

Commercial Building Prototypes Based on ANSI/ASHRAE/IES Standard 90.1-2019 Appendix G PRM

Technical Support Document

June 2024

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Abstract

The two paths for documenting compliance with ANSI/ASHRAE/IES¹ Standard 90.1 are the prescriptive path and the performance path. The Standard includes two variations of the performance path, the Energy Cost Budget Method and the Performance Rating Method, often referred to by its location in the Standard, Appendix G. In addition to demonstrating minimum compliance with the Standard, Appendix G is used by beyond code programs and rating systems (for example, USGBC-LEED²) to rate performance of buildings that exceed the minimum requirements. An update in the 2016 edition of Standard 90.1 approved the Appendix G Performance Rating Method (Appendix G PRM) for code compliance, extending its application and allowing for greater consistency of modeling rules for code and beyond code building energy modeling. The Appendix G PRM provides rules for the development of whole building energy models of baseline and proposed buildings used for calculating the “performance cost index target” value and the “building performance factors” published in Table 4.2.1.1 of the Standard. This report (1) provides an overview of the Appendix G PRM and documents the use of Pacific Northwest National Laboratory and U.S. Department of Energy commercial building prototypes to support the development of the Appendix G Performance Rating Method performance targets; (2) documents the historical development of building performance factors calculated using those models; (3) describes an updated approach to calculating building performance factors, which will lead to a more accurate assessment of the energy performance a proposed building design, (4) presents an updated set of building performance factors using the new approach for Standards 90.1-2019 and 90.1-2016 as well as proposed building performance factors for the 2022 Standard; (5) describes a methodology for creating building performance factors for metrics other than cost, such as source energy and carbon emissions.

¹ American National Standards Institute / American Society of Heating, Refrigerating and Air-Conditioning Engineers / Illuminating Engineering Society

² U.S. Green Building Council Leadership in Energy and Environmental Design

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Acronyms and Abbreviations

AC	air conditioning
AHU	air handling unit
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BECP	Building Energy Codes Program
bhp	break horsepower
BPF	building performance factor
Btu	British thermal units
CO _{2e}	carbon dioxide emission
COP	coefficient of performance
CRAC	computer room air conditioning
CV	constant volume
CZ	climate zone
DCV	demand-controlled ventilation
DDC	direct digital control
DOAS	dedicated outdoor air system
DOE	U.S. Department of Energy
ER	electric resistance
ERV	energy recovery ventilator
FPFC	four-pipe fan coil
HP	heat pump
HVAC	heating, ventilation, and air conditioning
HW	hot water
IES	Illuminating Engineering Society
LEED	Leadership in Energy and Environmental Design
LPD	lighting power density
MZ	multi-zone
OA	outdoor air
PCI	performance cost index
PCI _t	performance cost index target
PFP	parallel fan powered
PLR	part load ratio
PNNL	Pacific Northwest National Laboratory

PRM	performance rating method
PSZ	packaged single zone
PSZ-AC	packaged single zone air conditioner
PSZ-HP	packaged single zone heat pump
PTAC	packaged terminal air conditioner
PTHP	packaged terminal heat pump
SAT	supply air temperature
SHGC	solar heat gain coefficient
SRR	skylight roof ratio
SSPC	Standing Standard Project Committee
SWH	service water heating
SZ	single zone
U-factor	thermal transmittance
USGBC	U.S. Green Building Council
VAV	variable air volume
WSHP	water source heat pump
WWR	window-to-wall ratio

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1.0 Introduction

The two paths for documenting compliance with ANSI/ASHRAE/IES³ Standard 90.1 are the prescriptive path and the performance path. The Standard includes two variations of the performance path, the Energy Cost Budget (ECB) Method and the Performance Rating Method (PRM), often referred to by its location in the Standard, Appendix G. The two performance paths are similar in that they specify rules for using energy simulation to compare a proposed building design's energy cost to that of a baseline or reference building design, allowing designers to “trade-off” compliance by not meeting some prescriptive requirements if the energy cost impact can be offset by exceeding others. While similar, there are two important distinctions between ECB and Appendix G PRM. The ECB approach uses a baseline with systems and components mostly the same as the proposed building design with energy performance just meeting prescriptive requirements (dependent baseline). The Appendix G PRM baseline is more independent, with systems and components determined by typical practice for a given building's architectural program. For example, construction materials, HVAC systems, water heating systems, heating fuel type, and window area are all based on building type and climate zone, not on the systems in the proposed design. This allows more flexibility as well as credit for efficient design choices that are neither mandated by the prescriptive code nor credited in ECB. Because of these advantages, the Appendix G PRM was originally developed for use by beyond code programs and rating systems (for example, USGBC-LEED⁴) to rate building designs that exceed minimum requirements.

Addendum bm to Standard 90.1-2013 introduced the “stable baseline” to the Appendix G PRM (Rosenberg and Eley 2016). For all editions of Standard 90.1, the stable baseline is set approximately equal to the stringency of Standard 90.1-2004. With this method, rather than changing the stringency of the baseline with each subsequent edition of the Standard, compliance with new editions will simply require increased levels of performance relative to the stable baseline. Using this approach, buildings of any era can be rated using the same method. The intent is that any building energy code or beyond code program can use this methodology and merely set the appropriate performance target for their needs. Addendum bm also allows the Appendix G PRM to be used for minimum code compliance, extending its application, and allowing for greater consistency of modeling rules for code compliance and beyond code programs.

To show compliance with the Standard, a proposed building's “performance cost index” (PCI) is compared to a “performance cost index target” (PCI_t) value representing a design minimally compliant with the Standard. If the PCI is less than the PCI_t, the design complies. The PCI is simply the ratio of the proposed building's energy cost to that of the baseline building's energy cost. The Appendix G PRM provides rules for calculating the PCI and PCI_t using building performance factors (BPFs) published in Table 4.2.1.1 of the Standard. The (BPFs) for a given edition of the Standard represent the ratio of the energy cost associated with the regulated components of a building compliant with the prescriptive version of the Standard to that of a building meeting the

³ American National Standards Institute / American Society of Heating, Refrigerating and Air-Conditioning Engineers / Illuminating Engineering Society

⁴ U.S. Green Building Council Leadership in Energy and Environmental Design

requirements of the Appendix G PRM baseline. The use of BPF to calculate PCI_t is described in Section 2.0. Previously, the BPFs were developed based on energy use of the Pacific Northwest National Laboratory (PNNL) prototype buildings compliant with a given edition of Standard 90.1 compared to those same prototypes compliant with the 2004 edition of the Standard. This technical support document provides a detailed description of an alternative methodology for determining the BPFs using the modified versions of the prototypes. This new methodology was used to determine the BPFs included in ANSI/ASHRAE/IES Standard 90.1 2022 and will lead to a more accurate assessment of the energy performance of a proposed building design.

The remaining sections of this report describe the BPF calculation procedure, and the modeling assumptions followed to develop the *proposed* and *baseline* models. Section 2.0 describes the PRM, provides an overview of the PNNL and U.S. Department of Energy (DOE) commercial building prototypes, and introduces the concept of BPFs. Section 3.0 describes how the published BPFs have been historically calculated and PNNL's new approach to updating the published 2019 BPFs. Section 4.0 provides revised BPFs for the 2016 Standard and proposed BPFs for the 2022 Standard using the updated approach. Section 4.0 details the modeling assumptions used in *baseline* and *proposed* model development and compares these models against the prototypes built to Standard 90.1-2019. Section 5.0 describes a method for calculating BPFs for use with performance metrics other than cost, including site energy, source energy and carbon emissions.

2.0 Performance Rating Method Calculation

Normative Appendix G of ANSI/ASHRAE/IES Standard 90.1- 2019 (ASHRAE 2019) provides an alternate path to comply with the standard requirements. This alternate path is based on the use of whole building energy simulation to determine if the performance of the *proposed* building design meets or exceeds that of a *baseline* building. Normative Appendix G (hereafter referred as Appendix G) provides detailed modeling rules to model and calculate the performance of the *proposed* and *baseline* energy models. The performance of the *proposed* design built to these rules is calculated using the formula:

$$\text{Performance Cost Index} = \frac{\text{Proposed building performance}}{\text{Baseline building performance}} \quad \text{Equation 1: PCI}$$

where:

Proposed building performance = The annual energy cost for a proposed design calculated according to Standard 90.1, Appendix G

Baseline building performance = The annual energy cost for a baseline design calculated according to Standard 90.1, Appendix G

The rules describing the baseline building are established so that its stringency is approximately equal to that of a building designed in accordance with Standard 90.1-2004. A building designed at the energy cost level of the Appendix G baseline building will have a PCI of 1.0 and a net-zero energy cost building will have a PCI of zero. The performance cost index target (PCI target or PCI_t) represents the performance cost index required to demonstrate compliance with the mandatory and prescriptive requirements of a specific edition of ASHRAE Standard 90.1. The PCI_t is calculated for a specific edition of ASHRAE Standard 90.1 using BPFs. The BPF represents the reduction in regulated energy use that the mandatory and prescriptive requirements of a version of ASHRAE Standard 90.1 achieves relative to the Appendix G baseline building. A proposed design demonstrates compliance when the PCI is less than the PCI_t. PCI_t is calculated as follows:

$$PCI_t = \frac{(BBUEC + (BPF * BBREC))}{BBP} \quad \text{Equation 2: PCI Target}$$

where:

PCI_t = performance cost index
BBUEC = baseline building unregulated energy cost
BPF = building performance factor
BBREC = baseline building regulated energy cost
BBP = baseline building performance

2.1 Commercial Building Prototype Models

Calculation of the BPFs relies on the use of prototype building energy models representing buildings compliant with various editions of Standard 90.1. The commercial building prototypes (PNNL and BECP 2021) are a suite of energy models of 16 common commercial building types

in the United States. The commercial building prototypes shown in Figure 1 represent 75% of the total square footage of new commercial construction, including multi-family buildings more than three stories tall, consistent with the scope of Standard 90.1 (Lei et al. 2020). The energy models built with EnergyPlus™ (DOE 2021) are used extensively for various research activities conducted under the DOE Building Energy Codes Program (BECP 2021) for advancement of national model building energy codes. The prototype energy models are reviewed extensively by building industry experts including members of the ASHRAE Standard Project Committee (SSPC) 90.1 during development and assessment of multiple editions of Standard 90.1. Detailed descriptions of the models are available in previously published reports (Thornton et al. 2011; Goel et al. 2014). A high-level summary of key model descriptors is provided in Table 1. Commercial building prototype models have been developed to represent the minimum mandatory and prescriptive requirements of each version of ASHRAE Standard 90.1 from 2004 through 2019 as well as the International Energy Conservation Code from 2006 through 2019. The prototype energy models are available for download on the Building Energy Codes Program website at <https://www.energycodes.gov/prototype-building-models>.

The PNNL prototype energy models include 16 commercial building types in 19 ASHRAE climate zones (17 of which are in the U.S.). The 16 commercial prototypes are mapped to the eight building area types in Table 4.2.1.1 of the Standard, as shown in Table 2 of this report. Regulated energy of each building area type is calculated as the average of regulated energy of the corresponding prototype buildings. The “All other” building type is assumed to cover all other miscellaneous building area types that are not represented by the 16 commercial building prototypes. It is calculated by weighting the simulation results of the 16 commercial prototypes by the construction weights (Lei et al. 2020) in each of 17 U.S. climate zones. For non-U.S. climate zones, the building area types are weighted equally.

Table 1: Description of Prototype Models

Prototype Building	Building Name (used in document)	Floor Area (ft ²)	Predominant HVAC System Type
Small office	OfficeSmall	5,502	Packaged single zone heat pump
Medium office	OfficeMedium	53,628	Packaged variable air volume with electric reheat
Large office	OfficeLarge	498,588	Built-up variable air volume with hydronic reheat
Stand-alone retail	RetailStandalone	24,692	Packaged single zone air conditioner
Strip mall	RetailStripmall	22,500	Packaged single zone air conditioner
Primary school	SchoolPrimary	73,959	Packaged variable air volume with hydronic reheat
Secondary school	SchoolSecondary	210,887	Built-up variable air volume with hydronic reheat
Outpatient health care	OutPatientHealthCare	40,946	Built-up variable air volume with hydronic reheat
Hospital	Hospital	241,501	Built-up variable air volume with hydronic reheat
Small hotel	HotelSmall	43,202	Packaged terminal air conditioner
Large hotel	HotelLarge	122,120	Four-pipe fan coil
Non-refrigerated warehouse	Warehouse	52,045	Packaged single zone air conditioner
Quick-service restaurant	RestaurantFastFood	2,501	Packaged single zone air conditioner
Full-service restaurant	RestaurantSitDown	5,502	Packaged single zone air conditioner
Mid-rise apartment	ApartmentHighRise	33,741	Packaged single zone air conditioner
High-rise apartment	ApartmentMidRise	84,360	Water source heat pump

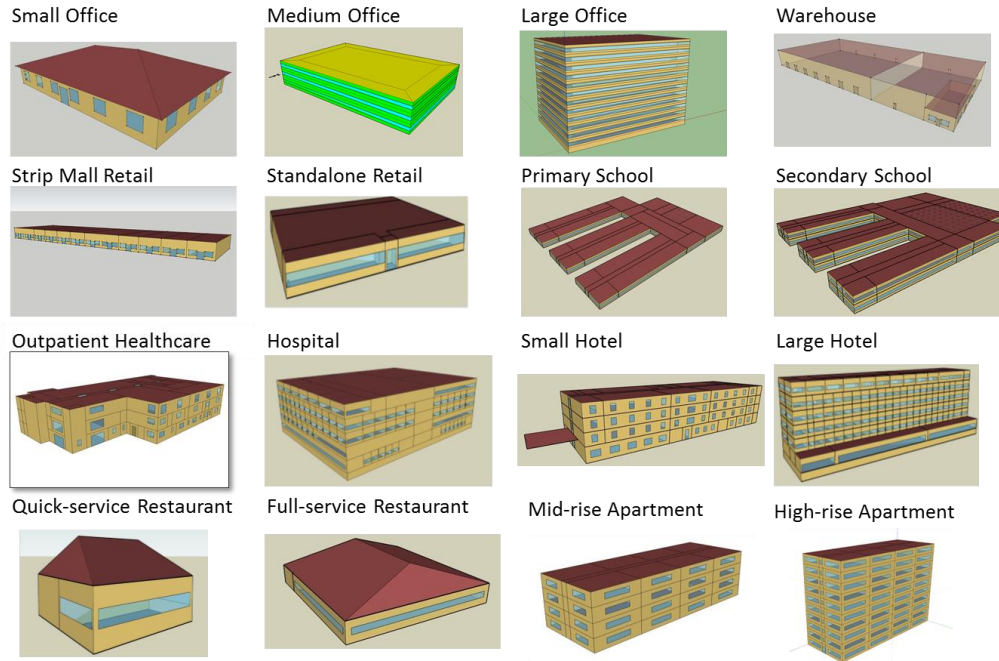


Figure 1: Prototype Building Model

Table 2: Mapping of Building Area Types to DOE Commercial Prototypes

Building Area Type (Table 4.2.1.1)	Prototype Building
Office	Small office
	Medium office
	Large office
Retail	Stand-alone retail
	Strip mall
School	Primary school
	Secondary school
Healthcare/hospital	Outpatient health care
	Hospital
Hotel/motel	Small hotel
	Large hotel
Warehouse	Non-refrigerated warehouse
Restaurant	Quick-service restaurant
	Full-service Restaurant
Multifamily	Mid-rise apartment
	High-rise apartment
All others ^(a)	All prototype buildings

(a) The BPF values for “All others” are developed for each climate zone except 0A, 0B, and 1B using weighted average values for each prototype building using national construction weights (Lei et al. 2020). For 0A, 0B, and 1B, straight numerical averages are used instead since those climate zones do not exist in the U.S. and there are no national construction weights.

2.2 Building Performance Factor

The BPFs for a given edition of the Standard represent the ratio of the energy cost associated with the regulated components of a building compliant with the prescriptive version of the Standard (*proposed* model) to that of a building meeting the requirements of the Appendix G PRM baseline (*baseline* model). The simulation end-uses used to determine the regulated energy use include interior lighting, exterior lighting, service hot water, space heating, space cooling, ventilation fan, pump, heat recovery, heat rejection, humidification, and regulated equipment. Plug-in equipment used for cooking, laundry, and miscellaneous purposes is unregulated by the Standard, and therefore is excluded from the BPF calculation. The regulated energy costs for *proposed* and *baseline* models are calculated using energy prices adopted by the ASHRAE SSPC 90.1 for development of Standard 90.1-2019 at \$0.1063/kWh for electricity and \$0.98/therm for fossil fuels (Zhang et al. 2021).

Since BPFs were first introduced as Addendum bm to Standard 90.1-2013, they have been calculated by PNNL using the simulated energy cost results of the prototype building models compliant with each edition of the Standard (PNNL and DOE 2021) and compared to the 90.1-2004 prototypes. This method, described in Rosenberg and Hart (2016), uses the 90.1-2004 prototype to represent the Appendix G stable baseline. Equation 3 illustrates the BPF calculation methodology.

$$BPF_{90.1-2019} = \frac{\sum \frac{\text{Prototype Building Regulated Energy Cost}_{90.1-2019}}{\text{Prototype Building Regulated Energy Cost}_{2004}}}{N_p}$$

Equation 3: BPF: Energy Cost Method

where,

*Prototype Building Regulated Energy Cost*_{90.1-2019} = regulated energy cost of the prototype model compliant with ASHRAE Standard 90.1-2019 for a given building type and climate zone

*Prototype Building Regulated Energy Cost*₂₀₀₄ = regulated energy cost of the prototype model compliant with ASHRAE Standard 90.1-2004 for a given building type and climate zone

N_p = number of prototype buildings of a particular building area type from Table 2

The major shortcoming of this method is that the 90.1-2004 prototypes are often not a good proxy for the Appendix G stable baseline. For example, they may have a different HVAC and service hot water heating system types compared to those prescribed in Appendix G for the given building occupancy type and location. Following the new method described in this report, the BPFs for a given edition of the Standard are calculated starting from the prototype models representing that edition of the Standard but further modified in accordance with the rules described in Appendix G. Therefore, they are different from BPFs calculated directly from the original prototypes. For example, they often have different HVAC system type, service hot water

type, and envelope infiltration values compared to the original prototype models. Section 5.0 provides a detailed description of all differences between the original prototypes and Appendix G versions. Equation 4 is used to calculate the BPF using this new method.

$$BPF_{90.1-2019} = \frac{\sum \frac{\text{Appendix G Proposed Regulated Energy Cost}_{90.1-2019}}{\text{Appendix G Baseline Regulated Energy Cost}}}{N_p}$$

Equation 4: BPF:
Energy Cost Method

where,

*Appendix G Proposed Regulated Energy Cost*_{90.1-2019} = regulated energy cost of Appendix G proposed model for a given building prototype, climate zone for ASHRAE Standard 90.1-2019

Appendix G Baseline Regulated Energy Cost = regulated energy cost of Appendix G baseline model for a given building prototype, climate zone

N_p = number of prototype buildings of a particular building area type from Table 2

BPFs calculated using the above approach are specific to energy cost. To allow for greater flexibility and to help meet jurisdiction policy goals of electrification and decarbonization, PNNL has developed a new approach based on regulated site energy coefficients, which allows for the creation of BPFs for metrics other than cost, such as source energy and carbon emissions. That new approach is described in Section 6.0.

3.0 Building Performance Factor Evolution in the Codes Development Process

This section describes how BPFs were developed through the publication of Standard 90.1-2019, details the steps used to modify that approach moving forward, and outlines the key differences.

3.1 Historical Approach to Developing Building Performance Factors

Addendum bm to Standard 90.1-2013 introduced the “stable baseline” to the Appendix G PRM (Rosenberg and Eley 2016). This new method only requires updating the BPF values (and hence the PCI_i) with each subsequent version of ASHRAE Standard 90.1 rather than having to change the stringency of the Appendix G baseline building requirements. Using this approach, buildings of any era can be rated using the same method. The intent is that any building energy code or beyond code program can use this methodology and merely set the appropriate PCI_i for their needs.

With this approach, a single set of simulations representing the Appendix G *baseline* can be compared against multiple versions of *proposed* models to create BPFs for any code. Prior to the new approach described below, the BPFs published in Table 4.2.1.1 of the Standard were calculated by PNNL using prototype models compliant with each edition of Standard 90.1, with models built to Standard 90.1-2004 representing the Appendix G *baseline* as summarized above and described in more detail in Rosenberg and Hart (2016). While the 2004 prototypes were thought to be a reasonable surrogate for this calculation, they do not fully capture the independence of the Appendix G baseline described in Section 1.0. The rationale for this simplification was that (1) the Appendix G baseline rules are similar to the requirements in Standard 90.1-2004 and (2) energy models built explicitly per Appendix G rules were not available. Although less impactful, there are also several rules in Appendix G for proposed building models that are not represented in the PNNL prototypes, including limitations on service water heating (SWH) circulation system heat loss and default infiltration assumptions.

A second issue confounds the development of BPFs. The American National Standards Institute consensus process used by ASHRAE to develop Standard 90.1 includes numerous opportunities for stakeholders to provide public input, which must be considered by the 90.1 SSPC before a new edition is published. Because of that, any given change (addendum) may take a year or more from the time it is first approved for public review until the process is completed and the addendum is ready for publication. While the performance paths try to incorporate all updates to the prescriptive path, that is not possible since the two are being developed in parallel. BPFs must be proposed for the next edition of the Standard between 6 months and a year before publication to ensure enough time for public input. At that point in the cycle of the last two editions of Standard 90.1, only half to three quarters of addenda that were eventually published were completed. Therefore, published BPFs are calculated during the initial stages based on a Preliminary Progress Indicator analysis of approved prescriptive and mandatory improvements to the Standard combined with the committee’s estimate of additional savings that may result from changes that have not yet completed the approval process.

Although Appendix G with the stable baseline approach has been in the Standard since 2016, state and incentive program adoption lags behind publication and it is only recently that significant feedback on this approach has been received. Anecdotally and in one published paper (Pillai et al. 2021), users of the Standard have noticed instances where designs compliant with the prescriptive requirements of the Standard were not showing compliance using Appendix G. While this is not unexpected, as Appendix G sets the performance target based not only on prescriptive compliance but on “good design practice” as well, some of the failing designs included that good design practice. It was these observations that inspired this current work to update the approach for calculating BPFs. The updated BPFs presented in this report are meant to address the issues described above, leading to a more accurate assessment of the energy performance of a proposed building design.

The following sections of this report describe the steps in the evolution of the updated BPFs.

1. BPFs as published in Standard 90.1-2019
2. Addition of the final addenda incorporated into Standard 90.1-2019 (Final Progress Indicator)
3. Enhancements and updates to the prototype models
4. Updates to the proposed and baseline prototypes used to calculate the BPFs to follow the modeling rules of Appendix G

3.2 BPFs in the Published Version of Standard 90.1-2019

The BPFs published in Table 4.2.1.1 of Standard 90.1-2019 were calculated as follows:

1. Simulation results of prototypes corresponding to Standard 90.1-2004 were used as *baseline*.
2. Prototype simulations based on the interim set of approved addenda to 90.1-2016 were used as *proposed*. The addenda included in this round are shown in Table 3.
3. A factor of 0.97 was applied to the final BPFs to adjust for the anticipated set of final approved addenda to 90.1-2016. The 0.97 factor was approved by SSPC 90.1 to account for additional addenda that could potentially be included in the final publication of Standard 90.1-2019 and was estimated to achieve an additional 3% reduction in regulated energy cost. These BPFs are shown in Table 4.

Table 3: Addenda Included in Interim Proposed Models⁵

Addenda Captured in January 2019 Interim Progress Indicator Analysis	
g	Occupied Standby Controls
k	Hotel/Motel HVAC Guest Room Controls
ap	SAT Reset
au	DDC VAV Min Damper
be	CRAC Unit Efficiencies
bq	Table 6.8.1.7 Heat Rejection Efficiency

⁵ These addenda are described in detail in Zhang et al. (2021).

Table 4: Published Energy Cost BPF: Table 4.2.1.1, Standard 90.1-2019

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.68	0.70	0.68	0.70	0.66	0.66	0.69	0.68	0.59	0.74	0.76	0.74	0.70	0.73	0.75	0.68	0.71	0.68	0.72
Healthcare/hospital	0.60	0.60	0.60	0.60	0.58	0.54	0.56	0.55	0.55	0.55	0.54	0.54	0.57	0.52	0.54	0.57	0.52	0.57	0.57
Hotel/motel	0.55	0.53	0.55	0.53	0.53	0.52	0.53	0.54	0.54	0.53	0.53	0.52	0.5	0.51	0.51	0.5	0.51	0.50	0.50
Office	0.52	0.57	0.52	0.57	0.50	0.56	0.53	0.56	0.48	0.51	0.52	0.49	0.51	0.51	0.49	0.52	0.51	0.49	0.51
Restaurant	0.63	0.64	0.63	0.64	0.60	0.60	0.60	0.61	0.58	0.62	0.57	0.61	0.63	0.60	0.64	0.65	0.62	0.67	0.70
Retail	0.51	0.54	0.51	0.54	0.49	0.55	0.51	0.55	0.53	0.51	0.55	0.54	0.50	0.54	0.55	0.50	0.51	0.48	0.50
School	0.39	0.47	0.39	0.47	0.38	0.43	0.38	0.42	0.40	0.37	0.40	0.38	0.36	0.40	0.36	0.36	0.37	0.36	0.37
Warehouse	0.38	0.42	0.38	0.42	0.40	0.42	0.43	0.44	0.43	0.44	0.43	0.46	0.49	0.47	0.48	0.54	0.51	0.57	0.57
All others	0.56	0.57	0.56	0.57	0.50	0.52	0.50	0.54	0.53	0.53	0.52	0.54	0.51	0.51	0.50	0.50	0.50	0.50	0.46

3.3 BPF Based on Final Progress Indicator Analysis

The BPFs were recalculated after the final version of the Standard was published. The final version of the Standard includes additional addenda that were not captured in the preliminary analysis. The final set of addenda included in the final version of Standard 90.1-2019 are shown in Table 5. The resulting 90.1-2019 BPF values are shown in Table 6. Table 7 shows the difference between the published BPF values in Table 4 and the final BPF values in Table 6.

Table 5: Addenda Included in Final Proposed Models⁶

Addenda Captured in 2019 Final Progress Indicator Analysis	
a	Outdoor and Return Dampers
g ^(a)	Occupied Standby Controls
h	ERV Sizing Requirements
k ^(a)	Hotel/Motel HVAC Guest Room Controls
v	Heat Recovery Chiller
an	Pump Efficiency
ap ^(a)	SAT Reset
au ^(a)	DDC VAV Min Damper
aw	Fenestration U and SHGC
ay	Residential Energy Recovery
bb	LPD Values Space by Space
bd	Chiller Tables
be ^(a)	CRAC Unit Efficiencies
bo	Table 6.8.1.5 Furnace
bp	Table 6.8.1.6 Boiler
bq	Table 6.8.1.7 Heat Rejection Efficiency
br	Table 6.8.1.13 & 12 Refrigeration
cg	LPD Building Area Method
cm	DDC VAV Min Damper (Exception 1)
cn	Walk-in Cooler/Freezer
co	Normative Reference Updates ^(a)
cw	Continuous Dimming Control ^(a)

(a) Addenda also included in interim analysis.

⁶ These addenda are described in detail in Zhang et al. (2021).

