U.S. DEPARTMENT OF ENERGY

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

Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010

BA Thornton MI Rosenberg EE Richman
W Wang Y Xie J Zhang
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B Liu, Project Manager

May 2011

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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

This project was conducted by Pacific Northwest National Laboratory (PNNL) in support of the U.S. Department of Energy's (DOE's) Building Energy Codes Program (BECP). DOE's BECP supports the upgrading of the building energy codes and standards, and the states' adoption, implementation, and enforcement of those codes and standards as they are incrementally upgraded. Building energy codes and standards set minimum requirements for energy-efficient design and construction for new and renovated buildings, and impact energy use and emissions for the life of buildings. They are part of a broader set of documents which govern the design and construction of buildings for the health and life safety of occupants. Energy codes and standards set a baseline for energy efficiency in construction by establishing minimum energy-efficiency requirements. Improving these documents generates consistent and long-lasting energy savings.

When the model energy codes and standards for buildings are being updated, BECP reviews the technical and economic basis of these documents. For commercial and multi-family high-rise residential buildings, which are the subject of this report, the basis for the energy codes is the ANSI/ASHRAE/IES[1] Standard 90.1. The 2004, 2007, and 2010 versions of Standard 90.1 are all utilized in the analysis described in this report (ANSI/ASHRAE/IESNA 2004, 2007 and ANSI/ASHRAE/IES 2010). These standards are referred to as 90.1-2004, 90.1-2007 and 90.1-2010 respectively in this report or as Standard 90.1 when referring to multiple versions of 90.1. For one and two family dwellings, townhouses and low-rise multi-family residential buildings, which are not the subject of this report, the relevant code is the International Energy Conservation Code (IECC).

BECP carries out the following activities:

- Recommends revisions and amendments to the model energy codes and standards during cyclical updates
- Seeks adoption of all technologically feasible and economically justified energy efficiency measures in these documents
- Participates in the processes that update and maintain these documents.

In 2007, as part of its Advanced Codes Initiative, DOE signed a memorandum of understanding (MOU) with ASHRAE to develop advanced commercial standards and included an agreement that 90.1-2010 would result in 30% energy savings relative to 90.1-2004. This MOU initiated the effort by BECP and ASHRAE which culminated in the release of 90.1-2010 in October 2010. This signed MOU introduced a new element and significant challenges for developing 90.1-2010. For the first time in the history of Standard 90.1, an energy goal was established for developing the new edition, 90.1-2010. The 30% energy efficiency goal led to a dramatic increase in the level of activity and enhancement of Standard 90.1 as reflected in the quantity of changes, called addenda, proposed and approved. Prior to the development of 90.1-2010, the last three updates of Standard 90.1 to the 2001, 2004 and 2007 editions generated 34, 32 and 44 approved addenda, respectively. When 90.1-2010 was published, 109 approved addenda to 90.1-2007 were incorporated.

[1] ANSI – American National Standards Institute; ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers; IES – Illuminating Engineering Society of North America; prior to 90.1-2010, IESNA rather than IES is identified as one of the originators, IESNA is Illuminating Engineering Society of North America.

PNNL was funded by DOE's BECP to provide both leadership and technical analysis support for 90.1-2010 to reach the 30% energy savings goal. To closely measure the progress towards the goal, PNNL developed a new metric and process called the "Progress Indicator" (PI). Using the PI, PNNL periodically reported the energy and cost saving impacts for the proposed and approved changes to Standard 90.1, called addenda, to DOE and the Standing Standards Project Committee (SSPC) for 90.1 during the three-year Standard development cycle. PNNL conducted the PI with inputs from many other contributors and sources of information. In particular, guidance and direction was provided by the Simulation Working Group under the auspices of the SSPC 90.1.

This report documents the PI process and analysis that PNNL developed to evaluate the potential energy savings from the application of 90.1-2010 to building design and construction compared to the application of 90.1-2004. The report describes PNNL's *EnergyPlus* simulation framework, and the building prototype simulation models. The combined upgrades from 90.1 -2004 to 90.1-2010 are described, and consist of a total of 153 approved addenda (44 addenda to 90.1-2007 and 109 addenda to 90.1-2010). PNNL reviewed and considered all 153 addenda for quantitative analysis in the PI process. Fifty-three of those addenda are included in the quantitative analysis. This report provides information on the categorization of all of the addenda, a summary of the content, and a more in-depth explanation of the impact and modeling of the 53 identified addenda and their quantitative savings.

The PI process was implemented using state-of-art energy simulation software—*EnergyPlus*—for the quantitative analysis. PNNL developed a suite of 16 prototype buildings based on DOE's Commercial Reference Building Models (Deru et al. 2011), with substantial modifications during the PI. These 16 prototype buildings represent 80% of the U.S. commercial building floor area and over 70% of the energy consumed in U.S. commercial buildings. The prototype buildings are simulated in eight climate zones that are utilized by ASHRAE for 90.1 Standard developments. The climate zones are further divided into moist and dry regions, represented by 17 climate locations, 15 of which are in the United States. Together, these provide a solid basis for reaching conclusions about the potential energy savings of applying 90.1-2010 compared to applying 90.1-2004.

The 16 prototype building models contain inputs consistent with the type of requirements in Standard 90.1. Each building prototype was first developed as a computer model in accordance with design and construction requirements found in 90.1-2004. Each building prototype was also developed as a model in accordance with the design and construction requirements of 90.1-2010. Different versions of the models were created to match the Standard 90.1 requirements that vary with climate such as wall insulation.

The set of 90.1-2004 and 90.1-2010 buildings were simulated and energy use statistics were extracted from each building model in the form of annual energy use by fuel type. The annual energy use was then converted to energy use intensity figures expressed in annual kBtu energy use per square foot of building area. Energy usage reported for the Progress Indicator was "site" energy, utility energy, electricity and natural gas, delivered and used at the site. This report also includes summary results in terms of "source" energy, energy consumed at the power plant to generate the electricity delivered to the site, and energy delivered to the site as fuel. Using weighting factors by building type and climate related geographic areas in the United States developed from five years of recent construction data, these energy use statistics were then aggregated nationally for each step in the revision of Standard 90.1 over the three year development cycle.

Standard 90.1 regulates the elements of commercial buildings that result in most of the energy used in those buildings. Some energy usage from what are sometimes called “process loads” come from equipment that is not directly regulated by Standard 90.1, including plug-in devices such as computers and appliances, and other equipment such as gas cooking equipment. This type of equipment uses energy directly and affects HVAC energy usage indirectly by generating heat in spaces, potentially increasing cooling energy and reducing heating energy. Plug and process loads (PPL) are incorporated in the prototypes used in the modeling for the PI. Changes to Standard 90.1 do not directly affect the energy efficiency of this type of equipment. Results are presented with PPL energy usage to show the impact on total commercial building energy usage and are also presented without PPL to show the impact on just the Standard 90.1 regulated energy usage.

Table ES.1 shows the final results of the PI. The DOE-ASHRAE goal of 30% savings for the application of 90.1-2010 compared to 90.1-2004 was achieved. The simulation results show 32.7% site energy savings and 29.5% energy cost savings, if plug and process loads are excluded in the percentage saving calculation. Including PPL in the percentage saving calculation, the site energy savings are 25.6% and energy cost savings are 23.2%. National aggregated source energy savings, not shown in the table, are 23.2% with all energy uses included.

Table ES.1. Energy and Cost Savings Results for 90.1-2010 vs. 90.1-2004

National-weighted Energy Savings	With Plug/Process Loads	Without Plug/Process Loads
Site Energy	25.6%	32.7%
Energy Cost	23.2%	29.5%

Table ES.2 and ES.3 separate the energy usage savings by prototype with and without PPL and show the percentage savings by prototype and the energy usage index in kBtu/ft^2 for both the 90.1 -2004 and 90.1-2010 cases. While the highest savings percentages occur in the school prototypes when PPL are not included; these percentages do not stand out as much when PPL are included. The lowest percentage savings occur in the quick-service restaurant and two apartment prototypes, particularly when PPL are included.

Table ES.2. Energy and Energy Cost Savings with Plug and Process Loads

Building Type	Building Prototype	Site Energy (kBtu/ft²/yr)		Energy Cost ($/ft²)		Site Energy Savings	Energy Cost Savings
		90.1-2004	**90.1-2010**	**90.1-2004**	**90.1-2010**		
Office	Small office	41.3	32.8	$1.17	$0.93	20.6%	20.3%
	Medium office	51.6	37.3	$1.42	$1.01	27.7%	29.1%
	Large office	46.0	33.4	$1.21	$0.92	27.5%	24.3%
Retail	Stand-alone retail	76.0	49.5	$1.89	$1.32	34.8%	29.9%
	Strip mall	80.4	56.9	$1.97	$1.42	29.2%	28.0%
Education	Primary school	73.4	50.2	$1.80	$1.33	31.6%	26.3%
	Secondary school	66.2	41.2	$1.64	$1.13	37.8%	31.0%
Health Care	Outpatient healthcare	163.3	123.6	$4.17	$3.15	24.3%	24.3%
	Hospital	157.4	118.4	$3.55	$2.81	24.8%	20.9%
Lodging	Small hotel	78.5	66.6	$1.72	$1.47	15.2%	14.4%
	Large hotel	163.9	125.9	$2.99	$2.42	23.2%	19.0%
Warehouse	Warehouse	26.3	19.0	$0.57	$0.42	27.7%	27.3%
Food Service	Quick service restaurant	570.1	519.9	$10.16	$9.12	8.8%	10.3%
	Full service restaurant	409.7	330.9	$7.96	$6.12	19.2%	23.1%
Apartment	Mid-rise apartment	47.0	41.2	$1.23	$1.11	12.3%	9.4%
	High-rise apartment	48.9	44.0	$1.35	$1.25	10.1%	7.3%
National-weighted average		**73.9**	**55.0**	**$1.75**	**$1.35**	**25.6%**	**23.2%**

Table ES.3. Energy and Energy Cost Savings without Plug and Process Loads

Building Type	Building Prototype	Site Energy (kBtu/ft²/yr)		Energy Cost ($/ft²)		Site Energy Savings	Energy Cost Savings
		90.1-2004	**90.1-2010**	**90.1-2004**	**90.1-2010**		
Office	Small office	32.2	24.4	$0.89	$0.66	24.4%	26.6%
	Medium office	36.6	23.9	$0.97	$0.56	34.8%	41.8%
	Large office	30.4	19.2	$0.85	$0.56	36.6%	34.0%
Retail	Stand-alone retail	68.5	42.1	$1.66	$1.10	38.6%	34.0%
	Strip mall	75.0	51.5	$1.81	$1.26	31.3%	30.5%
Education	Primary school	52.1	29.3	$1.30	$0.83	43.8%	35.8%
	Secondary school	51.8	27.1	$1.28	$0.78	47.6%	39.2%
Health Care	Outpatient healthcare	116.0	77.2	$2.88	$1.86	33.5%	35.3%
	Hospital	107.9	69.4	$2.69	$1.96	35.6%	27.2%
Lodging	Small hotel	56.1	44.4	$1.32	$1.07	20.8%	18.7%
	Large hotel	128.5	90.9	$2.57	$2.01	29.2%	21.9%
Warehouse	Warehouse	23.7	16.5	$0.49	$0.34	30.3%	31.5%
Food Service	Quick service restaurant	300.6	250.6	$7.50	$6.46	16.6%	13.9%
	Full service restaurant	256.3	178.1	$5.78	$3.94	30.5%	31.8%
Apartment	Mid-rise apartment	32.4	26.8	$0.79	$0.67	17.3%	14.7%
	High-rise apartment	35.7	31.0	$0.95	$0.86	13.2%	9.8%
National-weighted average		**56.8**	**38.2**	**$1.37**	**$0.96**	**32.7%**	**29.5%**

Acknowledgments

This document was prepared by Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Energy's (DOE's) Building Energy Codes Program. The authors would like to thank Mr. Ron Majette, DOE's Project Manager of Codes and Standards under the Building Energy Codes Program, for his dedicated support and thoughtful guidance during the three-year project life.

The authors would like to thank the members of the ASHRAE Standing Standards Project Committee (SSPC) for 90.1 for their tremendous volunteer efforts and insightful inputs and reviews of our energy analysis work during the development of the prototype models and quantification analysis of over 100 addenda. We especially want to express our appreciation of the 90.1 Simulation Working Group. This working group was charged to by the SSPC 90.1 to support PNNL's simulation analysis during the development of 90.1-2010. In addition to the SSPC 90.1 full committee's and subcommittees' meetings, this working group met three times in person and hosted countless conference meetings to establish the ground rules and provided insightful key information that contributed significantly for this analysis. The members of this working group include Ron Jarnagin, Drake Erbe, Dick Lord, Susanna Hanson, Bing Liu, Merle McBride, John Hogan, and Martha VanGeem.

The authors also would like to recognize Diana Shankle, the Program Manager who oversees the BECP Program at PNNL, for her strong support of this project. The authors greatly appreciate the assistance of Todd Taylor, Dr. Yulong Xie, and Hung Ngo at PNNL. They constructed the cluster simulation structure in *EnergyPlus*, which allowed us to evaluate the many variations of energy efficiency technologies in a timely fashion to meet the project's compressed schedule. Mark Halverson and Dave Conover at PNNL provided very detailed reviews on this report. Krishnan Gowri and Yunzhi Huang also contributed significantly at the early stage of this project. Mike Parker at PNNL provided the editorial and document production reviews for the report.

This project was a true team effort and the authors would like to express their deep appreciation to everyone who contributed to the completion of this work.

Bing Liu, P.E.
Project Manager
Pacific Northwest National Laboratory

Acronyms and Abbreviations

ACH	air changes per hour
AEDG	Advanced Energy Design Guide
AFUE	annual fuel utilization efficiency
AHU	air handling unit
AIA	American Institute of Architects
ANSI	American National Standards Institute
ARI	Air-conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing Materials
BECP	Building Energy Codes Program
C-factor	thermal conductance
CAV	constant air volume
CBECS	Commercial Buildings Energy Consumption Survey
CDD	cooling degree day
CFM	cubic feet per minute
CHW	chilled water
COP	coefficient of performance
CPU	central processing unit
CTI	Cooling Technology Institute
CQA	construction quality adjustment
DCV	demand controlled ventilation
DOAS	dedicated outdoor air system
DOE	Department of Energy (United States)
DX	direct expansion
E_c	combustion efficiency
EER	energy efficiency ratio
EIA	Energy Information Administration
EIR	energy input ratio
EPA	Environmental Protection Agency
ERV	energy recovery ventilator
E_t	thermal efficiency
EUI	energy use intensity
F-factor	heat transfer coefficient of a slab edge unit of perimeter length
FCU	fan coil units
FF	flow fraction
FLP	full load power

FLR	floor
FPLR	function of part load ratio
FT	function of temperature
GPARM	General PARaMetrics
gtp	ground temperature profiles
HDD	heating degree day
HSPF	heating seasonal performance factor
HVAC	heating, ventilation, and air conditioning
idd	Energy Plus input data dictionary
IECC	International Energy Conservation Code
IEER	integrated energy efficiency ratio
IES	Illuminating Engineering Society
IESNA	Illuminating Engineering Society of North America
idf	Energy Plus input file
IPLV	integrated part load value
kVA	kilo volt amperes
LBNL	Lawrence Berkeley National Laboratory
LL	load losses
LPD	lighting power density
MHC	McGraw-Hill Construction
MOU	memorandum of understanding
mph	miles per hour
NBI	New Buildings Institute
NC^3	National Commercial Construction Characteristics
NFRC	National Fenestration Rating Council
NLL	no load losses
NREL	National Renewable Energy Laboratory
OA	outdoor air
PI	Progress Indicator
PLF	part-load fraction
PNNL	Pacific Northwest National Laboratory
PPL	plug and process loads
PSZ-AC	packaged single zone air conditioner
PTAC	packaged terminal air conditioner
PTHP	packaged terminal heat pump
RCR	room cavity ratio
SA	supply air
SEER	seasonal energy efficiency ratio

SHGC	solar heat gain coefficient
SSPC	Standing Standard Project Committee
SRI	solar reflectance index
SWG	Simulation Working Group
TSP	total static pressure
U-factor	thermal transmittance
USACE	United States Army Corps of Engineers
USGBC	US Green Building Council
VAV	variable air volume
VFD	variable frequency drive
VLT	visible light transmittance
VRF	variable refrigerant flow
VRP	ventilation rate procedure
W	Watt
w.c.	water column
WSHP	water source heat pump
WWR	window-to-wall ratio

Contents

Figures

Tables

1.0 Introduction

This project was conducted by Pacific Northwest National Laboratory (PNNL) in support of the U.S. Department of Energy's (DOE) Building Energy Codes Program (BECP). BECP was founded in 1993 in response to the *Energy Policy Act of 1992*, which mandated that DOE participate in the development process for national model codes and standards and that DOE help states adopt and implement progressive energy codes. DOE has been supporting the development and implementation of more stringent building energy codes and standards since the 1970's, but the formation of the BECP was the first time a DOE organization was assigned energy codes and standards as the focus with specific mandates.

BECP supports the incremental upgrading of the model energy codes and energy standards, and the states' adoption, implementation, and enforcement of those documents as they are upgraded. Building energy codes and energy standards set baseline minimum requirements for energy-efficient design and construction for new and renovated buildings and impact energy use and emissions for the life of the buildings. The energy codes and standards are part of the overall documents which govern the design and construction of buildings for the health and life safety of occupants. Improving these documents generates consistent and long-lasting energy savings.

When the model building energy codes and standards are being updated, BECP reviews the technical and economic basis of those documents. For commercial and multi-family high-rise residential buildings, which are the subject of this report, the basis for the energy codes is ANSI/ASHRAE/IES Standard 90.1[1]. The 2004, 2007, and 2010 versions of Standard 90.1 are all utilized in the analysis described in this report (ANSI/ASHRAE/IESNA 2004, 2007 and ANSI/ASHRAE/IES 2010). These standards are referred to in this report as 90.1-2004, 90.1-2007 and 90.1-2010 respectively, or as Standard 90.1 when referring to multiple versions of 90.1. The references for the standards are implied and are not shown with each mention of Standard 90.1. For residential low-rise buildings, which are not the focus of this report, the relevant code is the International Energy Conservation Code (IECC).

BECP carries out the following activities:

- Recommends revisions amendments to the model energy codes and standards during cyclical updates
- Seeks adoption of all technologically feasible and economically justified energy efficiency measures in these documents
- Participates in the processes that update and maintain these documents.

As one of DOE's national laboratories, PNNL has played a major role in supporting DOE's BECP since its inception in 1993. PNNL is closely involved in the upgrading of the model codes and standards. Specifically, PNNL provides significant assistance to the ASHRAE Standing Standard Project Committee (SSPC) for 90.1 (SSPC 90.1). That assistance ranges from providing leadership and voting members to development committees to developing change proposals (called addenda) for standards and codes.

[1] ANSI – American National Standards Institute; ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers; IES – Illuminating Engineering Society; prior to 90.1-2010, IESNA rather than IES is identified as one of the originators, IESNA is Illuminating Engineering Society of North America.

PNNL also conducts analyses and supports DOE's determinations which are published in the *Federal Register*. Determinations confirm whether or not each new edition of the model codes or standards will improve the energy efficiency of buildings.[1]

Throughout this report, each addendum to Standard 90.1 is named according to a convention that begins with 90.1, followed by a hyphen, then the last two digits of the year version of Standard 90.1 that the addendum applies to, and finally the letter name of the addendum. For example, addendum c to 90.1-2004 is identified as addendum 90.1-04c and addendum q to 90.1-2007 is referred to as addendum 90.1-07q.

The rest of this chapter describes ASHRAE's process for updating Standards, in particular Standard 90.1, and provides an overview of the contents of this report.

1.1 ASHRAE Standard 90.1 Update Process

In 1999, the ASHRAE Board of Directors voted to place Standard 90.1 in a continuous maintenance process. With the publication of 90.1-2001, ASHRAE began publishing new building energy standards in its entirety on a three-year cycle, with ASHRAE issuing versions of Standard 90.1in 2004, 2007, 2010, and planning for a new version in 2013. This cycle allowed users to know when new editions would be published. Each new edition contained any errata, as well as all new addenda. The new addenda are processed through the continuous maintenance process rules approved by ANSI. Figure 1.1 illustrates ANSI consensus standards development process.

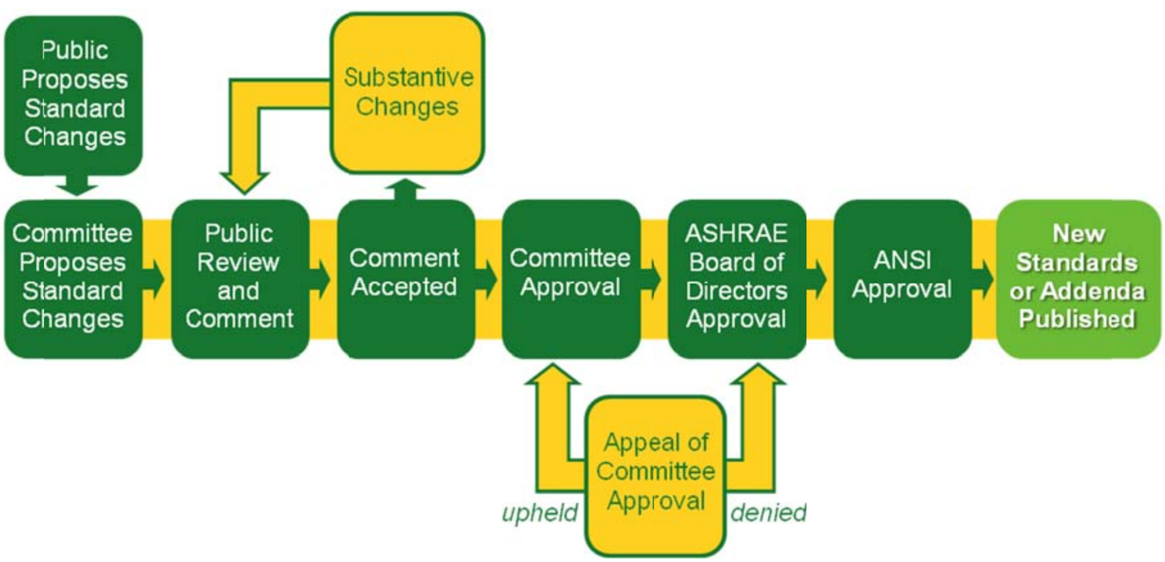

Figure 1.1. ANSI Consensus Standards Development Process

[1] For DOE's commercial code determination, see DOE's Energy Codes web site at http://www.energycodes.gov/status/all_about_determinations.stm.

1.2 Advanced Codes Initiative and 90.1-2010

In 2007, as part of its Advanced Codes Initiative, DOE signed a memorandum of understanding (MOU) with ASHRAE to develop advanced commercial building standards and codes, with the first step being a commitment that 90.1-2010 would lead to 30% energy savings compared to 90.1-2004. This MOU initiated the current efforts by BECP and ASHRAE, which culminated in 2010 with the release of 90.1-2010. The Advanced Codes Initiative also called for the development of advanced residential standards and codes (not addressed further in this report), with the first commitment that the 2012 IECC would be 30% better than the 2006 IECC.

This signed MOU introduced a new element and significant challenges for developing 90.1-2010. The 30% energy savings goal led to a dramatic increase in the level of activity and enhancement of Standard 90.1. For the first time in the history of Standard 90.1, an energy goal was set for developing the new edition of the standard. Prior to the development of 90.1-2010, the last three updates of Standard 90.1 to 2001, 2004 and 2007 editions generated 34, 32 and 44 approved addenda, respectively. By the time 90.1-2010 was published in October 2010, 109 addenda to 90.1-2007 were approved and incorporated in the new version.

PNNL was funded by DOE to provide both leadership and technical analysis support for 90.1-2010 to reach the 30% energy savings goal. To closely measure the progress towards the goal, PNNL developed a new metric and process named the "Progress Indicator" (PI). The PI is a process to measure progress toward the 30% improvement goal by 90.1-2010 relative to the baseline 90.1-2004. Using the PI, PNNL periodically reported the energy and cost saving impacts for the approved addenda to DOE and the SSPC 90.1 during the three-year Standard development cycle. PNNL conducted this analysis with inputs from many other contributors and sources of information. In particular, guidance and direction were provided by the Simulation Working Group (SWG) under the auspices of the SSPC 90.1.

1.3 Contents of Report

This report documents the approach and methodologies that PNNL developed to evaluate the energy savings achievable from use of 90.1-2010. The evaluation was carried out using computer simulations of 16 prototype buildings representing 80% of U.S. commercial building floor area. These 16 prototype buildings were constructed to fit the framework of the 90.1 Standard across a range of U.S. climates. Each building prototype used in the simulation analysis was first developed as a computer model in accordance with design and construction requirements found in 90.1-2004. Building models were also developed to reflect buildings designed and constructed under the requirements of 90.1-2010. The sets of 90.1-2004 and 90.1-2010 buildings were simulated and energy use statistics were extracted from each building model in the form of annual energy use by fuel type. The annual energy use was then converted to energy use intensity (EUI) figures expressed in energy use per square foot per year ($kBtu/ft^2$). Using weighting factors by building type and geographic area developed from five years of recent construction data, these energy use statistics were then aggregated to national results for each revision of Standard 90.1. Chapters 2, 3, and 4 in this report detail PNNL's PI process and methodology, *EnergyPlus* simulation framework, and prototype model descriptions, respectively.

This report covers the combined upgrades from 90.1-2004 to 90.1-2010, a total of 153 addenda. As these addenda were developed, PNNL went through a screening process. This screening focused on the

118 addenda that affect the mandatory and prescriptive requirements in Chapters 5 through 10 of Standard 90.1. Other addenda affected only items in areas such as definitions, normative references, the Energy Cost Budget Method, and the Appendix G performance rating method. The screening of the addenda, called addenda characterization, determined if the addenda provide savings relative to the earlier standard. If so, further evaluation determined if those savings could be captured in the quantitative analysis. Some addenda are believed to contribute savings but could not be quantified in some cases because the type of building component is not included in the building prototypes modeled and in other cases because of excessive obstacles to simulation in *EnergyPlus*. Of the 118 addenda that affect Standard 90.1 Chapters 5 through 10, 53 are expected to result in energy savings that are quantified in the PI; 19 would likely result in energy savings but are not quantified; the remaining 46 addenda were not identified with potential energy savings. Chapter 5 in this report includes a full listing of the addenda by these categories.

The 53 addenda with quantifiable savings were evaluated through the effort outlined in Chapter 2 in this report. Energy savings were evaluated for site energy use and corresponding energy cost. Site energy refers to the utility electricity and natural gas delivered and used at the building site. Energy cost savings are based on national average energy costs applied to the site energy usage results. Finally, energy savings were separated out into energy uses regulated by Standard 90.1 excluding plug and process loads and for all energy usage including plug and process loads. Energy usage and cost were aggregated using weighting factors based on the area of new building construction of the types of buildings included in the prototypes and based on climates locations modeled in the analysis. Source energy is also reported and is the energy used in generating the electricity used at the site and energy of fuel delivered to the site, such as natural gas. The results are provided in Chapter 6 of this report.

The report has six appendixes. Appendix A includes prototype building descriptions. Appendix B lists the internal loads for each thermal zone in all prototypes. Appendix C includes schedules used to model time of day variation of building operations. Appendix D lists the system name and type used in *EnergyPlus* models for all 16 prototype buildings. Appendix E includes the building envelope prescriptive values from 90.1 -2004 and 90.1-2010. Appendix F presents energy savings results by end uses.

2.0 Progress Indicator Process and Methodology

PNNL provided technical support during the development of 90.1-2010. The PI incorporated quantitative assessment of the changes between 90.1-2004 and 90.1-2010 that were identified as measurable using the simulation procedure. The process included addenda to 90.1-2004 that led to 90.1-2007 as well as addenda to 90.1-2007 that are now rolled into 90.1-2010.

A Simulation Working Group (SWG) was formed to guide the simulation effort conducted by PNNL. The SWG represented the SSPC 90.1 and its subcommittees, such as the Mechanical and Envelope Subcommittees. The SWG reviewed key building modeling inputs and assumptions and the energy savings results. The SWG also established the ground rules for modeling. Key guidelines developed with the SWG included the following:

- Comparison of the different versions of Standard 90.1 on a book-by-book basis, following the changes in the texts
- Prototype buildings to cover 80% of U.S. commercial building stock
- Prototype buildings to capture a reasonable level of accuracy with a reasonable level of effort
- Whole building energy usage in the models, including regulated and unregulated loads. This usage includes exterior lighting, plug loads (receptacle loads), cooking appliances, refrigeration equipment, elevators, and transformers.

PNNL updated the PI and reported to the SWG and the SSPC 90.1 at each of their quarterly meetings. PNNL also provided support to the SSPC 90.1 subcommittees such as the Envelope and Mechanical Subcommittees to evaluate new proposals being turned into addenda and provided load profile spreadsheet tools to the SSPC 90.1 Mechanical Subcommittee members. The load profile spreadsheet tools were directly used by the Mechanical Subcommittee members to evaluate the energy savings impacts of several change proposals, such as economizer and energy recovery ventilation. Figure 2.1 outlines the PI technical work done by PNNL.

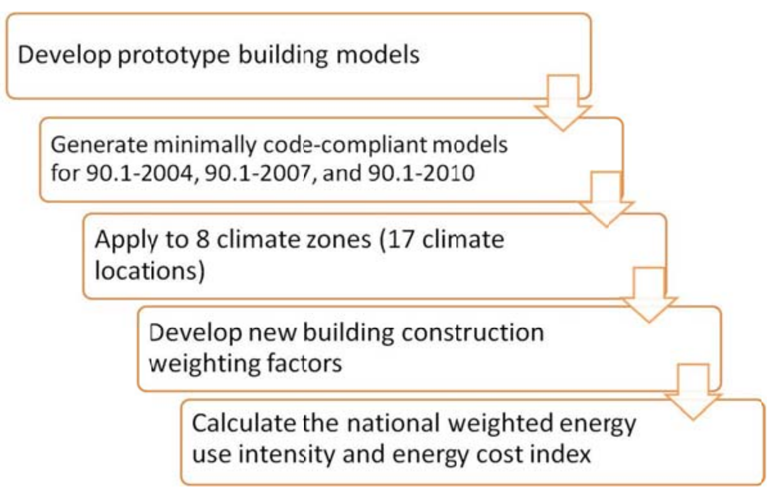

Figure 2.1. Progress Indicator Process

The rest of this chapter describes the development of the 16 prototype buildings, the development of the models, the climate zones used in the analysis, and the approach used to analyze the results.

2.1 Develop Prototype Building Models

The 90.1 prototype building models used in the PI analysis are primarily based on DOE's Commercial Reference Building Models. The development of these models is described in the report, *U.S. Department of Energy Commercial Reference Building Models of the National Building Stock* (Deru et al. 2011). DOE's Commercial Reference Building Models (in *EnergyPlus*) are available at http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html.

PNNL developed a suite of 16 prototype buildings covering the majority of the commercial building stock and mid-rise to high-rise buildings. This set of prototype buildings includes all the Reference Building types, except supermarkets, and adds a new building prototype representing high-rise apartment buildings. The high-rise apartment building was developed by PNNL based on the mid-rise apartment building and recommendations from the SSPC 90.1 Mechanical Subcommittee for the heating, ventilation, and air conditioning (HVAC) system type.

Chapter 4 in this report describes the prototypes in detail. Extensive information on the prototypes and the *EnergyPlus* model inputs and outputs are available for no charge at: http://www.energycodes.gov/commercial/901models/.

A number of resources were used in developing the 90.1 prototype building models to refine the prototypes used in this analysis and to quantify the savings from 90.1-2010, described in Chapter 5 of this report. Those resources included the following:

- 90.1 SWG and committee member expert recommendations and reviews
- *Advanced Energy Design Guides*, developed by ASHRAE, the American Institute of Architects (AIA), IESNA, the US. Green Building Council (USGBC), and DOE (http://www.ashrae.org/technology/page/938)
- The *Commercial Building Energy Consumption Survey 2003* (CBECS 2003) available as downloadable reports and micro-data files from the EIA website at http://www.eia.doe.gov/emeu/cbecs/. In the 2003 CBECS survey, 4,859 buildings were surveyed, and the sampled buildings represent the entire stock of U.S. commercial buildings.
- The F.W. Dodge database (F.W. Dodge 2002) provides detailed historical and forecast databases of construction activity available for a fee at http://dodge.construction.com/. It contains extensive, comprehensive coverage of existing building space throughout the United States. Up to 20 years of historical data are combined with up to 25 years of forecast data for 15 different project types. Details include floor space, number of buildings, etc.
- National Commercial Construction Characteristics (NC^3) Database, an internal database developed by PNNL to represent nationwide commercial construction energy-related characteristics (Richman et al. 2008). This database is derived from McGraw-Hill/F.W. Dodge drawings, part of the F.W. Dodge database described above and available for a fee at http://dodge.construction.com/Plans/Electronic/ViaInternet.asp. The building plans used were developed from 1996 to 2007. The current database includes over 300 commercial buildings.

The CBECS data are organized around 14 principal building activities. Figure 2.2 illustrates the annual energy consumption in trillions of Btus by the principal building activities, ranking from the most energy usage to the least energy usage sector. The prototype buildings cover the first seven principal building activities with the most energy consumption, representing 76% of the building energy usage of commercial buildings. In addition, the prototype buildings also include two more prototypes, mid-rise and high-rise apartment buildings, which are not included in CBECS but are regulated by Standard 90.1.

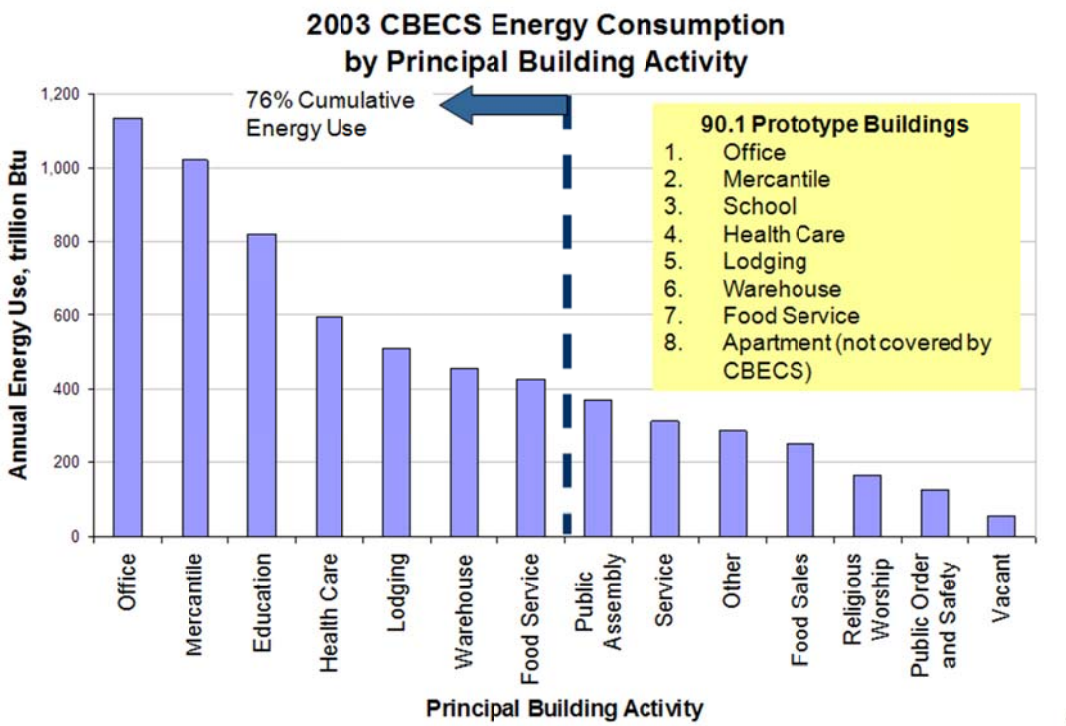

Figure 2.2. CBECS 2003 Energy Consumption by Principal Building Activity

Table 2.1 shows the 16 building prototypes, including 14 with the applicable principal building activity categories from CBECS and two added apartment building activity types. The prototypes include most of the characteristics of buildings that do not change with Standard 90.1 and climate zones. Characteristics include building size and shape, type of building activity and occupancy, and mechanical system type. Detailed descriptions of these prototypes are provided in Chapter 4 of this report.

Table 2.1. Prototype Buildings Used in the PI

Principal Building Activity	Building Prototype
Office	Small Office
	Medium Office
	Large Office
Mercantile	Standalone Retail
	Strip Mall
Education	Primary School
	Secondary School
Healthcare	Outpatient Healthcare
	Hospital
Lodging	Small Hotel
	Large Hotel
Warehouse	Warehouse (non-refrigerated)
Food Service	Quick-service Restaurant
	Full-service Restaurant
Apartment	Mid-rise Apartment
	High-rise Apartment

2.2 Generate Minimally Standard Compliant Models

As indicated in Section 2.1 of the report, most of the building characteristics and modeling inputs do not change for the various editions of Standard 90.1. However, some building characteristics do vary with the version of Standard 90.1 that applies and by climate zones. Values from the different standards are incorporated in different versions of the models to meet the mandatory and prescriptive requirements in the standards, such as prescriptive building envelope values for roofs, walls, windows, and other components. The 90.1-2004 values were incorporated into the baseline models. The 90.1-2007 values are not reported in the PI as a comparison between 2007 and 2004 editions. However, the changes in 90.1-2007 are reflected in the 90.1-2010 values. The 2010 values originate from the addenda to 90.1-2004 and 2007 with quantified savings that can be incorporated in the models. The final 90.1-2010 models include all of these addenda as incorporated in 90.1-2010. Chapter 3 of the report describes the simulation process that incorporates these values and Chapter 5 describes the modeling strategies for these quantified addenda.

2.3 Identify Climate Zones

The prototype buildings are simulated in eight climate zones of the International Energy Conservation Code (IECC) also used by ASHRAE for residential and commercial standards. The common set of climate zones includes eight zones covering the entire United States, as shown in Figure 2.3 (Briggs et al. 2003). Climate zones are categorized from 1 to 8, with increasing heating degree days (HDDs) and decreasing cooling degree days (CDDs). These climate zones may be mapped to other climate locations for international use. The climate zones are further divided into moist, dry, and marine regions.

For this analysis, a specific climate location (city) is selected as a representative of each climate zone. A set of 17 cities is used that represents the 17 climate conditions identified in Standard 90.1. Two of these cities are outside the United States because the climate subzones they represent do not exist in the United States. Riyadh, Saudi Arabia, represents climate zone 1B (very hot, dry) and Vancouver B.C., Canada, represents climate zone 5C (cool, marine).

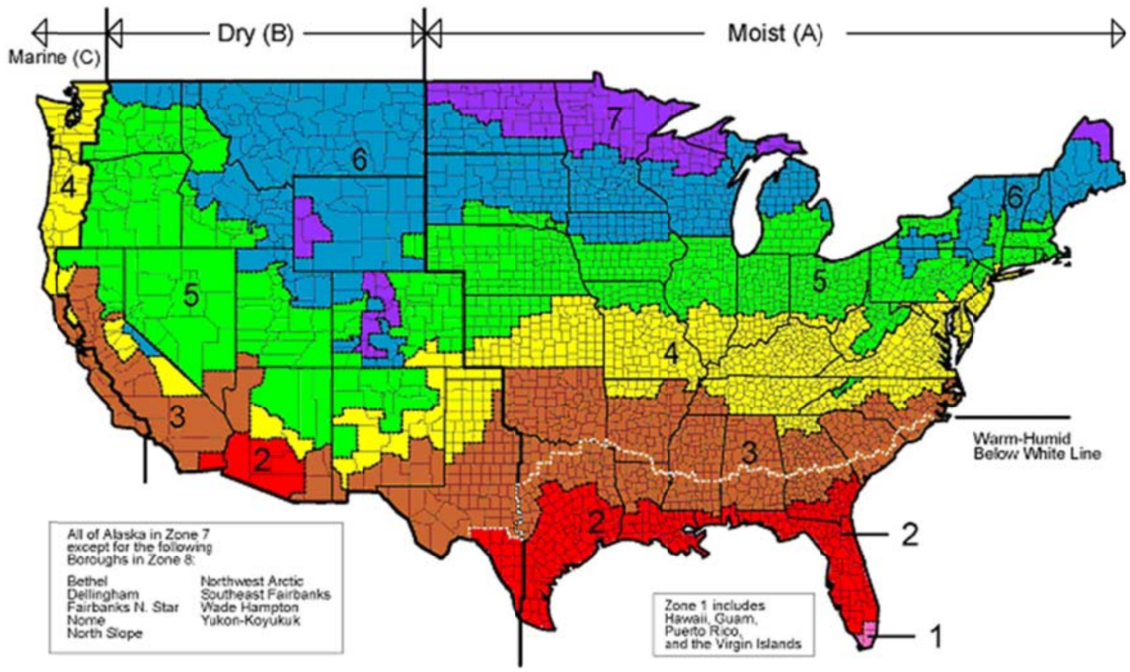

Figure 2.3. DOE-Developed Climate Zone Map

The 17 cities representing the climate zones are:

- 1A: Miami, Florida (very hot, humid)
- 1B: Riyadh, Saudi Arabia (very hot, dry)
- 2A: Houston, Texas (hot, humid)
- 2B: Phoenix, Arizona (hot, dry)
- 3A: Memphis, Tennessee (warm, humid)
- 3B: El Paso, Texas (warm, dry)
- 3C: San Francisco, California (warm, marine)
- 4A: Baltimore, Maryland (mixed, humid)
- 4B: Albuquerque, New Mexico (mixed, dry)
- 4C: Salem, Oregon (mixed, marine)
- 5A: Chicago, Illinois (cool, humid)
- 5B: Boise, Idaho (cool, dry)
- 5C: Vancouver B.C., Canada (cool, marine)
- 6A: Burlington, Vermont (cold, humid)
- 6B: Helena, Montana (cold, dry)
- 7: Duluth, Minnesota (very cold)
- 8: Fairbanks, Alaska (subarctic)

2.4 Analyze Results

The primary measurement reported for the PI is the national aggregated energy and cost savings. These savings are the percentage savings for the entire set of prototypes and all of the 15 U.S. climate subzones, which excludes Riyadh and Vancouver, BC. Percentages are calculated for the change in annual energy usage and the change in annual energy cost. Annual site energy usage is reported in the PI as site energy usage intensity (EUI) values – energy use per unit floor area, kBtu/ft^2. This includes electricity and natural gas converted by straight unit conversion to the kBtu unit. Energy usage by utility energy type is determined during the simulation, and electricity and natural gas usage is used to calculate energy cost. Energy cost is reported per unit area, an energy cost index similar to the energy usage index described above. Energy usage that would be delivered by the utility to the building, known as "site" energy, is reported. The simulation provides a break-down of energy end uses such as lighting, cooling, heating, fan, service hot water, and plug loads.

The "source" energy is also calculated. Source energy is the energy sage at the utility generating facility needed to provide the electricity used at the site, and energy of fuel delivered to the site such as natural gas. Source energy is calculated from site energy reported from the simulations using conversion factors from the Annual Energy Outlook for 2011 (EIA 2011).

Electricity: 3.2 source Btu per site Btu (10,918 source Btu per site kWh)

Natural Gas: 1.090 source Btu per site Btu

This natural gas source energy conversion factor was calculated by dividing the sum of all natural gas usage, including usage for natural gas field production, leases, plant fuel, and pipeline (compression) supply by delivered gas energy, to the four primary energy sectors: residential, commercial, industrial, and transportation.

Energy use and cost saving results are presented in Chapter 6 of this report.

The following subsections describe the use of the weighting factors, energy prices, outdoor air ventilation standards, and regulated and unregulated energy.

2.4.1 New Building Construction Weighting Factors

To estimate the energy savings impact on a national scale, PNNL acquired disaggregated construction volume data from McGraw-Hill Construction (MHC) Project Starts Database. The MHC database contains the floor area of new construction in the United States for the years 2003 to 2007. PNNL analyzed this MHC database to develop detailed construction weights by climate zones, subzones, and states (Jarnagin and Bandyopadhyay 2010). These weights are used in developing a weighted national energy savings estimate for the impact of the 2010 standard.

Table 2.2 summarizes the construction floor area and percentage weights by building type. As the table shows, these 16 prototypes cover 80% of new construction floor areas. Table 2.3 lists the weighting factors assigned to each prototype in all 15 U.S. climate subzones, using 16 prototypes representing the entire commercial building stock. The two climate subzones that occur only outside the United States, Riyadh and Vancouver, are not included in the weighted average. The energy and energy cost savings are weighted by the percentages shown in Table 2.2 and are summed to create the national weighted-average values.

Table 2.2. MHC Data by Building Type

Prototype	Total Floor Area (x1,000 ft^2)	Construction Weights
Small Office	371,009	4.5%
Medium Office	400,091	4.8%
Large Office	220,134	2.7%
Standalone Retail	1,009,246	12.2%
Strip Mall	375,093	4.5%
Primary School	330,418	4.0%
Secondary School	685,508	8.3%
Outpatient Healthcare	289,171	3.5%
Hospital	228,131	2.8%
Small Hotel	113,837	1.4%
Large Hotel	327,562	4.0%
Warehouse	1,105,951	13.4%
Quick Service Restaurant	38,809	0.5%
Full Service Restaurant	43,650	0.5%
Mid-rise Apartment	484,343	5.9%
High-rise Apartment	593,241	7.2%
Covered by Prototypes	**6,616,193**	**80%**
No prototype	**1,649,785**	**20%**
Total	**8,265,977**	**100%**

2.4.2 Energy Prices

PNNL calculated the energy cost savings using national average energy prices, derived from U.S. Energy Information Administration (EIA) values. The same energy prices have been approved and used by the SSPC 90.1 when evaluating the cost effectiveness of draft addenda during the development of 90.1-2010. These prices are $1.22/therm for natural gas and $0.0939/kWh for electricity (EIA 2006). These prices are applied to the energy use savings, separated by fuel type. The same rates are used for all prototypes and in all climate zones.

2.4.3 Outdoor Air Ventilation Standards

Outdoor air ventilation rates can have a significant impact on the energy use of commercial buildings. Minimum outdoor air ventilation requirements are specified in ASHRAE Standard 62-1999 prior and ANSI/ASHRAE Standard 62.1 2004 and 2007 (ASHRAE 1999, ANSI/ASHRAE 2004 and 2007). 90.1-2004 lists 62-1999, and 90.1-2007 lists 62.1-2004 and 90.1-2010 lists 62.1-2007 as the corresponding normative references for outdoor air ventilation. Minimum ventilation rates determined from ASHRAE 62-1999 are generally larger than rates determined under the 62.1-2004 standard. Minimum ventilation rates determined from 62.1-2004 and 62.1-2007 are the same in nearly all cases, including for all of the prototypes in this analysis.

Ventilation rates for both Standards 62-1999and 62.1-2004 were used when simulating the 90.1-2004 baseline for comparison of the impact of the two ventilation standards. The final simulation results used in the PI and presented in this report use the outdoor air ventilation rates corresponding to the normative references identified in the corresponding versions of Standard 90.1. The PI presents results for the 90.1-2004 baseline using 62-1999 outdoor air ventilation rates and for the 90.1-2010 models using the 62.1-2007 outdoor air ventilation rates.

2.4.4 Regulated and Unregulated Energy

Standard 90.1 regulates the elements of commercial buildings that result in most of the energy used in those buildings. Some energy usage from what are sometimes called “process loads” come from equipment that is not directly regulated by Standard 90.1, including plug-in devices such as computers and appliances, and other equipment such as gas cooking equipment. This type of equipment uses energy directly and affects HVAC energy usage indirectly by generating heat in spaces, potentially increasing cooling energy and reducing heating energy. Plug and process loads are incorporated in the prototypes used in the modeling for the PI. Changes to Standard 90.1 do not directly affect the energy efficiency of this type of equipment. Results are presented with plug and process load energy usage to show the impact on total commercial building energy usage and are also presented without plug and process loads to show the impact on just the Standard 90.1 regulated energy usage.

Table 2.3. Construction Area Weights by Building Prototype and Climate Zone

	1A Moist	2A Moist	2B Dry	3A Moist	3B Dry	3C Marine	4A Moist	4B Dry	4C Marine	5A Moist	5B Dry	6A Moist	6B Dry	7	8	Weights by Building Type
Small Office	0.084%	1.064%	0.289%	0.963%	0.475%	0.078%	0.936%	0.047%	0.123%	0.920%	0.322%	0.241%	0.030%	0.032%	0.005%	5.608%
Medium Office	0.129%	0.813%	0.292%	0.766%	0.715%	0.136%	1.190%	0.036%	0.196%	1.060%	0.342%	0.298%	0.035%	0.033%	0.007%	6.047%
Large Office	0.102%	0.326%	0.061%	0.445%	0.285%	0.117%	1.132%	0.000%	0.154%	0.442%	0.121%	0.133%	0.000%	0.011%	0.000%	3.327%
Standalone Retail	0.224%	2.220%	0.507%	2.386%	1.250%	0.191%	2.545%	0.119%	0.428%	3.429%	0.792%	0.948%	0.091%	0.109%	0.014%	15.254%
Strip Mall	0.137%	0.991%	0.254%	1.021%	0.626%	0.103%	1.008%	0.023%	0.107%	1.023%	0.201%	0.153%	0.016%	0.007%	0.001%	5.669%
Primary School	0.064%	0.933%	0.164%	0.944%	0.446%	0.048%	0.895%	0.030%	0.094%	0.920%	0.224%	0.168%	0.037%	0.023%	0.003%	4.994%
Secondary School	0.160%	1.523%	0.230%	1.893%	0.819%	0.109%	2.013%	0.063%	0.243%	2.282%	0.438%	0.415%	0.086%	0.075%	0.012%	10.361%
Outpatient Healthcare	0.037%	0.567%	0.134%	0.581%	0.275%	0.061%	0.818%	0.023%	0.181%	1.058%	0.218%	0.342%	0.033%	0.039%	0.002%	4.371%
Hospital	0.040%	0.479%	0.096%	0.468%	0.273%	0.039%	0.615%	0.022%	0.106%	0.812%	0.218%	0.221%	0.024%	0.034%	0.001%	3.448%
Small Hotel	0.010%	0.288%	0.030%	0.268%	0.114%	0.022%	0.315%	0.020%	0.039%	0.365%	0.089%	0.107%	0.031%	0.020%	0.004%	1.721%
Large Hotel	0.109%	0.621%	0.125%	0.635%	0.793%	0.106%	0.958%	0.037%	0.123%	0.919%	0.200%	0.227%	0.058%	0.038%	0.004%	4.951%
Warehouse	0.349%	2.590%	0.580%	2.966%	2.298%	0.154%	2.446%	0.068%	0.435%	3.580%	0.688%	0.466%	0.049%	0.043%	0.002%	16.716%
Quick-service Restaurant	0.008%	0.092%	0.020%	0.102%	0.063%	0.007%	0.089%	0.005%	0.014%	0.128%	0.026%	0.025%	0.003%	0.004%	0.000%	0.587%
Full-service Restaurant	0.009%	0.106%	0.025%	0.111%	0.047%	0.006%	0.127%	0.006%	0.010%	0.143%	0.031%	0.031%	0.004%	0.004%	0.000%	0.660%
Mid-rise Apartment	0.257%	1.094%	0.093%	0.825%	0.862%	0.260%	1.694%	0.022%	0.371%	1.122%	0.318%	0.313%	0.056%	0.032%	0.000%	7.321%
High-rise Apartment	1.521%	1.512%	0.076%	0.652%	0.741%	0.173%	2.506%	0.000%	0.358%	1.163%	0.115%	0.125%	0.016%	0.008%	0.000%	8.967%
Weights by Climate Zone	3.242%	15.217%	2.975%	15.025%	10.081%	1.609%	19.286%	0.522%	2.981%	19.366%	4.344%	4.214%	0.569%	0.513%	0.056%	100.000%

3.0 *EnergyPlus* Simulation Infrastructure

This chapter describes PNNL's *EnergyPlus* simulation infrastructure to support the development of 90.1-2010 through the PI. The PI primarily depends on conducting extensive building energy simulation to quantitatively evaluate the potential energy savings from the new 90.1-2010 relative to 90.1-2004. *EnergyPlus* (DOE 2010b) is the computer simulation software used to evaluate the energy savings impacts among various versions of Standard 90.1 and Standards 62 and 62.1. *EnergyPlus* is a complex building energy simulation program for modeling building heating, cooling, lighting, ventilation, and other energy uses in buildings. To run *EnergyPlus* simulation, the user needs to prepare a detail input file, the idf file, to specify the building characteristic as well as the requirements of different versions of Standard 90.1 and Standard 62 and 62.1. An *EnergyPlus* input data file (idf, which is also the file extension used in *EnergyPlus*) can easily have thousands of lines for numerous object blocks, which make the manual preparation both tedious and error-prone.

