Pacific Northwest
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PNNL-31572

Expanded Energy Credits in Energy Codes

Technical Brief

July 2021

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U.S. DEPARTMENT OF ENERGY

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Richland, Washington 99354

Preamble

The U.S. Department of Energy (DOE) and Pacific Northwest National Laboratory (PNNL) are developing a series of technical briefs supporting national, state, and local initiatives update and advance building energy codes. These technical briefs represent a 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 (IECC) or ASHRAE Standard 90.1, or adopted directly by state and local governments pursuing advanced energy savings and greenhouse gas (GHG) emissions reductions. The 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 package for different building types across climate zones range from 3.9% to 22% of building energy cost, while the advanced package building savings range from 8.4% to 44%. 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 (ECPA), 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 to ensure successful implementation of building energy codes, as well as a range of advanced technologies and construction practices, and encourages building standards which are proven practical, affordable, and efficient.

DOE Building Energy Codes Program

The U.S. Department of Energy 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 to 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 24 energy efficiency and renewable energy measures available. Building-type-specific targets were developed with a goal of 5% total energy cost savings.

This technical brief includes 26 energy efficiency measures and builds on the former energy credit approaches with a base goal of around 10% energy savings. The credits here are based on site energy use and each credit represents 1/10 of 1% building energy use. While measure goals vary by building type and climate zone, a national weighted goal is as follows:

- Base package of cost effective measures achieves an average of 9.4% energy cost savings
- Advanced package of practical measures achieves an average of 16.8% energy cost savings

If these measures were adopted nationally into energy codes, potential national savings for expected new construction using various metrics would be as shown in Table E.1.

Table E.1. Impact of Energy Credit Measures

Metric	Units	Base Package	Advanced Package
National Annual Energy Savings	million site Btu	8,515,000	15,310,000
Consumer Annual Energy Cost Savings	million $US	$185.5m	$335.0m
Annual Emission Reductions, CO_2	metric tons	1,135,000	2,085,000

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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 2019). 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 consider 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 24 energy efficiency and renewable energy measures available. Building-type-specific targets were developed with a goal of 5% total energy cost savings.

This technical brief includes 26 energy efficiency measures and builds on the former energy credit approaches with a base goal of around 7% energy savings. The credits here are based on site energy use and each credit represents 1/10 of 1% building energy use. While measure goals vary by building type and climate zone, a national weighted goal is as follows:

- Base package of cost effective measures achieves an average of 9.4% energy cost savings.
- Advanced package of practical measures achieves an average of 16.8% energy cost savings.

If these measures were adopted nationally into building codes, potential national savings for expected new construction using various metrics would be as given in Table 1.

Table 1. Impact of Energy Credit Measures

Metric[(a)]	Units	Base Package	Advanced Package
National Annual Site Energy Savings	million Btu	8,515,000	15,310,000
Consumer Annual Energy Cost Savings	million $US	$185.5m	$335.0m
Annual Emission Reductions, CO_2	metric tons	1,135,000	2,085,000

(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.

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 energy credits.

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. 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 to energy credit measures is different. Each measure can be selected for a particular building; however, not all measures are required, so the approach is to find at least one package of measures that are shown to be cost effective. More detail is included in Section 1.7.

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

[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.

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.

On-site renewable energy is included in both packages. The base package includes 0.2 W/ft^2 of renewable capacity, while the advanced package includes 0.5 W/ft^2 of renewable capacity. The requirements are in addition to any baseline prescriptive requirements in the particular energy code and are based on total building conditioned floor area. In some cases—tall buildings for example—there may not be adequate unshaded roof area to accommodate the total desired renewable energy system. In other cases, local insolation levels may be low, precluding on-site renewables as a cost effective option. In any of these cases, an adjustment of the required credits is allowed for.

1.2.1 Base Package

The base package is selected with a goal of 10% building energy savings. For some buildings or climate zones, this goal is not always practical, and the requirement is lower. For higher energy use buildings, 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 use buildings.

1.2.2 Advanced Package

The advanced package has savings that vary from 8.4% to 44% of total building energy use. While there are higher savings here, there is a tradeoff for reduced energy credit selection flexibility. The high end of the range of savings is based on installation of the same selected package of measures that is applied, even though 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, additional energy efficiency measures were assigned relative points by building type and climate zone rather than being all considered equal, as in the 2018 IECC (ICC 2018). Measures must be included in the building design until at least 10 points are achieved. This allows buildings to achieve about a 2.5% savings compared with the base prescriptive path requirements.

This tech brief evaluates expanding the number of measures in the 2021 IECC and provides variation in requirements based on building type and climate zone. The proposed requirements are similar to an expanded energy credit section being considered for ASHRAE Standard 90.1. The energy credits available for individual measures are based on building simulation prototype evaluation that assigns each item a credit value based on relatively equivalent energy savings. Here the measure credits are based on energy savings rather than cost, with each credit equal

to 0.1% of total building energy use on a site British thermal unit basis. So 10 credits represents a 1% energy reduction and 100 credits represents a 10% reduction.

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

The extra efficiency credit approach allows for designer and builder flexibility. While it is slightly more complicated to select multiple items and add up points, in many cases credit are given for measures that are often included in buildings but not previously accounted for. Expanding the measure options to achieve credits makes it possible for buildings to save more, and the credit requirements are expanded to 5% of building energy use in the base package. For advanced energy codes, a higher level of savings can be considered, reflected in the advanced package. Since both packages include on-site renewable energy that cannot always be installed, adjustment in the requirements is allowed where roof area is limited or solar insolation is low.