Table 6: Energy Cost BPF Calculated with Final 90.1-2019 Progress Indicator Analysis

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.68	0.71	0.71	0.72	0.71	0.73	0.71	0.74	0.65	0.69	0.76	0.73	0.67	0.73	0.75	0.65	0.68	0.65	0.68
Healthcare/hospital	0.65	0.65	0.64	0.63	0.62	0.58	0.58	0.58	0.58	0.56	0.57	0.56	0.58	0.56	0.59	0.56	0.55	0.57	0.57
Hotel/motel	0.56	0.52	0.54	0.53	0.52	0.53	0.52	0.56	0.53	0.50	0.55	0.52	0.49	0.52	0.52	0.49	0.52	0.48	0.48
Office	0.52	0.59	0.54	0.58	0.52	0.57	0.52	0.58	0.51	0.50	0.54	0.50	0.51	0.53	0.50	0.51	0.53	0.48	0.49
Restaurant	0.59	0.57	0.53	0.54	0.53	0.49	0.51	0.51	0.47	0.49	0.50	0.48	0.50	0.49	0.49	0.53	0.51	0.54	0.58
Retail	0.53	0.54	0.51	0.53	0.47	0.48	0.48	0.50	0.50	0.50	0.52	0.53	0.52	0.52	0.54	0.52	0.53	0.50	0.51
School	0.40	0.46	0.40	0.47	0.39	0.44	0.39	0.42	0.37	0.37	0.39	0.38	0.38	0.39	0.38	0.38	0.38	0.37	0.40
Warehouse	0.43	0.44	0.41	0.42	0.43	0.43	0.44	0.45	0.41	0.47	0.44	0.45	0.51	0.47	0.44	0.57	0.53	0.54	0.55
All others	0.54	0.56	0.56	0.55	0.51	0.51	0.50	0.54	0.55	0.52	0.50	0.56	0.52	0.52	0.53	0.53	0.50	0.50	0.49

Table 7: BPF Difference, Published vs. Final 90.-1-2019 Progress Indicator Analysis⁷

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	(0.00)	(0.01)	(0.03)	(0.02)	(0.05)	(0.07)	(0.02)	(0.06)	(0.06)	0.05	0.00	0.01	0.03	(0.00)	0.00	0.03	0.03	0.03	0.04
Healthcare/hospital	(0.05)	(0.05)	(0.04)	(0.03)	(0.04)	(0.04)	(0.02)	(0.03)	(0.03)	(0.01)	(0.03)	(0.02)	(0.01)	(0.04)	(0.05)	0.01	(0.03)	(0.00)	0.00
Hotel/motel	(0.01)	0.01	0.01	0.00	0.01	(0.01)	0.01	(0.02)	0.01	0.03	(0.02)	(0.00)	0.01	(0.01)	(0.01)	0.01	(0.01)	0.02	0.02
Office	(0.00)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	0.01	(0.02)	(0.03)	0.01	(0.02)	(0.01)	(0.00)	(0.02)	(0.01)	0.01	(0.02)	0.01	0.02
Restaurant ⁸	0.04	0.07	0.10	0.10	0.07	0.11	0.09	0.10	0.11	0.13	0.07	0.13	0.13	0.11	0.15	0.12	0.11	0.13	0.12
Retail	(0.02)	(0.00)	(0.00)	0.01	0.02	0.07	0.03	0.05	0.03	0.01	0.03	0.01	(0.02)	0.02	0.01	(0.02)	(0.02)	(0.02)	(0.01)
School	(0.01)	0.01	(0.01)	0.00	(0.01)	(0.01)	(0.01)	(0.00)	0.03	0.00	0.01	0.00	(0.02)	0.01	(0.02)	(0.02)	(0.01)	(0.01)	(0.03)
Warehouse	(0.05)	(0.02)	(0.03)	(0.00)	(0.03)	(0.01)	(0.01)	(0.01)	0.02	(0.03)	(0.01)	0.01	(0.02)	0.00	0.04	(0.03)	(0.02)	0.03	0.02
All others	0.02	0.01	(0.00)	0.02	(0.01)	0.01	(0.00)	0.00	(0.02)	0.01	0.02	(0.02)	(0.01)	(0.01)	(0.03)	(0.03)	0.00	(0.00)	(0.03)

⁷ Green shade indicates decrease in BPF (increased stringency) and orange shade indicates increase in BPF (decreased stringency)

⁸ Lower BPF in Restaurant Building Area Type due to – addenda bw (lighting power density) and cn (walk-in freezers and coolers) to 90.1-2016; and difference in prototype end-use subcategorization for calculating total regulated energy cost.

3.4 BPF Based on Final Progress Indicator Analysis and Prototype Enhancements

As part of routine prototype infrastructure maintenance efforts, the prototype models are enhanced to accommodate bug fixes, software updates, and improved modeling assumptions, and to expand prototype functionality to support new energy efficiency measure types and applications. Some of the major enhancements made to the prototypes since the Final Progress Indicator Analysis for Standard 90.1-2019 include:

Hospital humidity control: Switched from work-around to new native EnergyPlus capability

Chiller minimum part load ratio (PLR) and unloading ratio consistency

Split three zones served by single packaged single zone (PSZ) system to separate systems in the small hotel prototype

Update to mid-rise apartment outdoor air schedule for energy recovery ventilator operation

Changed outpatient healthcare AHU-2 from electric reheat to hot water reheat

Space condition category: Enhancements to non-res and res envelope classification mapping in the apartment, hotel, and hospital prototypes

Hot water loop: Modification to boiler loop delta T

Infiltration: Modification to infiltration design day schedule

Space types: Reassignment of space types for consistent methodology to determine lighting requirements across code versions. This enhancement was particularly impactful in the Warehouse prototype

Occupancy sensors: Updated occupancy sensor savings to align with Appendix G savings assumptions

Elevator lift motor power updated in several models

These enhancements were applied to all versions of the prototypes. Like previous versions described in Sections 3.2 and 3.3, BPFs recalculated after prototype enhancements are also calculated using prototype models. Prototypes corresponding to Standard 90.1-2004 are used as *baseline*. The proposed version uses the Standard 90.1-2019 models, including all addenda listed in the previous section and the enhancements listed above. Table 8 shows the ASHRAE Standard 90.1-2019 energy cost BPFs that account for the additional prototype enhancements described above. Table 9 shows the difference from the Final Progress Indicator energy cost BPF in Table 6.

Table 8: Energy Cost BPF Calculated after Enhancements to Prototype Models

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.70	0.70	0.72	0.72	0.71	0.72	0.70	0.72	0.66	0.70	0.75	0.73	0.69	0.73	0.74	0.68	0.69	0.67	0.71
Healthcare/hospital	0.65	0.64	0.63	0.64	0.61	0.61	0.60	0.62	0.58	0.59	0.61	0.59	0.60	0.60	0.62	0.60	0.61	0.62	0.63
Hotel/motel	0.57	0.53	0.57	0.54	0.56	0.56	0.56	0.57	0.54	0.56	0.58	0.56	0.55	0.57	0.57	0.55	0.54	0.54	0.55
Office	0.54	0.60	0.54	0.59	0.52	0.59	0.54	0.60	0.51	0.53	0.57	0.52	0.54	0.56	0.53	0.53	0.55	0.51	0.53
Restaurant	0.60	0.58	0.57	0.56	0.55	0.51	0.53	0.53	0.51	0.51	0.52	0.50	0.52	0.53	0.51	0.56	0.55	0.56	0.60
Retail	0.50	0.51	0.49	0.52	0.46	0.45	0.46	0.47	0.49	0.48	0.49	0.52	0.51	0.50	0.53	0.52	0.52	0.49	0.53
School	0.42	0.45	0.43	0.47	0.41	0.45	0.41	0.44	0.39	0.37	0.41	0.37	0.38	0.39	0.37	0.40	0.38	0.39	0.41
Warehouse	0.29	0.30	0.25	0.27	0.25	0.26	0.26	0.25	0.22	0.32	0.26	0.29	0.38	0.30	0.28	0.42	0.37	0.41	0.43
All others	0.57	0.57	0.57	0.56	0.51	0.50	0.50	0.52	0.54	0.53	0.50	0.56	0.52	0.53	0.54	0.54	0.52	0.52	0.51

Table 9: BPF Difference, Final 90.1-2019 Progress Indicator Analysis vs. Enhancements to Prototypes⁹

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	-0.02	0.01	-0.01	0.01	-0.01	0.01	0.01	0.02	-0.01	-0.01	0.01	0.00	-0.02	0.01	0.01	-0.02	-0.01	-0.03	-0.03
Healthcare/hospital	0.00	0.00	0.01	-0.01	0.01	-0.03	-0.02	-0.04	0.00	-0.03	-0.04	-0.02	-0.03	-0.04	-0.03	-0.05	-0.06	-0.05	-0.06
Hotel/motel	-0.01	-0.01	-0.03	-0.02	-0.03	-0.03	-0.04	-0.02	-0.01	-0.05	-0.03	-0.04	-0.06	-0.04	-0.05	-0.06	-0.03	-0.06	-0.06
Office	-0.01	-0.01	0.00	-0.01	0.00	-0.02	-0.02	-0.02	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	-0.02	-0.03	-0.03	-0.03	-0.04
Restaurant	-0.01	-0.01	-0.04	-0.02	-0.02	-0.03	-0.02	-0.02	-0.04	-0.02	-0.02	-0.02	-0.02	-0.04	-0.02	-0.03	-0.04	-0.02	-0.02
Retail	0.03	0.03	0.02	0.02	0.01	0.03	0.02	0.03	0.01	0.02	0.03	0.01	0.01	0.02	0.01	0.00	0.01	0.01	-0.02
School	-0.02	0.01	-0.03	0.00	-0.02	-0.01	-0.02	-0.01	-0.01	0.00	-0.01	0.01	-0.01	-0.01	0.01	-0.01	0.00	-0.01	-0.01
Warehouse ¹⁰	0.14	0.14	0.16	0.15	0.18	0.17	0.18	0.20	0.19	0.16	0.18	0.16	0.13	0.16	0.16	0.15	0.17	0.13	0.12
All others	-0.02	-0.01	-0.01	-0.01	0.00	0.01	0.00	0.02	0.00	0.00	-0.01	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02

⁹ Green shade indicates decrease in BPF (increased stringency) and orange shade indicates increase in BPF (decreased stringency).

¹⁰ Lower BPF in Warehouse Building area type is due to prototype enhancements that resulted in an increase in 90.1-2004 lighting end-use energy.

3.5 BPF Based on Final Progress Indicator Analysis, Prototype Enhancements, and Appendix G Prototypes

Since the introduction of energy cost BPF values in ASHRAE Standard 90.1-2016, the baseline models used for calculating BPFs, described previously, assume that the performance of the 90.1-2004 prototype models is approximately equal to performance of true Appendix G baselines. The 90.1-2004 commercial building prototype models follow several but not all the modeling rules prescribed for the Appendix G baseline building. Hence, this project established a new set of commercial building prototypes that more closely follow the Appendix G baseline building rules. This group of models is referred to as the “Appendix G Baseline” in this report and further described in the Simulation Model Specifications section of this document.

One of the key differences of these models compared to the standard prototypes is that they always have electric space heating systems in warmer climates and natural gas systems in cold climates, following the rules of 90.1 Appendix G for the baseline model. Another key difference is that service hot water systems in the Appendix G baseline use gas or electric resistance heating based on building type, with high hot water using building types (such as multifamily and restaurants) using natural gas while low hot water using types (such as retail and office buildings) use electric resistance. The standard prototypes did not consistently follow this convention. To eliminate the impact of fuel switching on the BPFs, a set of proposed design models, called “Appendix G Proposed,” was created that uses the same fuel source as the corresponding baselines. Key differences between the ASHRAE Standard 90.1-2019 Progress Indicator models (90.1-2019 PI) and the newly created Appendix G proposed models are provided in the Simulation Model Specifications section.

Table 10 shows the updated ASHRAE Standard 90.1-2019 BPF values calculated using the Appendix G Baseline and Appendix G proposed models. Table 11 shows the difference between the enhanced prototype BPF values in Table 8 and the BPFs in Table 10. Similarly, Table 12 shows the difference between the published ASHRAE Standard 90.1-2019 BPF values in Table 4 and the BPF values in Table 10.

The prototypes used to calculate final BPFs using this new methodology for 2019 and other editions of the Standard (as described in Section 4) are publicly available¹¹.

¹¹ <https://www.energycodes.gov/prototype-building-models>

Table 10: Final Energy Cost BPFs Calculated Using Appendix G Prototypes Using Appendix G PRM

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.73	0.67	0.71	0.68	0.71	0.67	0.69	0.68	0.59	0.69	0.69	0.67	0.68	0.68	0.68	0.69	0.68	0.69	0.75
Healthcare/hospital	0.73	0.73	0.73	0.74	0.74	0.72	0.72	0.74	0.71	0.72	0.73	0.71	0.74	0.73	0.77	0.73	0.76	0.76	0.77
Hotel/motel	0.71	0.69	0.71	0.69	0.70	0.68	0.69	0.71	0.69	0.69	0.70	0.70	0.69	0.70	0.70	0.68	0.69	0.68	0.68
Office	0.62	0.63	0.61	0.62	0.58	0.60	0.57	0.61	0.55	0.56	0.61	0.57	0.58	0.60	0.58	0.57	0.59	0.55	0.58
Restaurant	0.65	0.61	0.62	0.60	0.60	0.57	0.61	0.60	0.59	0.62	0.61	0.61	0.65	0.64	0.63	0.68	0.66	0.69	0.73
Retail	0.57	0.54	0.53	0.53	0.48	0.47	0.47	0.46	0.47	0.49	0.48	0.52	0.52	0.49	0.54	0.52	0.51	0.49	0.54
School	0.57	0.57	0.57	0.57	0.55	0.53	0.57	0.50	0.48	0.48	0.50	0.49	0.50	0.51	0.49	0.52	0.49	0.50	0.55
Warehouse	0.28	0.30	0.24	0.27	0.23	0.24	0.27	0.23	0.20	0.28	0.24	0.25	0.33	0.28	0.26	0.37	0.32	0.34	0.38
All others	0.64	0.62	0.63	0.61	0.57	0.53	0.56	0.54	0.56	0.57	0.55	0.58	0.57	0.56	0.61	0.59	0.59	0.59	0.61

Table 11: BPF Difference, Enhancements to Prototypes vs. Appendix G PRM¹²

Building	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	-0.03	0.03	0.01	0.04	0.01	0.04	0.02	0.04	0.07	0.01	0.06	0.05	0.00	0.04	0.06	-0.02	0.01	-0.01	-0.04
Healthcare/hospital	-0.08	-0.09	-0.10	-0.10	-0.13	-0.11	-0.12	-0.12	-0.13	-0.12	-0.13	-0.12	-0.14	-0.13	-0.15	-0.13	-0.15	-0.14	-0.14
Hotel/motel	-0.14	-0.17	-0.14	-0.15	-0.14	-0.11	-0.13	-0.13	-0.15	-0.13	-0.12	-0.13	-0.14	-0.13	-0.13	-0.13	-0.15	-0.13	-0.13
Office	-0.09	-0.03	-0.07	-0.02	-0.05	-0.01	-0.03	-0.02	-0.04	-0.03	-0.04	-0.05	-0.04	-0.04	-0.05	-0.04	-0.04	-0.04	-0.05
Restaurant	-0.04	-0.03	-0.05	-0.04	-0.05	-0.05	-0.08	-0.07	-0.08	-0.12	-0.09	-0.11	-0.13	-0.11	-0.13	-0.11	-0.11	-0.13	-0.13
Retail	-0.07	-0.03	-0.04	-0.01	-0.02	-0.02	-0.01	0.01	0.02	0.00	0.01	0.00	-0.01	0.01	-0.01	0.00	0.02	0.00	-0.02
School	-0.15	-0.12	-0.15	-0.10	-0.13	-0.08	-0.15	-0.06	-0.09	-0.11	-0.09	-0.11	-0.12	-0.11	-0.12	-0.12	-0.11	-0.12	-0.15
Warehouse	0.01	0.01	0.01	0.00	0.01	0.02	0.00	0.02	0.02	0.04	0.03	0.04	0.05	0.03	0.03	0.05	0.05	0.07	0.05
All others	-0.07	-0.05	-0.07	-0.05	-0.06	-0.03	-0.06	-0.02	-0.02	-0.04	-0.05	-0.02	-0.05	-0.04	-0.07	-0.05	-0.08	-0.07	-0.10

¹² Green shade indicates decrease in BPF (increased stringency) and red shade indicates increase in BPF (decreased stringency).

Table 12: BPF Difference, Published vs. Appendix G PRM¹³

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	-0.05	0.03	-0.03	0.02	-0.05	-0.01	0.00	0.00	0.00	0.05	0.07	0.07	0.02	0.05	0.07	-0.01	0.03	-0.01	-0.03
Healthcare/hospital	-0.13	-0.13	-0.13	-0.14	-0.16	-0.18	-0.16	-0.19	-0.16	-0.17	-0.19	-0.17	-0.17	-0.21	-0.23	-0.16	-0.24	-0.19	-0.20
Hotel/motel	-0.16	-0.16	-0.16	-0.16	-0.17	-0.16	-0.16	-0.17	-0.15	-0.16	-0.17	-0.18	-0.19	-0.19	-0.19	-0.18	-0.18	-0.18	-0.18
Office	-0.10	-0.06	-0.09	-0.05	-0.08	-0.04	-0.04	-0.05	-0.07	-0.05	-0.09	-0.08	-0.07	-0.09	-0.09	-0.05	-0.08	-0.06	-0.07
Restaurant	-0.02	0.03	0.01	0.04	0.00	0.03	-0.01	0.01	-0.01	0.00	-0.04	0.00	-0.02	-0.04	0.01	-0.03	-0.04	-0.02	-0.03
Retail	-0.06	0.00	-0.02	0.01	0.01	0.08	0.04	0.09	0.06	0.02	0.07	0.02	-0.02	0.05	0.01	-0.02	0.00	-0.01	-0.04
School	-0.18	-0.10	-0.18	-0.10	-0.17	-0.10	-0.19	-0.08	-0.08	-0.11	-0.10	-0.11	-0.14	-0.11	-0.13	-0.16	-0.12	-0.14	-0.18
Warehouse	0.10	0.12	0.14	0.15	0.17	0.18	0.16	0.21	0.23	0.16	0.19	0.21	0.16	0.19	0.22	0.17	0.19	0.23	0.19
All others	-0.08	-0.05	-0.07	-0.04	-0.07	-0.01	-0.06	0.00	-0.03	-0.04	-0.03	-0.04	-0.06	-0.05	-0.11	-0.09	-0.09	-0.09	-0.15

¹³ Green shade indicates decrease in BPF (increased stringency) and orange shade indicates increase in BPF (decreased stringency).

4.0 Building Performance Factors for Other Editions of ASHRAE Standard 90.1

This section of the report summarizes additional analysis to look at the impact of using the new Appendix G proposed and Appendix G baseline models to re-calculate the ASHRAE Standard 90.1-2016 and estimate ASHRAE 90.1-2022 BPF values based on Interim Progress Indicator Analysis. The analysis followed a similar methodology to that described in Section 3.0 for ASHRAE Standard 90.1-2019.

4.1 BPF 90.1-2016

BPF values for ASHRAE Standard 90.1-2016 were developed following a similar a process as the one used to develop BPFs for ASHRAE Standard 90.1-2019. The results are summarized in Table 13 through Table 20 as follows:

- Table 13 – Published energy cost BPF values based on Interim Progress Indicator
- Table 14 – Energy cost BPF values based on Final Progress Indicator (all addenda to 90.1-2013)
- Table 15 – Difference in BPF values between Interim Progress Indicator and Final Progress Indicator
- Table 16 – Energy cost BPF values based on prototype enhancements
- Table 17 – Difference in energy cost BPF values between Final Progress Indicator and prototype enhancements
- Table 18 – Final energy cost BPF values based on Appendix G proposed and Appendix G baseline models
- Table 19 – Difference in energy cost BPF values between final energy cost BPF and prototype enhancements
- Table 20 – Difference in energy cost BPF values between published BPF and final energy cost BPF

4.2 BPF 90.1-2022

BPF values published in ASHRAE Standard 90.1-2022 are calculated based on simulation results from Interim Progress Indicator. These values are developed using the new methodology based on Appendix G proposed and Appendix G baseline models. The calculated 90.1-2022 energy cost BPF is summarized in Table 21.

In addition to the energy cost BPF, Appendix I of ASHRAE Standard 90.1-2022 has BPFs for site energy, carbon Emissions, and source energy as shown in Table 22, Table 23, and Table 24, respectively. Section 6.0 of this report describes the BPF calculation process introduced in ASHRAE Standard 90.1-2022 that allows BPF adjustment based on localized conversion factors.

4.3 BPF Calculator

ASHRAE Standard 90.1-2022 includes Informative Appendix I which supports jurisdictions and beyond code programs that choose to use Appendix G compliance metrics other than energy cost. The appendix includes BPF tables based on site energy, source energy, and carbon emissions to replace the cost-based BPF values currently used. These alternate BPF values are calculated using national average conversion values similar to the current national average energy costs used for electricity and natural gas. The appendix also includes a methodology for calculating custom BPFs for jurisdictions and beyond code programs that choose to use local energy conversion factors for the selected metric in lieu of default values included in the appendix. That methodology is described in Section 6.0 of this report.

PNNL has developed a simple Excel-based calculator¹⁴ that will allow jurisdictions and users of Appendix G to directly calculate BPFs analogous to those published in Standards 90.1-2016, 2019, and 2022 for site energy as well as energy cost, source energy, and emissions using any jurisdiction-specific conversion factors, following the approach described in Informative Appendix I. In addition to calculating the BPFs analogous to those published in the various editions of the standard, the tool also calculates alternative BPFs using the updated approach based on the Final Progress Indicator results and Appendix G Baseline methodology described in Section 3.0. The intent is that a jurisdiction or rating authority may choose to adopt BPFs using the updated approach, as the authors believe these to be more technically sound.

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https://www.energycodes.gov/sites/default/files/2024-06/AppendixG_coeff_bpf_June_2024_Final.xlsx

Table 13: Published Energy Cost BPFs: Standard 90.1-2016

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.73	0.73	0.73	0.73	0.71	0.69	0.74	0.73	0.68	0.78	0.81	0.81	0.76	0.80	0.81	0.76	0.79	0.74	0.80
Healthcare/hospital	0.64	0.56	0.64	0.56	0.60	0.56	0.60	0.56	0.54	0.57	0.53	0.55	0.59	0.52	0.55	0.57	0.52	0.56	0.56
Hotel/motel	0.64	0.65	0.64	0.65	0.62	0.60	0.63	0.65	0.64	0.62	0.64	0.62	0.60	0.61	0.60	0.59	0.61	0.57	0.58
Office	0.58	0.62	0.58	0.62	0.57	0.62	0.60	0.64	0.54	0.58	0.60	0.58	0.60	0.61	0.58	0.61	0.61	0.57	0.61
Restaurant	0.62	0.62	0.62	0.62	0.58	0.61	0.60	0.60	0.61	0.58	0.55	0.60	0.62	0.58	0.60	0.63	0.60	0.65	0.68
Retail	0.52	0.58	0.52	0.58	0.53	0.58	0.54	0.62	0.60	0.55	0.60	0.60	0.55	0.59	0.61	0.55	0.58	0.53	0.53
School	0.46	0.53	0.46	0.53	0.47	0.53	0.49	0.52	0.50	0.49	0.50	0.49	0.50	0.50	0.50	0.49	0.50	0.47	0.51
Warehouse	0.51	0.52	0.51	0.52	0.56	0.58	0.57	0.59	0.63	0.58	0.60	0.63	0.60	0.61	0.65	0.66	0.66	0.67	0.67
All others	0.62	0.61	0.62	0.61	0.55	0.57	0.56	0.61	0.59	0.58	0.57	0.61	0.57	0.57	0.61	0.56	0.56	0.53	0.52

Table 14: Energy Cost BPFs: Standard 90.1-2016; Calculated Using Final 90.1-2016 Progress Indicator Analysis

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.73	0.76	0.73	0.76	0.72	0.71	0.75	0.78	0.65	0.79	0.81	0.80	0.81	0.78	0.74	0.72	0.76	0.72	0.76
Healthcare/hospital	0.63	0.63	0.63	0.63	0.61	0.56	0.60	0.57	0.58	0.58	0.56	0.56	0.56	0.55	0.60	0.59	0.54	0.59	0.59
Hotel/motel	0.63	0.60	0.63	0.60	0.61	0.61	0.63	0.63	0.64	0.60	0.62	0.61	0.60	0.58	0.57	0.57	0.58	0.55	0.55
Office	0.57	0.61	0.57	0.61	0.55	0.60	0.58	0.62	0.54	0.55	0.58	0.55	0.55	0.57	0.56	0.56	0.57	0.53	0.56
Restaurant	0.64	0.65	0.64	0.65	0.60	0.61	0.61	0.62	0.58	0.63	0.58	0.62	0.66	0.61	0.65	0.67	0.64	0.69	0.72
Retail	0.55	0.58	0.55	0.58	0.53	0.59	0.55	0.60	0.59	0.55	0.59	0.58	0.59	0.58	0.54	0.53	0.55	0.52	0.53
School	0.41	0.49	0.41	0.49	0.39	0.45	0.40	0.44	0.42	0.39	0.42	0.40	0.38	0.42	0.38	0.38	0.38	0.37	0.38
Warehouse	0.40	0.44	0.40	0.44	0.42	0.44	0.45	0.46	0.45	0.46	0.45	0.49	0.51	0.50	0.52	0.57	0.54	0.60	0.60
All others	0.60	0.61	0.60	0.61	0.53	0.56	0.54	0.59	0.57	0.56	0.55	0.58	0.54	0.55	0.55	0.54	0.54	0.53	0.50

Table 15: BPF Difference, Published vs. Final 90.-1-2016 Progress Indicator Analysis¹⁵

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.00	(0.03)	0.00	(0.03)	(0.02)	(0.01)	(0.05)	0.03	(0.00)	(0.00)	0.01	(0.01)	0.02	(0.05)	0.06	0.03	0.04	0.02	0.04
Healthcare/hospital	0.01	(0.07)	0.01	(0.07)	(0.01)	(0.00)	(0.01)	(0.04)	0.00	(0.04)	(0.01)	(0.01)	(0.03)	0.02	(0.04)	(0.02)	(0.02)	(0.03)	(0.02)
Hotel/motel	0.00	0.05	0.00	0.05	(0.00)	0.00	0.02	(0.00)	0.01	0.02	0.01	0.02	0.03	(0.00)	0.03	0.02	0.02	0.01	0.03
Office	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.00	0.02	0.02	0.04	0.03	0.04	0.05	0.02	0.04	0.05	0.04	0.05
Restaurant	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	0.03	(0.02)	(0.03)	(0.02)	(0.05)	(0.03)	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)
Retail	(0.03)	(0.01)	(0.03)	(0.01)	(0.01)	0.01	0.02	0.02	(0.00)	0.01	0.02	0.01	0.01	(0.04)	0.07	0.02	0.02	0.01	(0.01)
School	0.06	0.04	0.06	0.04	0.09	0.07	0.07	0.08	0.09	0.07	0.09	0.11	0.07	0.12	0.12	0.12	0.12	0.10	0.12
Warehouse	0.11	0.08	0.11	0.08	0.14	0.13	0.13	0.18	0.12	0.15	0.14	0.12	0.11	0.10	0.13	0.12	0.09	0.07	0.07
All others	0.02	0.00	0.02	0.00	0.02	0.02	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.03	0.06	0.02	0.02	0.00	0.02

Table 16: Energy Cost BPFs Calculated after Enhancements to Prototype Models

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.76	0.75	0.76	0.77	0.75	0.74	0.75	0.75	0.69	0.76	0.78	0.77	0.75	0.77	0.78	0.74	0.75	0.75	0.79
Healthcare/hospital	0.68	0.67	0.66	0.68	0.65	0.64	0.64	0.65	0.62	0.63	0.64	0.63	0.64	0.63	0.64	0.64	0.63	0.64	0.65
Hotel/motel	0.62	0.57	0.62	0.59	0.62	0.62	0.62	0.63	0.60	0.60	0.64	0.62	0.60	0.62	0.63	0.60	0.59	0.60	0.61
Office	0.57	0.65	0.59	0.65	0.57	0.65	0.60	0.65	0.57	0.58	0.62	0.58	0.59	0.61	0.58	0.58	0.60	0.56	0.58
Restaurant	0.65	0.63	0.62	0.61	0.60	0.56	0.58	0.58	0.58	0.56	0.57	0.56	0.57	0.58	0.56	0.62	0.60	0.62	0.64
Retail	0.53	0.54	0.52	0.55	0.50	0.48	0.50	0.51	0.54	0.52	0.52	0.56	0.54	0.53	0.57	0.55	0.55	0.51	0.55
School	0.45	0.48	0.47	0.51	0.46	0.49	0.47	0.48	0.44	0.42	0.45	0.43	0.43	0.44	0.43	0.44	0.43	0.43	0.46
Warehouse	0.30	0.31	0.26	0.29	0.26	0.27	0.27	0.26	0.24	0.33	0.28	0.30	0.38	0.31	0.29	0.42	0.37	0.42	0.43
All others	0.61	0.61	0.61	0.61	0.55	0.54	0.54	0.56	0.59	0.57	0.54	0.60	0.56	0.57	0.58	0.59	0.56	0.56	0.54

¹⁵Green shade indicates decrease in BPF (increased stringency) and orange shade indicates increase in BPF (decreased stringency).

