewhat equivalent to the 2021 IECC. The following process was used:

1. The measure was reviewed to determine the differences in building and system configuration that would contribute to energy savings.
2. One or more prototypes were used to run the baseline and improved building cases to find the relative savings in 19 ASHRAE climate zones. Prototypes were selected based on the relevance of each individual measure.
3. The energy savings were characterized as a percentage reduction in the modeled building prototype end uses.
4. End-use breakdowns from the Standard 90.1-2019 performance indicator analysis were used as prototype group[1] basis and the group prototype savings was projected based on proration of end-use savings by the analyzed prototype percentage end-use savings (Nambiar et al. 2021).

1.7 Cost Effectiveness Considerations

To demonstrate cost effectiveness for a base package of energy credit measure requirements, appropriate measures are selected for the different building use types in different climate zones. Costs are compared to expected savings and evaluated using the ASHRAE 90.1 Scalar Method. While there are many combinations that building designers can choose, the approach here is to demonstrate that at least one reasonable cost effective path exists.

1.7.1 Methodology

DOE uses three possible scenarios when evaluating cost effectiveness: (1) publicly owned method, (2) privately owned method, (3) ASHRAE Scalar Method (Hart and Liu 2015).[2] For this analysis of commercial building measures, the ASHRAE Scalar Method was applied, since this is the method used to evaluate the commercial model code.

The Scalar Method was developed by ASHRAE Standing Standard Project Committee (SSPC) 90.1 to examine the cost effectiveness of evaluating a specific addendum to Standard 90.1 (McBride 1995). The Scalar Method is an alternative life-cycle cost approach for individual energy efficiency changes with a defined useful life, taking into account first costs, annual energy cost savings, annual maintenance, taxes, inflation, energy escalation, and financing impacts. The Scalar Method allows a discounted payback threshold (scalar ratio limit) to be calculated based on the measure life. A measure is considered cost effective if the simple payback (scalar ratio) is less than the scalar limit. Limits for both heating (primarily gas, SRh) and cooling (primarily electricity, SRc) are shown in Figure 3.

[1] Prototype groups reflect the building use types that designate separate tables of available energy credits. For example, the school building use type is a composite of the primary and secondary school prototype end uses.
[2] https://www.energycodes.gov/commercial-energy-and-cost-analysis-methodology

Table 7 shows the economic parameters used for the ASHRAE Standard 90.1-2022 analysis that were also used for this study. These parameters were adopted by the ASHRAE 90.1 project committee.

Table 7. Scalar Ratio Method Economic Parameters and Scalar Ratio Limit

Input Economic Variables	Heating (gas) SRh	Cooling (electricity) SRc
Economic Life – Years (example)	40	40
Down Payment - $	0.00	0.00
Energy Escalation Rate - %[(a)]	2.90	2.25
Nominal Discount Rate - %[(b)]	8.1	8.1
Loan Interest Rate - %	5.0	5.0
Federal Tax Rate - %[(b)]	NA[(b)]	NA[(b)]
State Tax Rate - %[(b)]	NA[(b)]	NA[(b)]
Heating – Natural Gas Price, $/therm	0.983	
Cooling - Electricity Price $/kWh		0.1099
Scalar Ratio Limit (weight: 0.25/0.75)	**25.4**	**22.0**

(a) The energy escalation rate used in the scalar calculation for 90.1-2022 includes inflation, so it is a nominal rather than a real escalation rate.
(b) Beginning with addenda for 90.1-2016, SSPC 90.1 eliminated tax analysis from the Scalar Method by using a pre-tax discount rate.

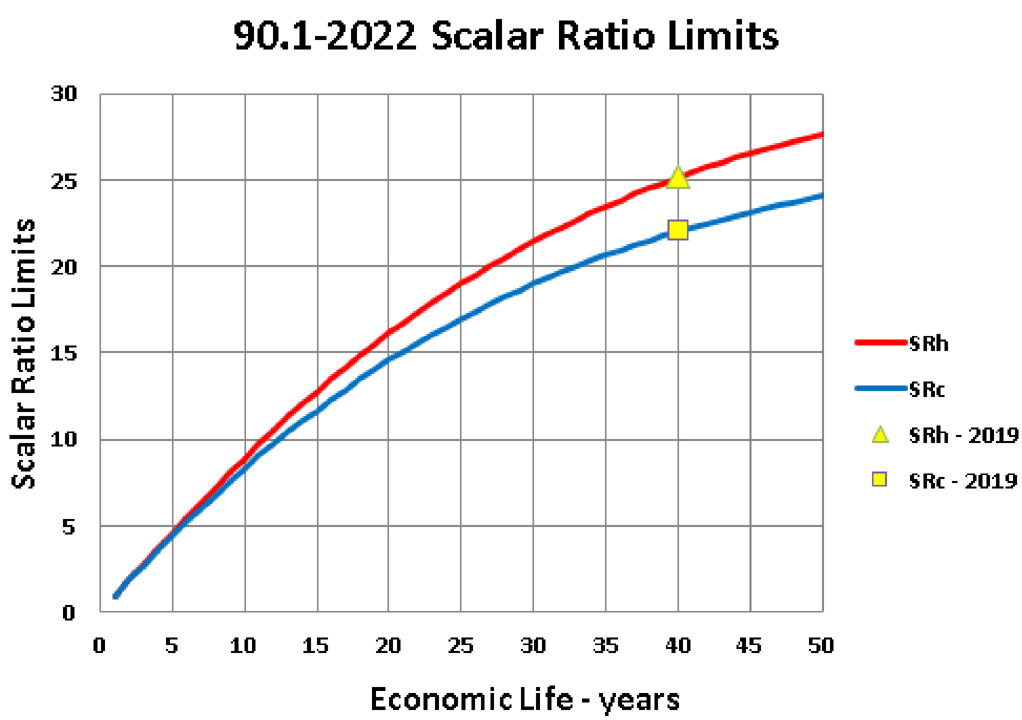

Figure 3. Scalar Ratio Limits Based on Measure Life

As the Scalar Method is designed to be used with a single measure with one value for useful life, it does not account for replacement costs. PNNL extended the Scalar Method to allow for the evaluation of multiple measures with different useful lives (Hart and Liu 2015). This extension is necessary to evaluate a package of measures. This extended method takes into account the variation in lives for different measures in the package. In some cases, the costs were negative, so the individual measure lives were weighted based on savings to determine a package weighted measure life. The scalar ratio limits ranged from 12.5 to 20.0 across all building types and climate zones with an average of 16.2. See Appendix E for detailed thresholds.

The measure costs and savings for the package are tallied and an overall payback is found. This result is compared to the scalar ratio limit for the savings weighted lives. Due to differing escalation rates for different energy types, the scalar threshold is determined separately for heating (primarily gas, SRh) and cooling (primarily electricity, SRc). To develop one scalar threshold that can be used across building types, the gas (SRh) and electric (SRc) scalar limits were weighted at 25% and 75%, respectively. The packages of changes for each combination of prototype and climate location were considered cost effective if the corresponding scalar ratio was less than the scalar ratio limit.

1.7.2 Cost Effective Energy Efficiency Demonstration Packages

The energy credit requirements are justified based on a selection of a package of measures that meet the requirement and are cost effective for each building use type and climate zone. About one quarter of the measures were selected for inclusion in the cost effectiveness analysis, based on their general applicability and reliable savings. Two demonstration packages were determined for evaluation of cost effectiveness:

- The base demonstration package included standard efficiency measures with a cap of 10% for required credits to allow for measure selection flexibility. While the energy credits are limited to 10% whole-building savings, in many cases the selected measures that were cost effective exceeded that savings level cap.
- The advanced demonstration package was selected by adding reasonable measures with a 12% savings target and a cap of 20% site energy savings. In some climate zones or building types, that goal could not reasonably be reached. Cost effectiveness was not determined for the advanced package.

1.7.2.1 Base Demonstration Package

Table 8 provides an overview of measures selected for inclusion in the base package. Measures are selected with the goal of 7% savings or 70 credits for this package. Measure selection may be climate zone specific. For example, cooling efficiency only makes sense in warm climate zones. The climate zones (CZ) or application of measures is shown along with individual measure lives shown for determining cost effectiveness.

Based on this selection of measures, the scalar value or payback for each building type for the selected group of measures is given in Table 9. This represents the cost for all measures included in the package divided by the annual consumer energy cost savings. Note that for multifamily buildings and hotels, the SHW distribution redesign results in a significant cost reduction, so the overall package cost is less than the baseline and the “CE” indicates that the packages in those buildings are immediately cost effective. A scalar limit or threshold is developed for each combination of climate zone and building type based on the individual measure lives shown in Table 8, weighted by the measure cost savings. The measures included in the base package and therefore credits required are adjusted so that all building types in all climate zones have a consumer payback that is less than the scalar limit, indicating cost effectiveness of at least one combination of measures for the efficiency credit requirements. The office and warehouse building type paybacks were closest to the scalar limits, but even there, the scalar limit was 1.3 times the lowest payback margin. See Appendix E for detailed results.

Table 8. Matrix of Base Demonstration Package Efficiency Measures

ID	Energy Credit Abbreviated Title	Measure Life, yr	Multifamily /Dormitory	Health Care	Hotel/Motel	Office	Restaurant	Retail	School/ Education	Warehouse/ Semiheated
E01	Glazing U & SHGC reduction	40	CZ 0A-1A	all CZ	all CZ	all CZ			all CZ	
E02	UA Reduction (15%)	40						All CZ		
H02	Heating efficiency	18		CZ 5-8	CZ 5-8	CZ 5-8	CZ 5-8	CZ 5B-8	CZ 5-8	CZ 4C-8
H03	Cooling efficiency.	15	CZ 0-2	CZ 0-2	CZ 0-3B	CZ 0-3B	CZ 0-3B	CZ 0-3B	CZ 0-3B	CZ 0-3B
H04	Residential HVAC control.	15	CZ 0-3, 6-8							
W02	Heat pump water heater	19					30% all CZ	CZ0, 4B-5		
W03	Efficient gas water heater	15	all CZ	all CZ	all CZ	all CZ	70% all CZ		all CZ	
W06	Thermostatic balancing valves	15	all CZ	all CZ	all CZ	all CZ			all CZ	
W08	SHW distribution sizing	15	all CZ		all CZ					
L03	Increase occupancy sensor	15		all CZ						all CZ
L04	Increase daylighting area	15						CZ 0-5		all CZ
L06	Light power reduction	20	5% all CZ	15% all CZ	15% all CZ	15% all CZ	10% all CZ	10% all CZ	15% all CZ	10-15% all CZ
Q02	Efficient kitchen equipment	15	(a)		(a)		all CZ		(a)	
Q04	Fault detection	15		all CZ	all CZ	CZ 0-4			all CZ	

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

Table 9. Scalar Ratios for Base Demonstration Package Efficiency Measures by Climate Zone and Building Type

	Climate Zone																		
Building Use Type	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily/Dormitory	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Health Care	3.0	3.3	3.3	3.3	3.2	3.6	2.7	2.8	2.4	2.5	2.6	2.3	2.6	2.6	2.0	2.6	2.5	2.3	2.3
Hotel/Motel	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Office	11.7	12.1	13.1	12.7	13.2	13.6	13.3	13.1	12.6	11.0	10.7	11.7	10.9	10.7	11.8	9.6	10.0	9.8	9.1
Restaurant	3.2	3.5	4.2	3.9	4.3	4.7	4.9	4.9	4.9	4.7	4.7	4.7	3.5	3.8	4.0	3.1	3.4	2.8	2.4
Retail Buildings	4.0	4.3	4.8	4.6	5.4	5.5	6.1	6.2	4.9	4.4	5.0	5.3	4.3	4.6	5.2	3.4	4.5	5.1	5.0
School/Education	6.5	7.3	8.5	7.8	8.8	9.8	9.1	9.0	8.0	7.1	7.1	7.8	6.6	6.1	7.2	5.4	6.1	5.2	4.4
Warehouse	8.3	8.1	9.4	8.9	9.8	9.5	8.0	7.7	2.7	2.8	2.7	2.9	1.8	2.4	3.0	1.4	1.8	1.5	1.5

1.7.2.2 Advanced Demonstration Package

Table 10 provides an overview of energy efficiency measures selected for inclusion in the advanced package. Reasonable measures were selected with a goal of 12% savings, or 120 credits. The climate zones or application of measures are shown along with individual measure lives shown for determining cost effectiveness. For the advanced package, direct energy cost savings for a broader selection of measures is considered. A reasonable, but aggressive, collection of measures is included. Cost effectiveness of this package was not estimated. The package is likely not cost effective in all building types based on direct consumer building energy cost savings. However, when societal costs, reduction of carbon emissions, or non-energy benefits are considered, the package may be considered cost effective in line with advanced energy policy. If a higher target of total savings is desired, then the required renewable resources can be increased, although these are included with the load management measures.

Table 10. Matrix of Advanced Demonstration Package Efficiency Measures

ID	Energy Credit Abbreviated Title	Measure Life, yr	Multifamily /Dormitory	Health Care	Hotel/Motel	Office	Restaurant	Retail	School/ Education	Warehouse/ Semiheated
E01	Glazing U & SHGC reduction	40	CZ 0-1	all CZ	all CZ	all CZ		all CZ	all CZ	
E02	15% UA reduction	40	CZ 0-4					all CZ		
E03	Leakage reduction to 0.25 cfm/ft^2	40	CZ 0-1	all CZ (0.15)	all CZ	all CZ x3C	all CZ			CZ 4-8
E04	Add R-5ci roof insulation	40							CZ 0-3	
E04	Add R-10ci roof insulation	40							CZ 4-8	all CZ
E06	Add R-2.5ci wall insulation	40		CZ 3-4A		all CZ x3C			all CZ	
H02	Heating efficiency	18	CZ 5A-8	CZ 2-8	CZ 5-8	CZ 4-8	CZ 3-8	CZ 5B-8	CZ 5-8	CZ 4C-8
H03	Cooling efficiency.	15	CZ 0-2	CZ 0-3B	CZ 0-3B	CZ 0-3B	CZ 0-2	CZ 0-3B	CZ 0-3B	CZ 0-3B
H04	Residential HVAC control.	15	CZ 0-3B, 6-8							
W01	Energy recovery SHW preheat	19		30% all CZ	30% all CZ					
W02	Heat pump water heater	19	30% all CZ	30% all CZ	30% all CZ		30% all CZ			
W03	Efficient gas water heater	15	70% all CZ	40% all CZ	40% all CZ	all CZ	70% all CZ	all CZ	all CZ	
W04	SHW heat trace system	15		all CZ	all CZ	all CZ				
W06	Thermostatic balancing valves	15	all CZ						all CZ	
W08	SHW distribution sizing	15	all CZ		all CZ					
W10	SHW shower drain heat recover	20								
P01	Energy monitoring	15		all CZ	all CZ	all CZ	CZ 0-3	all CZ	all CZ	all CZ
L02	Lighting dimming and tuning	15		all CZ		all CZ	all CZ	all CZ	all CZ	
L03	Increase occupancy sensor	15		all CZ		all CZ				all CZ
L04	Increase daylight area	15				all CZ		all CZ	all CZ	all CZ
L06	Light power reduction	20	15% all CZ	15% all CZ	15% all CZ	15% all CZ	15% all CZ	15% all CZ	15% all CZ	15% all CZ
Q01	Efficient Elevator	25	all CZ	all CZ	all CZ	all CZ				
Q02	Efficient kitchen equipment	15	(a)		(a)		all CZ		(a)	
Q03	Fault detection	0		all CZ	all CZ	all CZ	CZ 0-3		all CZ	

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

1.7.3 Load Management and Renewable Cost Effectiveness

Load management and renewable measure cost savings are not achieved by direct energy use reductions at the building. Instead, they are based on cost savings achieved from renewable energy generation or load time shifts impacting a time-of-use (TOU) electric pricing schedule. Therefore, the cost effectiveness of such measures is calculated separately from the efficiency measures.

The renewable and load management target credit requirement is based on a reasonable amount of renewable installation and the installation of the lighting control load management measure. The package is evaluated for cost effectiveness with the results shown in Tables 11 and 12. Lighting load management refers to reducing the lighting power density (LPD) to 80% of normal during TOU price peaks.

Based on a scalar analysis similar to the one discussed in Section 1.7.1, the renewable and lighting load management measures are analyzed with the cost basis shown in Table 11 and the scalar payback results for both measures shown in Table 12 by building type and climate zone.

Table 11. Costs for Lighting Load Management and Renewable by Building Type

Building Use Type	Prototype	Total Floor Area, sf	Renewable Energy Cost, $/sf	Lighting Load Management Cost, $/sf	Total Cost, $/sf	Total Cost, $
Multifamily/Dormitory	midrise apt.	33,741	$0.307	$0.082	$0.390	$13,000
Health Care	hospital	241,501	$0.181	$0.082	$0.264	$63,500
Hotel/Motel	small hotel	43,202	$0.314	$0.082	$0.396	$17,000
Office	small office	5,502	$0.560	$0.082	$0.643	$3,500
Office	medium office	53,628	$0.418	$0.082	$0.500	$27,000
Restaurant	sit down rest.	5,502	$0.496	$0.082	$0.578	$3,000
Retail Buildings	strip mall	22,500	$0.429	$0.082	$0.511	$11,500
School/Education	primary school	73,959	$0.394	$0.082	$0.476	$35,000
Warehouse	warehouse	52,045	$0.461	$0.082	$0.544	$28,500

Lighting load management costs are based on a related CASE report (CASE 2020), while renewable energy costs are based on NREL's U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark (Feldman et al., 2020).

Table 12. Scalar Ratios for Renewable & Load management Package by Climate Zone and Building Type

Building Use Type	Climate Zone																		
	0A	**0B**	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
Multifamily/Dormitory	9.6	9.8	9.1	9.2	9.2	8.0	9.7	7.7	8.3	10.9	7.9	11.4	12.7	8.9	12.4	11.4	10.4	12.0	14.8
Health Care	4.8	4.7	4.5	4.5	4.5	4.2	4.9	4.1	5.1	5.2	3.9	5.5	5.6	4.4	5.5	5.0	4.8	5.4	6.2
Hotel/Motel	9.5	9.6	9.1	9.1	9.2	8.0	9.5	7.8	8.3	10.6	8.0	11.4	12.5	9.0	12.1	11.2	10.2	12.0	14.6
Office	9.9	9.8	9.2	9.2	9.4	8.2	9.5	7.9	8.7	10.6	8.0	10.7	11.8	8.7	11.3	10.6	9.6	10.9	12.9
Restaurant	8.8	9.4	9.0	8.4	9.2	8.2	9.1	8.2	9.4	10.8	8.3	10.4	11.5	9.3	11.4	10.6	9.8	10.6	12.5
Retail Buildings	7.3	7.5	7.4	7.0	7.3	6.7	7.8	6.7	7.3	8.7	6.7	8.6	8.8	7.4	8.9	7.9	8.0	8.6	9.9
School/Education	11.2	10.9	10.6	10.3	10.7	9.3	11.2	9.0	10.2	12.9	9.3	12.9	15.0	10.5	13.4	12.5	12.1	13.5	15.8
Warehouse	13.4	13.2	12.5	12.7	12.9	11.1	13.2	11.0	11.9	15.2	11.2	14.8	16.4	12.3	16.3	14.1	13.1	15.0	17.3

1.8 National Efficiency Benefits Analysis

The consumer energy cost savings from the selected base and advanced efficiency credit demonstration packages are used to estimate U.S. national consumer savings. Annual savings will repeat year after year for the life of the various measures. Annual savings from adopting either the base level or the advanced level of energy credits are shown. These are based on the following steps:

1. Savings from the measures listed in Table 8 and Table 10 for each climate zone and building type group are tabulated separately to arrive at savings for each building type and climate zone.

2. These individual savings are factored by national climate zone and building type new construction weightings (Lei 2020) to arrive as national savings per square foot of floor area.

3. The floor area savings are multiplied by total expected 2022 commercial construction (Tyler et al. 2021) to arrive at national total savings.

4. The process is repeated for both base packages and advanced packages for the different savings metrics.

Since the energy credits requirements can be met in many alternative ways, the projected savings should be considered a maximum potential. Results are given in Table 13 and should be viewed with the following caveats:

- Savings are based on full implementation of the demonstration packages described in Section 1.7.2 and 1.7.3, even if these savings are greater than the caps used on the credit requirements.

- Savings results are based on application to building codes that do not currently have any extra efficiency options. We have not attempted to adjust the results for current code adoption across states. Savings will be greater for states that have older or no energy codes, and less for states that have adopted the 2021 IECC, which provides about 2.5% building energy cost savings.

- The base package is targeted at 7% building energy savings above the baseline prescriptive requirements or 4.5% greater savings than the 2021 IECC. The advanced package is targeted at 12% building energy savings or 9.5% greater than the 2021 IECC, although some climate zones have lower requirements. Note that the 2021 IECC may be equivalent to Standard 90.1-2019, as the energy credits in the IECC make up for other savings that 90.1 has that are not included in the IECC. This is a rough approximation, as the comparative analysis of these code editions has not been completed.

- These savings would continue year after year once the improved systems are installed.

- The savings in the base and advanced packages are based on efficiency credits alone. Renewable and load management credit cost savings are shown separately.

Table 13. National Annual Benefits of Adopting Energy Credits

Metric[a]	**Units**	**Base Package**	**Advanced Package**	**Renewable & Load Management**
National Annual Electric Savings	GWH	1,050	1,400	NA
National Annual Natural Gas Savings	million therms	42.5	77.8	NA
National Annual Site Energy Savings	million Btu	7,760,000	12,560,000	NA
Consumer Annual Energy Cost Savings	million $US	$154.0m	$223.5m	$158.2m
Annual Emission Reductions, CO_2	metric tons	995,000	1,405,000	NA

(a) The results shown here are based on national average values. Custom results can be generated for states and local jurisdictions to support adoption of advanced code concepts.

2.0 Energy Efficiency, Renewable Energy, and Load Management Credit Measures

Each of the energy credit measures included in the sample code language in Section 3.0 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
- How the measure relates to the measures included in C406 of the 2021 IECC

2.1 Building Envelope

Improvements to the building envelope can achieve energy credits either through the envelope performance (E01) or a combination of UA reduction (E02) and air barrier leakage reduction (E03).

2.1.1 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 heating, ventilation, and air conditioning (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.

All of these impacts can be modeled in the ASHRAE Standard 90.1 methodology that is accessible in COMcheck. The input to model these changes is the same as needed to verify compliance with the prescriptive requirements.

Compared to the 2021 IECC, this is a new measure and an alternative to the UA reduction (E02) and air leakage reduction (E03) energy credits.

2.1.2 E02: UA Reduction (15%)

UA (U-factor times envelope area) reduction captures HVAC energy savings related to reduction in overall heat transfer through the building envelope.

Measure E02 saves energy by reducing the conductive heat gains and losses through the building envelope. Depending on the coincident internal and solar heat loads, this reduction of envelope conduction will result in less HVAC energy use through reduced heating and cooling.

Compared to the 2021 IECC, this matches an existing measure. It is an alternative to the envelope performance (E01) energy credits.

2.1.3 E03: Envelope Leakage Reduction

Leakage reduction captures HVAC energy savings related to reduction in overall infiltration through the building envelope.

Measure E03 saves energy by reducing the infiltration and exfiltration of outside air through the building envelope. It is an alternative to the envelope performance (E01) energy credits. Depending on the coincident internal and solar heat loads, this reduction of envelope infiltration will result in less HVAC energy use through reduced heating and cooling. Compared to the 2021 IECC base requirement of 0.40 cfm/ft^2 at 75 Pa, three options are provided for leakage reduction:

- E03A requires less than 0.25 cfm/ft^2 leakage at 75 Pa and matches an existing 2021 IECC measure.
- E03B requires less than 0.15 cfm/ft^2 leakage at 75 Pa.
- E03C requires less than 0.08 cfm/ft^2 leakage at 75 Pa and matches passive house specifications.

2.1.4 E04-E11: Individual Envelope Improvements

While a full range of envelope insulation and leakage improvements can be assessed through measures E01 through E03, individual prescriptive type improvements are included that can be directly accessed. These include:

- E04 Add R-5 Roof Insulation
- E05 Add R-10 Roof Insulation
- E06 Add R-2.5ci Wall Insulation
- E07 Add R-5.0ci Wall Insulation
- E08 Fenestration U-0.45/0.21 SHGC for climate zones 0-2
- E09 Fenestration U-0.33/0.23 SHGC for climate zones 2-4
- E10 Fenestration U-0.31/0.36 SHGC for climate zones 4-6
- E11 Fenestration U-0.45/0.21 SHGC for climate zones 6-7

Measures E04 through E11 save energy by reducing the conductive heat gains and losses through the building envelope. Measures E08 through E11 provide additional savings by reducing solar heat gain and reducing cooling energy use. Depending on the coincident internal and solar heat loads, this reduction of envelope conduction will result in less HVAC energy use through reduced heating and cooling.