In Figure 1, the credits for selected measures in an office building are plotted so the range of savings for selected measures across climate zones can be seen. The values are based on 1 energy credit 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 multi-family building.

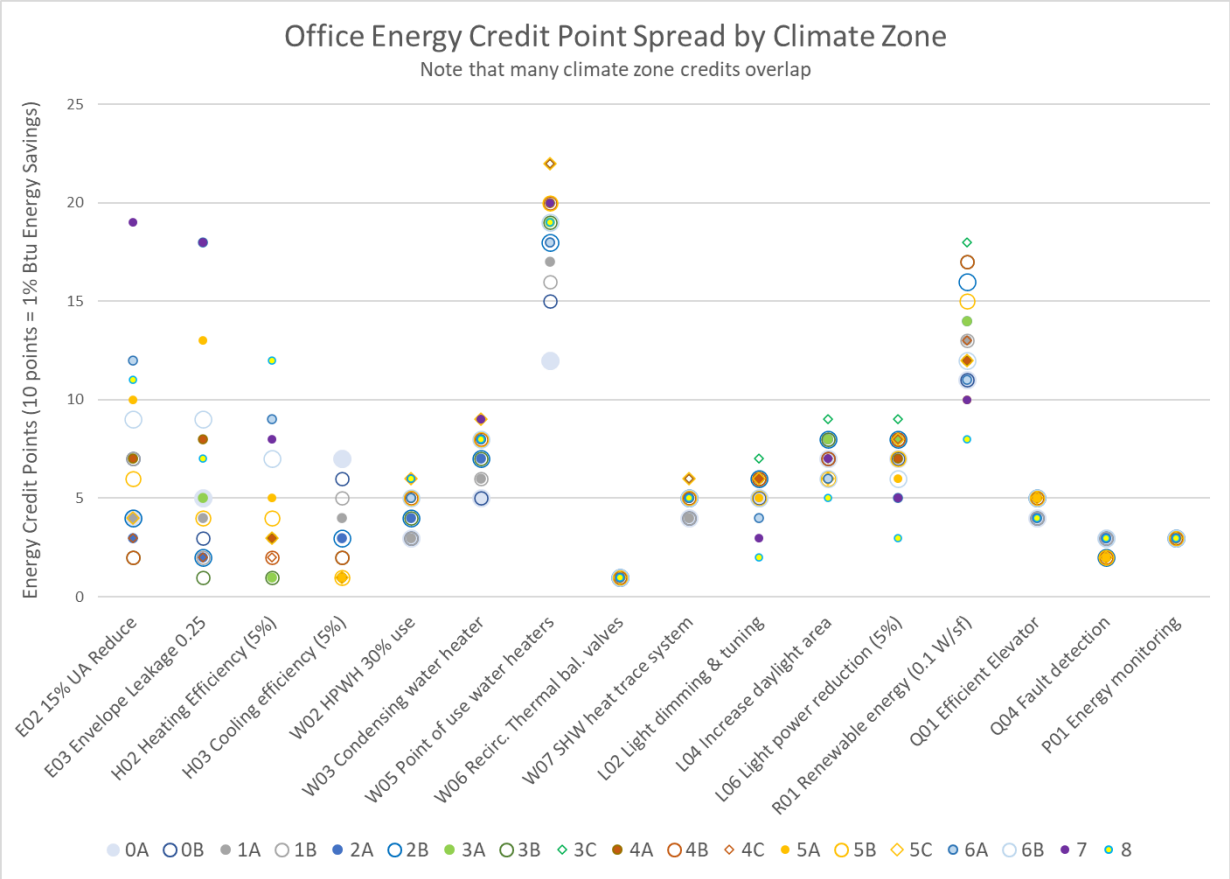

Figure 1. Range of Credits for Office Efficiency Options

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 multi-family buildings, SHW measures provide significant energy credit opportunities.