Table 17: BPF Difference, Final 90.-1-2016 Progress Indicator Analysis vs. Enhancements to Prototypes¹⁶

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	-0.03	0.01	-0.03	-0.01	-0.03	-0.03	0.00	0.03	-0.04	0.03	0.03	0.03	0.06	0.01	-0.04	-0.02	0.01	-0.03	-0.03
Healthcare/hospital	-0.05	-0.04	-0.03	-0.05	-0.04	-0.08	-0.04	-0.08	-0.04	-0.05	-0.08	-0.07	-0.08	-0.08	-0.04	-0.05	-0.09	-0.05	-0.06
Hotel/motel	0.01	0.03	0.01	0.01	-0.01	-0.01	0.01	0.00	0.04	0.00	-0.02	-0.01	0.00	-0.04	-0.06	-0.03	-0.01	-0.05	-0.06
Office	0.00	-0.04	-0.02	-0.04	-0.02	-0.05	-0.02	-0.03	-0.03	-0.03	-0.04	-0.03	-0.04	-0.04	-0.02	-0.02	-0.03	-0.03	-0.02
Restaurant	-0.01	0.02	0.02	0.04	0.00	0.05	0.03	0.04	0.00	0.07	0.01	0.06	0.09	0.03	0.09	0.05	0.04	0.07	0.08
Retail	0.02	0.04	0.03	0.03	0.03	0.11	0.05	0.09	0.05	0.03	0.07	0.02	0.05	0.05	-0.03	-0.02	0.00	0.01	-0.02
School	-0.04	0.01	-0.06	-0.02	-0.07	-0.04	-0.07	-0.04	-0.02	-0.03	-0.03	-0.03	-0.05	-0.02	-0.05	-0.06	-0.05	-0.06	-0.08
Warehouse ¹⁷	0.10	0.13	0.14	0.15	0.16	0.17	0.18	0.20	0.21	0.13	0.17	0.19	0.13	0.19	0.23	0.15	0.17	0.18	0.17
All others	-0.01	0.00	-0.01	0.00	-0.02	0.02	0.00	0.03	-0.02	-0.01	0.01	-0.02	-0.02	-0.02	-0.03	-0.05	-0.02	-0.03	-0.04

Table 18: Final Energy Cost BPFs Standard 90.1-2016 Calculated Using Appendix G Prototypes Using Appendix G PRM

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.80	0.73	0.77	0.74	0.75	0.71	0.76	0.72	0.63	0.77	0.73	0.73	0.78	0.75	0.75	0.78	0.76	0.79	0.87
Healthcare/hospital	0.78	0.78	0.80	0.80	0.80	0.78	0.81	0.80	0.79	0.79	0.79	0.79	0.81	0.78	0.80	0.79	0.78	0.79	0.80
Hotel/motel	0.78	0.75	0.78	0.75	0.78	0.76	0.79	0.78	0.78	0.75	0.77	0.78	0.76	0.76	0.78	0.75	0.76	0.76	0.77
Office	0.67	0.68	0.67	0.68	0.63	0.66	0.63	0.67	0.61	0.61	0.66	0.63	0.64	0.66	0.64	0.62	0.64	0.61	0.64
Restaurant	0.69	0.65	0.68	0.65	0.66	0.62	0.66	0.66	0.67	0.69	0.67	0.68	0.72	0.70	0.70	0.74	0.72	0.76	0.77
Retail	0.58	0.57	0.56	0.56	0.52	0.51	0.51	0.50	0.52	0.52	0.51	0.57	0.55	0.52	0.58	0.55	0.53	0.52	0.57
School	0.61	0.61	0.63	0.61	0.61	0.59	0.65	0.55	0.54	0.54	0.55	0.56	0.57	0.56	0.57	0.57	0.55	0.56	0.62
Warehouse	0.29	0.31	0.26	0.28	0.25	0.26	0.28	0.24	0.22	0.30	0.25	0.27	0.35	0.29	0.27	0.38	0.33	0.35	0.39
All others	0.69	0.66	0.68	0.66	0.62	0.58	0.62	0.59	0.62	0.63	0.60	0.64	0.63	0.61	0.66	0.65	0.64	0.64	0.65

¹⁶ Green shade indicates decrease in BPF (increased stringency) and orange shade indicates increase in BPF (decreased stringency).

¹⁷ Lower BPF in Warehouse Building area type is due to prototype enhancements that resulted in an increase in 90.1-2004 lighting end-use energy.

Table 19: BPF Difference, Enhancements to Prototypes vs. Appendix G PRM¹⁸

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5Q	5B	5C	6A	6B	7	8
Multifamily	-0.04	0.02	0.00	0.03	0.00	0.04	-0.01	0.03	0.06	-0.02	0.05	0.04	-0.03	0.02	0.03	-0.04	-0.01	-0.04	-0.08
Healthcare/hospital	-0.11	-0.11	-0.14	-0.12	-0.15	-0.14	-0.16	-0.15	-0.17	-0.15	-0.15	-0.16	-0.17	-0.15	-0.16	-0.15	-0.15	-0.15	-0.15
Hotel/motel	-0.16	-0.18	-0.16	-0.16	-0.16	-0.13	-0.17	-0.15	-0.17	-0.15	-0.14	-0.16	-0.16	-0.15	-0.15	-0.16	-0.17	-0.16	-0.17
Office	-0.10	-0.03	-0.08	-0.03	-0.06	-0.01	-0.04	-0.02	-0.04	-0.03	-0.04	-0.05	-0.05	-0.05	-0.05	-0.04	-0.04	-0.04	-0.06
Restaurant	-0.04	-0.03	-0.06	-0.04	-0.06	-0.06	-0.08	-0.08	-0.09	-0.13	-0.10	-0.13	-0.15	-0.12	-0.14	-0.13	-0.12	-0.14	-0.14
Retail	-0.05	-0.03	-0.04	-0.01	-0.02	-0.02	-0.01	0.00	0.02	-0.01	0.01	0.00	-0.02	0.01	-0.02	-0.01	0.01	0.00	-0.02
School	-0.16	-0.13	-0.16	-0.11	-0.15	-0.09	-0.18	-0.07	-0.10	-0.12	-0.10	-0.13	-0.13	-0.12	-0.14	-0.13	-0.12	-0.13	-0.16
Warehouse	0.01	0.00	0.01	0.00	0.01	0.02	0.00	0.02	0.02	0.03	0.03	0.03	0.04	0.02	0.02	0.05	0.04	0.06	0.04
All others	-0.08	-0.06	-0.08	-0.06	-0.07	-0.04	-0.07	-0.03	-0.03	-0.05	-0.06	-0.04	-0.07	-0.05	-0.08	-0.06	-0.09	-0.08	-0.11

Table 20: BPF Difference, Published vs. Appendix G PRM¹

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	-0.07	0.00	-0.04	-0.01	-0.04	-0.02	-0.02	0.01	0.05	0.01	0.08	0.08	-0.02	0.05	0.06	-0.02	0.03	-0.05	-0.07
Healthcare/hospital	-0.14	-0.22	-0.16	-0.24	-0.20	-0.22	-0.21	-0.24	-0.25	-0.22	-0.26	-0.24	-0.22	-0.26	-0.25	-0.22	-0.26	-0.23	-0.24
Hotel/motel	-0.14	-0.10	-0.14	-0.10	-0.16	-0.16	-0.16	-0.13	-0.14	-0.13	-0.13	-0.16	-0.16	-0.15	-0.18	-0.16	-0.15	-0.19	-0.19
Office	-0.09	-0.06	-0.09	-0.06	-0.06	-0.04	-0.03	-0.03	-0.07	-0.03	-0.06	-0.05	-0.04	-0.05	-0.06	-0.01	-0.03	-0.04	-0.03
Restaurant	-0.07	-0.03	-0.06	-0.03	-0.08	-0.01	-0.06	-0.06	-0.06	-0.11	-0.12	-0.08	-0.10	-0.12	-0.10	-0.11	-0.12	-0.11	-0.09
Retail	-0.06	0.01	-0.04	0.02	0.01	0.07	0.03	0.12	0.08	0.03	0.09	0.03	0.00	0.07	0.03	0.00	0.05	0.01	-0.04
School	-0.15	-0.08	-0.17	-0.08	-0.14	-0.06	-0.16	-0.03	-0.04	-0.05	-0.05	-0.07	-0.07	-0.06	-0.07	-0.08	-0.05	-0.09	-0.11
Warehouse	0.22	0.21	0.25	0.24	0.31	0.32	0.29	0.35	0.41	0.28	0.35	0.36	0.25	0.32	0.38	0.28	0.33	0.32	0.28
All others	-0.07	-0.05	-0.06	-0.05	-0.07	-0.01	-0.06	0.02	-0.03	-0.05	-0.03	-0.03	-0.06	-0.04	-0.05	-0.09	-0.08	-0.11	-0.13

¹⁸ Green shade indicates decrease in BPF (increased stringency) and red shade indicates increase in BPF (decreased stringency).

Table 21: Energy Cost BPF 90.1-2022 (Published)

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.69	0.68	0.71	0.70	0.72	0.72	0.71	0.76	0.63	0.69	0.76	0.71	0.66	0.72	0.71	0.65	0.67	0.65	0.67
Healthcare/hospital	0.69	0.69	0.70	0.68	0.67	0.65	0.65	0.66	0.64	0.64	0.66	0.63	0.67	0.65	0.65	0.66	0.67	0.68	0.70
Hotel/motel	0.66	0.66	0.69	0.65	0.65	0.64	0.64	0.66	0.65	0.63	0.65	0.63	0.62	0.63	0.62	0.61	0.62	0.59	0.58
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.51	0.54	0.48	0.48	0.53	0.48	0.49	0.52	0.48	0.48	0.49	0.46	0.48
Restaurant	0.62	0.59	0.57	0.57	0.57	0.53	0.57	0.53	0.51	0.55	0.54	0.54	0.57	0.56	0.55	0.59	0.58	0.61	0.64
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.43	0.44	0.42	0.43	0.46	0.43	0.42	0.47	0.43	0.43	0.41	0.44
School	0.52	0.57	0.57	0.56	0.52	0.53	0.52	0.49	0.50	0.46	0.47	0.47	0.47	0.46	0.46	0.46	0.44	0.45	0.45
Warehouse	0.26	0.26	0.22	0.25	0.21	0.22	0.25	0.21	0.19	0.25	0.22	0.22	0.28	0.24	0.22	0.31	0.28	0.29	0.32
All others	0.62	0.60	0.62	0.59	0.55	0.51	0.53	0.52	0.55	0.53	0.52	0.55	0.53	0.53	0.56	0.54	0.54	0.54	0.54

Table 22: Site BPF 90.1-2022 (Published)

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.72	0.71	0.75	0.73	0.76	0.76	0.77	0.75	0.70	0.61	0.71	0.64	0.56	0.63	0.63	0.54	0.57	0.54	0.56
Healthcare/hospital	0.67	0.66	0.68	0.65	0.65	0.61	0.62	0.64	0.63	0.62	0.63	0.61	0.65	0.63	0.68	0.64	0.68	0.69	0.71
Hotel/motel	0.69	0.69	0.72	0.68	0.69	0.68	0.69	0.70	0.71	0.65	0.69	0.68	0.63	0.66	0.67	0.60	0.64	0.59	0.58
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.50	0.54	0.47	0.47	0.52	0.48	0.49	0.52	0.49	0.48	0.50	0.43	0.46
Restaurant	0.64	0.61	0.60	0.59	0.60	0.57	0.61	0.62	0.61	0.66	0.65	0.66	0.69	0.69	0.68	0.71	0.71	0.72	0.74
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.44	0.44	0.47	0.45	0.50	0.52	0.47	0.52	0.52	0.50	0.48	0.49
School	0.52	0.57	0.57	0.56	0.52	0.53	0.53	0.52	0.55	0.42	0.49	0.53	0.44	0.50	0.51	0.43	0.42	0.42	0.44
Warehouse	0.26	0.26	0.22	0.25	0.21	0.22	0.25	0.21	0.18	0.38	0.27	0.31	0.46	0.37	0.31	0.49	0.42	0.43	0.47
All others	0.63	0.62	0.65	0.61	0.56	0.53	0.55	0.55	0.59	0.55	0.55	0.58	0.57	0.57	0.61	0.57	0.57	0.56	0.58

Table 23: Carbon Emission BPF 90.1-2022 (Published)

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.71	0.69	0.73	0.71	0.74	0.74	0.74	0.75	0.67	0.64	0.73	0.67	0.60	0.67	0.66	0.59	0.61	0.58	0.60
Healthcare/hospital	0.68	0.67	0.69	0.67	0.66	0.63	0.64	0.65	0.63	0.63	0.65	0.62	0.66	0.64	0.67	0.65	0.67	0.69	0.70
Hotel/motel	0.67	0.67	0.70	0.66	0.67	0.66	0.66	0.68	0.68	0.64	0.67	0.65	0.63	0.65	0.65	0.61	0.63	0.59	0.58
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.50	0.54	0.48	0.47	0.52	0.48	0.49	0.52	0.49	0.48	0.50	0.45	0.47
Restaurant	0.63	0.60	0.59	0.58	0.58	0.55	0.59	0.58	0.56	0.61	0.60	0.60	0.64	0.63	0.62	0.66	0.66	0.68	0.70
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.43	0.44	0.44	0.44	0.48	0.47	0.45	0.49	0.47	0.46	0.45	0.47
School	0.52	0.57	0.57	0.56	0.52	0.53	0.53	0.51	0.52	0.44	0.48	0.50	0.45	0.48	0.48	0.45	0.43	0.43	0.45
Warehouse	0.26	0.26	0.22	0.25	0.21	0.22	0.25	0.21	0.18	0.31	0.24	0.27	0.38	0.31	0.26	0.41	0.36	0.37	0.41
All others	0.63	0.61	0.63	0.60	0.55	0.52	0.54	0.54	0.57	0.54	0.53	0.56	0.55	0.55	0.58	0.56	0.56	0.55	0.56

Table 24: Source BPF 90.1-2022 (Published)

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.70	0.69	0.72	0.71	0.73	0.73	0.73	0.75	0.65	0.66	0.74	0.69	0.63	0.69	0.68	0.61	0.63	0.60	0.63
Healthcare/hospital	0.69	0.68	0.70	0.67	0.66	0.64	0.64	0.66	0.64	0.64	0.65	0.63	0.66	0.64	0.66	0.66	0.67	0.68	0.70
Hotel/motel	0.66	0.67	0.70	0.66	0.66	0.65	0.65	0.67	0.66	0.63	0.66	0.64	0.62	0.64	0.64	0.61	0.62	0.59	0.58
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.50	0.54	0.48	0.47	0.53	0.48	0.49	0.52	0.49	0.48	0.50	0.45	0.47
Restaurant	0.63	0.59	0.58	0.57	0.58	0.54	0.58	0.56	0.54	0.59	0.57	0.57	0.61	0.60	0.59	0.64	0.62	0.65	0.68
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.43	0.44	0.43	0.43	0.47	0.45	0.43	0.48	0.45	0.45	0.43	0.45
School	0.52	0.57	0.57	0.56	0.52	0.53	0.53	0.50	0.51	0.44	0.47	0.49	0.46	0.47	0.47	0.45	0.43	0.44	0.45
Warehouse	0.26	0.26	0.22	0.25	0.21	0.22	0.25	0.21	0.18	0.28	0.23	0.25	0.34	0.28	0.25	0.37	0.32	0.34	0.37
All others	0.62	0.61	0.63	0.60	0.55	0.52	0.54	0.53	0.56	0.54	0.53	0.56	0.54	0.54	0.57	0.55	0.55	0.55	0.56

5.0 Simulation Model Specifications

This section describes the methodology used to develop Appendix G proposed and Appendix G baseline models following the requirements of ANSI/ASHRAE/IES 90.1-2019. Since the introduction of energy cost BPF values in ASHRAE Standard 90.1-2016, the baseline models used for calculating BPFs, described previously, assume that the performance of the 90.1-2004 prototype models is approximately equal to performance of true Appendix G baselines. However, the 90.1-2004 commercial building prototype models follow many but not all the modeling rules prescribed for the Appendix G baseline building. Hence, this project established a new set of commercial building prototypes that more closely follow the Appendix G PRM baseline.

Section 5.1 covers the general simulation requirements of 90.1-2019 Section G2. Sections 5.4 through 5.11 cover modeling methodology for calculating *proposed* and *baseline* building performance in accordance with 90.1-2019 Section G3. Each subsection begins with a list of applicable Appendix G requirements, followed by a description of how the rules were applied to model parameters, and finally a list of prototype buildings to which the rules apply is presented. If the rules result in differences in modeled inputs between the *90.1-2019 Progress Indicator*, *proposed*, and *baseline* models, the differences and their impacts on the models are discussed. Additional details regarding model inputs are provided in Appendix A, Appendix B, and Appendix C of this report for envelope, lighting, and HVAC, respectively.

The following abbreviations are used to describe the different sets of energy models in Section 5.1 through Section 5.11:

90.1-2019 PI – Final ASHRAE Standard 90.1-2019 Progress Indicator energy models

Proposed – 90.1-2019 Appendix G proposed energy models

Baseline – 90.1-2019 Appendix G baseline energy models

The commercial prototype building energy models used in the Progress Indicator Analysis for ANSI/ASHRAE/IES Standard 90.1-2019 (Zhang et al. 2021) were used as the starting point. These models are publicly available for download at <https://www.energycodes.gov/>. As part of continued maintenance, several enhancements were made to the prototypes after the Progress Indicator Analysis was published; notable enhancements are listed in Section 3.0 of this document.

The Appendix G rules were then applied to these enhanced prototypes to develop the *baseline* models. Following 90.1 Table G3.1.1-3, the baseline design must be modeled with electric space heating in warmer climates and natural gas space heating in cold climates. Similarly, Table G3.1.1.2 prescribes that baseline SWH fuel-type buildings with high SWH loads must be modeled with natural gas water heaters and those with lower loads must be modeled with electric resistance water heaters. To avoid having different space or SWH fuels in the baseline compared to the proposed model, the proposed models were modified to have the same space and SWH fuel source as prescribed for the baseline. The ASHRAE SSPC 90.1 agreed with this change as both the prototype models and the Appendix G models are meant to represent standard practice

with regard to fuel choice. Their recommendation is to make this change to the prototype models for all future Standard 90.1 analyses.

5.1 General Simulation Information

90.1-2019 Appendix G rules covered under this section:

Table G2.1 Performance Calculations

Table G2.2 Simulation Program

Table G2.3 Climatic Data

The *proposed* and *baseline* simulation models use EnergyPlus™ (DOE 2021) v9.1. The simulations use the Typical Meteorological Year 3 (TMY3) weather files corresponding to each of the ASHRAE climate zones, shown in Figure 2, using the representative locations listed in Table 25.

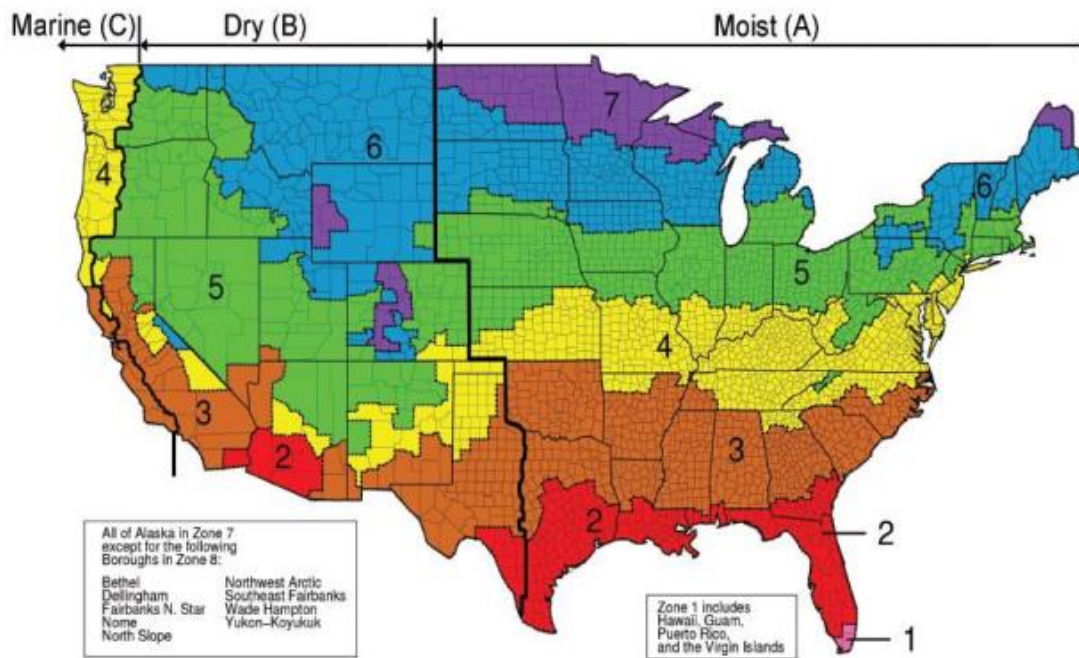


Figure 2: United States Climate Zone Map and Representative Cities

Table 25: Weather File Location by Climate Zone

Climate Zone	Weather File Location	Climate Type
0A	Ho Chi Minh City, Vietnam	Extremely hot, humid
0B	Dubai, United Arab Emirates	Extremely hot, dry
1A	Miami, FL	Very hot, humid
1B	New Delhi, India	Very hot, dry
2A	Tampa, FL	Hot, humid
2B	Tucson, AZ	Hot, dry
3A	Atlanta, GA	Warm, humid
3B	El Paso, TX	Warm, dry
3C	San Diego, CA	Warm, marine
4A	New York, NY	Mixed, humid
4B	Albuquerque, NM	Mixed, dry
4C	Seattle, WA	Mixed, marine
5A	Buffalo, NY	Cool, humid
5B	Denver, CO	Cool, dry
5C	Port Angeles, WA	Cool, marine
6A	Rochester, MN	Cold, humid
6B	Great Falls, MO	Cold, dry
7	International Falls, MN	Very cold
8	Fairbanks, AK	Subarctic

5.2 Building Model Classification

90.1-2019 Appendix G rules covered under this section:

Table G3.1.1 Design Model

Table G3.1.3 Space Use Classification

Table G3.1.7 Thermal Blocks – HVAC Zones Designed

Table G3.1.8 Thermal Blocks – HVAC Zones Not Designed

Table G3.1.9 Thermal Blocks – Multifamily Residential Buildings

The *90.1-2019 PI, proposed, and baseline* models have identical geometry, floor area, space type classification, and thermal blocks. Refer to Thornton et al. (2011); Goel et al. (2014); DOE (2018); DOE (2021a); DOE (2024) for detailed information.

5.3 Schedules

90.1-2019 Appendix G rules covered under this section:

Table G3.1.4 Schedule

The *90.1-2019 PI, proposed, and baseline* models have identical geometry, floor area, space type classification, and thermal blocks.

5.4 Building Envelope

90.1-2019 Appendix G rules covered under this section:

Table G3.1.5 Building Envelope

These building envelope rules in Appendix G Table G3.1 part 5 apply to all building envelope assemblies, including exterior walls, windows, doors, roofs, exterior floors (including floors above unconditioned spaces), slab-on-grade floors, below grade walls, and below grade floors. A detailed description of modeling parameters is provided in the subsections below. Simulation inputs that differ in the *baseline* and *proposed* models compared to the *90.1-2019 PI* models are indicated with an “x” in Table 26.

Table 26: Summary of Envelope Differences Between Models

Model Type	Dimension	Orientation	Infiltration	Assembly Type	U-factor	WWR	SRR
90.1-2019 PI							
Proposed			x				
Baseline		x		x	x	x	

5.4.1 Building Dimensions and Orientation

- The *90.1-2019 PI* and *proposed* models are simulated with a single orientation. Prototypes that are not square are oriented so that the window area facing the north and south is greater than the window area facing east and west.
- The *baseline* models are simulated with the same orientation as the *proposed* models and then again after rotating the entire building 90, 180, and 270 degrees. The baseline building performance is calculated by averaging the results of the four simulations.
- The proposed and baseline models have the same envelope shape, dimensions, number of floors, conditioned floor area, and thermal zoning as the *90.1 2019 PI* models.

5.4.2 Building Envelope Infiltration

- 90.1-2019 PI*: The air leakage rate of the building envelope at a pressure differential of 0.3 in. of water adjusted for wind speed is simulated at 1 cfm/ft² of above-grade exterior wall surface area. See Gowri et al. (2009) for details.
- Proposed*: The air leakage rate of the building envelope at a pressure differential of 0.3 in. of water is simulated at 0.6 cfm/ft².
- Baseline*: The air leakage rate of the building envelope at a pressure differential of 0.3 in. of water is simulated at 1 cfm/ft².

- d. The infiltration rate through operable doors and windows is modeled the same in the *90.1-2019 PI, baseline, and proposed* models.¹⁹
- e. Infiltration schedules are set to a fraction of 1.0 during unoccupied hours when fans are in cycle only mode and mechanical ventilation is shut off, and at 0.25 during occupied hours when fans operate continuously and provide mechanical ventilation. The same infiltration schedule is used in the *90.1-2019 PI, baseline, and proposed* models.

5.4.3 Opaque Building Envelope Assembly Type and U-factor

- a. The *90.1-2019 PI* and *proposed* models are modeled with the same construction assembly type for all envelope components. The assembly U-factor for both models meets the minimum U-factor requirements for each assembly type per the ASHRAE Standard 90.1-2019.
- b. The *baseline* models follow the Appendix G baseline envelope rules for envelope classification, assembly type, and climate-zone-specific U-factors prescribed in 90.1 Tables G3.4-1 through G3.4-8. The assumed envelope classification (nonresidential, residential, semi-heated) is shown in Table 27.

The exterior wall and roof type modeled in the *90.1 2019 – PI, baseline, and proposed* models is shown in Table 27. See Appendix A, Table A.1 for additional details.

Table 27: Envelope Classification Categories by Building

Building	Envelope Classification
ApartmentHighRise	Nonresidential (offices, corridors), Residential (apartments)
ApartmentMidRise	Nonresidential (offices, corridors), Residential (apartments)
Hospital	Nonresidential (all except patient rooms), Residential (patient rooms)
HotelLarge	Nonresidential (all except guest rooms), Residential (guest rooms)
HotelSmall	Nonresidential (all except guest rooms), Residential (guest rooms)
OfficeLarge	Nonresidential
OfficeMedium	Nonresidential
OfficeSmall	Nonresidential
OutPatientHealthCare	Nonresidential
RestaurantFastFood	Nonresidential
RestaurantSitDown	Nonresidential
RetailStandalone	Nonresidential
RetailStripmall	Nonresidential
SchoolPrimary	Nonresidential
SchoolSecondary	Nonresidential
Warehouse	Nonresidential, semi heated (bulk storage)

¹⁹ 90.1-2019 Appendix G does not prescribe infiltration rates for operable doors and windows.

Table 28: Envelope Construction Assembly Type^(a)

Building	Exterior Wall Type		Roof Type	
	90.1_2019 PI, Proposed	Baseline	90.1_2019 PI, Proposed	Baseline
ApartmentHighRise	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
ApartmentMidRise	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
Hospital	Mass	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
HotelLarge	Mass	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
HotelSmall	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
OfficeLarge	Mass	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
OfficeMedium	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
OfficeSmall	Wood-Framed and Other	Steel-Framed	Attic and Other	Insulation Entirely above Deck ^(b)
OutPatientHealthCare	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
RestaurantFastFood	Wood-Framed and Other	Steel-Framed	Attic and Other	Insulation Entirely above Deck ^(b)
RestaurantSitDown	Steel-Framed	Steel-Framed	Attic and Other	Insulation Entirely above Deck ^(b)
RetailStandalone	Mass	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
RetailStripmall	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
SchoolSecondary	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
SchoolPrimary	Steel-Framed	Steel-Framed	Insulation Entirely above Deck	Insulation Entirely above Deck
Warehouse	Metal Building	Steel-Framed	Metal Building	Insulation Entirely above Deck

(a) Opaque envelope types not listed in this table are modeled as same between 90.1-2019 PI, proposed, and baseline.

(b) These buildings are modeled with attic roof but, to comply with Appendix G requirements for envelope, the modeled baseline U-factors are for insulation entirely above deck assembly type.

5.4.4 Building Roof Solar Reflectance and Thermal Emittance

- a. The *90.1-2019 PI* and *proposed* building models are modeled with solar roof reflectance and emittance values shown in Table 29.
- b. The *baseline* buildings are modeled with a roof reflectance of 0.3 and a thermal emittance of 0.9.

Table 29: Roof Reflectance and Emittance

Building	90.1_2019, Proposed		Baseline	
	Reflectance	Emittance	Reflectance	Emittance
ApartmentHighRise	0.3	0.9	0.3	0.9
ApartmentMidRise	0.3	0.9	0.3	0.9
Hospital	0.3	0.9	0.3	0.9
HotelLarge	0.23	0.9	0.3	0.9
HotelSmall	0.23	0.9	0.3	0.9
OfficeLarge	0.3	0.9	0.3	0.9
OfficeMedium	0.3	0.9	0.3	0.9
OfficeSmall	0.3	0.9	0.3	0.9
OutPatientHealthCare	0.3	0.9	0.3	0.9
RestaurantFastFood	0.3	0.9	0.3	0.9
RestaurantSitDown	0.3	0.9	0.3	0.9
RetailStandalone	0.23	0.9	0.3	0.9
RetailStripmall	0.23	0.9	0.3	0.9
SchoolPrimary	0.23	0.9	0.3	0.9
SchoolSecondary	0.23	0.9	0.3	0.9
Warehouse	0.23	0.9	0.3	0.9

5.4.5 Vertical Fenestration Assembly

- a. The *90.1-2019 PI* and *proposed* buildings are modeled with above grade window to wall area ratio shown in Table 30. Windows are modeled as minimally compliant with the U-factor, solar heat gain coefficient (SHGC), and visible light transmittance required in 90.1 Tables 5.5-0 to 5.5-8.
- b. The *baseline* buildings are modeled with above grade window to wall area ratio in accordance with 90.1 Table G3.1.1-1, as shown in Table 30. Table 30 also shows the mapping of the prototype buildings to the building area types in Table G3.1.1-1. Windows are modeled with climate-specific performance levels (U-value, SHGC, and visible light transmittance) based on envelope classification (nonresidential, residential, semi heated, per Table 27) as prescribed in 90.1 Tables G3.4-1 through G3.4-8. See Appendix A, Table A.2 for details.