2.2 HVAC

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 dedicated outdoor air system (DOAS) (H05) measures can be completed independently or in conjunction with other HVAC measures.

2.2.1 H01: HVAC Performance (TSPR)

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 proposed HVAC system total system performance ratio (TSPR) is greater than the TSPR of a target system. To be effective, the TSPR language covered in a separate technical brief would also have to be adopted into the energy code (Goel et al. 2021). 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 dedicated outdoor air system (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.

Compared to the 2021 IECC, this creates a new measure. It is an alternative to other HVAC energy credits. In the base code language in Section 3.0, this is considered a future measure with a reserved space. If a jurisdiction wishes to adopt this measure as an energy credit, then the instructions in Appendix B should be followed.

2.2.2 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, use H01, TSPR, instead. 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.

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 is an alternative to the HVAC performance (H01) energy credits.

2.2.3 H03: Cooling Efficiency

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

- Replacing a standard AC unit, chiller, or heat rejection equipment with a higher efficiency AC unit, chiller, ore 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, use H01, TSPR, instead. 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.

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 is an alternative to the HVAC performance (H01) energy credits.

2.2.4 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 and 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 is less heating and cooling of outdoor air.

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).

2.2.5 H05: DOAS/Fan Control

Measure H05 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.

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.

2.3 Service Hot Water

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 and one may be selected. For recirculation, there is a choice of W05, W06, or W07. Other measures have specific building applications.

2.3.1 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 by between 30% and 80% the use of non-renewable energy sources for annual SHW heating.

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.

Compared to the 2021 IECC, this is a modification of an existing measure. It cannot be combined with other SHW efficiency (W02 and W03) energy credits. It can be combined with appropriate non-efficiency SHW (W04 through W10) energy credits.

2.3.2 W02: Heat Pump Water Heater

Measure W02 requires the installation of an air-source heat pump water heater 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 by between 30% and 80% the use of non-renewable energy sources for annual SHW heating.

Compared to the 2021 IECC, this is a modification of an existing measure. It cannot be combined with other SHW efficiency (W01 and W03) energy credits. It can be combined with appropriate non-efficiency SHW (W04 through W10) energy credits.

2.3.3 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. Through use of 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.

Compared to the 2021 IECC, this is a modification of an existing measure. It cannot be combined with other SHW efficiency (W01 and W02) energy credits. It can be combined with appropriate non-efficiency SHW (W04 through W10) energy credits.

2.3.4 W04: SHW Pipe Insulation

Measure W01 requires the installation of additional pipe insulation beyond the minimum required prescriptively.

Measure W01 saves energy primarily by reducing the heat loss from piping delivering the SHW or recirculating the SHW for temperature maintenance.

Compared to the 2021 IECC, this is a new measure. It is allowed in combination with other SHW efficiency (W02 and W03) energy credits.

2.3.5 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. 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.

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).

2.3.6 W06: Thermostatic Balancing Valves

Measure W06 requires the installation of thermostatic balancing valves for a recirculation system rather than manually adjusted balancing valves. The valves are required to minimize the return water flow when the branch return temperature is greater than 115°F. These valves reduce the balancing labor as they are self-balancing.

Measure W06 saves energy primarily by reducing the recirculation pipe temperature and associated heat loss.

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).

2.3.7 W07: SHW Heat Trace System

Measure W07 requires the installation of an electric heat trace system with proper controls in place of a recirculated hot water temperature maintenance system.

Measure W07 saves energy primarily by eliminating the recirculation piping, hence eliminating the heat loss from the piping. There is also savings as pumping energy is no longer required.

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).

2.3.8 W08: SHW Submeters

Measure W08 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.

Compared to the 2021 IECC, this is a new measure. It is allowed in combination with any other SHW efficiency energy credits.

2.3.9 W09: SHW Distribution Sizing

Measure W09 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 in accordance with IAPMO/ANSI, *WE●Stand – 2017 Water Efficiency and Sanitation Standard for the Built Environment* (IAPMO 2017)*.* 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 W09 saves energy primarily by reducing the SHW end use and by reducing the piping size, and therefore heat loss, of the SHW distribution piping.

Compared to the 2021 IECC, this is a new measure. It is allowed in combination with any other SHW efficiency energy credits.

2.3.10 W10: SHW Shower Drain Heat Recovery

Measure W10 requires the installation of shower drain heat recovery devices used to preheat the cold water serving showers.

Measure W10 saves energy primarily by reducing 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.

Compared to the 2021 IECC, this is a new measure. It is allowed in combination with any other SHW efficiency energy credits.

2.4 Power

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

2.4.1 P01: Energy Monitoring

Section C405.12 of the IECC requires energy monitoring in non-residential buildings 25,000 square feet 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 potentially saves energy by providing detailed energy use information to tenants and operating staff of buildings 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.

Compared to the 2021 IECC, this is essentially the same as an existing measure.

2.5 Lighting

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

2.5.1 L01: Lighting Performance (Reserved)

This is an alternative lighting performance path that is under development. It is currently out for public review consideration for Standard 90.1. 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 comprehensive alternative to L02, L03, L04, and L06.

2.5.2 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 needed task. This reduces the initial maximum light output

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.

2.5.3 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 based on the most expansive scheduled use of the space. Time controls require manual intervention, and eventually evolve to the worst case situation, with an extended “on” period.

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, even though the work is occurring in a small area. A time control, or even a bypass switch, lights up large areas of the building, whereas occupancy sensors control a small area where the work is actually occurring.

Compared to the 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.

2.5.4 L04: Increase Daylight Area

Measure L04 requires the installation of daylight 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 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.

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).

2.5.5 L05: Residential Lighting Control

Measure L05 requires the installation of a centralized switch near apartment or dorm room exits that can turn off the entire lighting in the building with one or two switch operations. This can be achieved by wiring the lighting circuits through a central switch at the building entrance. There is an additional requirement that there be two clearly identified switched receptacles in each room connected to a central control. It is anticipated 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 or dorm occupants to turn off all lighting in an apartment or dorm room when exiting the space. This reduces lighting operation and also reduces cooling energy use, although it may increase heating energy use in colder climates.

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).

2.5.6 L06: Lighting Power Reduction

Measure L06 requires that the installed lighting system be at least 5% lower LPD 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.

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 25% LPD reduction. It will be an alternative to the future lighting performance (L01) energy credits.

2.6 Equipment

More efficient equipment installed in buildings can save energy.

2.6.1 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 ASHRAE 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.

Compared to the 2021 IECC, this is a new measure. It can be applied in conjunction with other energy credits.

2.6.2 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 measures are required to be high efficiency.

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

Compared to the 2021 IECC, this is an existing measure. It can be applied in conjunction with other energy credits.

2.6.3 Q03: Efficient Residential Kitchen Equipment

Measure Q03 requires the installation of higher efficiency ranges and refrigerators in apartment and suite type hotel occupancies. These typically meet the highest Energy Star standard.

Measure Q03 saves energy by reducing the energy used in refrigeration and cooking. Through better appliance design and manufacturing, appliances can achieve significant improvements in energy efficiency. The result is less energy used to deliver the same service level.

Compared to the 2021 IECC, this is a new measure. It can be applied in conjunction with other energy credits.

2.6.4 Q04: Fault Detection

Measure Q04 requires the installation of a fault detection and diagnosis (FDD) system in buildings smaller than 100,000 square feet, where an FDD system is required prescriptively. This system detects failures in HVAC system equipment and controls and reports them automatically to building operators.

Measure Q04 saves energy by noting where controls have failed and alerting building maintenance staff to the problem.

Compared to the 2021 IECC, this is an existing measure. It can be applied in conjunction with other energy credits.

2.7 Renewable Energy

Site-based renewable energy is usually incorporated into a building with photovoltaic panels that produce electrical energy that is used by the building. In the few hours when more electrical energy is produced than can be used in the building, it 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.

2.7.1 R01: Renewable Energy

Measure R01 requires the installation of site-based renewable systems—typically photovoltaic panels—that use site-available solar energy sources to offset imported metered energy into the building.

Measure R01 saves energy by using renewable energy to offset purchased energy.

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/ft^2 of building area and having a separate measure to accommodate larger renewable installations, this measure starts at a minimum of 0.10 W/ft^2 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 to reduce complexity.

The language in Section 3.0 is designed to amend codes that do or do not have a prescriptive renewable energy requirement. Most codes do have exceptions that utilize renewable energy. Those exceptions and any prescriptive renewable energy requirements are treated the same and are not eligible for energy credits. There is an upper limit for photovoltaic panel installation without electric storage like batteries to avoid a large share of the power being exported from the building that might occur with a large array on a single-story warehouse or retail building. Above that limit, adequate storage for at least 3 hours would be required for the renewable energy credits above the limit to count.

2.8 Load Management Measures

Load management measures work in conjunction with an energy-efficient building to support grid modernization, 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, TOU price, or building peak demand monitoring to reduce or shift electric demand and decrease electricity costs. Typically, such communication interfaces also support value-add cloud-based services that provide improved 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.

2.8.1 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.

2.8.2 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.

2.8.3 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 allowed 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 reduced 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.

2.8.4 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.

2.8.5 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.

2.8.6 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.

2.8.7 G07: Building Thermal Mass

Measure G07 requires two complimentary 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.

3.0 Sample Code Language

The sample code language provided here is designed to amend the 2021 IECC. If another code is amended, then adaptations in format and section references will be required. This sample code language is not shown underlined as it is a replacement of the entire section C406. If you are amending a code that uses building use types rather than occupancy groups, the cross reference in Table 14 may be helpful:

Table 14. Cross Reference of Occupancy Groups to Building Use Types

Occupancy Groups	Building Use Types
R-2, R-4, and I-1	Multifamily, Dormitory, Retirement
I-2	Health Care
R-1	Hotel/ Motel
B	Office
A-2	Restaurant
M	Retail
E	School/ Education
S-1 and S-2	Warehouse and Storage

Replace 2021 IECC Section C406 in its entirety with the following language.

SECTION C406
ADDITIONAL EFFICIENCY, RENEWABLE AND LOAD MANAGEMENT REQUIREMENTS

C406.1 Compliance

New buildings and changes in space conditioning, change of occupancy and building additions in accordance with Chapter 5 exceeding 500 square feet of floor area shall comply with the requirements of Section C406.1.1. Alterations shall comply with C406.1.3.

C406.1.1 Additional energy efficiency credit requirements.

Projects shall comply with sufficient measures from C406.2 to achieve the minimum number of required efficiency credits from Table C406.1.1 based on building occupancy group and climate zone. Projects with multiple *occupancies*, unconditioned parking garages, alterations, and buildings with separate shell-and-core and initial build-out *construction* permits shall comply as follows:

1. Where a project contains multiple occupancies, credits in Table C406.1.1 from each building occupancy shall be weighted by the gross floor area to determine the weighted average project energy credits required.
2. Where separate permits are used for *building* core/shell and initial build-out construction then compliance shall be in accordance with Section C406.1.1.1.
3. Substantial *alterations* as described in Section C406.1.3 that are not initial build-out *construction* shall achieve half the credits required for the *building* occupancy.
4. Unconditioned parking garages shall achieve half the credits required for use groups S-1 and S-2 in Table C406.1.1.

Exceptions to C406.1.1:

1. Utility buildings, and miscellaneous use buildings up to 1000 ft^2 (90 m^2) that are not occupied except for maintenance
2. Industrial and manufacturing portions of factory use areas within buildings, not including office areas
3. Where the core/shell complied in accordance with C407, the initial build-out alterations do not need to achieve any energy credits

Table C406.1.1 Energy Credit Requirements by Building Occupancy Group

Building Occupancy Group	Climate Zone																		
	0A	**0B**	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
R-2, R-4, and I-1	85	85	91	100	100	100	100	100	100	94	100	100	93	100	100	100	100	100	100
I-2	50	49	47	46	46	48	44	44	45	48	48	49	54	55	56	55	56	58	59
R-1	59	57	60	60	62	62	65	67	68	67	70	73	78	75	82	86	82	94	100
B	66	63	65	68	64	63	67	68	68	70	73	74	83	83	84	95	92	94	100
A-2	74	74	75	76	79	79	77	80	87	73	78	82	100	98	100	100	100	100	100
M	95	94	95	93	94	97	87	85	97	82	75	68	79	94	83	100	98	100	87
E	67	68	68	70	72	71	72	76	77	77	83	79	83	86	89	90	89	88	89
S-1 and S-2	90	89	95	92	93	91	66	83	95	38	62	90	100	93	87	100	100	100	98
All Other	37	36	37	38	38	39	37	38	41	34	37	39	42	43	44	47	46	47	47

C406.1.1.1 Building Core/Shell and Initial Build-Out Construction

Where separate permits are used for *building* core/shell and initial build-out construction compliance shall be in accordance with the following requirements.

1. The building core and shell permit(s) shall achieve at least half the energy credits required in Table C406.1.1
2. The *building envelope*, *equipment,* and *systems* in initial build-out construction exceeding 500 square feet of floor area in *buildings* where the *alteration* did not have final lighting or HVAC systems installed under a prior building permit shall be deemed to comply with Section C406.1 where either:

   2.1 The energy credits achieved under the project plus the energy credits achieved under a prior core and shell permit total at least the credits required in Table C406.1.1 or

   2.2 The project achieves not less than one half of the credits required in Table C406.1.1.

C406.1.2 Additional renewable and load management credit requirements.

Projects in new buildings and *additions* that are greater than 5000 square feet (500 m^2) shall comply with sufficient measures from C406.3 to achieve the minimum number of required renewable and load management credits from Table C406.1.2 based on building occupancy group and climate zone.

Table C406.1.2 Renewable and Load Management Credit Requirements by Building Occupancy Group

Building Occupancy Group	Climate Zone																		
	0A	**0B**	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
R-2, R-4, and I-1	64	59	70	69	73	89	76	91	96	63	93	70	51	79	66	52	63	50	47
I-2	31	32	33	32	33	40	36	40	34	32	44	32	29	37	34	34	33	28	24
R-1	41	44	48	49	49	63	55	66	68	50	66	52	42	60	51	46	52	41	36
B	63	64	78	75	78	89	87	100	100	77	100	86	69	93	83	72	86	73	59
A-2	8	8	9	9	9	11	9	11	11	8	11	9	8	9	9	8	9	8	5
M	71	70	84	84	95	100	100	100	100	87	100	99	83	100	96	83	90	78	61
E	50	56	64	61	69	87	77	96	97	72	100	79	62	90	79	70	77	65	52
S-1 and S-2	100	100	100	100	100	100	100	100	100	98	100	100	78	100	100	69	94	70	60
All Other	55	55	66	63	69	81	72	87	89	61	87	69	53	75	67	54	63	52	43

C406.1.3 Substantial Alterations to Existing Buildings

The *building envelope*, *equipment,* and *systems* in *alterations* to *buildings* exceeding 5000 square feet of *gross conditioned floor area* shall comply with the requirements of Section C406.1.1 and C406.1.2 where the alteration includes replacement of two or more of the following:

1. HVAC unitary systems or HVAC central heating or cooling equipment serving the alteration area, not including ductwork or *piping*
2. 80% or more of the lighting fixtures in the *alteration* area
3. Building envelope components in the *alteration* area including new exterior cladding, fenestration, or insulation.

C406.1.4 Energy Credits Achieved

Energy credits achieved for the project shall be the sum of measure energy credits for individual measures included in the project. Credits are available for the measures listed in Section C406.2. Base energy credits are shown in Tables C406.1.4(1) through C406.1.4(9) based on building occupancies and climate zones. Measure energy credits achieved shall be determined in one of three ways, depending on the measure:

1. The measure energy credit shall be the base energy credit for the measure where no adjustment factor or formula is shown in the measure description in Section C406.2.
2. The measure energy credit shall be the base energy credit for the measure adjusted by a factor or formula as stated in the measure description in Section C406.2. Where adjustments are applied, each measure energy credit shall be rounded to the nearest whole number.
3. The measure energy credit shall be by direct formula as stated in the measure description in Section C406.2, where each individual measure credit shall be rounded to the nearest whole number.

Table C406.1.4(1) Base Energy Credits for Group R-2, R-4, and I-1 Occupancies

ID	Energy Credit Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	8	13	7	11	6	8	9	6	1	24	8	9	30	15	5	32	28	31	36
E03	Envelope leak reduction	C406.2.1.3	15	10	12	8	6	16	13	5	1	47	7	9	65	16	x	73	43	52	26
E04	Add R-5 Roof Insulation	C406.2.1.4	1	0	0	1	1	1	2	2	1	3	2	2	3	3	0	4	4	3	4
E05	Add R-10 Roof Insulation	C406.2.1.4	1	1	1	1	1	1	4	3	1	5	3	4	6	5	0	7	7	6	8
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	6	6	3	5	3	4	5	2	1	5	2	2	6	4	0	8	7	7	7
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	10	10	6	8	5	6	8	4	1	8	3	4	11	7	0	14	12	13	13
E08	Fenestration U-0.45	C406.2.1.6	0	0	0	0	14	17	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	7	9	15	6	0	0	7	2	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	5	0	1	16	0	0	16	10	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	42	35	25	14
H01	HVAC Performance	C406.2.2.1	20	19	16	17	14	13	11	11	5	13	10	8	15	12	7	18	14	17	19
H02	Heating efficiency	C406.2.2.2	x	x	x	x	x	x	3	1	1	6	2	3	10	5	2	14	10	13	16
H03	Cooling efficiency	C406.2.2.3	7	6	4	4	3	3	1	1	1	1	1	1	1	1	x	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	9	10	8	22	20	25	16	17	32	21	24	17	23	27	16	21	24	18	18
H05	DOAS/fan control	C406.2.2.5	32	31	27	28	23	23	28	21	12	42	24	24	56	36	19	73	54	70	79
W01	SHW preheat recovery	C406.2.3.1 a	61	63	74	74	85	88	101	100	121	103	109	122	102	111	130	93	106	99	96
W02	Heat pump water heater	C406.2.3.1 b	50	52	62	61	72	74	86	85	104	88	94	106	88	96	112	81	92	87	84
W03	Efficient gas water heater	C406.2.3.1 c	38	39	46	46	53	55	63	62	76	64	68	76	64	69	81	58	66	62	60
W04	SHW pipe insulation	C406.2.3.2	7	7	8	7	8	8	8	9	10	8	9	9	7	8	9	6	7	6	6
W05	Point of use water heaters	C406.2.3.3 a	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	3	3	3	3	3	3	3	3	4	3	3	4	3	3	4	3	3	3	2
W07	SHW heat trace system	C406.2.3.3 c	12	12	13	13	14	15	15	15	18	14	15	16	13	14	16	11	13	11	10
W08	SHW submeters	C406.2.3.4	11	11	13	13	15	16	18	18	22	19	20	22	19	20	24	17	20	18	18
W09	SHW distribution sizing	C406.2.3.5	45	46	55	54	63	65	74	73	89	75	80	89	74	81	95	68	77	72	70
W10	Shower heat recovery	C406.2.3.6	15	16	19	19	22	23	26	26	32	27	29	32	27	29	34	25	28	27	26
P01	Energy monitoring	C406.2.4	3	3	2	3	2	2	2	2	2	2	2	2	2	2	2	3	2	2	3
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L03	Increase occp. sensor	C406.2.5.3	3	3	4	4	4	4	3	4	3	2	3	2	1	2	2	1	1	1	1
L04	Increase daylight area	C406.2.5.4	5	5	5	5	5	5	4	4	4	4	4	3	3	4	3	2	3	3	2
L05	Residential light control	C406.2.5.5	8	8	9	9	9	9	8	8	10	6	8	7	4	6	8	3	5	4	3
L06	Light power reduction	C406.2.5.7	2	2	2	2	2	2	2	2	2	1	2	1	1	1	1	1	1	1	1
Q01	Efficient elevator	C406.2.7.1	4	4	4	4	5	5	5	5	5	4	5	5	4	4	5	4	4	4	3
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	15	15	17	16	17	18	17	18	20	16	17	18	15	16	18	13	15	13	12
Q04	Fault detection	C406.2.7.4	3	3	2	3	2	2	2	2	1	2	2	1	2	2	1	3	2	3	3

x indicates measure is not available for building occupancy in that climate zone

Table C406.1.4(2) Base Energy Credits for Group I-2 Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	6	11	6	11	7	9	6	6	2	3	3	3	4	3	7	5	5	17	3
E03	Envelope leak reduction	C406.2.1.3	5	3	4	3	5	8	8	3	2	6	2	2	7	3	1	9	7	19	5
E04	Add R-5 Roof Insulation	C406.2.1.4	0	0	0	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1	2
E05	Add R-10 Roof Insulation	C406.2.1.4	1	1	0	1	1	1	1	1	0	1	1	1	2	1	0	2	1	2	3
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	0	3	0	2	1	2	8	3	1	3	0	1	2	1	0	2	1	2	2
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	0	3	0	3	2	2	9	4	1	4	1	1	3	0	0	3	3	3	3
E08	Fenestration U-0.45	C406.2.1.6	0	0	0	0	1	2	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	2	3	2	3	1	0	1	0	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	3	1	2	2	1	1	1	0	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	6	5	1	0
H01	HVAC Performance	C406.2.2.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H02	Heating efficiency	C406.2.2.2	x	x	x	x	2	3	4	3	7	6	4	6	8	6	10	11	12	15	19
H03	Cooling efficiency	C406.2.2.3	6	6	4	4	3	3	2	2	1	1	1	1	1	1	1	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	8	8	6	18	16	17	11	12	23	13	16	13	14	17	17	13	19	15	17
H05	DOAS/fan control	C406.2.2.5	41	41	40	40	42	36	42	37	39	49	40	46	56	46	61	65	68	82	93
W01	SHW preheat recovery	C406.2.3.1 a	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6	5	5	5
W02	Heat pump water heater	C406.2.3.1 b	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
W03	Efficient gas water heater	C406.2.3.1 c	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
W04	SHW pipe insulation	C406.2.3.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W05	Point of use water heaters	C406.2.3.3 a	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W07	SHW heat trace system	C406.2.3.3 c	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
W08	SHW submeters	C406.2.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W09	SHW distribution sizing	C406.2.3.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W10	Shower heat recovery	C406.2.3.6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P01	Energy monitoring	C406.2.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	5	5	5	5	5	6	5	6	6	5	6	6	5	5	5	4	4	3	2
L03	Increase occp. sensor	C406.2.5.3	5	5	5	5	5	5	5	5	6	5	5	6	5	5	5	4	4	3	2
L04	Increase daylight area	C406.2.5.4	7	7	7	7	7	7	7	7	8	6	6	6	6	6	5	5	5	5	4
L05	Residential light control	C406.2.5.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L06	Light power reduction	C406.2.5.7	7	7	7	7	7	7	7	7	9	7	7	8	6	7	7	5	5	4	3
Q01	Efficient elevator	C406.2.7.1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q04	Fault detection	C406.2.7.4	3	3	3	3	3	3	3	3	2	3	3	2	3	3	3	3	3	4	4