During development of the PI, numerous *EnergyPlus* simulations were involved. Each of the 16 prototype buildings has a corresponding *EnergyPlus* simulation model, which consists of all the values needed to run *EnergyPlus* simulation. Most of the objects and their values are the characteristics of the prototype buildings, which are standard-and-climate-zone-independent, but others vary with the standards and climate zone (e.g., insulation of walls and equipment efficiencies).

By assigning standard-dependent values, the model of each of the prototype building expands into three different *EnergyPlus* models: one for 90.1-2004, one for 90.1-2007, and one for 90.1-2010 under development. The Standard 90.1 model for each prototype is paired with the corresponding versions of the Ventilation Standard 62 or 62.1 described in Section 4.5.5 in this report. Further considering the selected 17 climate locations, the three *EnergyPlus* models for each prototype are expanded into 51 sets of *EnergyPlus* models per building type. With all the combinations of the 16 prototypes, 3 versions of the 90.1 standard, and 17 climate locations, a total of 816 *EnergyPlus* models ($3 \times 17 \times 16$) are in each single batch of simulation runs.

For the PI, the results are used just for the baseline case for 90.1-2004 and 62-1999 and for the advanced case for 90.1-2010 and 62.1-2007.

PNNL further conducted sensitivity analysis to evaluate the energy savings results using ventilation standard 62.1-2004 with all three versions of Standard 90.1 considered. This additional analysis adds another set of 272 models to the batch runs, resulting in 1,088 models.

During the development of 90.1-2010, numerous batches of simulation runs were launched. For most of the addenda implemented to enhance 90.1-2010, periodic batches of simulation runs were conducted to verify the implementation and to estimate the energy savings resulting from the addenda as they were created. In addition, the PNNL simulation team provided quarterly PIs to the SSPC 90.1 to report timely progress towards the 30% improvement goal in 90.1-2010. All this translates to a large number of batches of simulations, each requiring the evaluation of over 1,000 *EnergyPlus* models. The massive numbers of *EnergyPlus* simulation runs present a challenge in preparing the idfs, conducting *EnergyPlus* simulations, and post-processing the output files to assemble building energy consumption information and to assess energy savings of the advanced standards against the baseline standard.

The following sections document the infrastructure that the PNNL simulation team developed to address this challenge, including the steps below:

1. Parameterizing the prototype building models into two sets of files, i.e., *template*s and *parm*s
2. Automating the *EnergyPlus* idf creation based on *template*s and *parm*s by a PNNL-developed program known as GPARM (General PARaMetrics)
3. Controlling the simulation process with *make* utility
4. Aggregating simulation output to assemble energy end-use results and to prepare energy savings through a series of Perl scripts.

All energy simulations were completed within a PNNL Linux energy simulation infrastructure, which manages inputs and outputs of the *EnergyPlus* simulations. This infrastructure includes creating *EnergyPlus* idfs with by GPARM, submitting input files to a computing cluster with 150 central processing units (CPUs) for batch simulation, and extracting energy end-use results. Figure 3.1 is a flow diagram of these procedures as described in the remainder of this chapter. An additional challenge discussed in this chapter is maintaining model idfs consistent with the different versions of *EnergyPlus* released periodically during the project.

3.1 Prototype Model Parameterization

Simulation for each round of PI required over 1,000 *EnergyPlus* models to capture the different versions of Standard 90.1 and Standards 62 and 62.1 and the different climate zones. To facilitate the automatic creation of the large number of *EnergyPlus* idfs, the prototype models were parameterized by splitting the prototype model into two separate but related associated file pairs called *template* and *parm* files.

The *template* is a modified *EnergyPlus* idfs where the values of the standard/climate zone dependent fields are replaced with replaceable tags (i.e., variables). The values of the variables are specified in a separate parameter file called *parm* file. The *parm* file is a simple rectangular comma delimited file. Each row of the *parm* file consists of the set of values that would be taken by those variables in the *template* file and represents one *EnergyPlus* idf to be generated. The combination of the *template* and *parm* pair uniquely defines all *EnergyPlus* models of a given prototype associated with different versions of Standard 90.1 and Standards, 62and 62.1, and climate locations.

3.2 Automation of the *EnergyPlus* Input File Creation

With the split of the prototype model into a *template*, which is a parameterized *EnergyPlus* idf, and a CSV formatted *parm* file, it is possible to automatically create the required *EnergyPlus* idfs for the combinations of the versions of Standard 90.1 and Standards 62 or 62.1 and the climate locations. The GPARM program was used for this idf creation. GPARM is a program, written in Perl, to help generate huge numbers of input files for programs like *EnergyPlus*. In its simplest function, GPARM is basically a generic system for doing a "mail merge." It works in a row-by-row fashion through the *parm* CSV file. Each time, it takes a row from the *parm* and uses the values specified in that row to replace the corresponding replaceable tags in the *template* file. After such a replacement, the *template* file represents a complete *EnergyPlus* idf, which can be saved and then used for subsequent *EnergyPlus* simulations.

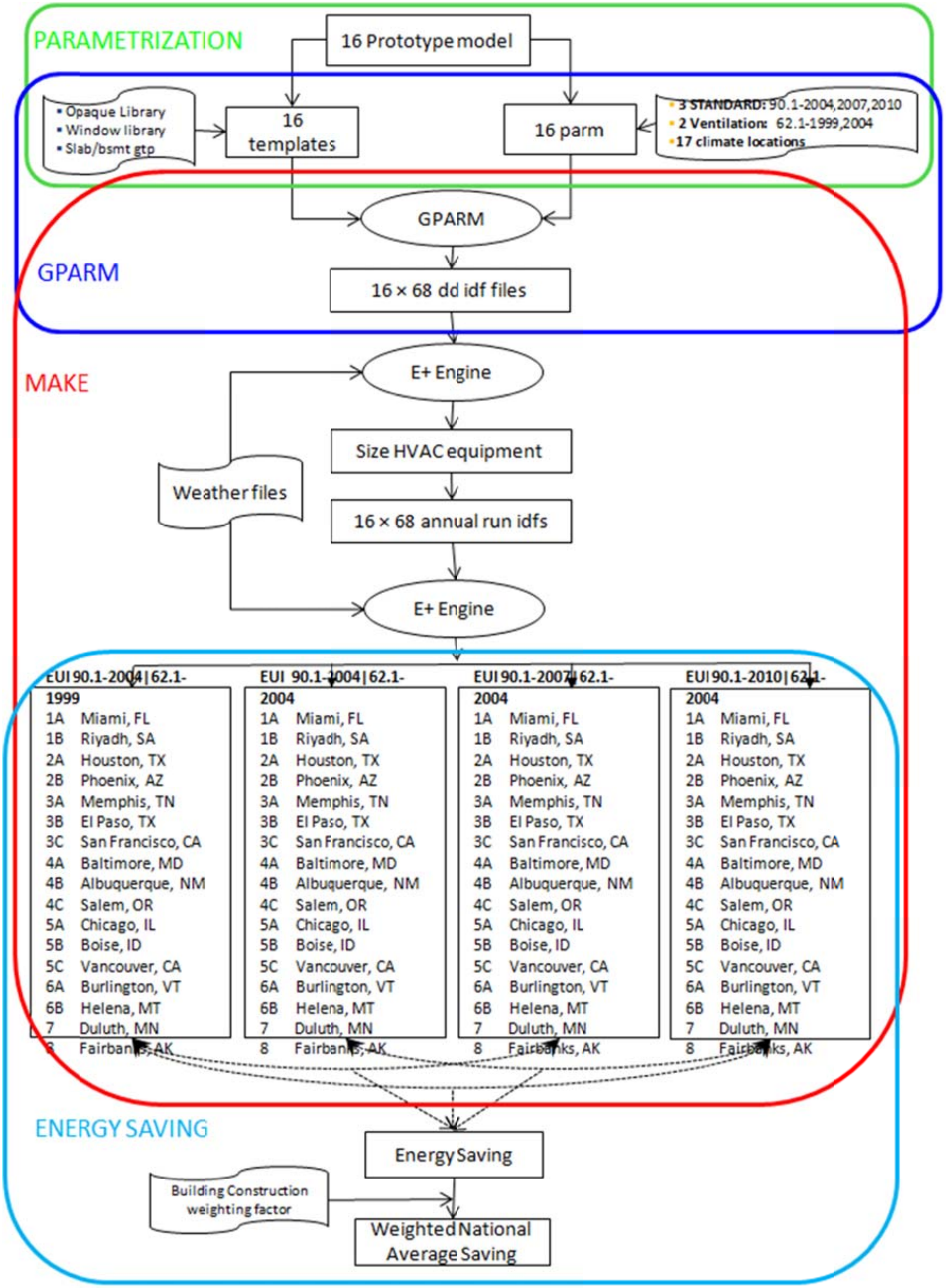

Figure 3.1. Flow Diagram of PI Simulation Framework

During the early development of *EnergyPlus* simulation for 90.1-2010, PNNL created an opaque construction (walls, roofs, etc.) library, a fenestration library, and prototype building/climate zone specific slab and basement ground temperature profiles (gtp). The opaque construction and fenestration libraries are text files in *EnergyPlus* idf format, which consist of a large number of construction materials, such as various types of walls, floors, roofs, ceilings, and windows. The prototype-building and climate-location-specific slab and basement gtp are sets of hundreds of files in *EnergyPlus* idf format. Both the construction libraries and the gtp need to be included in the *EnergyPlus* idfs for the simulation run.

3.3 Batch Simulation

One of the challenges in dealing with the required massive *EnergyPlus* simulations is solved by parameterizing the prototype model into *template* and *parm,* specifying Standard and climate-location-dependent values in the *parm* file, and using GPARM to combine the *template* and *parm* creating *EnergyPlus* idf. Another challenge is the time and complexity of running so many *EnergyPlus* simulations.

Each *EnergyPlus* simulation run takes time to complete. The computing time needed for the simulation of a single model ranges from minutes to over an hour, depending on the number of thermal zones in a prototype and the CPU used to run the model. A batch run with over 1,000 models needs significant time to finish. The simulation is conducted in a Linux cluster with around 150 CPUs. The Sun Grid Engine queuing system is used for scheduling and dispatching simulation jobs to the CPUs in the cluster. Simulation jobs are queued up in a single master list and sent out to the execution queues as slots become available.

As illustrated in Figure 3.1, a complete batch of simulations involves multiple steps occurring in sequence. What has been described above is the first step, which turns the prototype model into a series of *EnergyPlus* models distinguished by the combination of Standard 90.1, and Standards 62 and 62.1, and climate location by combining the *template* and *parm* files using the GPARM utility program.

These *EnergyPlus* idf files are created initially for design day simulation to size the mechanical equipment. The *EnergyPlus* simulation needs to run in design day mode, and the simulation outputs with the sizing information needs to be extracted and used to replace “auto-size” fields for annual simulation run. Additional information on the development of HVAC system capacity is included in Section 4.5.2 of this report. In addition, the mechanical equipment efficiencies need to be specified based on the sizing information from the design day simulation as well as the requirements of the different versions of Standard 90.1 and Standards 62 and 62.1 that are applied. Perl scripts have been written to automatically extract the sizing information from the design day simulation output files, to subsequently look up the required equipment efficiencies, and to use them to modify the design day idfs to idfs for annual simulation.

Each *EnergyPlus* simulation run generates dozens of miscellaneous output files. For a complete batch run of over 1,000 idfs, many thousand output files are generated. To assess the energy consumption in term of end-use categories (e.g., heating and interior lighting) and to evaluate the energy savings of the advanced case against the baseline case, the end-use energy consumption from the model runs need to be extracted from the corresponding output files in order to create energy consumption and energy savings tables. Another Perl script was written for aggregating all outputs into a single table. Further data extraction occurs after the batch simulation, described in Section 3.4 below.

3.4 Extraction of PI Results

The simulation process results in a large table of raw model output data aggregated from all of the models in a batch from the batch simulation process. The *EnergyPlus* annual simulation generates energy consumption in generic combined energy units (joules, millions of Btu) associated with energy end uses such as heating, cooling, and interior lighting. Visual basic macros are used to automatically load the aggregated outputs from the batch simulations and populate the numbers to separate spreadsheets with the energy consumption and energy savings tables and necessary unit conversion. The macros also automate this data loading and table-making process for all 16 prototype buildings, and create energy savings tables between pairs of 90.1 -2004 and 90.1-2007 or 90.1-2010. The spreadsheets calculate national averages of these results for each prototype and climate location using construction weights described in Chapter 2 of this report. Summary results with and without unregulated energy uses and energy costs are also extracted to overall results spreadsheets for all prototypes. Results compilation and content are described in Section 2.4 and are presented in Chapter 6 of this report.

3.5 Maintenance for New Versions of *EnergyPlus*

EnergyPlus has been under continuous development by DOE since 1996 (DOE 2010a). During the process of 90.1-2010 Standard development, the PNNL simulation team upgraded the prototype models several times from version 3.0 to version 6.0. Since the prototype models are parameterized using the pair of *template* and *parm* files and the *templates* carry the essence of the prototype model, the *templates* have to be upgraded whenever a new version of *EnergyPlus* was adapted as the simulation engine. Although there is a companion utility program for idf version transition associated with each newly released version of *EnergyPlus*, the programs cannot directly be used for the *template* files upgrade because of the existence of replaceable tags.

A Perl utility program developed by PNNL is used to automatically upgrade to a new version of the *template* files. The idea is to temporally comment out the replaceable tags in the *templates* and replace them with default values for those fields associated with replaceable tags based on the Input Data Dictionary (idd) files of *EnergyPlus*. By doing so, the *template* files are converted back to complete idf files that can then be upgraded to the new version by the version transition utility tool of *EnergyPlus*. The Perl utility program automates this process. The program automatically searches for replaceable tags in the *templates* files, comments them out, replaces the tags with default values from the idd file, and then saves the files to temporary idf files. It then invokes the *EnergyPlus* version transition tool to do the version upgrade. The program moves the commented replaceable tags in the upgraded idf files back to their original places, removes the comment characters, and then saves the files as upgraded *template* files. The development of this *template* version upgrade tool greatly facilitates the model upgrade between versions.

4.0 Prototype Building Models

This chapter describes the 16 prototype buildings used in the PI that were introduced in Section 2.1 of this report.

- Office
1. Small Office
2. Medium Office
3. Large Office
- Mercantile
4. Standalone Retail
5. Strip Mall
- Education
6. Primary School
7. Secondary School
- Healthcare
8. Outpatient Healthcare
9. Hospital
- Lodging
10. Small Hotel
11. Large Hotel
- Warehouse
12. Warehouse (non-refrigerated)
- Food Service
13. Quick-service Restaurant
14. Full-service Restaurant
- Apartment
15. Mid-rise Apartment
16. High-rise Apartment

Appendix A includes prototype building descriptions. Appendix B lists the internal loads for each thermal zone in all prototypes. Appendix C includes schedules used to model time of day variation of building operations. The prototype "Scorecards," spreadsheets that contain the key inputs shown in Appendixes A, B, and C, as well as other information are available online (http://www.energycodes.gov/commercial/901models/). The *EnergyPlus* model inputs and outputs for the prototype buildings representing 90.1 -2004, 2007, and 2010 are also available for free download at the same website.

For the prototype buildings, the following subsections discuss schedules, form, envelope, occupancy, HVAC requirements, service water heating equipment, lighting, other equipment, and plug and process loads.

4.1 Building Schedules

An important element in simulating buildings and in actual building energy usage is the time-of-day operation of the building. For simulation, this is defined by schedules that can correspond to operating hours in real-world buildings for some parameters. Schedules include values such as the fraction of lights that are on, whether HVAC systems are on or off, and thermostat temperature setpoints. Schedules contain information for each hour and may vary by day of the week and time of year. In addition to day-to-day operations, schedules are used to define values at design conditions for developing peak HVAC equipment capacities and related inputs that vary with capacity, such as motor size and efficiency. Table 4.1 shows an example schedule for interior lighting and building occupancy for the first 12 hours of the day; actual schedules continue through midnight. Values in the main body of the table are the proportion of the total lighting power that is on. Appendix C includes the operating schedules for all 16 prototypes.

Table 4.1. Example Simulation Schedules

Building Lighting Schedule	Hour of the day ending at hour shown (through noon shown)											
	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	Noon
Weekday	0.18	0.18	0.18	0.18	0.18	0.23	0.23	0.42	0.90	0.90	0.90	0.90
Weekend	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Winter Design Day	0	0	0	0	0	0	0	0	0	0	0	0
Summer Design Day	1	1	1	1	1	1	1	1	1	1	1	1

4.2 Building Form

For the prototypes, building form is selected to represent typical buildings of the corresponding prototype. The model prototypes use the same building forms as DOE's Commercial Building Reference Models (Deru et al. 2011), with the exception of the high-rise apartment prototype, which is not included in the reference models. PNNL developed the high-rise apartment prototype based on the mid-rise apartment and inputs from SSPC 90.1 members. Figure 4.1 illustrates the 3D rendering of the 16 prototype building models, representing a range of building shape, size, and number of floors. Table 4.2 lists the building floor area, number of floors, window-to-wall ratio (WWR), floor-to-floor height, and floor-to-ceiling height by building type.

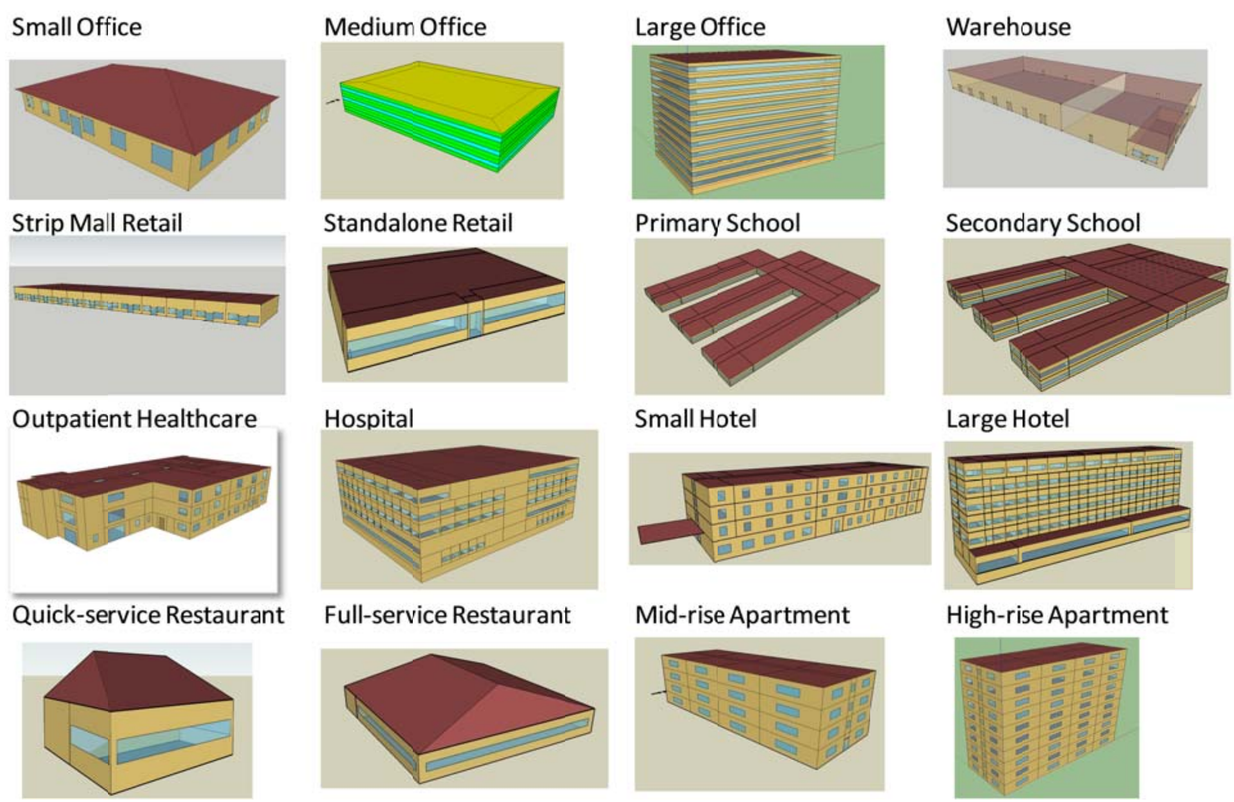

Figure 4.1. 3D Rendering of Prototype Building Models

Table 4.2. Building Form

Building Prototype	Floor area (ft²)	Number of Floors	Aspect Ratio	Window-to-Wall Ratio (WWR)	Floor-to-Floor Height (ft)	Floor-to-Ceiling Height (ft)
Small Office	5,500	1	1.5	15%	10	10
Medium Office	53,630	3	1.5	33%	13	9
Large Office	498,640	12[(a)]	1.5	40%	13	9
Standalone Retail	24,690	1	1.28	7%	20	20
Strip Mall	22,500	1	4	11%	17	17
Primary School	73,970	1	NA	35%	13	13
Secondary School	210,910	2	NA	33%	13	13
Outpatient Healthcare	40,950	3	NA	20%	10	10
Hospital	241,410	5[(a)]	1.33	16%	14	14
Small Hotel	43,210	4	3	11%	9 11[(d)]	9 11[(d)]
Large Hotel	122,120	6[(a)]	5.1 3.8[(b)]	27%	10 13[(d)]	10 13[(d)]
Warehouse	52,050	1	2.2	0.71%[(c)]	28	28
Quick-service Restaurant	2,500	1	1	14%	10	10
Full-service Restaurant	5,500	1	1	18%	10	10
Mid-rise Apartment	33,740	4	2.75	15%	10	10
High-rise Apartment	84,360	10	2.75	15%	10	10

(a) These buildings also include a basement, which is not included in the number of floors.
(b) The large hotel basement aspect ratio is 3.8; all other floors have an aspect ratio of 5.1.
(c) For the warehouse, 0.71% is the overall WWR. The warehouse area has no windows; the WWR for the small office in the warehouse is 12%.
(d) First floor only.

4.3 Building Envelope

Chapter 5 of Standard 90.1 provides prescriptive requirements for building envelope thermal performance and other characteristics. These values change with the version of Standard 90.1. Appendix E in this report includes the building envelope prescriptive values from 90.1-2004 and 90.1-2010. Some fundamental characteristics of the building envelope do not change, in particular, the construction type, as shown in Table 4.3. Foundations for all prototypes are slab-on-grade except large office, hospital and hotel which have basements. These constructions are consistent with DOE’s Commercial Building Reference Models (Deru et al. 2011). Originally many of these characteristics came from PNNL’s analysis of CBECS 2003 information (Winiarski et al. 2007).

To determine the modeled fenestration performance values for Standard 90.1 requirements, the type of fenestration must be defined. Table 4.4 includes weighting factors for the mix of window types in each prototype used to develop the fenestration inputs. For 90.1-2004 the types are operable or fixed. For 90.1-2007 and 90.1-2010, the types are nonmetal, metal curtain wall/storefront, metal entrance door, and all other metal windows.

Table 4.3. Roof and Wall Construction Types

Building Prototype	Roof	Exterior Wall
Small Office	Attic and Other	Wood-framed
Medium Office	Insulation Entirely Above Deck	Steel-framed
Large Office	Insulation Entirely Above Deck	Mass
Standalone Retail	Insulation Entirely Above Deck	Mass
Strip Mall	Insulation Entirely Above Deck	Steel-framed
Primary School	Insulation Entirely Above Deck	Steel-framed
Secondary School	Insulation Entirely Above Deck	Steel-framed
Outpatient Healthcare	Insulation Entirely Above Deck	Steel-framed
Hospital	Insulation Entirely Above Deck	Mass
Small Hotel	Insulation Entirely Above Deck	Steel-framed
Large Hotel	Insulation Entirely Above Deck	Mass
Warehouse	Metal Building Roof	Metal Building
Quick-service Restaurant	Attic and Other	Wood-framed
Full-service Restaurant	Attic and Other	Steel-framed
Mid-rise Apartment	Insulation Entirely Above Deck	Steel-framed
High-rise Apartment	Insulation Entirely Above Deck	Steel-framed

Table 4.4. Fenestration Type Weighting Factors

		90.1-2004		90.1-2010[a]		
ASHRAE and Prototype Building Types	Ducker Building Category	Fixed	Operable[a]	Nonmetal	Metal Curtain Wall/Storefront	Metal, All Other
Small Office	Office and Bank	95%	4.6%	2%	62%	36%
Medium Office		95%	4.6%			
Large Office		100%	0.0%			
Standalone Retail	Stores, Other Mercantile	98%	2%	10%	62%	28%
Strip Mall						
Quick-service Restaurant						
Full-service Restaurant						
Warehouse	Manufacturing/ Warehouse	95%	5%	2%	10%	88%
Primary School	Educational	65%	35%	22%	45%	34%
Secondary School						
Outpatient Healthcare	Hospital/Health Care	88%	12%	9%	60%	31%
Hospital						
Small Hotel	Hotel/Motel/Dormitory	78%	22%	11%	21%	68%
Hotel						
Mid-rise Apartment	High-rise Multifamily	42%	58%	32%	5%	63%
High-rise Apartment						

(a) Excludes entrance doors.

Air leakage reduction is also part of building envelope requirements in Standard 90.1. PNNL has done considerable work in estimating infiltration and air leakage through the building envelope, as described in *Infiltration Modeling Guidelines for Commercial Building Energy Analysis* (Gowri et al. 2009). Model values used for the 90.1-2004 baseline are generally 0.2016 cfm)/ft^2 of above-grade exterior wall surface area, adjusted by wind speed.

Addendum 90.1-04c and addendum 90.1-07q (Section 5.2.1.1 of this report) modify infiltration due to changes in vestibule requirements. Addenda 90.1-07am and 90.1-07bf (Section 2.2.1.6 in this report) result in changes to infiltration through the building envelope.

4.4 Building Occupancy

People contribute to space loads in the building. Table 4.5 shows the total number of people in each prototype. The number of occupants is modeled with values for each zone depending on type of occupancy, and zone by zone values are included with the zone summaries in Appendix B. The number of people is consistent with DOE's Commercial Reference Buildings Models (Deru et al. 2011), derived from multiple sources, including the *Advanced Energy Design Guides*. Occupancy is also related to ventilation; but for some prototypes, occupancy for interior loads differs from the default occupancy used to meet the ASHRAE 62.1 ventilation requirements (Section 4.5.5 in this report).

Table 4.5. Building Occupancy

Prototype Building	Total Floor Area (ft^2)	Occupancy (number of people)	Occupancy (people/1,000 ft^2)
Small Office	5,500	31	5.6
Medium Office	53,630	268	5.0
Large Office	498,640	2,493	5.0
Standalone Retail	24,690	371	15.0
Strip Mall	22,500	180	8.0
Primary School	73,970	1,477	20.0
Secondary School	210,910	6,096	28.9
Outpatient Healthcare	40,950	419	10.2
Hospital	241,410	767	5.0
Small Hotel	43,210	259	6.0
Large Hotel	122,120	1,494	12.2
Warehouse	52,050	5	0.1
Quick-service Restaurant	2,500	94	37.6
Full-service Restaurant	5,500	287	52.2
Mid-rise Apartment	33,740	79	2.3
High-rise Apartment	84,360	199	3.4

4.5 Building HVAC Requirements

Chapter 6 of Standard 90.1 provides HVAC requirements. The application of these requirements depends largely on the fundamental choice of HVAC system type(s) that are chosen for a building. Once system types are defined, other elements of the 90.1 requirements follow, including system heating and cooling equipment efficiency, fan power, and controls. Minimum outdoor airflow is another important characteristic of HVAC systems. Outdoor air requirements vary with the version of Standard 62.1, which sets minimum outdoor air requirements as referenced in the version of Standard 90.1 considered, as described in Chapter 2 in this report. Some characteristics of the HVAC systems, such as the type of HVAC systems, remain the same in most cases for the 90.1-2004 and 2010 models. These characteristics are addressed in this section. Controls vary the most with the changes introduced by the addenda and are addressed primarily in Chapter 5 of this report.

4.5.1 HVAC Equipment Types

For most of the prototypes, the primary HVAC system consists of unitary packaged equipment that delivers conditioned air to the thermal zones for comfort. In some cases, central plant equipment, such as chillers and boilers, provide heating and cooling to air-delivery systems. In some buildings, separate secondary systems provide conditioning to selected zones with different operating characteristics from the zones served by the primary systems. The types of systems are generally consistent with DOE's Commercial Reference Buildings which utilize analysis of CBECS 2003 information (Winiarski et al. 2008). Table 4.6 shows these system types.

In most cases, the system types are the same in the 90.1-2004 and 90.1-2010 models. Some single-zone systems that are constant air volume (CAV) systems in the 90.1-2004 models become variable air volume (VAV) systems in the 90.1-2010 models because of the requirement of addendum 90.1-07n (Section 5.2.2.12 in this report). This change occurs depending on system capacity which varies with climate zone. In the simulations, prototypes that experience this change for at least some climate zones are shown with footnote (b) in Table 4.6. Appendix D of this report lists the system name and type used in *EnergyPlus* models for all 16 prototype buildings.

4.5.2 HVAC Equipment Capacity

HVAC equipment capacity varies with external climate conditions, internal loads, and outdoor air ventilation rate. These characteristics change for the different climate locations simulated and for differences between 90.1-2004 and 90.1-2010. The procedures for defining system capacity do not change and are incorporated in the simulation methodology described in Chapter 3 in this report.

HVAC equipment sizing refers to the method used to determine the capacity of the HVAC equipment. *EnergyPlus* allows users to select a "design day" simulation method for sizing equipment. With this method, two separate design day inputs are specified, one for heating and one for cooling. The program determines the design peak loads by simulating the buildings for a 24-hour period on each of the design days. The design peak loads are then used by the subprogram for sizing HVAC equipment. The analysis for the PI uses the design day sizing method primarily for two reasons: (1) it is common practice for designers to choose the design day method for sizing the HVAC equipment; and (2) using the design day method prevents equipment over-sizing to meet the extreme peak weather conditions occurring for a very short period of time during a year.

The design day data for all 16 climate locations are developed based on the weather data contained in the accompanying CD-ROM of ASHRAE's 2009 *Handbook of Fundamentals* (ASHRAE 2009). In this data, the heating design day condition selected is based on the 99.6% annual frequency of occurrence.

Table 4.6. HVAC Primary and Secondary Equipment

Building Prototype	Heating	Cooling	Primary System	Secondary System
Small Office	Heat Pump	Unitary DX[(a)]	Packaged CAV	No
Medium Office	Gas Furnace	Unitary DX	Packaged VAV w/Reheat	No
Large Office	Boiler	Chiller, Cooling Tower	VAV w/Reheat	No
Standalone Retail	Gas Furnace	Unitary DX	Packaged CAV[(b)]	No
Strip Mall	Gas Furnace	Unitary DX	Packaged CAV[(b)]	No
Primary School	Gas Furnace	Unitary DX	Packaged CAV[(b)]	No
Secondary School	Boiler	Air-cooled Chiller	VAV w/Reheat	Packaged CAV
Outpatient Healthcare	Boiler	Unitary DX	Packaged VAV w/Reheat	No
Hospital	Boiler	Chiller, Cooling Tower	VAV w/Reheat	Central CAV
Small Hotel	Electricity	DX	PTAC[(c)]	No
Large Hotel	Boiler	Air-cooled chiller	Fan-coil Units	VAV w/Reheat
Warehouse	Gas Furnace	Unitary DX	Unit Heater	Packaged CAV
Quick-service Restaurant	Gas Furnace	Unitary DX	Packaged CAV	No
Full-service Restaurant	Gas Furnace	Unitary DX	Packaged CAV[(b)]	No
Mid-rise Apartment	Gas	DX	Split DX system	No
High-rise Apartment	Boiler	Fluid Cooler	WSHP	No

(a) DX – direct expansion.
(b) These systems are constant volume in the baseline, and in some cases are VAV in the 90.1-2010 models. See note in text above as well.
(c) PTAC – packaged terminal air conditioners.

The 99.6% condition means that the dry-bulb temperature occurs at or below the heating design condition for 35 hours per year in cold conditions. Similarly, annual cooling design condition is based on dry-bulb temperature corresponding to 0.4% annual frequency of occurrence in warm conditions. In *EnergyPlus* simulations, design day schedules can also be specified. To be consistent with the general design practice for HVAC equipment sizing, the internal loads (occupancy, lights, and plug loads) are scheduled as “0.0” on the heating design day, and “1.0” (maximum level) on the cooling design day.

4.5.3 HVAC Equipment Efficiency

Equipment efficiency is modeled using the same methodology in the 90.1-2004 and 90.1-2010 models. Efficiency values are assigned automatically according to system capacity as described in Section 3.3 of this report. However, efficiency values change with addenda for many types of equipment from 90.1-2004 to 90.1-2010, as shown in Chapter 5 of this report. Efficiency values are compared on a book-to-book basis between the published 90.1-2004 and 90.1-2010 models. Efficiency values used for the 90.1-2004 models are the values in the original effective date range when the standard began, where different effective dates are listed. For example, single package air conditioners under 65,000 Btu/h have an efficiency of 10 SEER, the value for equipment manufactured prior to January 23, 2006. Values from 90.1-2004 are shown in Tables 4.7 through 4.13. Equipment not shown in these tables is not represented in the prototypes. See 90.1-2004 for testing procedures for efficiency ratings and other notes and definitions.

Table 4.7. Unitary Air-Conditioner Efficiency, 90.1-2004

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency
Air Conditioners, Air Cooled	<65,000 Btu/h	All	Split System	10.0 SEER (before 1/23/2006) 12.0 SEER (as of 1/23/2006)
			Single Package	9.7 SEER (before 1/23/2006) 12.0 SEER (as of 1/23/2006)
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	10.3 EER
		All Other	Split System and Single Package	10.1 EER
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.7 EER
		All Other	Split System and Single Package	9.5 EER
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.5 EER 9.7 IPLV
		All Other	Split System and Single Package	9.3 EER 9.5 IPLV
	≥760,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.2 EER 9.4 IPLV
		All Other	Split System and Single Package	9.0 EER 9.2 IPLV

(a) EER – energy efficiency ratio
(b) IPLV – integrated part load value.

Table 4.8. Unitary Air-Cooled Heat Pump Efficiency, 90.1-2004

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency
Air Cooled (cooling mode)	>65,000 Btu/h	All	Split System	10.0 SEER (before 1/23/2006) 12.0 SEER (as of 1/23/2006)
			Single Package	9.7 SEER (before 1/23/2006) 12.0 SEER /(as of 1/23/2006)
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	10.1 EER
		All Other	Split System and Single Package	9.9 EER
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.3 EER
		All Other	Split System and Single Package	9.1 EER
	≥240,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.0 EER 9.2 IPLV
		All Other	Split System and Single Package	8.8 EER 9.0 IPLV

Table 4.8 (cont'd)

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency
Air Cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)		47°F db/43°F wb outdoor air	3.2 COP
			17°F db/15°F wb outdoor air	2.2 COP
	≥135,000 Btu/h (cooling capacity)		47°F db/43°F wb outdoor air	3.1 COP
			17°F db/15°F wb outdoor air	2.0 COP
Water-Source (cooling mode)	<17,000 Btu/h	All	86°F Entering Water	11.2 EER
	≥17,000 Btu/h and <65,000 Btu/h	All	86°F Entering Water	12.0 EER
	≥35,000 Btu/h and <135,000 Btu/h	All	86°F Entering Water	12.0 EER
Water-Source (heating mode)	<135,000 Btu/h		68°F Entering Water	4.2 COP

Table 4.9. Water Chilling Package Efficiency, 90.1-2004

Equipment Type	Size Category	Minimum Efficiency
Air-Cooled with Condenser	All Capacities	2.80 COP 3.05 IPLV
Air-Cooled without Condenser	All Capacities	3.10 COP 3.45 IPLV
Water Cooled, Reciprocating	All Capacities	4.20 COP 5.05 IPLV
Water Cooled, Rotary Screw	<150 tons	4.45 COP 5.20 IPLV
and Scroll	≥150 tons and <300 tons	4.90 COP 5.60 IPLV
	≥300 tons	5.50 COP 6.15 IPLV
Water Cooled, Centrifugal	<150 tons	5.00 COP 5.25 IPLV
	≥150 tons and <300 tons	5.55 COP 5.90 IPLV
	≥300 tons	6.10 COP 6.40 IPLV

Table 4.10. PTAC and Heat Pump Efficiency, 90.1-2004

Equipment Type	Size Category	Minimum Efficiency
PTAC (Cooling Mode)	All Capacities	12.5-(0.213 x capacity/1000) EER
PTHP[(a)] (Cooling Mode)	All Capacities	12.3-(0.213 x capacity/1000) EER
PTHP (Heating Mode)	All Capacities	3.2-(0.026 x capacity/1000) COP

(a) PTHP – packaged terminal heat pump

Table 4.11. Warm Air Furnace Efficiency, 90.1-2004

Equipment Types	Size Category (Input)	Minimum Efficiency
Warm Air Furnace, Gas-Fired	<225,000 Btu/h	78% AFUE[(a)] or 80% E_t[(b)]
	≥225,000 Btu/hr	80% E_t

(a) AFUE – annual fuel utilization efficiency.
(b) E_t – thermal efficiency.

Table 4.12. Boiler Efficiency, 90.1-2004

Equipment Types	Size Category (input)	Subcategory or Rating Condition	Minimum Efficiency
Boilers, Gas-Fired	<300,000 Btu/h	Hot Water	80% AFUE
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity	75% E_t[(a)]
	≥2,500,000 Btu/h	Hot Water	80% E_c[(b)]
(a) E_t – thermal efficiency. (b) E_c – combustion efficiency.			

Table 4.13. Heat Rejection Equipment Performance, 90.1-2004

Equipment Type	Size Category	Performance
Centrifugal Fan Cooling Towers	All Capacities	≥20.0 gpm/hp[(a)]
(a) gpm/hp – gallons per minute/horsepower.		

In *EnergyPlus*, the efficiency of DX cooling systems is indicated by entering a COP, which is defined as the cooling power output in watts (W) divided by the electrical power input in watts determined at the same environmental conditions as the EER. However, unlike EER, the COP input in *EnergyPlus* does not include the rated power consumption of the supply air fan, so the EER needs to be adjusted to remove the effect of the indoor fan energy. The COP input in *EnergyPlus* is determined by the following equation:

$$COP = (EER/3.413 + R) / (1-R)$$

where R is the ratio of supply fan power to total equipment power at the rating condition.

Typical values of fan power ratio R for a commercial rooftop unit vary from about 0.05 to 0.17, depending on specific product design choices. For this analysis, a ratio of 0.12 is assumed as being representative of the broad class of products (PNNL 2004).

For packaged single-zone equipment with cooling capacities under 65,000 Btu/h, efficiency is rated by SEER, which represents an average efficiency throughout the year. SEER is defined as the total cooling output of an air conditioner during its normal annual usage period for cooling (in Btu) divided by the total electricity used during the same period (in Wh). For equipment rated by SEER, a conversion from SEER to EER is also required (Wassmer and Brandemuehl 2006).

$$EER = -0.0182 * SEER^2 + 1.1088 * SEER$$

The *EnergyPlus* input for furnace efficiency is thermal efficiency E_t. 90.1-2004 allows gas furnaces with capacity under 225,000 Btu/h to have a minimum efficiency of 80% E_t or AFUE, which, like SEER, represents average annual efficiency. Furnaces with capacity of 225,000 Btu/h or greater must meet an 80% combustion efficiency (E_c) and are allowed up to 0.75% jacket losses. E_t equals the combustion efficiency minus jacket losses. So, the E_t for furnaces 225,000 Btu/h and larger are modeled as 79.25%, which is E_c of 80% minus 0.75% jacket losses.

4.5.4 HVAC System Fan Power

Fan power for the prototype HVAC systems is guided by the fan power limitation in Section 6.5.3.1 of Standard 90.1. These limits differ in 90.1-2004 and 90.1-2007. Section 5.2.2.5 on addendum 90.1-04ac in this report describes the specific development for fan power inputs under the 90.1-2004 and 90.1-2007 fan power allowances. The 90.1-2010 fan power allowance is the same as for 90.1-2007, except that single zone VAV systems are subject to the limitations for constant volume systems and except some other limited differences (addenda 90.1-07n and 90.1-07ca in Section 5.2.2.12 in this report). The general procedure for developing the fan power input is the same for the models under the different versions of Standard 90.1.

The *EnergyPlus* program simulates fan power by considering three inputs: the design total pressure drop, the total fan efficiency, and the motor efficiency. For modeling systems according to a version of Standard 90.1, where the maximum fan power allowance is provided, the approach is to calculate a corresponding design pressure drop for each air system using the following equation:

$$\text{Design Pressure Drop} = (\text{brake horsepower} \times \text{fan efficiency} \times 6356)/\text{cfm}$$

where,

cfm	=	design supply fan airflow as determined by *EnergyPlus* sizing runs
fan efficiency	=	65%, based on assumptions used by the SSPC 90.1 while developing fan power requirements for the standard
brake horsepower	=	allowed brake horsepower.

Once the brake horsepower is established for a fan system, the nameplate horsepower is calculated using a 10% over sizing factor (i.e., nameplate horsepower = brake horsepower × 1.1, as allowed under Standard 90.1). The nameplate motor horsepower is used in calculating the fan motor efficiency based on the requirements in 90.1.

4.5.5 Outdoor Air Ventilation

Outdoor air ventilation rates are not the same for the prototypes as modeled for 90.1 -2004 and 90.1-2010 because the source of outdoor air minimum flow rates is ASHRAE Standard 62.1, and different versions govern the inputs for 90.1-2004 and 90.1-2010 models (ventilation in this section refers to outdoor air flow). Standard 62-1999 is the reference standard for ventilation for 90.1-2004; Standard 62.1-2004 is the reference ventilation standard for 90.1-2007; and Standard 62.1-2007 is the reference standard in 90.1-2010. Standards 62.1-2004 and 62.1-2007 have identical minimum outdoor air rates for the prototype models. Hospital ventilation, described below, follows a similar approach using information from other sources in addition to Standard 62 or 62.1, including the *AIA Guidelines for Design and Construction of Hospitals and Health Care Facilities*, referred to as AIA Guidelines (AIA 2001). Ventilation rates are provided per person or per square foot in intermittently occupied spaces, such as corridors, or in some cases are provided as a prescriptive cfm value.

To use the ventilation rates in Standard 62 or 62.1, the modeled zones need to be identified by space type corresponding to the ventilation rates. Space types are not defined the same in all cases between the different versions of Standard 62. A consistent mapping of thermal zones to space types is needed. The space types in 62.1-2004 (and 2007) are used to identify spaces when possible. Where there is no direct equivalency in 62-1999 space types with those in 62.1-2004, assumptions are made about equivalent space types in Standard 62-1999. In some cases, ventilation rates depend on the number of occupants. To maintain consistency in occupancy numbers, the 62.1-2004 default occupancy density values are used when available for the 90.1-2004 models and subsequently for the 90.1-2010 models. 62-1999 default occupancy density values are used if values are not available in 62.1-2004.

Adjustments are made for particular prototypes and space types, including the following items:

- For the primary and secondary school buildings, the occupancy density from the technical support analysis for the *Advanced Energy Design Guide for K-12 Schools* (AEDG K-12 School) (Pless et al. 2007) is used, except the corridor and lobby areas, which are included with no occupancy.
- For the two hotel prototype buildings, an occupant density of 1.5 persons per standard guestroom (and 2 persons per suite) is used based on the technical support analysis for the *Advanced Energy Design Guide for Highway Lodging* (AEDG Highway Lodging) (Jiang et al. 2008).
- For hotel guestrooms, ASHRAE 62-1999 requires 30 cfm per living room and bedroom and 35 cfm per bath, regardless of area, for a total of 65 cfm. For bathrooms, the 35 cfm requirement is the installed capacity for intermittent use. Based on the interpretation from ASHRAE (http://www.ashrae.org/technology/page/913), the 35 cfm of outdoor air in bathrooms can be supplied to the hotel/motel bedroom and then exhausted through the bathroom at the same rate. Therefore, a ventilation rate of 35 cfm is used for guestrooms rather than 65 cfm. This rate is consistent with the technical support analysis for the AEDG Highway Lodging (Jiang et al. 2008).
- For apartment prototype residence zones, both Standards 62-1999 and 62.1-2004 require 0.35 air changes per hour (ACH) but not less than 15 cfm per person for each room in the living area, 25 cfm for the kitchen, and 20 cfm for baths (continuous). In addition, the ventilation standard also allows transfer air from living areas to compensate the exhausted air for kitchens and baths. Therefore, the outdoor air rate for a single-bedroom apartment is the maximum of 45 cfm (kitchen and bath) and 0.35 ACH. In the apartment prototypes, each apartment unit has 950 ft^2 conditioned floor area and a floor-to-ceiling height of 10 ft so 0.35 ACH for the apartments is 55 cfm. Thus, the outdoor air rate per single-bedroom apartment unit is 55 cfm, or 27.5 cfm/person.
- For hospitals and outpatient healthcare, ventilation rates are developed in medical critical zones using additional sources of information, including the AIA Guidelines identified above (AIA 2001).

Ventilation rates are determined for each zone based on its space type. Values shown in Table 4.14 are total ventilation airflows based on the sum of each zone's ventilation rate. For VAV systems, system ventilation rates are calculated using the multiple-zone re-circulating systems requirements in Standard 62.1-2004 (same in 62.1-2007) starting from the single-zone ventilation rates at the zone level. The multi-zone ventilation rate procedure results in different final outdoor ventilation air quantities for the same prototype in different climate zones and with different zones and system supply airflow. This procedure is described in this report in Section 5.2.2.21 on addendum 90.1-07ck in this report, which requires VAV systems to include ventilation reset controls.

Table 4.14. Prototypes Outdoor Air Ventilation

Prototype Building	Total Floor Area (ft²)	Total Occupants (based on 62.1-2004)	Total Outdoor Air Ventilation (cfm)		Total Outdoor Air Ventilation (cfm/ft²)	
			62-1999 (90.1-2004)	62.1-2007 (90.1-2010)	62-1999 (90.1-2004)	62.1-2007 (90.1-2010)
Small Office	5,500	28	550	468	0.100	0.085
Medium Office	53,633	268	5,363	4,559	0.100	0.085
Large Office	498,639	2,493	49,864	42,384	0.100	0.085
Standalone Retail	24,695	370	6,795	5,281	0.275	0.214
Strip Mall	22,500	337	6,750	5,231	0.300	0.233
Primary School	73,966	1,433	30,550	25,041	0.413	0.339
Secondary School	210,908	6,095	110,728	71,740	0.525	0.340
Outpatient Healthcare	40,946	419	9,959	8,389	0.243	0.207
Hospital	201,177	581	30,969	42,789	0.154	0.213
Small Hotel	43,207	239	5,699	3,914	0.132	0.091
Large Hotel	122,115	1,494	30,247	19,172	0.248	0.157
Warehouse	52,050	13	2,730	3,187	0.052	0.061
Quick-service Restaurant	2,501	94	1,841	1,757	0.736	0.703
Full-service Restaurant	5,503	288	5,715	3,872	1.039	0.704
Mid-rise Apartment	33,744	67	1,967	1,986	0.058	0.059
High-rise Apartment	84,361	163	4,858	4,927	0.058	0.058

4.6 Service Water Heating Equipment

Service water heating provides for general hot water usage such as lavatory sinks as well as specific loads, including commercial kitchens and laundry facilities, which are included in some of the prototypes. Peak loads are consistent with DOE's Commercial Reference Buildings (Deru et al. 2011). The simulations combine loads and storage into a single water heater for most prototype models, although loads on an hourly basis may use separate hourly schedules with the combined hourly load applied to the single water heater. Some prototypes model more than one water heater: the small hotel prototype separates the laundry and guestroom loads into two separate water heaters; the strip mall prototype includes one water heater per store; and, the apartment prototype includes one water heater per apartment. See Appendix C in this report for service water heating schedules that include hourly fraction of peak usage. Service water heating efficiency remains the same for the 90.1-2004 and 90.1-2010 models and complies with minimum efficiency requirements in 90.1-2004 (see Table 4.15).

Table 4.15. Service Water Heating Equipment

Prototype Building	Water Heater Energy Type	Modeled Water Heaters (quantity)	Storage Capacity (gallons)	Peak Load (gallons/hour)
Small Office	Natural Gas	1	40	3
Medium Office	Natural Gas	1	260	30
Large Office	Natural Gas	1	260	256
Standalone Retail	Natural Gas	1	40	18
Strip Mall	Natural Gas	7	6	2
Primary School[(a)]	Natural Gas	1	264	157
Secondary School[(b)]	Natural Gas	1	792	427
Outpatient Healthcare	Natural Gas	1	793	30
Hospital[(c)]	Natural Gas	1	800	265
Small Hotel - Laundry	Natural Gas	1	100	202
Small Hotel - Guestrooms	Natural Gas	1	200	135
Large Hotel[(d)]	Natural Gas	1	528	380
Warehouse	Electric	1	20	8
Quick-service Restaurant	Natural Gas	1	53	40
Full-service Restaurant	Natural Gas	1	53	133
Mid-rise Apartment (each)	Electric	1	20	4
High-rise Apartment (each)	Electric	1	20	4

(a) Primary school peak load includes 100 gallons per hour (gph) for kitchen and 56.5 gph for other uses.
(b) Secondary school peak load includes 133 gph for kitchen, 189.5 gph for gym locker rooms, and 104.4 gph for other uses.
(c) Hospital peak load includes 150 gph for kitchen and 115 gph for other uses.
(d) Large hotel peak includes 156.6 gph for laundry and 223.8 gph for guestrooms.

4.7 Lighting

4.7.1 Interior Lighting

Interior lighting is defined using the same methodology for the prototypes for both the 90.1-2004 and the 90.1-2010 models. For all of the models, except for the small, medium, and large office, the lighting power density (LPD) values are implemented using the space-by-space method in Standard 90.1 and zones are assigned to lighting space types with different LPD values for each space. For the offices, the general office LPD value from the building area method in Standard 90.1 is used since the zones are not broken out by 90.1 lighting space type. 90.1-2004 and 90.1-2007 have the same LPD values for interior lighting. A number of different addenda change the values going to 90.1-2010, principally addendum 90.1-07by (Section 5.2.4.7 in this report), which has an overall revision of the LPD allowance. Other addenda, such as addendum 90.1-07x (Section 5.2.4.3 in this report), which adds occupancy sensor control to more space types, also result in changes to modeled LPD. The retail strip mall values also include additional display lighting. Display lighting for the 90.1-2004 and 90.1-2010 models is described with addenda 90.1-04ai and 90.1-07bq (Section 5.2.4.6) which affect display lighting.