Table 30: Window to Wall Area Ratio by Prototype and Building Area Type

Building	Building Area Type 1			Building Area Type 2		
	Table G3.1.1-1 Building Area Type	WWR		Table G3.1.1-1 Building Area Type	WWR	
		90.1-2019 PI, Proposed	WWR Baseline		90.1-2019 PI, Proposed	WWR Baseline
ApartmentHighRise	Others	26%	19%	Office (≤50,000 ft ²)	30%	30%
ApartmentMidRise	Others	18%	18%	Office (≤50,000 ft ²)	20%	20%
Hospital	Hospital	16%	27%	-	-	-
HotelLarge	Hotel/motel (>75 rooms)	30%	34%	-	-	-
HotelSmall	Hotel/motel (≤75 rooms)	11%	24%	-	-	-
OfficeLarge	Office (>50,000 ft ²)	40%	40%	-	-	-
OfficeMedium	Office (5,000 to 50,000 ft ²)	33%	31%	-	-	-
OfficeSmall	Office (≤5,000 ft ²)	21%	19%	-	-	-
OutPatientHealthCare	Healthcare (outpatient)	20%	21%	-	-	-
RestaurantFastFood	Restaurant (quick service)	14%	34%	-	-	-
RestaurantSitDown	Restaurant (full service)	17%	24%	-	-	-
RetailStandalone	Retail (stand-alone)	7%	11%	-	-	-
RetailStripmall	Retail (strip mall)	11%	20%	-	-	-
SchoolPrimary	School (primary)	35%	22%	-	-	-
SchoolSecondary	School (secondary and university)	35%	22%	-	-	-
Warehouse	Warehouse (nonrefrigerated)	0%	6%	Office (≤5,000 ft ²)	2%	19%

5.4.6 Skylights

- a. The 90.1-2019 PI and proposed models have climate zone specific skylight to roof ratios, shown in Table 31. No skylights are modeled for building types not shown in the table. Skylight U-factor, SHGC, and visible light transmittance are modeled to minimally comply with requirements in 90.1 Tables 5.5-0 to 5.5-8. See Appendix A, Table A.3 for details.
- b. The baseline buildings are modeled with skylight area, orientation, and tilt matching the proposed model because the skylight to roof ratio of the proposed models do not exceed the 3% threshold. Skylight U-factor, SHGC, and visible light transmittance are modeled in accordance with space conditioning category and climate zone specific requirements in 90.1 Tables G3.4-1 through G3.4-8 based on envelope classification in Table 27. See Appendix A, Table A.3 for details.

Table 31: Skylight Roof Ratio by Climate Zone and Building for 90.1-2019 PI, Proposed, and Baseline

Building	CZ-0(A,B), 2(A,B), 3(A,B,C), 4(A,B,C), 5(A,B,C)	CZ-1(A,B)	CZ-6(A,B),7,8
RetailStandalone	1.0%	1.0%	0.3%
SchoolPrimary	0.2%	0.2%	0.2%
SchoolSecondary	1.1%	1.1%	1.1%
Warehouse	2.6%	1.5%	0.3%

5.5 Lighting

90.1-2019 Appendix G rules covered under this section:

- Table G3.1.6 Lighting

These rules apply to the indoor lighting and exterior lighting of all buildings. Indoor lighting power allowance in the 90.1-2019 PI *prototype*, Appendix G *proposed*, and Appendix G *baseline* models is determined based on the space-by-space method. See Appendix B, Table B.1 for space type mapping assumptions, which are the basis for establishing the indoor lighting power allowance and control requirements. Exterior lighting is modeled for tradable and non-tradable surfaces. Tradable applications include uncovered parking areas, building entrances, and exits, and building facades are treated as non-tradable for determining exterior lighting power allowance.

5.5.1 Indoor Lighting

5.5.1.1 Lighting Power Allowance

- The 90.1-2019 PI and *proposed* indoor lighting power is specified using the space-by-space method per procedure in Standard 90.1-2019, Section 9.6.1. The space type determination used for each prototype zone is detailed in Appendix B. Total connected lighting power in zones that include multiple space types is calculated as an area-weighted value as shown in the example in Table 32. In addition to lighting power for permanently installed hard wired lighting, lighting systems connected via receptacles are included in the apartment prototype (ApartmentMidrise, ApartmentHighrise) dwelling unit zones. Hardwired lighting power in dwelling units was modeled as 0.6 W/SF, per Table 90.1 G3.1 #6, Proposed column item (e). Additional lighting power is also included in the retail prototype RetailStripmall for display lighting. Details about the receptacle lighting in the multifamily prototypes and display lighting can be found in DOE (2018).
- The *baseline* indoor lighting power is specified per the space-by-space method prescribed in Table G3.7. Like the 90.1-2019 PI and *proposed* models, *baseline* lighting power in zones with multiple space types is area-weighted as shown in the example in Table 32. Receptacle and display lighting power are modeled with the same lighting power as the *proposed* models.

Table 32: Example of Space-by-Space Mapping for Total Lighting Power Allowance (LPD) Determination for Stand-alone Retail Prototype

Zone	Space Type	Area Fraction	LPD	
			Baseline	90.1-2019/ Proposed
Basement	Office – Open plan	0.43	1.03	0.62
	Office – Enclosed	0.19		
	Corridor – All other corridor	0.09		
	Storage Room – < 50 ft ²	0.05		
	Conference/Meeting/Multipurpose Room	0.05		
	Stairwell	0.04		
	Lobby – All other lobby	0.04		
	Restroom – All other restroom	0.04		
	Electrical/Mechanical Room	0.03		
	Storage Room – ≥ 50 ft ²	0.02		
	Lounge/Breakroom – All other lounge/breakroom	0.02		
Retail_1_Flr_1 & Retail_2_Flr_1	Sales Area	0.78	1.50	0.90
	Storage Room – ≥ 50 ft ²	0.22		
Mech_Flr_1	Electrical/Mechanical Room	1.00	1.50	0.43

5.5.1.2 Lighting Controls (other than daylighting)

- a. The 90.1-2019 PI and proposed models are modeled with the following lighting controls per requirements in Standard 90.1-2019, Section 9.6:
 - Manual control in all zones
 - Automatic partial and full off occupancy sensor controls (in applicable space types as required by Table 9.6.1 of the Standard)
 - Scheduled shut-off controls (in applicable spaces based on Table 9.6.1 of the Standard)
 - Guestroom lighting controls
 - Egress lighting controls

Lighting controls other than daylighting controls (discussed below) are modeled by adjusting the *baseline* lighting schedule per Table G3.7 of the Standard. For spaces where multiple controls are required per Table 9.6.1, overall lighting schedule adjustment fraction for individual zones is calculated as:

$$LSch_{adjfraction,z} = \sum_{c=1}^M \sum_{s=1}^N Areafraction_{c,s} \times Scheduleadjustment_{c,s}$$

Equation 5:
Lighting Schedule
Fraction
Adjustment

where

- $LSch_{adjfraction,z}$ = lighting schedule adjustment for zone z
- c = lighting control type (where M = “Required”, “Add1”, or “Add2”)
- s = space type, s in zone z (ranging from 1 to N)
- $Areafraction_{c,s}$ = area fraction of space s in zone z

$Scheduleadjustment_{c,s}$ = schedule adjustment fraction per Table G3.7

Note that if a space type in Table 9.6.1 is specified with multiple control options for “Add1” or “Add2”, one of the options for each requirement type is included in the overall lighting schedule adjustment calculation. The guestroom lighting and egress lighting control requirements are modeled separately and are not included in the lighting schedule adjustment calculation described above. See Thornton et al. (2011); Goel et al. (2014) for details.

- b. For the *baseline* model, automatic shutoff controls are required in buildings > 5000 ft². In addition, occupancy sensors are required in employee lunch and break rooms, conference/meeting rooms, and classrooms (not including shop classrooms, laboratory classrooms, and preschool through 12th grade classrooms). The lighting schedules in all prototype buildings reflect these control requirements.

5.5.1.3 Daylighting Controls

- a. The *90.1-2019 PI* and *proposed* models are modeled with automatic daylight controls in primary sidelighted, secondary sidelighted, and toplighted zones as per minimum requirements in the Standard using the native daylighting algorithms within Energy Plus.
- b. The *baseline* is modeled with no daylighting controls.

5.5.2 Exterior Lighting

- a. The *90.1-2019 PI* and *proposed* exterior lighting wattage is determined per Table 9.4.2.2 of the Standard. Controls for exterior lighting are modeled per Section 9.4.1.4 of the Standard. See Table 33 for exterior lighting wattage by surface type modeled in each prototype.
- b. *Baseline* exterior lighting wattage is modeled the same as proposed for non-tradable applications, which includes façade lighting. For the tradeable applications including building entrances and exits and uncovered parking areas, exterior lighting wattage is determined per 90.1 Table G3.6 as shown in Table 33. Only the automatic shut-off control based on astronomical clock is included in the baseline model.

Table 33: Exterior Lighting Wattage by Surface Type and Building*

Prototype	90.1-2019 PI, Proposed			Baseline		
	Façade (W)	Entrance (W)	Parking (W)	Façade (W)	Entrance (W)	Parking (W)
OfficeSmall	50.67	115.13	445.50	50.67	165.00	1336.50
OfficeMedium	519.19	375.66	4341.60	519.19	482.65	13024.80
OfficeLarge	12979.20	968.10	26009.00	12979.20	1036.80	48766.80
RetailStandalone	316.31	1304.00	1750.30	316.31	1564.65	5250.80
RetailStripmall	418.36	2520.30	2118.70	418.36	3600.00	6356.00
SchoolPrimary	150.48	1645.85	587.30	150.48	2794.28	2202.50
SchoolSecondary	441.84	2994.55	2965.80	441.84	4190.97	8897.30
OutPatientHealthCare	173.81	1402.00	4146.20	173.81	1724.90	12438.60
Hospital	2932.34	1499.00	5420.40	2932.34	1669.08	11615.20
HotelSmall	572.85	225.00	2020.80	572.85	246.91	5052.00
HotelLarge	4996.53	444.00	6197.70	4996.53	486.96	13280.70
Warehouse	113.75	3955.00	1002.40	113.75	4668.12	3007.10
RestaurantFastFood	122.81	42.00	607.50	122.81	60.00	1518.80
RestaurantSitDown	154.01	123.00	1336.50	154.01	148.50	3341.30
ApartmentMidRise	222.13	0.00	1428.90	222.13	0.00	4286.60
ApartmentHighRise	2493.31	0.00	5007.60	2493.31	0.00	10730.60

*Surface area and length are documented in Thornton et al. (2011)

5.6 HVAC Systems

90.1-2019 Appendix G rules covered under this section:

Table G3.1.10 HVAC Systems

Section G3.1.1 Baseline HVAC System Type and Description

Section G3.1.2 General Baseline HVAC System Requirements

Section G3.1.3 System-Specific Baseline HVAC System Requirements

5.6.1 HVAC System Type

- a. The *90.1-2019 PI* prototypes are modeled with HVAC systems listed in Table 1 and described in Thornton et al. (2011) and Goel et al. (2014) .
- b. The *proposed* prototypes are modified versions of the *90.1-2019 PI* prototypes. They have the same thermal zoning, cooling source, and air distribution types as the *90.1-2019* prototypes. Heating source type is modified to electric for climate zones 0 to 3A and natural gas for other climates.
- c. The *baseline* HVAC system types are determined based on requirements in Section G3.1.1 Baseline HVAC System Type and Description of ASHRAE Standard 90.1-2019 and are summarized in Table 34. A step-by-step process for baseline system type determination for each prototype is provided in Appendix C.

Comparison of the *90.1-2019 PI, proposed*, and *baseline* HVAC systems is provided in the Table 34 using the nomenclature described in Table 35. In addition to baseline system type, a major distinction between *proposed* and *baseline* is the system configuration for multi-zone systems. *Baseline* models with multi-zone systems are modeled as one system per floor per Appendix G rules, irrespective of the *90.1-2019* prototype configuration, except in the Hospital on floors that include a combination of zones requiring humidification and those without. In those cases, two multi-zone systems are included per floor. See Appendix C, Table C.2 for further details.

Table 34: Criteria for Appendix G Baseline HVAC System Type Determination

Step	Baseline System Determination	Options
1	Predominant building type	Residential Public Assembly Retail Hospital Heated-only Storage Other Nonresidential
2	No. of floors and conditioned floor area (sq ft)	<i>Residential</i> : Any size <i>Public Assembly</i> : < 120,000 ft ² , ≥ 120,000 ft ² <i>Retail</i> : ≤ 2 floors, > 2 floors <i>Hospital</i> : Not more than 5 floors and not >150,000 ft ² ; more than 5 floors or >150,000 ft ² . <i>Heated-only Storage</i> : Any size <i>Other Nonresidential</i> : Small, 3 floors or less and <25,000 ft ² ; Medium, 4 or 5 floors and <25,000 ft ² or 5 floors or less and 25,000 ft ² to 150,000 ft ² ; Large, more than 5 floors or >150,000 ft ²
3	Exceptions:	
	a. > 20,000 ft ² of non-predominant space type	
	b. i. MZ system with zone internal gain > 10 Btu/ft ²	
	b. ii. MZ system with zone schedule > 40 EFLH	
	c. Lab spaces with lab exhaust rate > 15,000 cfm	
	d. Heated only zones	
	e. Baseline system 9, 10	
	f. Computer rooms	
	h. Hospitals	

Table 35: HVAC System Types

No.	Acronym	System Type
1	PTAC	Packaged terminal air conditioner
1a	PTAC	Packaged terminal air conditioner with electric heat
2	PTHP	Packaged terminal heat pump
3	PSZ-AC	Packaged rooftop air conditioner
4	PSZ-HP	Packaged rooftop heat pump
4a	PSZ-HP with gas auxiliary ^a	Packaged rooftop heat pump with gas fired auxiliary heat
5	Packaged VAV with reheat	Packaged rooftop VAV with hydronic reheat
5a	Packaged VAV with electric reheat ^a	Packaged rooftop VAV with gas central heat and electric reheat
5b	Packaged VAV with electric reheat ^a	Packaged rooftop VAV with electric central heat and electric reheat
6	Packaged VAV with PFP boxes	Packaged rooftop VAV with parallel fan power boxes and electric reheat
7	VAV with reheat	VAV with hydronic reheat
7a	VAV with reheat ^a	VAV with boiler heat and electric reheat
8	VAV with PFP boxes	VAV with parallel fan power boxes and electric reheat
9	Heating and ventilation	Warm air furnace, gas fired
10	Heating and ventilation	Warm air furnace, electric
11a	SZ-VAV	Single-zone VAV (chilled water cooling, hot-water heating)
11b	SZ-VAV	Single-zone VAV (chilled water cooling, electric resistance heating)
12	SZ-CV-HW	Single-zone system (constant volume, chilled water-cooling hot water heating)
13	SZ-CV-ER	Single-zone system (constant volume, chilled water-cooling electric resistance heating)
14	WSHP ^a	Water-source heat pump
14a	WSHP ^a	Water-source heat pump with electric boiler
15	FPFC ^a	Four pipe fan coils
15a	TPFC ^a	Two pipe fan coils with electric resistance heating

^a Not included in ASHRAE Standard 90.1-2019 Table G3.1.1-4 Baseline System Descriptions

Table 36: HVAC System Types Comparison

Prototype	90.1-2019 PI	Proposed		Baseline	
		CZ 3B, 3C & 4 to 8	CZ 0 to 3A	CZ 3B, 3C & 4 to 8	CZ 0 to 3A
OfficeSmall	4a	3	4	3	4
OfficeMedium	5a	5	5b	5	6
OfficeLarge	7	7	7a	7	8
	14	14	14	3 11a	4 11b
RetailStandalone	3	3	4	3	4
	9	9	10	9	10
RetailStripmall	3	3	4	3	4
SchoolPrimary	5	5	5b	5	6
	3	3	4	3	4
SchoolSecondary	7	7	14	7	8
	3	3	4	3	4
OutPatientHealthCare	7	7	7	5 3	5 4
	7	7	7	7	7
Hospital	12	12	12	3	4
	7	7	7	7	7
HotelSmall	1a	1	1a	1	2
	3	3	4	9	10
	10	9	10		
HotelLarge	7	7	7a	1	2
	15	15	15a	5	6
				3	4
Warehouse	3	3	4	3	4
	9	9	9	9	10
RestaurantFastFood	3	3	4	3	4
RestaurantSitDown	3	3	4	3	4
ApartmentHighRise	14	14	14a	1	2
ApartmentMidRise	3	3	4	1	2

5.6.2 HVAC Equipment Efficiency

- The *90.1-2019 PI* and *proposed* models are modeled in accordance with minimum efficiency requirements in Section 6.8 of ASHRAE Standard 90.1-2019.
- The *baseline* HVAC systems follow the rules for HVAC system efficiency prescribed in Appendix G, Tables G3.5-1 through G3.5-6 of ASHRAE Standard 90.1-2019.

5.6.3 HVAC Equipment Capacity

- The *90.1-2019 PI* and *proposed* models are modeled identically per prototype specifications (PNNL and BECP 2021).
- The *baseline* HVAC system capacity is based on sizing runs for each orientation and is oversized by 15% for cooling and 25% for heating. Cooling sizing runs use the highest

hourly value in annual simulation for internal loads schedules,²⁰ and heating sizing runs use the lowest fraction for the entire design day. For infiltration, both cooling and heating sizing runs were based on the highest schedule values from the annual simulation.

5.6.4 Fan System Operation

- a. The *90.1-2019 PI* and *proposed* models are modeled identically per prototype specifications (PNNL and BECP 2021).
- b. The *baseline* HVAC system supply and return fans are required to operate continuously at occupied hours and cycle during unoccupied hours, with exception allowed for health and safety requirements and terminal units. This requirement is modeled identically in the *90.1-2019 PI*, *proposed*, and *baseline* models.

5.6.5 Ventilation

- a. The *90.1-2019 PI* and *proposed* models are modeled identically per prototype specifications (PNNL and BECP 2021).
- b. The *baseline* minimum ventilation system outdoor air flow rates are required to be modeled the same as *proposed* with exceptions per Appendix G Section G3.1.2.5. Prototypes where exceptions apply due to demand-control ventilation requirements include OutPatientHealthCare, HotelLarge, SchoolPrimary, and SchoolSecondary.

5.6.6 Economizers

- a. The *90.1-2019 PI* and *proposed* models are modeled identically per Section 6.5.1 of ASHRAE Standard 90.1-2019.
- b. The *baseline* models that have HVAC system types 3 through 8 or 11, 12, and 13 are modeled with integrated air economizer control per climate zone requirement following Table G3.1.2.6 of ASHRAE Standard 90.1-2019. Computer rooms in the OfficeLarge prototype that are served by HVAC system 3- PSZ-AC or 4-PSZ-HP are modeled without economizers per exception G3.1.2.6 (3) and Section G3.1.2.6.1. Fluid economizers are required in the OfficeLarge computer room served by System 11 SZ-VAV, but they were modeled as airside economizers due to software limitation.²¹ Economizers in baseline systems are modeled with dry-bulb fixed switch with high limit shutoff setpoint temperatures per Table G3.1.2.7.

5.6.7 Design Airflow Rate

- a. The *90.1-2019* and *proposed* models are modeled identically per prototype specifications (PNNL and BECP 2021).

²⁰ Lighting schedule is an exception and does not follow this rule in prototypes with residential space types due to prototype infrastructure workflow modeling limitation.

²¹ EnergyPlus version 9.1 does not support fluid economizers in unitary systems.

- b. The *baseline* system design supply airflow rates are modeled per requirements in Section G3.1.2.8 Design Airflow Rates. Baseline systems except types 9 and 10 are modeled with a supply air to room temperature setpoint difference of 20°F or minimum outdoor airflow rate, whichever is greater. No exceptions were applied for this requirement. Baseline systems 9 and 10 are modeled with a supply air temperature of 105°F.

5.6.8 System Fan Power

- a. The *90.1-2019 PI* and *proposed* models are modeled identically per prototype specifications (PNNL and BECP 2021).
- b. The *baseline* system fan power is modeled based on values specified in Sections G3.1.2.9 and G3.1.3.14, as well as Table G3.1.2.9, of the Standard. Key values are listed in Table 37. Motor efficiencies were calculated based on motor sizes according to Table G3.9.1 of the Standard. For systems where energy recovery ventilators were required in the *baseline* model, the additional fan power allowance specified in ASHRAE Standard 90.1-2019 Table 6.5.3.1-2 was added to the energy recovery system. No other adjustments from ASHRAE Standard 90.1-2019 Table 6.5.3.1-2 were applied to the baseline models.

Table 37: Baseline Fan Power Values

System Type	Units	Value
Constant volume systems 3, 4, 12, and 13	bhp/cfm	0.00094
Variable volume systems 5 to 8	bhp/cfm	0.0013
Variable volume system 11	bhp/cfm	0.00062
Parallel VAV fan-powered boxes, systems 6 and 8	W/cfm	0.35
Packaged terminal AC or HP, systems 1 and 2	W/cfm	0.3
Unit heater, systems 9 and 10	W/cfm	0.3

5.6.9 Exhaust Air Energy Recovery

- a. The *90.1-2019 PI* and *proposed* models are modeled identically per prototype specifications (PNNL and BECP 2021).
- b. The *baseline* systems with design supply air capacity of 5000 cfm or greater and with minimum design outdoor air supply of 70% or greater are required to have an energy recovery system with at least 50% enthalpy recovery ratio. Where an air economizer is required for a baseline system, controls are included in the models to bypass the energy recovery system during economizer operation. Exceptions to the energy recovery requirement are applied for kitchens, for heating systems in climate zones 0 through 3, and for cooling systems in climate zones 3C, 4C, 5B, 5C, 6B, 7, and 8. Based on these requirements, there were no systems with exhaust air energy recovery in any of the baseline models.

5.6.10 System-Specific Baseline Requirements

This section describes requirements specified by Appendix G for the baseline systems.

5.6.10.1 Heat Pumps

For systems 2 and 4, supplemental heating is provided by electric resistance coils, which are enabled as the second stage of heating only when outdoor temperature is less than 40°F.

5.6.10.2 Boiler Plants

Boilers are applicable to baseline HVAC systems 1, 5, 7, 11, and 12. If the boiler system serves a conditioned floor area of more than 15,000 ft², then two equally sized natural draft boilers are to be modeled, with staging as required by the load. All the prototypes that require boilers in the baseline model are above this threshold. The heating water loop is primary-only with continuous variable flow. Heating water pumps for buildings with a conditioned area greater than 120,000 ft² are controlled by variable speed drives. This includes the Hospital, the Large Office, and the Secondary School prototypes. All other prototypes that use boilers have constant speed pumps modeled as riding the pump curve.

5.6.10.3 Chiller Plants

The type and number of chillers is configured based on Appendix G Table G3.1.3.7 of the Standard. Total chiller plant capacity and the resulting plant configurations are shown in Table 38. Each chiller is modeled with its own chilled water and condenser water pumps, which are only allowed to operate when the associated chiller is on. The chilled water loop is primary/secondary with constant flow primary and variable flow secondary loops. Primary chilled water pumps are constant volume. Secondary pumps are modeled as riding the pump curve when total plant cooling capacity is less than 300 tons (Large Hotel), and with variable speed drives for larger systems (all other prototypes).

Table 38: Total Chiller Plant Capacity (tons) by Building Type and Climate

	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Hospital	555	541	539	494	537	430	483	397	390	481	375	378	447	361	348	481	369	448	358
HotelLarge	138	126	132	114	133	96	120	106	99	134	96	97	122	91	86	135	91	122	83
OfficeLarge	970	1,007	949	924	919	821	864	947	888	1,073	906	861	1,011	892	810	1,099	904	1,030	874
SchoolSecondary	732	757	738	667	735	556	660	534	481	631	483	453	602	459	395	670	468	581	415

	One water cooled screw chiller
	Two water cooled screw chillers
	Two water cooled centrifugal chillers

5.6.10.4 Heat Rejection Systems

The baseline chiller plants are always water-cooled with axial-fan open circuit cooling towers, configured as one tower per chiller. Fan power is set based on the requirement of 38.2 gpm/hp at 95°F entering water, 85°F leaving water, and 75°F entering air wet bulb. The design approach was calculated based on the formula from Appendix G Table G3.1.3.11, and the results for each climate zone are listed in Table 39, along with the leaving tower water setpoint prescribed by Appendix G Table G3.1.3.11.

Table 39: Cooling Tower 0.4% Design Outdoor Wet Bulb and Design Approach, °F

	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Design wet bulb	80.0	80.0	80.0	80.0	80.0	72.9	77.2	70.3	71.2	77.0	68.0	68.0	74.8	68.0	68.0	76.8	68.0	73.0	68.0
Design approach	38.5	38.5	38.5	38.5	38.5	40.2	39.2	40.8	40.6	39.2	41.4	41.4	39.8	41.4	41.4	39.3	41.4	40.2	41.4
Setpoint	80	70	80	70	80	70	75	70	70	75	70	70	70	65	65	70	65	70	65

5.6.10.5 Outdoor Air Reset Controls

Baselines for all applicable prototypes are modeled with reset controls for VAV air handler supply air temperature, chilled water supply temperature, and heating hot water supply temperature, as summarized in Table 40.

Table 40: Outdoor Air Reset Control Setpoints, °F

	Outdoor Low	Setpoint @ OA Low	Outdoor High	Setpoint @ OA High
Supply air temperature reset	50	60	70	55
Chilled water temperature reset	60	54	80	44
Heating water temperature reset	20	180	50	150

5.6.10.6 Pump Sizing and Power

Baseline pump power and flow rates are based on the values in Table 41. The power values for primary chilled water pumps and cooling tower pumps in the Large Office reflect the extra allowance for systems serving large data centers.

Table 41: Pump Sizing and Power Parameters

	Design Delta T °F	Applicable Prototypes other than Large Office W/gpm	Large Office W/gpm
Hot water pumps	50	19	19
Chilled water pumps - primary	12	9	12
Chilled water pumps - secondary	12	13	13
Cooling tower pumps	10	19	22

5.6.10.7 VAV System Fan Control

Baseline fans for baseline HVAC systems 5 through 8 are controlled with minimum flow setpoints that are the greater of 30% of peak zone air flow and design minimum outdoor air flow. For system 11, minimum flow setpoint is 50% of design zone air flow, and control is applied first to air flow, and second to supply air temperature. All VAV system supply fans in *baseline* models were assumed to have variable speed drives with performance as follows, based on Table G3.1.3.15 Method 2.

$$P_{fan_multiplierx} = 0.0013 + 0.1470 \times PLR_{fan} + 0.9506 \times (PLR_{fan})^2 - 0.0998 \times (PLR_{fan})^3$$

Equation 6:
VAV Fan
Performance

5.7 Service Water-Heating Systems

- a. The *proposed* models are modeled identical to the *90.1-2019 PI* prototype except for the following:
 - Pipe losses are not modeled for the *proposed* models as per Appendix G Table G3.1.11.
 - Fuel types for general purpose water heaters are modified to match Appendix G fuel types as shown in Table 43. Fuel types for booster and laundry heaters are kept the same as the prototypes. The prototypes are mapped to Appendix G Table G3.1.1-2 as shown in Table 42.
 - For the midrise apartment building, the *proposed* model used a single central gas storage water heater instead of 23 electric point-of-use water heaters as is currently modeled for the *90.1-2019 PI* prototype model.

- b. The *baseline* models are identical to the *proposed* models except for the following:
 - Fuel types for booster and laundry water heaters are changed to match the Appendix G requirements as shown in Table 43.
 - For the retail strip mall building type, the *proposed* model used a single central electric storage water heater instead of seven electric point-of-use water heaters as is currently modeled for the *90.1-2019 PI* prototype model.