x indicates measure is not available for building occupancy in that climate zone

Table C406.1.4(3) Base Energy Credits for Group R-1 Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	8	12	7	12	6	8	6	7	13	8	5	3	9	7	3	13	12	18	26
E03	Envelope leak reduction	C406.2.1.3	15	9	12	8	6	16	7	5	10	14	3	1	19	5	x	28	16	28	18
E04	Add R-5 Roof Insulation	C406.2.1.4	0	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	2
E05	Add R-10 Roof Insulation	C406.2.1.4	1	1	1	2	2	1	2	1	1	2	1	2	2	1	2	3	2	2	3
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	14	19	8	19	2	3	3	2	0	4	1	3	4	2	2	5	3	4	3
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	18	26	11	25	3	4	5	3	0	6	2	4	7	4	4	8	6	8	5
E08	Fenestration U-0.45	C406.2.1.6	2	2	1	2	2	3	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	2	3	4	3	1	1	6	3	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	4	1	3	6	1	3	6	4	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	13	8	5	2
H01	HVAC Performance	C406.2.2.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H02	Heating efficiency	C406.2.2.2	x	x	x	x	x	x	1	1	6	2	1	1	3	2	2	6	4	8	11
H03	Cooling efficiency	C406.2.2.3	7	6	4	4	3	2	1	2	1	1	2	1	1	1	1	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	8	8	6	31	28	36	19	23	54	21	31	22	22	30	21	19	24	18	19
H05	DOAS/fan control	C406.2.2.5	32	30	26	28	25	23	24	22	28	26	22	20	30	26	19	41	34	48	62
W01	SHW preheat recovery	C406.2.3.1 a	18	19	22	22	25	27	31	31	32	34	34	38	37	36	40	36	37	36	35
W02	Heat pump water heater	C406.2.3.1 b	14	15	18	17	20	22	25	25	27	29	29	32	31	31	34	30	32	31	30
W03	Efficient gas water heater	C406.2.3.1 c	11	12	14	14	16	17	19	19	20	21	21	24	23	23	25	22	23	23	22
W04	SHW pipe insulation	C406.2.3.2	3	3	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3
W05	Point of use water heaters	C406.2.3.3 a	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1
W07	SHW heat trace system	C406.2.3.3 c	5	6	6	6	6	7	7	7	7	7	7	8	7	7	8	7	7	6	6
W08	SHW submeters	C406.2.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W09	SHW distribution sizing	C406.2.3.5	13	14	16	16	18	20	22	22	23	25	25	28	27	26	29	26	27	26	25
W10	Shower heat recovery	C406.2.3.6	4	5	5	5	6	7	8	8	8	9	9	10	10	9	10	9	10	10	9
P01	Energy monitoring	C406.2.4	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L03	Increase occp. sensor	C406.2.5.3	3	3	3	3	3	3	3	3	4	2	3	3	2	2	3	2	2	1	1
L04	Increase daylight area	C406.2.5.4	4	5	5	4	5	5	4	4	5	4	4	4	3	4	3	3	3	3	2
L05	Residential light control	C406.2.5.5	7	7	8	8	8	8	8	8	9	6	7	7	5	7	7	4	5	4	3
L06	Light power reduction	C406.2.5.7	1	1	2	2	2	2	2	2	2	1	2	2	1	1	2	1	1	1	1
Q01	Efficient elevator	C406.2.7.1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	2	2	2	2
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	9	9	10	10	10	11	11	11	11	11	11	12	11	11	12	10	11	10	9
Q04	Fault detection	C406.2.7.4	3	3	3	3	2	2	2	2	2	2	2	1	2	2	1	2	2	2	2

x indicates measure is not available for building occupancy in that climate zone

Table C406.1.4(4) Base Energy Credits for Group B Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	4	7	4	7	3	4	7	2	0	7	2	3	10	6	4	12	9	19	11
E03	Envelope leak reduction	C406.2.1.3	5	3	4	2	2	2	5	1	0	8	0	2	13	4	0	18	9	18	7
E04	Add R-5 Roof Insulation	C406.2.1.4	1	1	1	1	1	1	2	1	0	2	1	1	2	2	1	3	3	4	5
E05	Add R-10 Roof Insulation	C406.2.1.4	2	2	2	2	2	2	3	2	1	3	1	2	3	2	2	3	3	2	3
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	9	9	5	7	2	2	4	2	0	3	1	2	3	2	2	5	4	6	4
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	13	14	8	11	4	4	7	4	0	5	2	4	6	4	3	9	7	10	8
E08	Fenestration U-0.45	C406.2.1.6	1	1	2	2	7	7	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	4	4	8	3	0	0	0	0	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	5	1	3	7	1	3	7	4	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21	17	8	0
H01	HVAC Performance	C406.2.2.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H02	Heating efficiency	C406.2.2.2	x	x	x	x	x	x	1	1	0	3	2	2	5	4	3	9	7	8	12
H03	Cooling efficiency	C406.2.2.3	7	6	4	5	3	3	1	2	1	1	2	1	1	1	1	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	8	9	7	9	7	8	5	7	7	7	9	6	9	11	7	11	12	8	10
H05	DOAS/fan control	C406.2.2.5	31	31	27	29	25	25	28	26	18	35	28	28	47	38	29	64	53	58	74
W01	SHW preheat recovery	C406.2.3.1 a	8	9	10	9	11	11	12	12	14	13	13	14	13	13	15	12	13	14	14
W02	Heat pump water heater	C406.2.3.1 b	3	3	3	3	4	4	5	4	5	5	5	6	5	5	6	5	5	6	6
W03	Efficient gas water heater	C406.2.3.1 c	5	5	6	6	7	7	8	7	8	8	8	9	8	8	9	8	8	9	8
W04	SHW pipe insulation	C406.2.3.2	3	3	4	4	4	4	4	4	5	4	4	5	4	4	5	4	4	4	4
W05	Point of use water heaters	C406.2.3.3 a	12	15	17	16	18	18	19	19	22	20	20	22	20	20	22	18	19	20	19
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	4	4	4	4	5	5	5	5	6	5	5	6	5	5	6	5	5	5	5
W08	SHW submeters	C406.2.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W09	SHW distribution sizing	C406.2.3.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P01	Energy monitoring	C406.2.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	5	5	6	6	6	6	6	6	7	6	6	6	5	5	6	4	5	3	2
L03	Increase occp. sensor	C406.2.5.3	5	6	6	6	6	6	6	6	8	6	6	6	5	5	6	4	5	4	3
L04	Increase daylight area	C406.2.5.4	7	7	8	8	8	8	8	8	9	6	7	7	6	6	6	6	6	7	5
L05	Residential light control	C406.2.5.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L06	Light power reduction	C406.2.5.7	7	7	8	8	8	8	8	8	9	7	8	8	6	7	8	5	6	5	3
Q01	Efficient elevator	C406.2.7.1	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q04	Fault detection	C406.2.7.4	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	3	3	3	3

x indicates measure is not available for building occupancy in that climate zone

Table C406.1.4(5) Base Energy Credits for Group A-2 Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	1	1	1	1	2	2	9	2	0	19	4	5	26	7	3	33	23	29	13
E03	Envelope leak reduction	C406.2.1.3	2	1	1	1	2	3	11	2	0	24	4	6	33	9	3	42	29	36	16
E04	Add R-5 Roof Insulation	C406.2.1.4	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1
E05	Add R-10 Roof Insulation	C406.2.1.4	1	1	0	1	1	1	2	1	1	1	1	1	2	2	1	2	2	1	2
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	1	1	0	1	1	1	2	2	0	1	0	1	2	1	1	1	1	1	1
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	1	1	0	1	1	2	3	3	1	2	1	2	2	2	2	2	2	2	2
E08	Fenestration U-0.45	C406.2.1.6	0	0	0	0	1	1	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	1	2	3	2	1	0	0	0	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	1	0	1	2	0	1	2	1	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	4	4	0	0
H01	HVAC Performance	C406.2.2.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H02	Heating efficiency	C406.2.2.2	x	x	x	x	1	1	6	3	3	10	6	8	15	11	10	19	15	23	28
H03	Cooling efficiency	C406.2.2.3	6	5	3	4	3	2	1	1	1	1	1	1	1	1	1	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	7	7	5	24	23	29	20	21	39	26	34	24	30	38	25	27	32	26	28
H05	DOAS/fan control	C406.2.2.5	29	27	20	25	24	21	36	27	15	51	35	38	67	53	45	84	70	97	115
W01	SHW preheat recovery	C406.2.3.1 a	24	26	31	29	33	35	37	38	45	38	41	44	37	40	44	34	38	33	30
W02	Heat pump water heater	C406.2.3.1 b	15	16	19	18	21	23	25	25	29	26	28	30	26	28	31	25	27	24	22
W03	Efficient gas water heater	C406.2.3.1 c	15	16	19	18	21	22	23	24	28	24	25	27	23	25	27	21	24	21	18
W04	SHW pipe insulation	C406.2.3.2	2	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	2	2	2
W05	Point of use water heaters	C406.2.3.3 a	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	3	4	4	4	4	4	4	4	4	4	4	4	3	4	4	3	3	3	3
W08	SHW submeters	C406.2.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W09	SHW distribution sizing	C406.2.3.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P01	Energy monitoring	C406.2.4	2	2	2	2	2	1	2	1	1	2	1	1	2	2	1	2	2	2	3
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	1	1	0
L03	Increase occp. sensor	C406.2.5.3	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	0
L04	Increase daylight area	C406.2.5.4	3	3	3	3	3	3	2	2	2	2	2	2	1	2	1	1	1	1	1
L05	Residential light control	C406.2.5.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L06	Light power reduction	C406.2.5.7	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	1	2	1	1
Q01	Efficient elevator	C406.2.7.1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Q02	Commercial kitchen equip.	C406.2.7.2	24	26	28	27	28	29	27	29	32	26	28	29	24	26	28	21	23	19	17
Q03	Residential kitchen equip.	C406.2.7.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q04	Fault detection	C406.2.7.4	3	2	2	2	2	2	2	2	1	2	2	1	2	2	2	3	2	3	4

x indicates measure is not available for building occupancy in that climate zone

Table C406.1.4(6) Base Energy Credits for Group M Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	2	2	2	2	2	3	15	2	0	36	5	9	45	11	5	51	36	35	15
E03	Envelope leak reduction	C406.2.1.3	3	3	2	2	3	3	19	3	0	44	6	11	56	13	6	64	44	43	19
E04	Add R-5 Roof Insulation	C406.2.1.4	4	3	3	4	4	4	10	9	2	11	10	11	12	13	13	13	15	13	17
E05	Add R-10 Roof Insulation	C406.2.1.4	8	6	5	7	7	7	18	16	4	19	18	20	21	22	23	24	26	24	30
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	46	47	34	45	8	9	14	11	3	16	13	16	15	14	14	13	14	14	9
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	64	65	48	62	13	15	23	18	4	27	21	27	25	24	25	23	24	24	16
E08	Fenestration U-0.45	C406.2.1.6	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	5	4	5	4	3	5	4	3	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	10	10	0	0
H01	HVAC Performance	C406.2.2.1	31	30	26	28	23	21	23	20	14	27	21	22	29	25	23	32	28	30	33
H02	Heating efficiency	C406.2.2.2	x	x	x	x	x	x	10	3	1	19	8	15	26	17	18	29	24	27	31
H03	Cooling efficiency	C406.2.2.3	10	9	7	7	5	4	2	2	1	1	2	1	1	1	1	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	11	12	9	18	15	17	19	15	19	31	27	26	35	38	27	31	35	25	27
H05	DOAS/fan control	C406.2.2.5	48	48	42	47	40	38	66	46	31	98	61	82	120	91	90	134	115	125	141
W01	SHW preheat recovery	C406.2.3.1 a	12	13	16	15	18	20	19	21	26	17	21	21	16	19	21	13	16	15	13
W02	Heat pump water heater	C406.2.3.1 b	3	3	4	3	4	5	5	5	7	5	6	6	4	5	6	4	4	4	4
W03	Efficient gas water heater	C406.2.3.1 c	6	7	8	8	10	10	10	11	14	9	11	11	8	10	11	7	8	8	7
W04	SHW pipe insulation	C406.2.3.2	3	3	4	4	4	4	4	4	5	4	4	5	4	4	5	4	4	4	4
W05	Point of use water heaters	C406.2.3.3 a	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	4	4	4	4	5	5	5	5	6	5	5	6	5	5	6	5	5	5	5
W08	SHW submeters	C406.2.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W09	SHW distribution sizing	C406.2.3.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P01	Energy monitoring	C406.2.4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	9	9	11	10	12	13	11	13	15	9	12	11	7	9	10	5	7	5	3
L03	Increase occp. sensor	C406.2.5.3	9	9	11	10	12	13	12	13	15	10	12	11	7	10	11	6	8	5	4
L04	Increase daylight area	C406.2.5.4	12	13	15	14	16	17	15	16	20	11	14	13	9	12	11	8	10	10	8
L05	Residential light control	C406.2.5.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L06	Light power reduction	C406.2.5.7	12	12	14	14	15	16	12	15	19	8	12	9	6	10	7	6	7	6	5
Q01	Efficient elevator	C406.2.7.1	3	3	4	3	4	4	4	4	5	3	4	4	3	4	4	3	3	3	2
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q04	Fault detection	C406.2.7.4	3	2	2	2	2	2	2	2	1	2	2	1	2	2	2	3	2	3	4

x indicates measure is not available for building occupancy in that climate zone

Table C406.1.4(7) Base Energy Credits for Group E Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	9	22	8	20	9	12	5	11	3	4	9	2	3	6	0	4	3	4	3
E03	Envelope leak reduction	C406.2.1.3	4	3	3	3	2	5	2	1	0	0	0	0	1	0	0	2	0	1	1
E04	Add R-5 Roof Insulation	C406.2.1.4	4	5	2	5	2	5	8	4	0	7	4	6	11	7	11	13	14	12	15
E05	Add R-10 Roof Insulation	C406.2.1.4	8	8	4	9	5	7	16	7	0	14	7	10	18	13	13	23	25	22	28
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	3	5	2	5	2	4	6	4	1	4	2	3	4	3	2	4	4	3	4
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	5	7	4	8	3	6	8	6	2	6	3	6	5	5	6	7	6	7	8
E08	Fenestration U-0.45	C406.2.1.6	0	0	0	0	4	6	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	1	5	15	8	0	1	2	4	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	10	4	10	15	4	11	13	12	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	34	29	12	10
H01	HVAC Performance	C406.2.2.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H02	Heating efficiency	C406.2.2.2	x	x	x	x	x	x	4	3	3	5	5	10	9	11	6	15	11	18	26
H03	Cooling efficiency	C406.2.2.3	9	8	6	7	5	4	2	2	1	1	1	1	1	1	1	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	10	11	8	14	11	14	11	12	17	12	20	18	16	28	13	18	20	18	23
H05	DOAS/fan control	C406.2.2.5	45	42	37	41	36	34	41	39	30	43	46	58	57	65	40	79	63	88	117
W01	SHW preheat recovery	C406.2.3.1 a	7	7	9	8	10	11	13	13	15	14	15	15	15	14	17	13	15	14	12
W02	Heat pump water heater	C406.2.3.1 b	4	4	6	5	7	7	9	9	10	10	10	11	11	10	12	10	11	10	9
W03	Efficient gas water heater	C406.2.3.1 c	4	4	6	5	6	7	8	8	9	9	9	10	9	9	11	8	10	9	7
W04	SHW pipe insulation	C406.2.3.2	3	3	4	4	4	4	4	5	6	5	5	6	5	5	7	4	5	4	4
W05	Point of use water heaters	C406.2.3.3 a	3	4	4	4	4	5	5	5	6	5	5	5	5	5	6	4	5	4	3
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	2	1	1
W07	SHW heat trace system	C406.2.3.3 c	4	4	4	4	5	5	5	6	7	6	6	7	6	6	8	5	7	5	5
W08	SHW submeters	C406.2.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W09	SHW distribution sizing	C406.2.3.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W10	Shower heat recovery	C406.2.3.6	2	2	2	2	3	3	3	3	4	3	3	4	3	3	4	3	3	3	3
P01	Energy monitoring	C406.2.4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	5	5	5	6	6	6	5	6	7	6	6	6	5	5	6	4	4	3	2
L03	Increase occp. sensor	C406.2.5.3	4	4	5	5	5	6	6	6	7	6	6	5	4	4	5	3	4	3	2
L04	Increase daylight area	C406.2.5.4	6	6	7	7	7	7	7	7	8	6	6	6	5	5	6	5	5	5	4
L05	Residential light control	C406.2.5.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L06	Light power reduction	C406.2.5.7	6	7	7	7	8	8	8	8	10	7	8	7	6	7	8	5	6	4	2
Q01	Efficient elevator	C406.2.7.1	3	4	4	4	4	5	5	5	5	5	5	5	5	5	5	4	5	4	3
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q04	Fault detection	C406.2.7.4	4	4	4	4	3	3	3	3	2	3	3	3	3	3	2	4	3	4	4

x indicates measure is not available for building occupancy in that climate zone

Table C406.1.4(8) Base Energy Credits for Group S-1 and S-2 Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	1	2	1	1	1	2	25	2	0	62	11	14	74	21	6	75	57	56	21
E03	Envelope leak reduction	C406.2.1.3	2	2	1	2	1	3	31	3	x	77	14	17	92	25	8	95	71	69	26
E04	Add R-5 Roof Insulation	C406.2.1.4	8	7	6	6	6	7	12	10	4	8	11	10	8	12	13	5	8	7	11
E05	Add R-10 Roof Insulation	C406.2.1.4	13	12	10	11	10	11	18	17	7	14	19	18	14	20	22	10	14	12	19
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	12	14	8	13	4	6	11	7	2	6	7	8	5	7	7	4	5	5	4
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	19	23	13	21	7	10	15	12	3	10	12	13	9	12	12	7	9	9	8
E08	Fenestration U-0.45	C406.2.1.6	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	4	0	5	8	0	5	6	3	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	3	3	10	12
H01	HVAC Performance	C406.2.2.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H02	Heating efficiency	C406.2.2.2	x	x	x	x	x	x	16	3	1	33	17	22	41	31	21	44	38	43	43
H03	Cooling efficiency	C406.2.2.3	7	7	4	5	3	3	1	1	1	1	1	1	1	1	1	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	8	9	6	6	4	5	21	8	2	44	38	30	50	57	26	42	48	36	34
H05	DOAS/fan control	C406.2.2.5	35	37	26	33	24	27	77	35	14	141	83	96	168	132	90	180	157	177	178
W01	SHW preheat recovery	C406.2.3.1 a	8	7	9	8	10	10	8	10	12	5	8	8	4	6	9	3	4	3	3
W02	Heat pump water heater	C406.2.3.1 b	2	2	2	2	2	2	2	2	3	1	2	2	1	2	2	1	1	1	1
W03	Efficient gas water heater	C406.2.3.1 c	4	4	5	4	5	5	4	5	6	3	4	4	2	3	5	2	2	2	2
W04	SHW pipe insulation	C406.2.3.2	3	3	4	3	3	3	2	3	4	2	2	3	1	2	3	1	1	1	1
W05	Point of use water heaters	C406.2.3.3 a	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	4	4	4	3	4	4	3	4	5	2	3	3	2	2	4	2	2	2	2
W08	SHW submeters	C406.2.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W09	SHW distribution sizing	C406.2.3.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P01	Energy monitoring	C406.2.4	5	5	6	6	6	6	5	6	6	5	5	5	5	5	6	5	5	5	5
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	10	10	12	11	12	14	9	12	14	6	9	9	3	6	9	3	5	3	2
L03	Increase occp. sensor	C406.2.5.3	12	12	14	13	15	14	12	14	17	7	11	11	5	7	11	4	6	3	3
L04	Increase daylight area	C406.2.5.4	15	14	18	16	18	17	13	16	21	7	12	11	5	8	10	4	6	6	5
L05	Residential light control	C406.2.5.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L06	Light power reduction	C406.2.5.7	14	14	17	16	17	17	13	17	19	8	13	12	5	8	12	4	6	4	2
Q01	Efficient elevator	C406.2.7.1	15	14	18	16	18	18	15	18	21	9	14	14	7	10	14	5	7	5	5
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q04	Fault detection	C406.2.7.4	3	3	2	3	2	2	3	2	1	5	3	3	5	4	3	6	5	6	6

x indicates measure is not available for building occupancy in that climate zone

Table C406.1(9) Base Energy Credits for Other[a] Occupancies

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
E01	Envelope Performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1																		
E02	UA reduction (15%)	C406.2.1.2	5	9	5	8	5	6	10	5	2	20	6	6	25	10	4	28	22	26	16
E03	Envelope leak reduction	C406.2.1.3	6	4	5	4	3	7	12	3	2	28	5	6	36	9	3	41	27	33	15
E04	Add R-5 Roof Insulation	C406.2.1.4	2	2	2	2	2	3	5	4	1	4	4	4	5	5	6	5	6	5	7
E05	Add R-10 Roof Insulation	C406.2.1.4	4	4	3	4	4	4	8	6	2	7	6	7	9	8	9	9	10	9	12
E06	Add R-2.5ci Wall Insulation	C406.2.1.5	11	13	8	12	3	4	7	4	1	5	3	5	5	4	4	5	5	5	4
E07	Add R-5.0ci Wall Insulation	C406.2.1.5	16	19	11	17	5	6	10	7	2	9	6	8	9	7	7	9	9	10	8
E08	Fenestration U-0.45	C406.2.1.6	0	0	0	1	4	5	x	x	x	x	x	x	x	x	x	x	x	x	x
E09	Fenestration U-0.33	C406.2.1.6	x	x	x	x	2	3	6	3	0	0	2	1	x	x	x	x	x	x	x
E10	Fenestration U-0.31	C406.2.1.6	x	x	x	x	x	x	x	x	x	5	1	4	8	1	4	7	5	x	x
E11	Fenestration U-0.45	C406.2.1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17	14	8	5
H01	HVAC Performance	C406.2.2.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H02	Heating efficiency	C406.2.2.2	x	x	x	x	x	x	6	2	3	11	6	8	15	11	9	18	15	19	23
H03	Cooling efficiency	C406.2.2.3	7	7	5	5	4	3	1	2	1	x	x	x	x	x	x	x	x	x	x
H04	Residential HVAC control	C406.2.2.4	9	9	7	18	16	19	15	14	24	22	25	20	25	31	19	23	27	21	22
H05	DOAS/fan control	C406.2.2.5	37	36	31	34	30	28	43	32	23	61	42	49	75	61	49	90	77	93	##
W01	SHW preheat recovery	C406.2.3.1 a	18	19	22	21	25	26	28	29	34	29	31	34	29	31	35	26	29	27	26
W02	Heat pump water heater	C406.2.3.1 b	12	12	15	14	17	17	20	20	24	21	22	25	21	23	26	20	22	21	20
W03	Efficient gas water heater	C406.2.3.1 c	11	11	13	13	15	16	17	17	21	18	19	21	18	19	22	16	18	17	16
W04	SHW pipe insulation	C406.2.3.2	3	3	4	4	4	4	4	4	5	4	4	5	4	4	5	3	4	3	3
W05	Point of use water heaters	C406.2.3.3 a	8	10	11	10	11	12	12	12	14	13	13	14	13	13	14	11	12	12	11
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1	1	1	1	1	1	2	1	1	2	1	1	2	1	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	5	5	5	5	6	6	6	6	7	6	6	7	5	6	7	5	5	5	5
W08	SHW submeters	C406.2.3.4	11	11	13	13	15	16	18	18	22	19	20	22	19	20	24	17	20	18	18
W09	SHW distribution sizing	C406.2.3.5	29	30	36	35	41	43	48	48	56	50	53	59	51	54	62	47	52	49	48
W10	Shower heat recovery	C406.2.3.6	6	6	7	7	8	9	10	10	11	10	11	12	10	11	12	10	11	10	10
P01	Energy monitoring	C406.2.4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4
L01	Lighting Performance	C406.2.5.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	5	5	5	5	6	6	5	6	7	5	5	5	4	4	5	3	4	3	2
L03	Increase occp. sensor	C406.2.5.3	5	6	6	6	7	7	6	7	8	5	6	6	4	5	6	3	4	3	2
L04	Increase daylight area	C406.2.5.4	7	8	9	8	9	9	8	8	10	6	7	7	5	6	6	4	5	5	4
L05	Residential light control	C406.2.5.5	8	8	9	9	9	9	8	8	10	6	8	7	5	7	8	4	5	4	3
L06	Light power reduction	C406.2.5.7	7	7	8	7	8	8	7	8	9	5	7	6	4	5	6	4	4	3	2
Q01	Efficient elevator	C406.2.7.1	4	4	5	4	5	5	5	5	6	4	5	5	4	4	5	3	4	3	3
Q02	Commercial kitchen equip.	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Residential kitchen equip.	C406.2.7.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q04	Fault detection	C406.2.7.4	3	3	3	3	3	2	3	2	2	3	3	2	3	3	2	4	3	4	4

x indicates measure is not available for building occupancy in that climate zone

[a] Other occupancy groups include all Groups except for Groups A-2, B, E, I, M, and R.

C406.2 Additional Energy Efficiency Credit Measures

Each energy efficiency credit measure used to meet credit requirements for the project shall include efficiency that is greater than the energy efficiency required for the building type and configuration requirements in Sections C402 through C405. Measures installed in the project that meet the requirements in Sections C406.2.1 through C406.2.7 shall achieve the credits listed for the measure and occupancy type in Tables C406.1.4(1) through C406.1.4(9) or where calculations required by Sections C406.2.1 through C406.2.7 create or modify the table credits, the credits achieved shall be based upon the section calculations.