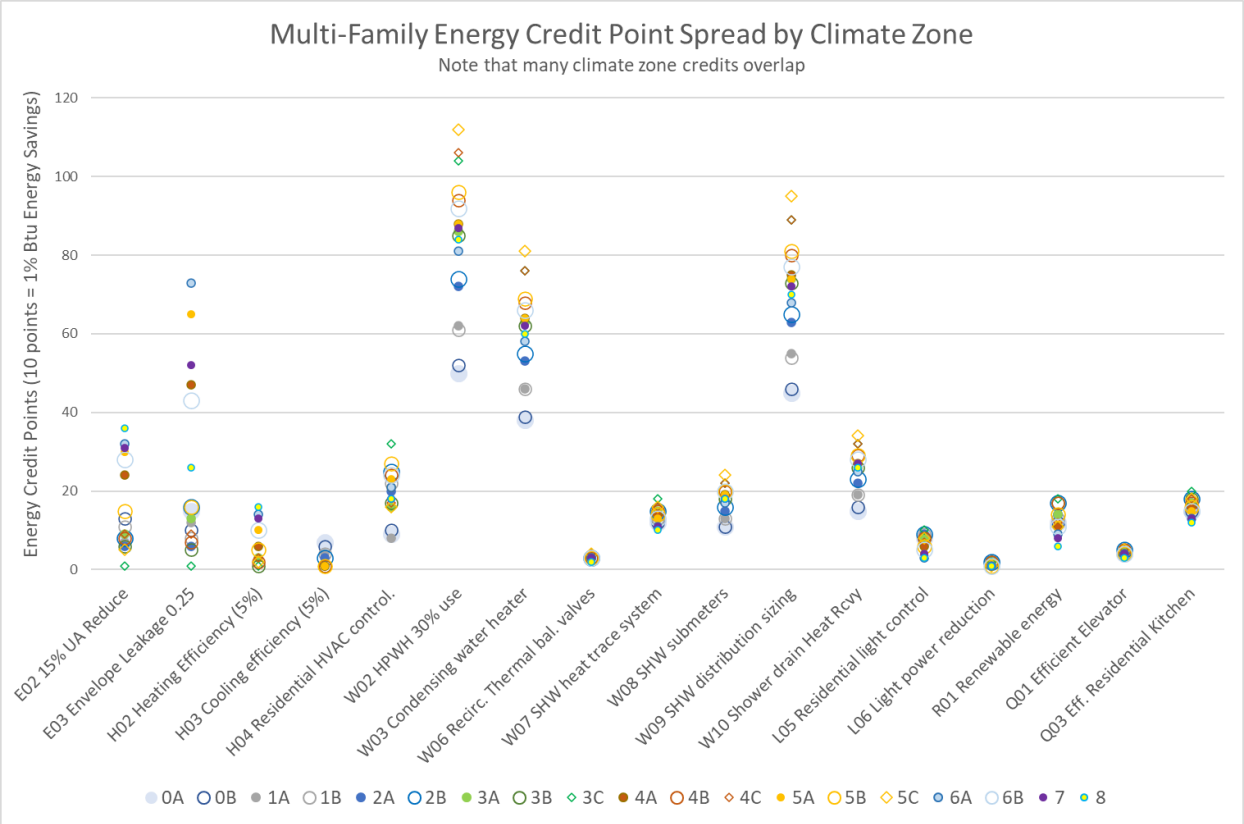

Figure 2. Range of Credits for Multi-Family Efficiency Options

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 much more expedient path than following the performance path that requires a custom building model. By expanding the number and flexibility of options for energy credits and setting appropriate targets for different building types, additional savings can be achieved with a simple menu format. To simplify review and implementation of this approach, the energy credit measures included in the COMcheck program for the 2021 IECC can be expanded for this new amendment, so that selection and adjustment of energy credit measures can be made and documented easily.

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 that have

been used in both residential and commercial energy codes, particularly in the Pacific Northwest. The Washington state and Seattle energy codes have successfully used such a structure to balance energy performance, design flexibility, and evolving technologies.

1.4 Energy Credit Development

Energy credits have been created from lists of energy saving measures developed over the years that save energy in new construction. 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 credits is flexible, they can go further in requirements that save energy. 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 only so low a baseline prescriptive requirement can go and still meet the needs of the construction industry. There are lower SHGC products available, and an energy credit can account for their use. If a particular design needs to stay at the baseline prescriptive level, the designer can choose some other energy credit measure, like increased cooling efficiency or added insulation in exterior walls.

Advanced building guidelines like the Advanced Energy Design Guidelines (ASHRAE 2019), prescriptive energy code requirements in general, measures in utility new construction programs, green building programs, and other building industry documentation were reviewed 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 2 lists the measures included in this technical brief and shows how they relate to measures in the 2021 IECC Section C406.

Table 2. 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
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
R01	C406.2.6	Renewable energy	C406.5.1	Expanded
	in above	Expanded renewable energy	C406.5.2	In R01
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

1.5 Savings and Emission Reductions

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 amendment 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 option will double. For the advanced option, savings would be the combination of the base package and advanced package if the current local energy code has no energy credits required.

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 3.

Table 3. Energy Savings Impact of Energy 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, with industry standard conversion factors for electricity and gas that do not vary by region or policy.

1.5.3 Carbon Emission Reductions

Carbon emissions resulting from the demonstration packages are based on the energy consumption on a national scale. Carbon emission metrics are provided by the U.S. Environmental Protection Agency (EPA) Greenhouse Gas Equivalencies Calculator.[1] Table 4 summarizes the carbon emission factors and Table 5 provides the annual national emission reductions if the credit packages were adopted nationwide in the U.S.

Table 4. 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 5. 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

1.6 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.

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

2. One or more prototypes were used to run a baseline and improved building to find the relative savings in 19 ASHRAE climate zones. Prototypes were selected for relevance to the 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.

Table 6 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.

[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 6. 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.