Table 42: Association of Prototypes to Appendix G Building Area Types

Prototype	Table G3.1.1-2 Building Area Type		
	Main	Booster/ Dishwash	Laundry
OfficeSmall	Office	NA	NA
OfficeMedium	Office	NA	NA
OfficeLarge	Office	NA	NA
RetailStandalone	Retail	NA	NA
RetailStripmall	Retail	NA	NA
SchoolPrimary	School	Dining: Cafeteria	NA
SchoolSecondary	School	Dining: Cafeteria	NA
OutPatientHealthCare	Hospital and outpatient surgery center	NA	NA
Hospital	Hospital and outpatient surgery center	Dining: Cafeteria	All others
HotelSmall	Hotel/Motel	Dining: Cafeteria	All others
HotelLarge	Hotel/Motel	Dining: Cafeteria	All others
Warehouse	Office	NA	NA
RestaurantFastFood	Dining: Cafeteria	NA	NA
RestaurantSitDown	Dining: Cafeteria	Dining: Cafeteria	NA
ApartmentMidRise	Multifamily	NA	NA
ApartmentHighRise	Multifamily	NA	NA

Table 43: Service Water Heater Type

Prototype	90.1-2019 PI			Proposed			Baseline		
	Main	Booster/ Dishwash	Laundry	Main	Booster/ Dishwash	Laundry	Main	Booster/ Dishwash	Laundry
OfficeSmall	Electric	NA	NA	Electric	NA	NA	Electric	NA	NA
OfficeMedium	Gas	NA	NA	Electric	NA	NA	Electric	NA	NA
OfficeLarge	Gas	NA	NA	Electric	NA	NA	Electric	NA	NA
RetailStandalone	Gas	NA	NA	Electric	NA	NA	Electric	NA	NA
RetailStripmall	Electric	NA	NA	Electric	NA	NA	Electric	NA	NA
SchoolPrimary	Gas	Electric	NA	Gas	Electric	NA	Gas	Gas	NA
SchoolSecondary	Gas	Electric	NA	Gas	Electric	NA	Gas	Gas	NA
OutPatientHealthCare	Gas	NA	NA	Gas	NA	NA	Gas	NA	NA
Hospital	Gas	Electric	Gas	Gas	Electric	Gas	Gas	Gas	Gas
HotelSmall	Gas	NA	Gas	Gas	NA	Gas	Gas	NA	Gas
HotelLarge	Gas	Electric	Gas	Gas	Electric	Gas	Gas	Gas	Gas
Warehouse	Electric	NA	NA	Electric	NA	NA	Electric	NA	NA
RestaurantFastFood	Gas	NA	NA	Gas	NA	NA	Gas	NA	NA
RestaurantSitDown	Gas	Electric	NA	Gas	Electric	NA	Gas	Gas	NA
ApartmentMidRise	Electric	NA	NA	Gas	NA	NA	Gas	NA	NA
ApartmentHighRise	Gas	NA	NA	Gas	NA	NA	Gas	NA	NA

Table 44: Service Water Heater Quantity and Capacity

Prototype	Quantity						Capacity per Heater (gal)		
	90.1-2019 PI, Proposed			Baseline			90.1-2019 PI, Proposed, Baseline		
	Main	Booster/ Dishwash	Laundry	Main	Booster/ Dishwash	Laundry	Main	Booster/ Dishwash	Laundry
OfficeSmall	1	NA	NA	1	NA	NA	40	NA	NA
OfficeMedium	1	NA	NA	1	NA	NA	100	NA	NA
OfficeLarge	1	NA	NA	1	NA	NA	300	NA	NA
RetailStandalone	1	NA	NA	1	NA	NA	40	NA	NA
RetailStripmall	7	NA	NA	1	NA	NA	40/40/100	NA	NA
SchoolPrimary	1	1	NA	1	1	NA	200	6	NA
SchoolSecondary	1	1	NA	1	1	NA	600	6	NA
OutPatientHealthCare	1	NA	NA	1	NA	NA	200	NA	NA
Hospital	1	1	1	1	1	1	600	6	300
HotelSmall	1	1	1	1	1	1	300	6	200
HotelLarge	1	1	1	1	1	1	600	6	300
Warehouse	1	NA	NA	1	NA	NA	20	NA	NA
RestaurantFastFood	1	NA	NA	1	NA	NA	100	NA	NA
RestaurantSitDown	1	1	NA	1	1	NA	200	6	NA
ApartmentMidRise	31/1 ^(a)	NA	NA	1	NA	NA	50/200/200	NA	NA
ApartmentHighRise	1	NA	NA	1	NA	NA	600	NA	NA

(a) Point-of-use water heaters in 90.1-2019 PI model, central water heater in proposed.

Table 45: Service Water Heater Efficiency and UA

Prototype	Efficiency		Heat Loss Coefficient – UA (Btu/h-F)	
	90.1-2019 PI	Baseline, Proposed	90.1-2019 PI	Baseline, Proposed
OfficeSmall	1.000	1.000	2.13	2.29
OfficeMedium	0.808	1.000	14.36	4.69
OfficeLarge	0.804	1.000	21.37	8.95
RetailStandalone	0.820	1.000	8.47	2.13
RetailStripmall	1.000	1.000	2.13	2.48
SchoolPrimary	0.805	0.805	18.31	18.31
SchoolSecondary	0.803	0.803	29.62	29.62
OutPatientHealthCare	0.805	0.805	18.31	18.31
Hospital	0.803	0.803	29.62	29.62
HotelSmall	0.804	0.804	21.37	21.37
HotelLarge	0.803	0.803	29.62	29.62
Warehouse	1.000	1.000	2.01	2.51
RestaurantFastFood	0.808	0.808	14.36	14.36
RestaurantSitDown	0.805	0.805	18.31	18.31
ApartmentMidRise	1.000	0.800	118.3	18.31
ApartmentHighRise	0.803	0.803	29.62	29.62

5.8 Receptacle and Other Loads

90.1-2019 Appendix G rules covered under this section:

Table G3.1.12 Receptacle and Other Loads

These rules apply to receptacle and process loads that represent typical general service loads served normally through electrical receptacles. They do not include task lighting or HVAC equipment. They are modeled by specifying the power and corresponding schedule. Receptacle and process loads are considered as unregulated loads by ASHRAE Standard 90.1-2019; hence, credit cannot be taken for improving the efficiency of this equipment when using the Appendix G PRM to demonstrate minimum compliance with the Standard. However, credit can be taken for automatic receptacle control for private offices, conference rooms, printing/copy rooms, break rooms, classrooms, and individual workstations meeting requirements of Section 8.4.2 of ASHRAE Standard 90.1-2019.

- a. The *90.1-2019 PI*, *proposed*, and *baseline* models are modeled with same receptacle power and schedules. The *90.1-2019* and *proposed* models have no additional spaces with automatic receptacle controls than those listed in ASHRAE Standard 90.1-2019 Section 8.4.2.

5.9 Distribution Transformers

90.1-2019 Appendix G rules covered under this section:

Table G3.1.15 Distribution Transformers

Appendix G rules in this section apply to buildings with large electric services when the proposed design exceeds the minimum efficiency required in Table 8.4.4 of ASHRAE Standard 90.1-2019. However, since seven buildings in the *90.1-2019 PI* prototype models have transformers, to be consistent, the *proposed* and *baseline* models are also modeled with distribution transformers with efficiency shown in Table 46.

Table 46: Distribution Transformer

Prototype	Rated Capacity (VA)	Efficiency %
OfficeMedium	45,000	98.4
OfficeLarge	500,000	99.1
SchoolPrimary	112,500	98.7
SchoolSecondary	225,000	98.9
Hospital	500,000	99.1
HotelLarge	150,000	98.8
ApartmentHighRise	75,000	98.6

5.10 Elevators

90.1-2019 Appendix G rules covered under this section:

Table G3.1.16 Elevators

These rules apply to elevator cab motors, ventilation fans, and lighting.

- a. The *90.1-2019 PI* and *proposed* models with elevators include OfficeMedium, OfficeLarge, Hospital, OutPatientHealthCare, HotelLarge, HotelSmall, ApartmentHighRise, ApartmentMidRise, and SchoolSecondary. The elevator cabs are modeled with a ventilation fan power of 0.33 W/cfm and lighting of 1.14 W/ft².
- b. The *baseline* models have the same number of elevators, type, weight, speed, mechanical efficiency, cab ventilation fan power (0.33 W/cfm), lighting power (3.14 W/ft²), and operation schedule as the *proposed*. The modeled lift motor power of the *baseline* models differs from the *proposed* as shown in Table 47. The baseline models and the proposed models through 90.1-2019 use the “2004 to 2019” values for design kW and standby kW, and the 90.1-2022 proposed models use the “2022 Proposed” kW values.

Table 47: Elevator Motor

Prototype	Num. floors	Num. lifts	Weight of car (lb)	Speed of car (fpm)	Annual ride hours	Running kW/ Rated kW	Design kW per elevator	Standby kW per elevator		
							2022 Proposed	2004 to 2019	2022 Proposed	
ApartmentHighRise	10	2	2500	492	1,250	0.65	49.9	33.3	1.6	0.8
Hospital	5	8	2500	492	1,129	0.50	49.9	33.3	1.6	0.8
HotelLarge	6	6	2500	492	1,089	0.45	49.9	33.3	1.6	0.8
OfficeLarge	12	12	2500	689	990	0.66	69.5	46.4	1.6	0.8
ApartmentMidRise	4	1	2500	128	559	0.26	38.4	25.6	1.6	0.8
HotelSmall	4	2	2500	128	559	0.26	38.4	25.6	1.6	0.8
OfficeMedium	3	2	2500	128	470	0.30	38.4	25.6	1.6	0.8
OutPatientHealthCare	3	2	2500	128	566	0.26	38.4	25.6	1.6	0.8
SchoolSecondary	2	2	2500	128	195	0.30	38.4	25.6	1.6	0.8

5.11 Refrigeration

90.1-2019 Appendix G rules covered under this section:

Table G3.1.17 Refrigeration

These rules apply to commercial refrigeration equipment (walk-in refrigerators, walk-in freezers, and refrigerated casework) listed in Table G3.10-1 and Table G3.10-2 of ASHRAE Standard 90.1-2019.

- a. The *90.1-2019* and *proposed* models with commercial refrigeration equipment include Hospital, HotelLarge, RestaurantFastFood, RestaurantSitDown, SchoolPrimary, and SchoolSecondary buildings. Table G3.10-1 of ASHRAE Standard 90.1-2019 applies to the reach-in freezers and reach-in refrigerators in these buildings. These buildings also have walk-in freezers and self-contained display cases not listed in Table G3.10-1 and Table G3.10-2 of ASHRAE Standard 90.1-2019.
- b. The *baseline* models follow the Appendix G performance requirements for reach-in-freezers and reach-in refrigerators as shown in Table 48. Walk-in freezers and self-contained display cases in the *baseline* are modeled with same performance characteristics as the *proposed* as shown in Table 49.

Table 48: Reach-in Refrigeration Equipment Performance

Building	Type	Number	90.1-2019, Proposed (kwh/day)	Baseline (kwh/day)
Hospital	Reach-in freezer	2	555	986
	Reach-in refrigerator	3	470	1095
HotelLarge	Reach-in freezer	1	277.5	493
	Reach-in refrigerator	1	156.7	365
RestaurantFastFood	Reach-in freezer	1	277.5	493
	Reach-in refrigerator	2	313.3	730
RestaurantSitDown	Reach-in freezer	1	277.5	493
	Reach-in refrigerator	2	313.3	730
SchoolPrimary	Reach-in freezer	2	555	986
	Reach-in refrigerator	2	313.3	730
SchoolSecondary	Reach-in freezer	2	555	986
	Reach-in refrigerator	2	313.3	730

Table 49: Additional Commercial Refrigeration Equipment

Building	Refrigeration Object Name	Case Length (m)	Cooling Capacity per unit length (W/m)	COP	Condenser Fan Power (W)	Evap Fan Power (W)	Light (W/m)	Case Temp (°C)
Hospital	WALKINFREEZER	10.98	734	2.3	1000	19.7	33	-23
	SELFCONTAINEDDISPLAYCASE	8.93	886.5	6.93	1000	19.1	40	2
HotelLarge	WALKINFREEZER	7.32	367	2.32	350	9.7	16.4	-23
	SELFCONTAINEDDISPLAYCASE	3.66	734	6.98	350	15.7	33	2
RestaurantFastFood	WALKINFREEZER	2.44	688	2.51	330	21.1	33	-23
	SELFCONTAINEDDISPLAYCASE	3.05	734	7.29	330	18.8	33	2
RestaurantSitDown	WALKINFREEZER	2.44	688	2.51	330	21.1	33	-23
	SELFCONTAINEDDISPLAYCASE	3.05	734	7.29	330	18.8	33	2
SchoolPrimary	WALKINFREEZER	3.66	734	2.32	350	19.5	33	-23
	SELFCONTAINEDDISPLAYCASE	3.66	734	6.98	350	15.7	33	2
SchoolSecondary	WALKINFREEZER	7.32	734	2.34	750	19.5	33	-23
	SELFCONTAINEDDISPLAYCASE	7.32	734	7.12	750	15.7	33	2

6.0 Calculating Building Performance Using Metrics Other than Energy Cost

To meet goals of building decarbonization and electrification, states and local jurisdictions have shown interest in using metrics other than energy cost to rate the performance of buildings. Because the cost of natural gas is lower than that of electricity in most locations in the U.S., a direct comparison of cost tends to encourage the use of fossil fuels for space and SWH. To address this conflict and meet the needs of policymakers, the authors have developed a new approach for using Appendix G in conjunction with performance metrics other than energy cost, including site energy, source energy and carbon emissions. This new approach is included as an informative appendix to ASHRAE Standard 90.1-2022.

Since 90.1 Appendix G uses energy cost as the basis of the compliance calculations, the BPFs provided in 90.1 Section 4 are calculated by converting site energy use of the prototype models to energy cost using the national average utility rates. In order to use metrics other than cost, the metric-specific BPFs must be used in place of cost-based BPFs. 90.1-2019 BPFs for site energy, source energy, and emission metrics derived using the new approach described in Section 3.0 are shown in Table 50, Table 51, and Table 52. These values were determined using Equation 7, which is analogous to Equation 3 but with the regulated energy use of the building prototypes expressed in metrics other than cost.

$$BPF_{90.1-2019,metric\ i} = \frac{\sum \frac{Appendix\ G\ Proposed\ Regulated\ Energy\ Use_{metric\ i}}{Appendix\ G\ Baseline\ Regulated\ Energy\ Use_{metric\ i}}}{N_p} \quad \text{Equation 7}$$

where,

Appendix G Proposed Regulated Energy Use_{metric i} = regulated energy use of Appendix G proposed model for a given building prototype, climate zone for ASHRAE Standard 90.1-2019 expressed in metric i

Appendix G Baseline Regulated Energy Use_{metric i} = regulated energy use of Appendix G baseline model for a given building prototype, climate zone expressed in metric i

N_p = number of prototype buildings of a particular building area type from Table 2

Metric I = metric selected to express energy use including site energy, energy cost, source energy, or carbon. Table 53 includes the conversion factors that were applied to electricity and natural gas use of the prototype models in order to determine the BPFs in Table 50, Table 51, and Table 52.

Table 50: Site Energy BPF: Standard 90.1-2019

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.76	0.71	0.76	0.73	0.76	0.73	0.76	0.74	0.69	0.71	0.74	0.72	0.68	0.72	0.73	0.67	0.69	0.67	0.73
Healthcare/hospital	0.71	0.71	0.71	0.72	0.74	0.70	0.72	0.73	0.71	0.72	0.73	0.71	0.74	0.73	0.85	0.73	0.79	0.80	0.82
Hotel/motel	0.74	0.73	0.75	0.73	0.74	0.73	0.75	0.77	0.76	0.75	0.78	0.78	0.74	0.77	0.78	0.72	0.76	0.72	0.72
Office	0.62	0.63	0.61	0.62	0.58	0.60	0.57	0.62	0.55	0.55	0.61	0.58	0.59	0.62	0.60	0.59	0.62	0.54	0.59
Restaurant	0.67	0.63	0.65	0.63	0.64	0.61	0.66	0.69	0.68	0.72	0.72	0.72	0.76	0.77	0.75	0.78	0.78	0.79	0.82
Retail	0.57	0.54	0.53	0.53	0.48	0.47	0.47	0.49	0.48	0.59	0.53	0.61	0.66	0.59	0.66	0.67	0.64	0.60	0.67
School	0.57	0.57	0.58	0.57	0.55	0.54	0.57	0.53	0.50	0.47	0.53	0.56	0.53	0.57	0.56	0.54	0.52	0.52	0.60
Warehouse	0.28	0.30	0.24	0.27	0.23	0.24	0.27	0.23	0.19	0.40	0.29	0.33	0.49	0.39	0.34	0.52	0.45	0.46	0.51
All others	0.66	0.63	0.66	0.63	0.59	0.55	0.58	0.58	0.61	0.61	0.60	0.64	0.64	0.63	0.70	0.66	0.66	0.64	0.68

Table 51: Source Energy BPF: Standard 90.1-2019

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.73	0.68	0.72	0.69	0.72	0.68	0.70	0.69	0.61	0.70	0.70	0.68	0.68	0.69	0.69	0.69	0.68	0.68	0.75
Healthcare/hospital	0.72	0.73	0.73	0.73	0.74	0.71	0.72	0.74	0.71	0.72	0.73	0.71	0.74	0.73	0.79	0.73	0.76	0.77	0.78
Hotel/motel	0.72	0.70	0.72	0.70	0.70	0.68	0.70	0.72	0.70	0.70	0.72	0.71	0.70	0.71	0.72	0.69	0.71	0.68	0.69
Office	0.62	0.63	0.61	0.62	0.58	0.60	0.57	0.62	0.55	0.56	0.61	0.57	0.58	0.61	0.58	0.57	0.60	0.55	0.58
Restaurant	0.65	0.61	0.62	0.61	0.61	0.57	0.61	0.62	0.61	0.65	0.63	0.64	0.68	0.67	0.66	0.70	0.69	0.72	0.75
Retail	0.57	0.54	0.53	0.53	0.48	0.47	0.47	0.47	0.47	0.50	0.49	0.54	0.54	0.51	0.56	0.55	0.53	0.51	0.57
School	0.57	0.57	0.57	0.57	0.55	0.53	0.57	0.51	0.48	0.48	0.50	0.50	0.51	0.52	0.50	0.52	0.50	0.51	0.56
Warehouse	0.28	0.30	0.24	0.27	0.23	0.24	0.27	0.23	0.20	0.30	0.24	0.27	0.36	0.30	0.27	0.40	0.35	0.37	0.41
All others	0.64	0.62	0.64	0.62	0.57	0.54	0.56	0.55	0.57	0.58	0.56	0.59	0.59	0.58	0.63	0.60	0.61	0.60	0.63

Table 52: Carbon BPF: Standard 90.1-2019

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.74	0.69	0.73	0.70	0.73	0.70	0.72	0.71	0.63	0.70	0.71	0.70	0.68	0.70	0.70	0.68	0.68	0.68	0.74
Healthcare/hospital	0.72	0.72	0.73	0.73	0.74	0.71	0.72	0.74	0.71	0.72	0.73	0.71	0.74	0.73	0.81	0.73	0.77	0.78	0.79
Hotel/motel	0.72	0.71	0.73	0.71	0.72	0.70	0.72	0.73	0.72	0.72	0.73	0.73	0.72	0.73	0.74	0.70	0.72	0.70	0.70
Office	0.62	0.63	0.61	0.62	0.58	0.60	0.57	0.62	0.55	0.55	0.61	0.57	0.58	0.61	0.59	0.58	0.61	0.54	0.58
Restaurant	0.66	0.62	0.63	0.61	0.62	0.59	0.63	0.64	0.63	0.67	0.66	0.67	0.71	0.70	0.69	0.73	0.72	0.74	0.78
Retail	0.57	0.54	0.53	0.53	0.48	0.47	0.47	0.47	0.47	0.53	0.50	0.56	0.58	0.53	0.59	0.59	0.56	0.54	0.60
School	0.57	0.57	0.58	0.57	0.55	0.54	0.57	0.51	0.49	0.47	0.51	0.52	0.51	0.54	0.52	0.53	0.50	0.51	0.58
Warehouse	0.28	0.30	0.24	0.27	0.23	0.24	0.27	0.23	0.20	0.33	0.26	0.29	0.41	0.33	0.29	0.44	0.38	0.40	0.45
All others	0.65	0.63	0.64	0.62	0.58	0.54	0.57	0.56	0.58	0.59	0.57	0.61	0.61	0.59	0.65	0.62	0.62	0.61	0.65

The conversion factors are based on a national average conversion factor for carbon emission, source energy, and site energy cost. The energy prices shown are based on values adopted by the ASHRAE 90.1 SSPC for development of Standard 90.1-2019, 90.1-2016 and 90.1-2022 and are used to calculate the BPFs published in Table 4.2.1.1 of the Standard. When local energy conversion factors differ from those specified in Table 53, or when different conversion factors

are adopted by the rating authority or jurisdiction, the BPFs should also be updated in accordance with Equation 8.

$$BPF_{ij} = \frac{(EC + A_{ij} * GC)}{(B_{ij} * EC + C_{ij} * GC)}$$

Equation 8: BPF: site energy coefficient method

where:

- BPF_{ij} = BPF of building area type i and climate zone j
- EC = custom electricity conversion factor expressed using units shown in Table 55, for the selected metric
- GC = custom gas conversion factor expressed using units shown in Table 55 for the selected metric
- $A_{i,j}, B_{i,j}, C_{i,j}$ = coefficients from Table 54: Coefficient A: Standard 90.1-2019 BPF Calculation, Table 55: Coefficient B: Standard 90.1-2019 BPF Calculation and Table 56: Coefficient C: Standard 90.1-2019 BPF Calculation for building area type i and climate zone j for Standard 90.1-2019

Table 53: Default Conversion Factors

Fuel Type	Units	Carbon Emissions CO ₂ e lb/unit ²²	Source Energy kBtu/unit ²³	90.1-2019 Energy Cost \$/unit	90.1-2016 Energy Cost \$/unit	90.1-2022 Energy Cost \$/unit
Electricity	kWh	1.2	9.008	0.1063	0.1013	0.1099
Natural gas	Therm	19.96	109.0	0.98	1.00	0.802

Coefficients $A_{i,j}, B_{i,j}, C_{i,j}$ are calculated from building type site energy using Equation 7: $A_{i,j}$, Equation 8: $B_{i,j}$, and Equation 9: $C_{i,j}$.

²² US EPA, “Greenhouse Gas Equivalencies Calculator.”

²³ Calculated using values in <https://www.eia.gov/outlooks/aeo>

$$A_{ij} = \frac{\sum_{n=1}^N \frac{\text{Proposed Regulated Gas Site Energy Use Index}}{N_i}}{\sum_{n=1}^N \frac{\text{Proposed Regulated Electric Site Energy Use Index}}{N_i}} \quad \text{Equation 7: } A_{ij}$$

$$B_{ij} = \frac{\sum_{n=1}^N \frac{\text{Baseline Regulated Electric Site Energy Use Index}}{N_i}}{\sum_{n=1}^N \frac{\text{Proposed Regulated Electric Site Energy Use Index}}{N_i}} \quad \text{Equation 8: } B_{ij}$$

$$C_{ij} = \frac{\sum_{n=1}^N \frac{\text{Baseline Regulated Gas Site Energy Use Index}}{N_i}}{\sum_{n=1}^N \frac{\text{Proposed Regulated Electric Site Energy Use Index}}{N_i}} \quad \text{Equation 9: } C_{ij}$$

where

- $A_{i,j}, B_{i,j}, C_{i,j}$ = coefficients from Table 54, Table 55, and Table 56 for building area type i and climate zone j for Standard 90.1-2019
- N_i = number of prototypes of building area type i
- Proposed Regulated Electric Site Energy Use Index* = total site energy of regulated electric use index of the proposed model in kbtu/sqft
- Proposed Regulated Gas Site Energy Use Index* = total site energy of regulated gas use index of the proposed model in kbtu/sqft
- Baseline Regulated Electric Site Energy Use Index* = total site energy of regulated electric use index of the baseline model in kbtu/sqft
- Baseline Regulated Gas Site Energy Use Index* = total site energy of regulated gas use index of the baseline model in kbtu/sqft

Table 54: Coefficient A: Standard 90.1-2019 BPF Calculation

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.3202	0.3471	0.4470	0.4293	0.5476	0.5719	0.7405	0.7587	1.2088	1.2631	0.9411	1.4472	1.7185	1.2744	1.5385	1.9332	1.7282	2.1342	2.5624
Healthcare	0.1256	0.1399	0.1648	0.1645	0.2439	0.2086	0.3225	0.2623	0.3007	0.4694	0.3224	0.5155	0.6343	0.4589	0.8201	0.7937	0.8033	1.1090	1.4330
Hotel/motel	0.3415	0.3636	0.4389	0.4305	0.5086	0.5775	0.6549	0.7739	0.8662	1.1295	1.0046	1.2793	1.4288	1.2570	1.4545	1.6549	1.6045	1.9615	2.5580
Office	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0472	0.0109	0.2494	0.0934	0.2260	0.4607	0.2651	0.2826	0.7034	0.5338	0.6866	1.0767
Restaurant	0.2438	0.2664	0.3571	0.3334	0.4304	0.5019	0.5787	0.8927	1.0238	1.9042	1.3806	2.0509	2.9239	2.1435	2.5454	3.7037	3.0742	4.7833	7.0495
Retail	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0939	0.0151	0.7073	0.2139	0.5158	1.1657	0.5741	0.6666	1.5120	1.0199	1.4566	2.0898
School	0.0349	0.0400	0.0488	0.0498	0.0602	0.0746	0.0801	0.2037	0.1931	0.4792	0.3620	0.7531	0.8949	0.7904	0.8618	1.3288	1.0594	1.6119	2.8447
Warehouse	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1234	0.0120	2.4944	0.8154	1.2124	4.3340	2.2027	1.1713	5.8632	3.6153	5.7104	6.3839
All others	0.1702	0.1831	0.2324	0.2241	0.2059	0.1821	0.2378	0.3646	0.4500	0.8450	0.4719	0.8796	1.2631	0.8641	0.9432	1.5643	1.2397	1.6035	2.3536

Table 55: Coefficient B: Standard 90.1-2019 BPF Calculation

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	1.4096	1.5386	1.4572	1.5316	1.4882	1.5699	1.5608	1.5699	1.9675	1.4661	1.5443	1.5984	1.4591	1.5354	1.5802	1.3860	1.5059	1.4034	1.2593
Healthcare	1.3583	1.3399	1.3477	1.3402	1.3467	1.3761	1.3814	1.3436	1.4073	1.3970	1.3575	1.4048	1.3559	1.3779	1.3908	1.3725	1.3722	1.3796	1.3711
Hotel/motel	1.4484	1.4892	1.4636	1.5043	1.5026	1.5630	1.5322	1.5090	1.5595	1.5659	1.5503	1.5845	1.5540	1.5674	1.5991	1.5645	1.5946	1.6024	1.6154
Office	1.6039	1.5981	1.6394	1.6210	1.7388	1.6587	1.7471	1.6329	1.7983	1.7951	1.6457	1.7773	1.7573	1.6787	1.7815	1.7916	1.7310	1.7986	1.7369
Restaurant	1.5714	1.6801	1.6690	1.7138	1.7295	1.8583	1.7422	1.8424	1.8882	1.8901	1.9039	1.9794	1.9049	1.9212	1.9789	1.8996	1.9352	1.9387	1.9412
Retail	1.7521	1.8534	1.8797	1.8857	2.0653	2.1365	2.1082	2.2069	2.1290	2.3199	2.1795	2.1067	2.3618	2.2921	2.0855	2.4427	2.3680	2.4769	2.3159
School	1.7631	1.7505	1.7452	1.7708	1.8390	1.8864	1.7794	2.0557	2.1670	2.0484	2.1068	2.2727	2.0493	2.1656	2.2790	2.0254	2.1476	2.0580	2.0429
Warehouse	3.5996	3.3744	4.0890	3.7035	4.2719	4.1009	3.7589	4.4501	4.8766	5.2688	4.9071	4.9570	5.4111	5.1946	4.8579	5.3240	4.9834	5.3269	4.9303
All others	1.5751	1.6379	1.6112	1.6594	1.8039	1.9139	1.8438	1.9357	1.8688	1.8643	1.9304	1.8842	1.9320	1.9399	1.8345	1.8847	1.8642	1.8489	1.8824