In the simulation, the spaces in the model that use the space-by-space method are all assigned a Standard 90.1 space type. For each space type, the value for the LPD is assigned for the 90.1-2004 models and the adjusted values with the cumulative addenda leading to the final 90.1-2010 models. Table 4.16 shows an example for the overall LPD values for the 90.1-2004 case and the development of the 90.1-2010 values. See the addendum descriptions in Chapter 5 in this report for the basis of the values and reductions shown.

Table 4.16. Secondary School Example of LPD Inputs Development

Index	Lighting Space Type Parameter	90.1-2004	90.1-2007	New Starting Values from Addendum 90.1-07by and 90.1-07de	Addendum 90.1-07x Reduction	Addendum 90.1-07cf Reduction	90.1-2010
		LPD (W/ft^2)					
1	LPD_classroom	1.4	1.4	1.24	0.0966	NA	1.1434
2	LPD_corridor	0.5	0.5	0.67	0.0966	0.0341	0.5393
3	LPD_lobby	1.3	1.3	0.9	0.0966	NA	0.8034
4	LPD_mechanic	1.5	1.5	0.95	0.0966	NA	0.8534
5	LPD_bath	0.9	0.9	0.98	0.0966	NA	0.8834
6	LPD_office	1.1	1.1	1.11	0.0966	NA	1.0134
7	LPD_gym	1.4	1.4	0.72	0.0966	NA	0.6234
8	LPD_kitchen	1.2	1.2	0.99	0.0966	NA	0.8934
9	LPD_cafeteria	0.9	0.9	0.65	0.0966	NA	0.5534
10	LPD_library	1.3	1.3	1.18	0.0966	NA	1.0834
11	LPD_auditorium	0.9	0.9	0.79	0.0966	NA	0.6934

4.7.2 Exterior Lighting

90.1-2004 introduced exterior lighting wattage allowances for different parts of building exteriors, such as parking areas, facades, building grounds, entrances, and exits. Exterior lighting power allowances are provided based on different units such as W/ft^2, W/ft and W/door. These allowances were not changed in 90.1-2007 but were changed in addendum i to 90.1-2007 (Section 5.2.4.2 in this report). To evaluate the savings for these changes, the exterior lighting is developed in greater detail than in earlier version of the prototype models. Addendum 90.1-07i includes the exterior lighting wattage values that are included in the simulations. This section presents the exterior lighting assumptions behind the development of the exterior wattage values. PNNL and the SSPC 90.1 Lighting Subcommittee developed the parking area, number of doors (entry, rolling, and other), and lit facade areas for each prototype. Tables 4.17 through 4.19 summarize the values determined for each component. The primary data source for the parking area and the door assumptions is the NC^3 database (Richman et al. 2008). The primary data for the facade lighting are from a PNNL survey of four experienced lighting design professionals on the SSPC 90.1 Lighting Subcommittee.

Table 4.17. Illuminated Parking Area

Building Prototype	Total Floor Area (ft²)	Number of Parking Spaces per Unit Shown	Total Parking Area (ft^2)
Small Office	5,500	4 per 1,000 ft²	8,910
Medium Office	53,600	4 per 1,000 ft²	86,832
Large Office	498,600	1 per 620 ft²	325,112
Standalone Retail	24,695	3.5 per 1,000 ft²	35,005
Strip Mall	22,500	1 per 215 ft²	42,373
Primary School	73,960	1 per 17 students	14,683
Secondary School	210,900	1 per 8 students	59,316
Outpatient Healthcare	40,950	1 per 200 ft²	82,924
Hospital	241,410	1.2 per bed	77,435
Small Hotel	43,200	1 per room	33,680
Large Hotel	122,130	1 per room	88,538
Warehouse	49,500	1 per 1,000 ft²	20,048
Quick-service Restaurant	2,500	1 per 100 ft²	10,125
Full-service Restaurant	5,500	1 per 100 ft²	22,275
Mid-rise Apartment	33,700	2.2 per unit	28,578
High-rise Apartment	84,360	2.2 per unit	71,537

Table 4.18. Number of Doors by Door Type

Building Prototype	Ground Floor Footprint Area ft^2	Rollup Doors per 10,000 ft^2 of Building Footprint	Entrance Doors per 10,000 ft^2 of Building Footprint	Other Doors per 10,000 ft^2 of Building Footprint	Total Rollup Doors[(a)]	Total Entrance Doors[(a)]	Total Other Doors[(a)]
Small Office	5,500	0.47	2.00	2.00	0.26	1.10	1.10
Medium Office	17,876	0.13	1.00	3.00	0.24	1.79	5.36
Large Office	38,400	0.00	1.00	3.00	0.02	3.84	11.52
Stand-alone Retail	24,695	1.84	1.00	2.93	4.54	2.47	7.23
Strip Mall	22,500	0.05	6.00	6.60	0.11	13.50	14.85
Primary School	73,960	0.07	2.00	3.30	0.54	14.79	24.38
Secondary School	128,242	0.10	2.00	2.45	1.31	25.65	31.38
Outpatient	40,950	0.10	1.00	5.19	0.40	4.10	21.26
Hospital	40,250	0.03	2.00	3.80	0.14	8.05	15.29
Small Hotel	10,800	0.00	2.00	28.91	0.00	2.16	31.22
Large Hotel	21,300	0.01	1.00	2.27	0.03	2.13	4.83
Warehouse	49,500	3.67	1.00	2.00	18.15	4.95	9.88
Quick-service Restaurant	2,500	0.00	2.00	1.00	0.00	0.50	0.25
Full-service Restaurant	5,500	0.00	1.00	3.00	0.00	0.55	1.65

(a) Number of doors values are representative averages used to calculate exterior lighting power.

Table 4.19. Illuminated Facade Areas

	Average Length of Lit Facade Wall (ft)				Wall Length (ft)				Wall Height	Illuminated Facade Area[a] (ft^2)				
Building Prototype	Front	Side 1	Side 2	Back	Front	Side 1	Side 2	Back	(ft)	Front	Side 1	Side 2	Back	Total
Small Office	27.5	10.0	10.0	3.8	91	61	61	91	10	250	61	61	34	405
Medium Office	41.3	15.0	15.0	3.8	164	109	109	164	39	2,638	638	638	240	4,154
Large Office	76.3	43.8	43.8	38.8	240	160	160	240	156	28,548	10,920	10,920	14,508	64,896
Standalone Retail	41.3	17.5	17.5	2.5	178	139	139	178	20	1,469	487	487	89	2,531
Strip Mall	61.3	6.3	6.3	1.3	300	75	75	300	17	3,124	80	80	64	3,347
Primary School	10.0	3.8	3.8	2.5	764	270	270	764	13	993	132	132	248	1,505
Secondary School	10.0	3.8	3.8	2.5	883	341	341	883	26	2,296	332	332	574	3,535
Outpatient Healthcare	18.8	3.8	3.8	3.8	166	120	120	166	30	934	135	135	187	1,391
Hospital	71.3	15.0	15.0	10.0	230	175	175	230	70	11,471	1,838	1,838	1,610	16,756
Small Hotel	30.0	16.3	16.3	15.0	180	60	60	180	38	2,052	371	371	1,026	3,819
Large Hotel	82.5	75.0	75.0	47.5	284	56	56	284	63	14,761	2,646	2,646	8,499	28,552
Warehouse	6.7	1.7	1.7	1.7	330	150	150	330	28	616	70	70	154	910
Quick-service Restaurant	63.8	51.3	40.0	8.8	50	50	50	50	10	319	256	200	44	819
Full-service Restaurant	52.5	41.3	41.3	3.8	74	74	74	74	10	389	305	305	28	1,027
Mid-rise apartment	18.8	7.5	7.5	5.0	152	56	56	152	40	1,140	167	167	304	1,777
High-rise apartment	42.5	32.5	32.5	27.5	152	56	56	152	100	6,460	1,804	1,804	4,180	14,248

(a) The lit facade area is the lit facade length divided by total facade length times the wall height. Wall height includes multiple floors.

4.8 Other Equipment

Chapter 10 of Standard 90.1 applies to specified energy using equipment not covered elsewhere in Standard 90.1. Prior to 90.1-2010, the chapter only includes requirements for electric motors. These mandatory requirements are minimum efficiency for National Electric Manufacturers Association (NEMA) Type A and Type B motors. Motor efficiency values are updated by addendum 90.1-07aj. Section 5.2.5.1 in this report describes how these values are changed from the 90.1-2004 and 90.1-2007 Table 10.8 values to the 90.1-2010 Tables 10.8A and B values.

Chapter 10 of 90.1-2010 introduces requirements for service water heating booster pumps, and elevator fans and lights. The service water heating booster pump requirements are added by addendum 90.1-07cv. None of the prototypes include service water heating booster pumps and potential energy savings for this addendum are not quantified in the PI. Elevator fans and lights are described in Section 4.8.2 of this report and under addendum 90.1-07df (Section 5.2.5.2 in this report).

Chapter 10 of 90.1 does not currently regulate most plug and process loads, but these may be the subject of future editions of Standard 90.1. However, these loads are included in the prototypes in order to more accurately capture typical building energy usage and to include the impact of these loads on HVAC sizing and energy usage. This section of the report describes these loads including general plug loads, elevators, commercial kitchens and laundry facilities.

4.8.1 General Plug Loads

Equipment loads for receptacle plug-in devices such as appliances, office equipment, and specialty medical equipment vary by building type. Table 4.20 summarizes the equipment power density for these types of loads. These loads do not include elevator, kitchen, and laundry equipment loads, which are described in Sections 4.9.2 through 4.9.5 below. The values shown for each prototype are the sum of the wattage for these types of loads, divided by the total building area. The values are consistent with DOE's Commercial Reference Building Models (Deru et al. 2011). The mid-rise and high-rise apartment building plug loads are developed based on research from DOE's Building America Research Benchmark (http://www1.eere.energy.gov/buildings/building_america/index.html). PNNL's scorecards contain detailed information in the corresponding model input worksheets (http://www.energycodes.gov/commercial/901models/).

4.8.2 Elevators

Elevators use energy for the elevator motors that move the elevators and for lights and fans that serve the elevator cabin. The characteristics of these energy uses in the prototypes are described in this section.

4.8.2.1 Elevator Motors

The energy usage of elevator motors is modeled for the prototype buildings with multiple floors as interior or exterior electric loads, depending on the number of building stories. For buildings with fewer

Table 4.20. General Plug Loads

Prototype Building	Total Floor Area (ft^2)	Plug Loads (W/ft^2)
Small Office	5,500	0.63
Medium Office	53,630	0.75
Large Office	498,640	0.73
Standalone Retail	24,690	0.50
Strip Mall	22,500	0.40
Primary School	73,970	1.00
Secondary School	210,910	0.67
Outpatient Healthcare	40,950	1.79
Hospital	241,410	1.05
Small Hotel	43,210	0.95
Large Hotel	122,120	0.58
Warehouse	52,050	0.19
Quick-service Restaurant	2,500	0.00
Full-service Restaurant	5,500	0.00
Mid-rise Apartment	33,740	0.56
High-rise Apartment	84,360	0.56

than six stories (including the basement), hydraulic motors are assumed and the electric load is added to first floor core zone. For buildings with six stories or more, traction motors are assumed and the load is modeled as exterior to the buildings. The peak power of elevator motors are estimated using the same assumptions as DOE's Commercial Reference Building Models (Deru et al. 2011) as shown in Table 4.21 below. *EnergyPlus* simulation does not directly model motor efficiency for elevators; wattage shown in Table 4.21 includes the effect of this motor efficiency. Because a high-rise apartment building is not included in the Commercial Reference Building Models, one elevator for every 90 units is assumed. The operation schedules of elevators are shown in Appendix C in this report.

4.8.2.2 Elevator Lights and Fans

The elevator lights and ventilation fans are also modeled as electric loads, which are applied to the same locations as the elevator motors. Their power is estimated based on a standard size elevator car with a length of 6.66 ft, width of 4.25 ft, and height of 8 ft. The lighting is assumed to be 70% from incandescent light source (10 lumens/W and 4 W/ft^2) and 30% from higher efficacy light source (35 lumens/W and 1.14 W/ft^2). The ventilation rate is assumed to be one air change per minute with ventilation power of 0.33 W/cfm. Based on these assumptions, the baseline lighting and ventilation fan power is calculated to be 88 W and 74 W per elevator car, respectively. Addendum 90.1-07df restricts elevator lights and fans, as shown in Section 5.2.5 of this report. Table 4.22 summarizes the baseline elevator lighting assumptions. The lights and fans are assumed to be always on. These assumptions were provided by the 90.1 Elevator Working Groups, which is also responsible for developing addendum 90.1-07df.

Table 4.21. Elevator Motor Power

Building Type	Number of Stories	Number of Elevators	Motor Type	Over Counter Weight (fraction of car capacity)	Weight of Car (lb)	Speed of Car (fpm)[(a)]	Mechanical Efficiency	Motor HP	Motor Efficiency	Model Input for Motor Peak Power (W/elevator)
Medium Office	3	2	Hydraulic	0%	2,500	150	58%	20	91%	16,055
Large Office	12	12	Traction	40%	2,500	350	64%	25	91%	20,370
Secondary School	2	2	Hydraulic	0%	2,500	150	58%	20	91%	16,055
Small Hotel	4	2	Hydraulic	0%	2,500	150	58%	20	91%	16,055
Large Hotel	6	6	Traction	40%	2,500	350	64%	25	91%	20,370
Hospital	6	8	Traction	40%	2,500	350	64%	25	91%	20,370
Outpatient Healthcare	3	3	Hydraulic	0%	2,500	150	58%	20	91%	16,055
Mid-rise Apartment	4	1	Hydraulic	0%	2,500	150	58%	20	91%	16,055
High-rise Apartment	10	1	Traction	40%	2,500	350	64%	25	91%	20,370

(a) fpm is feet per minute

Table 4.22. Elevator Lighting

Lighting Characteristic	Value
Design Lighting Level	30 lumens/ft^2
Light Loss Factor	75%
Needed Light Level	40 lumens/ft^2
Incandescent (70%)	10 lumens/W 4 W/ft^2
High Efficacy Source (30%)	35 lumens/W 1.14 W/ft^2
Average Efficacy	17.5 lumens/W
Average LPD	3.14 W/ft^2
Lighting Power	88 W/elevator

4.8.3 Commercial Kitchens

Six prototype buildings are modeled with commercial kitchens: primary school, secondary school, quick-service restaurant, full-service restaurant, large hotel, and hospital. The electric and gas energy consumption for food preparation is modeled as zone plug loads and include cooking appliances and reach-in refrigerators. Kitchen exhaust and use of transfer air are modeled. Walk-in coolers and freezers are modeled separately from reach-in refrigerators as described below. The gas cooking load is in kitchen zones and the electricity load is distributed in kitchen and dining zones.

Table 4.23 summarizes the peak load for cooking and other receptacle loads in the commercial kitchens for the six applicable prototypes. These loads represent the total installed capacity of the equipment. These values were derived from an earlier version of DOE's Commercial Reference Building Models. The operating schedules of the electric and gas loads are shown in Appendix C in this report.

Table 4.23. Kitchen Cooking Loads

	Food Preparation Load		
	Natural Gas in Kitchen (kW)	Electricity in Kitchen (kW)	Electricity in Dining Area (kW)
Primary School	240	32	8
Secondary School	363	48	48
Quick-service Restaurant	92	31	14
Full-service Restaurant	91	56	24
Large Hotel	250	52	22
Hospital	150	75	0

The selection of kitchen exhaust hoods should be specific to the cooking appliances used. Because the hypothetical kitchens of the prototype buildings do not have detailed kitchen equipment information, assumptions for total kitchen exhaust flow rate are made based on engineering judgment and a review of actual kitchen designs (see Table 4.24). A review of the F.W. Dodge Drawings for quick-service restaurants indicates that a common design practice is to transfer air from the dining zone to the kitchen as part of the replacement air for the exhaust hoods (F.W. Dodge 2002). The amount of transfer air depends on how much outdoor ventilation air is available in the dining zone. The other five buildings were assumed not to use transfer air, and the replacement air for kitchen exhaust hoods is assumed to be from zone supply air.

Refrigeration for commercial kitchens typically includes walk-in refrigerators and freezers. This type of refrigeration is included in selected prototypes as shown in Table 4.25 (Deru et al. 2011). The walk-in refrigeration equipment is modeled in *EnergyPlus* using the refrigeration module, not just wattage power, and schedules as are implemented with other receptacle loads. Smaller standalone refrigeration equipment is incorporated with the kitchen wattage inputs above.

4.8.4 Laundry

Laundry equipment is explicitly modeled for the small and large hotel. Laundry uses natural gas for service water heating and dryers and electricity for receptacle loads for the washers and dryers. Laundry service water heating loads are included in Table 4.15 above. The large hotel laundry receptacle load is 5.7 W/ft^2; the dryer gas load is equivalent to 49.8 W/ft^2; and the laundry room is 840 ft^2. The small hotel laundry receptacle load is 2.0 W/ft^2; the dryer gas load is equivalent to 17.1 W/ft^2; and the laundry room is 1,053 ft^2. These values are derived from DOE's Commercial Reference Buildings Models (Deru et al. 2011).

Table 4.24. Kitchen Exhaust and Transfer Air

	Total Exhaust Airflow Rate (cfm)	Use of Available Transfer Air
Primary School	5,000	No
Secondary School	6,000	No
Quick-service Restaurant	3,300	Yes
Full-service Restaurant	6,000	No
Large Hotel	4,000	No
Hospital	8,000	No

Table 4.25. Refrigeration – Walk-in Coolers and Freezers

Building Type	Area (ft^2)	Length (ft)	Cooling Capacity (kBtu/h)	COP	Evaporator Fan (W)	Condenser Fan (W)	Lighting (W/ft^2)	Defrost (W)	Anti-Sweat (W)	Heat Rejection Location
Walk-in Coolers										
Primary School	120	12	9.2	3	200	350	1	0	0	Outdoors
Secondary School	240	24	19.1	3	400	750	1	0	0	Outdoors
Quick-service Restaurant	100	10	7.7	3	200	330	1	0	0	Outdoors
Full-service Restaurant	100	10	7.7	3	200	330	1	0	0	Outdoors
Large Hotel	120	12	9.2	3	200	350	1	0	0	Outdoors
Hospital	360	29	27	3	600	1,000	1	0	0	Outdoors
Walk-in Freezers										
Primary School	120	12	9.2	1.5	250	350	1	2,000	0	Outdoors
Secondary School	240	24	18.3	1.5	500	750	1	3,000	0	Outdoors
Quick-service Restaurant	80	8	5.7	1.5	180	329	1	2,000	0	Outdoors
Full-service Restaurant	80	8	5.7	1.5	180	329	1	2,000	0	Outdoors
Large Hotel	120	24	9.2	1.5	250	350	1	2,000	0	Outdoors
Hospital	360	36	27.5	1.5	760	1,000	1	4,000	0	Outdoors

5.0 Modeling of Specific Addenda

With the agreement of DOE and ASHRAE to achieve 30% energy savings with the 90.1-2010 Standard, the number of addenda to 90.1-2007 approved during the three-year Standard development cycle is unprecedented compared with previous updates to the standard. 90.1-2010 incorporates 109 approved addenda to 90.1-2007. In contrast, 90.1-2007 contains 44 approved addenda to 90.1-2004. In the PI process, PNNL reviewed and considered the combined total of 153 addenda for quantitative analysis of the 2010 edition versus the 2004 edition. Of the 153 addenda, the energy savings of 53 are quantified in the final analysis. This chapter describes the categorization of all of the addenda, summarizes the content of the addenda, and provides modeling strategies and Energy Plus implementation for 53 identified addenda that can be quantified in the prototype building models.

5.1 Addenda Characterization

The 153 addenda reviewed in the PI can be sorted a number of different ways. There are 118 addenda that are incorporated in the mandatory and prescriptive requirements of Chapters 5 through 10 of 90.1-2010; the remaining 35 addenda only affect other chapters and appendixes. Of those that are incorporated in Chapters 5 to 10 of 90.1-2010, some are thought to result in energy savings that can be quantified in the analysis; some may result in energy savings but cannot be captured in the analysis; and some are not expected lead to energy savings. Figure 5.1 shows the number in each category and, for the addenda with quantified savings, shows the number of addenda associated with the chapters in 90.1-2010 that are affected. There are no addenda associated with Chapter 7 on service water heating.

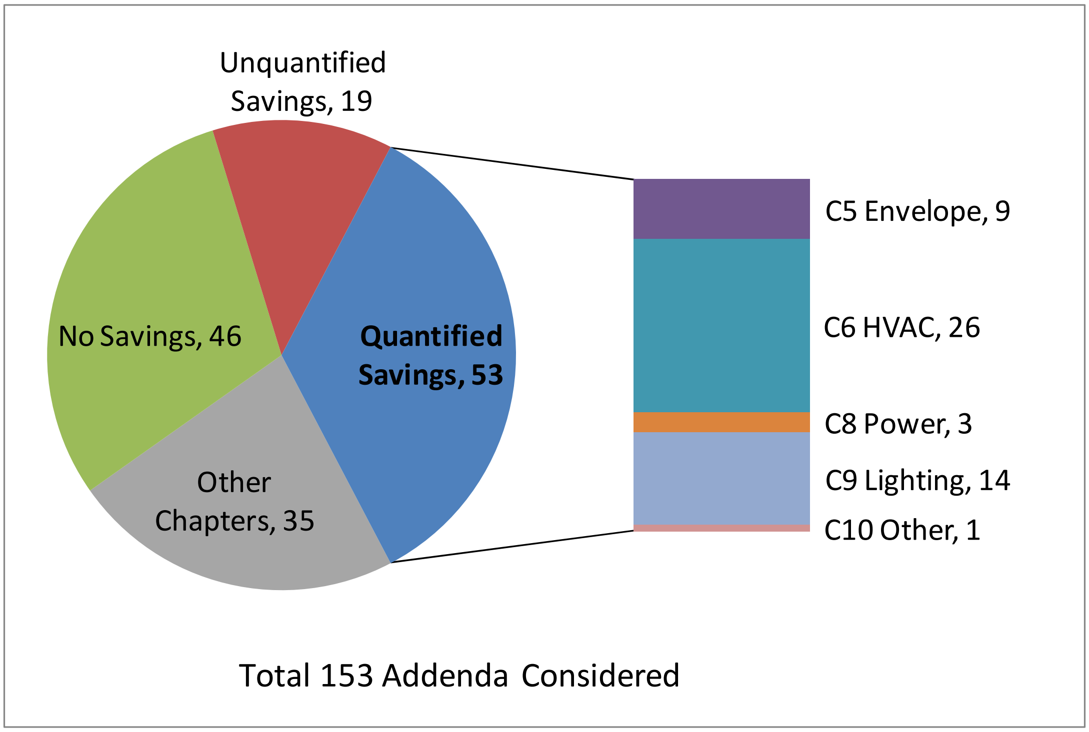

Figure 5.1. Addenda by Category and Quantity

Tables 5.1 through 5.3 include brief descriptions and other information for the 118 addenda in Chapters 5 through 10 of Standard 90.1. Table 5.1 includes the 53 addenda with quantified savings and identifies the affected prototypes in the modeling. Table 5.2 includes 19 addenda with potential savings not quantified in the PI and explains why the savings are not quantified. Table 5.3 includes the remaining addenda that do not have identified savings; 9 of these addenda may result in increased energy use believed to be negligible relative to total energy savings.

Addenda are listed in these tables in a sorted hierarchy: (1) by the relevant 90.1 chapter, (2) with 2004 addenda first, followed by 2007 addenda, and (3) sequentially by alphabetical letter name of the addenda with two letter names following single letter names, e.g., "t" before "aa."

Addenda that affect more than one chapter in 90.1, for example, those creating changes to the building envelope and lighting controls for daylighting, are sorted into the 90.1 chapter that is primarily responsible for the energy savings. For daylighting, adding skylights can actually increase energy usage; and while necessary to bring in the daylight, the lighting controls then allow energy to be saved. Therefore, these addenda are included with Standard 90.1, Chapter 9, lighting addenda. Other affected 90.1 chapters are identified in the list as well.

Table 5.1. Addenda with Quantified Savings in PI

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-04c	5. Envelope	Revises the definition of *building entrance* to include vestibules and clarifies the requirements and exceptions for vestibules.	X	X		X	X	X	X	X		X		X	X	X	X	
90.1-04as	5. Envelope	Modifies the opaque assembly requirements in Tables 5.5-1 through 5.5-8.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-04at	5. Envelope	Modifies the fenestration requirements in Tables 5.5-1 through 5.5-8.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-07f	5. Envelope	Sets requirements for high-albedo roofs.		X	X	X	X	X	X	X	X	X	X				X	X
90.1-07g	5. Envelope	Updates the building envelope criteria for metal buildings.												X				
90.1-07q	5. Envelope	Removes the exception to vestibule requirements in Climate Zone 4.	X												X	X		
90.1-07am	5. Envelope	Revises air leakage criteria for windows and doors.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-07bf	5. Envelope	Requires continuous air barrier and performance requirements for air leakage of opaque envelope elements.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-07bn	5. Envelope	Limits poorly oriented fenestration; favors south-facing fenestration over west-facing fenestration.									X	X						
90.1-04f	6. HVAC	Raises minimum efficiency for three-phase air-cooled central air conditioners and heat pumps <65,000 Btu/h consistent with federal minimum standards.	X			X	X	X				X		X	X	X	X	
90.1-04g	6. HVAC	Raises minimum efficiency levels of air-cooled air conditioners and heat pumps ≥65,000 Btu/h, consistent with federal minimum standards.	X	X		X	X	X		X		X		X	X	X	X	
90.1-04q	6. HVAC	Removes exception (a) to Section 6.4.3.2 for HVAC systems serving hotel/motel rooms and guestrooms.										X	X					
90.1-04s	6.HVAC and 12. Normative References	Updates language in the standard based on differences between Standards 62-1999 and 62.1-2004. Also, updates the normative reference.	X	X		X	X	X	X	X	X	X	X	X	X	X	X	
90.1-04v	6. HVAC	Modifies the provisions of Section 6.4.3.8 to allow for demand control ventilation.						X	X				X					

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected: Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-04ac	6. HVAC and 3. Definitions	Modifies the fan power limitation requirements in Section 6.5.3.		X	X	X	X	X	X	X	X	X	X			X		
90.1-04an	6. HVAC	Modifies the equipment efficiency requirements for commercial boilers in Table 6.8.1F.			X				X		X		X					
90.1-04ao	6. HVAC	Adds footnote for unit heater efficiency requiring intermittent ignition devices, power venting, or flue dampers to comply with federal law.												X				
90.1-04ar	6. HVAC	Lowers the part-load fan power limitation from 15 to 10 hp in Section 6.5.3.2.1.		X				X	X									
90.1-07e	6. HVAC	Modifies requirements for energy recovery.			X	X		X	X		X							
90.1-07h	6. HVAC	Revises the airflow limits for which new energy may be used for reheating or re-cooling in DDC systems.		X	X			X	X	X	X		X					
90.1-07m	6. HVAC	Increases minimum chiller performance and adds a second Path B for alternative chiller efficiency requirements.			X				X		X		X					

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-07n	6. HVAC	Establishes requirements for single zone VAV fan modulation on cooling units. For chilled water systems 5 hp and greater the requirement is effective 1/1/10. For DX systems 110,000 Btuh cooling capacity and greater, the requirement is effective 1/1/12.				X	X	X	X						X	X		
90.1-07u	6. HVAC	Requires open cooling towers with centrifugal fan units over 1,100 gpm at the rating conditions to meet the energy efficiency requirements for axial fan units.			X						X							
90.1-07af	6. HVAC	Prescribes maximum flow rates through chilled water and condenser water piping.			X				X		X		X					X

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-07ak	6. HVAC	1. Removes the requirement for VFDs on variable flow heating water systems. Lowers VFD threshold from 50 to 5 hp for chilled water systems. 2. Limits differential pressure setpoint and requires setpoint reset with DDC. 3. Adds water-cooled air conditioners to systems requiring isolation valves. 4. Adds VFD pumping requirement to hydronic heat pumps and water-cooled unitary air conditioners.			X				X		X		X					
90.1-07as	6. HVAC	Removes exception for VAV turndown for zones with special pressurization requirements. Reduces laboratory threshold requiring VAV or heat recovery.								X	X							
90.1-07ax	6. HVAC	Modifies the requirements for kitchen hood exhaust and make-up air systems.						X	X		X		X		X	X		
90.1-07bh	6. HVAC	Requires supply air temperature to be reset for multi-zone HVAC systems.		X	X			X	X	X	X		X					

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-07bw	6. HVAC	Improves PTAC and PTHP efficiency.										X						
90.1-07ca	6. HVAC	Requires that single-zone VAV systems meet the fan power requirements for constant volume systems.				X	X	X	X						X	X		
90.1-07cb	6. HVAC	Removes the exception for automatic damper requirements for buildings under3 stories in height.	X			X	X	X	X					X	X	X		
90.1-07cc	6. HVAC	Modifies pipe sizing table for 8" pipe.			X				X		X		X					X
90.1-07ck	6. HVAC and 12. Normative References	Requires multi-zone VAV systems to have controls that optimize ventilation.		X	X					X	X		X					
90.1-07cy	6. HVAC	Updates economizer requirements.	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
90.1-07dj	6. HVAC	Limits pressure drop of energy recovery devices.			X	X		X	X		X							
90.1-07o	8. Power	Establishes step-down transformer efficiencies.		X	X			X	X		X		X					X

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-07bs	8. Power	Requires noncritical receptacle loads to be automatically controlled (turned off) based on occupancy or scheduling.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-07d	9. Lighting	Requires automatic daylighting controls when skylights are present.				X		X	X					X				
90.1-07i	9. Lighting	Categories for external lighting allowances are expanded and LPDs are defined.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-07x	9. Lighting	Reduces the building size threshold where automatic lighting shutoff is required from 5,000 ft^2 to any size. Adds the following space types to those where occupancy sensor control is required: lecture halls, training rooms, supply and storage rooms (up to 1,000 ft^2), office spaces (up to 250 ft^2), restrooms, dressing rooms, locker rooms, and fitting rooms.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-07aa	9. Lighting	Requires automatic shutoff controls to be manual on except in certain spaces.	X	X	X													

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected: Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-07ab	9. Lighting	Defines top lit and side lit daylight spaces over a certain size; adds daylighting requirements.		X	X	X		X	X					X				
90.1-07al	9. Lighting and 5. Envelope	Requires skylights in spaces 10,000 $ft^2$and larger.				X			X					X				
90.1-07aw	9. Lighting	Removes bathrooms from the requirements for on/off controls located at the entry to hotel/motel guestrooms Requires automatic shutoff of bathroom lighting.										X	X					
90.1-07bq	9. Lighting	Reduces additional lighting power allowance for retail display.					X											
90.1-07by	9. Lighting	Makes major changes in LPD allowances.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-07cd	9. Lighting	1. Requires exterior lighting control rather than just control capability. 2. Adds bi-level control for general all-night applications such as parking lots to reduce lighting when not needed. 3. Adds control of	X	X	X	X	X	X	X					X	X	X		

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
		facade and landscaping lighting not needed after midnight.																
90.1-07cf	9. Lighting	Requires stairwell lighting to be controlled automatically using control devices such that the lighting power is reduced by at least 50% within 30 minutes of all occupants leaving that controlled zone.	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
90.1-07ct	9. Lighting	Requires daylight sensor control for sidelit spaces 250 ft^2 and larger.	X	X	X			X	X	X	X	X	X	X	X	X		
90.1-07dd	9. Lighting and 5. Envelope	Reduces the area threshold where skylights are required to be designed into building spaces down to 5,000 ft^2 and similarly reduces the threshold where daylighting controls must be applied to 900 ft^2.						X						X				
90.1-07de	9. Lighting	Reduces lighting power allowance for some lobbies to reflect advances in lighting technology.	X	X	X	X		X	X	X	X	X						

Table 5.1. (cont'd)

90.1 Addenda	90.1 Chapter(s) Affected	Description	Prototypes Affected															
			Small Office	Medium Office	Large Office	Standalone Retail	Strip Mall	Primary School	Secondary School	Outpatient Healthcare	Hospital	Small Hotel	Large Hotel	Warehouse	Quick-service Restaurant	Full-service Restaurant	Mid-rise Apartment	High-rise Apartment
90.1-07aj	10. Other Equipment	Updates motor efficiency tables.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
90.1-07df	10. Other Equipment	Adds requirements for elevator ventilation and lighting.		X	X				X	X	X	X	X				X	X

Table 5.2. Addenda with Potential Energy Savings but Not Quantified in PI

90.1 Addenda	90.1 Chapter Affected	Description	Why Potential Savings Are Not Quantified in PI
90.1-07ag	5. Envelope	Requires staggered joints in layered rigid insulation.	Does not change the minimum U-factor, which is what savings would be based on for the PI. This addendum has a potential to reduce thermal bridging and air leakage rate, but this cannot be quantified in the current prototype models.
90.1-04b	6. HVAC	Revises Table 6.8.1D and adds definitions for single-package vertical air conditioners and single-package vertical heat pumps.	No prototypes have single-package vertical air-conditioner or single-package vertical heat pump.
90.1-04h	6. HVAC	Revises the exceptions to Sections 6.4.3.1.2 and 6.4.3.6 by removing data processing centers from having specific exceptions on temperature deadband and humidification deadband.	No prototypes have data centers
90.1-07y	6. HVAC	Establishes AHRI 1160-2008 (AHRI 2008) as the test procedure for heat pump pool heaters and requires that the minimum COP of 4 be met at the low outdoor temperature of 50°F (instead of the high outdoor temperature of 80°F currently required).	No prototypes have swimming pools
90.1-07ae	6. HVAC	Requires insulation on the thermally ineffective surface of a radiant heating panel.	No prototypes have radiant panels
90.1-07ap	6. HVAC	Adds demand controlled ventilation (DCV) to simple systems, closing the loophole.	Simple system in restaurant is only prototype that would be affected and savings cannot be shown since transfer air to kitchen prevents DCV from being used in the dining room.
90.1-07bg	6. HVAC	Adds efficiency requirements for water-to-water heat pumps.	No prototypes have water-to-water heat pumps.
90.1-07bi	6. HVAC	Provides updated requirements for pipe insulation.	Not captured here since heat loss from piping is not included in the prototypes.
90.1-07bl	6. HVAC	Removes exemption for chillers with glycol.	No prototypes have chillers with glycol.
90.1-07bt	6. HVAC	Modifies centrifugal chiller adjustment factor for nonstandard conditions.	No prototypes have chillers that operate at nonstandard conditions.
90.1-07bu	6. HVAC	Adds efficiency requirements to HVAC systems dedicated to computer rooms and data centers.	No prototypes have data centers.
90.1-07bx	6. HVAC	Limits reheat temperatures to 20 degrees F. above room temperature for better air distribution effectiveness.	*EnergyPlus* limitations make it impractical to capture savings. May revisit after upgrade to EnergyPlus V.6.0

90.1 Addenda	90.1 Chapter Affected	Description	Why Potential Savings Are Not Quantified in PI
90.1-07co	6. HVAC	Updates EER and IEER values for condensing units and water and evaporatively cooled air conditioners with ≥65,000 Btu/h.	No Prototypes have water or evaporatively cooled air conditioners or separate condensing units.
90.1-07cq	6. HVAC	Modifies the duct sealing requirements.	Duct leakage not accounted for in the prototypes.
90.1-07di	6. HVAC	Requires parking garage ventilation systems to modulate airflow based on contaminant level.	No prototypes have parking garages.
90.1-07av	9. Lighting	Requires lighting alterations, to meet all Chapter 9 requirements (previously only required to meet LPD requirements).	Savings not captured since prototypes represent new construction only.
90.1-07br	9. Lighting	Adds exterior lighting zone zero for undeveloped areas of national parks.	No prototypes include national park locations.
90.1-07cz	9. Lighting	Incorporates bi-level control for parking garages to reduce the wasted energy associated with unoccupied periods for many garages AND allows an exception for lighting in the transition (entrance/exit) areas.	No prototypes have parking garages.
90.1-07cv	10. Other Equipment	Adds energy efficiency requirements for service water pressure booster systems.	No prototypes include service water pressure booster systems.

Table 5.3. Addenda with No Energy Savings

90.1 Addendum	90.1 Chapter Affected	Description	Why No Energy Savings Were Identified
90.1-04n	5. Envelope	Revises Section 5.5.4.4.1 to provide an exception to allow a user to take credit for overhangs towards compliance with the maximum solar heat gain coefficient (SHGC) requirements.	Provides a tradeoff with no savings.
90.1-04y	5. Envelope	Adds a reference and method of testing for deriving the solar reflectance index (SRI) American Society for Testing Materials (ASTM) Test Method E, 1980 (ASTM 2001)) for high albedo roofs. The changes are in both Section 5 and Appendix G.	Adds testing method only.
90.1-04ad	5. Envelope	Changes the exception to Section 5.3.1.1 to add a requirement that the values for solar reflectance and thermal emittance be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the Cool Roof Rating Council.	Adds testing service accreditation only.
90.1-04aj	5. Envelope	Modifies the exception to Section 5.5.3.1 by adding the ASTM Test	Adds testing method only.

90.1 Addendum	90.1 Chapter Affected	Description	Why No Energy Savings Were Identified
		Method E1980 (ASTM 2001).	
90.1-04av	5. Envelope	Adds an exception to Section 5.5.4.4.1 to allow credit for overhangs toward compliance with the maximum SHGC requirements.	Provides a tradeoff with no savings.
90.1-07bc	5. Envelope	Clarifies that the minimum skylight areas of addendum al also apply to unconditioned spaces.	Clarifies rules only.
90.1-07cl	5. Envelope	Clarifies how to interpret the use of dynamic glazing products that are designed to be able to vary a performance property such as SHGC, rather than having just a single value.	Clarifies rules only.
90.1-04t	6. HVAC	Changes Table 6.8.1F to add an additional requirement of combustion efficiency to the current requirement of thermal efficiency for boilers. The reference in Section 12 has also been changed to reflect the change in the table.	Doesn't change energy efficiency, just adds an additional equivalent requirement.
90.1-04ak	6. HVAC	Changes Table 6.2.1G to add requirements for cooling towers to be tested to Cooling Tower Institute (CTI) test procedures and to updates the corresponding references in Section 6.2.1.	Updates test procedure reference only.
90.1-07a	6. HVAC	Clarifies that Table 6.8.1.G applies to open cooling towers and not closed circuit cooling towers.	Clarifies rules only.
90.1-07b	6. HVAC	Changes exceptions, allowing simultaneous heating and cooling up to a limit set by the minimum outdoor air ventilation rate required by standards other than ASHRAE 62.	May cause modest increased energy use for optional exception.
90.1-07c	6. HVAC	Adds vivarium to the list of spaces where specific humidity levels are required to satisfy process needs, thus allowing those spaces an exemption from the simultaneous heating and cooling for dehumidification prohibition.	May cause modest increased energy use for a specialized application for a space type not captured in the prototypes.
90.1-07j	6. HVAC	Updates mechanical test procedures and references.	Changes normative reference only.
90.1-07k	6. HVAC	Clarifies warm air furnace and water heater references.	Clarifies rules only.
90.1-07l	6. HVAC	Efficiency requirements added for closed circuit cooling towers.	Only codifies standard practice.
90.1-07p	6. HVAC	Added pressure drop allowances for laboratory exhaust fans.	No prototypes have laboratory systems.
90.1-07s	6. HVAC	Updates the COP at 17°F efficiency levels for commercial heat pumps and introduces a new part-load energy efficiency descriptor for all commercial unitary products above 65,000 Btu/h of cooling capacity	The IEER and COP at 17°F levels in Tables 6.8.1A and 6.8.1B were derived based on the already expected performance of commercial unitary products meeting the new full-load EER and COP at 47°F requirements that took effect on January 1, 2010.

90.1 Addendum	90.1 Chapter Affected	Description	Why No Energy Savings Were Identified
90.1-07t	6. HVAC	Clarifies use of “standard” and “non-standard” PTACs.	Replacement exemption clarified to apply only to nonstandard sleeve size.
90.1-07v	6. HVAC	Adds requirement to calculate pump head according to ANSI/ASHRAE/ACCA Standard 183 (ANSI/ASHRAE/ACCA 2007).	Codifies standard calculation procedure.
90.1-07ad	6. HVAC	Adds a new testing procedure reference for liquid-to-liquid heat exchangers.	Adds testing method only.
90.1-07ao	6. HVAC	Modifies Table 6.8.1E (furnaces and unit heaters) to fix known errata and reorganizes table.	Fixes error and provides clarification.
90.1-07at	6. HVAC	Clarifies and cleans up of damper section.	Clarifies rules only.
90.1-07au	6. HVAC	Updates efficiency tradeoff table for eliminating economizers.	Provides tradeoff only, no savings.
90.1-07ba	6. HVAC	Allow non-metallic pipe to use a system performance option instead of minimum insulation level.	May increase energy use, but negligible impact and application not in prototypes.
90.1-07cp	6. HVAC	Establishes, for the first time in ASHRAE90.1, efficiency requirements for variable refrigerant flow air conditioners and heat pumps.	Codifies current practice.
90.1-07bd	8. Power	Exempts feeder conductors serving emergency circuits from voltage drop requirements.	Corrects error that affects safety.
90.1-07bk	8. Power	Clarifies motor efficiency requirements.	Clarifies rules only.
90.1-04e	9. Lighting	Recognizes that track and bus way type lighting systems can be limited by circuit breakers and permanently installed current limiters in Section 9.1.4.	May increase energy use but negligibly.
90.1-04i	9. Lighting	Adds language to Section 9.1.4(b) that allows additional flexibility in assigning wattage to luminaires with multi-level ballasts where other luminaire components would restrict lamp size.	May increase energy use but negligibly.
90.1-04j	9. Lighting	In Section 9.4.1.3 allows additional flexibility in complying with the controls requirements by allowing additional combinations of commonly available control equipment.	Primarily a clarification to allow commonly available alternative.
90.1-04m	9. Lighting	Revises the exception to Section 9.2.2.3 to provide an option for compliance that exempts the commonly used furniture mounted track lighting if it incorporates automatic shut-off.	May increase energy use but negligibly, since these are not usually part of the design documents and exemption may not affect regulated lighting allowance.
90.1-04p	9. Lighting	Modifies Exception (g) to Section 9.2.2.3 to allow for increased lighting for medical- and age-related issues in addition to visual impairment.	Addresses safety and usability; may result in modest energy increase.

90.1 Addendum	90.1 Chapter Affected	Description	Why No Energy Savings Were Identified
90.1-04aa	9. Lighting	Modifies Section 9.1 to clarify some lighting requirements.	Changes "current regulators" to "transformers" and "living units" to "dwelling units."
90.1-04ai	9. Lighting	Modifies the interior lighting power requirements for retail display lighting in Section 9.6.2.	Modifies display lighting classifications and not expected to change energy usage.
90.1-04ap	9. Lighting	Clarifies the intent of a "sales area" space in Table 9.6.1.	Clarifies that sales area can be in any building type.
90.1-07ac	9. Lighting	Adds incentives (increased LPD allowance) for lighting controls; allows actual used ballast factor for calculations when adjustable bf ballasts are used.	This addendum does not require the controls but only adds LPD allowance if controls are present. Therefore, if controls are already present, this is a net energy increase. SSPC 90.1 determined not to estimate savings or penalty.
90.1-07ar	9. Lighting	Clarifies exterior lighting power.	Clarifies rules only.
90.1-07ay	9. Lighting	Requires that lighting space types be divided by function regardless of partition walls.	May cause negligible increase in energy use not captured in the prototypes.
90.1-07az	9. Lighting	Requires functional testing for lighting controls.	No savings assumed for functional testing or commissioning.
90.1-07bp	9. Lighting	Allows auto on occupancy sensors for 50% of the lights instead of manual on when occupancy sensors are required (no savings since only option).	Provides a non-required option.
90.1-07ce	9. Lighting	Requires that all spaces (unless exempted) have multilevel control capability (also commonly known as bi-level switching).	Provides manual controls which are not counted for savings in PI.
90.1-07cn	9. Lighting	Adds controls incentives for occupancy sensor control of workstation-specific luminaires combined with dimming.	Provides trade-off only, no savings.
90.1-07cs	9. Lighting	Limits the space types where automatic receptacle control (addendum bs) is required.	Reduces application of addendum 90.1-07bs with negligible savings impact.
90.1-07dc	9. Lighting	Eliminates the requirement for tandem wiring for fluorescent fixtures with one or three lamps.	May result in minimal increase in energy not captured in prototypes.
90.1-07do	9. Lighting	Identifies required lighting system submittals.	Changes design documentation only.
90.1-07dr	9. Lighting	Removes the luminaire efficacy requirement for exterior building grounds lighting.	Removes now redundant requirement.

5.2 Addenda Implementation in Savings Analysis

Implementing the addenda for the PI follows the procedures outlined in Chapter 2 of this report. The procedures include developing model inputs, automatically inserting some requirements into the prototype models, running the simulations, and extracting and post-processing the results. This section focuses on explaining the addenda and their impact on energy savings, the modeling strategies and development of the simulation inputs for *EnergyPlus*. Each section describes one addendum or a group of related addenda that build on and adjust earlier addenda through the three-year Standard development cycle. Descriptions include identifying what is in the 2004 and/or 2007 standard and what is changed. The basis and supporting analysis used to develop model inputs are provided, as is information on the climate zones and prototypes affected. Any special issues in implementing the addenda in *EnergyPlus* are covered. Finally, in some cases other resources, such as published papers, are referenced for additional detail.

The PI analysis compares models of buildings that comply with 90.1-2004 with models that comply with 90.1-2010. The terminology "baseline" and "advanced" are used in some cases to describe the implementation of the addenda for the PI. The baseline is 90.1-2004. The advanced case is 90.1-2010. For addenda to 90.1-2007, the baseline is still considered 90.1-2004. In some cases, provisions are modified once from 90.1-2004 to 90.1-2007 and then are modified again from 90.1-2007 to 90.1-2010. For example, addendum q to 90.1-2007 builds on addendum c to 90.1-2004 on the topic of vestibules. In such cases, the 90.-2004 and 90.1-2007 addenda that coincide are described together in this report.

5.2.1 Building Envelope

The building envelope requirements change significantly between 90.1-2004 and 90.1-2007 for both opaque surfaces and fenestration, including a new classification system for types of windows. The changes also include enhancing the vestibule requirements. Addenda to 90.1-2007 include adjustments to a limited set of envelope performance values for metal buildings as well as provisions that impact infiltration, roof solar heat gain, and window area by wall orientation. Comprehensive changes to building envelope were included in addendum 90.1-07bb, which was not adopted because of controversy over some elements. An altered version of addendum bb is being considered as an amendment to 90.1-2010 for 90.1-2013.

5.2.1.1 Addenda 90.1-04c and 90.1-07q: Vestibules

Addendum 90.1-04c revises the 90.1-2004 definition of a "building entrance" and modifies Section 5.4.3.4, "Vestibules," when vestibules are required. Addendum 90.1-04c also explicitly requires that the exterior envelope of a conditioned vestibule comply with envelope requirements of a conditioned space and that the interior envelope of a vestibule comply with envelope requirements for semi-heated space.

Addendum 90.1-07q further modifies the vestibule requirements by changing the exceptions in Section 5.4.3.4 of 90.1-2007 by removing zone 4 from exception (e) and adding zone 4 to exception (f).

Under addendum 90.1-04c, the language regarding the envelope requirements for the outer wall of the vestibules and the adjoining wall between vestibule and interior building zone is more explicit than the language of 90.1-2004. However, this impact is not considered in the quantitative analysis because the impact is believed to be relatively minor. More significant are the treatment of the climate zones and building types for which vestibules would be required. Addendum 90.1-04c modifies Section 5.4.3.4 to require vestibules in many more building types. In particular, 90.1-2004 has an exception to vestibule requirements for buildings less than four stories in height. This exception is modified to apply only to buildings in climate zones 3 and 4 and then only to buildings smaller than 10,000 ft^2. An additional exception is provided for very small buildings (smaller than1,000 ft^2) in all climate zones.

The energy impacts of addendum 90.1-04c are modeled by first identifying which building prototypes are affected and in which climates. For this analysis, building types not affected by the vestibule requirement are given the same defined level of infiltration calculated for each building in the 90.1-2004 models. Baseline infiltration is developed using wind-driven models for exterior wall infiltration and an assumed air leakage rate of 1.8 cfm/ft^2 of exterior wall under a pressure differential of 0.30 in. water column (w.c.) (Gowri et al. 2009). In general, buildings considered not affected by addendum 90.1-04c are tall buildings having four or more stories.

The primary energy benefit of vestibules is to reduce infiltration in buildings during door openings. The infiltration rate for an open door is calculated for each building using a simplified method that takes into account design, wind speed, door area, and building height to a neutral pressure plan (used to estimate the stack effect driven air pressure on the door) of one half the building height and a multiplication coefficient that is a function of door opening frequency.

Peak infiltration rates are first defined on a per-unit door area for each prototype based on design day wind speeds of 15 mph, building height for each affected prototype, and average annual outdoor temperature and then are defined based on study data for different building types. In addition, reductions in peak infiltration rates using vestibules are derived for buildings with vestibules and automatic doors based on an ASHRAE research project study as a function of door opening frequency (Cho et al. 2010). Door opening frequency is estimated for a "peak period" and an off-peak period for each building prototype. The hours defined by peak door opening frequency are based on the building occupancy schedule and identification of hours where occupancy (as a proxy for door use) is significantly high compared with the low or no occupancy periods for each particular building type.

Table 5.4 shows the vestibule requirements for each prototype in each climate zone for 90.1-2004. Table 5.5 shows the same information for 90.1-2007 incorporated from addendum 90.1-04c. Addendum 90.1-07q modifies vestibule requirement exceptions in Section 5.4.3.4 of 90.1-2007. This modification removes zone 4 from exception (e) and adds zone 4 to exception (f). Table 5.6 shows the vestibule requirements for each prototype in each climate zone for 90.1-2010 with addendum 90.1-07q incorporated. The exceptions are described in PNNL publication (Cho et al. 2010), which also includes details on the analysis of infiltration, impact of vestibules and the modeling strategy for incorporating the addendum vestibule requirements into the 90.1-2010 models.