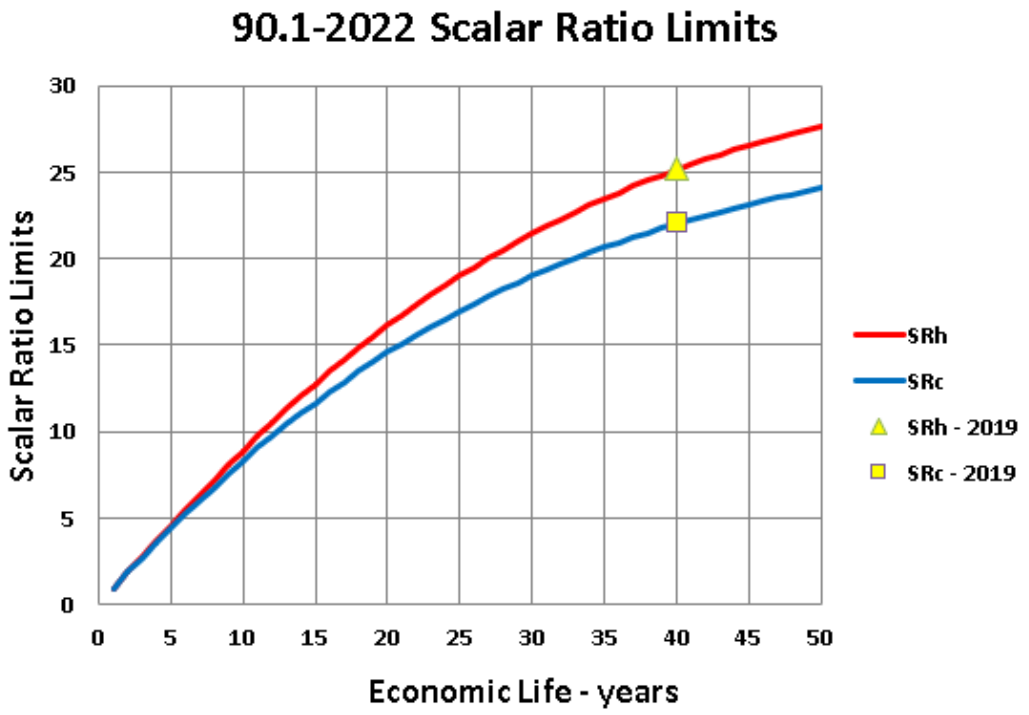

Figure 3. Scalar Ratio Limits Based on Measure Life

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. 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 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 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 requirement packages were determined for evaluation of cost effectiveness:

- The base package included standard efficiency measures and 0.2 W/ft^2 of site-based renewable energy in most building types 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.
- The advanced package was selected by adding reasonable measures with a 20% savings target. In some climate zones or building types, that goal could not reasonably be be reached. The package includes 0.5 W/ft^2 of site-based renewable energy. Cost effectiveness was not determined for the advanced package.

1.7.2.1 Base Demonstration Package

Table 7 provides an overview of measures selected for inclusion in the base package. Measures are selected with the goal of 10% savings or 100 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 8. This represents the cost for all measures included in the package divided by the annual consumer energy cost savings. Note that for multi-family buildings, 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 7, 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.

Table 7. Matrix of Base Package Measures

ID	Energy Credit Abbreviated Title	Measure Life, yr	Multifamily /Dormitory	Healthcare	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	
H02	Heating efficiency	18		CZ 5-8	CZ 5-8	CZ 5-8	CZ 5-8	CZ 5-8	CZ 5-8	CZ 4C-8
H03	Cooling efficiency.	15		CZ 0-2	CZ 0-2	CZ 0-2	CZ 0-3B	CZ 0-3	CZ 0-3A	CZ 0-2
H04	Residential HVAC control.	15	CZ 0-3, 6-8							
W02	Heat pump water heater	19					30% all CZ			CZ 4C, 5C
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				
W08	SHW distribution sizing	15	all CZ							
L03	Increase occupancy sensor	15		all CZ						all CZ
L04	Increase daylighting area	15						All CZ		all CZ
L06	Light power reduction	20	5% all CZ	5% all CZ	10% all CZ	10% all CZ	10% all CZ	10% all CZ	10% all CZ	10% all CZ
R01	Renewable energy, all CZ	25	0.1 W/sf	0.2 W/sf	0.2 W/sf	0.2 W/sf	0.1 W/sf	0.2 W/sf	0.2 W/sf	0.2 W/sf
Q02	Efficient kitchen equipment	15					all CZ			
Q04	Fault detection	15		all CZ	all CZ	CZ 0-4			all CZ	

Table 8. Scalar Ratios for Base 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	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Healthcare	5.0	5.4	5.4	5.4	5.3	5.8	4.9	4.9	4.3	4.6	4.5	4.3	4.8	4.6	3.7	4.7	4.3	4.0	4.0
Hotel/Motel	7.1	7.8	8.4	8.3	8.7	9.1	8.7	8.1	7.9	9.1	7.8	9.8	9.8	8.6	10.4	8.5	8.7	7.7	7.1
Office	11.7	12.0	12.2	12.0	12.3	11.9	11.4	10.4	11.2	11.1	9.8	11.8	11.4	10.2	12.2	10.0	10.1	10.3	10.0
Restaurant	3.5	3.8	4.5	4.2	4.6	5.0	5.2	5.2	5.3	5.1	5.1	5.2	3.9	4.1	4.4	3.4	3.7	3.1	2.7
Retail Buildings	6.3	6.5	6.7	6.6	7.2	6.9	7.6	7.3	7.7	7.1	7.1	8.2	7.1	6.7	8.0	5.0	5.8	6.1	6.6
School/Education	8.0	8.7	9.6	9.1	9.9	10.0	10.4	8.7	9.2	9.2	8.2	9.9	8.9	7.8	9.7	7.7	8.1	7.1	6.3
Warehouse	11.5	11.4	11.6	11.4	11.9	10.8	10.0	8.7	9.1	10.9	8.8	10.1	8.2	8.1	10.8	6.4	7.3	6.8	7.4

1.7.2.2 Advanced Demonstration Package

Table 9 provides an overview of measures selected for inclusion in the advanced package. Reasonable measures were selected with a goal of 20% savings, or 200 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 is likely to be considered cost effective in line with advanced energy policy.