Table 56: Coefficient C: Standard 90.1-2019 BPF Calculation

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.3202	0.3470	0.4469	0.4292	0.5476	0.5718	0.7403	0.8056	1.2325	1.7350	1.0782	1.7962	2.5221	1.6334	1.9167	2.9889	2.4752	3.2574	3.6278
Healthcare	0.2280	0.2702	0.2828	0.2849	0.3449	0.3529	0.4446	0.3748	0.4373	0.6503	0.4518	0.7314	0.8494	0.6245	0.7548	1.0785	0.8997	1.2438	1.6088
Hotel/motel	0.3530	0.3758	0.4526	0.4440	0.5237	0.5946	0.6722	0.7922	0.8931	1.2823	1.0325	1.3459	1.7219	1.3725	1.5316	2.1200	1.8408	2.5203	3.3113
Office	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0553	0.0562	0.4637	0.1498	0.3318	0.7115	0.3583	0.3444	1.1134	0.7445	1.3288	1.8001
Restaurant	0.2923	0.3196	0.4214	0.3942	0.5023	0.5851	0.6631	0.9193	1.1073	2.1255	1.3971	2.2318	3.2644	2.1703	2.7776	4.1472	3.2811	5.3710	7.9258
Retail	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0251	0.0034	0.5894	0.1119	0.3666	0.9245	0.3786	0.4484	1.2913	0.7833	1.6302	2.3288
School	0.0528	0.0600	0.0715	0.0726	0.0860	0.1062	0.1101	0.2187	0.2003	1.1096	0.4517	0.8531	1.5531	0.9528	1.0586	2.2782	1.8180	2.9800	4.3864
Warehouse	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3819	0.3370	3.4736	1.3793	1.6682	5.4999	3.0422	1.5691	7.8010	5.2326	9.1237	9.4500
All others	0.2069	0.2256	0.2554	0.2687	0.2424	0.2248	0.2773	0.4063	0.5195	1.1443	0.5243	1.0434	1.5852	0.9963	0.9273	2.0259	1.5269	2.2347	3.0522

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Appendix A – Building Envelope

Table A.1: Baseline Opaque Envelope Requirements by Assembly Type and Climate Zone

Unit	Insulated Entirely Above Deck			Steel Framed			Below-grade Wall			Steel-joint			Slab-on-grade Unheated			Swinging			Non-swinging		
	U value (Btu/(h·ft ² ·°F))			U value (Btu/(h·ft ² ·°F))			C-factor (Btu/ft ² ·°F·h)			U value (Btu/(h·ft ² ·°F))			F-factor (Btu/ft ² ·°F·h)			U value (Btu/(h·ft ² ·°F))			U value (Btu/(h·ft ² ·°F))		
	CZ	Non-res	Res	Semi-heat	Non-res	Res	Semi-heat	Non-res	Res	Semi-heat	Non-res	Res	Semi-heat	Non-res	Res	Semi-heat	Non-res	Res	Semi-heat	Non-res	Res
0A	0.06	0.06	1.28	0.12	0.12	0.35	1.14	1.14	1.14	0.35	0.35	0.35	0.73	0.73	0.73	0.70	0.70	0.70	1.45	1.45	1.45
0B	0.06	0.06	1.28	0.12	0.12	0.35	1.14	1.14	1.14	0.35	0.35	0.35	0.73	0.73	0.73	0.70	0.70	0.70	1.45	1.45	1.45
1A	0.06	0.06	1.28	0.12	0.12	0.35	1.14	1.14	1.14	0.35	0.35	0.35	0.73	0.73	0.73	0.70	0.70	0.70	1.45	1.45	1.45
1B	0.06	0.06	1.28	0.12	0.12	0.35	1.14	1.14	1.14	0.35	0.35	0.35	0.73	0.73	0.73	0.70	0.70	0.70	1.45	1.45	1.45
2A	0.06	0.06	0.22	0.12	0.12	0.35	1.14	1.14	1.14	0.05	0.05	0.35	0.73	0.73	0.73	0.70	0.70	0.70	1.45	1.45	1.45
2B	0.06	0.06	0.22	0.12	0.12	0.35	1.14	1.14	1.14	0.05	0.05	0.35	0.73	0.73	0.73	0.70	0.70	0.70	1.45	1.45	1.45
3A	0.06	0.06	0.22	0.12	0.08	0.35	1.14	1.14	1.14	0.05	0.05	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
3B	0.06	0.06	0.22	0.12	0.08	0.35	1.14	1.14	1.14	0.05	0.05	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
3C	0.06	0.06	0.22	0.12	0.08	0.35	1.14	1.14	1.14	0.05	0.05	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
4A	0.06	0.06	0.22	0.12	0.06	0.12	1.14	1.14	1.14	0.05	0.04	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
4B	0.06	0.06	0.22	0.12	0.06	0.12	1.14	1.14	1.14	0.05	0.04	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
4C	0.06	0.06	0.22	0.12	0.06	0.12	1.14	1.14	1.14	0.05	0.04	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
5A	0.06	0.06	0.17	0.08	0.06	0.12	1.14	1.14	1.14	0.05	0.04	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
5B	0.06	0.06	0.17	0.08	0.06	0.12	1.14	1.14	1.14	0.05	0.04	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
5C	0.06	0.06	0.17	0.08	0.06	0.12	1.14	1.14	1.14	0.05	0.04	0.07	0.73	0.73	0.73	0.70	0.70	0.70	1.45	0.50	1.45
6A	0.06	0.06	0.17	0.08	0.06	0.12	1.14	0.12	1.14	0.04	0.04	0.07	0.73	0.73	0.73	0.70	0.50	0.70	0.50	0.50	1.45
6B	0.06	0.06	0.17	0.08	0.06	0.12	1.14	0.12	1.14	0.04	0.04	0.07	0.73	0.73	0.73	0.70	0.50	0.70	0.50	0.50	1.45
7	0.06	0.06	0.17	0.06	0.06	0.12	0.12	0.12	1.14	0.04	0.04	0.05	0.73	0.54	0.73	0.70	0.50	0.70	0.50	0.50	1.45
8	0.05	0.05	0.09	0.06	0.06	0.12	0.12	0.12	1.14	0.04	0.03	0.05	0.54	0.52	0.73	0.50	0.50	0.70	0.50	0.50	1.45

Table A.2: Baseline Vertical Fenestration Performance by Window to Wall Area Ratio and Climate Zone

CZ	Window to Wall Ratio: 0% to 10.0%									Window to Wall Ratio: 10.1% to 20.0%									Window to Wall Ratio: 20.1% to 30.0%									Window to Wall Ratio: 30.1% to 40.0%								
	U value (Btu/(h·ft ² ·°F))			SHGC			Visible Transmittance			U value (Btu/(h·ft ² ·°F))			SHGC			Visible Transmittance			U value (Btu/(h·ft ² ·°F))			SHGC			Visible Transmittance			U value (Btu/(h·ft ² ·°F))			SHGC			Visible Transmittance		
	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat	Non res	Res	Semi- heat
0A	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44
0B	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44
1A	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44
1B	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44
2A	1.22	1.22	1.22	0.25	0.39	0.4	0.28	0.43	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44
2B	1.22	1.22	1.22	0.25	0.39	0.4	0.28	0.43	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44	1.22	1.22	1.22	0.25	0.25	0.4	0.28	0.28	0.44
3A	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.25	0.39	0.4	0.28	0.43	0.44	0.57	0.57	1.22	0.25	0.25	0.4	0.28	0.28	0.44	0.57	0.57	1.22	0.25	0.25	0.4	0.28	0.28	0.44
3B	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.25	0.39	0.4	0.28	0.43	0.44	0.57	0.57	1.22	0.25	0.25	0.4	0.28	0.28	0.44	0.57	0.57	1.22	0.25	0.25	0.4	0.28	0.28	0.44
3C	1.22	1.22	1.22	0.61	0.61	0.4	0.67	0.67	0.44	1.22	1.22	1.22	0.39	0.67	0.4	0.43	0.67	0.44	1.22	1.22	1.22	0.39	0.39	0.4	0.43	0.43	0.44	1.22	1.22	1.22	0.34	0.34	0.4	0.37	0.37	0.44
4A	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
4B	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
4C	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
5A	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
5B	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
5C	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
6A	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
6B	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44	0.57	0.57	1.22	0.39	0.39	0.4	0.43	0.43	0.44
7	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44	0.57	0.57	1.22	0.49	0.49	0.4	0.54	0.54	0.44
8	0.46	0.46	1.22	0.4	0.4	0.4	0.44	0.44	0.44	0.46	0.46	1.22	0.4	0.4	0.4	0.44	0.44	0.44	0.46	0.46	1.22	0.4	0.4	0.4	0.44	0.44	0.44	0.46	0.46	1.22	0.4	0.4	0.4	0.44	0.44	0.44

Table A.3: Baseline Skylight Performance by Skylight to Roof Ratio and Climate Zone

CZ	Skylight to Roof Ratio: 0% to 2.0%									Skylight to Roof Ratio: 2.1%+								
	U value (Btu/(h·ft ² ·°F))			SHGC			Visible Transmittance			U value (Btu/(h·ft ² ·°F))			SHGC			Visible Transmittance		
	Non res	Res	Semi-heat	Non res	Res	Semi-heat	Non res	Res	Semi-heat	Non res	Res	Semi-heat	Non res	Res	Semi-heat	Non res	Res	Semi-heat
0A	1.36	1.36	1.36	0.36	0.19	0.55	0.4	0.21	0.61	1.36	1.36	1.36	0.19	0.19	0.55	0.21	0.21	0.61
0B	1.36	1.36	1.36	0.36	0.19	0.55	0.4	0.21	0.61	1.36	1.36	1.36	0.19	0.19	0.55	0.21	0.21	0.61
1A	1.36	1.36	1.36	0.36	0.19	0.55	0.4	0.21	0.61	1.36	1.36	1.36	0.19	0.19	0.55	0.21	0.21	0.61
1B	1.36	1.36	1.36	0.36	0.19	0.55	0.4	0.21	0.61	1.36	1.36	1.36	0.19	0.19	0.55	0.21	0.21	0.61
2A	1.36	1.36	1.36	0.36	0.19	0.55	0.4	0.21	0.61	1.36	1.36	1.36	0.19	0.19	0.55	0.21	0.21	0.61
2B	1.36	1.36	1.36	0.36	0.19	0.55	0.4	0.21	0.61	1.36	1.36	1.36	0.19	0.19	0.55	0.21	0.21	0.61
3A	0.69	0.69	1.36	0.39	0.36	0.55	0.43	0.4	0.61	0.69	0.69	1.36	0.19	0.19	0.55	0.21	0.21	0.61
3B	0.69	0.69	1.36	0.39	0.36	0.55	0.43	0.4	0.61	0.69	0.69	1.36	0.19	0.19	0.55	0.21	0.21	0.61
3C	1.36	1.36	1.36	0.61	0.39	0.55	0.67	0.43	0.61	1.36	1.36	1.36	0.39	0.19	0.55	0.43	0.21	0.61
4A	0.69	0.58	1.36	0.49	0.36	0.55	0.54	0.4	0.61	0.69	0.58	1.36	0.39	0.19	0.55	0.43	0.21	0.61
4B	0.69	0.58	1.36	0.49	0.36	0.55	0.54	0.4	0.61	0.69	0.58	1.36	0.39	0.19	0.55	0.43	0.21	0.61
4C	0.69	0.58	1.36	0.49	0.36	0.55	0.54	0.4	0.61	0.69	0.58	1.36	0.39	0.19	0.55	0.43	0.21	0.61
5A	0.69	0.69	1.36	0.49	0.49	0.55	0.54	0.54	0.61	0.69	0.69	1.36	0.39	0.39	0.55	0.43	0.43	0.61
5B	0.69	0.69	1.36	0.49	0.49	0.55	0.54	0.54	0.61	0.69	0.69	1.36	0.39	0.39	0.55	0.43	0.43	0.61
5C	0.69	0.69	1.36	0.49	0.49	0.55	0.54	0.54	0.61	0.69	0.69	1.36	0.39	0.39	0.55	0.43	0.43	0.61
6A	0.69	0.58	1.36	0.49	0.49	0.55	0.54	0.54	0.61	0.69	0.58	1.36	0.49	0.39	0.55	0.54	0.43	0.61
6B	0.69	0.58	1.36	0.49	0.49	0.55	0.54	0.54	0.61	0.69	0.58	1.36	0.49	0.39	0.55	0.54	0.43	0.61
7	0.69	0.69	1.36	0.68	0.64	0.55	0.75	0.7	0.61	0.69	0.69	1.36	0.64	0.64	0.55	0.7	0.7	0.61
8	0.58	0.58	0.81	0.55	0.55	0.55	0.61	0.61	0.61	0.58	0.58	0.81	0.55	0.55	0.55	0.61	0.61	0.61

Appendix B – Lighting

Table B.1: Space by Space Mapping of Prototype Zones and Appendix G Baseline Interior Lighting Power Density

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)		
HotelLarge	BASEMENT	Office -- Open plan	0.43	1.03		
		Office -- Enclosed	0.19			
		Corridor -- All other corridor	0.09			
		Storage Room -- <50 ft ²	0.05			
		Conference/Meeting/Multipurpose Room	0.05			
		Stairwell	0.04			
		Lobby -- All other lobby	0.04			
		Restroom -- All other restroom	0.04			
		Electrical/Mechanical Room	0.03			
		Storage Room -- ≥50 ft ²	0.02			
		Lounge/Breakroom -- All other lounge/breakroom	0.02			
		RETAIL_1_FLR_1	Sales Area		0.78	1.50
		RETAIL_2_FLR_1	Storage Room -- ≥50 ft ²		0.22	
	MECH_FLR_1	Electrical/Mechanical Room	1.00	1.50		
	STORAGE_FLR_1	Storage Room -- ≥50 ft ²	0.86	0.80		
		Storage Room -- <50 ft ²	0.14			
	LAUNDRY_FLR_1	Laundry/Washing Area	1.00	0.6		
	CAFE_FLR_1	Dining Area -- Family dining	1.00	1.4		
	LOBBY_FLR_1	Lobby -- Hotel	1.00	1.3		
	ROOM_1_FLR_3	Guest Room-bathroom	0.69	1.14		
	ROOM_2_FLR_3					
	ROOM_3_MULT19_FLR_3					
	ROOM_4_MULT19_FLR_3					
	ROOM_5_FLR_3					
	ROOM_6_FLR_3					
	ROOM_1_FLR_6					
	ROOM_2_FLR_6					
ROOM_3_MULT9_FLR_6						
BANQUET_FLR_6	Dining Area -- Family dining	1.00	1.4			
DINING_FLR_6	Dining Area -- Family dining	1.00	1.4			
KITCHEN_FLR_6	Food Preparation Area	1.00	1.2			
CORRIDOR_FLR_3	Corridor -- All other corridor	1.00	0.5			
CORRIDOR_FLR_6						

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
SchoolPrimary	CORNER_CLASS_1_POD_1_ZN_1_FLR_1	Classroom/Lecture Hall/Training Room -- Preschool through 12th grade, laboratory, and shop classrooms	0.86	1.4
	MULT_CLASS_1_POD_1_ZN_1_FLR_1			
	CORRIDOR_POD_1_ZN_1_FLR_1			
	CORNER_CLASS_2_POD_1_ZN_1_FLR_1			
	MULT_CLASS_2_POD_1_ZN_1_FLR_1			
	CORNER_CLASS_1_POD_2_ZN_1_FLR_1	Laboratory -- In or as a classroom	0.14	
	MULT_CLASS_1_POD_2_ZN_1_FLR_1			
	CORNER_CLASS_2_POD_2_ZN_1_FLR_1			
	CORNER_CLASS_2_POD_3_ZN_1_FLR_1			
	MULT_CLASS_2_POD_3_ZN_1_FLR_1			
	COMPUTER_CLASS_ZN_1_FLR_1			
	CORRIDOR_POD_2_ZN_1_FLR_1	Corridor -- All other corridor	0.91	
	CORRIDOR_POD_3_ZN_1_FLR_1	Stairwell	0.09	
	MAIN_CORRIDOR_ZN_1_FLR_1			
	LOBBY_ZN_1_FLR_1	Lobby -- All other lobby	1.00	
	MECH_ZN_1_FLR_1	Electrical/Mechanical Room	1.00	
	BATH_ZN_1_FLR_1	Restroom -- All other restroom	1.00	
	OFFICES_ZN_1_FLR_1	Office -- Enclosed	0.57	
		Office -- Open plan	0.43	
	GYM_ZN_1_FLR_1	Gymnasium/Fitness Center -- Exercise area	0.75	
Locker Room		0.15		
KITCHEN_ZN_1_FLR_1	Food Preparation Area	1.00		
CAFETERIA_ZN_1_FLR_1	Dining Area -- Family dining	1.00		
LIBRARY_MEDIA_CENTER_ZN_1_FLR_1	Library -- Stacks	0.30		
	Library -- Reading area	0.70		
SchoolSecondary	CORNER_CLASS_1_POD_1_ZN_1_FLR_1	Classroom/Lecture Hall/Training Room -- Preschool through 12th grade, laboratory, and shop classrooms	0.86	
	CORNER_CLASS_1_POD_1_ZN_1_FLR_2			
	MULT_CLASS_1_POD_1_ZN_1_FLR_1			
	MULT_CLASS_1_POD_1_ZN_1_FLR_2			
	CORNER_CLASS_2_POD_1_ZN_1_FLR_1			
	CORNER_CLASS_2_POD_1_ZN_1_FLR_2			
	MULT_CLASS_2_POD_1_ZN_1_FLR_1			
	MULT_CLASS_2_POD_1_ZN_1_FLR_2			
	CORNER_CLASS_1_POD_2_ZN_1_FLR_1	Laboratory -- In or as a classroom	0.14	
	CORNER_CLASS_1_POD_2_ZN_1_FLR_2			
	MULT_CLASS_1_POD_2_ZN_1_FLR_1			
	MULT_CLASS_1_POD_2_ZN_1_FLR_2			
	CORNER_CLASS_2_POD_2_ZN_1_FLR_1			
	CORNER_CLASS_2_POD_2_ZN_1_FLR_2			
	MULT_CLASS_2_POD_2_ZN_1_FLR_1			
	MULT_CLASS_2_POD_2_ZN_1_FLR_2			

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
	CORNER_CLASS_1_POD_3_ZN_1_FLR_1			
	CORNER_CLASS_1_POD_3_ZN_1_FLR_2			
	MULT_CLASS_1_POD_3_ZN_1_FLR_1			
	MULT_CLASS_1_POD_3_ZN_1_FLR_2			
	CORNER_CLASS_2_POD_3_ZN_1_FLR_1			
	CORNER_CLASS_2_POD_3_ZN_1_FLR_2			
	MULT_CLASS_2_POD_3_ZN_1_FLR_1			
	MULT_CLASS_2_POD_3_ZN_1_FLR_2			
	CORRIDOR_POD_1_ZN_1_FLR_1	Corridor -- All other corridor	0.87	
	CORRIDOR_POD_1_ZN_1_FLR_2			
	CORRIDOR_POD_2_ZN_1_FLR_1			
	CORRIDOR_POD_2_ZN_1_FLR_2			
	CORRIDOR_POD_3_ZN_1_FLR_1	Stairwell	0.13	0.5
	CORRIDOR_POD_3_ZN_1_FLR_2			
	MAIN_CORRIDOR_ZN_1_FLR_1			
	MAIN_CORRIDOR_ZN_1_FLR_2			
	LOBBY_ZN_1_FLR_1	Lobby -- All other lobby	1.00	1.3
	LOBBY_ZN_1_FLR_2			
	BATHROOMS_ZN_1_FLR_1	Restroom -- All other restroom	1.00	0.9
	BATHROOMS_ZN_1_FLR_2			
	OFFICES_ZN_1_FLR_1	Office -- Enclosed	0.60	1.1
	OFFICES_ZN_1_FLR_2	Office -- Open plan	0.40	
	GYM_ZN_1_FLR_1	Gymnasium/Fitness Center -- Exercise area	0.80	1.4
	AUX_GYM_ZN_1_FLR_1	Locker Room	0.20	
	AUDITORIUM_ZN_1_FLR_1	Audience Seating Area -- Auditorium	1.00	0.9
	KITCHEN_ZN_1_FLR_1	Food Preparation Area	1.00	1.2
	LIBRARY_MEDIA_CENTER_ZN_1_FLR_2	Library -- Stacks	0.30	1.35
		Library -- Reading area	0.70	
	CAFETERIA_ZN_1_FLR_1	Dining Area -- Family dining	1.00	0.9
	MECH_ZN_1_FLR_1			
	MECH_ZN_1_FLR_2	Electrical/Mechanical Room	1.00	1.5
		Office -- Open plan	0.16	
		Office -- Enclosed	0.31	
	CORE_ZN	Conference/Meeting/Multipurpose Room	0.09	
	PERIMETER_ZN_1	Corridor -- All other corridor	0.13	
	PERIMETER_ZN_2	Storage Room -- ≥50 ft ²	0.15	0.99
	PERIMETER_ZN_3	Restroom -- All other restroom	0.04	
	PERIMETER_ZN_4	Electrical/Mechanical Room	0.02	
		Stairwell	0.03	
		Lobby -- All other lobby	0.06	

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)		
OfficeMedium	CORE_BOTTOM	Office -- Open plan	0.42	0.99		
	CORE_MID	Office -- Enclosed	0.19			
	CORE_TOP	Corridor -- All other corridor	0.09			
	PERIMETER_TOP_ZN_3	Storage Room -- <50 ft2	0.05			
	PERIMETER_TOP_ZN_2	Conference/Meeting/Multipurpose Room	0.05			
	PERIMETER_TOP_ZN_1	Stairwell	0.04			
	PERIMETER_TOP_ZN_4	Lobby -- All other lobby	0.04			
	PERIMETER_BOT_ZN_3	Restroom -- All other restroom	0.04			
	PERIMETER_BOT_ZN_2	Electrical/Mechanical Room	0.03			
	PERIMETER_BOT_ZN_1	Storage Room -- ≥50 ft2	0.02			
	PERIMETER_BOT_ZN_4	Lounge/Breakroom -- All other lounge/breakroom	0.02			
	PERIMETER_MID_ZN_3	Dining Area -- All other dining area	0.01			
	PERIMETER_MID_ZN_2	Classroom/Lecture Hall/Training Room --All other classroom/lecture hall/training room	0.01			
	PERIMETER_MID_ZN_1	Food Preparation Area	0.00			
	PERIMETER_MID_ZN_4					
	OfficeLarge		Office -- Open plan		0.571	1.08
			Electrical/Mechanical Room		0.062	
		Corridor -- All other corridor	0.043			
		Restroom -- All other restroom	0.031			
		Office -- Enclosed	0.185			
		Lobby -- All other lobby	0.023			
		Stairwell	0.017			
		Dining Area -- All other dining area	0.017			
BASEMENT		Conference/Meeting/Multipurpose Room	0.015			
		Storage Room -- <50 ft2	0.015			
		Storage Room -- ≥50 ft2	0.009			
		Atrium -- ≤40 ft in height	0.004			
		Classroom/Lecture Hall/Training Room --All other classroom/lecture hall/training room	0.004			
		Lounge/Breakroom -- All other lounge/breakroom	0.002			
		Workshop	0.001			
		Food Preparation Area	0.001			
		Locker Room	0.001			
	CORE_BOTTOM	Office -- Open plan	0.571	1.08		
	CORE_MID	Electrical/Mechanical Room	0.062			
	CORE_TOP	Corridor -- All other corridor	0.043			
	PERIMETER_BOT_ZN_3	Restroom -- All other restroom	0.031			
	PERIMETER_BOT_ZN_2	Office -- Enclosed	0.185			
	PERIMETER_BOT_ZN_1	Lobby -- All other lobby	0.023			

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)			
Prototype Building		PERIMETER_BOT_ZN_4	Stairwell	0.017			
		PERIMETER_MID_ZN_3	Dining Area -- All other dining area	0.017			
		PERIMETER_MID_ZN_2	Conference/Meeting/Multipurpose Room	0.015			
		PERIMETER_MID_ZN_1	Storage Room -- <50 ft ²	0.015			
		PERIMETER_MID_ZN_4	Storage Room -- ≥50 ft ²	0.009			
		PERIMETER_TOP_ZN_3	Atrium -- <40 ft in height	0.004			
		PERIMETER_TOP_ZN_2	Classroom/Lecture Hall/Training Room --All other classroom/lecture hall/training room	0.004			
		PERIMETER_TOP_ZN_1	Lounge/Breakroom -- All other lounge/breakroom	0.002			
		PERIMETER_TOP_ZN_4	Workshop	0.001			
			Food Preparation Area	0.001			
			Locker Room	0.001			
			Computer Room	0.95			
			DATACENTER_BOT_ZN_6	Copy/Print Room		0.05	1.08
			DATACENTER_MID_ZN_6				
			DATACENTER_TOP_ZN_6				
			DATACENTER_BASEMENT_ZN_6				
		Warehouse	ZONE1 OFFICE	Office -- Open plan		0.16	1.0
Office -- Enclosed	0.31						
Conference/Meeting/Multipurpose Room	0.08						
Corridor -- All other corridor	0.13						
Storage Room -- <50 ft ²	0.15						
Restroom -- All other restroom	0.04						
Lounge/Breakroom -- All other lounge/breakroom	0.02						
Electrical/Mechanical Room	0.02						
Stairwell	0.03						
Lobby -- All other lobby	0.06						
ZONE2 FINE STORAGE	Warehouse—Storage Area -- Smaller, hand-carried items			1.00	1.40		
ZONE3 BULK STORAGE	Warehouse—Storage Area -- Medium to bulky, palletized items			1.00	0.90		
Office				Office -- Enclosed	0.66	1.10	
		Office -- Open plan	0.34				
ApartmentHighRise	G SW APARTMENT G NW APARTMENT G NE APARTMENT G N1 APARTMENT G N2 APARTMENT G S1 APARTMENT G S2 APARTMENT F2 SW APARTMENT	Dwelling Unit	1.00	1.07(hardwired)			
				0.27(plug-in)			

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
		F2 NW APARTMENT		
		F2 SE APARTMENT		
		F2 NE APARTMENT		
		F2 N1 APARTMENT		
		F2 N2 APARTMENT		
		F2 S1 APARTMENT		
		F2 S2 APARTMENT		
		F3 SW APARTMENT		
		F3 NW APARTMENT		
		F3 SE APARTMENT		
		F3 NE APARTMENT		
		F3 N1 APARTMENT		
		F3 N2 APARTMENT		
		F3 S1 APARTMENT		
		F3 S2 APARTMENT		
		F4 SW APARTMENT		
		F4 NW APARTMENT		
		F4 SE APARTMENT		
		F4 NE APARTMENT		
		F4 N1 APARTMENT		
		F4 N2 APARTMENT		
		F4 S1 APARTMENT		
		F4 S2 APARTMENT		
		M SW APARTMENT		
		M NW APARTMENT		
		M SE APARTMENT		
		M NE APARTMENT		
		M N1 APARTMENT		
		M N2 APARTMENT		
		M S1 APARTMENT		
		M S2 APARTMENT		
		F6 SW APARTMENT		
		F6 NW APARTMENT		
		F6 SE APARTMENT		
		F6 NE APARTMENT		
		F6 N1 APARTMENT		
		F6 N2 APARTMENT		
		F6 S1 APARTMENT		
		F6 S2 APARTMENT		
		F7 SW APARTMENT		
		F7 NW APARTMENT		

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
	F7 SE APARTMENT			
	F7 NE APARTMENT			
	F7 N1 APARTMENT			
	F7 N2 APARTMENT			
	F7 S1 APARTMENT			
	F7 S2 APARTMENT			
	F8 SW APARTMENT			
	F8 NW APARTMENT			
	F8 SE APARTMENT			
	F8 NE APARTMENT			
	F8 N1 APARTMENT			
	F8 N2 APARTMENT			
	F8 S1 APARTMENT			
	F8 S2 APARTMENT			
	F9 SW APARTMENT			
	F9 NW APARTMENT			
	F9 SE APARTMENT			
	F9 NE APARTMENT			
	F9 N1 APARTMENT			
	F9 N2 APARTMENT			
	F9 S1 APARTMENT			
	F9 S2 APARTMENT			
	T SW APARTMENT			
	T NW APARTMENT			
	T SE APARTMENT			
	T NE APARTMENT			
	T N1 APARTMENT			
	T N2 APARTMENT			
	T S1 APARTMENT			
	T S2 APARTMENT			
	G CORRIDOR	Corridor -- All other corridor	0.75	
	F2 CORRIDOR			
	F3 CORRIDOR			
	F4 CORRIDOR			
	M CORRIDOR			
	F6 CORRIDOR	Stairwell	0.25	0.5
	F7 CORRIDOR			
	F8 CORRIDOR			
	F9 CORRIDOR			
	T CORRIDOR			
ApartmentMidRise	OFFICE	Office -- Enclosed	0.66	1.10