C406.2.1 More Efficient Building Envelope

A project shall achieve credits for improved envelope performance through compliance with the requirements of one of the following:

1. Section C406.2.1.1 (E01)
2. Section C406.2.1.2 (E02)
3. Section C406.2.1.3 (E03)
4. Both E02 and E03
5. Any combination of
   1.1. Section C406.2.1.3: E03A, E03B, or E03C
   1.2. Section C406.2.1.4: E04 or E05
   1.3. Section C406.2.1.5: E06 or E07
   1.4. Section C406.2.1.6: E08, E09, E10, or E11

C406.2.1.1 E01 Improved envelope performance 90.1 Appendix C

To achieve this credit, building envelope measures shall be installed to improve the energy performance of the project. The allowable energy credits shall be determined using Equation 4-13.

$$EC_{ENV} = 1000 \times \frac{EPF_B - EPF_P}{EPF_B} \qquad \text{(Equation 4-13)}$$

Where:

EC_{ENV} = E01 measure energy credits

EPF_B = base envelope performance factor calculated in accordance with ASHRAE 90.1-2019 Appendix C.

EPFP = proposed envelope performance factor calculated in accordance with ASHRAE 90.1-2019 Appendix C.

C406.2.1.2 E02 Total UA envelope reduction.

Energy credits shall be achieved where the total UA of the building thermal envelope as designed is not less than 15 percent below the total UA of the building thermal envelope in accordance with Section C402.1.5.

C406.2.1.3 E03 Reduced air infiltration.

Energy credits shall be achieved for tested air leakage less than thresholds in either section C406.2.1.3.1, C406.2.1.3.2, or C406.2.1.3.3 where tested in accordance with the following:

Air infiltration shall be verified by whole-building pressurization testing conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air-leakage rate of the project envelope shall not exceed the required cfm/ft^2 (L/s · m^2) under a pressure differential of 0.3 inches water column (75 Pa), with the calculated surface area being the sum of the above- and below-grade project envelope. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the code official and the building owner.

Alternate testing method: For projects having over 50,000 square feet (5 000 m^2) of conditioned floor area, air-leakage testing need not be conducted on the whole project where testing is conducted on representative above-grade sections of the project. Tested areas shall total not less than 25 percent of the conditioned floor area and shall be tested in accordance with this section.

C406.2.1.3.1 E03A Reduced air leakage to 0.25. The measured air-leakage rate of the project envelope shall not exceed 0.25 cfm/ft^2 (1.3 L/s × m^2) under a pressure differential of 0.3 inches water column (75 Pa), Multiply E03 Credits times 1.0.

C406.2.1.3.2 E03B Reduced air leakage to 0.15. The measured air-leakage rate of the project envelope shall not exceed 0.15 cfm/ft^2 (0.8 L/s × m^2) under a pressure differential of 0.3 inches water column (75 Pa), Multiply E03 Credits times 1.2.

C406.2.1.3.3 E03C Reduced air leakage to 0.08. The measured air-leakage rate of the project envelope shall not exceed 0.08 cfm/ft^2 (0.4 L/s × m^2) under a pressure differential of 0.3 inches water column (75 Pa), Multiply E03 Credits times 2.0.

C406.2.1.4 Improved Roof Insulation

Energy credits shall be achieved for improved insulation of all roof areas in the project meeting the requirements in either section C406.2.1.6.1 or C406.2.1.6.2. Such insulation shall be in addition to the required insulation in Table C402.1.3.

C406.2.1.4.1 E04 Add R-5 Roof Insulation. All roof area shall have additional R-5 continuous insulation included in the roof assembly. This can be achieved with 0.75 inches of polyisocyanurate, 1.25 inches of expanded polystyrene (EPS), or other insulation rated at R-10. For attics this is permitted to be achieved with fill or batt insulation rated at R-5 that is continuous and not interrupted by ceiling or roof joists. Where interrupted by joists, the added insulation shall be R-8 or more.

C406.2.1.4.2 E05 Add R-10 Roof Insulation. All roof area shall have additional R-10 continuous insulation included in the roof assembly. This can be achieved with 1.5 inches of polyisocyanurate, 2.5 inches of EPS, or other insulation rated at R-10. For attics this is permitted to be achieved with fill or batt insulation rated at R-10 that is continuous and not interrupted by ceiling or roof joists. Where interrupted by joists, the added insulation shall be R-13 or more.

C406.2.1.5 Improved Wall Insulation

Energy credits shall be achieved for improved insulation applied to at least 90% of all opaque walls in the project meeting the requirements in either section C406.2.1.5.1 or C406.2.1.5.2. Such insulation shall be in addition to the required insulation in Table C402.1.3.

C406.2.1.5.1 E06 Add R-2.5 to Walls. Opaque walls shall have additional R-2.5 continuous insulation included in the wall assembly. This can be achieved with 0.375 inches of polyisocyanurate, 0.625 inches of EPS, or other continuous wall insulation rated at R-2.5.

C406.2.1.5.2 E07 Add R-5 to Walls. Opaque walls shall have additional R-5 continuous insulation included in the wall assembly. This can be achieved with 0.75 inches of polyisocyanurate, 1.25 inches of EPS, or other continuous wall insulation rated at R-5.

C406.2.1.6 Improved fenestration.

Energy credits for one selected fenestration energy credit ID shall be achieved for improved energy characteristics of all vertical fenestration in the project meeting of the requirements in one of the rows of Table C406.2.1.6. All vertical fenestration shall have both the U-factor and SHGC equal to or less than the value shown in the selected table row and have visible transmittance (VT) equal to or greater than the value shown in the selected table row.

Table C406.2.1.6 Vertical Fenestration Requirements for Energy Credits

Energy Credit ID	Applicable Climate Zones	Maximum U-Factor	Maximum SHGC	Minimum VT
E08	0-2	0.45	0.21	0.230
E09	2-4	0.33	0.23	0.253
E10	4-6	0.31	0.36	0.396
E11	6-7	0.26	0.38	0.418

C406.2.2 More Efficient HVAC Equipment Performance

All heating and cooling systems shall meet the minimum requirements of Section C403 and efficiency improvements shall be referenced to minimum efficiencies listed in Tables referenced by Section C403.3.2. Where multiple efficiency requirements are listed, equipment shall meet the seasonal efficiencies including SEER, EER/integrated energy efficiency ratio (IEER), integrated part load value (IPLV), or AFUE. Equipment that is larger than the maximum capacity range indicated in Tables referenced by Section C403.3.2 shall utilize the values listed for the largest capacity equipment for the associated equipment type shown in the table. Where multiple individual heating or cooling systems serve the project, the improvement shall be the weighted average improvement based on individual system capacity.

HVAC systems are permitted to achieve energy credits by meeting the requirements of either:

1. C406.2.2.2 H02,
2. C406.2.2.3 H03,
3. C406.2.2.4 H04,
4. C406.2.2.5 H05,
5. Any combination of H02, H03, H04 and H05.

C406.2.2.1 H01 HVAC Performance (TSPR). Reserved.

[Reserved for future use; See Appendix B]

C406.2.2.2 H02 More efficient HVAC equipment heating performance

No less than 90 percent of the total HVAC capacity serving the total *conditioned floor area* of the entire building, or tenant space in accordance with Section C406.1.1, shall comply with the requirements of this Section.

1. Equipment installed shall be types that are listed in Tables referenced by Section C403.3.2 or air-to-water heat pumps. Electric resistance heating shall be limited to 20 percent of system capacity, with the exception of heat pump supplemental heating.
2. Equipment shall exceed the minimum heating efficiency requirements listed in Tables referenced by Section C403.3.2 by at least 5 percent. Where equipment exceeds the minimum annual heating efficiency requirements by more than 5 percent, energy efficiency credits for heating shall be determined using Equation 4-14 rounded to the nearest whole number.

$$EEC_{HEH} = EEC_{H5} \times \frac{HEI}{5\%} \quad \text{(Equation 4-14)}$$

Where:

EEC_{HEH} = energy efficiency credits for heating efficiency improvement

EEC_5 = C406.2.2.2 credits from Tables C406.1.4(1) through C406.1.4(9)

HEI = the lesser of: the improvement above minimum heating efficiency requirements or 20 percent. Where heating efficiency varies by system, use the capacity weighted average percentage for all heating equipment combined.

Exception: In low energy spaces complying with Section C402.1.1, no less than 90 percent of the installed heating capacity is provided by electric infrared or gas-fired radiant heating equipment for localized heating applications. Such spaces shall only achieve energy credits for EEC_5.

C406.2.2.3 H03 More efficient HVAC equipment cooling and fan performance.

No less than 90 percent of the total HVAC capacity serving the total *conditioned floor area* of the entire building, or tenant space in accordance with Section C406.1.1, shall comply with all of the requirements of this section. Where individual equipment efficiencies vary, weight them based on rated capacity.

1. Equipment installed shall be types that are listed in Tables referenced by Section C403.3.2 or air-to-water heat pumps. Air-to-water heat pumps do not have a requirement for minimum efficiency.
2. Equipment shall exceed the minimum cooling efficiency requirements listed in Tables referenced by Section C403.3.2 by at least 5 percent. Where equipment exceeds the minimum annual cooling efficiency and heat rejection efficiency requirements by more than 5 percent, energy efficiency credits for cooling shall be determined using Equation 4-15, rounded to the nearest whole number.

$$EEC_{HEC} = EEC_5 \times \frac{CEI}{5\%} \quad \text{(Equation 4-15)}$$

Where:

EEC_{HEC} = energy efficiency credits for cooling efficiency improvement

EEC_5 = C406.2.2.2 base energy credits from Tables C406.1.4(1) through C406.1.4(9)

CEI = the lesser of: the improvement above minimum cooling and heat rejection efficiency requirements, or 20 percent. Where cooling efficiency varies by system, use the capacity weighted average percentage for all cooling equipment combined.

Where fan energy is not included in packaged equipment rating or it is and the fan size has been increased from the as-rated equipment condition, fan power or horsepower shall be less than 95 percent of the allowed fan power in Section C403.8.1.

C406.2.2.4 H04 Residential HVAC control.

HVAC systems serving *dwelling units* or *sleeping units* shall be controlled with a programmable thermostat that is configured to automatically activate a setback condition of at least 5°F (3°C) for both heating and cooling. The programmable thermostat shall be configured to provide setback during occupied sleep periods. The unoccupied setback mode shall be configured to operate in conjunction with one of the following:

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

2. 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 all spaces being vacant immediately after a door switch operation. Where separate room HVAC units are used, an individual occupancy sensor on each unit that is configured to provide setback shall meet this requirement.
3. An advanced learning thermostat that senses occupant presence and automatically creates a schedule for occupancy and provides a dynamic setback schedule based on when the spaces are generally unoccupied.
4. An automated control and sensing system that uses geographic fencing connected to the dwelling unit occupants' cell phones and initiates the setback condition when all occupants are away from the building.

C406.2.2.5 H05 Dedicated Outdoor Air System

To achieve this credit, where single zone HVAC units are not required to have modulating fan control in accordance with Section C403.8.6.1, the base energy credits shown in Table 406.2 shall be prorated proportionately to the *conditioned floor area* served by single zone HVAC units with constant speed fans. HVAC controls and *ventilation* systems shall include all of the following:

1. Zone controls shall cycle the indoor fans with the load.
2. Outdoor air shall be supplied by an independent ventilation system designed to provide no more than 110% of the minimum outdoor air to each individual occupied zone, as specified by the *International Mechanical Code.*
3. The ventilation system shall have energy recovery with an *enthalpy recovery ratio* of 65% or more at heating design conditions in climate zones 3 through 8 and an enthalpy recovery ratio of 65% or more at cooling design conditions in climate zones 0, 1, 2, 3A, 3B, 4A, 4B, 5A, and 6A. In "A" climate zones, energy recovery shall include latent recovery.
4. Where the ventilation system serves multiple zones, an outdoor air bypass or wheel speed control shall automatically do one of the following:
   4.1. Set the energy recovery leaving-air temperature 55°F (13°C) or 100% outdoor air bypass when a majority of zones require cooling and outdoor air temperature is below 70°F (21°C).
   4.2. The HVAC system shall include supply-air temperature controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperatures. The controls shall reset the supply-air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room-air temperature.
5. Ventilation systems providing mechanical dehumidification shall use recovered energy for reheat.

C406.2.3 Reduced Energy Use In-service Water Heating

Projects with service water-heating equipment that serves the whole building, a building addition or a tenant space shall achieve credits through compliance with the requirements of this section. Systems are permitted to achieve energy credits by meeting the requirements of either:

1. C406.2.6.1 by selecting one allowed measure W01, W02 or W03
2. C406.2.6.2
3. C406.2.6.3 by selecting one allowed measure W05, W06, or W07
4. C406.2.6.4 W08

5. C406.2.6.5 W09
6. C406.2.6.6 W10
7. Any combination of measures in C402.2.6.1 through C402.2.6.6 as long no more than one allowed measure from C406.2.6.1 and C406.2.6.3 are selected.

C406.2.3.1 Service water-heating system efficiency

A project is allowed to claim energy credits from only one of the following water-heating system efficiency measures.

1. **W01 Recovered or renewable water heating.** The building service water-heating system shall have one or more of the following that are sized to provide not less than 30 percent of the building's annual hot water requirements or sized to provide 70 percent of the building's annual hot water requirements if the building is required to comply with Section C403.10.5:
   1.1. Waste heat recovery from SHW, heat recovery chillers, building equipment, or process equipment.
   1.2. A water-to-water heat pump that precools chilled water return for building cooling.
   1.3. On-site renewable energy water-heating systems.
2. **W02 Heat pump water heater.** To achieve this credit, air-source heat pump *water heater*s shall not draw conditioned air from within the *building*, except exhaust air that would otherwise be exhausted to the exterior. Any *recirculating system* and final heating shall be met with a separate non-heat pump heating source. Requirements shall be in accordance with one of the following:
   2.1. For multifamily, dormitories, and health care occupancies with a *recirculating system*, at least 30% of design end-use *service water-heating* requirements shall be met using heat pump preheat with a coefficient of performance (COP) of not less than 4.0 tested at 50°F (10°C) entering air and 70°F (21°C) entering water in accordance with AHRI Standard 1300. A preheat storage tank equal to 25% of peak demand shall be included in design.
   2.2. For office, restaurant and school *occupancies* with *piping* temperature maintenance, at least 30% of design end-use *service water-heating* requirements shall be met using heat pump preheat with a combined input-capacity-weighted-average UEF of 3.0 with a medium draw pattern for unitary *equipment* with either a *heat trace system* or a separate *water heater* in series for *recirculating system* and final heating.
   2.3. For retail, small office, and warehouse *occupancies* with no *recirculating system*, at least 30% of design end-use *service water-heating* requirements shall be met using the heat pump portion of a hybrid *water heater* with a combined input-capacity-weighted-average UEF of 3.0 with a medium draw pattern for unitary *equipment*, including *electric resistance* heating to meet peak loading.

   Where the heat pump capacity at 50°F (10°C) entering air and 70°F (21°C) entering water exceeds 50% of the design end-use load excluding *recirculating system* losses, the base credits from the Section C406.1 tables shall be prorated based on Equation 4-16.

$$\text{W02 credit} = \text{base W02 table credit} \times \frac{\text{HP}_{LF}}{50\%} \qquad \text{(Equation 4-16)}$$

Where:

HP_{LF} = Heat pump capacity as a fraction of the design end-use SHW requirements excluding recirculating system losses, not to exceed 80%.

3. **W03 Efficient fossil fuel water heater**. The combined input-capacity-weighted-average equipment rating of all fossil fuel water-heating equipment in the building shall be not less than 95% Et or 0.95 EF. This measure shall receive only half the listed energy credits for projects required to comply with C404.2.1.

C406.2.3.2 W04 Water-heating pipe insulation.

To achieve this credit, where SHW is provided by a central water-heating system, the hot water pipe insulation thickness shall be at least 1.5 times the thickness required in Table C403.12.3. All SHW piping shall be insulated from the hot water source to the fixture shutoff. For Group S (warehouse and storage) and Group M (retail) buildings, this measure is only available where a recirculation or heat trace system is used and piping length exceeds 80 lineal feet.

C406.2.3.3 Water-heating distribution temperature maintenance

A project is allowed to claim energy credits from only one of the following SHW distribution temperature maintenance measures.

1. **W05 Point of use water heaters**. Credits are available for office or school buildings larger than 10,000 ft^2 (930 m^2). Fixtures requiring hot water shall be supplied from a localized source of hot water with no recirculating system or heat trace piping. Supply piping from the water heater to the termination of the fixture supply pipe shall be insulated to the levels shown in Table C403.12.3 without exception. The volume from the water heater to the termination of the fixture supply pipe shall be limited as follows:

   1.1. Non-residential lavatories: not more than 2 oz (60 mL)

   1.2. All other plumbing fixtures or appliances: not more than 0.25 gallons (0.95 L)

   Exception: Where all remotely located hot water uses meet the requirements for measure W05, separate water heaters serving commercial kitchens or showers in locker rooms shall be permitted to have a local recirculating system or heat trace piping.

2. **W06 Thermostatic balancing valves.** Credits are available where service water heating is provided centrally and distributed throughout the building. Each recirculating system branch return connection to the main SHW supply piping shall have an automatic thermostatic balancing valve set to a minimal return water flow when the branch return temperature is greater than 115°F (46°C).

3. **W07 Heat trace system.** Credits are available for projects with gross floor area greater than 10,000 square feet and a central water-heating system. The energy credits achieved shall be from Tables C406.1.4(1) through C406.1.4(9). This system shall include self-regulating electric heat cables, connection kits, and electronic controls. The cable shall be installed directly on the hot water supply pipes underneath the insulation to replace standby losses.

C406.2.3.4 W08 Water-heating system submeters

To achieve this credit, each individual *dwelling unit* in a Group R-2 occupancy served by a central service water-heating system shall be provided with a SHW meter connected to a reporting system that provides individual *dwelling unit* reporting of actual domestic hot water use. Preheated water serving the cold water inlet to showers need not be metered. Where other codes or regulations require individual *dwelling unit* hot water metering, energy credits for this measure shall not be allowed.

C406.2.3.5 W09 Water heating distribution sizing

To achieve this credit, where Group R-1 and R-2 occupancies are served by a central SHW system, the distribution system serving dwelling units and guest rooms shall be sized using IAPMO/ANSI WE●Stand – 2017 Water Efficiency and Sanitation Standard for the Built

Environment. Plumbing fixtures in residential spaces that are connected to the service water-heating system shall have a flow or consumption rating ≤ the values shown in Table C406.2.3.5. Where other codes or regulations require fixture flows to be equal to or less than listed in Table C406.2.3.5 only half the base energy credits shall be achieved for this measure.

Table C406.2.3.5 Maximum Flow Rating for Residential Plumbing Fixtures with Heated Water

Plumbing Fixture	Maximum Flow Rate
Faucet for private lavatory,[a] hand sinks, or bar sinks	1.50 gpm at 60 psi (0.095 L/s at 410 kPa)
Faucet for residential kitchen sink [a, b, c]	1.8 gpm at 60 psi 0.11 L/s at 410 kPa)
Shower head (including hand-held shower spray) [a, b, d]	2.0 gpm at 80 psi (0.13 L/s at 550 kPa)

a. Showerheads, lavatory faucets and kitchen faucets are subject to U.S. Federal requirements listed in 10 CFR 430.32(o)-(p).
b. Maximum flow allowed is less than required by flow rates listed in U.S. 10 CFR 430.32(o)-(p) for showerheads and kitchen faucets.
c. Residential kitchen faucet may temporarily increase the flow above the maximum rate, but not above 2.2 gallons per minute at 60 psi (0.14 L/s at 410 kPa) and must default to the maximum flow rate listed.
d. When a shower is served by multiple shower heads, the combined flow rate of all shower heads controlled by a single valve shall not exceed the maximum flow rate listed or the shower shall be designed to allow only one shower head to operate at a time.

Note to adopting jurisdictions: Consider including the following informative note to clarify the requirements of C406.2.3.5

> ***Informative Note:*** *Where low water supply pressures are anticipated, user satisfaction may be enhanced if flow restrictors are specified to provide ≥80% of the rated flow at 20 psi (140 kPa).Where the distribution sizing protocol is applied to other than multifamily residential buildings, a variance to the plumbing code may be needed.*

C406.2.3.6 W10 Shower drain heat recovery

To achieve this credit, cold water serving building showers shall be preheated by shower drain heat recovery units that comply with CSA B55.2. Potable waterside pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. The efficiency of drain heat recovery units shall be 54% or greater measured in accordance with CSA B55.1. Full credits are applicable to the following building use types: health clinic, hospital, hotel, motel, multifamily, retirement facility, dormitory, and schools with more than eight showers. Partial credits are applicable to buildings where all but ground floor showers are served where the base energy credit from Tables C406.1.4(1) through C406.1.4(9) is adjusted by Equation 4-17.

$$\text{W10 credit} = \text{W10 base energy credit} \times \frac{\text{showers with drain heat recovery}}{\text{total showers in building}} \qquad \text{(Equation 4-17)}$$

C406.2.4 P01 Energy Monitoring

A project not required to comply with C405.12 can claim energy credits for installing an energy monitoring system that complies with all the requirements of C405.12.1 through C405.12.5.

C406.2.5 Energy Savings in Lighting Systems

Projects are permitted to achieve energy credits for increased lighting system performance by meeting the requirements of either:

1. C406.2.5.2 L02
2. C406.2.5.3 L03

3. C406.2.5.4 L04
4. C406.2.5.5 L05
5. C406.2.5.6 L06
6. Any combination of L03, L04, L05 and L06
7. Any combination of L02, L03 and L04

C406.2.5.1 L01 Lighting system performance (reserved)

Reserved for future use

C406.2.5.2 L02 Enhanced digital lighting controls.

Measure credits shall be achieved where no less than 50 percent of the gross floor area within the project shall comply with the requirements of this section.

1. **Lighting controls function.** Interior general lighting shall be located, scheduled and operated in accordance with Section C405.2 and shall be configured with the following enhanced control functions:
   1.1. Luminaires shall be configured for continuous dimming.

   1.2. Each luminaire shall be individually addressed.

   Exceptions to Item 1.2:
   1. Multiple luminaires mounted on no more than 12 linear feet of a single lighting track and addressed as a single luminaire.
   2. Multiple linear luminaires that are ganged together to create the appearance of a single longer fixture and addressed as a single luminaire, where the total length of the combined luminaires is not more than 12 feet.

   1.3. No more than eight luminaires within a *daylight zone* are permitted to be controlled by a single *daylight responsive control*.
2. Luminaires shall be controlled by a digital control system configured with the following capabilities:
   2.1. Scheduling and illumination levels of individual luminaires and groups of luminaires are capable of being reconfigured through the system.

   2.2. Load shedding.

   2.3. In open and enclosed offices, the illumination level of overhead general illumination luminaires are configured to be individually adjusted by occupants.

   2.4. Occupancy sensors and daylight responsive controls are capable of being reconfigured through the system.
3. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions required by this section.
4. **High-end trim.** Luminaires shall be initially configured with the following:
   4.1. High-end trim, setting the maximum light output of individual luminaires or groups of luminaires to support visual needs of a space or area, shall be implemented and construction documents shall state that maximum light output or power of controlled lighting shall be initially reduced by at least 15 percent from full output. The average maximum light output or power of the controlled lighting shall be documented without high-end trim and with high-end trim to verify reduction of light output or power by at least 15 percent when tuned.

   4.2. Where lumen maintenance control is used, controls shall be configured to limit the initial maximum lumen output or maximum lighting power to 85 percent or less of full light output or full power draw and lumen maintenance controls shall be limited to increasing lighting power by 1 percent per year.

4.3. High-end trim and lumen maintenance controls shall be accessible only to authorized personnel.

Where *general lighting* in more than 50 percent of the *gross lighted floor area* receives *high-end trim*, the base credits from Tables C406.1.4(1) through C406.1.4(9) shall be prorated as follows:

[Tuned lighted floor area,%] × [Base energy credits for C406.2.5.2] / 50%

C406.2.5.3 L03 Increase occupancy sensor

To achieve this credit, automatic partial OFF or automatic full OFF occupancy sensors shall be installed in all space types not required by C405.2.1 and shall be installed as follows:

1. Automatic shutoff or light reduction shall occur within 15 minutes of all occupants leaving each control zone.
2. For spaces with multiple control zones or automatic partial OFF control, automatic full shutoff shall occur within 15 minutes of all occupants leaving the space.
3. For spaces with one control zone, automatic full OFF control shall be used.
4. All areas of the project with automatic partial OFF or automatic full OFF control shall have one control device for every 600 ft^2 (60 m^2) of gross lighted area.

Exception: to automatic full OFF control requirement: Stairwells.