Table 5.4. 90.1-2004 Vestibule Requirements

Building Prototype	Zone 1	2	3	4	5	6	7	8
Small Office	No	No	No	No	No	No	No	No
Medium Office	No	No	No	No	No	No	No	No
Large Office	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Standalone Retail	No	No	No	No	No	No	No	No
Strip Mall	No	No	No	No	No	No	No	No
Primary School	No	No	No	No	No	No	No	No
Secondary School	No	No	No	No	No	No	No	No
Outpatient Healthcare	No	No	No	No	No	No	No	No
Hospital	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Small Hotel	No	No	No	No	No	No	No	No
Large Hotel	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Warehouse	No	No	No	No	No	No	No	No
Quick-service Restaurant	No	No	No	No	No	No	No	No
Full-service Restaurant	No	No	No	No	No	No	No	No
Mid-rise Apartment	No	No	No	No	No	No	No	No
High-rise Apartment	No	No	No	No	No	No	No	No

Table 5.5. 90.1-2007 Vestibule Requirements (with addendum 90.1-04c)

Building Prototype	Zone 1	2	3	4	5	6	7	8
Small Office	No	No	No	No	Yes	Yes	Yes	Yes
Medium Office	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Large Office	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Standalone Retail	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Strip Mall	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Primary School	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Secondary School	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Outpatient Healthcare	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Hospital	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Small Hotel	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Large Hotel	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Warehouse	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Quick-service Restaurant	No	No	No	No	Yes	Yes	Yes	Yes
Full-service Restaurant	No	No	No	No	Yes	Yes	Yes	Yes
Mid-rise Apartment	No	No	Yes	Yes	Yes	Yes	Yes	Yes
High-rise Apartment	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Table 5.6. 90.1-2010 Vestibule Requirements (with addendum 90.1-07q)

Building Prototype	Zone							
	1	2	3	4	5	6	7	8
Small Office	No	No	No	Yes	Yes	Yes	Yes	Yes
Medium Office	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Large Office	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Standalone Retail	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Strip Mall	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Primary School	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Secondary School	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Outpatient Healthcare	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Hospital	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Small Hotel	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Large Hotel	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Warehouse	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Quick-service Restaurant	No	No	No	Yes	Yes	Yes	Yes	Yes
Full-service Restaurant	No	No	No	Yes	Yes	Yes	Yes	Yes
Mid-rise Apartment	No	No	Yes	Yes	Yes	Yes	Yes	Yes
High-rise Apartment	No	No	Yes	Yes	Yes	Yes	Yes	Yes

5.2.1.2 Addendum 90.1-04as: Opaque Envelope Thermal Performance

90.1-2004 has specific envelope requirements, generally expressed in terms of maximum allowed U-factor for above ground opaque envelope components, including roofs, walls, opaque doors, and floors exposed to the ambient, maximum allowed C-factor for exterior below grade walls, and F-factors for slab-on-grade floors. These factors are defined for three distinct space type categories: nonresidential, residential, and semi-heated spaces. Addendum 90.1-04as modifies these requirements, increasing the stringency for many of them. Appendix E in this report includes tables of all of the opaque envelope thermal performance requirements for both 90.1-2004 and 90.1-2010 incorporating the changes from addendum 90.1-04as.

For modeling in *EnergyPlus*, the U-, C-, and F-factors corresponding to construction types and components defined in the prototype buildings (e.g., metal frame wall) are modified to reflect either the minimum requirements under 90.1 -2004 or 90.1-2007, as appropriate. The 90.1-2010 values match the 90.1-2007 values except for the metal building values changed by addendum 90.1-07g (Section 5.2.1.5 in this report).

5.2.1.3 Addendum 90.1-04at: Fenestration Requirements

90.1-2004 has requirements for fenestration SHGC and U-factor, including requirements for glass doors. As with the opaque envelope, these requirements are defined for three space type categories (nonresidential, residential, and semi-heated spaces) and by climate zone. The prescriptive requirements for windows are provided as a function of percentage of wall area that is glazed (here referred to as WWR in five WWR bins, up to a maximum of 50% WWR for vertical fenestration. WWR levels greater than 50% are not allowed in the prescriptive path; such buildings must use either the envelope tradeoff path found in Appendix C of Standard 90.1, or the performance path outlined in Standard 90.1, Chapter 11, "Energy Cost Budget Method," to show compliance with the standard.

U-factor requirements are provided for two types of vertical glazing, fixed and operable. In general, U-factors for a given type of vertical glazing are the same for all WWRs up to 40%. U-factor requirements for the 40.1% to 50% WWR bin are more stringent compared with the 30.1% to 40% WWR bin. This reduction in U-factor for the highest WWR bin was originally developed by the SSPC 90.1 Envelope Subcommittee using an energy tradeoff approach and was designed to provide roughly equal envelope energy impact for both 30.1% to 40% and 40.1% to 50% WWR bins.

SHGC requirements in 90.1-2004 are also provided by WWR bin, in general showing a reduction in allowed SHGC for higher WWR bins for nonresidential and residential space types. SHGC requirements do not exist for semi-heated space types. In addition, 90.1-2004 provides different, generally higher SHGC allowances for north-facing fenestration.

90.1-2004 also provides maximum U-factor and minimum SHGC requirements for skylights as a function of fraction of roof area that is glazed (up to a maximum of 5%).

Addendum 90.1-04at modifies the fenestration requirements in the following ways:

- Defines new types of vertical glazing: non-metal framing - all; metal framing - curtain wall/storefront; metal frame-entrance door; and metal framing-all other. These replace the previous operable and fixed vertical glazing categories.
- Limits the WWR ratio to 40% in the prescriptive path.
- Eliminates the variation in SHGC by WWR bin by defining requirements to be the same for vertical fenestration from 0% to 40% WWR.
- Defines U-factors for each of the four new vertical glazing types defined.
- Defines a single maximum SHGC allowance for all vertical glazing types up to 40% WWR for nonresidential and residential space types.

Taken in concert, these changes significantly alter vertical fenestration requirements between 90.1-2004 and 90.1-2007. A tabulated comparison of these differences in SHGC and U-factor by climate zone and space type is provided in Appendix E in this report. For most climate zones, U-factors are approximately equivalent to or somewhat reduced from the U-factors allowed by 90.1-2007. Maximum SHGC allowances move up or down depending on building WWR.

As described in Section 4.3 in this report, the prototype window performance values are developed by applying weighting factors for the different window types, fixed and operable for 90.1-2004, and nonmetal framing, metal frame - curtain wall/storefront; metal framing - all other. Metal frame: entrance door is not included in the weighting.

Regardless of the version of Standard 90.1, window requirements in the standard are defined by bulk properties of U-factor and SHGC. *EnergyPlus*, however, requires that the thermal/optical properties be defined for the window assembly layer by layer.

To analyze these changes, PNNL first establishes a method for selecting an actual window option, including framing that meet as closely as possible both the maximum U-factor and SHGC allowed for in 90.1-2004 or 90.1-2007. Glazing materials are selected to match the required assembly u-factor including framing. Assembly U-factor is used, and window frames are not modeled directly to reduce complexity in the *EnergyPlus* models and make the simulations run faster. The window performance is modeled for the entire glazed area. U-factor and SHGC values were treated as whole-assembly values. A total of 45 different combinations of U-factor, SHGC, and VLT are used from the *EnergyPlus* library. These combinations are developed into window constructions corresponding the 90.1-2004 or 90.1-2007 requirements and are included in a separate *EnergyPlus* construction library input file. The constructions are assigned in the model automatically through the parm structure described in Chapter 2 in this report. With this method, *EnergyPlus* window descriptions essentially meeting Standard 90.1 fenestration requirements, but reflecting windows with real window materials and glazing properties, are developed and used in the quantitative analysis.

The 90.1-2010 model values are the same as the 90.1-2007 and are incorporated in the 90.1-2010 models.

5.2.1.4 Addendum 90.1-07f: Cool Roofs

90.1-2004 and 90.1-2007 do not specify minimum reflectance or emittance requirements for roofs. Solar absorptance of 0.7 (solar reflectance of 0.3) and thermal emittance of 0.9 are used in the 90.1-2004 models representing typical roofing materials. Addendum 90.1-07f adds Section 5.5.3.1.2 to Standard 90.1 and establishes minimum requirements for solar reflectance and thermal emittance for certain types of roofs in climate zones 1 through 3.

Addendum 90.1-07f requires a minimum three-year-aged solar reflectance of 0.55 and a minimum three-year-aged thermal emittance of 0.75 for roofs in climate zones 1 through 3. The addendum includes exceptions for roofs having any one of the following properties:

- Ballasted roofs, vegetated roofs, and shaded roofs
- Steep sloped roofs (roofs with slopes greater than 2/12)
- Low-sloped metal building roofs in climate zones 2 and 3.
- Roofs over ventilated attics and over semi-heated spaces
- Metal building roofs in climate zones 2 and 3
- Asphaltic membranes in climate zones 2 and 3.

Exceptions apply to only four prototypes. The small office, quick-service restaurant, and full-service restaurant prototypes have steep sloped roofs and qualify for exception (2). The warehouse roof is over semi-heated space and is metal building construction so meets exceptions (4) and (5).

Current prototype models do not carry information to correctly account for exceptions (1) and (6). The modeling team approached the SSPC 90.1 Envelope Subcommittee (Envelope Subcommittee) to determine if certain prototypes needed to be excluded to account for the effect of ballasted roofs and asphaltic membranes. However, the Envelope Subcommittee could not reach consensus on this issue. Therefore, none of the prototypes have been exempted based on exceptions (1) and (6).

To implement addendum 90.1-07f into the 90.1-2010 models, the roof solar absorptance and roof emissivity of the topmost layer in the roof construction are changed. *EnergyPlus* uses solar absorptance as the input, which is one minus the solar reflectance value. The baseline models use an absorptance of 0.7 and emissivity of 0.9. The 90.1-2010 models use an absorptance of 0.45 (reflectance of 0.55) and an emissivity of 0.9. The emissivity for implementing the addendum is not lowered to the minimum allowed value of 0.75 since the baseline already has a value of 0.9. The addendum 90.1-07f values are applied to all prototypes only in climate zones 1 through 3 except those four prototypes that are exempt (small office, quick-service restaurant, full-service restaurant, and warehouse).

5.2.1.5 Addendum 90.1-07g: Opaque Envelope Performance for Metal Buildings

Addendum 90.1-07g updates the building envelope criteria for metal buildings in Section 5.5 and Appendix A of 90.1-2007. The updates from addendum 90.1-07g are included in the envelope tables provided in Appendix E in this report. The addendum changes at least some roof and exterior wall U-factor and insulation values for metal buildings in nearly all climates. The baseline requirements in 90.1-2004, and the same values which are in 90.1-2007, are also shown in Appendix E of this report.

The warehouse prototype is the only prototype that is a metal building. The changes resulting from addendum 90.1-07g apply in all climate zones. The 90.1-2010 models are modified with reduced assembly U-factor parameters to meet the new requirements. The office and fine storage areas in the warehouse are conditioned spaces, so the nonresidential envelope requirements criteria are applied to the models. The bulk storage area is a semi-heated space, and the semi-heated envelope requirements are applied in the models.

5.2.1.6 Addenda 90.1-07am and 90.1-07bf: Air Leakage

Addenda 90.1-07am and 90.1-07bf address air leakage through the building envelope. 90.1-2004 and 90.1- 2007, Section 5.4.3.1, require buildings to have continuous air barrier design, installation, materials, and assemblies. Section 5.4.3.2 of 90.1-2004 and 2007 specify that air leakage of fenestrations and doors shall be determined according to National Fenestration Rating Council (NFRC) 400 (NFRC 2004) and shall not be exceeded at the minimum requirements, described in Table 5.7 below.

Addendum 90.1-07am modifies building envelope component air leakage rate requirements in Section 5.4.3.2 to include additional options for air leakage testing for fenestration and doors, e.g., either AAMA/WDMA/CSA 101/I.S.2/A440 (AAMA/WDMA/CSA 2004) or NFRC 400 (NFRC 2004)for air leakage testing. Addendum 90.1-07bf modifies the language of the air barrier design requirement in Section 5.4.3.1.1 to include performance requirements for air leakage of the opaque envelope and to add and change acceptable materials and assemblies in Section 5.4.3.1.3. These addenda apply to all prototypes, and implementing the PI savings analysis for these addenda requires determining the whole building air leakage rates.

For the implementation of air barrier requirement, including addenda 90.1-07am and bf, the Envelope Subcommittee initially developed recommendations for baseline (i.e., 90.1-2004) and advanced (i.e., 90.1-2010) infiltration levels for building components, as shown in Table 5.7. These recommendations were provided for each opaque element of the envelope, such as walls, windows, and roofs. For each prototype, the total building infiltration rate is calculated by multiplying the component infiltration rate by the component area and summing the resulting values.

Table 5.7. Envelope Component Infiltration Rates

	Baseline Infiltration at 0.30 in. w.c. (cfm/ft^2)	Advanced Infiltration at 0.30 in. w.c. (cfm/ft^2)	Area Calculation Notes	Reference
Opaque Elements				
Roofs	0.12	0.04	Net opaque area of roof	Envelope Subcommittee
Above-Grade Walls	0.12	0.04	Net opaque area of above grade walls	Envelope Subcommittee
Below-Grade Walls	0.12	0.04	Net opaque area of below grade walls	Envelope Subcommittee
Floor	0.12	0.04	Net opaque area of floor over unconditioned space	Envelope Subcommittee
Floor	0.12	0.04	Net opaque area of slab	Envelope Subcommittee
Opaque Doors	0.40	0.20	Area of opaque doors	90.1, Section 5.4.3.2
Loading Dock Doors	0.40	0.20	Area of door, applicable only for warehouses	90.1, Section 5.4.3.2
Fenestration Elements				
Swinging or Revolving Glass Doors	1.00	1.00	Area of swinging or revolving glass doors	90.1, Section 5.4.3.2
Vestibule	1.00	1.00	Area of door	90.1, Section 5.4.3.2
Sliding Glass Doors	0.40	0.20	Area of sliding glass doors	90.1, Section 5.4.3.2
Windows	0.40	0.20	Area of windows	90.1, Section 5.4.3.2
Skylights	0.40	0.20	Area of skylights	90.1, Section 5.4.3.2
Total Component Infiltration Rate	Determined as the sum of the component infiltration rates. The individual component infiltration rates equal the infiltration rate per area times the component areas. The results are different for each prototype and for the baseline and advanced cases.			

The total infiltration for a building can be partially calculated by aggregating the component infiltration rates. Although the component infiltration rates specify the infiltration rate of the materials and components, leakage through interfaces between components and workmanship need to be accounted for in calculating the total building infiltration rate. The leakage and workmanship are called the construction quality adjustment (CQA).

The Envelope Subcommittee recommended using total building baseline 90.1-2004 infiltration rate of 1.8 cfm/ft^{2}at 0.3 in. w.c. of exterior above-grade envelope surface area, based on the average air tightness levels summarized in a National Institute of Science and Technology report (Emmerich et al. 2005).

The CQA is found by subtracting the total 90.1-2004 component infiltration rates from the assumed baseline infiltration rate of 1.8 cfm/ft^2. The CQA is different for each prototype building.

CQA = Baseline Total Building Infiltration Rate – (∑ baseline component infiltration rates)

Furthermore, the Envelope Subcommittee also recommended that the CQA calculated based on the baseline infiltration rate for each building be used to determine the total building infiltration rate for advanced requirements from addenda 90.1-07am and bf.

Advanced Total Building Infiltration Rate = CQA + (∑ advanced component infiltration rates)

This methodology shows that the reduction in infiltration level from addenda 90.1-07am and bf is relatively small compared with the reduction in practice when a good air barrier design is implemented. The analysis shows that the infiltration rate with the new requirements can be reduced from 1.8 cfm/ft^2 at 0.3 in. w.c. to an average of 1.7 cfm/ft^2 at the same pressure differential.

No definite requirement exists for the completed building envelope air leakage in 90.1-2010 and its predecessor standards. The Envelope Subcommittee recommended that a different value of 1.0 cfm/ft^2 at 0.3 in. w.c. be used as the whole building air leakage rate for the 90.1-2010 models. This implies a significant improvement in the construction quality in addition to reduced component infiltration. The following rationale was provided by the Envelope Subcommittee:

- The original air barrier proposal (addendum 90.1-07z) included an option of 0.40 cfm/ft^2 at 0.3 in. w.c. as the target whole building air leakage for the airtight building. This number was originally used for energy savings and scalar calculations for the air barrier proposal.
- The final version, addendum 90.1-07bf, does not have a whole building air-tightness option; therefore, the Envelope Subcommittee considered that taking the full credit for air leakage reduction (i.e., all the way to 0.40 cfm/ft^2 at 0.3 in. w.c.) would be unrealistic and too aggressive. Consequently, a more conservative target was selected.
- Addendum 90.1-07bf includes quantitative air leakage requirements for air barrier materials and air barrier assemblies, which are new requirements compared with 90.1-2007. In addition, addendum bf contains strong language on air barrier design and air barrier installation for continuity at critical interfaces and penetrations. Based on professional judgment, the Envelope Subcommittee members considered these requirements as sufficient to contribute to a significant air leakage reduction towards the 0.40 cfm/ft^2 target. The target of 0.4 cfm/ft^2 is 1.3 cfm/ft^2 below the 1.7 cfm/ft^2 baseline. The recommended value to use for the PI of 1.0 cfm/ft^2 at 0.3 in. w.c. is a reduction of 0.7 cfm/ft^2 below the 1.7 cfm/ft^2 baseline or about 55% of the 1.3 cfm/ft^2 total target reduction. Relative to the 1.8 cfm/ft^2 baseline, the corresponding reduction of 0.8 cfm/ft^2 is about a 60% reduction compared to the 1.3 cfm/ft^2 total target reduction.
- Establishment of this intermediate air leakage reduction is supported by the significant progress that the United States Army Corps of Engineers (USACE) achieved in the last two to three years to reduce infiltration. According to general contractor testimonials, this progress was largely the result of higher attention to details, already part of addendum bf. The study of USACE buildings (Zhivov 2010) shows that air leakage rate well below USACE standards of 0.25 cfm/ft^2 at 0.3 in. w.c. can be achieved, demonstrating that the recommended 1.0 cfm/ft^2 at 0.3 in. w.c. is a conservative value.

The changes in infiltration are implemented in *EnergyPlus* by changing the zone level infiltration inputs. Infiltration rates vary according to hourly schedules, which remain the same for the 90.1-2004 and

90.-2010 models. The total building infiltration schedule fraction is 1.0 when HVAC fans shut off and 0.25 when fans are on. See Appendix C in this report for infiltration schedules for the prototypes.

5.2.1.7 Addendum 90.1-07bn: Fenestration Orientation

90.1-2004 and 90.1-2007 do not specify requirements for orienting fenestration in a particular manner. Addendum 90.10bn adds Section 5.5.4.5 and attempts to limit poorly oriented fenestration. The addendum requires the total area of fenestration facing south to be greater than or equal to each of the total areas of fenestration facing east and west, governed by the area inequalities below.

$$A_s \geq A_w \text{ and } A_s \geq A_e$$

where,

A_s = the total fenestration area facing south (oriented no more than 45°of true south)
A_w = the total fenestration area facing west (oriented no more than 45° of true west)
A_e = is the total fenestration area facing east (oriented no more than 45° of true east).

Addendum 90.1-07bn provides an exception for east and west fenestration that is shaded by overhangs or fins for a certain period of the year. This exception is not implemented for two reasons: 1) the PI analysis generally does not include implementation of optional exceptions, and 2) none of the prototypes include east and west fins or overhangs.

All 16 prototypes are analyzed to determine if the conditions for the addendum were met. Only three prototypes do not satisfy the area conditions set by the addendum: warehouse, small hotel, and hospital. The application of addendum bn to these prototypes is discussed below.

Warehouse: The office is the only space in the warehouse prototype that does not meet the requirements of addendum bn. The office space area is very small compared with the total warehouse area. The impact of the addendum on the warehouse prototype is very small; therefore this space is assumed to be exempted from addendum bn. No changes are made to the warehouse prototype because of addendum bn.

Small Hotel: The small hotel prototype has its longer side along the north-south axis. The glazing cannot be reconfigured to meet the conditions of the area inequalities. The easiest way to apply addendum bn in this case is to rotate the building so the longer side is along the east-west axis. Accordingly, the small hotel prototype is rotated 90 degrees clockwise in the advanced case, thereby satisfying the area conditions.

Hospital: The hospital prototype does not satisfy the conditions of the area inequalities for the west facade. Similar to the small hotel prototype, the orientation of the hospital prototype is changed to comply with addendum bn. The hospital prototype is rotated 90 degrees counterclockwise in the advanced case, thereby satisfying the area conditions. Changing the building orientation for the advanced cases requires a change in the “North Axis” field of the “Building” object in *EnergyPlus*.

5.2.2 Heating, Ventilating and Air Conditioning

5.2.2.1 Addenda 90.1-04f and 90.1-04g: Unitary HVAC Equipment Efficiency

90.1-2004 Section 6.4.1.1 and its related tables include mandatory minimum efficiency values for HVAC equipment. Table 6.8.1 A applies to unitary air conditioners and condensing units. Table 6.8.1 B applies to unitary and applied heat pumps. Minimum efficiency values are provided for equipment with different cooling capacities and different manufacturing time periods.

Addendum 90.1-04f increases the efficiency values for unitary air conditioners and heat pumps under 65,000 Btu/h cooling capacity and manufactured on or after January 23, 2006. Table 5.8 shows the 90.1-2004 values and the amended values from addendum 90.1-04f for this size equipment manufactured on or after January 23, 2006. Table values not shown remain the same as in 90.1-2004.

Addendum 90.1-04g increases the efficiency values for equipment with cooling capacity of 65,000 Btu/h or larger when manufactured on or after January 1, 2010. Tables 5.9 and 5.10 show the 90.1-2004 values and the amended values from addendum 90.1-04g for unitary air conditioners and heat pumps manufactured on or after January 1, 2010. Table values not shown remain the same as in 90.1-2004.

Table 5.8. Unitary HVAC Equipment Efficiency (<65,000 Btu/h)

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	90.1-2004 Minimum Efficiency as of 1/23/2006	Addendum 90.1-04f Minimum Efficiency as of 1/23/2006
Air Conditioners Air Cooled	<65,000 Btu/h	All	Split System	12.0 SEER	13.0 SEER
			Single Package	12.0 SEER	13.0 SEER
Heat Pumps, Air Cooled (cooling mode)	<65,000 Btu/h	All	Split System	12.0 SEER	13.0 SEER
			Single Package	12.0 SEER	13.0 SEER
Heat Pumps, Air Cooled (heating mode)	<65,000 Btu/h (cooling capacity)	All	Split System	7.4 HSPF[a]	7.7 HSPF
			Single Package	7.4 HSPF	7.7 HSPF

(a) HSPF – heating seasonal performance factor.

Table 5.9. Unitary Air Conditioner Efficiency (≥65,000 Btu/h)

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	90.1-2004 Minimum Efficiency as of 1/1/2010	Addendum 90.1-04g Minimum Efficiency as of 1/1/2010
Air Conditioners, Air Cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	10.3 EER	11.2 EER
		All other	Split System and Single Package	10.1 EER	11.0 EER
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.7 EER	11.0 EER
		All Other	Split System and Single Package	9.5 EER	10.8 EER
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.5 EER 9.7 IPLV	10.0 EER 9.7 IPLV
		All Other	Split System and Single Package	9.3 EER 9.5 IPLV	9.8 EER 9.7 IPLV
	≥760,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.2 EER 9.4 IPLV	9.7 EER 9.4 IPLV
		All Other	Split System and Single Package	9.0 EER 9.2 IPLV	9.5 EER 9.2 IPLV

Table 5.10. Unitary Heat Pump Efficiency (≥65,000 Btu/h)

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	90.1-2004 Minimum Efficiency as of 1/1/2010	Addendum 90.1-04g Minimum Efficiency as of 1/1/2010
Air Cooled (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	10.1 EER	11.0 EER
		All Other		9.9 EER	11.0 EER
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.3 EER	11.0 EER
		All Other		9.1 EER	10.8 EER
	≥240,000 Btu/h	Electric Resistance (or none)	Split System and Single Package	9.0 EER 9.2 IPLV	10.0 EER 9.2 IPLV
		All Other		8.8 EER 9.0 IPLV	9.8 EER 9.0 IPLV
Air Cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)		47°F db/43°F wb Outdoor Air	3.2 COP	3.3 COP
			17°F db/15°F wb Outdoor Air	2.2 COP	2.2 COP
Air Cooled (heating mode)	≥135,000 Btu/h (cooling capacity)		47°F db/43°F wb Outdoor Air	3.1 COP	3.2 COP
			17°F db/15°F wb Outdoor Air	2.0 COP	2.0 COP

The changes are implemented in the analysis by modifying a script routine that extracts the equipment cooling capacity and assigns the corresponding equipment efficiency based on that capacity. Therefore, for the 90.1-2010 models, the higher efficiency values are applied for the applicable unit type and capacity. This affects the HVAC units in prototypes with unitary HVAC equipment, including the small office, medium office, standalone retail, strip mall, primary school, outpatient healthcare, small hotel, warehouse, quick-service restaurant, full-service restaurant, and mid-rise apartment.

5.2.2.2 Addendum 90.1-04q: Off-Hour Controls for Hotels and Motels

90.1-2004 has requirements for off-hour controls (e.g., thermostat setback) for most conditioned building spaces. An exception is provided for HVAC systems serving motel and hotel guestrooms. This original exception is based largely on the premise that such systems are not cost effective because hotel and motel guestrooms are under control of the occupant and a controller cannot be set up without prior knowledge of when a space would be unoccupied. Addendum 90.1-04q removes this exception, because controls specific to hotel/motel applications are now available that can be used to indicate when rooms are unoccupied (considered off-hour) and thus control certain HVAC functions, including thermostat setpoint.

To model the effect of addendum 90.1-04q on hotels and motels, the occupied guestroom heating and cooling thermostat setpoints are modified from a constant 70°F indoor setpoint condition to a setpoint schedule of 66°F for heating and 74°F for cooling from 9 am to 4 pm each day. This assumption is based on a similar analysis that PNNL conducted in support of the *Advanced Energy esign Guide for Highway Lodging* (Jiang et al. 2008)

5.2.2.3 Addendum 90.1-04s: Ventilation Outdoor Air Requirements

Chapter 12 ("Normative References") of 90.1-2004 has a normative reference to Standard 62-1999, *Ventilation for Acceptable Indoor Air Quality* (Standard 62-1999). 90.1-2004 also includes in Section 6.4.3.8, on ventilation controls for high occupancy areas a general requirement that ventilation controls be in compliance with Standard 62, as well as specifically referencing the ventilation standard and including language that is consistent with controls and other requirements of that standard.

Addendum 90.1-04s updates the ventilation standard to Standard 62.1-2004. The addendum also changes the text in Section 6.4.3.8 to refer to Standard 62.1-2004. Addendum 90.1-07ck (Section 5.2.2.21 in this report) updates Chapter 12 for 90.1-2010 to Standard 62.1-2007 which has identical requirements as 62.1-2004 as applied to the prototype models. Addendum 90.1-04s affects all prototypes in all climate zones.

Minimum outdoor air ventilation rates determined from Standard 62-1999 are generally larger than rates determined under 62.1-2004. 90.1-2004 models use outdoor rates calculated from Standard 62-1999. 90.1-2010 models use outdoor air ventilation rates as required by 62.1-2007 (equivalent to 62.1-2004). Chapter 4, Table 4.14 in this report provides the ventilation rates for both versions of the ventilation standard. Outdoor air rates are modeled by changing zone level outdoor air inputs in most cases.

For multi-zone HVAC systems affected by addendum 90.1-07ck (Section 5.2.2.21 in this report), system outdoor air is calculated for the baseline and advanced models using the multi-zone system requirements in Standard 62-1999 and 62.1-2007 respectively which start from the zone level minimum outdoor air requirements corresponding to these Standards.

5.2.2.4 Addendum 90.1-04v: Demand Control Ventilation

90.1-2004 has specific ventilation requirements for high-occupancy areas that require a method to automatically reduce the ventilation rates when spaces are partially occupied (Section 6.4.3.8, "Ventilation Controls for High Occupancy Areas"). High-occupancy areas for which these requirements apply are spaces with design occupancy of greater than 100 persons per 1000 ft^2 floor area served by systems with more than 3000 cfm of design outdoor airflow.

Addendum 90.1-04v modifies the provisions of Standard 90.1 Section 6.4.3.9 by expanding the criteria for requiring DCV. The addendum changes the minimum size threshold for the spaces so that it applies to spaces larger than 500 ft^2 and lowers the design occupancy density threshold from 100 persons per 1000 ft^2 to 40 persons per 1000 ft^2 of floor area.

The impact of this addendum is analyzed by first identifying buildings prototypes with spaces that would be qualified as the high-occupancy areas defined in addendum 90.1-04v. High-occupancy spaces are identified in three prototypes: primary school, secondary school, and large hotel.

For the primary and secondary schools, DCV controllers are implemented in the 90.1-2010 models for the cafeteria spaces. For the secondary school, the auditorium space already fell under the DCV requirements in 90.1-2004 and is modeled with this control in both 90.1-2004 and 90.1-2010. For the large hotel prototype, DCV controllers are implemented in the following zones: first floor cafeteria, sixth floor banquet room, and sixth floor dining room.

DCV is implemented in *EnergyPlus* by modifying the minimum outdoor air schedule from a fixed schedule to a controller-based schedule with the minimum outdoor air rate as required by Standard 62.1.

5.2.2.5 Addendum 90.1-04ac: Fan Power Requirements

90.1-2004 Section 6.5.3 specifies maximum fan power allowances for HVAC systems with total fan power greater than 5 hp. Addendum 90.1-04ac strengthens fan power limitations for simple systems and expands coverage for many complex systems to properly address complex exhaust fan systems associated with hospitals and laboratories, spaces that could be treated as exempt in 90.1-2004. Fans for these systems are not explicitly covered in 90.1-2004 and could be considered as exempt due to the overlap between fan system design and health and safety impacts for these types of buildings.

Addendum 90.1-04ac changes the fan power allowance structure to be based on a continuous curve for allowed horsepower as a function of design fan air volume (the 90.1-2004 requirement had a step function in the allowed motor horsepower curve based on system airflow volume). The addendum also provides two distinct compliance path options. The first path is similar to 90.1-2004 in that it defines total allowable fan system nameplate motor horsepower based on system design air volume (with different curves provided for constant volume and variable volume systems). The second path defines the allowable fan system fan brake horsepower as a function of design fan volume and specific pressure drop adjustments for key system components. The second path allows higher fan power to be provided, but only where it is actually needed due to the presence of specific system components, such as fully ducted return and exhaust systems, high efficiency particulate filtration, air cleaners, and heat recovery devices. Because these components are widely used in hospitals and laboratories, the second path in essence provides a path that eliminates a need to exempt these applications.

The *EnergyPlus* program simulates fan power by considering three inputs: the design pressure drop through the fan, total fan efficiency, and motor efficiency. For modeling systems according to where the maximum fan power has been specified (as in Standard 90.1), a corresponding design pressure drop for each air system is calculated using the following equation:

$$\text{Design Pressure Drop} = (\text{brake horsepower} \times \text{fan efficiency} \times 6356)/\text{cfm}$$

where,

cfm	=	supply fan airflow as determined by *EnergyPlus* sizing runs
fan efficiency	=	65%, based on assumptions used by the SSPC 90.1 while developing fan power requirements for Standard 90.1
brake horsepower	=	allowed brake horsepower.

Once the brake horsepower is established for a fan system, the nameplate horsepower is calculated using a 10% oversizing factor (i.e., nameplate horsepower = brake horsepower × 1.1, as allowed under Standard 90.1). The nameplate motor horsepower is used in calculating the fan motor efficiency.

To implement this addendum, a rule set was established for determining fan system brake horsepower based on fan system type, system air volume, and the fan efficiency. This rule set is shown in Table 5.11 and is based on the following assumptions.

- Systems of 5.0 nameplate horsepower or smaller are not regulated by Section 6.5.3.1 which limits fan power in either 90.1-2004 or 90.1-2007.
- For the calculations, fan mechanical efficiency is set to 65%.
- Total static pressure for constant volume fan systems with airflow larger than 7,437 cfm is assumed to be 2.5 in. w.c. based on the analysis done to support the Small Retail Building AEDG (Liu et al. 2006). The 7,437 cfm at 2.5 in. w.c. total static pressure requires 4.5 brake horsepower or larger than 5 nameplate motor horsepower once motor efficiencies and safety factors have been accounted for.
- For CAV fan systems, if system air volume is larger than 7,437 cfm, then the fan power limitation is assumed to apply.
- For VAV systems, if the design air volume is larger than 4,648 cfm, the fan power limitation is assumed to apply, based on an assumption of 4 in. w.c. static pressure for small VAV systems.
- Unit heater total static pressure is equal to 0.2 in. w.c. and motor efficiency is assumed equal to 82.5%, based on review of manufacturers' catalog data. This assumption is applied to all sizes of unit heater.
- The PTAC, PTHP, and fan coil units (FCU) are assumed to have total static pressure of 1.33 in. w.c. based on fan motor efficiency being set to 0.8 in. w.c. This assumption reflects total fan power for this equipment and is based on fan power assumptions used in 90.1-2007. More information can

be found in Appendix G, "Performance Rating Method," for modeling fan systems for these types of equipment.

Table 5.11. Rules for Establishing Fan Power Inputs for PI Analysis

System	CFM Range	TSP in. w.c.	Fan Efficiency
Fan Power Limitation Rule for 90.1-2004			
CAV	< 7,437	2.50	0.65
VAV	< 4,648	4.00	0.65
CAV	≥ 7,437 and < 20,000	4.46	0.65
CAV	≥ 20,000	4.09	0.65
VAV	≥ 4,648 and < 20,000	6.32	0.65
VAV	≥ 20,000	5.58	0.65
Unit Heater	All	0.2	0.65
PTAC, PTHP, or FCUs	All	1.33	0.65
Fan Power Limitation Rule for Addendum 90.1-04ac			
CAV	< 7,437	2.50	0.65
VAV	< 4,648	4.00	0.65
CAV	≥ 7,437	4.09	0.65
VAV	≥ 4,648	5.58	0.65
Unit Heater	All	0.2	0.65
PTAC, PTHP, or FCUs	All	1.33	0.65

The last required input, motor efficiency, is taken directly from Table 10.8 in Standard 90.1- 2004 and reflects minimum federal efficiency standards, based on motor nameplate size and assuming enclosed motors operating at 1,800 rotations per minute (rpm).

5.2.2.6 Addendum 90.1-04an: Boiler Efficiency

Boiler efficiency minimum requirements are provided in Table 6.8.1F of 90.1-2004. This table is impacted by two addenda to that standard's addendum: 90.1-04an and 90.1-04t. Addendum 90.1-04t is described but does not affect the progress indicator result. Addendum 90.1-04an impacts savings and is implemented for the PI.

Addendum 90.1-04t modifies the baseline efficiency requirements for certain classes of boilers by adding a requirement for thermal efficiency. 90.1-2004 only includes minimum efficiency requirements for combustion efficiency. A DOE review of commercial boiler efficiency suggested that 75% thermal efficiency proposed by addenda 90.1-04t for boilers with a minimum 80% combustion efficiency would have no significant impact on products available or likely to become available in the market. No credit has been given for this addendum in the quantitative analysis (DOE 2010a).

Addendum 90.1-04an improves the thermal efficiency requirements for most classes of commercial boilers. The thermal efficiency improvements for gas boilers were effective in on March 2, 2010, within three years of the publication date of 90.1-2007, therefore the change in efficiency is included in the quantitative analysis.

The addendum does not address boilers under 300,000 Btu/h input capacity, which are covered as residential products. For boilers under 300,000 Btu/h capacity, the efficiency requirement is actually expressed in terms of AFUE but has been approximated as thermal efficiency for the *EnergyPlus* simulations. Because this efficiency did not change between different versions of Standard 90.1, this was considered to be a reasonable approximation for the quantitative analysis.

For boilers larger than 2,500,000 Btu/h capacity, the requirement in Standard 90.1 is expressed in terms of combustion efficiency. Combustion efficiency is converted to a thermal efficiency by assuming a 0.007% difference between combustion and thermal efficiency for boilers in this size range.

Six prototypes use commercial gas-fired hot water boilers for space heating: large office, large hotel, hospital, outpatient healthcare, primary school, and secondary school. None of the prototypes use steam or oil-fired boilers. For each building model in each climate simulated, the buildings boilers are sized using the design day sizing analysis, and the efficiency of boilers is determined for both 90.1-2004 and addendum 90.1-04an, as listed in Table 5.12 below. The 90.1-2010 values are the same as in 90.1-2007 (i.e., addendum 90.1-04an). Where multiple boilers exist in a prototype, the total heating capacity is first calculated using the *EnergyPlus* design day sizing run and is divided by the number of boilers prior to establishing the thermal efficiency of each boiler.

Table 5.12. Boiler Efficiency Used in PI Analysis

Gas Hot Water Boiler (input) Capacity	Thermal Efficiency Used in Prototype Simulation	
	90.1-2004	Addendum 90.1-04an
<300 kBtu/h	0.80[(a)]	0.80[(a)]
≥300 kBtu/h and <2,500 kBtu/h	0.75	0.80
>2,500 kBtu/h	0.793	0.813

(a) Based on 0.80 AFUE requirement

5.2.2.7 Addendum 90.1-04ao: Unit Heater Equipment

90.1-2004, Table 6.8.1E, sets minimum efficiency requirements for warm air heating equipment. Addendum 90.1-04ao adds a footnote (h) to Table 6.8.1E. The footnote requires that gas-fired and oil-fired warm air unit heaters include an interrupted or intermittent ignition device and have either power venting or an automatic flue damper. A vent damper is an acceptable alternative to a flue damper for unit heaters where combustion air is drawn from the conditioned space.

To analyze the energy savings impact of this addendum, the unit heaters in the 90.1-2004 baseline models are assumed to include 250-W pilot lights (850 Btu/h). This assumption is derived from engineering specifications and catalogs of the available commercial products. Addendum 90.1-04ao is applied to the warehouse prototype building, which uses gas-fired unit heaters in the bulk storage area. The number of unit heaters is determined based on typical unit heater sizes, design practice, and heating loads at design condition. The number of unit heaters in the warehouse models is listed in Table 5.13 for all 17 climate locations.

5.2.2.8 Addendum 90.1-04ar: Part Load Fan Power Limitation

90.1-2004, Section 6.5.3.2.1 on fan part load power limitations requires that individual VAV fan systems with motors 15 hp or larger will either (a) be driven by a mechanical or electrical variable-speed drive, (b) be a vane axial fan with variable pitch blades, or (c) have other controls or devices so the fan motor demand be no more than 30% of design wattage at 50% of design airflow rate

Table 5.13. Quantity of Unit Heaters in Warehouse Prototype

Location	Number of Heaters	Location	Number of Heaters	Location	Number of Heaters
1A Miami	7	3C San Francisco	8	5C Vancouver	13
1B Riyadh	9	4A Baltimore	20	6A Burlington	19
2A Houston	12	4B Albuquerque	15	6B Helena	26
2B Phoenix	7	4C Salem	12	7 Duluth	19
3A Memphis	16	5A Chicago	20	8 Fairbanks	21
3B El Paso	9	5B Boise	19		

when the static pressure setpoint equals one third of total design static pressure, based on manufacturer's certified fan data. This requirement provides two prescriptive design options and one performance option to provide for acceptably low fan part-load fan power for VAV fan systems.

Addendum 90.1-04ar reduces the fan motor size threshold in Section 6.5.3.2.1 from 15 hp to 10 hp, increasing the number of VAV fan systems that would have to meet one or another of the three prescribed options. This addendum is incorporated into the simulation routines by first calculating a total fan air volume for any VAV system based on design day sizing, then calculating a brake horsepower requirement for that fan system using the methodology discussed previously under addendum 90.1-04ac, and then using the required motor efficiency to calculate a motor input power in watts. Motors with input power thresholds under 7,378 W (equivalent to 9.9 hp of electrical power input) are deemed equivalent to less than 15 hp nameplate horsepower given nominal motor sizes available in this size range (7.5, 10, 15, and 20 hp). Motors with input power thresholds of less than 5,626 W (equivalent to 7.54 hp of electrical power input) are deemed equivalent to less than 10 hp nameplate horsepower given nominal motor sizes available. If the motor input power is less than 7,378 W in the 90.1-2004 models or less than 5,626 W in the addendum 90.1-04ar models, then VAV fan system part-load curve A is used in the *EnergyPlus* simulation, effectively representing a VAV fan controlled using outlet dampers only. For motor input power at or above these thresholds, VAV fan system part-load curve B is used in the *EnergyPlus* simulation, representative of a fan system curve complying with Option C of Section 6.5.3.2.1.

EnergyPlus uses a fourth order polynomial curve, which gives the part load fraction (PLF), the fraction of full load power of the supply fan as a function of flow fraction (FF), which is the air mass flow rate divided by the maximum air mass flow rate (design maximum). The curve is of the form:

$$PLF= C_1 + C_2 \times FF + C_3 \times FF^2 + C_4 \times FF^3 + C_5 \text{ x } FF^4$$

Table 5.14 shows the coefficients C_1 through C_5 for both VAV fan performance curve A and fan performance curve B.

Table 5.14. Fan Performance Curves

Coefficients	C_1	C_2	C_3	C_4	C_5
Curve A	0.18984763	0.31447014	0.49568211	0	0
Curve B	0.0408	0.0880	-0.0729	0.9437	0

The implementation to capture the impact of addendum 90.1-04ar is made in the modeling scripts. Only the primary school has some VAV systems with fan power of between 10 hp and 15 hp in the 90.1-2004 models in some climate zones; therefore addendum 90.1-04ar only affects the primary school.

5.2.2.9 Addendum 90.1-07e and 90.1-07dj: Exhaust Air Energy Recovery

90.1-2004 and 90.1-2007 7 require that exhaust air energy recovery ventilator (ERV) be used if a fan system meets the following two criteria:

- The design supply air capacity is 5,000 cfm or larger
- The design minimum outdoor air supply is 70% or more of the design supply air.

Addendum 90.1-07e greatly expands the scope of requirements for energy recovery by establishing a range of values for systems, in some cases lowering the thresholds for design supply air capacity with lower ratios of outdoor air varying by climate zone. The expanded energy recovery requirements in addendum 90.1-07e depend on the design supply airflow, climate zone, and the outdoor air fraction at design supply airflow rate, as shown in Table 5.15. Addendum 90.1-07dj sets limits on the pressure drop allowed through energy recovery devices.

Based on the system sizing information from the *EnergyPlus* simulation, each air system of all 16 building prototypes in all 17 climate locations is checked against the values in Table 5.15 below to determine whether energy recovery is applicable. Table 5.16 shows which HVAC systems in the affected prototypes are required to included energy recovery ventilators.

Table 5.15. Energy Recovery Requirements by Climate Zone and Outdoor Air Fraction

	Outdoor Air Fraction at Design Air Flow Rate					
	30-40%	40-50%	50-60%	60-70%	70-80%	≥80%
Climate zone	Design Supply Fan Airflow Rate (cfm)					
3B, 3C, 4B, 4C, 5B	NR[(a)]	NR	NR	NR	≥5,000	≥5,000
1B, 2B, 5C	NR	NR	≥26,000	≥12,000	≥5,000	≥4,000
6B	≥11,000	≥5,500	≥4,500	≥3,500	≥2,500	≥1,500
1A, 2A, 3A, 4A, 5A, 6A	≥5,500	≥4,500	≥3,500	≥2,000	≥1,000	≥0
7, 8	≥2,500	≥1,000	≥0	≥0	≥0	≥0

(a) NR –not required

The modeled energy recovery effectiveness is listed in Table 5.17, as suggested by the 90.1 SWG. The implemented effectiveness values are higher than the minimum requirement of 50% recovery effectiveness in Standard 90.1, mainly because, in practice, the energy recovery wheels are the most commonly used technology to comply with this requirement and ERV wheels can achieve much higher effectiveness than the values in Table 5.17. Therefore, the modeled effectiveness values are reasonable to capture the savings from addendum 90.1-07e.

The fan energy associated with energy recovery is modeled as the wheel parasitic power. This is a work-around solution in *EnergyPlus* because fan energy for ERV is not an input of the ERV module and the ERV fan energy cannot simply be added to the system supply fan since the ERV may be bypassed when energy recovery does not save energy. Modeled as parasitic power, ERV fan energy occurs only when the ERV runs, which is the desired behavior. The ERV fan energy is calculated from the following assumptions:

- ERV pressure drop of on the outdoor air side is 0.65 in. w.c.
- ERV pressure drop on the exhaust air side is 0.65 in. w.c.
- Additional pressure drop due to filter on the outdoor air side is 0.20 in. w.c.
- Total fan efficiency (fan efficiency and motor efficiency) is 50%
- Exhaust airflow is 90% of outdoor airflow after considering leakage and zone exhaust.

ERV running status depends on the air economizer status: ERVs turn off when the air economizer is on; ERVs turns on when air economizer is off due to economizer high-limit shutoff control or other economizer constraints, such as minimum outdoor air temperature. ERVs are bypassed for both the supply and the exhaust air whenever it is off.

Supply air bypass is the strategy used in the simulation for ERV frost control. When the outdoor air temperature is below -10ºF, ERV control cycles off the supply airflow through the heat exchanger for a certain period of time while the exhaust air continues to flow through the exhaust side of the heat exchanger.

90.1-2004 and 90.1-2007 Section 6.5.3.1 sets the maximum system power allowed and includes pressure drop adjustments in Table 6.5.3.1.1B that can increase the standard maximum fan power limitation. In this section 90.1-2004 and 90.1-2007 allow the energy recovery device pressure drop at design conditions to be used as the adjustment and do not set any limit on the pressure drop of energy recovery devices. Addendum 90.1-07dj restricts the fan power limit pressure drop adjustment for energy recovery devices in Table 6.5.3.1.1B to the following values:

- For coil runaround loop, the pressure drop limitation is 0.6 in. w.c. for each air stream.
- For energy recovery devices other than coil runaround loop, the pressure drop limitation for each air stream is given by Equation: (2.2 x Energy Recovery Effectiveness) – 0.5 in. w.c.

Enthalpy wheels are used in all those air systems that have energy recovery devices. In the simulation work for addendum e to 90.1-2007, it is assumed that (1) the energy recovery effectiveness is 0.6; and (2) the pressure drop on each air stream is 0.65 in. w.c. This assumption satisfies addendum dj, which requires the maximum pressure drop for each airstream to be 2.2 * 0.6—0.5 = 0.82 in. w.c.

Table 5.16. HVAC Systems Required to Have Energy Recovery

Climate Location	Building prototypes					
	Large Office	Hospital	Primary School[(a)]	Secondary School[(b)]	Standalone Retail	Large Hotel
1A Miami	CAV_base	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	None	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS
1B Riyadh	CAV_base	None	None	PSZ-AC:3:7, PSZ-AC:5:9	None	None
2A Houston	CAV_base	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:2	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS
2B Phoenix	None	None	None	VAV_Pod_1, VAV_Pod_2, PSZ-AC:3:7, PSZ-AC:5:9	None	None
3A Memphis	CAV_base	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:2	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS
3B El Paso	None	None	None	PSZ-AC:3:7, PSZ-AC:5:9	None	None
3C San Francisco	None	None	None	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC:3:7, PSZ-AC:5:9	None	None
4A Baltimore	CAV_base	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:2	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS
4B Albuquerque	None	None	None	PSZ-AC:3:7, PSZ-AC:5:9	None	None
4C Salem	None	None	None	VAV_Pod_1, VAV_Pod_2, PSZ-AC:3:7, PSZ-AC:5:9	None	None
5A Chicago	CAV_base	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:2	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS
5B Boise	None	None	None	PSZ-AC:3:7, PSZ-AC:5:9	None	None
5C Vancouver	None	None	None	PSZ-AC:3:7, PSZ-AC:5:9	None	VAV with Reheat,
6A Burlington	CAV_base	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:2	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS
6B Helena	CAV_base	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:3	VAV with Reheat,

Table 5.16 (cont'd)

Climate Location	Building prototypes					
	Large Office	**Hospital**	**Primary School[a]**	**Secondary School[b]**	**Standalone Retail**	**Large Hotel**
7 Duluth	CAV_bas	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:5, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:4	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS
8 Fairbanks	CAV_bas	VAV_ICU, VAV_PATRMS	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_2:5, PSZ-AC_2:7	VAV_Pod_1, VAV_Pod_2, VAV_Pod_3, PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC:3:7, PSZ-AC:5:9	PSZ-AC:5	VAV with Reheat, FLR_3_DOAS, FLR_6_DOAS

(a) ICU – intensive-care unit; PATRMS – Patient Rooms
(b) PZA-AZ –packaged single zone air conditioner; DOAS – dedicated outdoor air system; FLR – Floor

Table 5.17. Energy Recovery Effectiveness

	Energy Recovery Effectiveness	
Condition	Sensible	Latent
Heating @ 100% Airflow	0.70	0.60
Heating @ 75% Airflow	0.70	0.60
Cooling @ 100% Airflow	0.75	0.60
Cooling @ 75% Airflow	0.75	0.60

5.2.2.10 Addendum 90.1-07h: VAV Reheat Control

90.1-2004 and 90.1-2007 require zone thermostatic controls to prevent simultaneous operation of heating and cooling systems to the same zone. The requirement limits the amount of air that involves simultaneous heating and cooling. This is specified as zones for which the volume of air that is reheated, recooled, or mixed is no greater than the larger of the following:

- The volume of outdoor air required to meet the ventilation requirements of Section 6.2 of Standard 62-1999 for 90.1-2004 or 62.1-2004 for 90.1-2007 for the zone
- 0.4 cfm/ft^2 of the zone conditioned floor area
- 30% of the zone design peak supply rate
- 300 cfm—this exception is for zones whose peak flow rate totals no more than 10% of the total fan system flow rate
- Any higher rate that can be demonstrated, to the satisfaction of the authority having jurisdiction, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in outdoor air intake for the system.

Addendum h to 90.1-2007 contains two major changes in the clause to limit simultaneous heating and cooling:

- Delete exceptions (b) and (d) above.
- Add a new exception to the reheating and recooling limitation for meeting the following three requirements:
  - The volume of air that is reheated, recooled, or mixed in deadband between heating and cooling will not exceed the larger of the following: (a) 20% of the zone design peak supply rate; (b) the volume of outdoor air required to meet the ventilation requirements of Section 6.2 of ASHRAE Standard 62.1 for the zone; (c) any higher rate that can be demonstrated, to the satisfaction of the authority having jurisdiction, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in outdoor air intake
  - The volume of air that is reheated, recooled, or mixed in peak heating demand shall be less than 50% of the zone design peak supply rate.
  - Airflow between deadband and full heating or full cooling shall be modulated.

Because this addendum relates to VAV terminal box control, it impacts building prototypes with an air system serving multiple zones: large office, medium office, hospital, outpatient healthcare, large hotel, primary school, and secondary school.

This addendum is analyzed through *EnergyPlus* simulation with different terminal box control sequences. The single-maximum control sequence is assumed in the 90.1-2004 baseline models while the dual-maximum control sequence is assumed after applying addendum 90.1-07h. The working principles can be illustrated with Figures 5.2 and 5.3, respectively.

The single-maximum control sequence has only one maximum damper position for cooling. When the zone is in the deadband and heating modes, the damper stays at the minimum position. This minimum damper position is set as the higher value of 30% and the minimum position to meet the outdoor ventilation air requirement.