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
		Office -- Open plan	0.34	
	G SW APARTMENT G NW APARTMENT G NE APARTMENT G N1 APARTMENT G N2 APARTMENT G S1 APARTMENT G S2 APARTMENT M SW APARTMENT M NW APARTMENT M SE APARTMENT M NE APARTMENT M N1 APARTMENT M N2 APARTMENT M S1 APARTMENT M S2 APARTMENT T SW APARTMENT T NW APARTMENT T SE APARTMENT T NE APARTMENT T N1 APARTMENT T N2 APARTMENT T S1 APARTMENT T S2 APARTMENT	Dwelling Unit	1.00	1.07(hardwired) 0.27(plug-in)
	T CORRIDOR	Corridor -- All other corridor	0.59	
	G CORRIDOR M CORRIDOR	Stairwell	0.41	0.5
HotelSmall	REARSTAIRSFLR1 FRONTSTAIRSFLR1 REARSTAIRSFLR2 FRONTSTAIRSFLR2 REARSTAIRSFLR3 FRONTSTAIRSFLR3 REARSTAIRSFLR4 FRONTSTAIRSFLR4	Stairwell	1.00	0.6
	CORRIDORFLR1 CORRIDORFLR2 CORRIDORFLR3 CORRIDORFLR4	Corridor -- All other corridor	1.00	0.5
	REARSTORAGEFLR1 FRONTSTORAGEFLR1	Storage Room -- ≥50 ft ² Storage Room -- <50 ft ²	0.95 0.05	0.8

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
	REARSTORAGEFLR2			
	REARSTORAGEFLR3			
	FRONTSTORAGEFLR3			
	REARSTORAGEFLR4			
	FRONTSTORAGEFLR4			
	FRONTLOUNGEFLR1	Lobby -- Hotel	1.00	1.2
	RESTROOMFLR1	Restroom -- All other restroom	1.00	0.9
	MEETINGROOMFLR1	Conference/Meeting/Multipurpose Room	1.00	1.3
	MECHANICALROOMFLR1	Electrical/Mechanical Room	1.00	1.5
	GUESTROOM101	Guest Room	0.69	
	GUESTROOM102			
	GUESTROOM103			
	GUESTROOM104			
	GUESTROOM105			
	GUESTROOM201			
	GUESTROOM202_20			
	GUESTROOM206_208			
	GUESTROOM209_212			
	GUESTROOM213			
	GUESTROOM214			
	GUESTROOM215_218			
	GUESTROOM219			
	GUESTROOM220_223			
	GUESTROOM224	Guest Room-bathroom	0.31	1.14
	GUESTROOM301			
	GUESTROOM302_305			
	GUESTROOM306_308			
	GUESTROOM309_312			
	GUESTROOM313			
	GUESTROOM314			
	GUESTROOM315_318			
	GUESTROOM319			
	GUESTROOM320_323			
	GUESTROOM324			
	GUESTROOM419			
	GUESTROOM420_423			
	GUESTROOM424			
	EMPLOYEELOUNGEFLR1	Lounge/Breakroom -- All other	1.00	1.2
	LAUNDRYROOMFLR1	Laundry/Washing Area	1.00	0.6
	ELEVATORCOREFLR1			
	ELEVATORCOREFLR2	other	1.00	0

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
	ELEVATORCOREFLR3			
	ELEVATORCOREFLR4			
	EXERCISECENTERFLR1	Gymnasium/Fitness Center -- Exercise area	1.00	0.9
	FRONTOFFICEFLR1	Office -- Enclosed	0.75	1.1
		Office -- Open plan	0.25	
	Floor 1 Bio Haz			
	Floor 1 Med Gas			
	Floor 1 Nurse Janitor			
	Floor 1 Utility Janitor	Storage Room -- ≥50 ft2	1.00	0.8
	Floor 2 Janitor			
	Floor 2 Storage 1			
	Floor 3 Janitor			
	Floor 1 CAFE	Dining Area -- Family dining	1.00	0.9
	Floor 1 Anesthesia			
	Floor 1 Clean			
	Floor 1 Clean Work			
	Floor 1 Electrical Room			
	Floor 1 Elevator Pump Room			
	Floor 1 MRI Control Room			
	Floor 1 MRI Room			
	Floor 1 Procedure Room			
	Floor 1 Soil			
	Floor 1 Soil Hold			
	Floor 1 Soil Work			
OutPatientHealthCare	Floor 2 Exam 1	Healthcare Facility -- Exam/treatment room	1.00	1.5
	Floor 2 Exam 2			
	Floor 2 Exam 3			
	Floor 2 Exam 4			
	Floor 2 Exam 5			
	Floor 2 Exam 6			
	Floor 2 Exam 7			
	Floor 2 Exam 8			
	Floor 2 Exam 9			
	Floor 2 X-Ray			
	Floor 3 Mechanical			
	Floor 3 Treatment			
	Floor 1 Dictation			
	Floor 1 Dressing Room			
	Floor 1 Humid	Office -- Enclosed	1.00	1.1
	Floor 1 IT Room			
	Floor 1 Scheduling			

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
	Floor 2 Dictation Floor 3 Dressing Room Floor 3 Humid Floor 3 Office			
	Floor 1 IT Hall	Corridor -- All other corridor	0.89	
	Floor 1 Lobby Hall Floor 1 Locker Room Hall Floor 1 MRI Hall Floor 1 Nurse Hall Floor 1 Pre-Op Hall Floor 1 Reception Hall Floor 1 Scrub Floor 1 Sub-Sterile Floor 1 Sterile Hall Floor 1 Utility Hall Floor 1 Vestibule Floor 2 Exam Hall 1 Floor 2 Exam Hall 2 Floor 2 Exam Hall 3 Floor 2 Exam Hall 4 Floor 2 Exam Hall 5 Floor 2 Exam Hall 6 Floor 2 Reception Hall Floor 2 Office Hall Floor 2 Work Hall Floor 3 Elevator Hall Floor 3 Mechanical Hall Floor 3 Office Hall NE Stair NW Elevator NW Stair SW Stair	Stairwell	0.11	1.0
	Floor 1 Lobby Floor 1 Reception Floor 2 Reception Floor 1 MRI Toilet	Lobby -- All other lobby	1.00	1.3
	Floor 1 Lobby Toilet Floor 1 Nurse Toilet Floor 1 Pre-Op Toilet Floor 2 Conference Toilet Floor 2 Work Toilet	Restroom -- All other restroom	1.00	0.9

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
	Floor 3 Lounge Toilet			
	Floor 3 Office Toilet			
	Floor 3 Physical Therapy Toilet			
	Floor 2 Reception Toilet			
	Floor 1 Locker Room			
	Floor 1 Lounge			
	Floor 2 Lounge	Lounge/Breakroom -- Healthcare facility	1.00	0.8
	Floor 3 Locker			
	Floor 3 Lounge			
	Floor 1 Nourishment			
	Floor 1 Nurse Station			
	Floor 2 Nurse Station 1	Healthcare Facility -- Nurse's station	1.00	1.0
	Floor 2 Nurse Station 2			
	Floor 1 Office	Office -- Enclosed	0.64	
	Floor 2 Office			
	Floor 2 Scheduling 1			
	Floor 2 Scheduling 2	Office -- Open plan	0.36	1.1
	Floor 2 Work			
	Floor 3 Work			
	Floor 1 Operating Room 1			
	Floor 1 Operating Room 2	Healthcare Facility -- Operating room	1.00	2.2
	Floor 1 Operating Room 3			
	Floor 1 PACU			
	Floor 1 Recovery Room	Healthcare Facility -- Recovery room	1.00	0.8
	Floor 1 Step Down			
	Floor 1 Pre-Op Room 1			
	Floor 1 Pre-Op Room 2	Healthcare Facility -- Patient room	1.00	0.7
	Floor 1 Sterile Storage	Storage Room -- ≥ 50 ft ²	0.68	
	Floor 1 Storage			
	Floor 1 Utility Room			
	Floor 2 Storage 2			
	Floor 2 Storage 3			
	Floor 2 Utility			
	Floor 3 Storage 1	Storage Room -- < 50 ft ²	0.32	0.8
	Floor 3 Storage 2			
	Floor 3 Undeveloped 1			
	Floor 3 Undeveloped 2			
	Floor 3 Utility			
	Floor 2 Conference	Conference/Meeting/Multipurpose Room	1.00	1.3
	Floor 3 Physical Therapy 1			
	Floor 3 Physical Therapy 2	Healthcare Facility -- Physical therapy room	1.00	0.9

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)	
RestaurantSitDown	DINING	Dining Area -- Family dining	0.87	0.9	
		Corridor -- All other corridor	0.05		
		Restroom -- All other restroom	0.08		
		Stairwell	0.00		
	KITCHEN	Food Preparation Area	0.57	1.20	
		Lobby -- All other lobby	0.03		
		Storage Room -- ≥50 ft ²	0.35		
Office -- Enclosed		0.04			
RestaurantFastFood	DINING	Dining Area -- Family dining	0.76	2.10	
		Restroom -- All other restroom	0.14		
		Corridor -- All other corridor	0.10		
	KITCHEN	Food Preparation Area	0.75	1.20	
		Storage Room -- ≥50 ft ²	0.22		
		Office -- Enclosed	0.03		
		Storage Room -- ≥50 ft ²	0.83		
RetailStandalone	BACK_SPACE	Office -- Enclosed	0.11	0.84	
		Restroom -- All other restroom	0.06		
		Core Retail Point of Sale Front Retail	Sales Area		1.00
	FRONT_ENTRY	Lobby -- All other lobby	0.60	1.3	
		Stairwell	0.40		
		Sales Area	0.74		
RetailStripMall	LGSTORE1 LGSTORE2	Storage Room -- ≥50 ft ²	0.21	1.48	
		Office -- Enclosed	0.05		
		Stairwell	0.00		
		Sales Area	0.78		
	SMSTORE1 SMSTORE2 SMSTORE3 SMSTORE4 SMSTORE5 SMSTORE6 SMSTORE7 SMSTORE8	Storage Room -- ≥50 ft ²		0.22	1.48
Hospital	BASEMENT	Office -- Open plan	0.42	1.07	
		Office -- Enclosed	0.19		
		Corridor -- All other corridor	0.09		
		Storage Room -- Hospital	0.05		
		Conference/Meeting/Multipurpose Room	0.05		
		Stairwell	0.04		

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
		Lobby -- All other lobby	0.04	
		Restroom -- All other restroom	0.04	
		Electrical/Mechanical Room	0.03	
		Storage Room -- ≥50 ft ²	0.02	
		Lounge/Breakroom -- All other lounge/breakroom	0.02	
		Dining Area -- All other dining area	0.01	
		Classroom/Lecture Hall/Training Room --All other classroom/lecture hall/training room	0.01	
		Food Preparation Area	0.00	
	ER_EXAM1_MULT4_FLR_1 ER_TRAUMA1_FLR_1 ER_EXAM3_MULT4_FLR_1 ER_TRAUMA2_FLR_1 ER_TRIAGE_MULT4_FLR_1 RADIOLOGY_FLR_4	Healthcare Facility -- Exam/treatment room	1.00	1.5
	OFFICE1_MULT4_FLR_1	Office -- Enclosed	1.00	OFFICE1_MULT4_FLR_1
	LOBBY_RECORDS_FLR_1	Lobby -- All other lobby	0.90	1.28
		Office -- Open plan	0.10	
	CORRIDOR_FLR_1 CORRIDOR_FLR_2 CORRIDOR_SE_FLR_3 CORRIDOR_NW_FLR_3 CORRIDOR_SE_FLR_4 CORRIDOR_NW_FLR_4 CORRIDOR_FLR_5	Corridor -- Hospital	0.91	
		Stairwell	0.09	1.0
	ER_NURSESTN_LOBBY_FLR_1	Lobby -- All other lobby	0.40	1.12
		Healthcare Facility -- Nurse's station	0.60	
	OR1_FLR_2 OR2_MULT5_FLR_2 OR3_FLR_2 OR4_FLR_2	Healthcare Facility -- Operating room	1.00	2.2
	IC_PATROOM1_MULT5_FLR_2 IC_PATROOM2_FLR_2 IC_PATROOM3_MULT6_FLR_2 ICU_FLR_2	Healthcare Facility -- Recovery room	1.00	0.8
	ICU_NURSESTN_LOBBY_FLR_2	Healthcare Facility -- Nurse's station	1.00	1.18
	OR_NURSESTN_LOBBY_FLR_2	Lobby -- All other lobby	0.60	
	NURSESTN_LOBBY_FLR_3 NURSESTN_LOBBY_FLR_4 NURSESTN_LOBBY_FLR_5	Healthcare Facility -- Nurse's station	0.40	1.0

Prototype Building	Zone	Appendix G Space Types	Area Fraction	Baseline Lighting Power Density (W/m ²)
	PATROOM1_MULT10_FLR_3			
	PATROOM2_FLR_3			
	PATROOM3_MULT10_FLR_3			
	PATROOM4_FLR_3			
	PATROOM5_MULT10_FLR_3			
	PATROOM6_FLR_3			
	PATROOM7_MULT10_FLR_3			
	PATROOM8_FLR_3			
	PATROOM1_MULT10_FLR_4	Healthcare Facility -- Patient room	1.00	0.7
	PATROOM2_FLR_4			
	PATROOM3_MULT10_FLR_4			
	PATROOM4_FLR_4			
	PATROOM6_FLR_4			
	PATROOM7_MULT10_FLR_4			
	PATROOM8_FLR_4			
	PATROOM5_MULT10_FLR_4			
	PHYSTHERAPY_FLR_3	Healthcare Facility -- Physical therapy room	1.00	0.9
	LAB_FLR_3			
	LAB_FLR_4	Laboratory -- All other laboratory	1.00	1.4
	DINING_FLR_5	Dining Area -- Cafeteria or fast-food dining	2.00	0.9
	KITCHEN_FLR_5	Food Preparation Area	1.00	1.2
	OFFICE1_FLR_5	Office -- Enclosed	0.85	
	OFFICE2_MULT5_FLR_5			
	OFFICE3_FLR_5	Office -- Open plan	0.15	1.1
	OFFICE4_MULT6_FLR_5			

Appendix C – HVAC

This section documents the details of the modelled HVAC systems. Table C.1 shows the process we followed to determine the baseline HVAC system per Appendix G rules for each prototype. The resulting baseline HVAC system for each zone of every prototype is shown in Table C.2. Note that because of this process; the zone group to HVAC systems assignment differs between the 90.1-2019 PI, Proposed and Baseline versions of the prototypes. Instances where the same group of zones assigned to a HVAC system don't match between the Proposed and Baseline models are shown in *italics* in Table C.2 with footnotes describing the change.

Table C.1: Step- by-step Appendix G Based Baseline System Determination

Prototype	Baseline System Determination Step	Step Result	Final Baseline HVAC System Type	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A
OfficeSmall	Predominant Building Type	Other Nonresidential		
	No. of floors	1		
	Conditioned Floor Area (sq ft)	5,502 Small, 3 floors or less and <25,000 ft ²	3. PSZ-AC	4. PSZ-HP
	Exceptions	NA		
OfficeMedium	Predominant Building Type	Other Nonresidential		
	No. of floors	3		
	Conditioned Floor Area (sq ft)	53,628 Medium, 4 or 5 floors and <25,000 ft ² or 5 floors or less and 25,000 ft ²	5. Packaged VAV with reheat	6. Packaged VAV with PFP boxes
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	No		
	b. ii. MZ system with zone schedule > 40 EFLH	No		
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
	d. Heated only zones	No		
	e. Baseline System 9, 10	No		
	f. Computer Rooms	No		
h. Hospitals	No			
OfficeLarge	Predominant Building Type	Other Nonresidential		
	No. of floors	12		
	Conditioned Floor Area (sq ft)	498,588 Large, more than 5 floors or >150,000 ft ²	7. VAV with reheat	8. VAV with PFP boxes
	Exceptions for multi-zone (MZ) systems			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	Yes	3. PSZ-AC	4. PSZ-HP
	b. ii. MZ system with zone schedule > 40 EFLH	No		
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
d. Heated only zones	No			
e. Baseline System 9, 10	No			

Prototype	Baseline System Determination Step	Step Result	Final Baseline HVAC System Type	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A
RetailStandalone	f. Computer Rooms	Yes	11.a. SZ-VAV	11.b. SZ-VAV
	h. Hospitals	No		
	Predominant Building Type	Retail		
	No. of floors	1		
	Conditioned Floor Area (sq ft)	24,692 ≤ 2 floors	3. PSZ-AC	4. PSZ-HP
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	Yes		
	b. ii. MZ system with zone schedule > 40 EFLH	No		
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
d. Heated only zones	Yes	9. Heating and ventilation	10. Heating and ventilation	
e. Baseline System 9, 10	No			
f. Computer Rooms	No			
h. Hospitals	No			
RetailStripmall	Predominant Building Type	Retail		
	No. of floors	1		
	Conditioned Floor Area (sq ft)	22,500 ≤ 2 floors	3. PSZ-AC	4. PSZ-HP
	Exceptions for multi-zone (MZ) systems	NA		
SchoolPrimary	Predominant Building Type	Other Nonresidential		
	No. of floors	1		
	Conditioned Floor Area (sq ft)	73,959 Medium, 4 or 5 floors and <25,000 ft ² or 5 floors or less and 25,000 ft ²	5. Packaged VAV with reheat	6. Packaged VAV with PFP boxes
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	Yes	3. PSZ-AC	4. PSZ-HP
	b. ii. MZ system with zone schedule > 40 EFLH	Yes	3. PSZ-AC	4. PSZ-HP
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
	d. Heated only zones	No		
	e. Baseline System 9, 10	No		
f. Computer Rooms	No			
h. Hospitals	No			

Prototype	Baseline System Determination Step	Step Result	Final Baseline HVAC System Type	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A
SchoolSecondary	Predominant Building Type	Other Nonresidential		
	No. of floors	5		
	Conditioned Floor Area (sq ft)	210,887 Large, more than 5 floors or >150,000 ft ²	7. VAV with reheat	8. VAV with PFP boxes
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	Yes	3. PSZ-AC	4. PSZ-HP
	b. ii. MZ system with zone schedule > 40 EFLH	Yes	3. PSZ-AC	4. PSZ-HP
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
	d. Heated only zones	No		
	e. Baseline System 9, 10	No		
	f. Computer Rooms	No		
h. Hospitals	No			
OutPatientHealthCare	Predominant Building Type	Other Nonresidential		
	No. of floors	3		
	Conditioned Floor Area (sq ft)	40,946 Medium, 4 or 5 floors and <25,000 ft ² or 5 floors or less and 25,000 ft ²		
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	Yes	3. PSZ-AC	4. PSZ-HP
	b. ii. MZ system with zone schedule > 40 EFLH	Yes	3. PSZ-AC	4. PSZ-HP
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
	d. Heated only zones	No		
	e. Baseline System 9, 10	No		
	f. Computer Rooms	No		
h. Hospitals	Yes	5. Packaged VAV with reheat	5. Packaged VAV with reheat	
Hospital	Predominant Building Type	Other Nonresidential		
	No. of floors	5		
	Conditioned Floor Area (sq ft)	241,501 Large, more than 5 floors or >150,000 ft ²		
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	Yes	3. PSZ-AC	4. PSZ-HP
	b. ii. MZ system with zone schedule > 40 EFLH	Yes	3. PSZ-AC	4. PSZ-HP
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
	d. Heated only zones	No		
	e. Baseline System 9, 10	No		
	f. Computer Rooms	No		
h. Hospitals	Yes	7. VAV with reheat	7. VAV with reheat	

Prototype	Baseline System Determination Step	Step Result	Final Baseline HVAC System Type	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A
HotelSmall	Predominant Building Type	Residential		
	No. of floors	4		
	Conditioned Floor Area (sq ft)	43,202	1.PTAC	2.PTHP
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	No		
	b. ii. MZ system with zone schedule > 40 EFLH	No		
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
	d. Heated only zones	Yes	9. Heating and ventilation	10. Heating and ventilation
	e. Baseline System 9, 10	No		
f. Computer Rooms	No			
h. Hospitals	No			
HotelLarge	Predominant Building Type	Residential		
	No. of floors	6		
	Conditioned Floor Area (sq ft)	122,116	1.PTAC	2.PTHP
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	Yes	5. Packaged VAV with reheat 3. PSZ-AC	6. Packaged VAV with PFP boxes 4. PSZ-HP
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	Yes	3. PSZ-AC	4. PSZ-HP
	b. ii. MZ system with zone schedule > 40 EFLH			
	c. Lab spaces with lab exhaust rate > 15,000 cfm			
	d. Heated only zones			
	e. Baseline System 9, 10			
f. Computer Rooms				
h. Hospitals				
Warehouse	Predominant Building Type	Heated-only Storage		
	No. of floors	1		
	Conditioned Floor Area (sq ft)	52,045	9. Heating and ventilation	10. Heating and ventilation
	Exceptions:			
	a. > 20,000 sq ft of non-predominant space type	No		
	b. i. MZ system with zone internal gain > 10 Btu/sq ft	No		
	b. ii. MZ system with zone schedule > 40 EFLH	No		
	c. Lab spaces with lab exhaust rate > 15,000 cfm	No		
	d. Heated only zones	No		
	e. Baseline System 9, 10	Yes	3. PSZ-AC	4. PSZ-HP
f. Computer Rooms	No			
h. Hospitals	No			

Prototype	Baseline System Determination Step	Step Result	Final Baseline HVAC System Type	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A
RestaurantFastFood	Predominant Building Type	Other Nonresidential		
	No. of floors	1		
		Small, 3 floors or less and <25,000 ft ²		
	Conditioned Floor Area (sq ft)	2,501	3. PSZ-AC	4. PSZ-HP
	Exceptions:	NA		
RestaurantSitdown	Predominant Building Type	Other Nonresidential		
	No. of floors	1		
		Small, 3 floors or less and <25,000 ft ²		
	Conditioned Floor Area (sq ft)	5,502	3. PSZ-AC	4. PSZ-HP
	Exceptions:	NA		
ApartmentMidRise	Predominant Building Type	Residential		
	No. of floors	4		
	Conditioned Floor Area (sq ft)	33,741	1.PTAC	2.PTHP
	Exceptions:	NA		
ApartmentHighRise	Predominant Building Type	Residential		
	No. of floors	10		
	Conditioned Floor Area (sq ft)	84,360	1.PTAC	2.PTHP
	Exceptions:	NA		

Table C.2: HVAC System Type Mapping Comparison

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
OfficeSmall	Core_Zn	4a. PSZ-HP with gas auxiliary	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Perimeter_Zn_1	4a. PSZ-HP with gas auxiliary	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Perimeter_Zn_2	4a. PSZ-HP with gas auxiliary	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Perimeter_Zn_3	4a. PSZ-HP with gas auxiliary	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Perimeter_Zn_4	4a. PSZ-HP with gas auxiliary	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
OfficeMedium	Core_Bottom, Perimeter_Bot_Zn_1, Perimeter_Bot_Zn_2, Perimeter_Bot_Zn_3, Perimeter_Bot_Zn_4	5a. Packaged VAV with electric reheat	5. Packaged VAV with reheat	5b. Packaged VAV with electric reheat	5. Packaged VAV with reheat	6. Packaged VAV with PFP boxes
	Core_Mid, Perimeter_Mid_Zn_1 Perimeter_Mid_Zn_2 Perimeter_Mid_Zn_3 Perimeter_Mid_Zn_4	5a. Packaged VAV with electric reheat	5. Packaged VAV with reheat	5b. Packaged VAV with electric reheat	5. Packaged VAV with reheat	6. Packaged VAV with PFP boxes
	Core_Top, Perimeter_Top_Zn_1, Perimeter_Top_Zn_2, Perimeter_Top_Zn_3, Perimeter_Top_Zn_4	5a. Packaged VAV with electric reheat	5. Packaged VAV with reheat	5b. Packaged VAV with electric reheat	5. Packaged VAV with reheat	6. Packaged VAV with PFP boxes
	Basement	12. SZ-CV-HW	12. SZ-CV-HW	12a. SZ-CV-E	7. VAV with reheat	8. VAV with PFP boxes
	Core_Bottom, Perimeter_Bot_Zn_1, Perimeter_Bot_Zn_2, Perimeter_Bot_Zn_3, Perimeter_Bot_Zn_4	7. VAV with reheat	7. VAV with reheat	7a. VAV with electric reheat	7. VAV with reheat	8. VAV with PFP boxes
OfficeLarge	Core_Mid, Perimeter_Mid_Zn_1, Perimeter_Mid_Zn_2, Perimeter_Mid_Zn_3, Perimeter_Mid_Zn_4	7. VAV with reheat	7. VAV with reheat	7a. VAV with electric reheat	7. VAV with reheat	8. VAV with PFP boxes
	Core_Top, Perimeter_Top_Zn_1, Perimeter_Top_Zn_2, Perimeter_Top_Zn_3, Perimeter_Top_Zn_4	7. VAV with reheat	7. VAV with reheat	7a. VAV with electric reheat	7. VAV with reheat	8. VAV with PFP boxes
	Datacenter_Bot_Zn_6	14. WSHP	14. WSHP	14a. WSHP	3. PSZ-AC	4. PSZ-HP
	Datacenter_Mid_Zn_6	14. WSHP	14. WSHP	14a. WSHP	3. PSZ-AC	4. PSZ-HP
	Datacenter_Top_Zn_6	14. WSHP	14. WSHP	14a. WSHP	3. PSZ-AC	4. PSZ-HP
Datacenter_Basement_Zn_6	14. WSHP	14. WSHP	14a. WSHP	11.a. SZ-VAV	11.b. SZ-VAV	
RetailStandalone	Back_Space	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Core_Retail	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Point_Of_Sale	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Front_Retail	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Front_Entry	9. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
Retailstripmall	Lgstore1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Smstore1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Smstore2	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Smstore3	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Smstore4	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Lgstore2	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Smstore5	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Smstore6	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Smstore7	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
Smstore8	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP	
SchoolPrimary ²⁴	<i>Corner_Class_1_Pod_1_Zn_1_Flr_1, Mult_Class_1_Pod_1_Zn_1_Flr_1, Corridor_Pod_1_Zn_1_Flr_1, Corner_Class_2_Pod_1_Zn_1_Flr_1, Mult_Class_2_Pod_1_Zn_1_Flr_1</i>	5. Packaged VAV with reheat	5. Packaged VAV with reheat	5b. Packaged VAV with electric reheat		
	<i>Corner_Class_1_Pod_2_Zn_1_Flr_1 Mult_Class_1_Pod_2_Zn_1_Flr_1 Corridor_Pod_2_Zn_1_Flr_1 Corner_Class_2_Pod_2_Zn_1_Flr_1 Mult_Class_2_Pod_2_Zn_1_Flr_1</i>	5. Packaged VAV with reheat	5. Packaged VAV with reheat	5b. Packaged VAV with electric reheat		
	<i>Corner_Class_1_Pod_3_Zn_1_Flr_1 Mult_Class_1_Pod_3_Zn_1_Flr_1 Corridor_Pod_3_Zn_1_Flr_1 Corner_Class_2_Pod_3_Zn_1_Flr_1 Mult_Class_2_Pod_3_Zn_1_Flr_1</i>	5. Packaged VAV with reheat	5. Packaged VAV with reheat	5b. Packaged VAV with electric reheat		
	<i>Computer_Class_Zn_1_Flr_1, Main_Corridor_Zn_1_Flr_1, Lobby_Zn_1_Flr_1, Mech_Zn_1_Flr_1, Bath_Zn_1_Flr_1, Offices_Zn_1_Flr_1, Library_Media_Center_Zn_1_Flr_1</i>	5. Packaged VAV with reheat	5. Packaged VAV with reheat	5b. Packaged VAV with electric reheat		
	<i>Gym_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP		
	<i>Kitchen_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	<i>Cafeteria_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	<i>Corner_Class_1_Pod_1_Zn_1_Flr_1, Mult_Class_1_Pod_1_Zn_1_Flr_1, Corridor_Pod_1_Zn_1_Flr_1, Corner_Class_2_Pod_1_Zn_1_Flr_1, Mult_Class_2_Pod_1_Zn_1_Flr_1, Corner_Class_1_Pod_2_Zn_1_Flr_1 Mult_Class_1_Pod_2_Zn_1_Flr_1 Corridor_Pod_2_Zn_1_Flr_1</i>	-	-	-	5. Packaged VAV with reheat	6. Packaged VAV with PFP boxes

²⁴ Zone groups to HAVC system mapping differs between proposed and baseline. In the 90.1-2019 PI and Proposed models all zones in each wing is assigned to a unique HVAC system. The application of the Appendix G rules results in a single HVAC system with exceptions applied to the Kitchen and Cafeteria zones as shown in the last row of the School Primary list.