C406.2.5.4 L04 Increase daylight area

To achieve this credit, the total daylight area of the project (DLA_{BLDG}) with continuous daylight dimming meeting the requirements of C405.2.4 shall be at least 5% greater than the typical daylit area (DLA_{TYP}). Where the actual daylight area includes additional daylit areas beyond the primary sidelighted areas, secondary sidelighted areas, daylight area under skylights, or daylight area under roof monitor then:

1. An analysis based on IES LM83 shall be submitted demonstrating that the spatial daylight autonomy (sDA) is at least 200, 60% for the additional actual daylight area (DLA_{BLDG}).
2. Additional daylit areas shall be separately controlled by automatic daylighting controls.

Credits for measure L04 shall be determined based on Equation 4-18:

$$\mathrm{EC_{DL}} = \mathrm{EC_{DL5}} \times 20 \times \left(\frac{\mathrm{DLA_{BLDG}}}{\mathrm{GLFA}} - \mathrm{DLA_{TYP}}\right) \qquad \text{(Equation 4-18)}$$

Where:

EC_{DL} = C406.2.5.4 L04 measure base energy credits

DLA_{BLDG} = The lesser of actual daylight area of the project with continuous daylight dimming, ft^2 or m^2 and DLA_{max} in Table C406.2.5.4

GLFA = Project gross lighted floor area, ft^2 or m^2

DLA_{TYP} = Typical % of building area with daylight control (as a fraction) from Table C406.2.5.4:

EC_{DL5} = C406.2.5.4 L04 base energy credits from Tables C406.1.4(1) through C406.1.4(9)

Table C406.2.5.4 Added Daylighting Parameters

Building **use type**	**DLA_{TYP}**	**DLA_{max}**
Small Office ≤ 5000 ft^2 (460 m^2)	10%	20%
Office > 5000 ft^2 (460 m^2)	21%	31%
Single-floor retail ≤ 3000 ft^2 (280 m^2) or retail with ≤ 1000 ft^2 (900 m^2) *roof* area	0%	20%
Retail >3000 ft^2 (280 m^2) of single-floor area	60%	80%
School	42%	52%
Warehouse and semiheated	50%	70%
Medical, hotel, multifamily, dormitory, and other	NA	NA

Note to adopting jurisdictions: Consider including the following informative note to clarify the requirements of C406.2.5.4

> ***Informative Note:*** *In IES LM83, spatial daylight autonomy (sDA) means the amount of daylight received in a space over a portion of operating hours each year. It is written as sDA###,YY% where the ### indicates the desired lux provided by the daylight. The YY% indicates the portion of operating hours per year to receive that daylight. It also includes an area requirement or statement. For example, sDA200,60% for 30% of regularly occupied spaces means that 30% of regularly occupied spaces receive at least 200 lux for at least 60% of the operating hours each year.*

C406.2.5.5 L05 Residential light control

To achieve this credit, in buildings with nontransient residential spaces interior lighting systems shall comply with the following:

1. Restrooms, laundry rooms, storage rooms, utility rooms, and interior parking areas shall have automatic full OFF occupancy sensor controls that comply with the requirements of C405.2.1.1. Each additional control device shall control no more than 5,000sq.ft.
2. Stairwells, lobbies, and corridors shall have automatic partial OFF occupancy sensor controls that shall reduce general lighting power in the space by at least 66% of full lighting power within 15 minutes of all occupants leaving the space.
3. Each *dwelling unit* shall have a main control by the main entrance that turns off all the lights and all switched receptacles in the *dwelling unit*. Two switched receptacles shall be provided in living and sleeping rooms or areas and clearly identified. All switched receptacles shall be located within 12 inches (30 cm) of an unswitched receptacle. The main control shall be permitted to have two controls, one for permanently wired lighting and one for switched receptacles. The main controls should be clearly identified as “lights master off” and “outlets master off.”

Where item 2 is not practicable, it is permitted to be excluded and measure credits shall be 85% of base credits from Tables C406.1.4(1) through C406.1.4(9) or EC_{rl} calculated using Equation 4-19.

Where automatic lighting controls similar to item 3 are required in some *dwelling units* by C405.2, base credits shall be prorated using Equation 4-19.

$$\mathrm{EC_{rl}} = \mathrm{EC_t} \times \left(0.8 \times \left(1 - \frac{\mathrm{Area_{durl}}}{\mathrm{Area_{du}}}\right) + 0.2\right) \quad \text{(Equation 4-19)}$$

where:

EC_{rl} = Residential lighting control measure energy credit achieved for the project

EC_t = C406.2.5.5 L05 base energy credit for building use type and Climate Zone

$Area_{durl}$ = Dwelling unit gross lighted floor area where similar controls are required by Section C405.2

$Area_{du}$ = Total project dwelling unit gross lighted floor area

C406.2.5.6 L06 Reduced lighting power.

Interior lighting within the whole project shall achieve energy credits by complying with all the requirements of this section.

1. The net connected interior lighting power (LPn) shall be 95% or less than the net interior lighting power allowance (LPAn) determined in accordance with Section C405.3.2.2. In R-1 and R-2 occupancies the credit is calculated for all common areas other than dwelling units and sleeping units. Energy credits shall be determined based on one of the following:
   1.1. Where $LP_n \leq 80\%$ of LPA_n, four times the C406.2.5.6 credits from Tables C406.1.4(1) through C406.1.4(9) .
   1.2. Where $LP_n > 80\%$ of LPA_n and $LP_n \leq 95\%$ of LPA_n energy credits shall be determined using Equation 4-20 .

$$EC_{LPA} = EC_5 \times 20 \times \frac{LPA_n - LP_n}{LPA_n} \quad \text{(Equation 4-20)}$$

Where:

EC_{LPA} = additional energy credit for lighting power reduction

LP_n = net connected interior lighting power calculated in accordance with SectionC405.3.1, watts, less any additional lighting power allowed in Section C405.3.2.2.1

LPA_n = interior lighting power allowance calculated in accordance with the requirements of Section C405.3.2.2, watts, less any additional interior lighting power allowed in Section C405.3.2.2.1

EC_5 = L06 base credit from Tables C406.1.4(1) through C406.1.4(9)

2. No less than 95 percent of the permanently installed light fixtures in *dwelling units* and *sleeping units* shall be provided by high efficacy lamps with a minimum efficacy of 90 lumens per watt.

C406.2.7 Efficient Equipment Credits

C406.2.7.1 Q01 Efficient Elevator Equipment

Qualifying elevators in the building shall be Energy efficiency class A per ISO 25745-2, Table 7. Only buildings 3 or more floors above grade may use this credit. Credits shall be prorated based on Equation 4-22, rounded to the nearest whole credit. Projects with a compliance ratio below 0.5 do not qualify for this credit.

$$\mathrm{EC_e} = \mathrm{EC_t} \times \mathrm{CR}_e \quad \text{(Equation 4-22)}$$

where:

EC_e = Elevator energy credit achieved for Building

EC_t = C406.2.7.1 Table energy credit
CR_e = Compliance Ratio = (F_A / F_B)
F_A = Sum of floors served by class A elevators
F_B = Sum of floors served by all building elevators and escalators

C406.2.7.2 Q02 Efficient Commercial Kitchen Equipment.

For buildings and spaces designated as Group A-2, or facilities whose primary business type involves the use of a commercial kitchen with at least one gas or electric fryer, all fryers, dishwashers, steam cookers and ovens shall comply with all of the following:

1. Achieve performance levels in accordance with the equipment specifications listed in Tables C406.12 (1) through C406.12 (4) when rated in accordance with the applicable test procedure.
2. Be installed before the issuance of the Certificate of Occupancy.
3. Have associated performance levels listed on the construction documents submitted for permitting.

C406.2.7.3 Q03 Efficient Residential Kitchen Equipment.

For projects with Group R-1 and R-2 occupancies, energy credits shall be achieved where all dishwashers, refrigerators, and freezers comply with all of the following:

1. Achieve the Energy Star Most Efficient 2021 label in accordance with the specifications current as of:
   1.1. Refrigerators and freezers 5.0, 9/15/2014
   1.2. Dishwashers 6.0, 1/29/2016
2. Be installed before the issuance of the certificate of occupancy.

For Group R-1 where only some guest rooms are equipped with both refrigerators and dishwashers, the table credits shall be prorated as follows:

[Tables C406.1.4(1) through C406.1.4(9) base credits] × [floor area of guest rooms with kitchens] / [total guest room floor area]

C406.2.7.4 Q04 Fault detection and diagnostics system.

A project not required to comply with C403.2.3 can claim energy credits for installing a fault detection and diagnostics system to monitor the HVAC system's performance and automatically identify faults. The installed system shall comply with items 1 through 6 in Section C403.2.3.

Table C406.2.7.2 (1) Minimum Efficiency Requirements: Commercial Fryers

	Heavy-Load Cooking Energy Efficiency	Idle Energy Rate	Test Procedure
Standard Open Deep-Fat Gas Fryers	≥ 50%	≤ 9,000 Btu/hr	ASTM F1361
Standard Open Deep-Fat Electric Fryers	≥ 83%	≤ 800 watts	
Large Vat Open Deep-Fat Gas Fryers	≥ 50%	≤ 12,000 Btu/hr	ASTM F2144
Large Vat Open Deep-Fat Electric Fryers	≥ 80%	≤ 1,100 watts	

For SI: BTU/h = 0.293W

Table C406.2.7.2 (2) Minimum Efficiency Requirements: Commercial Steam Cookers

Fuel Type	Pan Capacity	Cooking Energy Efficiency[a]	Idle Energy Rate	Test Procedure
Electric Steam	3-pan	50%	-	ASTM F1484
	4-pan	50%	-	
	5-pan	50%	-	
	6-pan and larger	50%	-	
Gas Steam	3-pan	38%	-	
	4-pan	38%	-	
	5-pan	38%	-	
	6-pan and larger	38%	-	

a. Cooking Energy Efficiency is based on heavy-load (potato) cooking capacity

Table C406.2.7.2 (3) Minimum Efficiency Requirements: Commercial Dishwashers

Machine Type	High Temperature Efficiency Requirements		Low Temperature Efficiency Requirements		Test Procedure
	Idle Energy Rate[a]	Water Consumption[b]	Idle Energy Rate[a]	Water Consumption[b]	
Under Counter	≤ 0.50 kW	≤ 0.86 GPR	≤ 0.50 kW	≤ 1.19 GPR	ASTM F1696 ASTM F1920
Stationary Single Tank Door	≤ 0.70 kW	≤ 0.89 GPR	≤ 0.60 kW	≤ 1.18 GPR	
Pot, Pan , and Utensil	≤ 1.20 kW	≤ 0.58 GPR	≤ 1.00 kW	≤ 0.58 GPSF	
Single Tank Conveyor	≤ 1.50 kW	≤ 0.70 GPR	≤ 1.50 kW	≤ 0.79 GPR	
Multiple Tank Conveyor	≤ 2.25 kW	≤ 0.54 GPR	≤ 2.00 kW	≤ 0.54 GPR	
Single Tank Flight Type	Reported	GPH ≤ 2.975x + 55.00	Reported	GPH ≤ 2.975x + 55.00	
Multiple Tank Flight Type	Reported	GPH ≤ 4.96x + 17.00	Reported	GPH ≤ 4.96x + 17.00	

a. Idle results should be measured with the door closed and represent the total idle energy consumed by the machine including all tank heaters and controls. Booster heater (internal or external) energy consumption shall not be part of this measurement unless it cannot be separately monitored.
b. GPR = gallons per rack, GPSF = gallons per square foot of rack, GPH = gallons per hour, x = maximum conveyor belt speed (feet/minute) x conveyor belt width (feet)

Table C406.2.7.2 (4) Minimum Efficiency Requirements: Commercial Ovens

Fuel Type	Classification	Idle Rate	Cooking Energy Efficiency, %	Test Procedure
Convection Ovens				
Gas	Full-Size	≤ 12,000 Btu/h	≥ 46	ASTM F1496
Electric	Half-Size	≤ 1.0 Btu/h	≥ 71	
	Full-Size	≤ 1.60 Btu/h		
Combination Ovens				
Gas	Steam Mode	≤ $200P^a$ + 6,511 Btu/h	≥ 41	ASTM F2861
	Convection Mode	≤ $150P^a$ + 5,425 Btu/h	≥ 56	
Electric	Steam Mode	≤ $0.133P^a$ + 0.6400 kW	≥ 55	
	Convection Mode	≤ $0.080P^a$ + 0.4989 kW	≥ 76	
Rack Ovens				
Gas	Single	≤ 25,000 Btu/h	≥ 48	ASTM F2093
	Double	≤ 30,000 Btu/h	≥ 52	

P = Pan Capacity: the number of steam table pans the combination oven is able to accommodate in accordance with ASTM F1495

C406.3 Renewable and Load Management Credits.

Renewable energy and load management measures installed in the building that meet the requirements in Sections C406.3.1 through C406.3.8 shall achieve the credits listed for the occupancy group in Tables C406.3(1) through C406.3(9) or where calculations required in Sections C406.3 create credits or modify the table credits, the credits achieved shall be based upon the Section C406.3 calculations.

The load management measures in Sections C406.3.2 through C406.3.7 require load management control sequences that are capable of and configured to automatically provide the load management operation specified based on a demand response signal from the controlling entity, such as a utility or service operator. When communications are disabled or unavailable, all demand responsive controls shall continue to perform all other control functions provided by the control and shall continue backup demand response based on a local schedule or building demand monitoring. The local building schedule shall be adjustable without programming and reflect the electric rate peak period dates and times The load management control sequences shall be activated by either:

1. A certified OpenADR 2.0a or OpenADR 2.0b Virtual End Node (VEN), as specified under Clause 11, Conformance, in the applicable OpenADR 2.0 Specification, or
2. A device certified by the manufacturer as being capable of responding to a demand response signal from a certified OpenADR 2.0b VEN by automatically implementing the control functions requested by the VEN for the equipment it controls, or
3. A device that complies with IEC 62726-10-1, an international standard for the open automated demand response system interface between the smart appliance, system, or energy management system and the controlling entity, or

4. An interface that complies with the communication protocol required by a controlling entity, to participate in an automated demand response program, or
5. Where the controlling entity does not have a demand response program or protocol available, local demand response control shall be provided based on either building demand management controls that monitor building electrical demand, or a local building schedule that reflects the electric rate peak period dates and times. In this case binary input(s) to the control system shall be provided that activate the demand response sequence when connected in the future to an interface that receives a controlling entity demand response signal.

Table C406.3(1) Renewable and Load Management Credits for Multifamily/Dormitory

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	9	15	11	17	18	20	19	21	13	10	13	9	9	11	10	9	10	9	7
G01	Lighting load management	C406.3.2	16	7	9	12	12	16	11	14	12	11	16	14	8	11	14	5	7	7	11
G02	HVAC load management	C406.3.3	42	41	21	35	23	37	30	28	28	17	33	24	20	22	23	10	13	15	17
G03	Automated shading	C406.3.4	11	x	7	18	10	13	5	13	12	2	14	7	10	13	11	1	8	8	16
G04	Electric energy storage	C406.3.5	10	10	10	11	10	13	13	14	17	16	13	17	14	13	17	14	14	14	15
G05	Cooling energy storage	C406.3.6	28	6	31	13	22	21	21	37	11	12	22	11	9	17	9	7	17	2	3
G06	SHW energy storage	C406.3.7	17	17	19	18	19	19	20	20	22	19	19	21	19	19	20	18	19	18	17
G07	Building thermal mass	C406.3.8	7	2	11	5	16	28	22	27	60	19	43	46	32	58	37	27	45	40	19

x = Credits excluded from this *building* use type and climate zone.

Table C406.3(2) Renewable and Load Management Credits for Health Care Buildings

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	6	6	6	6	6	8	7	9	8	6	8	6	6	7	7	6	7	5	4
G01	Lighting load management	C406.3.2	11	12	13	13	13	12	12	12	6	13	16	12	13	14	15	14	14	12	12
G02	HVAC load management	C406.3.3	10	11	10	10	8	21	10	10	13	11	18	11	12	14	13	12	11	9	7
G03	Automated shading	C406.3.4	1	1	1	1	x	x	x	1	x	x	2	x	x	2	x	x	1	1	x
G04	Electric energy storage	C406.3.5	13	13	13	13	14	15	14	15	15	14	15	15	14	15	15	13	14	13	12
G05	Cooling energy storage	C406.3.6	25	6	33	14	25	19	27	37	27	16	22	19	14	18	11	11	20	2	3
G06	SHW energy storage	C406.3.7	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
G07	Building thermal mass	C406.3.8	6	2	10	4	15	25	20	24	57	18	39	44	31	53	33	26	40	34	14

x = Credits excluded from this *building* use type and climate zone.

Table C406.3(3) Renewable and Load Management Credits for Hotel/Motel

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	9	8	12	9	11	11	10	12	13	9	12	8	9	11	9	8	9	7	5
G01	Lighting load management	C406.3.2	12	12	11	12	12	14	14	13	15	14	13	11	10	11	14	9	11	8	8
G02	HVAC load management	C406.3.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
G03	Automated shading	C406.3.4	2	2	2	3	1	2	3	2	4	3	2	1	0	1	3	1	2	0	0
G04	Electric energy storage	C406.3.5	9	9	10	10	9	13	13	15	13	14	13	14	14	12	16	13	12	12	13
G05	Cooling energy storage	C406.3.6	31	7	38	17	29	24	31	44	26	18	26	16	15	21	11	12	24	2	4
G06	SHW energy storage	C406.3.7	25	25	28	26	28	29	29	30	31	29	30	31	28	29	31	26	28	25	24
G07	Building thermal mass	C406.3.8	6	1	10	4	14	24	19	23	53	17	38	41	30	52	33	26	42	37	17

x = Credits excluded from this *building* use type and climate zone.

Table C406.3(4) Renewable and Load Management Credits for Office Buildings

ID	Energy Credit Abbreviated Title	Section	Climate Zone 0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	14	14	17	15	17	19	18	22	24	17	22	16	14	18	18	14	17	14	11
G01	Lighting load management	C406.3.2	10	11	11	12	11	11	11	12	9	10	11	10	10	11	10	10	11	10	9
G02	HVAC load management	C406.3.3	x	10	10	9	9	3	8	12	7	12	8	11	9	10	12	8	9	10	2
G03	Automated shading	C406.3.4	4	7	7	8	7	8	5	6	6	4	6	5	4	5	5	5	5	4	7
G04	Electric energy storage	C406.3.5	14	15	14	14	16	16	17	16	18	17	16	18	17	17	18	16	15	17	18
G05	Cooling energy storage	C406.3.6	28	7	36	16	27	24	28	45	27	17	27	15	15	20	9	12	25	2	4
G06	SHW energy storage	C406.3.7	5	5	6	6	6	6	7	7	8	7	7	7	7	7	8	6	7	6	6
G07	Building thermal mass	C406.3.8	3	1	5	2	6	9	6	7	14	4	11	8	9	15	5	8	12	15	7

x = Credits excluded from this *building* use type and climate zone.

Table C406.3(5) Renewable and Load Management Credits for Restaurant Buildings

ID	Energy Credit Abbreviated Title	Section	Climate Zone 0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	2	2	2	2	2	2	2	3	4	2	3	2	2	3	2	2	2	2	1
G01	Lighting load management	C406.3.2	4	4	5	5	4	5	5	5	5	4	5	5	4	4	5	4	5	4	1
G02	HVAC load management	C406.3.3	32	26	37	28	31	26	27	22	23	20	17	14	19	14	10	16	14	14	1
G03	Automated shading	C406.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
G04	Electric energy storage	C406.3.5	4	4	4	4	5	5	5	5	4	4	4	4	3	4	4	4	3	3	2
G05	Cooling energy storage	C406.3.6	15	4	17	8	12	10	10	16	6	5	7	3	3	4	1	2	4	0	0
G06	SHW energy storage	C406.3.7	13	13	15	14	15	16	16	17	19	16	17	19	16	17	18	15	16	14	13
G07	Building thermal mass	C406.3.8	3	1	5	2	7	12	8	10	21	6	15	14	8	18	10	6	12	8	3

x = Credits excluded from this *building* use type and climate zone.

Table C406.3(6) Renewable and Load Management Credits for Retail Buildings

ID	Energy Credit Abbreviated Title	Section	Climate Zone 0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	8	8	12	9	11	12	12	17	17	11	13	9	10	11	10	9	10	9	6
G01	Lighting load management	C406.3.2	16	16	18	19	17	19	19	21	17	18	21	21	18	21	22	18	22	18	16
G02	HVAC load management	C406.3.3	x	15	16	15	15	6	15	21	13	23	15	23	17	19	26	14	17	18	3
G03	Automated shading	C406.3.4	7	11	11	12	11	13	10	11	11	7	11	11	8	10	11	8	9	8	12
G04	Electric energy storage	C406.3.5	6	10	8	10	11	12	11	10	14	11	10	12	10	11	12	11	9	10	8
G05	Cooling energy storage	C406.3.6	40	9	51	22	35	31	34	53	21	17	28	10	11	19	4	9	18	2	2
G06	SHW energy storage	C406.3.7	3	3	4	3	4	4	4	4	5	4	4	5	4	4	5	4	4	4	3
G07	Building thermal mass	C406.3.8	5	1	6	3	8	12	10	10	20	7	17	15	14	24	10	13	20	24	12

x = Credits excluded from this *building* use type and climate zone.

Table C406.3(7) Renewable and Load Management Credits for School/Education Buildings

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	10	11	13	12	13	16	15	21	22	15	19	15	14	17	16	13	16	12	10
G01	Lighting load management	C406.3.2	7	12	12	13	13	15	14	16	13	12	16	16	10	14	18	16	13	14	14
G02	HVAC load management	C406.3.3	18	22	32	23	25	31	26	26	20	23	31	24	20	31	12	18	27	16	9
G03	Automated shading	C406.3.4	7	13	16	12	18	17	17	18	13	12	17	17	10	15	13	14	10	16	17
G04	Electric energy storage	C406.3.5	16	16	18	17	19	21	21	23	26	22	24	24	23	24	24	20	22	19	19
G05	Cooling energy storage	C406.3.6	36	9	46	21	36	32	39	62	39	24	37	22	20	28	13	16	31	3	4
G06	SHW energy storage	C406.3.7	5	5	6	5	6	6	7	7	8	7	7	8	7	7	8	7	7	7	6
G07	Building thermal mass	C406.3.8	7	2	11	5	17	28	23	27	63	21	44	48	37	60	38	31	50	47	21

x = Credits excluded from this *building* use type and climate zone.