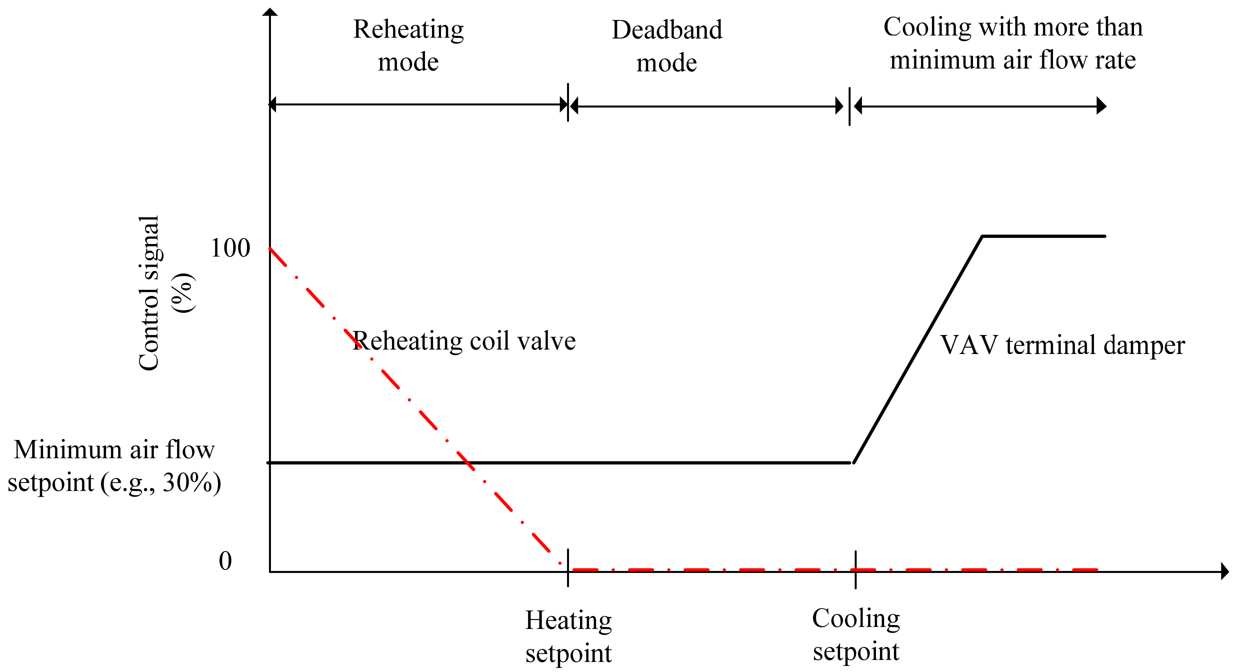

Figure 5.2. Single-maximum Terminal Box Control Sequence

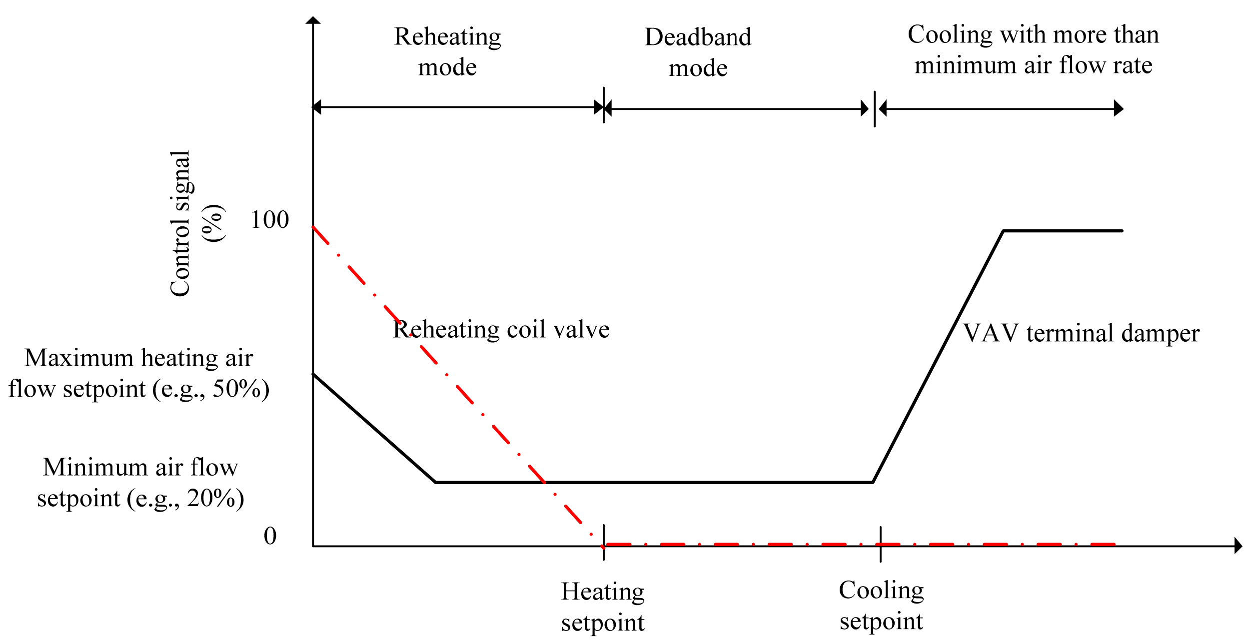

Figure 5.3. Dual-maximum Terminal Box Control Sequence

The dual-maximum control sequence has one maximum damper position for cooling and one for heating. When the zone is in the deadband mode, the damper stays at the minimum position, which is the higher value of 20% and the minimum position to meet the ventilation requirement. When the zone temperature falls below the heating setpoint and the zone mode changes to the heating mode, the reheating coil valve opens up increasingly while the damper position is still at the minimum position. With increasing heating load, the reheat coil valve can open up until the supply air temperature reaches the predefined maximum value. Then, the damper position increases up to the maximum heating airflow setpoint if more heat is needed for zone heating.

Addendum 90.1-07h may be affected by addendum 90.1-07ck, which may override the minimum damper position in some zones to satisfy Standard 62.1 multi-zone ventilation requirement.

5.2.2.11 Addendum 90.1-07m: Chiller Efficiency Improvements

The minimum efficiency requirements for air-cooled and water-cooled chillers are specified in 90.1 - 2004 and 90.1-2007 Section 6.4.1.2, Tables 6.8.1C, 6.8.1H, 6.8.1I, and 6.8.1J. While addendum 90.1-07m made several changes to these sections, only the changes that impact energy use are discussed here: the minimum efficiency requirements for all chillers, except absorption chillers, are revised; and an additional compliance path (Path B) is added for water-cooled chillers. Table 5.18 summarizes the efficiency changes for the types of chillers used in the prototypes.

Table 5.18. 90.1-2004 and 90.1-2010 Chiller Efficiencies

Equipment Type	Size Category	90.1-2004 Minimum Efficiency	90.1-2010 Path A Minimum Efficiency	90.1-2010 Path B Minimum Efficiency
Air Cooled	< 150 tons	9.562 EER and 10.416 IPLV	9.562 EER 12.500 IPLV	NA
	≥ 150 tons		9.562 EER 12.750 IPLV	NA
Water Cooled, Positive Displacement	< 75 tons	0.790 kW/ton and 0.676 IPLV	0.780 kW/ton and 0.630 IPLV	0.800 kW/ton and 0.600 IPLV
	≥ 75 tons and < 150 tons		0.775 kW/ton and 0.615 IPLV	0.790 kW/ton and 0.586 IPLV
	≥ 150 tons and < 300 tons	0.717 kW/ton and 0.627 IPLV	0.680 kW/ton and 0.580 IPLV	0.718 kW/ton and 0.540 IPLV
	≥ 300 tons	0.639 kW/ton and 0.571 IPLV	0.620 kW/ton and 0.540 IPLV	0.639 kW/ton and 0.490 IPLV
Water Cooled, Centrifugal	< 150 tons	0.703 kW/ton and 0.669 IPLV	0.634 kW/ton and 0.596 IPLV	0.639 kW/ton and 0.450 IPLV
	≥ 150 tons and < 300 tons	0.634 kW/ton and 0.596 IPLV		
	≥ 300 tons and < 600 tons	0.576 kW/ton and 0.549 IPLV	0.576 kW/ton and 0.549 IPLV	0.600 kW/ton and 0.400 IPLV
	≥ 600 tons		0.570 kW/ton and 0.539 IPLV	0.590 kW/ton and 0.400 IPLV

Because this addendum impacts prototypes with water chilling equipment, the large hotel, secondary school, large office, and hospital prototypes are affected. To quantify the energy savings from this addendum, credit is taken from applying only the full-load efficiency improvements as described below.

Air-Cooled Chillers:

The large hotel and secondary school prototypes have air-cooled chillers. The chillers are modeled using an *EnergyPlus* chiller model based on condenser entering condition. The efficiency improvement is implemented through the energy input ratio function of temperature (EIR-FT) curve.

Water-Cooled Chillers

The large office and hospital prototypes have water-cooled chillers. The type of water-cooled chiller used in simulation depends on capacity required. Screw chillers are used for cooling capacity of equal or less than 300 tons and centrifugal chillers are used for capacity greater than 300 tons. Two compliance paths are available for water-cooled chillers: Path A is intended for applications where significant operating time is expected at full-load conditions, whereas Path B is intended for applications where significant operating time is expected at part-load conditions. Therefore, Path B allows for better part-load performance but results in a small decrease in full-load efficiency due to losses inherent in variable speed drives.

Based on input from the 90.1 SWG, the large office prototype is assumed to follow Path B and the hospital prototype is assumed to follow Path A. Large office buildings typically operate at part-load chiller operation, which is more applicable to Path B. Hospitals operate continuously and tend to be dominated by internal loads so the chillers will operate at closer to full-load much of the time making Path A the better choice. The condenser leaving condition is used to define the *EnergyPlus* chiller model. The efficiency improvement is implemented through the EIR-FT curve.

5.2.2.12 Addendum 90.1-07n and 90.1-07ca: Single-Zone VAV

90.1-2004 and 90.1-2007 do not require HVAC systems serving a single zone to have fan speed control; a constant speed fan is allowed in a HVAC system that serves a single zone (single zone VAV).

Addendum 90.1-07n requires VAV fan control be used for single zone units above certain size thresholds. Depending on the cooling coil type, the addendum has the following requirements:

- For air-handling units with chilled-water cooling coils, if the supply fan motor power is 5 hp or larger, the fan is required to be controlled by a two-speed motor or a variable-speed drive. When the cooling demand is 50% or less than the unit's cooling capacity, the fan speed control must be able to reduce the airflow no greater than the larger of the following: (1) one half of the full fan speed or (2) the outdoor air volume required to meet the ventilation requirement by Standard 62.1. This requirement took effect on January 1, 2010.
- For air-handling units with DX cooling coils, if the DX cooling capacity at ARI rated conditions is 110,000 Btu/h or greater, the fan must be controlled by a two-speed motor or a variable-speed drive. When the cooling demand is 50% or less of the unit's capacity, the fan speed control should be able to reduce the airflow no greater than the larger of the following: (1) two-thirds of the full fan speed or (2) the outdoor air volume required to meet the ventilation requirement by Standard 62.1. This specification takes effect on January 1, 2012.

Addendum n does not specify the applicable fan power limitation (90.1-2010, Section 6.5.3.1) for single zone VAV systems. This could lead to the use of VAV system fan power limitation by mistake which has a higher limit compared to constant volume fan systems. To address this issue, Addendum 90.1-07ca clarifies that single zone VAV systems must comply with the constant volume fan power limitation.

Based on the system sizing information from *EnergyPlus* design day runs, each cooling system serving a single zone is checked against the cooling capacity (for DX cooling) or the supply fan motor power (for chilled water cooling) to determine whether or not single zone VAV requirements are applicable. Table 5.19 summarizes which air systems use single-zone VAV according to addendum 90.1-07n. During the process of determining the applicability of single-zone VAV, special attention is given to systems with high outdoor air demand for ventilation, such as the system serving the auditorium in the school prototypes and the kitchens in the restaurant prototypes. The high outdoor air demand may deactivate the use of single zone VAV even if the cooling capacity is above the threshold value.

No straightforward way exists to model single-zone VAV in the versions of *EnergyPlus* available during the PI analysis. A work-around solution is developed to approximate the control mechanism of single zone VAV. This solution involves replacing the single zone constant volume cooling system with a single zone VAV system. Major aspects modeling single-zone VAV systems include the following:

- The HVAC unit tries to find the highest supply air setpoint temperature that will satisfy the zone cooling load at the minimum supply airflow rate. If that setpoint temperature is less than the minimum set at 55°F, the temperature remains at the minimum, and the supply air flow rate is increased to meet the loads.
- VAV terminal units have a minimum airflow fraction set at the higher value of 0.67 and the minimum needed to meet ventilation requirements.
- The central heating coil is disabled while the terminal reheating coil is sized with sufficient capacity to meet the zone heating demand.

Addendum 90.1-07ca is also implemented. The supply fans for single zone VAV systems are sized to meet the constant volume fan power limitation.

Addendum 90.1-07n may be affected by addendum 90.1-07ax, which requires a certain amount of transfer air from adjacent spaces to a kitchen. When the space served by a single-zone VAV system provides transfer air, the transferred air volume could affect the minimum airflow turndown ratio of the single-zone VAV system.

5.2.2.13 Addendum 90.1-07u: Open-Circuit Cooling Tower Performance

90.1-2004 and 90.1-2007 Section 6.5.5 require cooling towers to meet the following performance criteria at standard rating conditions (95°F entering water, 85°F leaving water, and 75°F wb outdoor air):

- For propeller or axial fan cooling towers, the maximum flow rating of the tower divided by the fan nameplate rated motor power must be at least 38.2 gpm/hp.
- For centrifugal fan cooling towers, the maximum flow rating of the tower divided by the fan nameplate rated motor power must be at least 20.0 gpm/hp.

Table 5.19. HVAC Systems Subject to Single Zone VAV Requirement

	Building Prototype				
Climate/Location	**Standalone Retail**	**Strip Mall**	**Primary School**	**Secondary School**	**Full-service Restaurant**
1A Miami	PSZ-AC:1, PSZ-AC:2	PSZ-AC_1:1	PSZ-AC_2:5, PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
1B Riyadh	PSZ-AC:1, PSZ-AC:2	PSZ-AC_1:1	PSZ-AC_2:5, PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
2A Houston	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
2B Phoenix	PSZ-AC:2	PSZ-AC_1:1	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
3A Memphis	PSZ-AC:1, PSZ-AC:2	PSZ-AC_1:1	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
3B El Paso	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
3C San Francisco	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
4A Baltimore	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
4B Albuquerque	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
4C Salem	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
5A Chicago	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
5B Boise	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
5C Vancouver	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6, PSZ-AC_4:8	PSZ-AC_1:1
6A Burlington	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
6B Helena	PSZ-AC:2	None	PSZ-AC_1:6	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
7 Duluth	PSZ-AC:2	None	None	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1
8 Fairbanks	PSZ-AC:2	None	None	PSZ-AC_1:5, PSZ-AC_2:6	PSZ-AC_1:1

Addendum 90.1-07u requires that fans in centrifugal fan open-circuit cooling towers with rated capacity of 1,100 gpm or greater meet the more stringent performance requirement of axial fan open-circuit cooling towers (at least 38.2 gpm/hp).

Of the 16 building prototypes, large offices and hospitals use chilled water systems with cooling towers. PNNL assumed that centrifugal fan open-circuit cooling towers are used in large offices and hospitals. Therefore, these two building prototypes are affected by Addendum 90.1-07u.

This addendum was implemented through a Perl script, which automatically calculates the cooling tower fan power in the following procedure:

- Extract the design cooling tower water flow rate from an *EnergyPlus* design day run.
- Calculate the cooling tower fan brake horsepower. Assuming that the fan brake horsepower is 90% of the fan nameplate rated motor power, the fan brake horsepower is calculated using the following equation:

$$FanBHP = \frac{0.9 * WaterFlowRate}{FanPerformance}$$

where,

FanBHP = cooling tower fan brake horsepower

WaterFlow rate = cooling tower design water flow rate (gpm)

FanPerformance = the cooling tower design water flow rate divided by the fan nameplate rated motor power (gpm/hp). FanPerformance = 38.2 gpm/hp (WaterFlow rate larger than 1100 gpm).

- Determine the fan motor efficiency based on the fan brake horsepower. The motor efficiency is defined by the motor efficiency in Table 10.8A of Standard 90.1. In this step, the motor power is assumed to be at least 10% greater than the fan brake horsepower from the previous step.
- Calculate the fan motor power, which is equal to the fan brake horsepower divided by motor efficiency.
- Feed the fan motor power into the *EnergyPlus* cooling tower module.

The above implementation procedure also applies to the 90.1-2004 baseline models for large office and hospital prototypes. However, in the baseline implementation, the FanPerformance is assigned the value 20.0 gpm/hp, the minimum required in 90.1-2004.

5.2.2.14 Addenda 90.1-07af and 90.1-07cc: Chilled Water and Condenser Water Pipe Sizing

Addendum 90.1-07af introduces pipe sizing criteria in Section 6.5.4.5 of 90.1-2010, and. addendum 90.1-07cc fixes a mistake in 90.1-07af. The requirements only apply to chilled water and condenser water piping that affect the critical circuit, that is, the circuit that has the highest pressure drop required to satisfy its load. Each such piping segment is to be sized per the requirements in Table 6.5.4.5 in addenda 90.1-07af and 90.1-07cc. This table presents the maximum allowable flow per pipe section as a function of pipe size, annual hours of operation, and system flow and control.

The SSPC 90.1 Mechanical Subcommittee estimated that the average net piping pressure drop reduction due to addendum af and addendum cc is 83% compared with standard design practice. Table 5.20 summarizes the calculation provided by the subcommittee. The estimation in Table 5.20 is based on the following assumptions:

- For chilled water systems, pipe friction accounts for 70% of total system pressure drop.
- For condenser water systems, pipe friction accounts for 50% of total system pressure drop.
- The baseline column represents standard practice, based on 4.5 ft pressure drop/100 ft pipe and 12 feet per second.
- When standard practice without addenda 90.1-07af and cc is less than that with the addenda (2½" to 4" pipe size), designers will not increase flow based on the new requirements.
- Average velocity reduction for all pipe sizes is used for entire system reduction.
- All systems use the 2,000- to 4,400-hour-per-year category.
- Chilled water system pressure drop is 75 ft of head with a 65% combined pump and motor efficiency, based on Standard 90.1, Appendix G (22 W/gpm).
- Condenser water system pressure drop is 60 ft of head with a 60% combined pump and motor efficiency, based on Standard 90.1, Appendix G (19 W/gpm).
- $Head_2 = Head_1 \times (Flow_2/Flow_1)^{1.85}$ (pump affinity law adjusted due to decrease in the Fanning friction factor with increasing velocity).

Table 5.20. Piping Pressure Drop Reduction

	Addendum 90.1-07af and cc (90.1-2010)		Baseline (90.1-2004/2007)		
Operating Hours/Yr	>2,000 and ≤4,400 Hours/Year		All Hours/Year	% Reduction	
Nominal Pipe Size (in.)	Other	Variable Flow/ Variable Speed	Constant and Variable Speed/Variable Flow	Percentage of Base Flow Rate	Net Reduction
2 1/2	85	130	78	138%	100%
3	140	210	140	125%	100%
4	260	400	290	114%	100%
5	310	470	525	74%	74%
6	570	860	850	84%	84%
8	900	1,400	1,500	77%	77%
10	1,300	2,000	2,500	66%	66%
12	1,900	2,900	3,500	69%	69%
Maximum Velocity for Pipes Over 12 in. Size	6.5	9.5	10	80%	80%
Average Net Reduction for Average System					83%

When the average piping pressure drop of 83% is applied to a chilled water system, the modeled total system pressure drop is 75 ft for the 90.-2004 baseline models and 59.9 ft for the 90.1-2010 models. When the 83% is applied to the condenser water system, the total system pressure drop is 60 ft for the baseline model and 49.7 ft for 90.1-2010 models. The energy savings impact is shown in five prototype buildings: large office, hospital, secondary school, large hotel, and high-rise apartment.

5.2.2.15 Addendum 90.1-07ak: Hydronic Variable Flow Control

The energy savings from addendum 90.1-07ak primarily results from three changes as below:

- Modifies Section 6.5.4.1 in 90.1-2007 by lowering the variable flow threshold for individual chilled water pumps from 50 hp to 5 hp and requires that variable flow be controlled through differential pressure setpoint reset.
- Adds water-cooled air conditioners to systems requiring isolation valves.
- Adds a VFD pumping requirement to hydronic heat pumps and water-cooled air conditioners having total pump system power exceeding 5 hp.

Chilled water pumping systems are used in four prototype buildings: large office, secondary school, large hotel, and hospital. The primary-secondary chilled water pump systems are modeled in these four prototypes to reflect common practices. The primary pumps are modeled as constant flow pumps, and the secondary pumps are modeled as variable flow pumps. 90.1-2004 and 90.1-2007, Section 6.5.4, include the requirement that HVAC pumping systems having a total pump system power exceeding 10 hp to be designed with variable fluid flow. The baseline 90.1-2004 models and 90.1-2010 models for the four relevant prototypes all exceed the 10 hp limit.

Section 6.5.4.1 of 90.1-2004 and 90.1-2007 require individual pumps having a pump head exceeding 100 ft and motor exceeding 50 hp to have controls and/or devices to achieve variable flow control (such as variable-speed drives). Addendum 90.1-07ak requires pumping systems with variable flow control to have differential pressure reset. The energy savings impact of addendum 90.1-07ak is modeled by specifying different model inputs for the secondary pump to meet the differential pressure setpoint reset requirement. This requirement is implemented for chilled water systems for all four of the prototypes identified as subject to this addendum.

Hydronic heat pumps are used in high-rise apartments only, and no water-cooled air conditioner is used in any prototype buildings. Because the total pump system power and individual pump power for the heat pump system in the high-rise apartment models in all climate locations are less than the thresholds specified by 90.1-2004, -2007 and -2010, a primary-only water loop system with constant speed pump is used for both baseline and 2010 models.

EnergyPlus models variable-speed pumps using a part-load performance curve. The fraction of full load power, *FractionFullLoadPower,* is determined by the cubic equation:

$$\text{FractionFullLoadPower} = C_1+C_2\text{PLR} +C_3\text{PLR}^2 +C_4\text{PLR}^3$$

As Table 5.21 shows, PNNL developed three pump curves to represent (1) a constant speed pump (pump rides on the curve), (2) a variable-speed pump without constant pressure setpoint, and (3) a variable-speed pump with pressure setpoint reset. These curves are applied to the modeled pumps.

Table 5.21. Pump Curves

	C_1	C_2	C_3	C_4
Constant Speed Pump (pump rides on the curve)	0	3.2485	-4.7443	2.5294
Variable Speed Pump Without Pressure Setpoint Reset	0	0.5726	-0.301	0.7347
Variable Speed Pump with Pressure Setpoint Reset	0	0.0205	0.4101	0.5753

5.2.2.16 Addendum 90.1-07as: Laboratory Fan Systems

90.1-2004 and 90.1-2007 include exception (b) to the simultaneous heating and cooling prohibition in Section 6.5.2.1 for "zones where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that variable air volume systems are impractical." This exception allows designers to use constant volume reheat systems in critical areas of hospitals and similar spaces needing pressure differentials with adjacent areas. 90.1-2004 and 2007 include in Section 6.5.7.2 ("Fume Hoods") a threshold of 15,000 cfm exhaust air, above which laboratory exhaust and makeup systems must include energy saving features such as VAV, heat recovery, or minimally conditioned direct makeup air.

In place of the blanket exception (b) to Section 6.5.2.1, addendum 90.1-07as added an allowance to the airflow rate that can be reheated in order to achieve reasonable energy savings in these types of spaces, while not compromising health and safety. That allowance states "the air flow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates." Therefore, if the peak design airflow to any of these spaces is greater than the required minimum air change rate or the minimum rate required maintaining pressure differentials, the system must use variable air volume, reducing airflow as much as possible before reheat is allowed. Also, if the minimum air change rate is only required during occupied periods (as in operating rooms), the airflow must be reduced during those unoccupied periods before reheat is allowed. Several of the zones in the hospital and outpatient healthcare prototypes include critical spaces that are affected by the change in Section 6.5.2.1 under addendum 90.1-07as.

Addendum 90.1-07as also reduces the section S.5.7.2 fume hood requirements' threshold of 15,000 cfm of exhaust air to 5,000 cfm. Since none of the prototypes include laboratory exhaust systems larger than 5,000 cfm, the change in Section 6.5.7.2 is not included in the savings analysis of this addendum.

The following subsections describe the implementation of addendum 90.1-07as in the hospital and outpatient healthcare prototypes for the change in Section 6.5.2.1.

Hospital Modeling Strategy

In the hospital prototype, five space types are identified as critical spaces: operating rooms, patient rooms, emergency rooms, intensive care units, and laboratories. For the baseline, the spaces are modeled with constant volume reheat by using VAV reheat terminal units with a minimum airflow fraction equal to 1.0. Each critical space type is grouped together and is served by a dedicated air-handling unit. To determine if airflow to these zones needs to be reduced during reheat to comply with addendum 90.1-07as, the peak design airflow from each of these air handlers is compared with the sum of the minimum airflow requirements for each of the critical zone types according to the most commonly used accreditation standard for hospitals, *AIA Guidelines for Design and Construction of Hospital and Health Care Facilities (*AIA 2001). If the peak airflow is greater than the accreditation standard airflow rate, the terminal units need to be changed to VAV with a minimum airflow ratio equal to the required accreditation standard airflow divided by the peak airflow.

To simplify the analysis, sample representative climate zones, 2A, 4A, and 6A are considered. Table 5.22 shows that for the selected climates, the ratio of minimum supply air to peak does not vary significantly and the average can reasonably be used. The table shows that of the five space types, only the patient rooms had a minimum airflow rate required by the accreditation standard that is significantly less than the peak design airflow in any of the three climate zones. In fact, for the patient rooms, the minimum airflow rate required by the accreditation standard is approximately 50% of the peak design rate in each of the three climate zones. Therefore, in implementing addendum 90.1-07as, the minimum airflow fraction of terminal units serving the patient rooms is reduced from 100% to 50%. Table 5.22 also shows that the laboratories are not supplying the minimum airflow rate required (6 air changes per hour), and that needs to be corrected in future versions of the prototypes.

As mentioned previously, in addition to savings resulting from reduced reheat when the accreditation standard minimum airflow rate is less than the peak design airflow rate, there is also potential savings when the accreditation standard minimum airflow rate is only required during occupied periods and the space is sometimes unoccupied. Of the five space types identified as critical spaces in the hospital, only the operating rooms are not occupied continuously. When unoccupied, the operating room still must be maintained under positive pressure, so the system cannot be shut down completely. Based on input from the Mechanical Subcommittee, maintaining positive pressure is assumed to be accomplished with 20% of the peak design airflow, as is required by addendum 90.1-07h (Section 5.2.2.10 above). Therefore, for the implementation of addendum 90.1-07as, the minimum airflow fraction of terminal units serving the operating rooms is reduced from 100% to 20% during unoccupied periods.

Table 5.22. Hospital Prototype Critical Space Airflow Requirements

Zone Type	Peak Design Supply Air (cfm)			Minimum Required SA[a] (cfm)	Ratio of Min SA to Peak SA			Average Ratio of Min SA to Peak SA
	Houston	Baltimore	Burlington		Houston	Baltimore	Burlington	
Emergency	11,758	11,758	11,758	11,754	1.00	1.00	1.00	1.00
Operating Room	23,096	23,096	23,096	23,087	1.00	1.00	1.00	1.00
Intensive Care	13,674	13,514	13,425	13,190	0.96	0.98	0.98	0.97
Patient Room	29,115	28,684	28,558	14,273	0.49	0.50	0.50	0.50
Laboratory	4,662	4,668	4,696	7,977	1.71	1.71	1.70	1.71

(a) Minimum supply air required by AIA Guidelines (AIA 2001). Supply Air (SA)

Outpatient Healthcare Implementation

For the outpatient healthcare prototype, a similar approach to the hospital prototype is s used. Like the hospital, the critical zones are served by VAV reheat terminal units with a minimum airflow fraction equal to 1.0, making these essentially CAV systems. However, unlike the hospital, the critical zones in the outpatient healthcare baseline are not served by dedicated air handlers but are instead served by air handlers that also serve true VAV nonmedical critical zones. Therefore, each zone needs to be evaluated individually instead of by each air handler serving a group of similar critical zones.

Table 5.23 identifies the critical zones, including the peak design supply airflow in each of the three representative climate zones, and the minimum airflow rate required by the accreditation standard. Of the 37 zones listed in the table, 12 (shaded in the table) have a minimum airflow rate required by the accreditation standard that is significantly less than the peak design airflow in any of the three climate zones. For those zones, the minimum airflow fraction of the terminal units is reduced to the value in the column titled "Average Ratio of Min SA to Peak SA" for the implementation of addendum 90.1-07as. Like the hospital, the outpatient healthcare prototype also includes operating rooms that can have airflow reduced to 20% during the unoccupied period to comply with addendum 90.1-07as.

Table 5.23. Outpatient Healthcare Prototype Critical Space Airflow Requirements

Zone Name (floor number first)	Peak Design Supply Air (cfm)			Minimum Required SA[(a)] (cfm)	Ratio of Min SA to Peak SA			Average Ratio of Min SA to Peak SA
	Houston	Baltimore	Burlington		Houston	Baltimore	Burlington	
1 Anesthesia	144	144	144	144	1.00	1.00	1.00	1.00
1 Clean	84	85	84	84	1.00	0.99	1.00	1.00
1 Clean Work	110	110	110	110	1.00	1.00	1.00	1.00
1 Lobby Toilet	90	90	90	90	1.00	1.00	1.00	1.00
1 MRI Toilet	90	90	90	90	1.00	1.00	1.00	1.00
1 Nurse Toilet	90	90	90	90	1.00	1.00	1.00	1.00
1 Operating Room. 1	1,797	1,834	1,738	1,534	0.85	0.84	0.88	0.86
1 Operating Room. 2	1,794	1,824	1,741	1,600	0.89	0.88	0.92	0.90
1 Operating Room. 3	1,587	1,587	1,587	1,587	1.00	1.00	1.00	1.00
1 PACU	108	108	108	108	1.00	1.00	1.00	1.00
1 Pre-Op Room 1	189	189	189	189	1.00	1.00	1.00	1.00
1 Pre-Op Room 2	338	338	338	338	1.00	1.00	1.00	1.00
1 Pre-Op Toilet	90	90	90	90	1.00	1.00	1.00	1.00
1 Procedure Room	712	712	712	713	1.00	1.00	1.00	1.00
1 Recovery Room	592	658	616	540	0.91	0.82	0.88	0.87
1 Soil	210	210	210	210	1.00	1.00	1.00	1.00
1 Soil Hold	93	93	93	93	1.00	1.00	1.00	1.00
1 Soil Work	300	300	300	300	1.00	1.00	1.00	1.00
1 Step Down	440	455	409	300	0.68	0.66	0.73	0.69
2 Conf. Toilet	107	107	107	107	1.00	1.00	1.00	1.00
2 Exam 1	755	725	656	360	0.48	0.50	0.55	0.51
2 Exam 2	540	540	540	540	1.00	1.00	1.00	1.00
2 Exam 3	720	720	720	720	1.00	1.00	1.00	1.00
2 Exam 4	128	135	132	84	0.66	0.62	0.64	0.64
2 Exam 5	548	523	464	350	0.64	0.67	0.75	0.69
2 Exam 6	258	240	225	225	0.87	0.94	1.00	0.94

Table 5.23 (cont'd)

Zone Name (floor number first	Peak Design Supply Air (cfm)			Minimum Accreditation Standard[(a)] Required SA (cfm)	Ratio of Min SA to Peak SA			Average Ratio of Min SA to Peak SA
	Houston	Baltimore	Burlington		Houston	Baltimore	Burlington	
2 Exam 7	792	792	792	792	1.00	1.00	1.00	1.00
2 Exam 8	316	291	270	270	0.86	0.93	1.00	0.93
2 Exam 9	396	396	396	396	1.00	1.00	1.00	1.00
2 Reception Toilet	210	210	210	210	1.00	1.00	1.00	1.00
2 Work Toilet	90	90	90	90	1.00	1.00	1.00	1.00
3 Lounge Toilet	320	320	320	320	1.00	1.00	1.00	1.00
3 Office Toilet	90	90	90	90	1.00	1.00	1.00	1.00
3 Phys. Therapy 1	1,842	1,905	1,897	1,300	0.71	0.68	0.69	0.69
3 Phys. Therapy 2	745	726	675	592	0.79	0.82	0.88	0.83
3 Physical Therapy Toilet	140	140	140	140	1.00	1.00	1.00	1.00
3 Treatment	616	600	560	476	0.77	0.79	0.85	0.81

(a) Minimum supply air required by AIA Guidelines (AIA 2001). Supply Air (SA)

5.2.2.17 Addendum 90.1-07ax: Kitchen Exhaust Hoods

Section 6.5.7.1 in 90.1 -2004 and 90.1-2007 has requirements for individual kitchen exhaust hoods with exhaust airflow greater than 5,000 cfm. Based on engineering judgment and inputs from ASHRAE Technical Committee TC5.10 (Kitchen Ventilation), none of the individual exhaust hoods in the prototype buildings are over 5,000 cfm. Therefore, the requirements in the Section 6.5.7.1 of 90.1-2004 and 90.1-2007 do not apply to the baseline buildings.

Addendum 90.1-07ax adds new requirements for all kitchen hood exhaust systems, listed as new subsections Sections 6.5.7.1.1 through 6.5.7.1.5. This addendum also adds and modifies requirements for kitchen hoods that exceed 5,000 cfm of exhaust. The new requirements are as follows:

- Section 6.5.7.1.1 requires all kitchen hoods not to be "short-circuit" hoods that directly introduce replacement air in the kitchen hood cavity for more than 10% of the hood exhaust airflow rate.
- Section 6.5.7.1.2 requires all available transfer air from adjacent spaces to be used before any other makeup air is introduced to the kitchen for any size hood.
- Section 6.5.7.1.3 requires using hoods that meet the Table 6.5.7.1.3 requirements if the total kitchen exhaust airflow rate in the kitchen/dining facility is greater than 5,000 cfm.
- Section 6.5.7.1.4 requires kitchen/dining facilities with total kitchen hood exhaust airflow rate larger than 5,000 cfm to meet one of the three options: (a) at least 50% of replacement air from transfer air; (b) cooking-load-based demand control ventilation; (c) energy recovery devices on exhaust airflow.
- Section 6.5.7.1.5 requires performance testing on design airflow rates and on capture and containment performance of the exhaust system for all kitchen hoods.

Modeling Strategy

The modeling strategy for these requirements includes the following:

- Section 6.5.7.1.1: Because no statistical data shows short-circuit hoods are a common design practice, the energy savings impact of this provision is not simulated.
- Section 6.5.7.1.2: To comply with this requirement, the 90.1-2010 models are modified using all available transfer air in spaces close to the kitchen (on the same floor as kitchen) before bringing any makeup air in through the kitchen air conditioning system. When the available transfer air varies with time (e.g., under a demand control ventilation system), the minimum available transfer air is used. For the quick-service restaurant, transfer air is also used in the baseline because this is common practice.
- Section 6.5.7.1.3: The exhaust airflow flow rates in Table 6.5.7.1.3 are 30% below the minimum airflow rates in ASHRAE Standard 154-2003 (ANSI/ASHRAE 20-03). Some hoods in baseline buildings are assumed to already meet Table 6.5.7.1.3 and others just meet the minimum requirements in ASHRAE Standard 154-2003. On average the 90.1-2010 compliant hoods have 10% flow reduction comparing to the baseline hoods. 10% exhaust airflow rate reduction is assumed when listed and/or tested hoods are compared to hoods in the baseline models. The 10% number is an assumption, under which some baseline buildings are considered to have already been designed with listed and/or tested hoods.
- Section 6.5.7.1.4: Transfer air, option (a) under this section, is considered as the first choice because it is required by Section 6.5.7.2. When the requirement in option (a) is not met, options (b) and (c) are considered for the models run under 90.1-2010.
- Section 6.5.7.1.5: No savings are estimated for the testing requirement.

Six of the 16 prototype buildings contain commercial kitchens: quick-service restaurant, full-service restaurant, hospital, large hotel, primary school, and secondary school. Because the applicability of addendum 90.1-07ax requirements to the six buildings varies, the differences between the baseline and 2010 models are summarized in Table 5.24.

Table 5.24. Application of Addendum 90.1-07ax to Prototypes

	Section 6.5.7.1.2 Use of Available Transfer Air		Section 6.5.7.1.3 Total Exhaust Airflow Rate (cfm)		Section 6.5.7.1.4 Selected Option Under Section 6.5.7.1.4	
Prototype	2004 Model	2010 Model	2004 Model	2010 Model	2004 Model	2010 Model
Quick-service Restaurant	yes	yes	3,300	3,300	a	a
Full-service Restaurant	yes	yes	6,000	5,400	a	a
Hospital	no	yes	8,000	7,200	N/A	a
Large Hotel	no	yes	4,000	4,000	N/A	a
Primary School	no	yes	5,000	4,500	N/A	a
Secondary School	no	yes	6,000	5,400	N/A	a or a+b

The quick-service and full-service restaurants use transfer air in the baseline model because it is common design practice. The options applied for secondary school vary with climate.

5.2.2.18 Addendum 90.1-07bh: Supply Air Temperature Reset

90.1-2004 and 90.1 2007 do not require multi-zone HVAC systems to include supply air temperature reset. As a result, following the prescriptive path of 90.1-2004 or 2007, a multi-zone system can maintain a constant cooling supply air temperature selected to satisfy the peak cooling load. However, in most applications, cooling loads are usually below the peak design condition for most periods of system operation. In such cases, a warmer supply air temperature can satisfy the cooling load. Elevating the supply air temperature will decrease both cooling and reheat energy. It will also increase the benefit of air economizers because the economizers can be used at higher ambient temperatures.

Addendum 90.1-07bh requires that multi-zone HVAC systems reset supply air temperature based on either of two alternative strategies: (1) reset based on the representative building loads or (2) reset based on outdoor air temperature. The first control strategy means that the supply air temperature is reset to meet the cooling requirement of the warmest zone. For both control strategy options, this addendum requires that the supply air temperature be reset higher to at least 25% of the difference between the design supply air temperature and the design room air temperature.

Addendum 90.1-07bh has three exceptions:

- Climate zones 1a, 2a, and 3a (intended to avoid the humidity issue due to increased supply air temperature)
- Systems that prevent reheating, recooling, or mixing of heated and cooled supply air
- Systems in which at least 75% of the energy for reheating (on an annual basis) is from site-recovered or site solar energy sources.

As required by this addendum, supply air temperature reset is applied to the VAV systems in seven building prototypes with VAV system: large office, medium office, hospital, outpatient healthcare, large hotel, and primary and secondary schools.

The supply air temperature reset is implemented in all climate zones except 1a, 2a, and 3a. To simplify the modeling analysis and reflect the most common practice, PNNL uses the reset control strategy based on outdoor air temperature. *EnergyPlus* has the capability to reset supply air temperature based on outdoor air temperature. Therefore, the implementation is straightforward. The reset rule is presented below:

- The supply air setpoint temperature is 55°F if the outdoor high temperature is at or above 70°F.
- The supply air setpoint temperature is 60°F if the outdoor high temperature is at or below 50°F.
- The supply air setpoint temperature is linearly interpolated in the simulation between 55°F and 60°F if the outdoor high temperature is between 70°F and 50°F.

5.2.2.19 Addendum 90.1-07bw: PTAC and PTHP Equipment Efficiency

Table 6.8.1 D in 90.1-2004 and 90.1-2007 requires minimum efficiency levels for PTACs and PTHPs. In 2008, DOE issued a Final Rule, which amends the existing energy efficiency levels for PTACs and PTHPs, as published in 90.1-2007. This amended federal energy conservation rule applies for both standard size and nonstandard size PTACs and PTHPs.

Addendum 90.1-07bw adopts this newly issued federal mandatory efficiency standard into its tabulated efficiency requirement as Table 6.8.1D in 90.1-2010, with the same effective date as provided by the federal standard. Table 5.25 lists the new efficiency levels introduced by addendum bw for standard size equipment only Table 4.10 in Chapter 4 of this report provides the baseline efficiency levels.

Table 5.25. PTACs and PTHPs Efficiency, 90.1-2010

Equipment Type	Size Category	Minimum Efficiency (effective as of 10/08/2012)
PTAC (cooling mode)	All Capacities	13.8 -(0.3 x capacity/1,000) EER
PTHP (cooling mode)	All Capacities	14.0 -(0.3 x capacity/1,000) EER
PTHP (heating mode)	All Capacities	3.7 -(0.052 x capacity/1,000) COP

This addendum applies to the small hotel prototype, where PTAC units provide cooling and heating to the guestrooms. This addendum is implemented in *EnergyPlus* with two steps: (1) separating the fan power from the EER rating, as shown in Table 5.26 and (2) converting the EER to the required modeling inputs as $COP_{cooling}$ in *EnergyPlus*. The calculations are described below.

Table 5.26. Example PTAC/PTHP Fan Power Calculation

Product	Cooling Capacity (Btu/h)	Fan Motor W/cfm	Supply Airflow	W
PTAC/PTHP	9,000	0.30	275 cfm	82.5

The addendum 90.1bw efficiency calculations are as follows:

$$\begin{aligned} EER &= 13.8 - (0.3 \times Capacity/1{,}000) \\ &= 13.8 - (0.3 \times 9{,}000\ Btu/h/1{,}000) \\ &= 11.1 \end{aligned}$$

$$\text{Energy Input Ratio (EIR)} = (\text{Capacity/EER} - \text{FanPower})/(\text{Capacity}/3.413 + \text{FanPower})$$

$$= \left(\frac{9{,}000}{11.1} - 82.5\right)/\left(\frac{9{,}000}{3.413} + 82.5\right)$$

$$= 0.267813$$

$$\text{COPcooling} = \frac{1}{\text{EIR}} = 3.734$$

5.2.2.20 Addendum 90.1-07cb: Outdoor Air Damper Requirements

Addendum 90.1-07cb includes a number of changes to outdoor air damper requirements:

- Requires simple systems to meet prescriptive outdoor air damper requirements. HVAC systems using the simplified approach (Section 6.3 in 90.1-2004 and 90.1-2007) are not required to meet the outdoor air damper requirements as systems using the mandatory and prescriptive requirements (Sections 6.4 and 6.5 respectively in 90.1-2004 and 90.1-2007). Addendum 90.1-07cb adds a new section in the simplified approach, which requires simplified systems to meet the outdoor air damper requirements.
- Allows backdraft dampers only for exhaust and relief dampers in buildings less than three stories in height. Section 6.4.3.4.3 of 90.1-2004 and 90.1-2007 has an exception that allows gravity (nonmotorized) dampers in buildings less than 3 stories in height and for buildings of any height in climate zones 1 through 3. The addendum distinguishes outdoor air ventilation backdraft dampers from exhaust and relief dampers and rewords the exception to exclude the exception for ventilation intake dampers in climate zones 4 through 8.
- Requires backdraft dampers on outdoor air intakes to be protected from wind-limiting, wind-blown infiltration through the damper.
- Moves climate zone 5a to the category of climates that require low leakage dampers. Section 6.4.3.4.4 in 90.1-2004 and 90.1-2007 include low leakage damper requirements. These requirements are more stringent for climate zones 1, 2, 6, 7, and 8, and nonmotorized dampers are not allowed in these climates. This addendum adds climate zone 5 to the climate zones that are not allowed to use non-motorized dampers of the time regulated by Section 6.4.3.4.3.

The energy saving impacts from the first two changes above are considered significant and are accounted for in the PI analysis. The savings result because the gravity backdraft outdoor air intake dampers are open whenever the fan is running. The damper will bring in minimum levels of outdoor ventilation air, which must be conditioned even when the HVAC system cycles on to meet the temperature setpoints during unoccupied periods or when the fan system comes on during a pre-occupancy warm-up/cool-down period. When automatically controlled motorized outdoor air intake dampers are used, the dampers can be closed when outdoor air is not required. This change leads to savings in climate zones 4 through 8 for the eight prototypes that are less than three stories: small office, standalone retail, strip mall, quick-service restaurant, full-service restaurant, primary and secondary schools, and warehouse.

In the simulation, this addendum is implemented by varying the outdoor air schedules in the outdoor air control in *EnergyPlus*. In the baseline case, the eight prototypes less than three stories in climate zones 4 through 8 are assigned a minimum outdoor air schedule with a value of “1” at all times. The value of “1” means that whenever the fan is running, the outdoor air damper is open, bringing in minimum levels of ventilation. For the 2010 PI, those same prototypes are assigned a minimum outdoor air schedule with a value of “1” from the beginning to the end of the occupied period in the spaces served by each system and a value of “0” when the space is unoccupied. The value of “0” causes the damper to remain closed even if the fan is running, unless the air economizer is on.

An added complication when accounting for savings from this addendum is that systems with an economizer will always have an automatic damper. Many of the eight prototypes less than three stories in climate zones 4 through 8 are required to have economizers in the baseline, based on the climate zone as well as the size of the HVAC system. It is assumed that, if the system is required to have an economizer in the baseline, it must already have an automatic damper even if not required specifically in 90.1-2004 or 90.1-2007. Therefore, those systems are assigned an outdoor air schedule that applies a motorized damper in the baseline and the 90.1-2010 models and do not show savings from addendum 90.1-07cb.

5.2.2.21 Addendum 90.1-07ck: Outdoor Air Ventilation Optimization Control

90.1-2004 and 90.1-2007, Section 6.5.3, requires that each HVAC system having a total fan system motor nameplate power larger than 5 hp meet Sections 6.5.3.1 and 6.5.3.2, which govern fan maximum allowed horsepower and VAV fan control. 90.1-2007, Section 12, includes Standard 62.1-2004 as the reference standard for ventilation.

Addendum 90.1-07ck adds a new section, Section 6.5.3.3, “Multiple-zone VAV System Ventilation Optimization Control”. The addendum also updates the reference standard from 62.1-2004 to 62.1-2007 in Section 12. However, note that all of the elements of Standard 62.1-2007 relevant to this addendum are identical in Standard 62.1-2004.

Addendum ck adds the requirement that multiple-zone VAV systems with DDC control of terminal units include means to automatically reduce outdoor air intake flow below the design rate in response to changes in system ventilation efficiency, as defined by Standard 62.1-2007, Appendix A. This new section includes three exceptions: (a) three types of VAV systems, including those with zonal transfer fans for recirculation, dual-duct dual fan VAV systems, and VAV systems with fan-powered boxes, (b) systems required to have energy recovery under 90.1-2010, Section 6.5.6.1, and (c) systems with total design exhaust airflow more than70% of total design outdoor air intake.

Ventilation Standard 62.1-2007, Table 6.1, provides prescriptive zone outdoor air requirements based on number of occupants and zone floor area. For a multiple-zone VAV system, the sum of the prescriptive zone outdoor air requirements is the minimum system outdoor air intake. Standard 62.1-2007, Section 6.2.5, for multiple-zone recirculating systems, governs the system design outdoor air intake modified to account for system ventilation efficiency. Standard 62.1-2007, Section 6.2.7, for dynamic reset, allows outdoor air intake flow to be reset as operating conditions change, including the changes to system ventilation efficiency as outdoor air is distributed to the zones under different ventilation airflows and temperatures. The ventilation optimization required by addendum ck is equivalent to this dynamic reset. An ASHRAE journal article, *Dynamic Reset for Multiple Zone Systems* (Stanke 2010) provides an overview of the calculation steps required in Standard 62.1, as well as a discussion of the benefits of dynamic reset.

Outdoor air ventilation requirements are discussed in Chapter 4, Section 4.5.5 of this report. Table 4.14 presents the minimum outdoor air rate calculated as the sum of the prescriptive single zone values based on number of occupants and zone area, without incorporating the multiple-zone rules in Standard 62.1-2007. In implementing addendum ck, system level outdoor air intake flow is adjusted to meet the multi-zone ventilation requirements. Development of these multi-zone system outdoor air intake rates is discussed at the end of this section. Some parameters of this calculation require explanation here to understand how the ventilation optimization results in energy savings.

One parameter in the Standard 62.1-2007 multiple-zone ventilation calculation is the system ventilation efficiency. System ventilation efficiency is a measure of how much the system outdoor air intake must be increased beyond the sum of the minimum zone prescriptive requirements that provide the minimum outdoor air to the zones. The system ventilation efficiency depends on the ventilation requirements of the zone or zones, which have the highest ratios of zone ventilation requirement to zone design airflow at minimum damper position. These zones are known as critical zones. Typically, in practice, design calculation of the system ventilation efficiency is made at the cooling design condition (or heating if heating load is dominant). Other conditions may occur with lower system ventilation effectiveness, which can be revealed by hourly load analysis, but this is not generally applied.

To satisfy Standard 62.1, a VAV system without ventilation optimization must maintain outdoor air intake airflow at the design value, even as supply air varies with space load. This requires airflow sensing and adjustment of the outdoor air damper. Real systems do not always work this way, but this is a way to fully meet Standard 62.1. Ventilation optimization allows the system outdoor air intake to be adjusted in response to changing airflow at the system and at the zone with changing loading conditions. The Standard 62.1 multiple-zone calculations are carried out automatically in the control equipment using airflow and damper position data.

Implementing addendum ck for the PI requires two main steps: (1) identifying the prototypes and VAV systems required to provide the ventilation optimization control and (2) adding the control in the *EnergyPlus* simulation.

As Table 5.27 shows, there are 21 VAV systems in 7 of the prototypes. Some systems in some climate zones meet the new Section 6.5.3.3 exception (b) for systems requiring energy recovery. Exceptions (a) and (c) do not apply. Also, two hospital and one outpatient healthcare systems include substantial proportion of zones with ventilation dominated by AIA guideline ventilation requirements (AIA 2001) and are not subject to the multiple-zone ventilation requirements in ASHRAE 62.1 or addendum ck. Table 5.27 summarizes the systems that are and are not required to meet the ventilation optimization control rules in the prototypes with VAV systems.

Ventilation optimization is implemented in the PI using a control algorithm that is available in *EnergyPlus*. For systems and climate zones with ventilation optimization, the Controller:MechanicalVentilation object is used with System Outdoor Air field set to ventilation rate procedure (VRP), the option for meeting ventilation requirements in Standard 62.1, which includes the multiple-zone calculations. When using the VRP option, *EnergyPlus* implements the Standard 62.1 multiple-zone calculation at each time step and calculates system efficiency and system outdoor air intake.

The VRP option in *EnergyPlus* is capable of implementing DCV as well as the ventilation optimization required by addendum ck. However, DCV is not part of the ventilation optimization control requirement in addendum ck. The *EnergyPlus* mechanical ventilation controller input fields include single-zone minimum outdoor air requirement per area and per occupant as determined by Standard 62.1, Table 6.1. The VRP option would adjust the per-occupant ventilation at each time step based on the scheduled occupancy, DCV, if allowed to. To avoid DCV where not required in Standard 90.1, the total zone outdoor air is combined, including both the floor area based and occupant based values, and is entered in the zone outdoor air per unit area field in the mechanical ventilation control object. This allows automatic calculation of the ventilation optimization without DCV. For cases with required DCV, the outdoor air is input, with area- and occupant-based values separated; and the VRP option performs ventilation optimization with DCV.

Table 5.27. Applicability of Addendum 90.-07ck to Prototypes

Prototype	HVAC System	Systems and Climates Affected by Addendum 90.1-07ck
Medium Office	PACU_VAV_BOT	All Systems, All Climate Zones
	PACU_VAV_MID	
	PACU_VAV_TOP	
Large Office	VAV_BOT	All Systems, All Climate Zones
	VAV_MID	
	VAV_TOP	
Primary School	VAV_POD_1	All Climate Zones Except 1A, 2A, 3A, 4A, 5A, 6A,7, and 8, which have ERV
	VAV_POD_2	
	VAV_POD_3	
	VAV_OTHER	All Climate Zones
Large Hotel	VAV WITH REHEAT	All Climate Zones Except 1A, 2A, 3A, 4A, 5A, 6A, 7, 8, which have ERV
Outpatient Healthcare	AHU-1[(a)]	Excluded, AIA Ventilation Requirements
	AHU-2	All Climate Zones
Hospital	VAV_1	All Climate Zones
	VAV_2	
	VAV_OR	Excluded, AIA Ventilation Requirements
	VAV_PATRMS	
Secondary School	VAV_POD_1	All Climate Zones Except 1A, 2A, 3A, 4A, 5A, 6A, 7, and 8, which have ERV
	VAV_POD_2	
	VAV_POD_3	
	VAV_OTHER	All Climate Zones

(a) AHU – air handling unit.