Table 9. Matrix of Advanced Package Measures

ID	Energy Credit Abbreviated Title	Measure Life, yr	Multifamily /Dormitory	Healthcare	Hotel/Motel	Office	Restaurant	Retail	School/ Education	Warehouse/ Semiheated
E01	Glazing U & SHGC reduction	40	CZ 0-2A, 4A	all CZ	all CZ	all CZ	all CZ	all CZ	all CZ	
E02	15% UA reduction	40						all CZ		
H02	Heating efficiency	18	CZ 5-8	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 0-2	CZ 0-3B	CZ 0-3B	CZ 0-3B	CZ 0-2
H04	Residential HVAC control.	15	CZ 0-3B, 6-8							
W01	Energy recovery SHW preheat	19		30% all CZ	30% all CZ	30% all CZ				
W02	Heat pump water heater	19	30% all CZ	30% all CZ	30% all CZ		60% all CZ	CZ 4C,5C		
W03	Efficient gas water heater	15		40% all CZ	40% all CZ	70% all CZ	40% all CZ			
W05	Point of use water heaters	15				CZ 0B-8			all CZ	
W06	Thermostatic balancing valves	15	all CZ	all CZ	all CZ	CZ 0A				
W08	SHW distribution sizing	15	all CZ		all CZ					
W10	SHW shower drain heat recovery	20		all CZ						
P01	Energy monitoring	15		all CZ					all CZ	
L02	Lighting dimming and tuning	15						all CZ	all CZ	
L03	Increase occupancy sensor	15		all CZ						all CZ
L04	Increase daylight area	15		all CZ				all CZ	all CZ	all CZ
L06	Light power reduction	20	5% all CZ	10% all CZ	10% all CZ	10% all CZ	10% all CZ	10% all CZ	10% all CZ	10% all CZ
R01	Renewable, all CZ	25	0.5 W/sf	0.5 W/sf	0.5 W/sf	0.5 W/sf	0.5 W/sf	0.5 W/sf	0.5 W/sf	0.5 W/sf
Q02	Efficient kitchen equipment	15					all CZ			
Q03	Fault detection	0		all CZ	all CZ	all CZ			all CZ	

1.8 National Benefits Analysis

The consumer energy cost savings from the selected base and advanced 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 7 and Table 9 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 and Liu 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 10 and should be viewed with the following caveats:

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

- In all cases, renewable energy credits are included in the packages. In actual practice, either due to limited roof area or low solar insolation, the credit requirement may be reduced, resulting in lesser savings.

- 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 10% building energy savings or 7.5% greater than the 2021 IECC. The advanced package is targeted at 20% building energy savings or 17.5% greater than the 2021 IECC, although some climate zones have lower requirements. Note that the 2021 IECC is roughly equivalent to Standard 90.1-2019.

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

Table 10. National Annual Benefits of Adopting Energy Credits

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.

2.0 Energy 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. 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, this matches an existing measure. It is an alternative to the envelope performance (E01) energy credits.

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 measure (H04) can be completed independently or in conjunction with the HVAC performance measure (H01).

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 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 on a seasonal basis can be documented
- 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 multi-family 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 multi-family 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 multi-family 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 multi-family 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 lighting power density (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 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.

2.6.1 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—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 the 2021 IECC that does not have a prescriptive renewable energy requirement. If the base code being amended has a prescriptive renewable energy requirement, see Appendix C for code language modifications that are necessary.

2.7 Equipment

More efficient equipment installed in buildings can save energy.

2.7.1 Q01 Efficient Elevator

Measure Q01 requires the installation of higher efficiency elevator equipment than is typical. The requirement is for class A elevators based on ISO 25745-2. The level of efficiency according to this standard is required to be documented in 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.

2.7.2 Q02 Efficient Commercial Kitchen Equipment

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

2.7.3 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.

2.7.4 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.

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 11 may be helpful:

Table 11. Cross Reference of Occupancy Groups to Building Use Types

Occupancy Groups	Building Use Types
R-2, R-4, and I-1	Multi-family, Dormitory, Retirement
I-2	Healthcare
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 REQUIREMENTS

C406.1 Compliance

C406.1.1 Additional energy efficiency credit requirements.

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 this Section. Projects shall comply with sufficient measures from C406.2 to achieve the minimum number of required efficiency credits from Table C406.1.1(1) based on building occupancy group and climate zone. Projects with multiple *occupancies*, unconditioned parking garages, projects using on-site renewable energy, 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(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 compliance shall be in accordance with Section C406.1.1.1.
3. Substantial *alterations* as described in Section C406.1.1.2 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 *semiheated building* use type in Table C406.1(1)

5. Where *roof* space or insolation available for *renewable energy resources* is limited, energy credits in Table C406.1(1) shall be adjusted using Equation 4-12. ECadj shall be used in place of ECreq where ECadj < ECreq:

$$ECadj = ECreq - PVadj \times \left(1 - \frac{RAnet}{Gfloor \times PVincl \times 0.20\ (0.018)}\right) \quad \text{(Equation 4-12)}$$

Where:

ECreq = Energy Credit requirement from Table C406.1.1(2)
ECadj = Adjusted Energy Credit requirement used instead of the energy credit requirement from Table C406.1.1(1)
RAnet = Horizontal projection of *roof* area available for *renewable energy resources*
PVincl = PVincl for building type from Table C406.1.1(2), W/ft^2 (W/m^2)
PVadj = PVadj for *building* type from Table C406.1.1(2)
Gfloor = *Gross floor area* of *building*, ft^2, (m^2)

Exceptions:

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(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	83	85	97	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
I-2	44	43	43	42	42	46	40	42	39	42	46	41	50	51	50	53	54	56	57
R-1	50	48	52	52	53	56	53	57	61	53	61	57	62	64	63	71	68	77	84
B	74	72	79	81	84	87	85	90	95	87	99	92	97	100	100	100	100	100	100
A-2	75	75	76	77	80	81	78	82	89	74	80	83	100	99	100	100	100	100	100
M	76	79	89	85	93	100	95	98	100	92	87	73	89	100	95	100	100	100	100
E	78	80	84	84	84	90	89	98	100	92	100	94	95	100	100	100	100	100	98
S-1 and S-2	100	100	100	100	100	100	100	100	100	76	100	100	100	100	100	100	100	100	100
All Other	40	40	44	43	46	49	44	49	53	39	47	45	45	50	50	52	52	52	50

Table C406.1.1(2) Renewable Adjustment Credits

Building Occupancy Group	PVadj by Climate Zone																			PV
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8	incl
R-2, R-4, and I-1	12	12	14	9	0	0	0	0	0	7	0	0	8	0	0	0	0	0	0	0.1
I-2	8	8	10	10	10	12	10	12	12	8	12	8	8	10	8	8	8	6	4	0.2
R-1	12	12	14	14	14	18	14	18	18	12	18	14	12	16	12	12	14	10	8	0.2
B	22	22	26	26	28	32	28	34	36	24	34	26	20	24	24	10	14	11	2	0.2
A-2	1	1	1	1	1	2	1	2	2	1	2	1	0	1	0	0	0	0	0	0.1
M	16	18	22	20	24	27	24	32	21	18	30	20	14	11	18	0	0	0	0	0.2
E	18	20	24	22	26	32	26	36	35	24	27	24	20	24	22	20	21	17	12	0.2
S-1 and S-2	31	32	26	29	27	29	49	36	24	46	51	10	0	7	13	0	0	0	2	0.2
All Other	8	8	9	8	8	10	10	11	9	9	11	6	5	6	6	3	4	3	2	0.1

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(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 where either:
    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(1) or

       The project achieves not less than one half of the credits required in Table C406.1.1(1).

C406.1.2 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 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.

C406.1.2 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 C406.1.2(1) through C406.1.2(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 C406.1.2(1) Base Energy Credits for Group R-2, R-4, and I-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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	15	10	12	8	6	16	13	5	1	47	7	9	65	16	x	73	43	52	26
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
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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	12	12	14	13	14	17	14	17	18	11	17	12	9	14	11	9	11	8	6
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 C406.1.2(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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	5	3	4	3	5	8	8	3	2	6	2	2	7	3	1	9	7	19	5
H01	HVAC Performance (TSPR)	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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	4	4	5	5	5	6	5	6	6	4	6	4	4	5	4	4	4	3	2
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 C406.1.2(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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	15	9	12	8	6	16	7	5	10	14	3	1	19	5	x	28	16	28	18
H01	HVAC Performance (TSPR)	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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	6	6	7	7	7	9	7	9	9	6	9	7	6	8	6	6	7	5	4
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 C406.1.2(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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	5	3	4	2	2	2	5	1	0	8	0	2	13	4	0	18	9	18	7
H01	HVAC Performance (TSPR)	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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	11	11	13	13	14	16	14	17	18	12	17	13	10	15	12	11	12	10	8
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 C406.1.2(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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	2	1	1	1	2	3	11	2	0	24	4	6	33	9	3	42	29	36	16
H01	HVAC Performance (TSPR)	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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	1	1	1	1	1	2	1	2	2	1	2	1	1	1	1	1	1	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	Efficient commercial kitchen equipment	C406.2.7.2	24	26	28	27	28	29	27	29	32	26	28	29	24	26	28	21	23	19	17
Q03	Efficient residential kitchen equipment	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 C406.1.2(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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	3	3	2	2	3	3	19	3	0	44	6	11	56	13	6	64	44	43	19
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
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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	8	9	11	10	12	15	12	16	18	9	15	10	7	11	9	6	8	6	4
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 C406.1.2(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 (90.1 Appendix C)	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 Leakage Reduction	C406.2.1.3	4	3	3	3	2	5	2	1	0	0	0	0	1	0	0	2	0	1	1
H01	HVAC Performance (TSPR)	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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	9	10	12	11	13	16	13	18	18	12	18	12	10	14	12	10	12	9	6
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 C406.1.2(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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	2	2	1	2	1	3	31	3	x	77	14	17	92	25	8	95	71	69	26
H01	HVAC Performance (TSPR)	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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	44	41	54	48	56	61	42	65	72	23	50	33	14	31	32	12	18	12	9
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 (90.1 Appendix C)	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 leakage reduction	C406.2.1.3	6	4	5	4	3	7	12	3	2	28	5	6	36	9	3	41	27	33	15
H01	HVAC Performance (TSPR)	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 balancing 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	SHW shower drain 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 occupancy 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
R01	Renewable energy	C406.2.6	12	12	15	14	15	18	14	19	20	10	17	12	8	12	11	7	9	7	5
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	Efficient commercial kitchen equipment	C406.2.7.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Q03	Efficient residential kitchen equipment	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 C406.1.2(1) through C406.1.2(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 either:

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

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.

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

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 performance.

The total UA of the building thermal envelope as designed shall be 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.

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 building envelope shall not exceed 0.25 cfm/ft^2 (2.0 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 building 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.

Exception: For buildings having over 250,000 square feet (5 000 m2) of conditioned floor area, air leakage testing need not be conducted on the whole building where testing is conducted on representative above-grade sections of the building. Tested areas shall total not less than 25 percent of the conditioned floor area and shall be tested in accordance with this section.