Table C406.3(8) Renewable and Load Management Credits for Warehouse and Semiheated Building Areas

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	38	37	55	45	53	53	49	58	66	36	56	38	29	41	36	24	32	23	16
G01	Lighting load management	C406.3.2	13	26	32	28	32	35	36	33	36	31	27	37	32	23	28	36	22	25	22
G02	HVAC load management	C406.3.3	18	46	37	37	28	36	29	26	22	23	17	12	16	13	5	14	8	10	3
G03	Automated shading	C406.3.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
G04	Electric energy storage	C406.3.5	40	40	47	41	47	44	40	44	42	30	38	31	21	31	26	24	29	23	21
G05	Cooling energy storage	C406.3.6	20	5	21	11	14	14	11	21	5	5	9	2	2	5	1	1	3	x	x
G06	SHW energy storage	C406.3.7	3	3	3	3	4	3	4	4	4	3	4	4	3	3	4	2	2	2	2
G07	Building thermal mass	C406.3.8	7	2	12	5	17	29	23	28	66	18	44	47	28	56	37	20	39	29	13

Table C406.3(9) Renewable and Load Management Credits for Other Buildings

ID	Energy Credit Abbreviated Title	Section	Climate Zone																		
			0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
R01	On-Site Renewable Energy	C406.3.1	12	13	16	14	16	18	17	20	21	13	18	13	12	15	14	11	13	10	8
G01	Lighting load management	C406.3.2	11	13	14	14	14	16	15	16	14	14	16	16	13	14	16	14	13	12	12
G02	HVAC load management	C406.3.3	24	24	23	22	20	23	21	21	18	18	20	17	16	18	14	13	14	13	6
G03	Automated shading	C406.3.4	5	6	7	9	8	9	7	9	8	5	9	7	5	8	7	5	6	6	9
G04	Electric energy storage	C406.3.5	14	15	16	15	16	17	17	18	19	16	17	17	15	16	17	14	15	14	14
G05	Cooling energy storage	C406.3.6	28	7	34	15	25	22	25	39	20	14	22	12	11	17	7	9	18	2	3
G06	SHW energy storage	C406.3.7	9	9	11	10	11	11	11	12	13	11	12	13	11	11	12	10	11	10	9
G07	Building thermal mass	C406.3.8	6	2	9	4	13	21	16	20	44	14	31	33	24	42	25	20	33	29	13

C406.3.1 R01 On-Site Renewable Energy
Where an unshaded flat plate collector oriented toward the equator and tilted at an angle from horizontal equal to the latitude receives an annual daily average incident solar radiation equal or greater than 1.1 kBtu/ft²·day (3.5 kWh/m²·day), projects installing *on-site renewable energy* systems with a capacity of at least 0.1 watts per gross square foot (1.08 W/m^2) of *building* area shall achieve energy credits for this measure, calculated as follows:

$$\mathrm{AEC_{RRa}} = \mathrm{AEC_{0.1}} \times \frac{RR_t - RR_e}{0.1 \times \mathrm{PGFA}}$$

Where:

AEC_{RRa}	=	C406.3.1 R01 energy credits achieved for this project
RR_t	=	actual total rating of on-site renewable energy systems (W)
PGFA	=	Project gross floor area, ft^2
$AEC_{0.1}$	=	C406.3.1 R01 base credits from Tables C406.3(1) through C406.3(9)
RR_e	=	rating (W) of *on-site renewable energy* systems excluded from credit calculated as follows:

$$\mathrm{RR_e} = \mathrm{RR_r} + \text{greater of } \left\{0 \text{ or } \left(\mathrm{RR_t} - \mathrm{PFGA} \cdot \mathrm{RA}_L - \frac{\mathrm{ESC}}{3}\right)\right\}$$

Where:

RR_r	=	rating of *on-site renewable energy* systems required by other Sections of this code (W) plus the rating of any *on-site renewable energy* systems used to qualify for exceptions elsewhere in this code.
PGFA	=	Project gross floor area, ft^2 (m^2)
RA_L	=	Limit of *on-site renewable energy* systems rating per gross floor area that exceed the rating per gross floor area in Table C406.3.1 without electrical storage installed in accordance with Section C406.3.5. For office and residential buildings, see RA_L adjustments in table footnotes.
ESC		Electric Storage Capacity in Watt·hours installed in the project in accordance with Section C406.3.5

Table C406.3.1 Renewable Capacity Limits (RA_L) without Electric Storage, W/ft^2

Building Occupancy Group	**Climate Zone**																		
	0A	**0B**	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
RA_{L1}: R-2, R-4, and I-1 with gas water heat [a]	1.3	1.3	1.0	1.0	1.0	0.9	0.9	0.8	0.7	0.9	0.8	0.9	0.9	0.9	0.9	1.0	0.9	1.0	1.3
RA_{L2}: R-2, R-4, and I-1 with electric or solar water heat [a]	7.6	6.8	5.9	5.1	4.2	4.2	4.2	3.4	2.5	4.2	3.4	3.4	3.4	3.4	3.4	4.2	3.4	4.2	5.1
I-2	10	9.7	8.2	8.2	8.2	7.3	7.2	6.2	6.2	7.5	6.2	7.3	7.5	6.5	7.3	7.3	7.2	7.2	8.8
R-1	4.1	3.8	3.4	2.9	3.1	2.7	2.6	2.3	2.2	2.7	2.0	2.7	2.7	2.1	1.9	2.6	2.2	2.7	3.2
RA_{L3}: B with IT & phone equip. > 0.5 W/ft^2 [b]	5.2	5.2	4.6	4.6	4.3	4.0	4.0	3.8	3.5	3.8	3.8	4.0	4.0	4.0	4.0	4.0	4.0	4.3	5.2
RA_{L4}: B with IT & phone equip. ≤ 0.5 W/ft^2 [b]	2.7	2.7	2.1	2.1	2.1	1.9	1.9	1.6	1.6	1.8	1.6	1.8	1.8	1.8	1.8	1.9	1.9	2.0	2.6
A-2	27	26	19	20	18	15	15	14	13	15	13	14	14	13	13	14	14	14	17
M	6.5	6.4	4.5	4.8	4.3	3.5	3.5	3.0	2.9	3.2	2.9	3.2	3.2	2.9	2.8	3.1	2.9	3.1	3.3
E	3.9	4.2	2.8	3.0	2.6	2.1	2.0	1.7	1.6	1.9	1.4	1.9	1.9	1.9	1.9	1.9	1.9	1.9	2.4
S-1 and S-2	1.3	1.3	1.0	1.0	0.7	0.7	0.7	0.7	0.6	0.7	0.6	0.7	0.7	0.7	0.7	0.9	0.9	0.9	1.0
All Other	3.4	3.3	2.6	2.5	2.9	2.7	2.7	2.1	2.3	2.6	2.3	2.7	2.7	2.5	3.1	3.1	2.8	3.2	3.2

[a] For buildings that include residential occupancy (Group R-2, R-4 and I-1), RA_L shall be adjusted as follows:

1. Where 70% or more of service water-heating capacity is gas, $RA_L = RA_{L1}$
2. Where 70% or more of service water-heating capacity is electric resistance or solar water/pool heating is included with electric resistance backup, use RA_{L2}
3. Where 70% or more of service water-heating capacity is heat pump water heating, adjust as follows: $RA_L = RA_{L1} + \{ (RA_{L2} - RA_{L1}) / 3 \}$
4. Where solar water/pool heating is included with gas backup, prorate based on relative capacity as follows: RA_L = [% gas peak capacity] · RA_{L1} + [% solar peak capacity] · RA_{L2}
5. Where electric water heating is mixed with gas water heating, prorate based on relative capacity as follows: RA_L = [% gas peak capacity] · RA_{L1} + [% electric peak capacity] · RA_{L2}

[b] Office (Group B) IT & phone equipment density is calculated based on total building area, not just server and equipment room area, and power for distributed computers or terminals in office areas is not included. Where the total building density of IT & phone equipment is greater than 0.5 W/sf, $RA_L = RA_{L3}$, otherwise $RA_L = RA_{L4}$.

SI units:

Table C406.3.1 Renewable Capacity Limits (RA_L) without Electric Storage, W/m^2

Building Occupancy Group	Climate Zone																		
	0A	**0B**	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
RA_{L1}: R-2, R-4, and I-1 with gas water heat [a]	14	14	11	11	11	10	10	9	8	10	9	10	10	10	10	11	10	11	14
RA_{L2}: R-2, R-4, and I-1 with electric or solar water heat [a]	82	73	64	55	45	45	45	37	27	45	37	37	37	37	37	45	37	45	55
I-2	111	104	89	88	88	78	78	67	67	81	67	78	81	70	79	78	78	78	94
R-1	44	40	36	31	33	29	28	24	24	29	22	29	29	23	21	28	24	29	34
RA_{L3}: B with IT & phone equip. > 0.5 W/ft^2 [b]	56	56	50	50	46	43	43	41	38	41	41	43	43	43	43	43	43	46	56
RA_{L4}: B with IT & phone equip. ≤ 0.5 W/ft^2 [b]	29	29	23	23	23	20	20	17	17	19	17	19	19	19	19	20	20	22	27
A-2	289	283	209	215	193	160	160	150	136	159	135	150	147	141	142	155	147	155	178
M	70	68	48	51	46	38	38	32	31	35	31	35	35	31	30	34	31	33	36
E	42	45	31	32	28	23	22	18	17	21	15	21	21	21	20	21	20	20	26
S-1 and S-2	14	14	11	11	8	8	8	8	6	8	6	8	8	8	8	10	10	10	11
All Other	36	35	28	27	32	29	29	23	24	28	25	29	29	27	34	33	30	35	34

[same footnotes as IP version]

Informative note:
On-site renewable energy may include thermal service water heating or pool water heating in which case ratings in Btu/h can be converted to W where W = Btu/h / 3.413.

C406.3.2 G01 Lighting Load Management
Luminaires shall have dimming capability and automatic load management controls that shall gradually reduce *general lighting* power during peak electric price periods coincident with high building loads. The load management controls shall reduce lighting power in 75% of the building area by at least 20% with *continuous dimming* over a period no longer than 15 minutes. F Where less than 75%, but at least 50% of the project *general lighting* is controlled, the credits from Tables C406.3 shall be prorated as follows:

[Area of building with lighting load management, %] x [table credits for C406.3.2] / 75%

Exception: Warehouse or retail storage building areas shall be permitted to achieve this credit by switching off at least 25% of lighting power in 75% of the building area without dimming.

C406.3.3 G02 HVAC Load Management
Automatic load management controls shall be configured:

1. Where electric cooling is in use to gradually increase the cooling setpoint by at least 3°F over a minimum of three hours over the period coincident with high *building* electric load and high electric energy or demand price periods.
2. Where electric heating is in use to gradually decrease the heating setpoint by at least 3°F over a minimum of three hours over the period coincident with high building electric load and high electric energy or demand price periods.

3. Where HVAC systems are serving multiple zones and have less than 70% outdoor air required, include controls that provide excess *outdoor air* preceding the summer peak electric price period and reduce *outdoor air* by at least 30% during summer in the period of coincident high *building* load and summer peak electric price, in accordance with ASHRAE Standard 62.1 Section 6.2.5.2 Short Term Conditions.

C406.3.4 G03 Automated Shading Load Management
Where fenestration on south and west exposures exceeds 20% of wall area, automatic controls shall be configured to operate movable exterior shading devices or dynamic glazing to reduce solar gain through sunlit fenestration on southern and western exposures by at least 50% during summer peak electric price periods.

> ***Informative note:***
> *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 allowed as long as they provide an effective 50% reduction in net solar gain, e.g., have a shading coefficient of less than 0.5 for the shading material itself. Interior shading devices will not meet the requirement. Electrochromatic windows that achieve 50% of SHGC would qualify.*

C406.3.5 G04 Electric Energy Storage
Electric storage devices shall be charged and discharged by automatic load management controls to store energy during non-peak periods and use stored energy during peak periods to reduce building demand. Electric storage devices shall have a minimum capacity of 1.5 Wh/ft^2 (87 Wh/m^2) of gross building area. Base credits in Tables C406.3-1 through C406.3-8 are based on installed electric storage of 5 Wh/ft^2 (54 Wh/m^2) and shall be prorated for actual installed storage capacity between 1.5 and 15 Wh/ft^2 (16 to 160 Wh/m^2), as follows:

[Installed electric storage capacity, Wh/ft^2 (Wh/m^2)]] / 5 (54) × [C406.3.5 Credits from Tables]

Larger energy storage shall be permitted however, credits are limited to the range of 1.5 to 15 Wh/ft^2 value.

C406.3.6 G05 Cooling Energy Storage
Automatic load management controls shall be capable of activating ice or chilled water storage *equipment* to reduce demand during summer peak electric price periods. To achieve this credit,

1. the storage tank shall be certified by the manufacturer to have no more than 2% of storage capacity standby loss over a 24 hour period, or
2. have tank insulation values that meet or exceed the following:
    a. R-9 (RSI-1.5): ice storage tank
    b. R-3 (RSI-0.5): above-ground chilled water tank
    c. None: below-ground chilled water tanks

Base credits in Tables C406.3-1 through C406.3-8 are for storage capacity of 1.0 ton-hours per design day ton of cooling load with a 1.15 sizing factor. Credits shall be prorated for installed storage systems sized between 0.5 and 4.0 ton-hours per design day ton (kWh/*kW*) of cooling load rounded to the nearest whole credit. Larger storage shall be permitted but the associated credits are limited to the 4.0 ton-hours storage per ton of design day value. Energy credits shall be determined as follows:

$$EC_s = EC_{1.0} \times \frac{(1.44 \times SR + 0.71)}{2.15}$$

Where:

EC_s = Cooling Storage credit achieved for Project

$EC_{1.0}$ = G05 base energy credit for *building* use type and climate zone based on 1.0 ton-hours storage per design day ton (kWh/*kW*) of cooling load

SR = Storage ratio in ton-hours storage per design day ton (kWh/*kW*) of cooling load where $0.5 \leq SR \leq 4.0$

C406.3.7 G06 SWH Energy Storage

To achieve this credit, where SHW is heated by electricity, automatic load management controls comply with ANSI/CTA-2045-B shall preheat stored SHW before the electric peak price period and suspend electric water heating during the period of peak prices coincident with peak building load. Storage capacity shall be provided by either:

1. Preheating water above 140°F (60°C) delivery temperature with at least 1.34 kWh of energy storage per kW of water-heating capacity. Tempering valves shall be provided at the water heater delivery location.
2. Providing additional heated water tank storage capacity above peak SHW demand with equivalent peak storage capacity to item 1. Where heat pump water heating is used, the credits achieved shall be 1/3 of the credits in Tables C406.3(1) through C406.3(9).

C406.3.8 G07 Building Thermal Mass

The project shall have additional passive interior mass and a night flush control of the HVAC system. The credit is available to projects that have at least 80% of gross floor area unoccupied between midnight and 6:00 a.m.

1. Provide 10 pounds of passive thermal mass per square foot of building floor area. Locate the mass construction interior to the building, indoor-facing to the exterior wall or floor construction. Mass construction is allowed in direct contact with the air in conditioned spaces or directly attached to interior-facing gypsum board or interior-facing hard surface flooring. Mass with carpet or furred wallboard shall not be counted toward the building mass required. For integral insulated concrete block walls complying with ASTM C90 with an exterior face, only the mass of the interior face shall be counted toward the building mass required.

2. HVAC units that supply 80% or more of the airflow in the project shall be included in the night flush control sequence and be equipped with outdoor air economizers and fans that have variable or low speed capability to operate at 66% or lower of design airflow.

3. Night flush controls shall be configured with the following sequence or alternative night flush strategy where the alternative sequence is demonstrated to be effective, avoids added morning heating, and is approved by the authority having jurisdiction.
   a. Summer mode shall be activated when outdoor air temperature exceeds 70°F (21°C) and shall continue uninterrupted until deactivated when outdoor air temperature falls below 45°F (7°C). During summer mode, the occupied cooling set point shall be reset 1°F (0.5°C) higher than normal and the occupied heating set point shall be reset 2°F (1.0°C) lower than normal.
   b. During active summer mode for hours that indoor average temperature is 5ºF or more above outdoor temperature and between 10:00 p.m. and 6:00 a.m., automatic night flush controls shall operate outdoor air economizers at fan speed less than 66% design airflow during the unoccupied period until the average indoor air temperature falls to the occupied heating setpoint.

Informative Note:

The simplified night flush sequence described will operate in "Summer Mode" below the 70F

OA trigger temperature down until OA of 45F is hit when the “Summer Mode” is deactivated until the OA rises above 70F again. Other strategies may be implemented that cool the space below the heating setpoint and adjust the morning heating setpoint to avoid morning reheating.

Modify C407.2 as follows (strikeout and underline is used here) Note: new equations not shown underlined for clarity; renumber equations as needed:

C407.2 Mandatory Requirements. Compliance based on total building performance requires that a proposed design meet all of the following:

1. The requirements of the sections indicated within Table C407.2

2. An annual energy cost that is less than or equal to ~~85~~ the percentage of the annual energy cost (PAEC) of the standard reference design calculated in Equation 4-23. Energy prices shall be taken from a source approved by the code official, such as the Department of Energy, Energy Information administration’s State Energy Data System Prices and Expenditures reports. Code officials shall be permitted to require time-of-use pricing in energy cost calculations. The reduction in energy cost of the proposed design associated with on-site renewable energy shall be not more than 5 percent of the total energy cost. The amount of renewable energy purchased from off-site sources shall be the same in the standard reference design and the proposed design.

   Exception: Jurisdictions that require site energy (1 kWh = 3433 Btu) rather than energy cost as a metric of comparison.

$$\boldsymbol{PAEC} = 100 \times \left(0.85 + 0.025 - \frac{EC_r}{1000}\right) \qquad \text{(Equation 4-23)}$$

where:

PAEC = *Percentage of annual energy cost applied to standard reference design*

EC$_r$ = Energy efficiency credits required for the *building* in accordance with Section C406.1 (do not include load management and renewable credits)

Informative note: The formula above allows adjustment for the current energy credits required in the IECC (2.5% or 0.025) and the new energy efficiency credit requirements that come from Section C406.1.1.

Modify Table C407.2 by inserting the line shown

Table C407.2

REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

SECTION	TITLE
Mechanical	
C406.1.2	Additional renewable and load management credit requirements

Add the following referenced standards to Chapter 6:

CTA

Consumer Technology Association Technology & Standards Department
1919 S Eads Street
Arlington, VA 22202

ANSI/CTA-2045-B – 2018: Modular Communications Interface for Energy Management

C406.3

IEC

IEC Regional Centre for North America
446 Main Street 16th Floor
Worcester, MA 01608

IEC 62746-10-1 - 2018 Systems interface between customer energy management system and the power management system - Part 10-1: Open automated demand response

C406.3

OpenADR

OpenADR Alliance
111 Deerwood Road
Suite 200
San Ramon, CA 94583

OpenADR 2.0a and 2.0b – 2019: Profile Specification Distributed Energy Resources

C406.3

4.0 References

42 USC 6833. *Energy Conservation and Policy Act*, Public Law 94-385, as amended. http://www.gpo.gov/fdsys/pkg/USCODE-2011-title42/pdf/USCODE-2011-title42-chap81-subchapII.pdf. Also see https://www.energycodes.gov/about/statutory-requirements.

ASHRAE. 2019a. *ASHRAE/ANSI/IES Standard 90.1-2019: Energy Standard for Buildings except Low-Rise Residential Buildings*. American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA. https://ashrae.iwrapper.com/ASHRAE_PREVIEW_ONLY_STANDARDS/STD_90.1_2019

ASHRAE. 2019b. *Advanced Energy Design Guides (AEDG)*. American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA, 2004 to 2019. https://www.ashrae.org/technical-resources/aedgs

Codes and Standards Enhancement (CASE) Initiative 2022 California Energy Code, Nonresidential Grid Integration, Final CASE Report, August 2020. https://efiling.energy.ca.gov/GetDocument.aspx?tn=234550&DocumentContentId=67382

Feldman, David, Vignesh Ramasamy, Ran Fu, Ashwin Ramdas, Jal Desai, and Robert Margolis. 2021. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2020. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-77324. https://www.nrel.gov/docs/fy21osti/77324.pdf

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Goel S, R Hart, M Tillou, M Rosenberg, J Gonzalez, K Devaprasad, and J Lerond. 2021. *HVAC System Performance for Energy Codes.* Pacific Northwest National Laboratory, Richland WA. https://www.energycodes.gov/sites/default/files/2021-07/TechBrief_HSP_July2021.pdf

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Hart R and B Liu. 2015. *Methodology for Evaluating Cost-effectiveness of Commercial Energy Code Changes.* PNNL-23923, Rev. 1, Pacific Northwest National Laboratory for U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. https://www.energycodes.gov/development/commercial/methodology

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ICC. 2018. *2018 International Energy Conservation Code (IECC)*. International Code Council, Country Club Hills, IL. https://codes.iccsafe.org/content/iecc2018/

ICC. 2021. 2021 International Energy Conservation Code (IECC). International Code Council, Country Club Hills, IL. https://codes.iccsafe.org/content/IECC2021P1Lee, K, and J. Braun. “A Data-Driven Method for Determining Zone Temperature Trajectories That Minimize Peak Electrical Demand.” In ASHRAE Transactions, 2008, Vol. 114. ASHRAE, 2008. https://www.techstreet.com/standards/sl-08-007-a-data-driven-method-for-determining-zone-temperature-trajectories-that-minimize-peak-electrical-demand?product_id=1715426

Lei X, JB Butzbaugh, Y Chen, J Zhang, and MI Rosenberg. 2020. Development of National New Construction Weighting Factors for the Commercial Building Prototype Analyses (2003-2018). PNNL-29787, Pacific Northwest National Laboratory, Richland, WA. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23269.pdf

McBride M. 1995. “Development of Economic Scalar Ratios for ASHRAE Standard 90.1 R.” In *Proceedings of Thermal Performance of the Exterior Envelopes of Buildings VI, ASHRAE*. http://consensus.fsu.edu/FBC/2010-Florida-Energy-Code/901_Scalar_Ratio_Development.pdf

Nambiar C, R Hart, Y Xie, and J Zhang. “End Use Data from Performance Indicator Analysis of 90.1-2019.” 2021. Pacific Northwest National Laboratory, Richland, WA, April 2021. https://www.energycodes.gov/sites/default/files/documents/2019EndUseTables.zip

PNNL. 2020. “Commercial Prototype Building Models.” Updated August 17, 2020. https://www.energycodes.gov/development/commercial/prototype_models

Tyler M, D Winiarski, M Rosenberg, and B Liu. 2021. *Impacts of Model Building Energy Codes – Interim Update*. PNNL-31437, Pacific Northwest National Laboratory, Richland, WA. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-31437.pdf

WSBCC. 2015. *2015 Washington State Energy Code, Commercial Provisions*. Washington State Building Council, Olympia, WA. https://sbcc.wa.gov/sites/default/files/2019-12/2015%20Com%20Energy_3rd_2019.pdf

Appendix A – Code Language for Advanced Package

This appendix includes the sample code language adjustments necessary if a more aggressive advanced requirement for energy credits is desired by the jurisdiction. The measure selections for the demonstration advanced package are described in Section 1.7.2.2 with savings results in Section 1.5 with analysis described in Section 1.6,. To use the advanced package and increase the savings requirements, simply replace the values in Section 3.0 "sample code language," Table C406.1 with the following values:

Table C406.1 Energy Credit Requirements by Building Occupancy Group

Building Occupancy Groups	Climate Zone																		
	0A	**0B**	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
R-2, R-4, and I-1	179	174	188	197	200	200	200	200	200	200	200	200	193	200	200	200	200	200	200
I-2	78	75	73	71	80	90	100	85	90	97	83	90	99	90	96	107	106	130	117
R-1	106	100	110	105	109	122	123	125	131	137	129	136	157	139	147	171	158	180	176
B	114	110	112	115	108	107	116	111	114	126	118	123	135	125	125	152	142	153	141
A-2	83	81	82	82	86	86	108	91	97	126	99	111	147	117	113	160	143	163	151
M	113	113	121	118	123	127	116	116	133	109	100	92	99	134	125	171	146	150	137
E	91	95	91	100	96	100	105	104	101	113	110	110	120	117	122	131	132	126	131
S-1 and S-2	108	106	111	109	109	108	89	106	108	134	100	130	200	143	123	200	190	189	148
All Other	54	53	55	56	57	60	61	60	63	68	60	65	73	68	69	84	79	84	78

If even greater advanced savings are desired, then increase the renewable plus load management credit requirements to represent increased renewable credits where possible or added load management credits. Such increases will have to be reviewed for applicability to particular climate zones and building types.

Appendix B – Code Language for H01 HVAC Performance

This appendix includes the code language adjustments necessary if the jurisdiction wishes to add the HVAC System Performance method as a more flexible HVAC energy credit measure. This is an alternate to the simplified efficiency measures H02 and H03, and also is an alternative to measure H05, DOAS. Those measures can remain in the energy credits, so they can be used alternatively for a project without using the HVAC Performance Method. To add the HVAC Performance Method as an energy credit measure, take these two actions:

1. *Incorporate the HVAC Performance Method as a requirement in the code. Language for this measure can be found in a separate technical brief:*

   Goel S, R Hart, M Tillou, M Rosenberg, J Gonzalez, K Devaprasad, and J Lerond. 2021. *HVAC System Performance for Energy Codes.* Pacific Northwest National Laboratory, Richland WA.

2. *Make the following changes to the sample code language in Section 3.0:*

C406.2.2 More Efficient HVAC Equipment Performance

All heating and cooling systems shall meet the minimum requirements of Section C403 and efficiency improvements shall be referenced to minimum efficiencies listed in Tables referenced by Section C403.3.2. Where multiple efficiency requirements are listed, equipment shall meet the seasonal efficiencies including SEER, EER/integrated energy efficiency ratio (IEER), integrated part load value (IPLV), or AFUE. Equipment that is larger than the maximum capacity range indicated in Tables referenced by Section C403.3.2 shall utilize the values listed for the largest capacity equipment for the associated equipment type shown in the table. Where multiple individual heating or cooling systems serve the project, the improvement shall be the weighted average improvement based on individual system capacity.

For occupancies and systems allowed to use Section C403.1.3, HVAC total system performance ratio, credits shall be achieved by meeting the requirements of C406.2.2.1 (H01). Such systems shall also be permitted to achieve credits with C406.2.2.4 (H04). Other systems are permitted to achieve credits by meeting the requirements of either:

1. C406.2.2.2 H02,
2. C406.2.2.3 H03,
3. C406.2.2.4 H04,
4. C406.2.2.5 H05, or
5. Any combination of H02, H03, H04 and H05

C406.2.2.1 H01 HVAC System Performance.