Calculating Standard 62.1 Multiple-zone System Outdoor Air Flow

Minimum outdoor air ventilation rates at the zone level are described in Section 4.5.5 in this report for all prototypes. To implement addendum ck, the design outdoor air intake flow rates are developed to meet the multiple-zone system ventilation requirements in Standard 62.1. These ventilation rates are calculated for the VAV systems that are identified in Table 5.27 and that are subject to addendum ck. Rates are calculated for the 90.1-2004 baseline models as well as for the 90.1-2010 models. The multiple-zone calculation procedures don't change among different ventilation standards (62-1999 62.1 2004 and 62.1-2007), except that the 62-1999 does not include zone ventilation effectiveness. Item 1, Zone Outdoor Airflow, in the calculation steps below explains how this one difference is addressed.

Standard 62.1-2007, Section 6.2.5, on multiple-zone recirculating systems, governs the design outdoor air intake flow at the system level for VAV systems. The major elements of the calculations involved and some of the simplifying assumptions used to allow these calculations to be performed are described in that section. These assumptions are consistent with input provided by members of the

Mechanical Subcommittee. Calculations are done at the system cooling design condition after verifying that higher system airflows do not occur at the heating design condition. Another option that some designers use includes hourly loads analysis to determine if any other condition results in higher outdoor air with these calculations. PNNL used the approach based on peak cooling load conditions in order to keep the modeling manageable; this method is often used in industry.

The multi-zone calculations include the following steps:

- Zone outdoor airflow (V_{oz}) is found for each zone from the sum of the outdoor airflow per person and the outdoor airflow per area required in Standard 62.1. This value is divided by zone air distribution effectiveness from Table 6-2 in Standard 62.1. For this analysis, a value of 1.0 for zone ventilation effectiveness is used in all cases. This allows consistency when applying ventilation Standard 62-1999 for the 90.1-2004 baseline models. Standard 62-1999 has effectively the same method for determining multiple-zone system ventilation but does not include the range of zone air distribution effectiveness as in Standards 62.1-2004 and 62.1-2007. Also, addendum 90.1-07 bx sets the reheat delta-T low enough that heating zone ventilation effectiveness of 1.0 is achieved. Because of limitations in the *EnergyPlus* simulation, addendum bx was not implemented and savings were not included in the PI.
- Zone discharge outdoor air fraction (Z_{dz}) is the ratio of the zone outdoor airflow divided by zone discharge airflow (V_{pz}) (the airflow to meet the thermal comfort conditions for the zone). A range of values may be used for the zone discharge air (Stanke 2010). One option is to use the discharge airflow at the zone based on the minimum damper position. This is a worst case that may not occur at design conditions but is often used by designers. These values can result in higher values for Z_{dz} than actually occur, but determining the actual maximum discharge airflow that occurs was not practical for this analysis, and there was no other recognized simple assumption to use.
- Uncorrected Outdoor Intake (V_{ou}) is the sum of the zone outdoor air requirements for airflow per occupant and airflow per area, adjusted for diversity of the zone population. For this analysis, diversity is assumed to be 1, a simplification since actual diversity values are not known. This is the same value as listed in Table 4.14 of this report for all prototypes.
- Average Outdoor Air Fraction (X_s) is the fraction of uncorrected outdoor air intake divided by the system primary airflow, V_{ou}/V_{ps}. V_{ps} is the system primary airflow, the system airflow at design conditions. In the simulation this initially is the sum of the coincident zone airflows that occur at the design conditions.
- Zone Ventilation Efficiency (E_{vz}) Zone ventilation efficiency, E_{vz}, is determined for each zone and is equal to the sum of 1 and the average outdoor air fraction minus the zone discharge outdoor air fraction, $1+X_s-Z_{dz}$.
- System Ventilation Efficiency (E_v) System ventilation effectiveness, E_v, is the lowest E_{vz} value for the zone that is considered the critical zone.
- Outdoor Air Intake Flow (V_{ot}) for the system is the uncorrected outdoor air intake divided by the system ventilation effectiveness, $V_{ot} = V_{ou}/E_v$.

For many design projects, this outdoor air intake flow in bullet 7 would be the stopping point. System ventilation efficiency may be near or at 1.0 and the outdoor air intake flow will be reasonably close to the uncorrected outdoor air intake. However, often in reality, and for many of the prototype models, the system ventilation efficiency calculated with the initially determined minimum damper positions is significantly less than 1.0. This low calculated ventilation efficiency can lead to a design with excessively high levels of ventilation air, which would require significant energy to condition.

Standard 62.1 allows an option for designers to increase the zone supply airflow over the minimum required for space conditioning to reduce the ratio of outdoor air to supply air that leads to low system efficiency values. One way to achieve this is to increase the minimum damper position of these zones. Section 6.5.2.1 in 90.1-2007 places restrictions on the highest value that the minimum damper position for VAV systems can have when using reheating or recooling. However, the section allows the rate to be higher than the prescriptive minimum values if energy usage can be demonstrated to be lower than would occur from restricting the minimum airflow to the allowed values. Net energy savings can be realized by increasing the minimum airflow at selected zones. This may increase reheating/recooling but will also increase system ventilation effectiveness and reduce system outdoor air intake, potentially resulting in a net reduction in energy needed to temper outdoor air. In practice, designers may make these types of adjustments to minimum damper position to improve system ventilation effectiveness without proving the energy usage is reduced based on experience and agreement with local code review. A rule of thumb approach may be followed, such as restricting the increase to 70% or some other value. The increase only needs to be made at critical zones that drive down the system ventilation effectiveness.

Implementing the Multi-zone Outdoor Air Requirements for the PI

For the PI analysis, a calculation is made to increase minimum damper positions of critical zones if needed so that the system ventilation efficiency is no less than 0.6. If the calculated system efficiency is more than this value, minimum damper positions are left at the value needed to meet Standard 90.1. The value of 0.60 was chosen based on trial analysis with the medium office building, which resulted in adjusting the critical zone minimum damper position to 0.6 to 0.7, a value that is tolerable in actual design practice. For most of the zones in the prototypes and for the medium and large office prototypes, this approach is implemented and results in appropriate outdoor air intakes.

To develop the new ventilation rates, a partially automated procedure was developed. These procedures are incorporated in Perl scripts. The scripts extract output information from intermediate model runs (prior to adding multi-zone outdoor air rates) to use in the calculations. These values are passed to another script, which runs the multi-zone calculations and exports to a spreadsheet intermediate multi-zone calculation values, and data for model inputs populate the model input file. The intermediate multi-zone calculation values are examined manually to identify and process any special case inputs. The procedure includes the following steps:

- An initial pre-run of the baseline and progress indicator models is made with starting values for minimum damper position.
- Data relevant to determining the system ventilation efficiency are extracted from the model output files, including the variables identified in the multiple-zone calculation outline above.
- A spreadsheet calculates the system ventilation efficiency. If the result is less than 0.6, a minimum damper position is determined for the critical zone or zone that allows system ventilation efficiency to reach at least 0.6. Some special cases were found that initially result in system ventilation efficiency of less than 1.0, or very small values driving outdoor air intake to very high values. How these cases were addressed is described below.

- A system outdoor air intake value is determined by dividing the sum of the single zone required ventilation by the system ventilation efficiency.
- Minimum damper positions and system outdoor air intake values are added to the adjusted models.

For the prototypes, adjustments are made to address special case zones. These prototypes still apply system ventilation efficiency no less than 0.6. Medium and large offices prototypes do not include any special case zones requiring adjustments.

Hospital: For the hospital prototype, hard-coded zone supply airflow rate for the ICU nurse station zone on the second floor are set to equal the zone outdoor air flow divided by 0.7. This method is a rough approximation to adding a fan-powered box for this one zone, or breaking it out as a separate small system, options that are described below.

Large Hotel: For the large hotel kitchen, the minimum damper position calculated exceeds 1.0. The minimum damper is reset to 1.0 for these cases. In reality, the kitchen would probably be served by a separate makeup air system. For the basement zone, the heating design airflow is used because it is larger than for cooling. This allows implementation to go forward with other zones becoming the critical zones.

Outpatient Healthcare: The target system efficiency was set at 0.7 instead of 0.6. This allows minimum damper positions for all zones to be less than 1.

Primary School: The initial minimum damper position for the VAV zones is 0.3 or 0.2. Using these values as the starting point for calculating the initial system efficiency leads to negative values for system ventilation efficiency in many zones. The initial values for the minimum damper position are adjusted to 0.7 for the calculation. This adjustment allows the calculation of system efficiency to result in positive values and then allows the calculation of minimum damper positions for critical zones to result in a system ventilation effectiveness of 0.6.

Secondary School: Calculations for many zones result in negative or very low values for system ventilation effectiveness. A reasonable method for addressing this is not included in the multi-zone outdoor airflows at this time and the minimum zone level outdoor air requirements are used. In reality, this prototype would likely more closely determine the worst case conditions for determining the critical zone, use fan-powered terminal units, or use other methods to address the multi-zone outdoor air requirements, as described below.

Another way to address critical zones is to provide fan-powered boxes, which increase the supply airflow at the terminal unit. This approach has pros and cons as well. Additional energy usage is required to run the terminal unit fans, and additional expense occurs for the fan powered terminal units. The added energy usage for the zone fans can be offset by increasing ventilation effectiveness and reducing system outdoor air intake. This method was not applied for the PI because of issues with implementing this in the model in an automated fashion. The approach may be appropriate for the schools in particular, where zone outdoor air requirements are close or even in excess of the space load requirement. Systems with fan powered boxes are exempt from the addendum 90.1-07ck ventilation optimization control required by addendum ck.

Finally, another approach would be to break out critical zones as separate systems. This approach is potentially an option for zones such as the kitchen in the large hotel prototype.

Further refinement of implementing the Standard 62.1 multiple-zone outdoor intake airflows will be considered for future work to address some of these special issues.

5.2.2.22 Addendum 90.1-07cy: Economizers

90.1-2004 and 90.1-2007 include all requirements for economizers in Section 6.5.1. Addendum 90.1-07cy changes several provisions of Section 6.5.1. The changes from addendum cy that result in significant savings include increasing the number of climate zones in which systems are required to have air economizers, lowering the cooling capacity size limit above which an economizer is required, and eliminating the exceptions for nonintegrated economizers. All of the changes to economizer requirements that are now in 90.1-2010, including those that do not impact savings, are outlined here.

- Section 6.5.1 exceptions (c), (d), and (i) are changed.

  Exception (c) is modified for hospitals and ambulatory surgery centers when humidity control is required. The modification changes the percentage of supply air of a system serving spaces to be humidified from a minimum of 25% to a minimum of 75% to trigger the exception.

  Exception (d) wording is clarified for economizers with systems subject to Section 6.5.6.2 heat recovery for service water heating.

  Exception (i) is changed to clarify that only economizers that provide comfort cooling are eligible to use the alternative compliance path in Section 6.3.2 based on improved system cooling efficiency.

- Table 6.5.1, which sets climate and cooling capacity criteria for when economizers are required, is split into two parts. Part A applies to comfort cooling applications and part B applies to computer room applications. Part B uses the same categorization that Table 6.5.1 did for all economizers before the addendum. Part A includes the following changes:

  Economizer requirements are added for climate zones 2a, 3a, and 4a, which were formerly exempt. Climate zones 1a and 1b remain exempt.

  The cooling capacity above which an economizer is required is reduced to 54,000 Btu/h for all climate zones except 1a and 1b. This change reduces the threshold down from 135,000 Btu/h for climate zones 2b, 5a, 6a, 7 and 8 and down from 65,000 Btu/h for climate zones 3b, 3c, 4b, 4c, 5b, 5c, and 6b.

- Section 6.5.1.3 exceptions to requirements for integrated economizers are removed:

  (a) DX systems that reduce outdoor air volume for frost control with the lowest step of compressor unloading provided that is no more than 25% of total system cooling capacity.

  (b) DX units with capacity less than 65,000 Btu/h

  (c) Systems in climate zones 1, 2, 3a, 4a, 5a, 5b, 6a, 6, 7, and 8.

- Tables 6.5.1.1.3A and B for economizer controls are modified so that fixed dry bulb control is no longer allowed for climate zones 1a, 2a, 3a, and 4a. Note that economizers previously were not required in these four climate zones.

- Section 6.3.2, exception (c), is changed to eliminate redundancy in the language that systems meet the economizer requirements.

- Table 6.3.2 is replaced by a new Table 6.3.2, adopted with addendum 90.1-07au, which provides exceptions for economizer requirements for systems that meet cooling efficiency thresholds above the mandatory cooling efficiency requirements in Standard 90.1 Chapter 6.

Only some of these changes are incorporated in the modeling for the PI analysis. These changes include the new Table 6.5.1A capacity thresholds and climate zone applicability, and the Section 6.5.1.3 removal of exceptions for integrated economizer control. These changes also include the modification of Tables 6.5.1.1.3A and B, which do not allow differential dry bulb control for humid climates. This modification is implemented by applying differential enthalpy control for economizers in climate zones 1a, 2a, 3a, and 4a, as now required under Table 6.5.1A.

Other addendum cy changes are not implemented to capture savings for several reasons:

- Section 6.5.1 exceptions(c), (d), and (i).

  Exception (c) regarding hospitals and ambulatory surgery centers with humidity control does not change the models since in the hospital and outpatient healthcare prototypes' economizers are excluded for all systems with humidification, and these generally exceed both the 25% and the 75% threshold.

  Exception (d) regarding Section 6.5.6.2 heat recovery for service water heating does not apply because no prototypes include this type of heat recovery.

  Exception (i) refers to the alternative compliance path using improved cooling efficiency and is not applied in the progress indicator process.

- Section 6.5.1.3, exception (b), which removes exception for integrated economizers with systems with cooling capacity under 65,000 Btu/h, does not apply because systems below this capacity are not required to have economizers in the baseline.

- The change to Section 6.3.2 language does not impact savings.

- The replacement of Table 6.3.2 does not apply. The alternative compliance path is not considered.

Addendum cy implementation results in model changes that alter energy usage in all prototypes except small office, warehouse, and high-rise and mid-rise apartments. The HVAC systems in these prototypes do not reach the capacity thresholds that trigger the inclusion of air economizers. Guestroom HVAC systems in small and large hotels also are not impacted. Savings are added to all climate zones except climate zone 1a and 1b, which continue to have no economizer requirements. Table 5.28 shows the impact for each prototype, HVAC system, and climate zone that are subject to the addendum changes. The values in the tables refer to the following addendum changes.

- Change 1: Economizers are added for climate zones 1a, 2a, 3a, 4a, as shown in 90.1-2010, Table 6.5.1A.

- Change 2: Economizers have integrated controls because of the removal of Section 6.5.1.3, exception (a), for VAV DX systems.

- Change 3 Economizers have integrated controls because of the removal of Section 6.5.1.3, exception (c), for climate zones 2b, 5a, 5b, 6a, 6b, 7, and 8. Note that this is shown for all systems other than those shown as VAV DX. It also applies to VAV DX systems, but those are already covered under Item 2.

- Change 4: Economizers are added in some cases for the climate zone and system types where the new cooling capacity thresholds shifted under Table 6.5.1A in 90.1-2010. For example, a system that has a capacity of 60,000 Btu/h in climate 3b has an economizer required under the addendum but not under the thresholds in 90.1-2007. This was observed in some intermediate stages in the modeling and is expected for some of these climate zones in the final progress indicator models.

There are some systems identified in the column headings as VAV DX that include footnote (b). These are systems that for some climate zones are constant volume DX in the baseline models, but are variable air volume DX in the advanced models. This change of system type was triggered by the addendum 90.1-07n single-zone VAV requirement. The VAV DX systems are subject to the same economizer requirements as are other VAV DX systems.

Prototype systems in climate zones that are shaded in Table 5.28 meet economizer requirements in 90.1-2004 and are not affected by this addendum.

Model changes are made by an automated process using a Perl script that identifies the cooling capacity of systems in sizing runs for each climate zone and then includes economizers and the correct economizer controls as required by this addendum.

Table 5.28. Applicability of Addendum 90.1-07cy by Prototype and Climate Zone

Prototype		Medium Office	Large Office	Standalone Retail		Strip Mall		Primary School			Outpatient Healthcare	
System Type		VAV DX	VAV, CAV CHW)	VAV DX(a)	CAV DX	VAV DX(a)	CAV DX	VAV DX	VAV DX(a)	CAV DX	VAV DX (without humid.)	VAV DX (with humid.)
Climate Zone												
2A	Houston	1	1	1	1	1	1	1	1	1	1	
2B	Phoenix	2	3	2	3	2	3	2	2	3	2	
3A	Memphis	1	1	1	1	1	1	1	1	1	1	
3B	El Paso	2		2	4	2	4	2	2		2	
3C	San Francisco	2		2	4	2	4	2	2		2	
4A	Baltimore	1	1	1	1	1	1	1	1	1	1	
4B	Albuquerque	2		2	4	2	4	2	2		2	
4C	Salem	2		2	4	2	4	2	2		2	
5A	Chicago	2	3	2	3	2	3	2	2	3	2	
5B	Boise	2	3	2	3	2	3	2	2	3	2	
5C	Vancouver	2		2	4	2	4	2	2		2	
6A	Burlington	2	3	2	3	2	3	2	2	3	2	
6B	Helena	2	3	2	3	2	3	2	2	3	2	
7	Duluth	2	3	2	3	2	3	2	2	3	2	
8	Fairbanks	2	3	2	3	2	3	2	2	3	2	

Prototype		Secondary School			Hospital		Small Hotel	Large Hotel	Quick-service Restaurant	Full-service Restaurant	
System Type		VAV DX	CAV DX	VAV CHW	VAV DX (without humid.)	VAV DX (with humid.)	CAV DX	VAV, CAV CHW	CAV DX	VAV DX(a)	CAV DX
Climate Zone											
2A	Houston	1	1	1	1		1	1	1	1	1
2B	Phoenix	2	3	3	3		3	3	3	2	3
3A	Memphis	1	1	1	1		1	1	1	1	1
3B	El Paso	2	4				4			2	
3C	San Francisco	2	4				4			2	
4A	Baltimore	1	1	1	1		1	1	1	1	1
4B	Albuquerque	2	4				4			2	
4C	Salem	2	4				4			2	
5A	Chicago	2	3	3	3		3	3	3	2	3
5B	Boise	2	3	3	3		3	3	3	2	3
5C	Vancouver	2	4				4			2	
6A	Burlington	2	3	3	3		3	3	3	2	3
6B	Helena	2	3	3	3		3	3	3	2	3
7	Duluth	2	3	3	3		3	3	3	2	3
8	Fairbanks	2	3	3	3		3	3	3	2	3

(a) As described in the text, in some climate zones, these systems are CAV in the baseline and VAV in the advanced models.

5.2.3 Power

Standard 90.1, Section 8, Power, applies to all building power distribution systems. Two addenda are added that expand the coverage of this section beyond the limited mandatory design voltage drop requirements for feeder and branch circuits in earlier versions of Standard 90.1. These addenda extend the regulation of power equipment and controls to address step-down voltage transformers in buildings and to begin the regulation of receptacle loads by adding automatic controls for receptacles. Regulation of plug loads will likely grow in future versions of Standard 90.1.

5.2.3.1 Addendum 90.1-07o: Transformers

Low voltage dry-type transformers are used in many commercial buildings to lower the primary voltage of the electrical service provided by the utility company from 277 volts (single phase) or 480 volts (3 phase) to 120 volts (single phase) or 208 volts (3 phase). Loads commonly served by such transformers include wall plugs, lights, fans, and equipment such as computers, printers, and small industrial machinery (Cadmus Group 1999). The *Energy Policy Act of 2005* created new federal minimum efficiency standards for low-voltage dry-type transformers. Addendum 90.1-07o adopts the federal mandatory requirements by adding them to 90.1-2010. Prior to this addendum, this class of equipment had no efficiency requirements. Table 5.29 includes the new efficiency requirements from addendum o. This addendum defines the term kilo volt amperes (kVA) and efficiency and defines the regulated type of transformer: "a low voltage distribution transformer is a transformer that is air-cooled, does not use oil as a coolant, has an input voltage of 600 Volts or smaller, and is rated for operation at a frequency of 60Hz."

Table 5.29. Low Voltage Dry-Type Transformer Efficiency Requirements

Single-Phase Transformers		Three-Phase Transformers	
kVa	Efficiency (%)	kVA	Efficiency (%)
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
NA	NA	750	98.8
NA	NA	1,000	98.9

To quantify savings from this addendum, a number of assumptions are made after consulting members of the SSPC 90.1 Lighting Subcommittee:

- All prototypes with floor areas greater than 50,000 ft^2 are assumed to include step-down transformers (Cadmus Group 1999). Included in this group are large office, medium office, primary school, secondary school, hospital, large hotel, and high-rise apartment prototypes.
- All miscellaneous plug loads and incandescent lighting in the above buildings will be fed through 120-V circuits served by step-down transformers.
- Based on lighting models used by the Lighting Subcommittee to create lighting power densities allowances, the following percentages of lighting in each of the affected prototypes are assumed to be incandescent.

Prototype	% of Incandescent Lighting
Large Office	2.81%
Medium Office	2.81%
Primary School	1.19%
Secondary School	1.94%
Hospital	2.20%
Large Hotel	3.52%
High-rise Apartment	0.15%[1]

- A key input for estimating distribution transformer energy use is transformer loading (DOE 2004). To develop part-load performance characteristics, a peak load factor is required. The peak load on a transformer typically ranges from 60% to 90% if electrical engineers accurately size dry-type transformers conservatively with a 10% safety margin relative to the nameplate capacity (DOE 2004). The value of 75% was chosen for this analysis. This value enables each building to be modeled with a single transformer with average oversizing.

- DOE created 10 product classes and 13 design lines of distribution transformers for developing efficiency standards (DOE 2004). For this analysis, Product Class 4, Design Line 7, which covers low-voltage, three-phase distribution transformers from 15 kVA to 150 kVA, was chosen as typical of the transformers covered by addendum 90.1-07o as recommended by the Lighting Subcommittee. Within the Product Class 4, Design Line 7, DOE selected the 75-kVA transformer as the representative unit for developing the requirements. Research done for the DOE rulemaking process setting the transformer efficiency standards identified baseline and target levels of efficiency for each transformer line. Figure 5.4 shows how these efficiency values vary as a function of part load for the reference transformer.

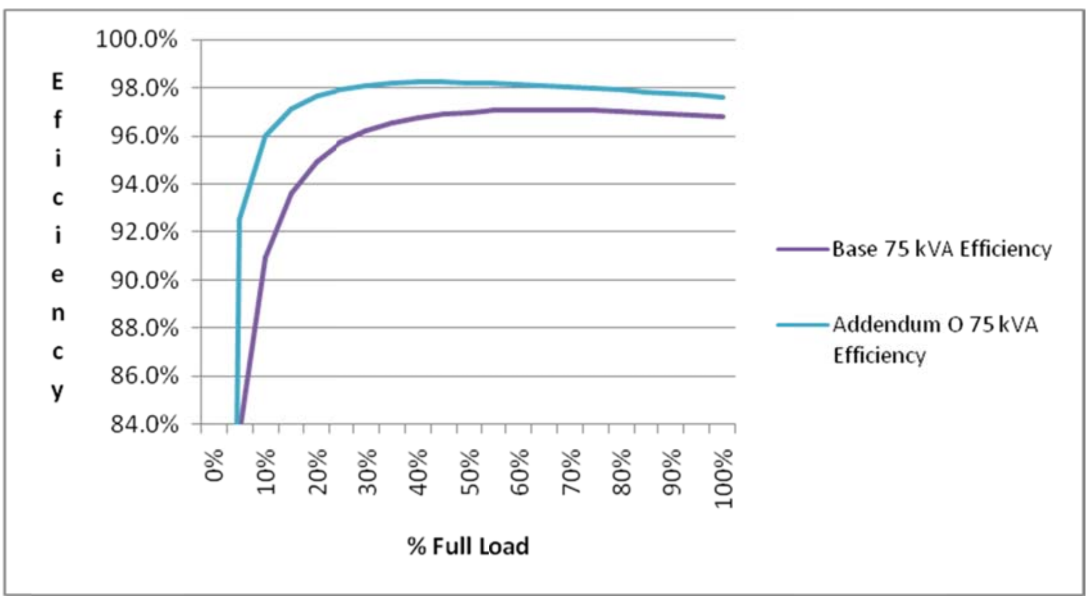

Figure 5.4. Baseline and Addendum 90.1-07o Transformer Efficiency Comparison

[1] Plug-in lighting within residences is not considered here because it is included as a plug load.

Modeling Strategy

Quantifying the losses due to the inefficiencies of transformers pre- and post-addendum 90.1-07o requires the mathematical descriptions of those losses because the load on the transformer varies. The efficiency of transformers depends on two types of losses. No load losses (NLL) are due to switching of magnetic fields in the core material and remain roughly constant as long as the transformer is energized. Load losses (LL) are due to electric resistance losses in the windings and vary approximately with the square of the load plus a small temperature correction. Knowing the NLL and LL at peak capacity for a particular transformer allows for calculation of the energy used by the transformer at any given time (DOE 2004):

$$E_{DT}(t) = E_{NL} + E_{LL} \times [Load(t)/(L_{rated} \times PF)]^2$$

where,

$E_{DT}(t)$	=	the energy used by the distribution transformer at time *t*
E_{NL}	=	the no-load losses at rated load
E_{LL}	=	the load losses at rated load
$Load(t)$	=	the load served by the transformer at time *t*
L_{rated}	=	the rated load of the transformer
PF	=	the power factor of the load served by the transformer (assumed to be 1.0 for this analysis).

NLL- and LL-developed transformer losses through the DOE rulemaking process for the reference 75-kVA baseline and target transformers are shown in Table 5.30 (DOE 2004). To apply the same efficiency as the reference transformer to the prototype transformer, a relationship between transformer losses and percent loading was developed. Based on the results of the following equations, transformer loss as a function of part-load ratio (Trans-Loss-FPLR) was calculated as shown in Table 5.31. The polynomial curve fit is shown in Figure 5.5.

$$Trans\text{-}Loss\text{-}FPLR = E_{DT}(t) /(LFFL)*L_{rated}$$

where,

$LFFL$ = Loss Fraction at Full Load = Loss at full load $/L_{rated}$

The transformer loss curves are applied to the affected prototypes by post-processing hourly results using the following procedure. *Note that because savings for this addendum are calculated via post-processing of hourly results, EnergyPlus input and output files do not include this addendum.*

- For each hour, the total energy use of miscellaneous electric equipment and the fraction of lighting assumed to be incandescent (see assumptions above) are summed to represent the hourly load on the transformer ($Load(t)$).
- The transformer size is calculated by determining the peak annual hourly load, assuming a peak load-to-rated capacity ratio of 0.75 (L_{rated}).
- For each hour, the transformer loss ($E_{DT}(t)$) is calculated according to the equation:

$$E_{DT}(t) = L_{rated} * LFFL * Trans\text{-}Loss\text{-}FPLR$$

- The sum of the hourly losses is added to the total annual energy use for each prototype.

Table 5.30. Reference Transformer Losses

	No Load Loss (W)	Load Loss, 100% (W)	Loss Fraction at Full Load	Efficiency at 35% Load
Baseline Transformer Losses	730.3	1,733.9	0.03286	96.6%
Addendum 90.1-07o Transformer Losses	298.4	1,535.5	0.02445	98.2%

Table 5.31. Transformer Loss as a Function of Part Load Ratio

Part Load Ratio (PLR)	Load (W) (Load(t))	Baseline Transformer Losses (W) (EDT(t))	Baseline Transformer Transformer Loss (FPLR)	Addendum 90.1-07o Transformer Losses (W) (EDT(t))	Addendum 90.1-07o Transformer Transformer Loss (FPLR)
0%		730	29.6%	298	16.3%
5%	3,750	735	29.8%	302	16.5%
10%	7,500	748	30.3%	314	17.1%
15%	11,250	769	31.2%	333	18.2%
20%	15,000	800	32.5%	360	19.6%
25%	18,750	839	34.0%	394	21.5%
30%	22,500	886	36.0%	437	23.8%
35%	26,250	943	38.3%	487	26.5%
40%	30,000	1,008	40.9%	544	29.7%
45%	33,750	1,081	43.9%	609	33.2%
50%	37,500	1,164	47.2%	682	37.2%
55%	41,250	1,255	50.9%	762	41.6%
60%	45,000	1,355	55.0%	851	46.4%
65%	48,750	1,463	59.4%	947	51.6%
70%	52,500	1,580	64.1%	1,051	57.3%
75%	56,250	1,706	69.2%	1,162	63.4%
80%	60,000	1,840	74.7%	1,281	69.9%
85%	63,750	1,983	80.5%	1,408	76.8%
90%	67,500	2,135	86.6%	1,542	84.1%
95%	71,250	2,295	93.1%	1,684	91.8%
100%	75,000	2,464	100.0%	1,834	100.0%

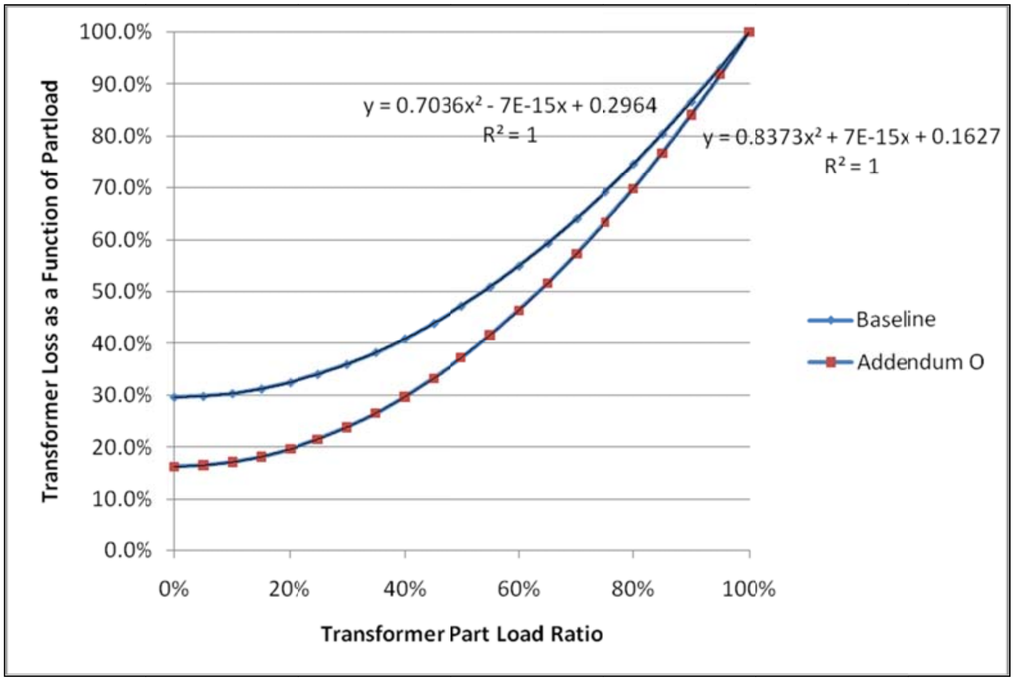

Figure 5.5. Transformer Loss Curves as a Function of Part Load

5.2.3.2 Addendum 90.1-07bs: Plug Receptacle Control

Chapter 8 in 90.1-2004 and 2007 regulates power equipment and only includes mandatory requirements for voltage drops in wiring. Addendum 90.1-07bs adds a requirement (Section 8.4.2) for automatic receptacle control. The addendum requires at least 50% of the 120- to 125-V receptacles in an enclosed space be controlled using a schedule or a signal from a control system based on occupancy and requires these receptacles to be switched off during unoccupied periods. Addendum 90.1-07bs is further modified by addendum 90.1-07cs, which limits the application of this addendum to private offices, open offices, and computer classrooms. Addendum 90.1-07cs is included in Table 5.3 in this report with the addenda that do not add to savings.

The NC^3 database (Richman et al. 2008) is used for the preliminary assessment of the amount of open office, private office, and computer classroom areas for each prototype building. As shown in Table 5.32, the NC^3 database shows that each prototype building type has some percentage of open or private offices or both. For prototype models without separate private and open office zones and separate office/classroom equipment schedules defined in the model, area fractions determined from the NC^3 data are used. The mid-rise and high-rise apartment and small hotel prototypes are not shown in the table because office equipment usage is separated out with its own office zone and plug equipment operating schedule. The NC^3 data also does not include classroom area for these three building types. Computer classroom area for the primary and secondary schools are not specifically separated out in the NC^3 data from other classrooms. The area fraction for computer classrooms is determined by using the area of the computer classroom zones in the prototype models.

Table 5.32. Open and Private Office Area as Percentage of Total Building Area

	Open Office	Private Office
Prototype	Percentage of Total Building Area	
Small Office	18.5%	19.8%
Medium Office	42.3%	18.6%
Large Office	72.9%	2.5%
Standalone Retail	0.6%	1.7%
Strip Mall	0.6%	1.7%
Primary School	0.5%	3.0%
Secondary School	1.2%	5.3%
Outpatient Healthcare	7.3%	13.0%
Hospital	0.9%	5.3%
Large Hotel	0.7%	1.1%
Warehouse	1.3%	0.8%
Quick-service Restaurant	0.6%	1.3%
Full-service Restaurant	0.1%	1.1%

This addendum is implemented by modifying the building plug load equipment schedules based on area weighting fractions for each of the three applicable space types to estimate savings from this addendum. A conservative estimate of potential savings from using occupancy sensors during occupied hours for the three space types is selected from the lower quadrant of various industry estimates summarized in IES paper 43 (VonNeida et al. 2000). These estimates are for occupancy sensor control of lighting believed to be a reasonable proxy for plug load control savings potential since the savings are based on amount of time the spaces are unoccupied. Table 5.33 shows these fractions for each applicable space type.

Table 5.33. Savings from Occupancy Sensors During Occupied hours

Area	Savings During Occupied Hours
Private Offices	22%
Open Offices	21%
Computer Classrooms	32%

Not all loads in an office can be unplugged when not in use. Therefore, a load fraction for the proportion of the load that can be unplugged is estimated from the plug load equipment inventory reported in two PNNL reports on approaches to achieve 50% energy savings in small and medium offices (Thornton et al. 2009, 2010). The PI analysis makes assumptions about which items in the inventory can be assumed to be controlled by the occupancy-based control system. For the small office prototype, Table 5.34 shows the plug load equipment inventory and identifies which loads can be controlled and the total fraction of the plug load power that can be controlled, i.e., 45%.

Table 5.34. Plug Load Equipment Breakdown for Small Office Prototype

Plug Load Equipment Inventory	Can Be Controlled	Qty.	Plug Load Per Unit (W/unit)	Plug Load (W)
Computers – servers	No	2	65	130
Computers – desktop	No	44	65	2,860
Computers – laptop	No	44	19	836
Monitors – server – liquid crystal display	Yes	2	35	70
Monitors – desktop – liquid crystal display	Yes	88	35	3,080
Laser Printer – network	Yes	2	215	430
Copy Machine	Yes	2	1,100	2,200
Fax Machine	Yes	2	35	70
Water Cooler	No	2	350	700
Refrigerator, 18 ft^3 side mount freezer, through-door ice	No	2	76	152
Vending machine,18 ft^3	No	2	770	1,540
Coffee Maker	No	2	1,050	2,100
Portable HVAC (heaters, fans)	Yes	18	30	540
Other Small Appliances, Chargers, Network Components	Yes	88	4	352
Total Plug Load (W)				15,060
Plug Load That Can Be Controlled (W)				6,742
Percentage that can be controlled				45%

The building equipment operating schedules are then modified to approximate savings from reduced equipment "on" hours from this addendum. The fraction in the schedule that plug equipment is on during occupied hours is reduced by the sum of the savings percentage for each space type identified as having savings (open office, private office, and classroom) multiplied by the proportion of building area that is associated with the corresponding space type. For zones defined as 100% a particular space type, for example, open office, the savings reduction is just the savings estimate percentage for that space type. For unoccupied hours, the space type area percentage is still used if applicable and the savings percentage is assumed to be 100%. Table 5.35 provides an example of the development of these calculated schedule fraction reductions for the primary school. For example, if the occupied equipment schedule fraction is 0.95 during occupied hours in the baseline, the schedule fraction in the 90.1-2010 model is 0.936.

Table 5.35. Primary School Prototype Example of Receptacle Control Schedule Reduction

	Open Office Area Fraction	Private Office Area Fraction	Computer Classroom Area Fraction	Occupancy Sensor Savings Estimate			Reduction to Plug Loads Schedule
				Open Office	Private Office	Classroom	
Occupied Hours	0.50%	3.00%	2.36%	21%	22%	32%	1.5%
Unoccupied Hours	0.50%	3.00%	2.36%	100%	100%	100%	5.9%

5.2.4 Lighting

90.1-2010 incorporates major changes that reduce lighting energy usage. For the first time, addenda introduce rules that require access to daylight and daylighting controls. Changes also include extensive updates to both interior and exterior basic lighting power allowances. Finally, significant controls requirements are added or changed for both interior and exterior lighting.

5.2.4.1 Addenda 90.1-07d, ab, al, and dd: Daylighting and Skylights

90.1-2004 and 90.1-2007, Chapter 9, "Lighting," and Chapter 5, "Building Envelope," do not specify requirements related to the minimum skylight fenestration area, minimum daylight area, or automatic dimming control of light fixtures in daylit areas. Addenda d, ab, al, and dd represent a series of revisions to 90.1-2007 that establish minimum requirements for skylight fenestration area, daylight area, and automatic dimming control. In 90.1-2007, Sections 5.5.4.2.2, 5.5.4.2.3, 9.4.1.3, and 9.4.1.4 were added and revised by these addenda. In this report these addenda are addressed with lighting because the energy savings for these addenda come from the lighting controls that are applied. Adding skylights without lighting controls will generally increase energy usage. The addition or revision made by each addendum is explained below, along with the final implementation of these addenda into the 16 prototype buildings.

The first addendum to add a requirement for daylighting in Standard 90.1 is addendum 90.1-07d. This addendum adds Section 9.4.1.4, which requires automatic dimming control in spaces where the combined daylit area under skylights exceeds 5,000 ft^2. Addendum 90.1-07ab, which was drafted after addendum 90.1-07d, modifies Section 9.4.1.4 by reducing the minimum required combined daylit area under skylights to 4,000 ft^2 from 5,000 ft^2. Addendum ab also introduces automatic dimming controls for sidelit spaces, where the combined primary sidelit area exceeds 1,000 ft^2. This sidelighting requirement under addendum ab is described in Section 5.2.4.10 (addendum 90.1-07ct) of this report.

Addendum 90.1-07al, drafted after addenda 90.1-07d and 90.1-07ab, introduces a requirement for spaces greater than 10,000 ft^2 to provide a minimum daylit area equal to half the total floor area. Addendum al requirements are added under Sections 5.5.4.2.2 and 5.5.4.2.3 of 90.1-2007. Thus, daylighting control requirements are added by addenda 90.1-07d and ab, whereas skylight and daylight area requirements are added by addendum al.

Addendum 90.1-07dd modifies the requirements of both addenda 90.1-07ab and 90.1-07al. The minimum daylit area threshold, established by addendum ab through Section 9.4.1.4, is reduced from 4,000 ft^2 to 900 ft^2. Therefore, automatic dimming controls are now required in daylit areas greater than 900 ft^2. The minimum enclosed area threshold, established by addendum al through Sections 5.5.4.2.2 and 5.5.4.2.3, is reduced from 10,000 ft^2 to 5,000 ft^2. Therefore, spaces greater than 5,000 ft^2 are now required to have skylights.

The final requirements related to minimum skylight fenestration area and automatic dimming controls can be summarized as follows:

- Maximum Skylight Fenestration Area (Section 5.5.4.2.2): The total skylight area must not exceed 5% of the gross roof area.
- Minimum Skylight Fenestration Area (Section 5.5.4.2.3): In any enclosed space directly under a roof with a ceiling height greater than 15 feet, the total daylight area under skylights must be a

minimum of half the floor area. Additionally, the minimum skylight area to daylight area ratio must be greater than 3% with a skylight visible light transmittance of at least 0.4. Buildings in climate zones 6 through 8 are exempted from these requirements. Spaces with general lighting power densities less than 0.5 W/ft^2 are also exempted. See 90.1-2010 for other exceptions that are not applicable to the prototype buildings.

- Automatic Daylighting Controls for Toplighting (Section 9.4.1.4): Lamps for general lighting over the daylit area must be separately controlled by multi-level photocontrol devices when the total daylit area under skylights exceeds 900 ft^2. Additionally, the multi-level photocontrol must be capable of lowering the design lighting power to at least 35%, with one intermediate step between 50% and 70%. Buildings in climate zone 8 with daylight areas less than 1,500 ft^2 are exempted. See Standard 90.1-2010 for other exceptions that are not applicable to the prototype buildings.

Implementation of Skylight Fenestration Area and Daylight Area

90.1-2010 Section 5.5.4.2.3 is used to identify spaces in the prototype buildings that are required to have daylit areas from skylights. Table 5.36 shows implementation of skylights into Standard 90.1 prototypes meeting the requirements of Section 5.5.4.2.3 for addendum dd. Details of skylight and daylight areas and their applicability in different climate zones are also shown in Table 5.36.

In the two school prototypes, existing baseline modeled skylights in gymnasiums and multipurpose rooms are providing daylighting to the entire space areas. Therefore, skylights are not added to the 90.1-2010 cases for the primary and secondary school prototypes.

A study of buildings from the NC^3 and CBECS datasets revealed that the warehouse prototype's bulk storage space and the standalone retail prototype's core retail space are likely to have skylights. Therefore, skylights were added to the baseline of these two buildings with the skylight area determined from NC^3 data and from the requirements of Section 5.5.4.2.3. The NC^3 database showed that fine storage spaces in warehouses are not typically daylit. Therefore, the warehouse baseline does not have skylights in the fine storage space.

Skylight U-factors and SHGC values are consistent with those from Tables 5.5.1 through Table 5.5.8 of Chapter 5 in Standard 90.1. Skylights are considered to have curbs and to be made of glass. In some climate zones, the allowed assembly U-factor is above 1 Btu/hr-ft^2-F which is due to the high u-factor of the curbs. Since curbs are not modeled in the prototype skylights, frames are added instead as an approximation with width and U-factor sufficient to raise the overall skylight assembly u-factor are combined the glazing U-factor to the required value.

Implementation of Daylighting Control

Addendum 90.1-07dd, Section 9.4.1.4 , is modeled by adding automatic, stepped dimming controls to the 90.1-2010 models in spaces with daylight areas larger than 900 ft^2. Two sensors are assigned to each daylight area in a space, each controlling half the daylight area. Sensors are placed such that savings from the control of lighting in the daylit area captures representative areas of expected illuminance levels.

Table 5.36. Skylight Fenestration Areas and Daylit Areas in Prototype Buildings

Prototype/Space	Area (ft^2)	Ceiling Height (ft)	Minimum Required Daylit Area (ft^2)	Actual Daylit Area (ft^2)	Baseline Skylight Area (ft^2)	PI Skylight Area (ft^2)	PI Skylight Area to Daylight Area Ratio	Applied to Climate Zones
Primary School								
Multipurpose Room	3,843	13	-	3,843	144	144	4%	1-8
Secondary School								
Gymnasium	21,269	26	10,635	21,269	864	864	4%	1-8
Auxiliary Gymnasium	13,433	26	6,717	13,433	576	576	4%	1-8
Warehouse								
Bulk Storage	34,497	28	17,248	17,248	160	512	3%	1-5
Fine Storage	15,000	28	7,500	7,500	0	220	3%	1-5
Standalone Retail								
Core Retail	17,227	20	8,614	8,614	72	256	3%	1-5

Table 5.37 shows details of the daylighting dimming controls implemented in Standard 90.1 prototypes. The fraction of zone controlled depends on the ratio of daylight area to floor area. The target illuminance levels are based on common and recommended indoor light levels from IESA. The dimming controls can lower the peak lighting power in two steps of 33% each (66%, 33%) in response to daylight illuminance levels.

Table 5.37. Automatic Daylighting Controls for Toplit Spaces in Standard 90.1 Prototypes

Prototype/Space	Area (ft^2)	Actual Daylit Area (ft^2)	Daylit Area to Zone Area Ratio	Fraction of Zone Area Controlled by Automatic Dimming Devices	Sensors (no.)	Target Illumi-nance (lux)	Control Type	Applied to Climate Zones
Primary School								
Multipurpose Room	3,843	3,843	100%	100%	2	500	3-step	1-8
Secondary School								
Gymnasium	21,269	21,269	100%	100%	2	500	3-step	1-8
Auxiliary Gymnasium	13,433	13,433	100%	100%	2	500	3-step	1-8
Warehouse								
Bulk Storage	34,497	17,248	50%	50%	2	200	3-step	1-5
Fine Storage	15,000	7,500	50%	50%	2	300	3-step	1-5
Standalone Retail								
Core Retail	17,227	8,614	50%	50%	2	200	3-step	1-5

5.2.4.2 Addenda 90.1-07i: Exterior Lighting

Both 90.1-2004 and 90.1-2007 include the same lighting power limits for various exterior applications. These limits were developed based on the amount of light needed to illuminate the various applications in typical conditions. Since these limits were developed, additional lighting industry work has been done on the amount of illumination needed in various exterior environments. This work is based on the realization that contrast with the lighted surroundings is a critical lighted environment criterion and areas with less ambient light such as rural areas require less produced light. Similarly, areas with higher ambient light levels, such as city centers, require more illumination for contrast and eye adaptation.

Addendum 90.1-07i applies four exterior lighting zones to buildings with exterior lighting as shown in Table 5.38 (reproduced from 90.1-2010, Table 9.4.3A). The addendum provides exterior lighting power requirements that vary for the four exterior lighting zone types. This approach recognizes the varying lighting needs and design differences associated with different building locations. Lighting power limits are highest in downtown city centers and then are reduced in mixed commercial/high-rise residential districts, then in residential areas, and finally in rural areas. Several organizations, including the IESNA, have been working to develop a zonal approach to exterior lighting recommended practice. This change in the standard will follow that guidance. Most building sites fall into lighting zones 2, 3, or 4, and the sites that remain in lighting zone 1 will generally be relatively small.

Table 5.38. Exterior Lighting Zones

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High activity commercial districts in major metropolitan areas as designated by the local jurisdiction

The first change in the existing exterior building lighting power section in the 90.1-2004 is the deletion of the 5% additional power allowance, which is replaced by a base wattage allowance per site. The added “Base Site Allowance” for each zone takes into account that most sites are not rectangular or do not match the iso-diagram of typical light luminaires. The new exterior lighting power allowances, including these changes and the 90.1-2004 baseline, are shown in Table 5.39.

The analysis for this addendum is built on the analysis done for the original exterior lighting addendum to 90.1-2001 which led to 90.1-2004. That addendum initially introduced the expanded exterior lighting requirements table. This earlier analysis provides estimates of exterior lighting applications in terms of areas (i.e., parking lots) and/or counts (i.e., entrance doors) that are applied to the appropriate lighting allowance from the standard to calculate a power total for the building. This method is not complete because that area or count data are not available for some applications, so some potential savings are not counted. However, the larger applications that are expected to account for the majority of exterior lighting energy use are represented and include parking lots, facades, and doors. The result of the estimate of these exterior lighting applications is included in Section 4.7.2 and Tables 4.17 through 4.19 of this report. Other applications, such as landscaping and sales lots, are expected to account for significant exterior lighting portions in some limited building types but overall will account for a small percentage of the national building mix total. This approach is considered to cover the majority of applications and is therefore considered to be conservative.

Each prototype is assigned to one or a mix of exterior lighting zones from Table 5.38 based on judgment about where the prototype is commonly found. Table 5.40 shows these zone assignments. These zone assignments are then used to identify the new power limit for the various applications in the analysis. The calculation of savings is a direct comparison of the estimate of exterior lighting use under Standard 90.1-2004 (applying 2004 power limits) and the expected use under 90.1-2010 (using the zone based power limits for individual or averaged zones), as shown in Table 5.41. The exterior lighting wattage inputs are changed in the prototype models to reflect the differences.