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
SchoolSecondary ²⁵	Corner_Class_2_Pod_2_Zn_1_Flr_1					
	Mult_Class_2_Pod_2_Zn_1_Flr_1,					
	Corner_Class_1_Pod_3_Zn_1_Flr_1					
	Mult_Class_1_Pod_3_Zn_1_Flr_1					
	Corridor_Pod_3_Zn_1_Flr_1					
	Corner_Class_2_Pod_3_Zn_1_Flr_1					
	Mult_Class_2_Pod_3_Zn_1_Flr_1,					
	Computer_Class_Zn_1_Flr_1,					
	Main_Corridor_Zn_1_Flr_1,					
	Lobby_Zn_1_Flr_1,					
	Mech_Zn_1_Flr_1,					
	Bath_Zn_1_Flr_1,					
	Offices_Zn_1_Flr_1,					
	Library_Media_Center_Zn_1_Flr_1,					
	Gym_Zn_1_Flr_1					
Corner_Class_1_Pod_1_Zn_1_Flr_1	7. VAV with reheat	7. VAV with reheat	7. VAV with electric reheat	-	-	
Corner_Class_1_Pod_1_Zn_1_Flr_2						
Mult_Class_1_Pod_1_Zn_1_Flr_1						
Mult_Class_1_Pod_1_Zn_1_Flr_2						
Corridor_Pod_1_Zn_1_Flr_1						
Corridor_Pod_1_Zn_1_Flr_2						
Corner_Class_2_Pod_1_Zn_1_Flr_1						
Corner_Class_2_Pod_1_Zn_1_Flr_2						
Mult_Class_2_Pod_1_Zn_1_Flr_1						
Mult_Class_2_Pod_1_Zn_1_Flr_2						
Corner_Class_1_Pod_2_Zn_1_Flr_1	7. VAV with reheat	7. VAV with reheat	7. VAV with electric reheat	-	-	
Corner_Class_1_Pod_2_Zn_1_Flr_2						
Mult_Class_1_Pod_2_Zn_1_Flr_1						
Mult_Class_1_Pod_2_Zn_1_Flr_2						
Corridor_Pod_2_Zn_1_Flr_1						
Corridor_Pod_2_Zn_1_Flr_2						
Corner_Class_2_Pod_2_Zn_1_Flr_1						
Corner_Class_2_Pod_2_Zn_1_Flr_2						
Mult_Class_2_Pod_2_Zn_1_Flr_1						
Mult_Class_2_Pod_2_Zn_1_Flr_2						
Corner_Class_1_Pod_3_Zn_1_Flr_2	7. VAV with reheat	7. VAV with reheat	7. VAV with electric reheat	-	-	
Mult_Class_1_Pod_3_Zn_1_Flr_1						
Mult_Class_1_Pod_3_Zn_1_Flr_2						
Corridor_Pod_3_Zn_1_Flr_1						
Corridor_Pod_3_Zn_1_Flr_2						
Corner_Class_2_Pod_3_Zn_1_Flr_1						
Corner_Class_2_Pod_3_Zn_1_Flr_2						
Mult_Class_2_Pod_3_Zn_1_Flr_1						
Mult_Class_2_Pod_3_Zn_1_Flr_2						

²⁵ Zone groups to HAVC system mapping differs between proposed and baseline. In the 90.1-2019 PI and Proposed models all zones in each wing is assigned to a unique HVAC system. The application of the Appendix G rules results in a single HVAC system per floor with exceptions applied to the Auditorium, Kitchen and Cafeteria zones as shown in the last row of the School Secondary list.

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	<i>Corner_Class_1_Pod_3_Zn_1_Flr_1</i>					
	<i>Main_Corridor_Zn_1_Flr_2</i>	7. VAV with reheat	7. VAV with reheat	7. VAV with electric reheat	-	-
	<i>Lobby_Zn_1_Flr_1</i>					
	<i>Lobby_Zn_1_Flr_2</i>					
	<i>Bathrooms_Zn_1_Flr_1</i>					
	<i>Bathrooms_Zn_1_Flr_2</i>					
	<i>Offices_Zn_1_Flr_1</i>					
	<i>Offices_Zn_1_Flr_2</i>					
	<i>Library_Media_Center_Zn_1_Flr_2</i>					
	<i>Mech_Zn_1_Flr_1</i>					
	<i>Mech_Zn_1_Flr_2</i>					
	<i>Gym_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	-	-
	<i>Aux_Gym_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	-	-
	<i>Auditorium_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	<i>Kitchen_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	<i>Cafeteria_Zn_1_Flr_1</i>	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	<i>Corner_Class_1_Pod_1_Zn_1_Flr_1</i>	-	-	-	7. VAV with reheat	8. VAV with PFP boxes
	<i>Mult_Class_1_Pod_1_Zn_1_Flr_1</i>					
	<i>Corridor_Pod_1_Zn_1_Flr_1</i>					
	<i>Corner_Class_2_Pod_1_Zn_1_Flr_1</i>					
	<i>Mult_Class_2_Pod_1_Zn_1_Flr_1</i>					
	<i>Corner_Class_1_Pod_2_Zn_1_Flr_1</i>					
	<i>Mult_Class_1_Pod_2_Zn_1_Flr_1</i>					
	<i>Corridor_Pod_2_Zn_1_Flr_1</i>					
	<i>Corner_Class_2_Pod_2_Zn_1_Flr_1</i>					
	<i>Mult_Class_2_Pod_2_Zn_1_Flr_1</i>					
	<i>Mult_Class_1_Pod_3_Zn_1_Flr_1</i>					
	<i>Corridor_Pod_3_Zn_1_Flr_1</i>					
	<i>Corner_Class_2_Pod_3_Zn_1_Flr_1</i>					
	<i>Mult_Class_2_Pod_3_Zn_1_Flr_1</i>					
	<i>Corner_Class_1_Pod_3_Zn_1_Flr_1</i>					
	<i>Lobby_Zn_1_Flr_1</i>					
	<i>Bathrooms_Zn_1_Flr_1</i>					
	<i>Offices_Zn_1_Flr_1</i>					
	<i>Mech_Zn_1_Flr_1</i>					
	<i>Gym_Zn_1_Flr_1</i>					
	<i>Aux_Gym_Zn_1_Flr_1</i>					
	<i>Corner_Class_1_Pod_1_Zn_1_Flr_2</i>	-	-	-	7. VAV with reheat	8. VAV with PFP boxes
	<i>Mult_Class_1_Pod_1_Zn_1_Flr_2</i>					
	<i>Corridor_Pod_1_Zn_1_Flr_2</i>					
	<i>Corner_Class_2_Pod_1_Zn_1_Flr_2</i>					
	<i>Mult_Class_2_Pod_1_Zn_1_Flr_2</i>					
	<i>Corner_Class_1_Pod_2_Zn_1_Flr_2</i>					
	<i>Mult_Class_1_Pod_2_Zn_1_Flr_2</i>					
	<i>Corridor_Pod_2_Zn_1_Flr_2</i>					
	<i>Corner_Class_2_Pod_2_Zn_1_Flr_2</i>					
	<i>Mult_Class_2_Pod_2_Zn_1_Flr_2</i>					
	<i>Corner_Class_1_Pod_3_Zn_1_Flr_2</i>					

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	<i>Multi_Class_1_Pod_3_Zn_1_Flr_2</i>					
	<i>Corridor_Pod_3_Zn_1_Flr_2</i>					
	<i>Corner_Class_2_Pod_3_Zn_1_Flr_2</i>					
	<i>Multi_Class_2_Pod_3_Zn_1_Flr_2</i>					
	<i>Main_Corridor_Zn_1_Flr_2</i>					
	<i>Lobby_Zn_1_Flr_2</i>					
	<i>Bathrooms_Zn_1_Flr_2</i>					
	<i>Offices_Zn_1_Flr_2</i>					
	<i>Library_Media_Center_Zn_1_Flr_2</i>					
	<i>Mech_Zn_1_Flr_2</i>					
	<i>Floor 1 Anesthesia, Floor 1 Bio Haz</i>	7. Packaged VAV with reheat	7. Packaged VAV with reheat	7. Packaged VAV with reheat	-	-
	<i>Floor 1 Café, Floor 1 Clean</i>					
	<i>Floor 1 Clean Work, Floor 1 Dictation</i>					
	<i>Floor 1 Dressing Room,</i>					
	<i>Floor 1 Electrical Room</i>					
	<i>Floor 1 Elevator Pump Room</i>					
	<i>Floor 1 Humid, Floor 1 It Hall</i>					
	<i>Floor 1 It Room, Floor 1 Lobby</i>					
	<i>Floor 1 Lobby Hall, Floor 1 Lobby Toilet</i>					
	<i>Floor 1 Locker Room,</i>					
	<i>Floor 1 Locker Room Hall,</i>					
	<i>Floor 1 Lounge, Floor 1 Med Gas</i>					
	<i>Floor 1 Mri Control Room</i>					
	<i>Floor 1 Mri Hall, Floor 1 Mri Room</i>					
	<i>Floor 1 Mri Toilet, Floor 1 Nourishment</i>					
	<i>Floor 1 Nurse Hall,</i>					
	<i>Floor 1 Nurse Janitor</i>					
OutPatientHealthCare ²⁶	<i>Floor 1 Nurse Station,</i>					
	<i>Floor 1 Nurse Toilet</i>					
	<i>Floor 1 Office,</i>					
	<i>Floor 1 Operating Room 1</i>					
	<i>Floor 1 Operating Room 2</i>					
	<i>Floor 1 Operating Room 3</i>					
	<i>Floor 1 Pacu, Floor 1 Pre-Op Hall</i>					
	<i>Floor 1 Pre-Op Room 1</i>					
	<i>Floor 1 Pre-Op Room 2</i>					
	<i>Floor 1 Pre-Op Toilet,</i>					
	<i>Floor 1 Procedure Room</i>					
	<i>Floor 1 Reception,</i>					
	<i>Floor 1 Reception Hall</i>					
	<i>Floor 1 Recovery Room,</i>					
	<i>Floor 1 Scheduling</i>					
	<i>Floor 1 Scrub, Floor 1 Soil</i>					
	<i>Floor 1 Soil Hold, Floor 1 Soil Work</i>					
	<i>Floor 1 Step Down, Floor 1 Sterile Hall</i>					

²⁶ Zone groups to HAVC system mapping differs between proposed and baseline. See rows in italics in the OutPatientHealthCare list for details.

Prototype	Zone Name	90.1-2019 PI	Proposed			Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A	
	<i>Floor 1 Sterile Storage, Floor 1 Storage Floor 1 Sub-Sterile, Floor 1 Utility Hall Floor 1 Utility Janitor, Floor 1 Utility Room Floor 1 Vestibule</i>						
	<i>Floor 2 Conference, Floor 2 Conference Toilet, Floor 2 Dictation Floor 2 Exam 1, Floor 2 Exam 2 Floor 2 Exam 3, Floor 2 Exam 4 Floor 2 Exam 5, Floor 2 Exam 6 Floor 2 Exam 7, Floor 2 Exam 8 Floor 2 Exam 9, Floor 2 Exam Hall 1 Floor 2 Exam Hall 2, Floor 2 Exam Hall 3 Floor 2 Exam Hall 4, Floor 2 Exam Hall 5 Floor 2 Exam Hall 6, Floor 2 Janitor Floor 2 Lounge, Floor 2 Nurse Station 1 Floor 2 Nurse Station 2, Floor 2 Office Floor 2 Office Hall, Floor 2 Reception Floor 2 Reception Hall, Floor 2 Reception Toilet, Floor 2 Scheduling 1, Floor 2 Scheduling 2 Floor 2 Storage 1, Floor 2 Storage 2 Floor 2 Storage 3, Floor 2 Utility Floor 2 Work, Floor 2 Work Hall Floor 2 Work Toilet, Floor 2 X-Ray Floor 3 Dressing Room, Floor 3 Elevator Hall, Floor 3 Humid Floor 3 Janitor, Floor 3 Locker Floor 3 Lounge, Floor 3 Lounge Toilet Floor 3 Mechanical, Floor 3 Mechanical Hall Floor 3 Office, Floor 3 Office Hall Floor 3 Office Toilet, Floor 3 Physical Therapy 1 Floor 3 Physical Therapy 2 Floor 3 Physical Therapy Toilet Floor 3 Storage 1, Floor 3 Storage 2 Floor 3 Treatment, Floor 3 Undeveloped 1 Floor 3 Undeveloped 2, Floor 3 Utility Floor 3 Work, NE Stair, NW Elevator NW Stair, SW Stair</i>	7. Packaged VAV with reheat	7. Packaged VAV with reheat	7. Packaged VAV with reheat	-	-	
	<i>Floor 1 Anesthesia, Floor 1 Bio Haz Floor 1 Clean, Floor 1 Clean Work</i>	-	-	-	5. Packaged VAV with reheat	5. Packaged VAV with reheat	

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	<i>Floor 1 Dictation,</i>					
	<i>Floor 1 Dressing Room</i>					
	<i>Floor 1 Electrical Room, Floor 1 Humid</i>					
	<i>Floor 1 It Hall, Floor 1 It Room</i>					
	<i>Floor 1 Lobby, Floor 1 Lobby Hall</i>					
	<i>Floor 1 Lobby Toilet,</i>					
	<i>Floor 1 Locker Room</i>					
	<i>Floor 1 Locker Room Hall,</i>					
	<i>Floor 1 Lounge</i>					
	<i>Floor 1 Med Gas, Floor 1 Mri Hall</i>					
	<i>Floor 1 Mri Toilet, Floor 1 Nourishment</i>					
	<i>Floor 1 Nurse Hall,</i>					
	<i>Floor 1 Nurse Janitor</i>					
	<i>Floor 1 Nurse Station,</i>					
	<i>Floor 1 Nurse Toilet</i>					
	<i>Floor 1 Office, Floor 1 Pacu</i>					
	<i>Floor 1 Pre-Op Hall,</i>					
	<i>Floor 1 Pre-Op Room 1,</i>					
	<i>Floor 1 Pre-Op Room 2</i>					
	<i>Floor 1 Pre-Op Toilet,</i>					
	<i>Floor 1 Procedure Room</i>					
	<i>Floor 1 Reception,</i>					
	<i>Floor 1 Reception Hall</i>					
	<i>Floor 1 Recovery Room,</i>					
	<i>Floor 1 Scheduling</i>					
	<i>Floor 1 Scrub, Floor 1 Soil,</i>					
	<i>Floor 1 Soil Hold, Floor 1 Soil Work</i>					
	<i>Floor 1 Step Down, Floor 1 Sterile Hall</i>					
	<i>Floor 1 Sterile Storage, Floor 1 Storage</i>					
	<i>Floor 1 Sub-Sterile, Floor 1 Utility Hall</i>					
	<i>Floor 1 Utility Janitor,</i>					
	<i>Floor 1 Utility Room</i>					
	<i>Floor 1 Vestibule</i>					
	Floor 1 Café	-	-	-	3. PSZ-AC	4. PSZ-HP
	Floor 1 Elevator Pump Room	-	-	-	3. PSZ-AC	4. PSZ-HP
	Floor 1 Mri Control Room	-	-	-	3. PSZ-AC	4. PSZ-HP
	Floor 1 Mri Room	-	-	-	3. PSZ-AC	4. PSZ-HP
	Floor 1 Operating Room 1	-	-	-	3. PSZ-AC	4. PSZ-HP
	Floor 1 Operating Room 2	-	-	-	3. PSZ-AC	4. PSZ-HP
	Floor 1 Operating Room 3	-	-	-	3. PSZ-AC	4. PSZ-HP
	<i>Floor 2 Conference,</i>	-	-	-	5. Packaged VAV with reheat	5. Packaged VAV with reheat
	<i>Floor 2 Conference Toilet</i>					
	<i>Floor 2 Dictation, Floor 2 Exam 1</i>					
	<i>Floor 2 Exam 2, Floor 2 Exam 3</i>					
	<i>Floor 2 Exam 4, Floor 2 Exam 5</i>					
	<i>Floor 2 Exam 6, Floor 2 Exam 7</i>					
	<i>Floor 2 Exam 8, Floor 2 Exam 9</i>					
	<i>Floor 2 Exam Hall 1,</i>					

Prototype	Zone Name	90.1-2019 PI	Proposed			Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A	
	<i>Floor 2 Exam Hall 2</i>						
	<i>Floor 2 Exam Hall 3,</i>						
	<i>Floor 2 Exam Hall 4</i>						
	<i>Floor 2 Exam Hall 5,</i>						
	<i>Floor 2 Exam Hall 6</i>						
	<i>Floor 2 Janitor, Floor 2 Lounge</i>						
	<i>Floor 2 Nurse Station 1,</i>						
	<i>Floor 2 Nurse Station 2</i>						
	<i>Floor 2 Office, Floor 2 Office Hall</i>						
	<i>Floor 2 Reception,</i>						
	<i>Floor 2 Reception Hall</i>						
	<i>Floor 2 Reception Toilet</i>						
	<i>Floor 2 Scheduling 1</i>						
	<i>Floor 2 Scheduling 2</i>						
	<i>Floor 2 Storage 1, Floor 2 Storage 2</i>						
	<i>Floor 2 Storage 3, Floor 2 Utility</i>						
	<i>Floor 2 Work, Floor 2 Work Hall</i>						
	<i>Floor 2 Work Toilet, NE Stair</i>						
	<i>NW Elevator, NW Stair, SW Stair</i>						
	<i>Floor 2 X-Ray</i>	-	-	-	3. PSZ-AC	4. PSZ-HP	
	<i>Floor 3 Dressing Room,</i>	-	-	-	5. Packaged VAV with reheat	5. Packaged VAV with reheat	
	<i>Floor 3 Elevator Hall, Floor 3 Humid</i>						
	<i>Floor 3 Janitor, Floor 3 Locker</i>						
	<i>Floor 3 Lounge, Floor 3 Lounge Toilet</i>						
	<i>Floor 3 Mechanical,</i>						
	<i>Floor 3 Mechanical Hall</i>						
	<i>Floor 3 Office, Floor 3 Office Hall</i>						
	<i>Floor 3 Office Toilet</i>						
	<i>Floor 3 Physical Therapy 1</i>						
	<i>Floor 3 Physical Therapy 2</i>						
	<i>Floor 3 Physical Therapy Toilet</i>						
	<i>Floor 3 Storage 1, Floor 3 Storage 2</i>						
	<i>Floor 3 Treatment,</i>						
	<i>Floor 3 Undeveloped 1</i>						
	<i>Floor 3 Undeveloped 2, Floor 3 Utility</i>						
	<i>Floor 3 Work</i>						
Hospital Notes		Exam, patient, OR, ICU, and labs are each isolated to separate VAV systems due to humidity requirements.	Same as prototype		Since humidity controls are same as proposed, the system-zone assignments are also made the same as proposed for zones that need humidity control. Otherwise VAV systems are set up as one per floor. Radiology and kitchen are split to separate PSZ systems due to high equipment loads.		
Hospital ²⁷	<i>Basement</i>	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	-	-	
	<i>Office1_Mult4_Flr_1</i>						
	<i>Lobby_Records_Flr_1</i>						
	<i>Corridor_Flr_1</i>						

²⁷ Zone groups to HAVC system mapping differs between proposed and baseline. See Hospital notes and rows in italics in the Hospital list for details.

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	<i>Er_Nursestn_Lobby_Flr_1</i>					
	<i>Icu_Nursestn_Lobby_Flr_2</i>					
	<i>Corridor_Flr_2</i>					
	<i>Or_Nursestn_Lobby_Flr_2</i>					
	<i>Er_Exam1_Mult4_Flr_1</i>	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat
	<i>Er_Trauma1_Flr_1</i>					
	<i>Er_Exam3_Mult4_Flr_1</i>					
	<i>Er_Trauma2_Flr_1</i>					
	<i>Er_Triage_Mult4_Flr_1</i>					
	<i>Or1_Flr_2</i>	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat
	<i>Or2_Mult5_Flr_2</i>					
	<i>Or3_Flr_2</i>					
	<i>Or4_Flr_2</i>					
	<i>Ic_Patroom1_Mult5_Flr_2</i>	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat
	<i>Ic_Patroom2_Flr_2</i>					
	<i>Ic_Patroom3_Mult6_Flr_2</i>					
	<i>Icu_Flr_2</i>					
	<i>Patroom1_Mult10_Flr_3</i>	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat
	<i>Patroom2_Flr_3</i>					
	<i>Patroom3_Mult10_Flr_3</i>					
	<i>Patroom4_Flr_3</i>					
	<i>Patroom5_Mult10_Flr_3</i>					
	<i>Patroom6_Flr_3</i>					
	<i>Patroom7_Mult10_Flr_3</i>					
	<i>Patroom8_Flr_3</i>					
	<i>Patroom1_Mult10_Flr_4</i>					
	<i>Patroom2_Flr_4</i>					
	<i>Patroom3_Mult10_Flr_4</i>					
	<i>Patroom4_Flr_4</i>					
	<i>Patroom5_Mult10_Flr_4</i>					
	<i>Patroom6_Flr_4</i>					
	<i>Patroom7_Mult10_Flr_4</i>					
	<i>Patroom8_Flr_4</i>					
	<i>Nursestn_Lobby_Flr_3</i>	-	-	-		
	<i>Lab_Flr_3</i>					
	<i>Phystherapy_Flr_3</i>	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	-	-
	<i>Nursestn_Lobby_Flr_3</i>					
	<i>Corridor_Se_Flr_3</i>					
	<i>Corridor_Nw_Flr_3</i>					
	<i>Radiology_Flr_4</i>					
	<i>Nursestn_Lobby_Flr_4</i>					
	<i>Corridor_Se_Flr_4</i>					
	<i>Corridor_Nw_Flr_4</i>					
	<i>Dining_Flr_5</i>					
	<i>Nursestn_Lobby_Flr_5</i>					
	<i>Office1_Flr_5</i>					
	<i>Office2_Mult5_Flr_5</i>					
	<i>Office3_Flr_5</i>					

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	<i>Office4_Mult6_Flr_5</i>					
	<i>Corridor_Flr_5</i>					
	Lab_Flr_3	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat	7. VAV with reheat
	Lab_Flr_4					
	Kitchen_Flr_5	12. SZ-CV-HW	12. SZ-CV-HW	12. SZ-CV-HW	3. PSZ-AC	4. PSZ-HP
	Basement	-	-	-	7. VAV with reheat	7. VAV with reheat
	<i>Office1_Mult4_Flr_1</i>	-	-	-	7. VAV with reheat	7. VAV with reheat
	<i>Lobby_Records_Flr_1</i>					
	<i>Corridor_Flr_1</i>					
	<i>Er_Nursestn_Lobby_Flr_1</i>					
	<i>Icu_Nursestn_Lobby_Flr_2</i>				7. VAV with reheat	7. VAV with reheat
	<i>Corridor_Flr_2</i>					
	<i>Or_Nursestn_Lobby_Flr_2</i>					
	<i>Phystherapy_Flr_3</i>	-	-	-	7. VAV with reheat	7. VAV with reheat
	<i>Nursestn_Lobby_Flr_3</i>					
	<i>Corridor_Se_Flr_3</i>					
	<i>Corridor_Nw_Flr_3</i>					
	<i>Radiology_Flr_4</i>	-	-	-	3. PSZ-AC	4. PSZ-HP
	<i>Nursestn_Lobby_Flr_4</i>	-	-	-	7. VAV with reheat	7. VAV with reheat
	<i>Corridor_Se_Flr_4</i>					
	<i>Corridor_Nw_Flr_4</i>					
	<i>Dining_Flr_5</i>	-	-	-	7. VAV with reheat	7. VAV with reheat
	<i>Nursestn_Lobby_Flr_5</i>					
	<i>Office1_Flr_5</i>					
	<i>Office2_Mult5_Flr_5</i>					
	<i>Office3_Flr_5</i>					
	<i>Office4_Mult6_Flr_5</i>					
	<i>Corridor_Flr_5</i>					
	Rearstairsflr1	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Corridorflr1	1a. PTAC	1 PTAC	1a. PTAC	1. PTAC	2. PTHP
	Frontloungeflr1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	Restroomflr1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	Meetingroomflr1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	Mechanicalroomflr1	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Guestroom101	1a. PTAC	1 PTAC	1a. PTAC	1. PTAC	2. PTHP
	Guestroom102	1a. PTAC	1 PTAC	1a. PTAC	1. PTAC	2. PTHP
	Guestroom103	1a. PTAC	1 PTAC	1a. PTAC	1. PTAC	2. PTHP
	Guestroom104	1a. PTAC	1 PTAC	1a. PTAC	1. PTAC	2. PTHP
	Guestroom105	1a. PTAC	1 PTAC	1a. PTAC	1. PTAC	2. PTHP
	Employeeeloungeflr1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	Exercisecenterflr1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	Frontofficeflr1	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	Frontstairsflr1	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Rearstairsflr2	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Corridorflr2	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom201	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	Guestroom202_205	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom206_208	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom209_212	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom213	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom214	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom215_218	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom219	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom220_223	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom224	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Frontstairsflr2	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Rearstairsflr3	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Corridorflr3	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom301	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom302_305	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom306_308	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom309_312	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom313	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom314	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom315_318	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom319	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom320_323	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom324	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Frontstairsflr3	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Rearstairsflr4	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
	Corridorflr4	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom401	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom402_405	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom406_408	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom409_412	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom413	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom414	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom415_418	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom419	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom420_423	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Guestroom424	1a. PTAC	1 PTAC	1a. PTHP	1. PTAC	2. PTHP
	Frontstairsflr4	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
<i>HotelLarge Notes</i>		Guest rooms served by FPFC with DOAS; Basement on one VAV system; second VAV serves multiple floors	Same as prototype, but hot climates have electric heat		Guest rooms served by PTAC or PTHP without DOAS	Public zones have one VAV per floor.
HotelLarge ²⁸	<i>Basement, Retail_1_Flr_1 Retail_2_Flr_1, Mech_Flr_1</i>	7. VAV with reheat	7. VAV with reheat	7a. VAV with reheat	-	-

²⁸ Zone groups to HAVC system mapping differs between proposed and baseline. In the 90.1-2019 PI and Proposed models all non guest-room zones are served by a VAV system. The non-guest rooms in the baseline are served by VAV system per floor with exceptions applied to the laundry, café and kitchen zones as shown in the HotelLarge list.

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	<i>Storage_Flr_1, Laundry_Flr_1 Cafe_Flr_1, Lobby_Flr_1 Corridor_Flr_3, Banquet_Flr_6 Dining_Flr_6, Kitchen_Flr_6 Corridor_Flr_6</i>					
	Room_1_Flr_3, Room_2_Flr_3 Room_3_Mult19_Flr_3, Room_4_Mult19_Flr_3 Room_5_Flr_3, Room_6_Flr_3 Room_1_Flr_6, Room_2_Flr_6 Room_3_Mult9_Flr_6	15. FPFC	15. FPFC	15a. FC-E_heat	1. PTAC	1. PTHP
	<i>Basement</i>	-	-	-	3. PSZ-AC	4. PSZ-HP
	<i>Retail_1_Flr_1, Retail_2_Flr_1 Mech_Flr_1, Storage_Flr_1 Lobby_Flr_1</i>	-	-	-	7. Packaged VAV with reheat	8. Packaged VAV with PFP boxes
	<i>Banquet_Flr_6, Dining_Flr_6</i>	-	-	-	7. Packaged VAV with reheat	8. Packaged VAV with PFP boxes
	<i>Laundry_Flr_1</i>	-	-	-	3. PSZ-AC	4. PSZ-HP
	<i>Cafe_Flr_1</i>	-	-	-	3. PSZ-AC	4. PSZ-HP
	<i>Kitchen_Flr_6</i>	-	-	-	3. PSZ-AC	4. PSZ-HP
	<i>Corridor_Flr_3</i>	-	-	-	1. PTAC	2. PTHP
	<i>Corridor_Flr_6</i>	-	-	-	1. PTAC	2. PTHP
Warehouse	Zone1 Office	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Zone2 Fine Storage	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Zone3 Bulk Storage	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation	9. Heating and ventilation	10. Heating and ventilation
RestaurantFastFood	Dining	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Kitchen	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
RestaurantSitFood	Dining	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
	Kitchen	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	3. PSZ-AC	4. PSZ-HP
ApartmentMidRise	G Sw Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	G Nw Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	Office	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	G Ne Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	G N1 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	G N2 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	G S1 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	G S2 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M Sw Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M Nw Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M Se Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M Ne Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M N1 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M N2 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M S1 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	M S2 Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP
	T Sw Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP

Prototype	Zone Name	90.1-2019 PI	Proposed			Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A	
	T Nw Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP	
	T Se Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP	
	T Ne Apartment	3. PSZ-AC	3. PSZ-AC	4. PSZ-HP	1. PTAC	2. PTHP	
	G Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	G Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	Office	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	G Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	G N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	G N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	G S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	G S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F2 S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
ApartmentHighRise	F3 N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F3 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F4 S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	M S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F6 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	
	F6 Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP	

Prototype	Zone Name	90.1-2019 PI	Proposed		Baseline	
			CZ 3B, 3C and 4 to 8	CZ 0 to 3A	CZ 3B, 3C and 4 to 8	CZ 0 to 3A
	F6 Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F6 Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F6 N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F6 N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F6 S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F6 S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F7 S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F8 S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	F9 S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T Sw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T Nw Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T Se Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T Ne Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T N1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T N2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T S1 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP
	T S2 Apartment	14. WSHP	14. WSHP	14a. WSHP	1. PTAC	2. PTHP

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