~~Reserved for future use.~~

For systems allowed to use Section C403.1.3, HVAC total system performance ratio, the HVAC *TSPR* shall exceed the minimum requirement by 5 percent. If improvement is greater, base energy credits from Table C406.1.4(1) through C406.1.4(9) are permitted to be prorated up to a 20 percent improvement using Equation 4-14. Energy credits for H01 may not be combined with energy credits from HVAC measures H02, H03 and H05.

$$\text{H01 energy credit} = \text{H01 base energy credit} \times \frac{\text{TSPR\%}}{5\%} \qquad \text{(Equation 4-14)}$$

Where:

TSPR% = Percentage by which TSPR of proposed design exceeds minimum TSPR requirement. The value of TSPR% cannot exceed 20% for purposes of calculating H01 energy credits.

Update the base energy credits for measure H01 in Tables C406.1.4(1) through C406.1.4(9) as follows:

Table C406.1.4(1)

H01	HVAC Performance (TSPR)	C406.2.2.1	20	19	16	17	14	13	11	11	5	13	10	8	15	12	7	18	14	17	19

Table C406.1.4(2)

H01	HVAC Performance (TSPR)	C406.2.2.1	23	22	21	21	20	19	19	18	16	19	18	16	19	18	18	21	21	24	26

Table C406.1.4(3)

H01	HVAC Performance (TSPR)	C406.2.2.1	21	20	17	18	16	13	12	12	11	11	11	8	11	11	8	13	11	14	16

Table C406.1.4(4)

H01	HVAC Performance (TSPR)	C406.2.2.1	22	22	19	20	17	17	15	15	11	15	15	11	16	15	11	19	17	18	20

Table C406.1.4(5)

H01	HVAC Performance (TSPR)	C406.2.2.1	18	17	13	15	13	10	12	10	6	14	11	10	16	14	11	20	17	22	25

Table C406.1.4(6)

H01	HVAC Performance (TSPR)	C406.2.2.1	31	30	26	28	23	21	23	20	14	27	21	22	29	25	23	32	28	30	33

Table C406.1.4(7)

H01	HVAC Performance (TSPR)	C406.2.2.1	30	28	25	26	23	21	20	18	15	19	18	17	19	20	15	23	20	25	29

Table C406.1.4(8)

H01	HVAC Performance (TSPR)	C406.2.2.1	20	21	14	18	12	13	20	13	6	31	21	22	36	30	20	39	34	38	38

Table C406.1.4(9)

H01	HVAC Performance (TSPR)	C406.2.2.1	23	22	19	20	17	16	17	15	11	19	16	14	20	18	14	23	20	24	26

Notes to adopting authority:
When adding energy credit H01 HVAC System Performance:

1. *Confirm renumbering of equations throughout C406.*
2. *Confirm that section references are correct.*

3. *If alternate language requiring TSPR compliance is adopted, then change the word "allowed" to "required" in Sections* C406.2.2 (second paragraph, first sentence) and C406.2.2.1 (first sentence) *above.*

Appendix C – Basis of Savings

This appendix describes the basis for analysis and modeling methodology used for analyzing the energy efficiency credits. The analysis was primarily conducted by applying measures to the U.S. Department of Energy (DOE) Commercial Prototype Building Models for ASHRAE Standard 90.1-2019. These models were then simulated using EnergyPlus. Some credits were analyzed using methods other than hourly simulation, such as engineering calculations, where appropriate.

C.1 General Approach to Savings Analysis

To estimate energy savings for this project, Pacific Northwest National Laboratory (PNNL) used one or more prototype buildings from the ASHRAE Standard 90.1 model code analysis process (PNNL 2020). The baseline used was ASHRAE Standard 90.1-2019. This baseline is somewhat equivalent to the 2021 IECC. The following process was used:

1. The measure was reviewed to determine the differences in building and system configuration that would contribute to energy savings.
2. One or more prototypes were used to run a baseline and improved building to find the relative savings in 19 ASHRAE climate zones.
3. The energy savings were characterized as a percentage reduction in various building prototype end uses for each climate zone.
4. End-use breakdowns from the 90.1-2019 performance indicator analysis (Nambiar et al. 2019) were used as prototype basis and adjusted based on related analyzed end-use savings.

C.2 Energy Credit Measure Basis of Savings

C.2.1 Building Envelope Measures

C.2.1.1 E01 Envelope Performance (90.1 Appendix C)

The envelope performance measure is calculated using an overall 10% reduction in Envelope Performance Factor based on the ASHRAE 90.1 Appendix C methodology. The measure savings was calculated using a 10% reduction in energy cost index savings for the energy end uses regulated in Appendix C. The baseline value is the total of both the non-regulated and regulated uses without any reduction applied.

C.2.1.2 E02 UA Reduction (15%)

Savings from the 15% UA (U-factor times envelope area) reduction measure was estimated based on simulation results generated for the 2021 IECC energy credits (Hart et al. 2019). For that analysis, the measure was modeled in four different prototype models (midrise apartment, medium office, stand-alone retail, and primary school) across all 17 U.S climate zones. The individual end-use savings were used to prorate simulation results generated for (Zhang et al. 2020). For building types not represented in (Hart et al. 2019), end-use results were prorated based on the end-use savings from the stand-alone retail model. The only exception is the hospital (used to represent the medical building type in this report), which used the results from the medium office building as the basis for the proration. The simulation results included in the original energy credit tech brief (Hart et al. 2019) did not provide results for Climate Zone 0. Results for Climate Zone 1 were used for the proration.

C.2.1.3 E03 Envelope Leakage Reduction

Savings from the envelope leakage reduction measure were estimated similarly as measure E02, with different leakage rates compared to the 0.40 cfm/ft2 base leakage rate. These are simulated by changing the infiltration rate of the building.

C.2.1.4 E04-E11 Discrete Envelope Improvements

Savings from the discrete envelope improvements were made by creating prototype analysis runs with both base and improved envelope characteristics for each relevant climate zone. Then the savings is determined by comparing the baseline and improved simulation analysis.

C.2.2 HVAC Measures

C.2.2.1 H01 HVAC Performance (TSPR)

Savings from the HVAC performance measure (total system performance ratio, TSPR) were estimated by reducing the overall HVAC energy use from the 90.1-2019 end-use analysis (Nambiar et al. 2019) by 5% for each building type and all climate zones.

C.2.2.2 H02 Heating Efficiency

This measure was analyzed by comparing energy simulation results of a baseline case to a measure case in EnergyPlus. The measure case annual heating efficiency was improved by 5% for all heating systems compared to the baseline. For heat pumps, heating seasonal performance factor is specified, the 5% improvement was applied on the tested value and then converted to coefficient of performance (COP), which was used in EnergyPlus. This was done to address the input requirements of EnergyPlus, which requires COP as the cooling efficiency metric and needs the fan portion of the testing metric to be removed.

C.2.2.3 H03 Cooling Efficiency

This measure was analyzed by comparing energy simulation results of a baseline case to a measure case in EnergyPlus. The measure case annual cooling efficiency was improved by 5% for all cooling systems compared to the baseline.

Where integrated part load value (IPLV) or integrated energy efficiency ratio (IEER) is specified, the 5% improvement was applied on the tested value and then converted to COP, which was used in EnergyPlus. This was done to address the input requirements of EnergyPlus, which requires COP as the cooling efficiency metric and needs the fan portion of the testing metric to be removed.

C.2.2.4 H04 Residential HVAC Control.

This measure was analyzed by comparing energy simulation results of a baseline case to a measure case in EnergyPlus. The measure case was modeled with a heating and cooling temperature setback of 5°F for a total of 9 hours (4 hours during the day and 5 hours at night).

C.2.2.5 H05 DOAS/Fan Control.

This measure was modeled using the results from the DOE TSPR analysis tool to model the impact of dedicated outdoor air system (DOAS) with fan control for the multifamily prototype. A separate DOAS system was included for the measure, and zonal heating and unit fans were cycled. The energy savings for heating, cooling, and fan energy end use were prorated based on the respective end uses for other prototypes. Energy savings based on TSPR analysis was 12.76% for fan, -23.58% for heating, and 6.76% for cooling.

C.2.3 Service Hot Water Measures

For energy credits related to heating service hot water (SHW), the base parameters used for water usage, pipe and tank losses, and generation efficiency are those documented in the 90.1 progress indicator enhancements (Goel et al. 2014). In many cases, a building type group is represented by two distinct building prototypes (PNNL 2020). For example, school buildings are represented by both primary and secondary school prototypes. The SHW measures were analyzed by post-processing of prototype model results. For each prototype, annual SHW energy was itemized into categories of water-heating energy use, pipe loss, dump or warmup loss, and tank loss. These values were then adjusted for the individual SHW measures according to the measure technologies under consideration.

C.2.3.1 W01 SHW Preheat Recovery

This measure assumes the use of heat recovery from a water-cooled chiller or water source heat pump, and accounts for 30% savings in water-heating energy (including losses). The measure also accounts for increased pumping energy in the central plant required by the energy recovery equipment.

C.2.3.2 W02 Heat Pump Water Heater

This measure is based on a multi-fuel baseline SHW system in which 20% of the water-heating load is handled by electric resistance and 80% is handled by a gas storage water heater. For the measure, it is estimated that the entire water-heating load is met by an air-source heat pump water heater system, and that the average COP is 2.6, including the effects of any supplemental electric resistance heat.

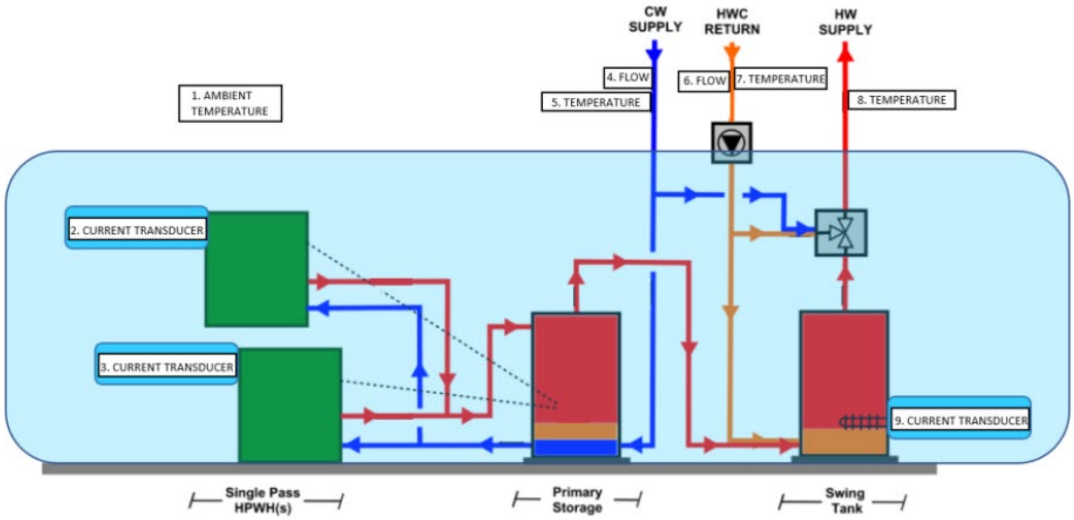


Figure D.1. Example Heat Pump Water Heater Configuration

The energy credits for heat pump water heating require a minimum of 30% end-use water heating be served by the heat pump without supplemental heat. If more is served, up to 80% of the credits are increased. To avoid operating the heat pump at a high delivery temperature, an arrangement like that shown in Figure D.1 allows storage of preheated water that is finished to final temperature with a gas or electric resistance final heater. This configuration is appropriate for larger systems, while smaller systems may use a single hybrid tank that has a finishing heater at the top.

C.2.3.3 W03 Efficient Gas Water Heater

This measure was analyzed by post-processing of prototype model results. The baseline is modeled as a gas storage water heater with a thermal efficiency of 80.3% and the measure assumes a condensing system with an efficiency of 95%. The result is an overall energy savings of 15.47%.

C.2.3.4 W04 SHW Pipe Insulation

The SHW pipe insulation measure was evaluated by developing a representative pipe run for a typical multifamily building using the standard Hunter's Curve method. Baseline pipe insulation was set based on ASHRAE 90.1-2019 Table 6.8.3-1 (1 inch thick insulation for nominal pipe sizes less than 1.5 inch and 1.5 inch thick insulation for larger pipes). For the measure, the insulation thickness was increased by 1 inch for all pipe sizes. Overall thermal resistance for each pipe size was determined using the energy calculator for horizontal piping on the Whole Building Design Guide website.[1] The overall reduction in pipe heat loss was thus estimated to be 24.7% of the baseline pipe heat loss.

[1] https://www.wbdg.org/guides-specifications/mechanical-insulation-design-guide/design-objectives/energy-calculator-horizontal-piping

C.2.3.5 W05 Point of Use Water Heaters

Measure W05 is based on a multi-fuel baseline SHW heating system in which 20% of the water-heating load is handled by an electric resistance heater and 80% of the load is handled by a gas storage water heater. The measure reduces pipe loss by converting from central water-heating system with recirculation piping to distributed point of use systems. The conversion is estimated to reduce overall piping loss by about 80%. For the school system, the showers and kitchen remain on gas water systems with local recirculation, while hot water for restrooms is provided by small local electric water heaters that do not have recirculation piping.

C.2.3.6 W06 Thermostatic Balancing Valves

Measure W06 savings is based on the installation of dynamic thermostatic balancing valves that decrease the temperature of water in the recirculation piping from an average of 130°F to 115°F. Based on the reduction in temperature difference from an ambient temperature of 70°F, this leads to a 33% reduction in heat loss from the recirculation piping.

C.2.3.7 W07 SHW Heat Trace System

Measure W07 savings is based on the recirculation return piping being removed from the building and a self-regulating electric resistance cable system attached to the hot water distribution supply pipes underneath the insulation. Thus, the recirculation piping heat loss is eliminated, and the supply piping heat loss replacement is converted from gas to electric resistance.

C.2.3.8 W08 SHW Submeters

Measure W08 savings is based on reducing water use and the energy to heat by 5%. There is no impact on piping or tank losses. Several studies showing an actual 15% savings impact from individual apartment electric meters support this estimate.

C.2.3.9 W09 SHW Distribution Sizing

Measure W08 uses a baseline piping layout established for a typical building using the standard Hunter’s Curve method, and an alternative layout for the same building developed using the Appendix M method of the 2018 Uniform Plumbing Code. This results in the use of smaller diameter piping, with a corresponding 26.2% overall reduction in pipe heat loss. There is also a reduction in actual water use from requiring water wise low flow residential fixtures.

C.2.3.10 W10 SHW Shower Drain Heat Recovery

Measure W10 was evaluated based on a 54% recovery effectiveness for a heat exchanger device that recovers heat from drainwater and preheats the incoming cold water. The resulting increase in cold water supply temperature into the shower results in a 7.2% savings in hot water energy use, with no impact on pipe or tank loss.

C.2.4 Power Measure

C.2.4.1 P01 Energy Monitoring

Energy monitoring of electrical end uses is required for buildings greater than 25,000 square feet. This credit applies to smaller buildings that install similar monitoring. The monitoring equipment is much less expensive when installed in a new building rather than retrofit. Monitored information can be used by building operating staff and managers to identify high energy use at unexpected times and improve lighting and HVAC controls or to provide feedback to occupants who can reduce energy use.

C.2.5 Lighting Measures

Lighting measures are evaluated in the prototype models.

C.2.5.1 L01 Lighting Performance (Reserved)

A lighting performance method is under development that would form an alternative to L03, L04, and L06. It uses a spreadsheet method to

C.2.5.2 L02 Lighting Dimming & Tuning

Measure L02 was analyzed by comparing energy simulation results of a baseline case to a measure case in EnergyPlus. The measure case lighting power density is set by reducing 75% of the space lighting by 7.5% compared to the baseline. This reflects a 15% reduction in initial tuned light power that is then slowly increased until lamps are replaced. The space types and modeled lighting power densities for the baseline and measure case for each prototype analyzed are shown in the table below:

Prototype	Space Type	Baseline (W/ft^2)	Measure (W/ft^2)
ApartmentMidRise	Corridor	0.49	0.46
	Office	0.74	0.70
Hospital	Basement	0.64	0.60
	Corridor	0.71	0.67
	Dining	0.40	0.38
	Exam Room	1.40	1.32
	Nurse Station	1.04	0.98
	ICU	1.25	1.18
	Kitchen	1.09	1.03
	Lab	1.33	1.26
	Lobby	0.82	0.77
	Operating Room	2.26	2.13
	Office	0.64	0.60
	Patient Room	0.68	0.64
	Physical Therapy	0.91	0.86
HotelSmall	Corridor	0.49	0.46
	Lounge	0.42	0.40
	Gym	1.08	1.02
	Office	0.74	0.70
	Stairs	0.49	0.46
	Storage	0.38	0.36
	Laundry	0.53	0.50
	Mechanical Room	0.95	0.90
	Conference Room	0.97	0.92
	Restroom	0.63	0.59
OfficeSmall	Office	0.64	0.60
RestaurantSitDown	Dining	0.60	0.57
	Kitchen	1.09	1.03
SchoolPrimary	Bath	0.63	0.59
	Café	0.40	0.38
	Computer Room	0.71	0.67
	Classroom	0.71	0.67
	Gym	0.90	0.85
	Kitchen	1.09	1.03
	Library	0.83	0.78
	Lobby	0.84	0.79
	Mechanical Room	0.95	0.90
	Office	0.74	0.70
Warehouse	Bulk Storage	0.33	0.31
	FineStorage	0.69	0.65
	Office	0.64	0.60

C.2.5.3 L03 Increase Occupancy Sensor

This measure was analyzed by comparing energy simulation results of a baseline case to a measure case in EnergyPlus. The measure cases are modeled by adjusting the lighting schedules in spaces that do not contain occupancy sensors in the baseline.

The space types in individual prototypes where this measure was applied, and the corresponding lighting schedule adjustment rates, are as given in table below:

Prototype	Space Type	% Floor Area with Occupancy Sensor in Measure Case	% Lighting Schedule Reduction in Measure Case
Small Office	Open Office	18%	24%
Primary School	Kitchen	100%	24%
	Library - Stacks	100%	24%
Hospital	Laboratory	100%	10%
	Kitchen	100%	24%

C.2.5.4 L04 Increase Daylight Area

This measure was analyzed in EnergyPlus using the prototype models by increasing the fraction of electric lights that can be dimmed when daylight is available at or above illuminance levels required to perform visual tasks. For this measure, the fraction of floor area capable of being daylight controlled was increased by 5% compared to the baseline as shown in the table below. This was accomplished by increasing the fraction of the zone controlled by daylight control reference point objects in EnergyPlus. Additionally, visible transmittance property of the windows was increased by a fraction of 1.5 times the minimum solar heat gain coefficient (SHGC) requirements for non-residential windows per 90.1-2019.

Prototype	Baseline	Measure
Medium Office	21%	26%
Primary School	42%	47%
Retail Stand-alone	35%	40%
Warehouse	49%	54%

C.2.5.5 L05 Residential Light Control

This measure was analyzed in EnergyPlus using the prototype models by reducing the lighting schedule fraction by 10% for residential spaces and 15% for corridor spaces compared to the baseline. This measure was only applied to the Midrise Apartment prototype.

C.2.5.6 L06 Lighting Power Reduction

This measure was analyzed in EnergyPlus using the prototype models by reducing the lighting power density (LPD) in non-residential space types by 10% compared to the baseline.

For non-residential spaces specialized light types including task and display lighting were omitted from the LPD reduction. This applies to the Retail Stripmall prototype.

Prototype	Space Type	Baseline (W/ft²)	Measure (W/ft²)
ApartmentMidRise	Corridor	0.49	0.44
	Office	0.74	0.67
Hospital	Basement	0.64	0.58
	Corridor	0.71	0.64
	Dining	0.40	0.36
	Exam Room	1.40	1.26
	Nurse Station	1.04	0.93
	ICU	1.25	1.13
	Kitchen	1.09	0.98
	Lab	1.33	1.20
	Lobby	0.82	0.74
	Operating Room	2.26	2.03
	Office	0.64	0.58
	Patient Room	0.68	0.61
	Physical Therapy	0.91	0.82
HotelSmall	Corridor	0.49	0.44
	Lounge	0.42	0.38
	Gym	1.08	0.97
	Office	0.74	0.67
	Stairs	0.49	0.44
	Storage	0.38	0.34
	Laundry	0.53	0.48
	Mechanical Room	0.95	0.86
	Conference Room	0.97	0.87
	Restroom	0.63	0.57
OfficeSmall	Office	0.64	0.58
RestaurantSitDown	Dining	0.60	0.54
	Kitchen	1.09	0.98
SchoolPrimary	Bath	0.63	0.57
	Café	0.40	0.36
	Computer Room	0.71	0.64
	Classroom	0.71	0.64
	Gym	0.90	0.81
	Kitchen	1.09	0.98
	Library	0.83	0.75
	Lobby	0.84	0.76
	Mechanical Room	0.95	0.86
	Office	0.74	0.67
Warehouse	Bulk Storage	0.33	0.30
	FineStorage	0.69	0.62
	Office	0.64	0.58

C.2.6 Equipment Measures

C.2.6.1 Q01 Efficient Elevator

The efficient elevator measure is modeled as a reduction in the total electricity consumption of 0.05 kW/ft^2. This is based on an analysis of PNNL prototypes with an upgrade of elevators from standard to premium VDI grade A.

C.2.6.2 Q02 Efficient Commercial Kitchen Equipment

The efficient commercial kitchen measure is calculated based on a more efficient fryer replacing a standard fryer. The high efficiency fryer is estimated to reduce the total cooking energy end use by 5.4%. No credit is taken for either lighting or HVAC energy reduction for this measure.

C.2.6.3 Q03 Efficient Residential Kitchen Equipment

This measure assumes that high efficiency refrigerators and dishwashers are used in dwelling units. These appliance improvements result in an estimated per dwelling unit savings of 199 kWh. Energy savings per square foot was determined for the apartment and hotel prototypes by multiplying the appliance savings by the number of dwelling units.

C.2.6.4 Q04 Fault Detection

The fault detection measure is modeled by based on an HVAC energy savings of 0.75% by reducing the system operation faults. This measure is only applied to HVAC energy and lighting energy reduction is not applied for this measure.

C.2.7 Renewable Measure

C.2.7.1 R01 Renewable Energy

Measure R01 is modeled as 0.1 W rated power of installed photovoltaics per square foot of building gross floor area. Total system rated power is calculated by multiplying the prototype gross square footage by 0.1 W. The total array size is estimated using an assumption of 250 W and 17.6 ft^2 per module.

Module insolation is determined for each prototype and climate zone using a calculator that computes the annual insolation from collector azimuth and tilt for each climate zone. AC power is calculated from insolation, module efficiency, and system efficiency. The calculator is based on the EnergyPlus photovoltaic model.

Model assumptions are:

- Tilt: Same as latitude
- Azimuth: South
- Inverter efficiency: 96%
- System losses: 14%

The electricity savings is calculated by subtracting the generated AC power from the baseline electricity consumption for each prototype and climate zone. The credits for renewable energy systems are based on the % of building cost reduction achieved through electric generation that is used in the building, without credit for net metering.

C.2.8 Load Management Measures

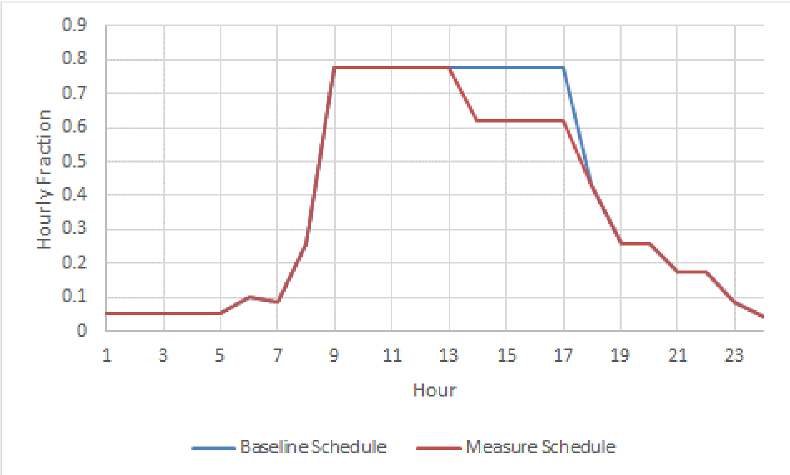
Dissimilar to the energy efficiency credits that are based on energy use savings, the load management credits are based on energy cost savings. The credit values are determined using a representative electricity time-of-use (TOU) rate. The rate includes a summer high price period based on electric demand that occurs during weekday afternoon hours. The rate also includes a winter high price period based on electric energy use that occurs during early morning and early evening weekday hours. More information about the TOU rate and its development are presented in Appendix E.