Table 5.39. Exterior Lighting Power Allowances

		90.1-2004	90.1-2010			
		All Zones (zones not defined in 90.1-2004)	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**
Base Site Allowance (2010 base allowance may be used in tradable or non-tradable surfaces)		5% Additional Allowance for Tradable Surfaces Wattage	500 W	600 W	750 W	1300 W
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**Uncovered Parking Areas**					
	Parking areas and drives	0.15 W/ft^2	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
	Building Grounds					
	Walkways less than 10 feet wide	1.0 W/linear foot	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater	0.2 W/ft^2	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.20 W/ft^2
	Plaza areas					
	Special Feature Areas					
	Stairways	1.0 W/ft^2	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
	Pedestrian Tunnels	Na	0.15 W/ft^2	0.15 W/ft^2	0.20 W/ft^2	0.30 W/ft^2
	Landscaping	Na	0.04 W/ft^2	0.05 W/ft^2	0.05 W/ft^2	0.05 W/ft^2
	Building Entrances and Exits					
	Main entries	30 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry Canopies	1.25 W/ft^2 (also applies to overhangs under Canopies and Overhangs)	0.25 W/ft^2	0.25 W/ft^2	0.40 W/ft^2	0.40 W/ft^2
	Sales Canopies					
	free standing and attached	1.25 W/ft^2 (not explicitly listed)	0.6 W/ft^2	0.6 W/ft^2	0.8 W/ft^2	1.0 W/ft^2
	Outdoor Sales					
	Open areas (including vehicle sales lots)	0.5 W/ft^2	0.25 W/ft^2	0.25 W/ft^2	0.5 W/ft^2	0.7 W/ft^2

		90.1-2004	90.1-2010			
		All Zones (zones not defined in 90.1-2004)	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**
	Street frontage for vehicle sales lots in addition to "open area" allowance	20 W/linear foot	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and can-not be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "tradable Surfaces" section of this table.)	**Building Facades**	0.2 W/ft^2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length	No allowance	0.1 W/ft^2 for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length	0.15 W/ft^2 for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length	0.2 W/ft^2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft^2 of uncovered area (covered areas included with Canopies and Overhangs)	1.25 W/ft^2 of uncovered area (covered areas included with Canopies and Overhangs)	1.25 W/ft^2 of uncovered area (covered areas included with Canopies and Overhangs)	1.25 W/ft^2 of uncovered area (covered areas included with Canopies and Overhangs)	1.25 W/ft^2 of uncovered area (covered areas included with Canopies and Overhangs)
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft^2 of uncovered areas (covered areas included with Canopies and Overhangs)	0.5 W/ft^2 of uncovered areas (covered areas included with Canopies and Overhangs)	0.5 W/ft^2 of uncovered areas (covered areas included with Canopies and Overhangs)	0.5 W/ft^2 of uncovered areas (covered areas included with Canopies and Overhangs)	0.5 W/ft^2 of uncovered areas (covered areas included with Canopies and Overhangs)
	Drive-up windows/doors	400 W per drive-through (explicitly says at fast food restaurants)	400 W per drive-through	400 W per drive-through	400 W per drive-through	400 W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

Table 5.40. Building Prototype Exterior Zone Assignment

Prototype	Exterior Lighting Zone Type (s)	Prototype	Exterior Lighting Zone Type(s)
Small Office	2,3	Hospital	3,4
Medium Office	2,3	Small Hotel	3
Large Office	4	Large Hotel	3,4
Standalone Retail	2,3	Warehouse	2,3
Strip Mall	2,3	Quick-service Restaurant	2,3,4
Primary School	2	Full-service Restaurant	2,3,4
Secondary School	2,3	Mid-rise Apartment	2,3
Outpatient Healthcare	2,3	High-rise Apartment	3,4

Table 5.41. Exterior Lighting Savings Summary for Addendum 90.1-07i

	Parking Lot		Doors		Facade		Total Exterior Lighting		
Prototype	90.1 2004 Load (W)	90.1 2010 Load (W)	90.1 2004 Load (W)	90.1 2010 Load (W)	90.1 2004 Load (W)	90.1 2010 Load (W)	90.1 2004 Load (W)	90.1 2010 Load (W)	Savings (W)
Small Office	1,215	648	255	240	72	36	1,543	925	618
Medium Office	13,122	6,998	1,442	1,442	349	261	14,913	8,702	6,211
Large Office	48,904	42,383	8,449	8,449	2,864	2,864	60,216	53,696	6,520
Stand-alone Retail	3,189	1,701	950	950	193	145	4,333	2,796	1,537
Strip Mall	2,119	1,130	709	574	130	65	2,958	1,769	1,189
Primary School	2,204	881	2,905	2,461	109	54	5,217	3,397	1,821
Secondary School	8,859	4,725	7,290	6,030	183	92	16,333	10,847	5,486
Outpatient Healthcare	3,038	1,620	421	391	60	30	3,519	2,041	1,478
Hospital	9,623	7,377	8,294	8,294	995	746	18,911	16,417	2,494
Small Hotel	4,678	3,119	7,659	7,659	310	233	12,646	11,010	1,637
Large Hotel	10,874	8,337	2,286	2,286	1,771	1,328	14,931	11,951	2,980
Warehouse	3,038	1,620	4,715	4,565	52	26	7,805	6,211	1,594
Quick-service Restaurant	1,519	979	209	209	164	123	1,891	1,311	581
Full-service Restaurant	1,519	979	382	382	206	154	2,107	1,515	591
Mid-rise Apartment	4,274	2,279	NA	NA	142	107	4,416	2,386	2,030
High-rise Apartment	10,685	8,192	NA	NA	783	587	11,467	8,779	2,689

5.2.4.3 Addendum 90.1-07x: Occupancy Sensor Control of Interior Lighting

Addendum 90.1-07x includes several changes that affect the following sections of 90.1-2007:

- Section 9.1.2, is modified so that Section 9.4.1.2 includes the occupancy sensor control requirements in subsection (a) in addition to the previous requirement to comply with Section 9.4.1.2b, which allows manual or occupancy control in space types not covered in subsection (a).
- Section 9.4.1.1, is modified so that it applies automatic shut-off controls to buildings of any size, not just buildings larger than 5,000 ft^2. Exception (a) is also modified so that lighting "intended" for 24-hour operation is changed to "required."
- Section 9.4.1.2a is changed to add space types subject to required shutoff within 30 minutes.
    - Lecture halls and non-shop or laboratory classrooms in preschool through 12th grade are added to classrooms.
    - Training rooms are added to conference and meeting rooms.
    - Storage and supply rooms between 50 ft^2 and 1,000 ft^2, copy and printing rooms, offices up to 250 ft^2, restrooms, and dressing, locker, and fitting rooms are added.
    - Exceptions are also modified. The multi-scene control exception remains and a definition is added to 90.1-2007, Section 3.2. As noted above, shop and laboratory classrooms are also included, spaces where control would endanger safety or where 24-hour lighting is required.
- Section 9.4.1.2b is modified so that spaces other than those in Section 9.4.1.2 a. and that require manual or automatic controls allow occupant override of two hours rather than four hours during time-of-day shutoff periods.

Savings for these changes implemented in the PI are limited to the expansion of space types with required occupancy lighting control in Section 9.4.1.2. The prototypes are all considered new construction, so Section 9.1.2 for lighting alterations is not considered. All prototypes are larger than 5,000 ft^2, so the change to Section 9.4.1.1 does not apply. Occupant override is considered a limited occurrence that cannot be estimated effectively, and the difference between a maximum of two and four hours for the limited hours with override would result in modest savings.

Implementing the PI savings analysis for Section 9.4.1.2a requires identifying the appropriate building areas by space type to apply the occupancy sensor control, determining the amount of reduction in lighting energy for the control for each space type, and applying this to the building prototype lighting power inputs. An outline of the implementation steps is provided below. Note that this procedure uses and is applied to the new addendum 90.1-07by LPD values that are described in Section 5.2.4.7 in this report.

- The NC^3 database (Richman 2008) provides a compilation of Standard 90.1- prototype buildings and the proportion of the building area assigned to the 90.1-2007 space type per Table 9.6.1 which provides LPDs for the space-by-space method. The data do not distinguish lecture halls, dressing or fitting rooms, or copying and printing rooms; however, some of these types of rooms are likely included in other space types such as classrooms for lecture halls. Table 5.42 shows an example of these space-types percentage areas for the large hotel prototype. Space types subject to the new occupancy sensor requirements, such as restrooms, are shown in bold in Table 5.4.2.

- Target percentage lighting reductions are determined for adding occupancy sensors. These lighting reduction values are estimated as the average of occupied hour percentage reductions from two primary sources (Richman 1994 and VonNeida et. al. 2000). For locker rooms and dressing/fitting rooms, Standard 90.1-07's Appendix G assumption of 10% reduction is used. Table 5.43 summarizes the resulting reduction for each space type affected.
- As a simplification (and as allowed in Appendix G of Standard 90.1-07), this percentage savings is applied as a reduction to LPD for all hours of the day. The savings percentage is reduced for spaces in proportion to the lighting that is on during the occupied hours compared to the lighting that is on for all hours. The lighting that is on during the occupied hours is the sum of the hourly schedule fractions of lighting for the occupied hours. The lighting that is on for all hours is the sum of the hourly schedule fractions for all hours. See Section 4.1 of this report for an example of the fractional hourly schedules, and Appendix C for a listing of all of the model schedules including lighting. For example, the medium office savings reduction is adjusted to 89% of the percentage savings determined for office spaces. The hourly model schedules already account for off-hour lighting control based on sweep control or a similar method. Counting the savings reduction for addendum 90.1-07x during unoccupied hours would double count the savings. The percentage reduction in lighting is not reduced for spaces that are occupied 24 hours per day.

Table 5.42. Large Hotel Example of Percentage of Building Area by Space Type

Space Type	Percentage of Total Area
Guestrooms	59.3%
Corridor/Transition	11.4%
Fitness Area	5.0%
Lobby	3.9%
Conference Meeting/Multipurpose	3.2%
Dining Area	3.2%
Stairway	2.6%
Electrical/Mechanical	2.6%
Active Storage >=50 and <=1,000[a]	**1.9%**
Food Preparation	1.1%
Office – Enclosed[a]	**1.1%**
Locker Room[a]	**0.9%**
Laundry – Washing	0.9%
Restrooms[a]	**0.9%**
Office - Open Plan	0.7%
Lounge/Recreation	0.5%
Active Storage <50 and >1,000	0.3%
Merchandising Sales Area	0.2%
Exam/Treatment	0.1%
Workshop	0.1%
Total	100.0%

(a) Controls are added to these space types for addendum 90.1-07x

Table 5.43. Occupancy Sensor Control Lighting Reduction by Space Type

Space types	Reduction Estimate
Pre-K to 12 Classrooms	32%
Storage and Supply (50-1,000 ft^2)	48%
Offices (private up to 250 ft^2)	22%
Restrooms	34%
Dressing/Fitting Rooms	10%
Locker Rooms	10%

- Wattage savings for each space type in each prototype is calculated as the product of the following values: (1) the proportion of each space type to total prototype building area, (2) the target occupancy sensor savings percentage, (3) the ratio of occupied lighting usage to total lighting usage, (4) the space-by-space LPD, and (5) the prototype total building area.
- The LPD reduction for each prototype is determined as the sum of the wattage savings for each space type affected by the control divided by prototype total area. The sum of the wattage savings for each space type is applied to all spaces in a prototype in order to capture savings for space types that are not represented in the prototype or are represented out of proportion to the proportion of the space type in the NC^3 database.
- Final LPD inputs to each 90.1-2010 model are calculated by subtracting LPD reductions from the LPDs for all zones in the prototype models. Table 5.44 shows the final adjustment applied to the LPD values.

Table 5.44. Summary of Addendum 90.1-07x Lighting Power Reductions by Prototype

Prototype	LPD Reduction (W/ft^2)	Prototype	LPD Reduction (W/ft^2)
Small Office	0.0493	Hospital	0.0316
Medium Office	0.0562	Small Hotel	0.0095
Large Office	0.0522	Large Hotel	0.0119
Standalone Retail	0.0119	Warehouse	0.0021
Strip Mall	0.0063	Quick-service Restaurant	0.0545
Primary School	0.1269	Full-service Restaurant	0.0472
Secondary School	0.0966	Mid-rise Apartment	0.0089
Outpatient Healthcare	0.0595	High-rise Apartment	0.0406

5.2.4.4 Addendum 90.1-07aa: Lighting Occupancy Sensor Control Type

90.1-2004 and 90.1-2007 Section heading 9.4.1 Lighting Control does not include any separate text from the sub-sections that follow it. These sub-sections under 9.4.1, 9.4.1.1, 9.4.1.2 and 9.4.1.4, include requirements for occupancy sensors and automatic controls. Addendum 90.1-07aa affects these lighting controls sections by adding language to Section 9.4.1 to explicitly apply to all of the lighting control subsections and by adding language regarding automatic shut-off controls as applied in Sections 9.4.1.1, 9.4.1.2 and 9.4.1.4:

- Automatic controls are required to be manual on, that is, not come on automatically.
- Exceptions are provided for public corridors and stairwells, restrooms, primary building entrances, and areas where manual on would endanger safety or security.

Addendum 90.1-07aa also results in small changes to the savings implementation presented in this report's Section 5.2.4.3 on addendum 90.1-07x.

Addendum 90.1-07bp is related to addendum 90.1-07aa and adds an option for 50%-on occupancy sensors. This type of occupancy sensor may add a little more savings than manual-on sensor, but there is no compelling evidence for this; and throughout the progress indicator process, no credit for savings from optional provisions is taken. No implementation of addendum 90.1-07bp is included in the PI.

Implementing the PI savings analysis for addendum 90.1-07aa requires determining the added benefit of this type of occupancy sensor compared with automatic on and off occupancy sensors. A limited study supports savings estimate for perimeter daylit offices only and therefore savings is applied to small, medium, and large office prototypes only (DiLouie 2009). With such a limited basis for estimating savings, a conservative approach is taken.

A similar methodology to that taken for addendum 90.1-07x is applied. Savings analysis is applied to the small, medium, and large office prototypes based on the proportion of daylit perimeter enclosed office space. Enclosed office space as a proportion of total building area is determined using the NC^3 database (Richman 2008). Daylit perimeter enclosed office space is assumed to be 50% of total enclosed office area. The percentage reduction for the manual control is 46% and is further reduced to 25% of this value for a reduction of 11.5%. A total wattage reduction is determined and divided by total building area, resulting in a LPD reduction. For each office prototype, the corresponding LPD reduction is applied. The LPD model inputs are found by applying the savings reduction to the interior lighting LPD values calculated when applying addenda 90.1-07x and 90.1-07by.

Table 5.45. Manual-On Occupancy Sensor Lighting Power Reduction

Prototype	LPD reduction (W/ft^2)
Small Office	0.0217
Medium Office	0.0191
Large Office	0.0143

5.2.4.5 Addendum 90.1-07aw: Lodging Guestroom Bathroom Lighting Control

90.1-2004 and 90.1-2007, Section 9.4.1.4, requires a master lighting control at the point of entry/exit for all permanently installed luminaires and switched receptacles in hotel and motel guestrooms and guest suites. Addendum 90.1-07aw modifies this requirement to allow multiple control devices that collectively control all permanently installed luminaires except those in the bathrooms. The bathrooms are required to have a separate control device capable of turning off the bathroom lighting, except night lighting not exceeding 5 W, within 60 minutes of an occupant leaving the space.

Addendum 90.1-07aw applies to the small and large hotel prototypes. Bathroom lights are assumed to account for 31% of all guest room lighting in hotels and motels, based on input from the Lighting Subcommittee. Occupancy sensors are assumed to reduce energy consumption by 10% according to 90.1-2007, Appendix G, Table G3.2 which provides factors for lighting reduction depending on applicability of other lighting controls that are also required. The LPD for guestrooms in hotels and motels is reduced to capture savings from this addendum as shown below:

$$1.1\ W/ft^2 * 31\% * 10\% = 0.034\ W/ft^2 \text{ reduction}$$

The 90.1-2004 guest room LPD is 1.1 W/ft^2 and for 90.1-2010 is 1.067 W/ft^2.

5.2.4.6 Addendum 90.1-07bq: Retail Display Lighting

90.1-2004 Section 9.6.2 includes two categories of retail display lighting eligible for additional lighting power allowances, normal merchandise and valuable merchandise. Section 9.6.2 in 90.1-2007 provides additional LPD allowances for display lighting (only where used to light merchandise) in sales areas for four merchandise categories:

- Retail Area 1: general, not listed in Retail Areas 2 through 4
- Retail Area 2: vehicles, sporting goods, and small electronics
- Retail Area 3: furniture, clothing, cosmetics, and artwork
- Retail Area 4: jewelry, crystal, and china.

Addendum 90.1-04ai (i.e., 90.1-2007) is the source of this change from 90.1-2004 to 90.1-2007, and is not intended to result in savings, and therefore is not treated separately in this report. However, to consistently implement retail display lighting for the different versions of the models, the 90.1-2007 additional display lighting allowance used as the starting point for addendum 90.1-07bq is calculated as being somewhat lower than for 90.1-2004, as shown in Table 5.46.

Addendum 90.1-07bq reduces the display lighting LPD allowances for the four sales area categories introduced in 90.1-2007.

Only the strip mall prototype includes display lighting. Based on information provided by the Lighting Subcommittee, the standalone retail prototype does not include display lighting.

The strip mall includes eight stores, which are assigned to the different retail display allowance categories. Retail areas type 2 and 3 are assigned to portions of the strip mall prototype. Addendum 90.1-07bq reduces the added lighting allowance for retail area type 2 from 1.7 W/ft^2 to 0.6 W/ft^2 and for retail area type 3 from 2.6 W/ft^2 to 1.4X W/ft^2.

Where display lighting is included, it is assumed to light 25% of the zone. A weighted average of the display lighting allowance is determined by multiplying the percentage of the entire strip mall area for each store by the percentage of area with display lighting by the added display lighting allowance, as shown in Table 5.46. The total display lighting allowance is added to the other retail lighting determined by the space-by-space method.

Retail areas type 1 and 4 allowance values are not used in the modeling and are not shown in Table 5.46. For addendum 90.1-07bq, the Retail Area 1 added lighting allowance is reduced from 1.0 W/ft^2 to 0.6 W/ft^2, and the Retail Area 4 allowance is reduced from 4.2 W/ft^2 to 2.5 W/ft^2.

Table 5.46. Adjusted Display Lighting Allowance for Strip Malls

Zones	Percentage of Total Building Area	Zone Area with Display Lighting	90.1-2004 Display Type	90.1-2004 Added Display (W/ft^2)	90.1-2007 Display Type	90.1-2007 Added Display (W/ft^2)	90.1-2010 Display Type	90.1-2010 Added Display (W/ft^2)
LGSTORE1 SMSTORE1	25%	25%	valuable merchandise	3.9	Type 2	2.6	Type 2	0.6
SMSTORE2 SMSTORE3 SMSTORE4	25%	25%	normal merchandise	1.6	Type 3	1.7	Type 3	1.4
LGSTORE2 SMSTORE5 SMSTORE6 SMSTORE7 SMSTORE8	50%	0%	None	0	none	0	none	0
Display Lighting Added to Total LPD	none	none	None	0.344	none	0.269	none	0.125

5.2.4.7 Addendum 90.1-07by and 90.1-07de: Interior LPD Allowance

90.1-2007, Chapter 9, includes requirements for maximum LPD. Two prescriptive methods are allowed and tables of values are provided. The primary compliance path uses Table 9.5.1 which includes LPDs that are applied to an entire building area. An alternative path uses Table 9.6.1, which allows assignment of maximum LPDs to specific space types.

Addendum 90.1-07by is a full update of the values in both Tables 9.5.1 and 9.6.1 of the standard. The maximum allowed LPD values decrease generally with some exceptions. This addendum also introduces Section 9.6.3, “Room Geometry Adjustment,” which defines a room cavity ratio (RCR) threshold. RCR is defined as the product of 2.5, room cavity height, and room perimeter length divided by room area. Room cavity height is the luminaire mounting height minus the work plane height. The RCR threshold values are added to Table 9.6.1 for each space type. If the RCR calculated for a space is greater than the threshold, then an additional allowance of 20% can be added to the normal LPD allowance in Table 9.6.1. Corridor/transition spaces are allowed in the adjustment if they are less than eight-feet wide, regardless of the RCR.

Tables 9.5.1 and 9.6.1 in 90.1-2004, 90.1-2007, and 90.1-2010 are not included in this report and can be viewed in those different versions of Standard 90.1.

Implementing addendum 90.1-07by is straightforward for most prototypes and zones apart from the RCR allowance. All prototypes and all climate zones are affected by addendum 90.1-07 by LPD changes because all have LPD values that are based on either the building area method for small, medium, and large offices, or the space-by-space method for other prototypes and zones. In some cases, zones include a mix of space types, and the values are a weighted average of those different space types. The LPD is recalculated using the new space-by-space allowance and the area weighting.

Completing implementation of addendum 90.1-07by requires addressing the RCR. PNNL developed a set of RCR data based on the NC^3 dataset of spaces in different buildings, representing many of the space types in Standard 90.1, Table 9.6.1. Zones in the prototypes are evaluated to determine which are eligible and should apply the RCR 20% increased LPD allowance by multiplying four values:

- The area weighted proportion of each space type with areas for spaces that meet or exceed the RCR level. This calculation results in a percentage of that space type total area that is eligible for the adjustment.
- The assumed proportion of projects that use the space-by-space method: 50%.
- The assumed proportion of those projects that will calculate the RCR: 50%
- The allowed percentage LPD increase if the RCR threshold is met: 20%

If the result exceeds a 1% increase in LPD, an LPD adjustment is considered. Three space types are identified with the RCR adjustment applied in addendum 90.1-07by to the 90.1-2010 models:

- Hotel, Exercise: +5.0%. All four cases exceed the RCR limit.
- Hospital, Exam/Treatment: +3.3%. Four of six cases exceed the RCR limit and two other cases are close.
- Corridor/Transition: +1.1%. The adjustment applies to all building types, with 5 of the 22 spaces meeting the less than 8 ft-width criteria.

Addendum 90.1-07de further modifies Table 9.6.1 as follows:

- Changes the general lobby allowance to 0.90 W/ft^2 from the 0.65 W/ft^2 allowed in addendum 90.1-07by.
- Introduces an elevator lobby allowance of 0.64 W/ft^2.
- Eliminates the LPD allowance for audience seating in the fitness center.

Addendum 90.1-07de is implemented differently for different prototypes. Small hotels, outpatient healthcare, primary and secondary schools include zones defined with the general lobby space-type, so the LPD for these areas is increased by 0.25 W/ft^2. High-rise and mid-rise apartments, quick-service and full-service restaurants, strip malls, and warehouses do not have lobby zones defined in the model or in NC^3 database. Therefore, this addendum is not applied to these prototypes. The large hotel prototype includes a lobby zone, but hotel lobby is a separate space type from general lobby in 90.1-2010 and has a separate LPD limit, which is not changed by addendum 90.1-2007de. Calculations described below are made for the remaining prototypes, including hospital, standalone retail, and small, medium and large offices.

For the hospital and standalone retail prototypes, the lobby space type is not identified for a modeled zone. For offices, the LPD is defined by the building area method. The same value is used for all zones, and separate space types are not explicitly identified in the model. For these prototypes, the NC^3 database includes the lobby space-type as part of the building area (Richman et al. 2008). LPD adjustments are made to reflect the increase in LPD for general lobby space weighted by the effective lobby area in the prototype. These adjustments are similar to the methodology described in Section 5.2.4.3 for addendum 90.1-07x, using the NC^3 database. For offices, the LPD adjustment is applied to all zones in proportion to the NC^3 ratio of lobby area to total area. Table 5.47 shows the increase in LPD allowance by zone for these prototypes.

Table 5.47. Lobby Lighting Reduction for Selected Zones by Prototype

Prototype	Area	LPD Increase (W/ft^2)
Small Office	LPD_Office (all zones)	0.0233
Medium Office	LPD_Office (all zones)	0.0090
Large Office	LPD_Office (all zones)	0.0068
Standalone Retail	LPD_Entry	0.2500
Hospital	LPD3_Records	0.2250
	LPD5_NurseStn_Lobby1	0.1000
	LPD9_NurseStn_Lobby2	0.1500

5.2.4.8 Addendum 90.1-07cd: Exterior Lighting Automatic Controls

90.1-2007, Section 9.4.1.3, requires lighting for all exterior applications to have automatic controls capable of turning the lights off when sufficient daylight is available or when lighting is not required during night time hours. The lighting that is not designed for dusk-to-dawn operation is to be controlled by either a photosensor and time switch or an astronomical time switch. 90.1-2007, Section 9.4.5, lists the exterior lighting applications exempt from the requirements of Section 9.4.1.3. Addendum 90.1-07cd modifies these sections as follows:

- Section 9.4.1.3 is modified to expand the scope of exterior lighting control. It requires lighting for exterior application not exempt in Section 9.1 to be controlled by a device that automatically shuts off lighting when sufficient daylight is available. Exterior facade and landscape lighting is to be automatically turned off between business closing or midnight, whichever is later, and until 6 am or business opening, whichever is earlier. Exterior lighting not specified as facade or landscape lighting, including advertising signage, is to be automatically reduced to 30% of its peak power between midnight or within 1 hour of business closing, whichever is later, and until 6 am or business opening, whichever is earlier, and during any period activity is not detected for a time longer than 15 minutes.
- Section 9.4.5 exceptions are expanded to include lighting for hazardous locations, swimming pools and water features, and searchlights.

Facilities that are open 24 hours a day, such as hospitals, outpatient healthcare, small and large hotels, and high-rise and mid-rise apartments, which do not have close of business hours, do not have to turn lights off when the night time setback control would otherwise be required by this addendum.

This addendum is implemented by separating the exterior facade lighting from the total exterior lighting and modifying the exterior lighting operating schedules. This separation includes the reduction in exterior lighting power and the allocation of exterior lighting power shown in this report's Section 5.2.4.2 for addendum 90.1-07i. Table 5.48 provides an example of this separation for the Large Office.

Table 5.48. Large Office Example of Facade Lighting Reduction for Controls

Case	All Exterior Lights (W)	Facade Exterior Lights (W)	Other Exterior Lights (W)
Baseline	62,787		
PI		12,979	43,305

Exterior lighting operating schedules are changed to reflect the minimum required power reduction during the midnight to 6 am period. The exterior lighting schedule is separated into a facade schedule with lights off from midnight to 6 am and the rest of the exterior lighting schedule with lights reduced to 30% from midnight to 6 am. The facade exterior lights schedule is applied to the facade exterior lights wattage, and the other schedule is applied to the rest of the exterior lights wattage.

5.2.4.9 Addendum 90.1-07cf: Stairwell Lighting Controls

90.1-2007, Section 9.4.1.4, provides requirements for lighting control for specialized applications. Addendum 90.1-07cf expands this section by adding a requirement for control lighting serving interior stairways. The addendum requires stairwell lighting to be controlled automatically so that lighting power is reduced to 50% within 30 minutes of all occupants leaving the zone. Stairwell lighting under 90.1-2010 has a lighting power allowance of 0.6 W/ft^2.

This addendum is implemented by reducing the LPD of stairwells in the prototype models. The occupancy percentage of stairwells is assumed to be 10%, based on the supporting information in the foreword to the public review of this addendum. The stairwell is therefore unoccupied 90% of the time. The control is calculated as a 50% reduction in lighting when unoccupied as required by the addendum.

LPD reduction = 0.6W/ft^2 * 0.9 (unoccupied fraction) * 50% (control) = 0.27 W/ft^2

The reduction is applied to a zone or zones existing in the prototype model and adjusted so that the effect is in proportion to the area of stairs in typical buildings of the respective prototype. The stairwell area weighting fractions are calculated using area information from the NC^3 database. For the small hotel, a stairwell zone is defined in the model and is used directly without an area fraction adjustment. For the quick-service restaurant prototype, the NC^3 database has no stairwell area and so no reduction in interior lighting is made.

An example of how the stairwell lighting control applies is provided for the high-rise apartment. In the high-rise apartment, the reduction is applied to the lighting power input for the corridor zones because there are not separately defined stairwell zones. The corridor zones are 10% of the building area. Stairwells are 2.5% of typical high-rise apartment buildings from NC^3 data. The calculation below shows how these factors are applied to develop the lighting reduction of 0.0675 W/ft^2 which is applied to the high-rise apartment corridor zones.

$0.27\ W/ft^2 \cdot 2.5\%/10\% = 0.0675\ W/ft^2$

Table 5.49 provides the LPD reductions for all of the affected prototypes.

Table 5.49. LPD Reduction for Stairwell Occupancy Sensor Controls

Prototype	LPD Reduction (W/ft^2)	Prototype	LPD Reduction (W/ft^2)
Small Office	0.0019	Hospital	0.0233
Medium Office	0.0097	Small Hotel	0.2700
Large Office	0.0046	Large Hotel	0.0994
Standalone Retail	0.1080	Warehouse	0.0055
Strip Mall	0.0011	Full-service Restaurant	0.0007
Primary School	0.0248	Mid-rise Apartment	0.1095
Secondary School	0.0341	High-rise Apartment	0.0675
Outpatient Healthcare	0.0288		

5.2.4.10 Addendum 90.1-07ct: Sidelighting Controls

90.1-2004 and 90.1-2007, Chapter 9, do not specify requirements for automatic daylighting controls in sidelit spaces. Addendum 90.1-07ct modifies Section 9.4.1.3 and requires lamps for general lighting to be separately controlled by automatic daylighting controls when the primary sidelit area in a space is 250 ft^2 or larger. There are some detailed descriptions, figures and exceptions that are not replicated here; refer to 90.1-2010, Section 9.4.1.3. See 90.1-2010, Chapter 3, for the definitions of primary sidelit area and sidelighting effective aperture.

Retail spaces (standalone retail and strip mall prototypes) and spaces where the sidelighting effective aperture is less than 0.1 are exempted from the requirements of addendum 90.1-07ct. The mid-rise and high-rise apartment prototypes are excluded from the analyzed savings since interior lighting in dwellings is exempt from the requirements in 90.1-2010, Section 9.1.1, exception b. Other spaces in the apartment prototypes either do not have access to daylight or are relatively small compared with the total building areas and are also excluded from the savings analysis.

Addendum 90.1-07ab, drafted prior to addendum ct, introduces the requirements for primary sidelighted areas. This addendum is primarily concerned with skylights and toplighting controls and is covered in Section 5.2.4.1 of this report. The minimum primary sidelighted area threshold set by addendum 90.1-07ab is 1,000 ft^2. Addendum ct lowers the minimum primary sidelighted area threshold from 1,000 ft^2 to 250 ft^2.

In implementing addendum 90.1-07ct, the primary sidelighted area in each applicable space is calculated. Spaces with less than 250 ft^2 of primary sidelighted area were discarded. Next, the sidelighting effective aperture is calculated in spaces that have over 250 ft^2 of primary sidelighted area. Again, spaces with an effective aperture of less than 0.1 were discarded. Automatic daylighting controls are then placed in the remaining spaces.

Table 5.50 shows the application of the requirements of addendum ct to the Standard 90.1 prototypes. The fraction of zones controlled by automatic dimming controls is equal to the ratio of primary sidelighted area to floor area of the space. Two sensors are placed in each sidelighted area, with each sensor controlling half the total sidelighted area. The dimming control is of the stepped type, and it can lower the peak lighting power in two steps to 66% and 33% of peak power.

For the small, medium, and large office prototypes, additional calculations are required to determine the proportion of modeled exterior fenestration that is accessible for daylighting. Three space types, open offices, enclosed offices and conference rooms, are identified as most likely to have access to windows as well as floor areas of 250 ft^2 and larger in typical office buildings. From the NC^3 database, office building data is separated out into small, medium, and large office datasets based on floor area. The primary sidelighted area in each of the three typical office building types is determined from the NC^3 data. For the large office prototype, usable data in the NC^3 database came from only one building. Therefore, the medium office data was used for the large office prototype.

The primary sidelit area per square foot of floor area, obtained from the NC^3 database, is multiplied by the prototype building's floor area to yield the primary sidelighted area in that prototype. Using this approach, total primary sidelighted areas are calculated for each of the three office prototypes. The next step is to assign the calculated sidelighted areas to different zones in the prototype models. Because no rationale favors a particular facade when distributing sidelit areas total sidelit areas for the office prototypes are distributed equally between their four facades.

Table 5.50. Sidelighting Analysis and Implementation

Prototype and Zone	**Effective Aperture**				**Primary Sidelighted Area (PSA) (ft²)**	**Zone Area (ZA) (ft²)**	**Fraction of Zone Controlled = PSA/ZA**	**Target Illuminance (FC)**
	CZ 1,2,3C	**CZ 3**	**CZ 4,5,6**	**CZ 7,8**				
Small Office								
Perimeter_ZN_1								
Perimeter_ZN_3	0.12	0.41	0.66	0.58	385	1,221	12%	50
Perimeter_ZN_2								
Perimeter_ZN_4	0.13	0.41	0.66	0.58	225	724	21%	50
Medium Office[1]								
Perimeter_mid_ZN_1								
Perimeter_mid_ZN_3	0.14	0.18	0.28	0.25	1,256	2,232	54%	50
Perimeter_mid_ZN_2	0.14	0.18	0.28	0.25	837	1,413	55%	50
Large Office[1]								
Perimeter_mid_ZN_1								
Perimeter_mid_ZN_3	0.16	0.2	0.32	0.28	1,957	3,374	56%	50
Perimeter_mid_ZN_2								
Perimeter_mid_ZN_4	0.16	0.2	0.32	0.28	1,304	2,174	57%	50
Primary School[2]								
Corner_Class_1_Pod_1_ZN_1_FLR_1	0.16	0.42	0.67	0.6	473	1,066	44%	50
Mult_Class_1_Pod_1_ZN_1_FLR_1	0.14	0.18	0.28	0.25	1,435	5,134	28%	50
Mult_Class_2_Pod_3_ZN_1_FLR_1	0.14	0.18	0.28	0.25	947	3,391	28%	50
Computer_Class_ZN_1_FLR_1	0.14	0.18	0.28	0.25	487	1,744	28%	50
Lobby_ZN_1_FLR_1	0.14	0.18	0.28	0.25	514	1,840	28%	35
Offices_ZN_1_FLR_1	0.15	0.38	0.61	0.54	1,069	4,747	23%	50
Gym_ZN_1_FLR_1	0.14	0.18	0.28	0.25	460	3,843	12%	35
Cafeteria_ZN_1_FLR_1	0.15	0.38	0.61	0.54	906	3,391	27%	35
Library_Media_Center_ZN_1_FLR_1	0.15	0.38	0.61	0.54	1,015	4,295	24%	50

Table 5.50 (cont'd)

Prototype and Zone	Effective Aperture				Primary Sidelighted Area (PSA) (ft²)	Zone Area (ZA) (ft²)	Fraction of Zone Controlled = PSA/ZA	Target Illuminance (FC)
	CZ 1,2,3C	CZ 3	CZ 4,5,6	CZ 7,8				
Secondary School[2,3]								
Corner_Class_1_Pod_1_ZN_1_FLR_1	0.16	0.42	0.67	0.6	473	1,066	44%	50
Mult_Class_1_Pod_1_ZN_1_FLR_1	0.14	0.18	0.28	0.25	1,435	5,134	28%	50
Lobby_ZN_1_FLR_1	0.14	0.18	0.28	0.25	406	2,260	18%	35
Offices_ZN_1_FLR_1	0.15	0.39	0.63	0.56	1,339	5,726	23%	50
Aux_Gym_ZN_1_FLR_1	0.06	0.16	0.26	0.23	4,863	13,433	36%	35
Cafeteria_ZN_1_FLR_1	0.15	0.38	0.60	0.53	1,286	6,717	19%	35
Library_Media_Center_ZN_1_FLR_2	0.15	0.38	0.60	0.53	1,529	9,042	17%	50
Auditorium_ZN_1_FLR_1	0.05	0.07	0.11	0.1	2,659	10,635	25%	35
Outpatient Healthcare								
Floor 2 Reception	0.13	0.47	0.75	0.66	360	984	37%	35
Hospital								
Office1_Flr_5, Office3_Flr_5	0.14	0.38	0.61	0.54	335	750	45%	50
Lobby_Records_Flr_1	0.14	0.18	0.28	0.25	1,207	15,875	8%	35
Small Hotel[3]								
Front Lounge Flr1	0.09	0.12	0.19	0.17	423	1,755	24%	35
Large Hotel								
LobbyFlr1	0.23	0.29	0.46	0.41	1,020	14,081	7%	35
Café	0.22	0.29	0.46	0.4	787	2,032	39%	35
Dining_Flr6	0.13	0.16	0.25	0.23	693	3,567	19%	35
Banquet_Flr6	0.13	0.16	0.25	0.23	693	3,567	19%	35
Warehouse[3]								
Office	0.08	0.21	0.34	0.3	560	2,550	22%	50
Quick Service Restaurant								
Dining	0.13	0.33	0.52	0.46	554	1,250	44%	35
Full Service Restaurant								
Dining	0.12	0.29	0.47	0.41	1,100	4,001	27%	35

1. Daylighting controls are not applied to spaces in those climate zones where the effective aperture drops below 0.1.
2. School prototypes have multiple identical zones with identical properties as some of those shown in table, and are not all shown in table.
3. Large and Medium Office prototypes have zone multipliers. The daylighting controls shown in the table are used by the zone multipliers and applied to the affected zones.

5.2.5 Other Equipment

Standard 90.1, Chapter 10, “Other Equipment,” regulates equipment not covered in other chapters of the standard. The only other equipment covered in 90.1-2004 and 90.1-2007 are electric motors subject to the *Energy Policy Act of 1992*. Addendum 90.1-07aj expands the scope of motors covered by Standard 90.1 and increases the minimum motor efficiency values consisting with Federal law and federal rulemaking. Addendum 90.1-07df sets requirements on elevator lights and ventilation fans. This section discusses the modeling strategies for addenda aj and df. Addendum 90.1-07cv adds energy efficiency requirements for service water heating booster pumps, however, service water heating booster pumps are not specifically modeled in any of the prototypes, and no savings are quantified for addendum cv.

5.2.5.1 Addendum 90.1-07aj: Motor Efficiency

90.1-2004 and 90.1-2007 provide minimum motor efficiency requirements in Chapter 10, “Other Equipment.” The requirements apply to motors covered in the *Energy Policy Act of 1992*, identified in 90.1-2004 and 2007 Table 10.8 as general purpose design A and design B motors from 1 to 200 horsepower rated under National Electrical Manufacturers Association Standard MG 1-2006 (ANSI/NEMA 2006).

Addendum 90.1-07aj includes updated minimum efficiency values for motors manufactured as of December 19, 2010. Such motors must comply with the requirements of the *Energy Independence and Security Act of 2007*. Additional motor sizes larger than 200 hp are added in 50 hp increments from 250 to 500 hp. Addendum 90.1-07aj introduces a new motor table, Table 10.8B, for motors manufactured on or after December 19, 2010. This addendum also includes Table 10.8A, which covers motors manufactured before December 19, 2010, and is the same as Table 10.8 in 90.1-2007.

The published 90.1-2010 differs from the final version of addendum 90.1-07aj, and includes three tables instead of 2. Tables 10.8A and 10.8B are as described in the preceding paragraph on addendum aj. The additional table, Table 10.8C, covers Subtype II and Design B motors and, for the motors from 1 hp to 200 hp, includes the same efficiency requirements as in Table 10.8 in 90.1 -2004 and 90.1-2007.

Motors in the prototype buildings are understood to be the Subtype I motors covered in the Table 10.8 in the two earlier versions of Standard 90.1 and in Tables 10.8 A and B in 90.1-2010. The change in the motor efficiency requirements is applied to all prototypes and climate zones that include 1 hp or larger standard motors. The change is implemented in the PI process through a script that uses the equipment sizing information produced in initial sizing runs and assigns motor efficiency based on nominal motor size. Nominal motor size is calculated by determining the next motor size in the table that is greater than 110% of the brake horsepower reported from the sizing runs. Motor brake horsepower results from load on the motor and other modeled inputs described in Chapter 4 in this report for the corresponding equipment such as fans and pumps.

The changes in motor efficiency requirements from the addendum add up to 3% to the earlier efficiency values, with larger increases for smaller motors. For example, the motor efficiency requirement for a 10 hp, open 4-pole, 1800 rpm motor increases from 89.5% to 91.7%. The full listing of the values for comparison is available in Table 10.8 in Standards 90.1-2004 and 90.1-2007, and in Table 10.8B in Standard 90.1-2010.

5.2.5.2 Addendum 90.1-07df: Elevator Lighting and Ventilation

90.1 -2004 and 90.1-2007 do not specify any requirements for building elevators. Addendum 90.1-07df adds three provisions:

- Section 10.4.3.1, “Lighting.” All cab lighting systems must have efficacy of not less than 35 lumens per watt.
- Section 10.4.3.2, “Ventilation Power Limitation.” Cab ventilation fans for elevators without air-conditioning must not consume over 0.33 W/cfm at maximum speed.
- Section 10.4.3.3, “Standby Mode.” When stopped and unoccupied with doors closed for over 15 minutes, cab interior lighting and ventilation must be de-energized until required for operation.

To analyze the energy savings from Section 10.4.3.1 of 90.1-2010, the elevator lighting systems in the baseline models are assumed to be composed of two lighting sources: 70% incandescent (10 lumens/W) and 30% high efficacy (35 lumens/W) as described in Section 4.9.2 of this report. The elevator lighting in the 90.1-2010 models is assumed to use all high efficacy light sources. Table 5.51 shows the assumed elevator size. Based on the elevator floor area and LPD calculated from the required illumination levels and efficacy, the lighting power is calculated to be 88 W per elevator for the baseline and 32 W per elevator for 90.1-2010 (see Table 5.52). Table 4.21 in Chapter 4 of this report shows the number of elevators per prototype used to calculate total elevator lighting power for each prototype.

Based on engineering judgment, the ventilation power limitation specified in Section 10.4.3.2 of 90.1-2010 is close to common design practice. Therefore, the ventilation fan power in the baseline buildings is assumed to be the same as that in the 90.1-2010 buildings, as shown in Table 5.53.

To analyze the energy savings from Section 10.4.3.3 of the 90.1-2010, the elevator fan and lights are assumed to always be on in the baseline buildings. In the 90.1-2010 models, the schedules of the elevator fan and lights are assumed to be on the same fractional amount as the elevator motor schedules with one exception. This reflects the portion of the time the lights and fan are on, not the portion of the lighting and fan equipment that are on. The exception is that, when the elevator motor schedule fraction is ≥0.75, the elevator fan and lights are scheduled completely on, a 1.0 value in the model schedule.

Table 5.51. Elevator Size

Elevator Size	Length	6.66 ft.
	Width	4.25 ft.
	Height	8 ft.
	Floor area	28 ft^2
	Volume	224 ft^3

Table 5.52. Elevator Lighting Power

Elevator Lighting Characteristics	Values	Units
Design Lighting Level	30	lumens/ft^2
Light Loss Factor	75%	
Needed Light Level	40	lumens/ft^2
Baseline Lighting		
Incandescent (70%)	10	lumens/W
	4	W/ft^2
High Efficacy Source (30%)	35	lumens/W
	1.14	W/ft^2
Average Efficacy	17.5	lumens/W
Average LPD	3.14	W/ft^2
Lighting Power	88.0	W per elevator
Addendum 90.1-07 Lighting		
Efficacy Required by Addendum 90.1-07df (100%)	35	lumens/W
LPD	1.14	W/ft^2
Lighting Power	32.0	W per elevator

Table 5.53. Elevator Cab Ventilation Fan Power

Air Change Rate	1	air change per minutes
Ventilation Airflow Rate	224	cfm
Ventilation Power Limitation per Addendum df	0.33	W/cfm
Cab Ventilation Fan power	73.9	W per elevator

6.0 Energy Savings Analysis Results

This chapter provides the results of the PI quantitative savings analysis, the estimated energy and cost savings from 90.1-2010 compared with 90.1-2004. The savings include the impact of the addenda that changed 90.1-2004 to 90.1-2010. The quantitative analysis demonstrates that the DOE and ASHRAE goal of 30% savings is realized based on PNNL's analysis. Table 6.1 presents the national aggregated results using the construction weighting factors (Table 2.2 in this report). Site energy savings are 32.7% and energy cost savings are 29.5%, if plug and process loads are excluded. With plug and process loads included in the percentage saving calculations, the site energy savings are 25.6% and energy cost savings are 23.2%. Site energy is utility electricity and natural gas delivered and used at the building site. Energy cost savings are based on the site energy usage results.

Source energy, the energy used (such as the energy in coal) in generating electricity, and primary energy usage at the site such as natural gas burned in a furnace is also determined. Source energy for electricity is generally much larger than site energy as it accounts for generation efficiencies and distribution losses. Conversion from site energy results from the simulation to source energy results is described in Section 2.4 in this report. Source energy savings are 23.2% with plug and process loads included.

Table 6.1. 90.1 -2010 vs. 90.1-2004 Site Energy Savings Results

National-Weighted Energy Savings	With Plug and Process Loads	Without Plug and Process Loads
Site Energy	25.6%	32.7%
Energy Cost	23.2%	29.5%

Figures 6.1 and 6.2 separate the energy usage savings by prototype with and without plug and process loads and show the percentage savings by prototype and the energy usage index in kBtu/ft^2 for both the 90.1 -2004 and 90.1-2010 cases. While the highest savings percentages occur in the school prototypes when plug and process loads are not included, these percentages do not stand out as much when plug and process loads are included. The lowest percentage savings occur in the quick-service restaurant and two apartment prototypes, particularly when plug and process loads are included.

In the weighting factors in Table 2.2 in this report, the schools represent a relatively large percentage of building area constructed and restaurants represent a small percentage, helping explain how the overall savings percentage is relatively high compared with lowest savings prototypes. These figures also highlight the high energy intensity of the restaurants and the healthcare prototypes. Tables 6.2 and 6.3 provide the same information in tabular form and show similar trends when energy cost is considered.

The results can be examined in other ways, such as aggregated energy savings by climate location and savings by energy end use (e.g., heating, cooling or lighting, and energy). Table 6.4 summarizes the EUI and energy savings aggregated by climate location. One trend in these results for different prototypes is that the overall percentage savings increase in the colder climates. Heating energy becomes a large proportion of total energy usage in those climates, and many changes in the addenda generate heating savings. Table 6.5 shows national aggregated energy savings from each end usage. The savings show that heating, exterior lights, and pumping have the greatest percentage change in energy usage. These energy usage categories are proportionally the most affected by the addenda. Out of the total national weighted annual average savings of 19 kBtu/ft^2, heating is by far the largest energy savings category, almost half of the total savings, at 9 kBtu/ft^2. Cooling, interior lighting, fans, and exterior lighting follow with contributions from 3.0 kBtu/ft^2 down to 1.6 kBtu/ft^2 respectively, with small savings for other specified usage categories. The column labeled "other" shows a small increase overall in energy, primarily due to energy usage for energy recovery ventilators added in the 90.1-2010 models, which is part of this category. Appendix F in this report includes energy end-use data for all 16 prototypes in each representative climate location.