C406.2.2 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/IEER, 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.

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 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 C406.1.2(1) through C406.1.2(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 C406.1.2(1) through C406.1.2(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. Where ventilation is provided by a separate system, it shall be turned off when the units are in unoccupied setback. 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 following 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 Cod*
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 service hot water, 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 multi-family, dormitories, and healthcare 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 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 service hot water 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 service hot water is provided by a central water-heating system, the hot water pipe insulation thickness shall be at least 1.5 times the thickness required in Table C403.12.3. All service hot water 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. Nonresidential 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 service hot water supply piping shall have an automatic thermostatic balancing valve set to a minimal return water flow when the branch return temperature is greater than 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 C406.1.2(1) through C406.1.2(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 service hot water 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 service hot water 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 multi-family 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 C406.1.2(1) through C406.1.2(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 C406.1.2(1) through C406.1.2(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:

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

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 C406.1.2(1) through C406.1.2(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, multi-family, 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 C406.1.2(1) through C406.1.2(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.

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

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 C406.1.2(1) through C406.1.2(9) .

1.2. Where LP_n > 80% of LPA_n and LP_n ≤ 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 C406.1.2(1) through C406.1.2(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.

406.2.6 R01 On-site renewable energy.

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. Credits shall be prorated from the table value as follows:

$$\mathrm{AEC_{RRa}} = \mathrm{AEC_{0.1}} \times \frac{RR_t}{0.1 \times \mathrm{PGFA}} \quad \text{(Equation 4-21)}$$

Where:

AEC_{RRa} = C406.2.6 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

$AEC_{0.1}$ = C406.2.6 base credits from Tables C406.1.2(1) through C406.1.2(9)

Note to adopting jurisdictions: Consider including the following informative note to clarify the requirements of C406.2.6

Informative note:
Onsite 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.

C406.2.7 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 prior to 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 prior to 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 C406.1.2(1) through C406.1.2(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 conveyer belt speed (feet/minute) x conveyer 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	≤ 200*P*[a] + 6,511 Btu/h	≥ 41	ASTM F2861
	Convection Mode	≤ 150*P*[a] + 5,425 Btu/h	≥ 56	
Electric	Steam Mode	≤ 0.133*P*[a] + 0.6400 kW	≥ 55	
	Convection Mode	≤ 0.080*P*[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

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-fo-use pricing in energy cost calculations. The reduction in energy cost of the proposed design associated with onsite 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*

$\boldsymbol{EC_r}$ = Energy credits required for the *building* in accordance with Section C406.1

4.0 References

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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 and expected savings are described in Sections 1.6 and 1.7.2.1. To use the advanced package and increase the savings requirements, simply replace the values in Section 3.0, Tables C406.1(1) and C406.1(2) with the following values:

Table C406.1(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	194	194	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
I-2	91	90	91	90	90	97	85	91	92	84	95	85	107	108	111	113	115	118	121
R-1	99	98	107	106	111	122	120	133	133	119	136	131	132	139	138	140	142	143	146
B	129	142	159	159	169	178	172	186	200	168	196	179	173	197	186	188	192	185	181
A-2	93	94	99	98	104	111	108	115	122	108	118	119	151	146	153	156	154	168	178
M	119	124	145	135	154	176	159	175	200	147	164	135	134	172	155	190	183	174	144
E	119	125	133	132	142	156	142	171	170	139	174	140	134	155	148	138	146	134	122
S-1 and S-2	200	200	200	200	200	200	200	200	200	145	200	200	172	200	200	164	190	163	143
All Other	71	71	81	78	85	92	81	95	103	72	90	81	79	91	89	85	88	85	81

Table C406.1(2) Renewable Adjustment Credits

Building Occupancy Groups	PVadj by Climate Zone																		PV incl
	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	60	60	54	43	27	22	19	20	1	21	21	0	0	0	0	0	0	0	0	0.5
I-2	20	20	25	25	25	30	25	30	30	20	30	20	20	25	20	20	20	15	10	0.5
R-1	30	30	35	35	35	45	35	45	45	30	45	35	30	40	30	30	35	25	20	0.5
B	55	55	65	65	70	80	70	85	90	60	85	65	50	75	60	55	60	50	40	0.5
A-2	5	5	5	5	5	10	5	10	10	5	10	5	5	5	5	5	5	5	5	0.5
M	40	45	55	50	60	75	60	80	89	45	75	50	35	55	45	30	40	30	20	0.5
E	45	50	60	55	65	80	65	90	90	60	90	60	50	70	60	50	60	45	30	0.5
S-1 and S-2	131	132	130	134	130	132	149	136	124	115	151	110	70	107	113	60	90	60	45	0.5
All Other	24	25	27	26	26	30	27	31	30	22	32	22	16	24	21	16	19	14	11	0.3

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/IEER, 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 required to comply with Section C403.1.1, credits shall be achieved by meeting the requirements of C406.2.2.1. Other systems are permitted to achieve credits by meeting the requirements of either:

1. C406.2.2.1 H01,
2. C406.2.2.2 H02,
3. C406.2.2.3 H03,
4. C406.2.2.3 H04,
5. C406.2.2.5 H05,
6. Any combination of H02, H03, H04 and H05, or
7. The combination of H01 and H04.

C406.2.2.1 H01 HVAC System Performance.