Establishing load management value through the energy credit code mechanism ensures a standardized, consistent assessment of impact is applied for compliance purposes. Invariably, actual building load management operation will be influenced by the building actual electric rate pricing, building load shape, self-utilization of on-site renewable energy, and other factors. Nonetheless, the approach credits indicate the relative ability to save electricity costs by reducing or shifting loads based on a representative rate.

C.2.8.1 G01 Lighting Load Management

Measure G01 was analyzed by comparing energy simulation results of the baseline case to the measure case in EnergyPlus using the energy code prototype building simulation models. The lighting load management measure sheds load during the high-cost electric demand periods. For the representative TOU rate, this period occurs June through September from 1 PM to 9 PM on weekdays.

The lighting load management measure decreases ambient lighting levels by 20% compared to their baseline operating capacity during the representative TOU rate summer peak demand period that is coincident with normal building operating hours. The measure is modeled by adjusting the interior lighting operating schedule profiles for the general lighting. The figure below provides an example of this adjustment applied to the medium office building. It indicates the baseline design lighting power fraction and the adjusted lighting power fraction for the measure. The lighting power in the analysis is determined for each simulation timestep by multiplying the total installed lighting power by the hourly fraction indicated in the schedule. Since this measure aims to decrease lighting and coincident cooling loads, the modified measure schedule occurs during the hour interval in which the TOU summer peak demand period coincides with normal building operating hours. For the medium office building, this results in a lighting schedule modification for hours 1 PM to 5 PM for June through September.

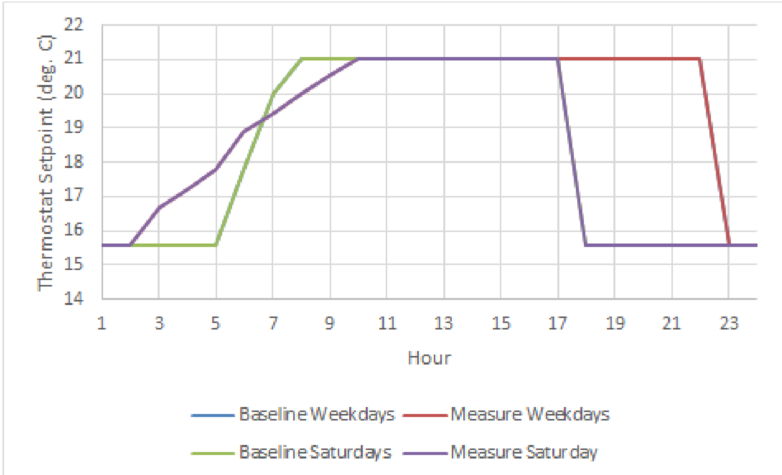


C.2.8.2 G02 HVAC Load Management

The G02 measure was analyzed by comparing energy simulation results of the baseline case to the measure case in EnergyPlus using the energy code prototype building simulation models. The measure sheds cooling loads during the high-cost electric demand hours. It also ramps electric preheat during high electricity energy use periods. For the representative TOU rate, the high-cost electric demand period occurs June through September from 1 PM to 9 PM on weekdays. The high-cost electric use period impacting morning warm up occurs from 6 AM to 10 AM during non-summer months

The shedding of cooling load is initiated on weekdays during the months of June through September. In the analysis, the baseline cooling setpoint temperature increases by 3 F starting at 3 PM. The setup schedule continues until the night-time temperature schedule commences. Implementing the measure later in the day after the start of the peak demand period helps to maintain comfort conditions through the end of the workday while still providing energy cost benefit resulting from reduced building electric demand.

To reduce energy costs associated with electric heating, a ramped preheat is initiated 2-hours early compared to the baseline case during the months of October through May. The strategy reduces the amount of electric energy used for preheating for hours after 6 AM during non-summer months. To implement the measure, the heating setpoints during the “winter period” (October to May) were modified to incorporate a longer ramped setpoint morning warm up. The figure below provides an example of this adjustment applied to the medium office building.



C.2.8.3 G03 Automated Shading Load Management

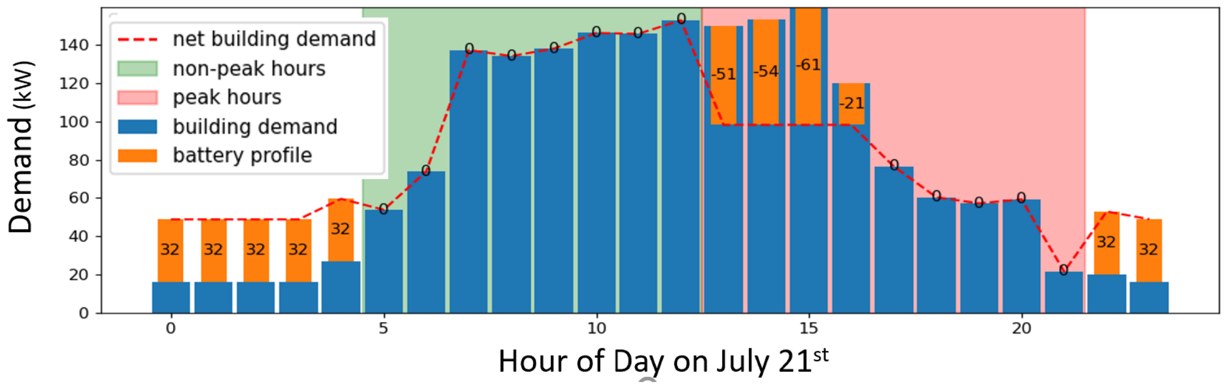
For the representative TOU rate, the high-cost electric demand period occurs June through September from 1 PM to 9 PM on weekdays. The high-cost electric use period impacting morning warm up occurs from 6 AM to 10 AM during non-summer months

To estimate the impact of automated shading during peak TOU pricing periods, the modeled solar heat gain coefficient (SHGC) of window assemblies was reduced during these periods by 50%. The same adjustment was made for all building types and climate zones.

C.2.8.4 G04 Electric Energy Storage

For measure G04, electric energy storage is used to shift energy use out of the high-cost electric demand price period. For the representative TOU rate, the high-cost electric demand period occurs June through September from 1 PM to 9 PM on weekdays. The battery storage analysis is implemented as Python scripts that post-process annual hourly demand time-series data from EnergyPlus simulation output for the code prototype building models. The analysis determines the annual hourly battery charge/discharge time-series profile and the hourly building electric demand and energy consumption. The energy costs savings are determined by applying the representative TOU rate to the building electricity consumption profiles and comparing the results of the baseline case to the measure case. For the representative TOU rate, the high-cost electric demand period occurs June through September from 1 PM to 9 PM on weekdays.

The applied strategy is referred to as the semi-optimized TOU strategy. The strategy discharge the battery during the “daytime” hours, from 5 AM – 10 PM, and the battery recharge occurs evenly across each hour during “night-time” from 10 PM to 5 AM. The figure below depicts the effect of applying the battery operation strategy to the medium office building in climate zone 2A on July 21st.



The analysis relies on anticipating each day's demand load profile in the electric billing cycle month. The semi-optimized TOU strategy is designed to minimize monthly demand costs. It provides a customized battery operation strategy based on the building load profile and the representative TOU rate peak demand period. The procedure is outlined below.

1. Specify the "night-time" period in which the building's electricity demand is at its minimal and the TOU rate has the lowest demand charge. The period is 10 PM to 5 AM in this analysis. The battery is charged evenly each hour over this period to achieve full capacity.

2. Based on the building's historic (e.g., baseline) hourly electricity time-series data, identify the "worst" demand day for each month.

a. For each month, denote the period with the peak demand rate as period $P_{m,max}$.

b. If the month's TOU rate includes a peak demand period, identify its "worst" day as the day that contains the highest hourly demand, $HD_{m,max}$, in period $P_{m,max}$ after applying the battery's full discharge potential across the hours with the highest demand in period $P_{m,max}$.

c. If the month's TOU rate does not contain a peak demand period, consider all non "night-time" hours as the peak period $P_{m,max}$ and identify the "worst" day and $HD_{m,max}$ the same way as above.

During the building's real-time operation, the battery is discharged for each month during its $P_{m,max}$ hours if that hour's instantaneous demand, P_i, is higher than the month's $HD_{m,max}$. The discharge power for that hour is ($HD_{m,max}$ - P_i) or based on the available battery discharging power at that time, whichever is less. In short, the battery operation strategy aims to maintain the monthly building peak demand during $P_{m,max}$ to be no larger than $HD_{m,max}$. The battery operating strategy is intended to level out demand across the hours in the month that have the highest demand without the battery applied. The approach reduces the cost associated with the maximum peak demand while minimizing the discharge of the battery during hours when there is no cost benefit.

C.2.8.5 G05 Cooling Energy Storage

The G05 measure was analyzed by comparing energy simulation results of the baseline case to the measure case in EnergyPlus using the large office prototype building simulation model. The measure reduces cooling electric demand during high-cost electricity demand price periods. For the representative TOU rate, this period occurs June through September from 1 PM to 9 PM on weekdays.

An EnergyPlus model was developed for an ice storage system serving the large office prototype building. The large data center zone was removed from the large office model to make the baseline energy use profile more representative of a typical commercial building. Simulations were performed for all ASHRAE climate zones at a storage tank capacity of 1.0 ton-hours per ton of design day cooling load. Additional simulations were performed for three climate zones and sizing configurations ranging from 0.5 to 3.0 ton-hours/ton to establish a relationship between overall performance and system capacity. Energy savings were evaluated based on the ASHRAE TOU rate. The large office energy results were prorated to other prototypes based on ratio of peak cooling tons to building floor area.

C.2.8.6 G06 SHW Energy Storage

The G06 measure was analyzed by comparing the SHW energy use and costs for the baseline and the measure case for each code prototype building. The measure shifts electric SHW load from high-cost electricity demand price periods to base-cost periods. For the representative TOU rate, the high cost demand period occurs June through September from 1 PM to 9 PM on weekdays.

Evaluation of SWH storage was done using spreadsheet calculations based on the PNNL prototype equipment sizing and hourly hot water use schedules. The storage capacity was based on the tank size in the prototype, and an assumption that water in the tank could be heated to a temperature 40 °F above the normal storage setpoint. It was then assumed that the stored energy would be discharged at a constant rate during the TOU peak period, effectively giving a peak period demand reduction equal to one fourth of the stored energy. If the SWH load during the peak period was less than the stored energy, then the peak period reduction was limited by the load.

C.2.8.7 G07 Building Thermal Mass

The G07 measure was analyzed by comparing energy simulation results of the baseline case to the measure case in EnergyPlus using the energy code prototype building simulation models. These measure was analyzed for each code prototype building model and climate zone locations. The measure reduces cooling load and supports shifting cooling loads from the high-cost electric demand period to the base-cost period.

Thermal mass was added to the prototype building models to provide 10 pounds/ft^2 (50 kg/m^2) of project conditioned floor area of interior-facing exposed thermal mass. Along with thermal mass, a “night flush” ventilation strategy was modeled.

Night flush is activated when the building is unoccupied and “summer mode” is activated. Summer mode is activated when the outdoor air temperature exceeds 70 deg. F and is deactivated when outdoor air temperature falls below 45 deg. F. During night flush, the system outdoor air damper is open and the fan is running at its minimum speed (assumed to be 66%), then the outdoor air is then effectively pre-cooling the building. Night flush is stopped if the indoor average zone temperature is less than morning occupied setpoint, the outdoor air temperature is less than 5 deg. F below indoor average zone temperature, and in climate zone 0A through 3A if the outdoor dewpoint is below 50 deg F.

Appendix D – Development of the Representative Time-of-Use Rate

The introduction of a time-of-use (TOU) rate into the code development process allows demand flexibility and distributed energy resource measures, which may not provide an overall reduction in energy use, to be justified based on cost effectiveness. The representative TOU rate was specifically developed because of this issue. The rate represents a typical U.S. TOU rate. The rate values and TOU structure were developed from published utility rate data and information gathered from an investor-owned utility (IOU) survey. More details about the rate, its development approach, and data sources are provided below.

The representative TOU rate was developed by the ASHRAE 90.1 SSPC Economics Working Group (EWG) in the summer of 2019 as part of their regular duties to update economic parameters utilized in the code development process. The update occurs at the beginning of each new code cycle. Their recommendations are incorporated into the ASHRAE 90.1 2022 Work Plan, which is drafted to direct the development of the new code. The Work Plan is voted on by the full ASHRAE 90.1 SSPC during the ASHRAE Winter Conference Meeting. For the ASHRAE 90.1-2022 code cycle, the committee voted on February 3, 2020 and approved including the representative TOU rate as an optional alternative for evaluating code change proposals. The rate, as stated in the ASHRAE 90.1-2022 Work Plan, is defined as follows.

Winter (October through May)

$0.0946 per kWh, peak hours

$0.0571 per kWh, off-peak hours

$5.59 per kW, base

No peak kW charges

Peak: Monday–Friday, 6 AM to 10 AM and 5 PM to 9 PM

Summer (June – September)

$0.1104 per kWh, peak

$0.0586 per kWh, off-peak

$ 5.59 per kW, base

$10.99 per kW, peak

As mentioned, the rate was developed from published and survey data. The utility rate data source is the OpenEI database[1], which includes over 15,000 published commercial and industrial rates offered by municipalities, cooperatives, and IOUs. A dataset was created from the OpenEI data that includes nearly 8,000 rates, after excluding industrial and unique commercial rates (such as agricultural pumping). The dataset encompasses 2,400 utilities representing 70% of the electric load across the lower 48 U.S. states (NREL 2017).[2] Based on an analysis of the dataset, the approximately 6,200 rates listed without demand charges have

[1] For more information about database, refer to Utility Rate Database: https://openei.org/wiki/Utility_Rate_Database

[2] The NREL dataset was developed to support a market potential study for battery energy storage. It is available for download at https://data.nrel.gov/submissions/74.

an average maximum allowable customer demand of 52 kW. This implies that rates without demand charges are available generally for smaller buildings. Nearly 1,700 of the listed rates include demand charges and have an average maximum allowable demand of 700 kW, with minimum demand to qualify ranging from 50 to 3000 kW. For those rates including a demand charge, the average cost is $10.18/kW (the standard deviation is $7.35/kW and the maximum listed is $90/kW). This average demand charge was used as the starting point for establishing the demand charge in the representative rate.

The representative TOU rate includes electricity kWh and kW charges that vary by hour of day and season. The on-peak off-peak rate schedule and kWh values were established based on survey data. The survey was developed by the Edison Electric Institute (EEI) and provided to member IOUs.[1] The survey respondents represent ~ 13% of U.S. IOU commercial customers.[2] A summary of key survey results that informed the ASHRAE TOU rate are provided below.

- About 80% of TOU rate customers have kW demand charges.
- Many customers have two demand charges and two season – a peak and non-peak season with a peak demand charge and a monthly base demand charge. The difference between the peak and base demand charge ranged from ~ $4.00 to $5.50 per kW.
- The average energy rate for summer on-peak and off-peak charges are $0.096/kWh and $0.066/kWh. The average difference between on-peak and off-peak charges is $0.030/kWh.
- The average energy rate for Winter on-peak and off-peak charges are $0.092/kWh and $0.064/kWh. The average difference between on-peak and off-peak charges is $0.028/kWh. The average difference between Winter on-peak and off-peak energy charges is $0.028 per kWh.
- The number of on-peak hours per week averaged 39 for summer and 33 for winter.
- The average summer weekday schedule started/ended at 12:45 PM and 8:00 PM.
- The average Winter weekday schedule started/ended at 7:50 AM and 1:30 PM and 5:00 PM and 9:15 PM.

Based on the data outlined above, as well as professional judgment and some additional data not reported herein (including the most common responses for peak period start and end times), the values underlying the ASHRAE TOU rate are as follows.

Winter (October through May)

$0.0876 per kWh, peak hours

$0.0528 per kWh, off-peak hours

$5.18 per kW, base

No peak kW charges

Peak: Monday–Friday, 6 AM to 10 AM and 5 PM to 9 PM

Summer (June – September)

[1] Organized in 1933, EEI provides public policy leadership, strategic business intelligence, and essential conferences and forums to all U.S. investor-owned electric companies.

[2] ASHRAE TOU rate presentation made by Stephen Rosenstock to the ASHRAE 90.1 EWG on September 19, 2019.

$0.1023 per kWh, peak

$0.0543 per kWh, off-peak

$ 5.18 per kW, base

$10.18 per kW, peak

Peak: Monday–Friday, 1 PM to 9 PM

This initial rate was then adjusted based on simulation analysis results for the code medium office prototype building, which was modeled in climate zones 2A, 4A, and 6A. Specifically, each initial rate TOU price component (kWh and kW price during winter and summer) was scaled by a factor of 1.08 in order for the average of the annual energy costs determined for the three climate zones would to be equal to that determined for the Blended Rate established in the ASHARE 90.1-2022 Work Plan, which equals $0.1099/kWh .

Appendix E – Cost Effectiveness Detail

Five tables related to the cost effectiveness of the base demonstration package (See Section 1.7.2 for detailed descriptions) are included here:

- Table E-1 shows the annual cost savings in $/1000 square feet based on U.S. average annual energy prices for the measures in the base demonstration package. For multifamily and hotel the costs are negative as the rightsizing of hot water distribution piping provides a significant cost reduction.
- Table E-2 shows the incremental measure cost in $/1000 square feet for the measures in the base demonstration package. CE indicates the overall cost is negative.
- Table E-3 shows the scalar payback for the measures in the base demonstration package. CE indicates the case is cost effective.
- Table E-4 shows the scalar threshold for the measures in the base demonstration package.
- Table E-5 shows the ratio of the scalar threshold to the scalar payback. Where this ratio is greater than 1.0, the base demonstration package is cost effective.

Table E-1. Base Demonstration Package Cost Savings, $/thousand ft^2

Building Use Type	**Climate Zone**																		
	0A	**0B**	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
Multifamily/Dormitory	64	63	56	57	47	47	40	40	32	34	34	35	36	36	36	49	48	49	50
Healthcare	188	174	174	172	177	156	161	152	179	173	167	186	173	171	220	171	182	198	197
Hotel/Motel	112	99	85	87	81	69	65	64	62	61	61	58	67	66	62	75	70	86	99
Office Buildings	86	83	77	79	71	69	70	72	63	73	75	68	78	80	72	89	85	87	94
Restaurant Buildings	570	520	437	468	426	392	377	374	330	348	347	343	477	439	417	542	493	603	702
Retail Buildings	178	169	147	152	130	128	115	113	102	112	103	97	99	102	90	110	83	91	92
School/Education Buildings	111	100	86	92	82	74	72	73	65	73	73	67	80	88	74	98	88	103	123
Warehouse and Semiheated	33	34	29	31	28	28	26	26	25	24	25	25	39	30	24	54	43	52	50

Table E-2. Base Demonstration Package Incremental Cost, $/thousand ft²

Building Use Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily/Dormitory	-980	-980	-980	-1015	-1025	-1025	-1079	-1079	-1232	-1232	-1232	-1232	-1232	-1232	-1232	-1079	-1079	-1079	-1079
Healthcare	568	568	568	568	568	568	431	431	431	431	431	431	450	450	450	450	450	450	450
Hotel/Motel	-841	-841	-841	-841	-841	-841	-909	-909	-1046	-1046	-1046	-1046	-990	-990	-990	-990	-990	-990	-990
Office Buildings	1006	1006	1006	1006	938	938	938	938	801	801	801	801	852	852	852	852	852	852	852
Restaurant Buildings	1832	1832	1832	1832	1832	1832	1832	1832	1627	1627	1627	1627	1664	1664	1664	1664	1664	1664	1664
Retail Buildings	720	720	699	699	699	699	699	699	494	494	515	515	429	466	466	374	374	464	464
School/Education Buildings	725	725	725	725	725	725	656	656	520	520	520	520	531	536	536	536	536	536	536
Warehouse and Semiheated	271	271	271	271	271	271	203	203	67	67	67	71	72	72	72	75	75	77	77

Table E-3. Base Demonstration Package Scalar Payback

Building Use Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily/Dormitory	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Healthcare	3.0	3.3	3.3	3.3	3.2	3.6	2.7	2.8	2.4	2.5	2.6	2.3	2.6	2.6	2.0	2.6	2.5	2.3	2.3
Hotel/Motel	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Office Buildings	11.7	12.1	13.1	12.7	13.2	13.6	13.3	13.1	12.6	11.0	10.7	11.7	10.9	10.7	11.8	9.6	10.0	9.8	9.1
Restaurant Buildings	3.2	3.5	4.2	3.9	4.3	4.7	4.9	4.9	4.9	4.7	4.7	4.7	3.5	3.8	4.0	3.1	3.4	2.8	2.4
Retail Buildings	4.0	4.3	4.8	4.6	5.4	5.5	6.1	6.2	4.9	4.4	5.0	5.3	4.3	4.6	5.2	3.4	4.5	5.1	5.0
School/Education Buildings	6.5	7.3	8.5	7.8	8.8	9.8	9.1	9.0	8.0	7.1	7.1	7.8	6.6	6.1	7.2	5.4	6.1	5.2	4.4
Warehouse and Semiheated	8.3	8.1	9.4	8.9	9.8	9.5	8.0	7.7	2.7	2.8	2.7	2.9	1.8	2.4	3.0	1.4	1.8	1.5	1.5

Table E-4. Base Demonstration Package Scalar Limit or Threshold

Building Use Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily/Dormitory	13.9	13.9	14.3	13.1	13.4	13.4	13.9	13.8	14.3	14.3	14.3	14.3	14.3	14.3	14.3	13.8	13.8	13.9	13.9
Healthcare	15.5	15.5	16.3	16.1	16.9	16.8	18.1	18.0	18.5	18.7	18.5	19.0	18.3	18.4	19.4	18.4	18.6	18.8	18.8
Hotel/Motel	14.5	14.6	15.4	15.3	16.0	16.0	17.2	17.0	17.8	17.8	17.7	17.3	17.0	17.4	17.1	16.9	17.0	17.0	16.8
Office Buildings	16.4	16.5	17.3	17.3	18.2	18.3	19.2	19.1	19.3	19.9	19.8	19.8	19.9	19.9	19.8	19.9	19.9	20.0	19.9
Restaurant Buildings	12.5	12.5	12.6	12.6	12.6	12.7	12.7	12.7	12.7	12.8	12.8	12.8	13.1	13.0	12.9	13.2	13.1	13.2	13.3
Retail Buildings	13.5	13.5	13.7	13.6	13.7	13.9	14.4	13.8	13.6	15.7	14.0	14.1	16.3	14.2	13.7	17.7	17.0	17.1	15.7
School/Education Buildings	15.6	15.9	16.9	16.7	17.5	17.9	19.0	19.1	19.2	19.9	19.9	19.9	19.8	19.4	19.6	19.4	19.5	19.2	18.7
Warehouse and Semiheated	13.5	13.5	13.6	13.6	13.7	13.7	13.8	13.8	13.8	13.8	13.9	13.6	13.7	13.6	13.6	13.7	13.7	13.7	13.7

Table E-5. Ratio of Scalar Limit or Threshold to Scalar Payback

Building Use Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily/Dormitory	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Healthcare	5.2	4.8	5.0	4.9	5.3	4.6	6.8	6.3	7.7	7.5	7.2	8.2	7.0	7.0	9.5	7.0	7.5	8.2	8.2
Hotel/Motel	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Office Buildings	1.4	1.4	1.3	1.4	1.4	1.3	1.4	1.5	1.5	1.8	1.9	1.7	1.8	1.9	1.7	2.1	2.0	2.0	2.2
Restaurant Buildings	3.9	3.6	3.0	3.2	2.9	2.7	2.6	2.6	2.6	2.7	2.7	2.7	3.7	3.4	3.2	4.3	3.9	4.8	5.6
Retail Buildings	3.4	3.2	2.9	3.0	2.5	2.5	2.4	2.2	2.8	3.6	2.8	2.7	3.8	3.1	2.6	5.2	3.7	3.4	3.1
School/Education Buildings	2.4	2.2	2.0	2.1	2.0	1.8	2.1	2.1	2.4	2.8	2.8	2.6	3.0	3.2	2.7	3.6	3.2	3.7	4.3
Warehouse and Semiheated	1.6	1.7	1.5	1.5	1.4	1.4	1.7	1.8	5.1	5.0	5.1	4.7	7.4	5.6	4.5	10.0	7.8	9.2	9.0

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