~~Reserved for future use.~~

For systems required to comply with Section C403.1.1, HVAC total system performance ratio, the *TSPR* shall exceed the minimum requirement by 5 percent. If improvement is greater, base energy credits from Table C406.1.2(1) through C406.1.2(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.

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

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 C406.1.2(1) through C406.1.2(9) as follows:

Table C406.1.2(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 C406.1.2(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 C406.1.2(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 C406.1.2(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 C406.1.2(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 C406.1.2(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 C406.1.2(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 C406.1.2(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 C406.1.2(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.*

Appendix C – Code Language for Renewable Coordination

*This appendix includes the code language adjustments necessary if the base code being amended has mandatory or prescriptive renewable requirements. The changes below are necessary to make sure that the energy credits are provided for **additional** renewable energy capacity. To adapt to a base code with mandatory or prescriptive renewable requirements, replace Section C406.2.6 in Section 3.0 with the following:*

C406.2.6 R01 On-site renewable energy.

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 that are in addition to the *on-site renewable energy* capacity required by Section <*add correct reference to mandatory/prescriptive renewables*>, without exception, shall achieve energy credits for this measure. Renewable energy systems installed on site as part of this requirement shall not be used to satisfy other requirements of this code. Credits shall be prorated from the table value as follows:

$$\mathrm{AEC_{RRa}} = \mathrm{AEC_{0.1}} \times \frac{RR_t - RR_r}{0.1 \times \mathrm{PGFA}} \quad \text{(Equation 4-21)}$$

Where:

$\mathrm{AEC_{RRa}}$ = C406.2.6 R01 energy credits achieved for this project
RR_t = actual total rating of on-site renewable energy systems (W)
RR_r = rating of *on-site renewable energy* systems required by Section <*add correct reference*> (W), without exception
PGFA = Project gross floor area, ft^2
$\mathrm{AEC_{0.1}}$ = C406.2.6 R01 base credits from Tables C406.1.2(1) through C406.1.2(9)

Note to adopting authority:

Confirm that Section references are correct when amending energy credit R01 On-site Renewable Energy.

Appendix D – 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.

D.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.

D.2 Energy Credit Measure Basis of Savings

D.2.1 Building Envelope Measures

D.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.

D.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, standalone retail, and primary school) across all 17 U.S climate zones. The individual end-use savings were used to pro-rate 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 standalone 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.

D.2.1.3 E03 Envelope Leakage Reduction

Savings from the envelope leakage reduction measure were estimated similarly as measure E02 (UA reduction (15%).

D.2.2 HVAC Measures

D.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.

D.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 (HSPF) 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.

D.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.

D.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).

D.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.

D.2.3 Service Hot Water (SHW) 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.

D.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 (WSHP), 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.

D.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.

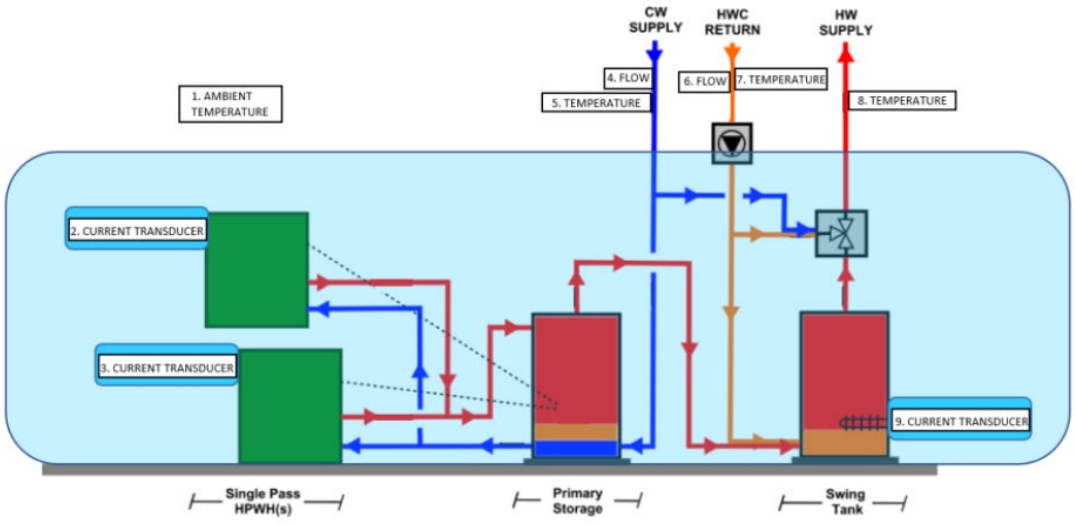

Figure D.1. Example Heat Pump Water Heater Configuration

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.

D.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%.

D.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.

D.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.

D.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.

D.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.

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

D.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.

D.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.

D.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.

D.2.4 Power Measure

D.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.

D.2.5 Lighting Measures

Lighting measures are evaluated in the prototype models.

D.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

D.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

D.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%

D.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 Standalone	35%	40%
Warehouse	49%	54%

D.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.

D.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/ft^2)	Measure (W/ft^2)
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

D.2.6 Renewable Measure

D.2.6.1 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: Latitude
- Azimuth: South
- Inverter efficiency: 96%
- System losses: 14%
- Module type: Standard efficiency
- Module rated efficiency: 15% efficiency

The electricity savings is calculated by subtracting the generated AC power from the baseline electricity consumption for each prototype and climate zone.

D.2.7 Equipment Measures

D.2.7.1 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.

D.2.7.2 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.

D.2.7.3 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.

D.2.7.4 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.

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