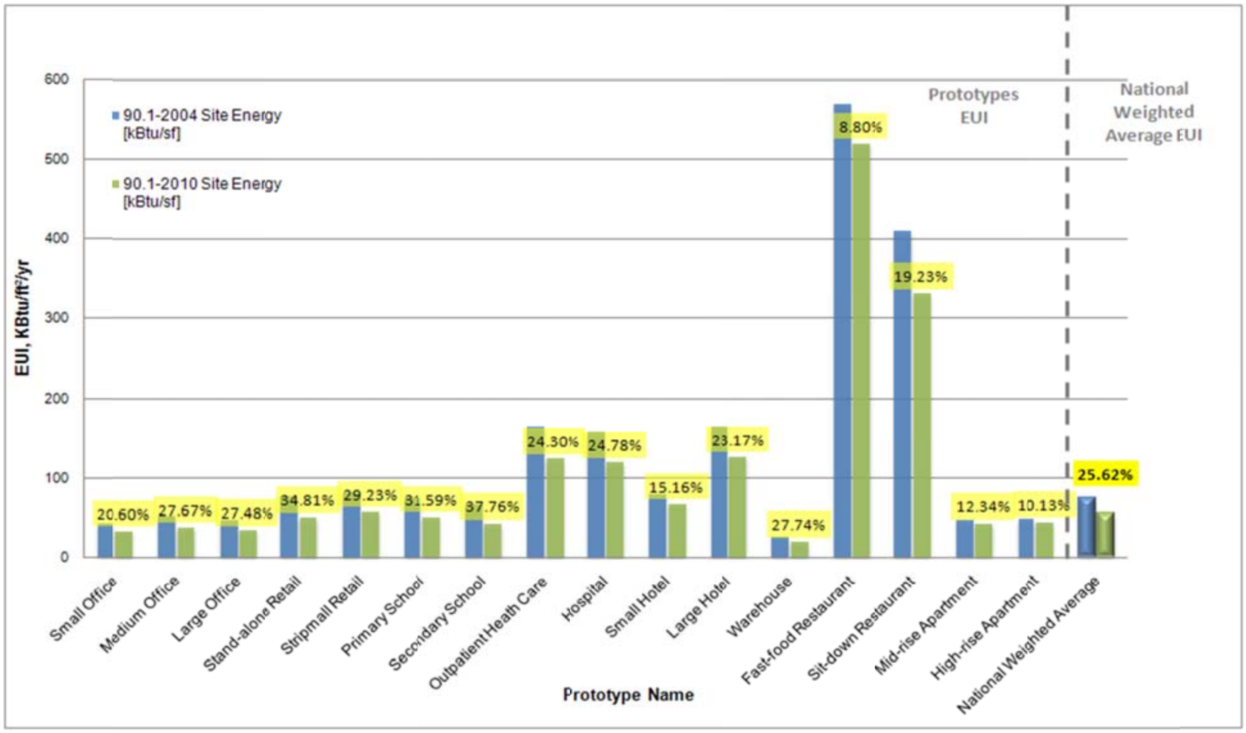

Figure 6.1. Energy Savings with Plug and Process Loads in the Percentage Calculations

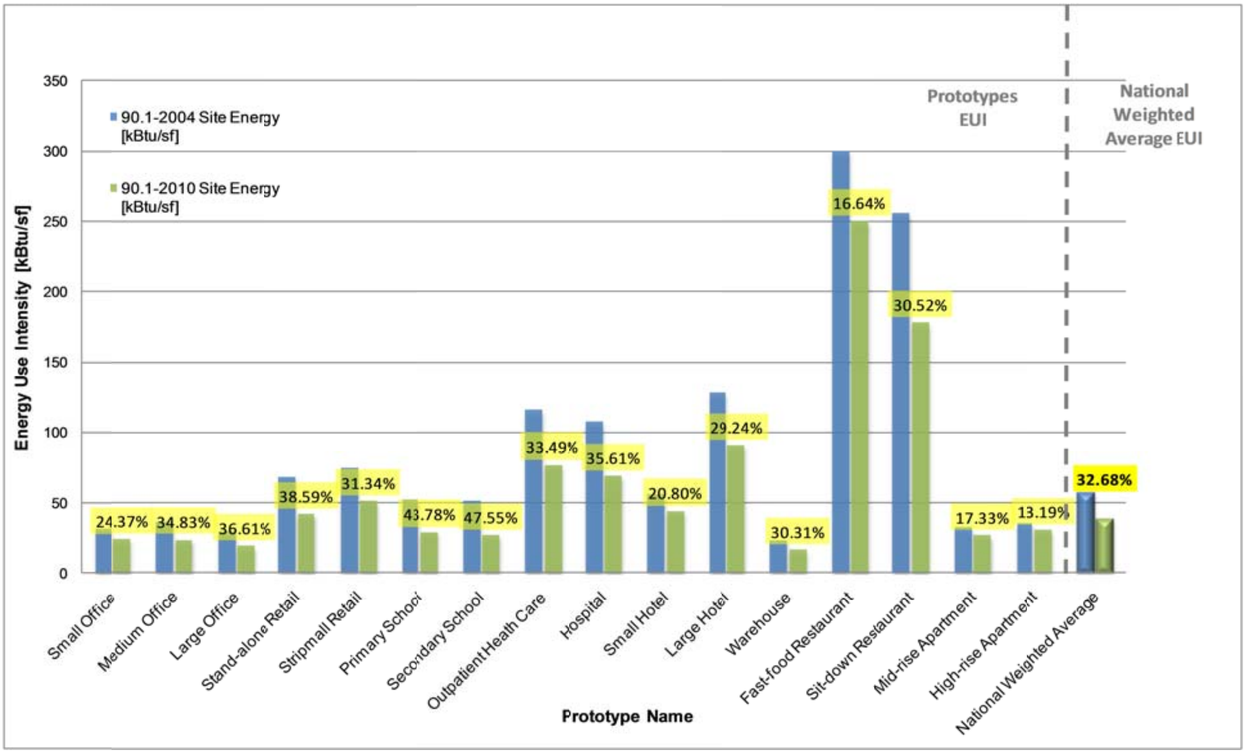

Figure 6.2. Energy Savings without Plug and Process Loads in the Percentage Calculations

Table 6.2. Energy and Energy Cost Savings with Plug and Process Loads

Building Type	Building Prototype	Site Energy (kBtu/ft²/yr)		Energy Cost ($/ft²)		Site Energy Savings	Energy Cost Savings
		90.1-2004	90.1-2010	90.1-2004	90.1-2010		
Office	Small office	41.3	32.8	$1.17	$0.93	20.6%	20.3%
	Medium office	51.6	37.3	$1.42	$1.01	27.7%	29.1%
	Large office	46.0	33.4	$1.21	$0.92	27.5%	24.3%
Retail	Stand-alone retail	76.0	49.5	$1.89	$1.32	34.8%	29.9%
	Strip mall	80.4	56.9	$1.97	$1.42	29.2%	28.0%
Education	Primary school	73.4	50.2	$1.80	$1.33	31.6%	26.3%
	Secondary school	66.2	41.2	$1.64	$1.13	37.8%	31.0%
Health Care	Outpatient healthcare	163.3	123.6	$4.17	$3.15	24.3%	24.3%
	Hospital	157.4	118.4	$3.55	$2.81	24.8%	20.9%
Lodging	Small hotel	78.5	66.6	$1.72	$1.47	15.2%	14.4%
	Large hotel	163.9	125.9	$2.99	$2.42	23.2%	19.0%
Warehouse	Warehouse	26.3	19.0	$0.57	$0.42	27.7%	27.3%
Food Service	Quick service restaurant	570.1	519.9	$10.16	$9.12	8.8%	10.3%
	Full service restaurant	409.7	330.9	$7.96	$6.12	19.2%	23.1%
Apartment	Mid-rise apartment	47.0	41.2	$1.23	$1.11	12.3%	9.4%
	High-rise apartment	48.9	44.0	$1.35	$1.25	10.1%	7.3%
National-weighted average		**73.9**	**55.0**	**$1.75**	**$1.35**	**25.6%**	**23.2%**

Table 6.3. Energy and Energy Cost Savings without Plug and Process Loads

Building Type	Building Prototype	Site Energy (kBtu/ft²/yr)		Energy Cost ($/ft²)		Site Energy Savings	Energy Cost Savings
		90.1-2004	90.1-2010	90.1-2004	90.1-2010		
Office	Small office	32.2	24.4	$0.89	$0.66	24.4%	26.6%
	Medium office	36.6	23.9	$0.97	$0.56	34.8%	41.8%
	Large office	30.4	19.2	$0.85	$0.56	36.6%	34.0%
Retail	Stand-alone retail	68.5	42.1	$1.66	$1.10	38.6%	34.0%
	Strip mall	75.0	51.5	$1.81	$1.26	31.3%	30.5%
Education	Primary school	52.1	29.3	$1.30	$0.83	43.8%	35.8%
	Secondary school	51.8	27.1	$1.28	$0.78	47.6%	39.2%
Health Care	Outpatient healthcare	116.0	77.2	$2.88	$1.86	33.5%	35.3%
	Hospital	107.9	69.4	$2.69	$1.96	35.6%	27.2%
Lodging	Small hotel	56.1	44.4	$1.32	$1.07	20.8%	18.7%
	Large hotel	128.5	90.9	$2.57	$2.01	29.2%	21.9%
Warehouse	Warehouse	23.7	16.5	$0.49	$0.34	30.3%	31.5%
Food Service	Quick service restaurant	300.6	250.6	$7.50	$6.46	16.6%	13.9%
	Full service restaurant	256.3	178.1	$5.78	$3.94	30.5%	31.8%
Apartment	Mid-rise apartment	32.4	26.8	$0.79	$0.67	17.3%	14.7%
	High-rise apartment	35.7	31.0	$0.95	$0.86	13.2%	9.8%
National-weighted average		**56.8**	**38.2**	**$1.37**	**$0.96**	**32.7%**	**29.5%**

Table 6.4. EUI and Energy Savings by Climate Zones

Climate Zone	Climate Location	Construction Weights	90.1-2004 Site Energy (kBtu/ft²/yr)	90.1-2010 Site Energy (kBtu/ft²/yr)	Site Energy Savings
1A	Miami	3.24%	56.6	47.9	15.4%
2A	Houston	15.22%	69.0	52.4	24.0%
2B	Phoenix	2.98%	70.1	53.8	23.3%
3A	Memphis	15.03%	70.1	52.0	25.7%
3B	El Paso	10.08%	61.2	49.1	19.7%
3C	San Francisco	1.61%	57.0	45.1	20.8%
4A	Baltimore	19.29%	75.2	54.7	27.3%
4B	Albuquerque	0.52%	76.6	60.1	21.5%
4C	Salem	2.98%	65.7	51.2	22.1%
5A	Chicago	19.37%	85.1	60.8	28.6%
5B	Boise	4.34%	75.9	58.5	22.9%
6A	Burlington	4.21%	97.1	67.8	30.1%
6B	Helena	0.57%	92.8	66.6	28.3%
7	Duluth	0.51%	112.8	76.2	32.4%
8	Fairbanks	0.06%	130.1	87.4	32.8%

Table 6.5. EUI by Prototype and Energy Usage Category

Units in kBtu/ft²/year	Interior Lights		Exterior Lights		Plug Loads		Fans		Pumps		Cooling		Heating		Service Water Heater		Others		Total	
Prototype	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**	**90.1-2004**	**90.1-2010**
Small Office	12.2	10.2	4.4	1.6	9.1	8.4	4.4	3.9	0.0	0.0	4.9	3.7	4.4	3.2	1.8	1.8	0.0	0.0	41.3	32.8
Medium Office	9.8	6.8	4.0	1.4	15.0	13.5	2.1	1.5	0.0	0.0	8.4	5.9	8.8	4.7	3.5	3.5	0.0	0.0	51.6	37.3
Large Office	9.8	7.2	1.9	1.0	15.6	14.1	2.0	1.6	1.8	1.1	6.2	3.9	8.1	3.8	0.6	0.6	0.0	0.0	46.0	33.4
Standalone Retail	18.8	17.0	4.4	1.8	7.5	7.5	15.0	8.2	0.0	0.0	10.4	6.1	18.7	7.1	1.2	1.2	0.0	0.6	76.0	49.5
Strip Mall	24.2	18.8	6.1	2.3	5.4	5.4	11.1	8.2	0.0	0.0	11.4	7.6	20.4	12.7	1.9	1.9	0.0	0.0	80.4	56.9
Primary School	15.5	10.4	1.1	0.5	21.3	20.9	6.8	4.6	0.0	0.0	11.8	7.5	14.9	3.7	1.0	1.0	1.0	1.7	73.4	50.2
Secondary School	14.8	9.7	1.0	0.4	14.4	14.0	7.4	4.5	0.6	0.2	12.1	8.0	14.6	2.4	0.5	0.5	0.7	1.5	66.2	41.2
Outpatient Healthcare	14.2	12.3	5.3	3.0	47.3	46.5	13.7	9.4	0.5	0.4	26.4	18.6	49.8	29.4	1.1	1.1	5.1	2.8	163.3	123.6
Hospital	16.6	14.2	1.0	0.8	49.6	49.0	17.2	11.4	5.3	3.4	18.6	11.7	47.1	25.6	1.1	1.1	0.8	1.2	157.4	118.4
Small Hotel	10.9	9.0	2.1	1.4	22.5	22.2	8.8	7.9	0.0	0.0	9.4	7.3	13.7	7.5	11.2	11.2	0.0	0.0	78.5	66.6
Large Hotel	11.3	10.6	2.4	1.8	35.4	35.0	6.0	5.1	2.4	0.7	23.1	16.4	34.7	6.1	48.2	48.2	0.6	1.9	163.9	125.9
Warehouse	8.8	6.1	2.2	1.2	2.5	2.4	1.0	0.8	0.0	0.0	0.6	0.5	11.0	7.8	0.1	0.1	0.0	0.0	26.3	19.0
Quick Service Restaurant	28.5	13.5	10.4	4.4	274.6	274.5	32.4	32.9	0.0	0.0	31.4	25.3	143.9	120.6	24.2	24.2	24.8	24.6	570.1	519.9
Full Service Restaurant	32.0	13.5	10.0	4.3	157.6	157.1	33.5	16.0	0.0	0.0	28.1	18.4	104.0	77.5	33.3	33.3	11.1	10.9	409.7	330.9
Mid-rise Apartment	2.8	2.9	2.0	1.1	14.5	14.4	5.7	5.0	0.0	0.0	5.1	4.0	9.3	6.4	7.4	7.4	0.0	0.0	47.0	41.2
High-rise Apartment	2.6	2.7	2.2	1.7	13.2	13.0	5.5	4.9	0.7	0.5	9.3	9.0	7.9	4.8	7.4	7.4	0.0	0.0	48.9	44.0
National Weighted Average	12.4	9.8	3.0	1.4	17.2	16.8	7.6	5.2	0.5	0.3	9.8	6.8	17.8	8.8	5.0	5.0	0.6	0.8	73.9	55.0
% Savings by Each End-use Category	21.1%		51.7%		2.2%		31.4%		45.5%		30.5%		50.4%		0.0%		0.0%		25.6%	

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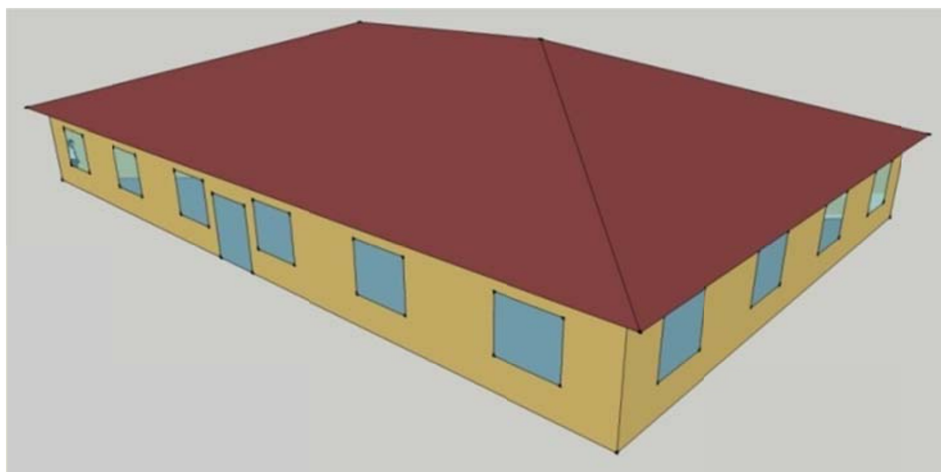
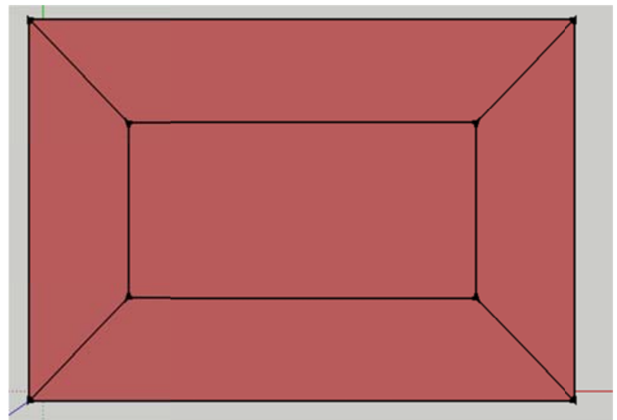
Appendix A

Energy Modeling Building Descriptions

A.1 Small Office Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**OFFICE**	
	Building Prototype	**Small Office**	
Form			
	Total Floor Area (sq. feet)	5500 (90.8 ft x 60.5ft)	
	Building shape		

	Item	Descriptions	Data Source
	Aspect Ratio	1.5	
	Number of Floors	1	
	Window Fraction (Window-to-Wall Ratio)	24.4% for South and 19.8% for the other three orientations (Window Dimensions: 6.0 ft x 5.0 ft punch windows for all façades)	2003 CBECS Data and PNNL's CBECS Study 2007.
	Window Locations	evenly distributed along four façades	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	Perimeter zone depth: 16.4 ft. Four perimeter zones, one core zone and an attic zone. Percentages of floor area: Perimeter 70%, Core 30% 	
	Floor to floor height (feet)	10	
	Floor to ceiling height (feet)	10	
	Glazing sill height (feet)	3 (top of the window is 8 ft high with 5 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Wood-Frame Walls (2X4 16IN OC) 1in. Stucco + 5/8 in. gypsum board + wall Insulation+ 5/8 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Wood-Framed	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	

	Item	Descriptions	Data Source
	Tilts and orientations	vertical	
	Roof		
	Construction	Attic Roof with Wood Joist: Roof insulation + 5/8 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Attic	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	Hipped roof: 10.76 ft attic ridge height, 2 ft overhang-soffit	
	Window		
	Dimensions	punch window, each 5 ft high by 6 ft wide	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 20-30%, U_fixed	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	0	Ducker Fenestration Market Data provided by the 90.1 envelope subcommittee
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	8" concrete slab poured directly on to the earth	
	Thermal properties for ground level floor: U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	

	Item	Descriptions	Data Source
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Air-source heat pump with gas furnace as back up	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Air-source heat pump	
	Distribution and terminal units	Single zone, constant air volume air distribution, one unit per occupied thermal zone	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Packaged Heat Pumps	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Packaged Heat Pumps and Warm Air Furnaces	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	85°F Cooling/60°F Heating	
	Supply air temperature	Maximum 104F, Minimum 55F	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1

	Item	Descriptions	Data Source
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan Hourly Operation Schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	Depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	NA	
	Rated Pump Head	NA	
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Efficiency	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	40	
	Water temperature setpoint	120F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)

	Item	Descriptions	Data Source
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Peak Power	NA	
	Schedule	NA	
	Exterior Lighting		
	Peak Power (W)	1,634	ASHRAE 90.1
	Schedule	See Appendix C	

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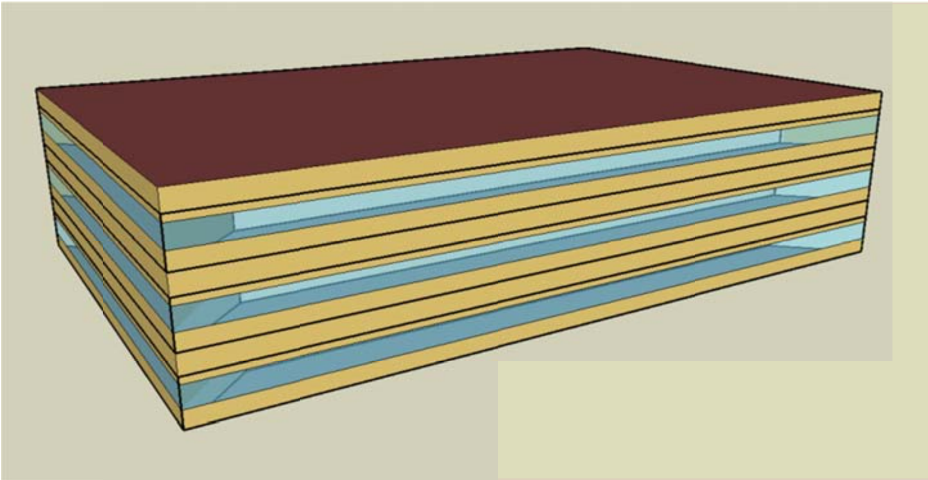
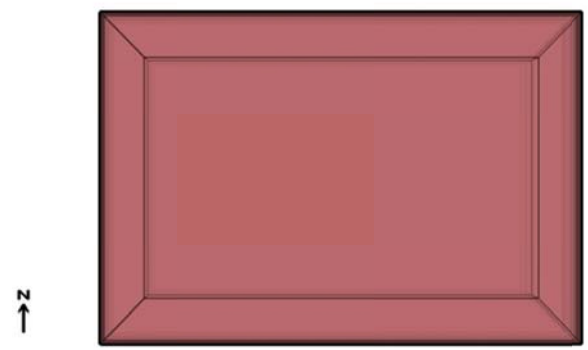
A.1 Medium Office Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**OFFICE**	
	Building Prototype	**Medium Office**	
Form			
	Total Floor Area (sq. feet)	53,600 (163.8 ft x 109.2 ft)	
	Building shape		
	Aspect Ratio	1.5	

	Item	Descriptions	Data Source
	Number of Floors	3	
	Window Fraction (Window-to-Wall Ratio)	33% (Window Dimenstions: 163.8 ft x 4.29 ft on the long side of facade 109.2 ft x 4.29 ft on the short side of the façade)	2003 CBECS Data and PNNL's CBECS Study 2007.
	Window Locations	even distribution among all four sides	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	Perimeter zone depth: 15 ft. Each floor has four perimeter zones and one core zone. Percentages of floor area: Perimeter 40%, Core 60% 	
	Floor to floor height (feet)	13	
	Floor to ceiling height (feet)	9 (4 ft above-ceiling plenum)	
	Glazing sill height (feet)	3.35 ft (top of the window is 7.64 ft high with 4.29 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Steel-Frame Walls (2X4 16IN OC) 0.4 in. Stucco+5/8 in. gypsum board + wall Insulation+5/8 in.	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft² * °F) and/or R-value (h * ft² * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		

	Item	Descriptions	Data Source
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 31.1-40%, U_fixed	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	0	Ducker Fenestration Market Data provided by the 90.1 envelope subcommittee
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	8" concrete slab poured directly on to the earth	
	Thermal properties for ground level floor: U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	
	Dimensions	based on floor plan and floor-to-floor height	

	Item	Descriptions	Data Source
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Gas furnace inside the packaged air conditioning unit	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Packaged air conditioning unit	
	Distribution and terminal units	VAV terminal box with damper and electric reheating coil Zone control type: minimum supply air at 30% of the zone design peak supply air.	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	80°F Cooling/60°F Heating	
	Supply air temperature	Maximum 104F, Minimum 55F	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1

	Item	Descriptions	Data Source
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	60% to 62% depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	NA	
	Rated Pump Head	NA	
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Efficiency	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	260	
	Water temperature setpoint	120F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)

	Item	Descriptions	Data Source
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	2	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Motor type	hydraulic	
	Peak Motor Power (W/elevator)	16,055	
	Heat Gain to Building	Interior	
	Peak Fan/lights Power (W/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See Appendix C	DOE Commercial Reference Building TSD and models (V1.3_5.0) and Addendum DF to 90.1-2007
	Exterior Lighting		
	Peak Power (W)	14,385	ASHRAE 90.1
	Schedule	See Appendix C	

References

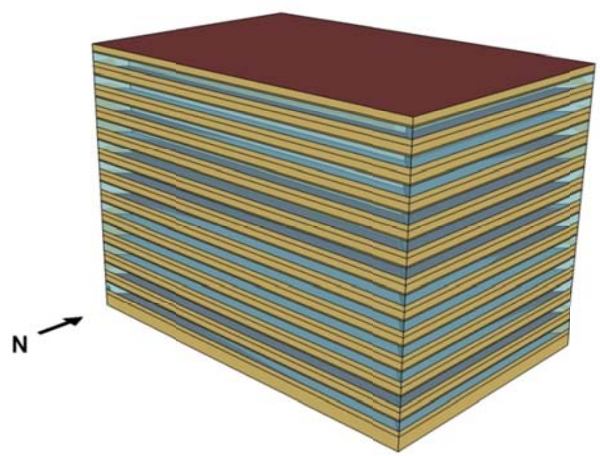
Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

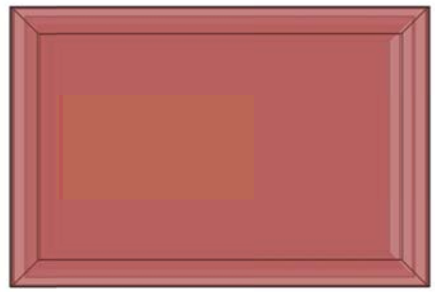
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

A.2 Large Office Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**OFFICE**	
	Building Prototype	**LARGE OFFICE**	
Form			
	Total Floor Area (sq. feet)	498,600 (240 ft x 160 ft)	*Time Saver Standards;* Large Office studies (ConEd, EPRI, MEOS, NEU1(1-4), NEU2, PNL) cited in Huang et al. 1991
	Building shape		
	Aspect Ratio	1.5	
	Number of Floors	12 (plus basement)	

	Item	Descriptions	Data Source
	Window Fraction (Window-to-Wall Ratio)	40% of above-grade gross walls 37.5% of gross walls (including the below-grade walls)	
	Window Locations	even distribution among all four sides	PNNL's CBECS Study
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	 Perimeter zone depth: 15 ft. Each floor has four perimeter zones and one core zone. Percentages of floor area: Perimeter 33%, Core 67%	*Time Saver Standards;* Large Office studies (ConEd, EPRI, MEOS, NEU1(1-4), NEU2, PNL) cited in Huang et al. 1992
	Floor to floor height (feet)	13	
	Floor to ceiling height (feet)	9	
	Glazing sill height (feet)	3 ft	
Architecture			
	Exterior walls		
	Construction	Mass (pre-cast concrete panel): 8 in. Heavy-Weight Concrete + Wall Insulation + 0.5 in. gypsum board	Construction type: PNNL's CBECS Study
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Construction type: PNNL's CBECS Study Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	

	Item	Descriptions	Data Source
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	0%	Ducker Fenestration Market Data provided by the envelope subcommittee
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Basement (unconditioned)	
	Construction	8" concrete wall; 6" concrete slab, 140 lbs heavy-weight aggregate	
	Thermal properties for ground level floor: U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Floors, Mass	ASHRAE 90.1
	Thermal properties for basement walls	No insulation	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft^2)	
	Air Barrier System		

	Item	Descriptions	Data Source
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	PNNL's Infiltration Study
HVAC			
	System Type		
	Heating type	Gas boiler	PNNL's CBECS Study
	Cooling type	Two water-cooled centrifugal chillers	
	Distribution and terminal units	VAV terminal box with damper and hot-water reheating coil Zone control type: minimum supply air at 30% of the zone design peak supply air.	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Varies by climate locations based on cooling capacity	ASHRAE 90.1
	Heating	Varies by climate locations based on heating capacity	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	90.1 Simulation Working Group
	Thermostat Setback	85°F Cooling/60°F Heating	
	Supply air temperature	Maximum 110F, Minimum 52F	
	Chilled water supply temperatures	44 F	
	Hot water supply temperatures	180 F	
	Economizers	Air-side economizer only in all the zones except: 1a, 1b, 2a, 3a, and 4a.	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	No	ASHRAE 90.1
	Energy Recovery	No	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	60% to 62% depending on the fan motor size	ASHRAE 90.1
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	CHW and HW: variable speed; CW: constant speed	
	Rated Pump Head	CHW: 56 ft HW and CW: 60 ft	ASHRAE 90.1

	Item	Descriptions	Data Source
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	open cooling tower with two-speed fans	ASHRAE 90.1
	Cooling Tower Power	autosized	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	80%	
	Tank Volume (gal)	260	
	Water temperature setpoint	180 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building-Area Method	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	No	
	Occupancy Sensors	No	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	ASHRAE 90.1
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	ASHRAE Ventilation Standard 62.1
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	12	DOE Commercial Reference Building TSD (unpublished) and models (V1.3_5.0).
	Motor type	traction	
	Peak Motor Power (W/elevator)	20370	
	Heat Gain to Building	Exterior	
	Peak Fan/lights Power (W/elevator)	161.9	90.1 Mechnical Subcommittee, Elevator Working Group

	Item	Descriptions	Data Source
	Motor and fan/lights Schedules	See Appendix C	DOE Commercial Reference Building TSD (unpublished) and models (V1.3_5.0) and Appendix DF 2007
	Exterior Lighting		
	Peak Power (W)	60,216	ASHRAE 90.1-2004; PNNL study; 90.1 Lighting Subcommittee inputs
	Schedule	Astronomical Clock	ASHRAE 90.1-2004

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

McGraw-Hill Companies, Inc. (2001). *Time-Saver Standards for Building Types*. New York, NY.

LBNL (1991). Huang, Joe, Akbari, H., Rainer, L. and Ritschard, R. 481 Prototypical Commercial Buildings for 20 Urban Market Areas, prepared for the Gas Research Institute, Chicago IL, also LBL-29798, Berkeley CA.

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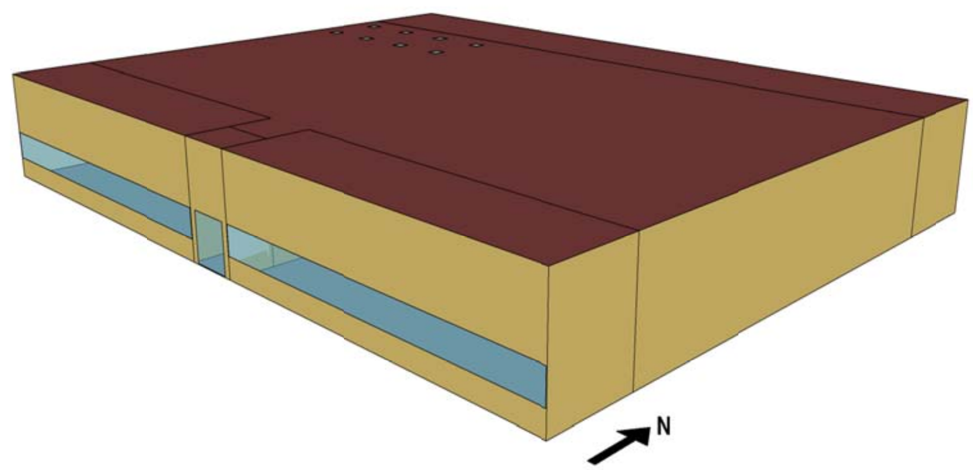
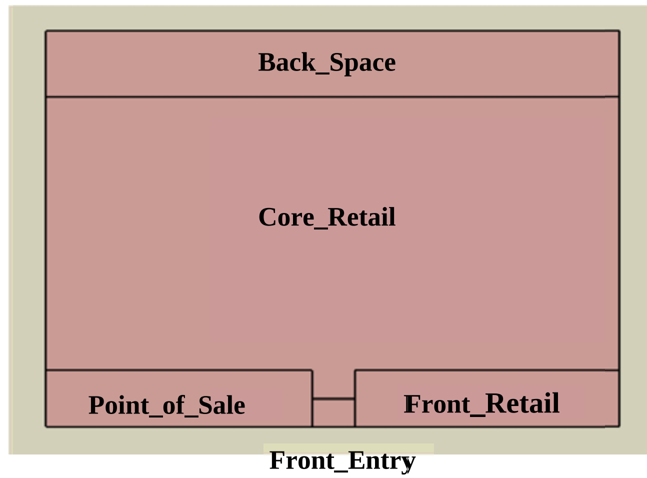
PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

A.3 Stand-alone Retail Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**RETAIL**	
	Building Prototype	**Standalone Retail**	
Form			
	Total Floor Area (sq. feet)	24695 (178 ft x 139 ft)	
	Building shape		
	Aspect Ratio	1.28	

	Item	Descriptions	Data Source
	Number of Floors	1	
	Window Fraction (Window-to-Wall Ratio)	7.1% (Window Dimensions: 82.136 ft x 5 ft, 9.843 ft x 8.563 ft and 82.136 ft x 5 on the street facing facade)	2003 CBECS Data and PNNL's CBECS Study 2007.
	Window Locations	Windows only on the street facing façade (25.4% WWR)	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	Five thermal zones (See Appendix B) 	
	Floor to floor height (feet)	N/A	
	Floor to ceiling height (feet)	20	
	Glazing sill height (feet)	5 ft (top of the window is 8.73 ft high with 3.74 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Concrete Block Wall: 8 in. CMU+Wall Insulation+0.5 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Mass	ASHRAE 90.1

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	Vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 20.1-30.0%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	Ducker Fenestration Market Data provided by the 90.1 envelope subcommittee
	Operable area	2%	Ducker Fenestration Market Data provided by the envelope subcommittee
	Skylight		
	Dimensions	Core Retail, Rectangular skylight 4 ft x 4 ft = 16 ft² per skylight Number of skylights and total skylight area vary according to ASHRAE 90.1 Requirements	ASHRAE 90.1
	Glass-Type and frame	Hypothetical glass and frame meeting ASHRAE 90.1 Requirements below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Skylight with Curb, Glass	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth with carpet	

	Item	Descriptions	Data Source
	Thermal properties for ground level floor: U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	0.5 in gypsum board + 0.5 in gypsum board	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Gas furnace inside the packaged air conditioning unit for back_space, core_retail, point_of_sale, and front_retail. Standalone gas furnace for front_entry.	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Packaged air conditioning unit for back_space, core_retail, point_of_sale, and front_retail; No cooling for front_entry.	
	Distribution and terminal units	Constant air volume air distribution 4 single-zone roof top units serving four thermal zones (back_space, core_retail, point_of_sale, and front_retail)	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	85°F Cooling/60°F Heating	

	Item	Descriptions	Data Source
	Supply air temperature	Maximum 104°F, Minimum 55°F	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Mechanical Efficiency (%)	Various depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	Service hot water	
	Rated Pump Heat	No	
	Pump Power	100% eff. motor. Negligible power consumption	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Efficiency	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	40	
	Water temperature setpoint	120 °F	
	Water consumption	BLDG_SWH_SCH See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method	
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	

	Item	Descriptions	Data Source
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Peak Power	NA	
	Schedule	NA	
	Exterior Lighting		
	Peak Power	7,322 watts	ASHRAE 90.1
	Schedule	See Appendix C	

References

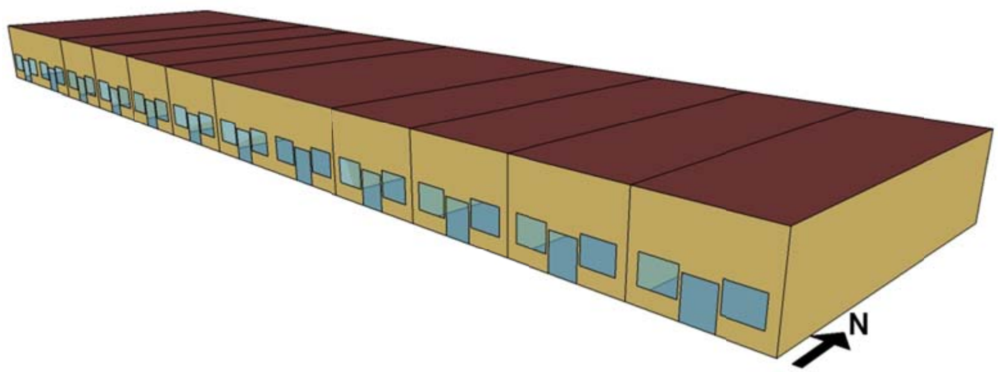
Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

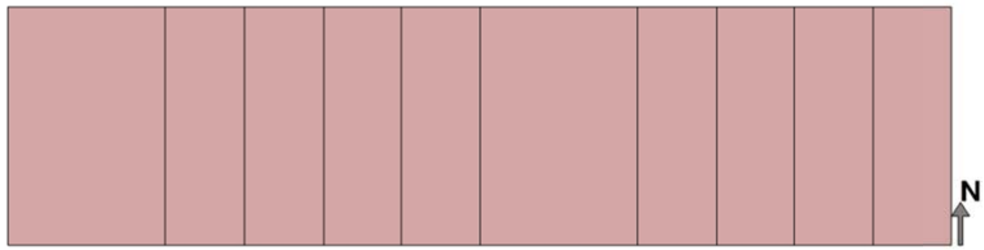
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

A.4 Strip Mall Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**RETAIL**	
	Building Prototype	**Stripmall**	
Form			
	Total Floor Area (sq feet)	22,500 ft² (300 ft x 75 ft)	
	Building shape		
	Aspect Ratio	4 (0.33 for small store & 0.67 for large store)	

	Item	Descriptions	Data Source
	Number of Floors	1	
	Window Fraction (Window-to-Wall Ratio)	10.5% (Window Dimensions: 24 windows, 7 ft x 5 ft each and 12 doors, 6 ft x 7 ft each, on the street facing façade with south WWR 26%)	
	Window Locations	Windows only on the street facing façade	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	 10 thermal zones (from left to right): LGStore1 (Type 1), SMStore1 (Type 1), SMStore2 (Type 2), SMStore3 (Type 3), SMStore4 (Type 2), LGStore2 (Type 3), SMStore5 (Type 3), SMStore6 (Type 3), SMStore7 (Type 3), and SMStore8 (Type 3). (See Appendix B)	
	Floor to floor height (feet)	17	
	Floor to ceiling height (feet)	17	
	Glazing sill height (feet)	3.0 ft (top of the window is 8 ft high)	
Architecture			
	Exterior walls		
	Construction	Steel-framed Wall: 1 in. Stucco + 0.625 in. gypsum board + wall insulation + 0.625 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel Frame	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	

	Item	Descriptions	Data Source
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 20.1-30.0%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	Ducker Fenestration Market Data provided by the 90.1 envelope subcommittee
	Operable area	2%	Ducker Fenestration Market Data provided by the envelope subcommittee
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth with carpet	
	Thermal properties for ground level floor: U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1

	Item	Descriptions	Data Source
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	0.5 in gypsum board + 0.5 in gypsum board	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Gas furnace inside the packaged air conditioning unit	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Packaged air conditioning unit	
	Distribution and terminal units	10 single-zone rooftop units with Constant air volume air distribution. One unit serving one store.	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	85°F Cooling/60°F Heating	
	Supply air temperature	Maximum 104°F, Minimum 55°F	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	

	Item	Descriptions	Data Source
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	OA Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	60% to 62% depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	NA	
	Rated Pump Head	NA	
	Pump Power	NA	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1	ASHRAE 90.1
	Tank Volume (gal)	6	
	Water temperature setpoint	120 °F	
	Water consumption	BLDG_SWH_SCH See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method	
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)

	Item	Descriptions	Data Source
	Schedule	See Appendix C	
	Occupancy		
	Peak people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator	NA	
	Peak Power	NA	
	Schedule	NA	
	Exterior Lighting		
	Peak Power	9153 watts	ASHRAE 90.1
	Schedule	See Appendix C	

References

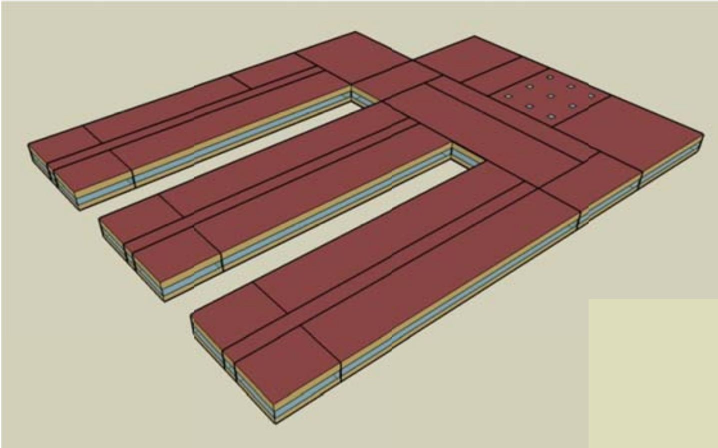
Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

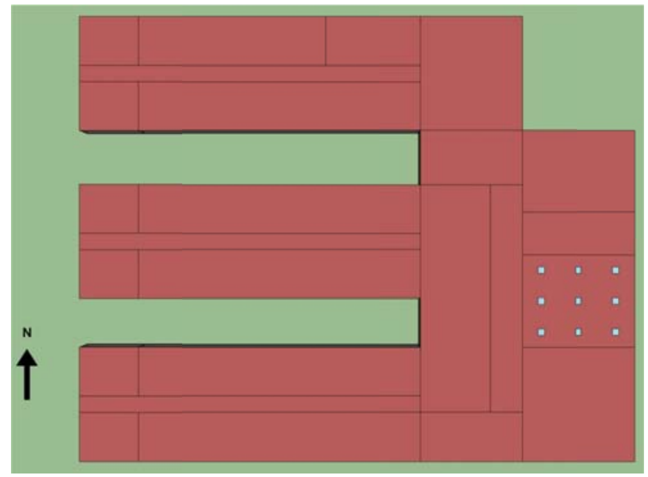
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

A.5 Primary School Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**EDUCATION**	
	Building Prototype	**Primary School**	
Form			
	Total Floor Area (sq. feet)	73, 960 (340 ft x 270 ft)	
	Building shape		
	Aspect Ratio	1.3	

	Item	Descriptions	Data Source
	Number of Floors	1	
	Window Fraction (Window-to-Wall Ratio)	35% for all facades Ribbon window across all facades	
	Window Locations	Continuous Band	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	Classrooms zoned by exposure. Corner classrooms separated out from single exposure classrooms. Double loaded corridors zoned separately. Administrative area, Gymnasium , mechanical, media center, lobby, kitchen, and cafeteria are single zones. See Appendix B. 	
	Floor to floor height (feet)	13	
	Floor to ceiling height (feet)	13	
	Glazing sill height (feet)	3.6 (top of the window is 8.1 ft high with 4.5 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Steel-framed Walls (2x4, 16" OC) 0.75" stucco + 0.625" gypsum board + Cavity insulation + 0.625" gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed	ASHRAE 90.1

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof Roof membrane + Roof insulation + Metal decking	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Area (ft2)	73,960	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with no frame and meeting ASHRAE 90.1 Requirements	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 30.1-40%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with no frame and meeting ASHRAE 90.1 Requirements	
	Operable area	35%	PNNL 's Glazing Market Data for ASHRAE spreadsheet
	Skylight		
	Dimensions	Gymnasium/Multipurpose Room (4 ft x 4 ft) x 9 skylights = 144 ft² total Skylight Area 3.75% of gym roof area	AEDG K-12 Guide
	Glass-Type and frame	Hypothetical glass and frame meeting ASHRAE 90.1 Requirements below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Skylight with curb, Glass, 2.1-5%	ASHRAE 90.1
	SHGC		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth + carpet	
	Thermal properties for ground level floor: F-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for basement walls:	NA	

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/ft² of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	1. Gas furnace inside packaged air conditioning unit 2. Hot water from a gas boiler for heating	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Packaged air conditioning unit	
	Distribution and terminal units	1. CAV systems: direct air from the packaged air conditioning unit 2. VAV systems: VAV terminal box with damper and hot water reheating coil Zone Control Type: minimum supply air at 30% of the zone design peak supply air	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Varies by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	Varies by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces Minimum equipment efficiency for Gas and Oil-fired Boilers	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	80°F Cooling/60°F Heating	
	Supply air temperature	Minimum 50 °F and maximum 122 °F	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	180 °F	

	Item	Descriptions	Data Source
	Economizers	Varies by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	Outdoor Air Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Mechanical Efficiency	Varies depending on the fan motor size and type of fan	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	Variable speed	
	Rated Pump Head	60 ft	
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	264	
	Water temperature setpoint	120 F	
	Water consumption (peak gpm)	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Lighting power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Space-By-Space Method See Appendix B	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)
	Schedule	See Appendix C	

	Item	Descriptions	Data Source
	Occupancy		
	Average people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Peak Power	NA	
	Schedule	NA	
	Exterior Lighting		
	Peak Power (W)	ASHRAE 90.1 Lighting Power Densities For Building Exteriors	ASHRAE 90.1
	Schedule	See Appendix C	

References

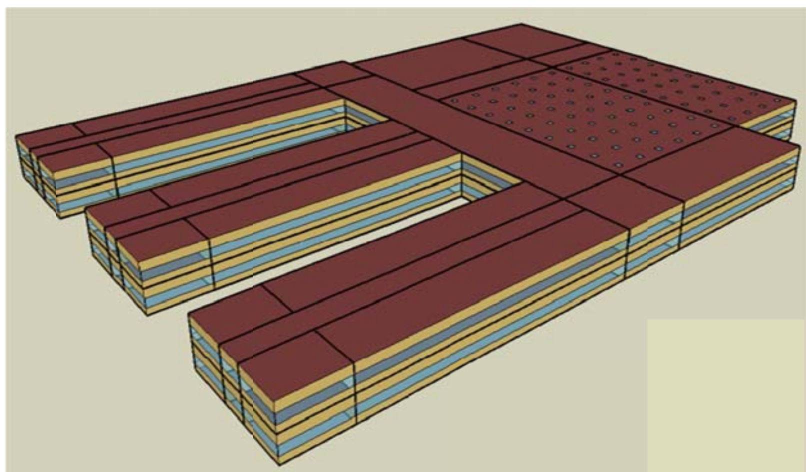
Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

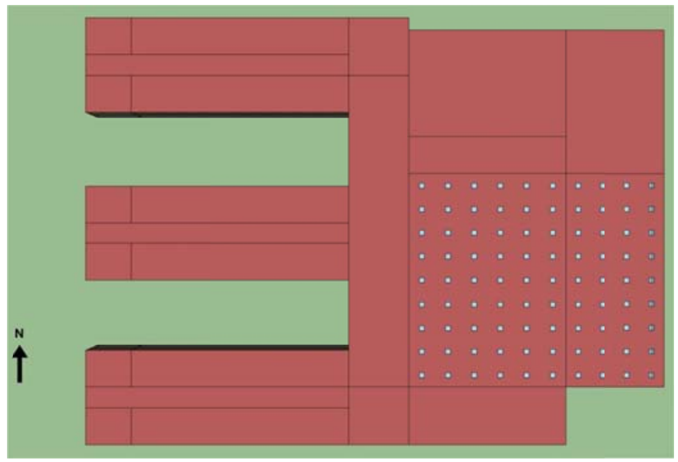
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

“Study of the U.S. Market For Windows, Doors, and Skylights”, American Architectural Manufacturers Association, Window & Door Manufacturers Association, 2006.

A.6 Stand-alone Retail Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**EDUCATION**	
	Building Prototype	**Secondary School**	
Form			
	Total Floor Area (sq. feet)	210,900 (340 ft x 460 ft)	
	Building shape		
	Aspect Ratio	1.4	

	Item	Descriptions	Data Source
	Number of Floors	2	
	Window Fraction (Window-to-Wall Ratio)	33% Ribbon window across all facades on both floors	
	Window Locations	Continuous Band	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	Classrooms zoned by exposure. Corner classrooms separated out from single exposure classrooms. Double loaded corridors zoned separately. Administrative areas zoned by exposure. Gymnasium , auxiliary gym, auditorium, kitchen, and cafeteria are single zones. See Appendix B. 	
	Floor to floor height (feet)	13	
	Floor to ceiling height (feet)	13	
	Glazing sill height (feet)	3.6 (top of the window is 8.1 ft high with 4.5 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Steel-Framed Walls (2X4 16IN OC) 0.4 in. Stucco+5/8 in. gypsum board + wall Insulation+5/8 in	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed	ASHRAE 90.1

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with no frame and meeting ASHRAE 90.1 Requirements	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 31.1-40%, U_fixed	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with no frame and meeting ASHRAE 90.1 Requirements	
	Operable area	35%	PNNL 's Glazing Market Data for ASHRAE spreadsheet
	Skylight		
	Dimensions	Gymnaisum (4 ft x 4 ft) x 54 skylights = 864 ft2 of total skylight area 4% of Gym roof area Auxiliary Gymnasium (4 ft x 4 ft) x 36 skylights = 576 ft2 of total skylight area 4.3% of Aux. Gym roof area	AEDG K-12 Guide
	Glass-Type and frame	Hypothetical glass and frame meeting ASHRAE 90.1 Requirements below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Skylight with curb, Glass, 2.1-5%	ASHRAE 90.1
	SHGC		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth + carpet	
	Thermal properties for ground level floor: U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1

	Item	Descriptions	Data Source
	and/or R-value (h * ft^2 * °F / Btu)		
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated steel stud wall	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/ft² of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	1. Gas furnaces inside packaged air conditioning units 2. Gas-fired boiler provide heating hot water and chilled water to these AHUs.	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	1. Packaged air conditioner 2. Air-cooled Chiller	
	Distribution and terminal units	1. CAV system: direct air from the packaged unit 2. VAV System: VAV terminal box with damper and hot water reheating coil Zone Control Type: minimum supply air at 30% of the zone design peak supply air	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units Minimum equipment efficiency for Air-cooled Chillers	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces Minimum equipment efficiency for Gas and Oil-fired Boilers	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	85°F Cooling/60°F Heating	

	Item	Descriptions	Data Source
	Supply air temperature	Minimum 50 °F, maximum 122 °F	
	Chilled water supply temperatures	44 °F	
	Hot water supply temperatures	180 °F	
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Mechanical Efficiency (%)	Varies depending on fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	Variable speed	
	Rated Pump Head	CW: 75 ft HW: 60 ft	
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	792	
	Water temperature setpoint	120 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Space-By-Space Method See Appendix B	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	

	Item	Descriptions	Data Source
	Plug load		
	Average power density (W/ft^2)	See Appendix B	
	Schedule	See Appendix C	
	Electric load (cooking)		
	Average power density (W/ft^2)	20.6 W/ft^2 - 30% Radiant fraction , 25% latent, 20% lost	
	Schedule	See Appendix C	
	Gas Equip Cooking		
	Average power density (W/ft^2)	156 W/ft^2 - 20% Radiant fraction , 10% latent, 70% lost	
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	2	DOE Commercial Reference Building TSD (unpublished) and models (V1.3_5.0).
	Motor type	hydraulic	
	Peak Motor Power (W/elevator)	16055	
	Heat Gain to Building	Interior	
	Peak Fan/lights Power (W/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See Appendix C	DOE Commercial Reference Building TSD (unpublished) and models (V1.3_5.0) and Appendix DF 2007
	Exterior Lighting		
	Peak Power	ASHRAE 90.1 Lighting Power Densities For Building Exteriors	ASHRAE 90.1
	Schedule	See Appendix C	

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

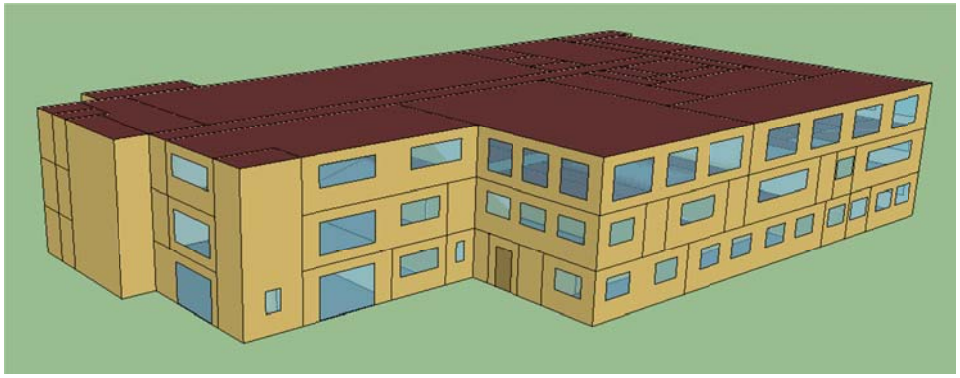
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

	Item	Descriptions	Data Source

"Study of the U.S. Market For Windows, Doors, and Skylights", American Architectural Manufacturers Association, Window & Door Manufacturers Association, 2006.

A.7 Outpatient Healthcare Modeling Description

	Item	Descriptions			Data Source
Program					
	Vintage	**NEW CONSTRUCTION**			
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine)	Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine)	Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity			
	Building Type (Principal Building Function)	**Health Care**			
	Building Prototype	**OUTPATIENT HEALTHCARE**			
Form					
	Total Floor Area (sq. feet)	40,950			
	Building shape				
	Aspect Ratio	NA			
	Number of Floors	3			
	Window Fraction (Window-to-Wall Ratio)	North: 20.5%, East:19.1%, South: 24.1%, West: 12.9% Average Total: 20%			

	Item	Descriptions	Data Source
	Window Locations	See pictures	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	See Appendix B	
	Floor to floor height (feet)	10 ft	
	Floor to ceiling height (feet)	10 ft	
	Glazing sill height (feet)	3 ft (4 ft high windows)	
Architecture			
	Exterior walls		
	Construction	Steel-Frame Walls (2X4 16IN OC) 0.4 in. Stucco+5/8 in. gypsum board + wall Insulation+5/8 in.	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 31.1-40%, U_fixed	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	

	Item	Descriptions	Data Source
	Operable area	12%	Ducker Fenestration Market Data provided by the 90.1 envelope subcommittee
	Skylight		
	Dimensions	NA	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth	
	Thermal properties for ground level Floor: U-factor (Btu / h * ft2 * °F) and/or R-value (h * ft2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2x4 steel-frame with gypsum board	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	Interior furnishings: 6 inches standard wood (16.6 lb/ft^2)	
	Air Barrier System		
	Infiltration	25% of 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Gas boiler	
	Cooling type	DX cooling coil	
	Distribution and terminal units	VAV terminal box with damper and hot water reheating coil Electric resistance reheat in AHU-2	
	HVAC Sizing		

	Item	Descriptions	Data Source
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	Administration zones: 72°F Cooling/70°F Heating Critical zones: 72°F Cooling/70°F Heating Operating rooms: 65°F Cooling/65°F Heating	
	Thermostat Setback	Administration zones: 77°F Cooling/65°F Heating Critical zones: no setback Operating rooms: 72°F Cooling/65°F Heating	
	Supply air temperature	Cooling temps: design = 49 deg F, operation = 52 deg F for critical spaces (first floor) Cooling temps: design = 52 deg F, operation = 55 deg F for admin spaces (second and third floor)	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	180 F	
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	OA Ventilation	Both OA and TSA design air flowrate are derived from two sources: 1. Minimum OA and TSA air requirements specified by AIA Guidelines for Design and Construction of Health Care Facilities and 2. ASHRAE Standard 62.1-2004	AIA Guidelines; ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	60% to 62% depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	Constant speed	
	Rated Pump Head	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	

	Item	Descriptions	Data Source
	SWH Design Capacity (kBtu/h)	2,883	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >70,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	793	
	Water temperature setpoint	140 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	ASHRAE 90.1
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	3	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Motor type	hydraulic	
	Peak Motor Power (W/elevator)	16,055	
	Heat Gain to Building	Interior	
	Peak Fan/lights Power (W/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See Appendix C	DOE Commercial Reference Building TSD and models (V1.3_5.0) and Addendum DF to 90.1-2007
	Exterior Lighting		
	Peak Power (W)	14,442	ASHRAE 90.1
	Schedule	See Appendix C	

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

	Item	Descriptions	Data Source

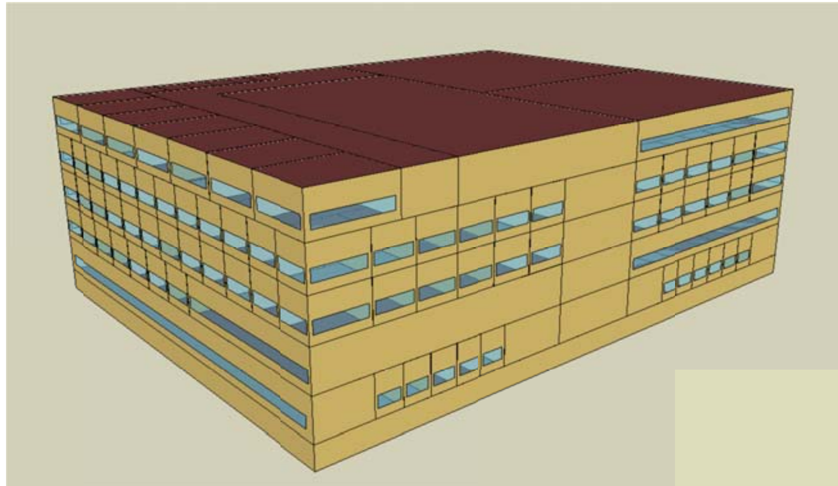
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

A.8 Hospital Modeling Description

	Item	Descriptions			Data Source
Program					
	Vintage	**NEW CONSTRUCTION**			
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine)	Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine)	Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity			
	Building Type (Principal Building Function)	**Health Care**			
	Building Prototype	**Hospital**			
Form					
	Total Floor Area (sq. feet)	241,410 (including basement)			

	Item	Descriptions	Data Source
	Building shape		Reference: *Time Saver Standards; Hospital studies (ConEd, EPRI, MEOS, LBL) cited in Huang et al. 1991*
	Aspect Ratio	1.31 (230 ft x 175 ft for each floor)	
	Number of Floors	5 (plus basement)	
	Window Fraction (Window-to-Wall Ratio)	North: 12%, East: 13%, South: 15%, West: 24% Average Total: 16%	
	Window Locations	See pictures	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	See Appendix B for thermal zoning layout, including Emergency Room, Office, Lobby, Nurse Station, Operating Room, Patient Room, Physical Therapy, Lab, Radiology, Dining, Kitchen, and Corridors. Percentages of floor area: Clinic 25%, Core/Public 35%, Perimeter (patient rooms and offices) 15%, Kitchen 5%, Lobby/Hallway 20%	Reference: *Time Saver Standards; Hospital studies (ConEd, EPRI, MEOS, LBL) cited in Huang et al. 1991*
	Floor to floor height (ft)	14 ft above ground 8 ft basement	
	Floor to ceiling height (ft)	No ceiling plenum is modeled	
	Glazing sill height (ft)	3 ft (4 ft high windows)	
Architecture			
	Exterior walls		

	Item	Descriptions	Data Source
	Construction	Mass (concrete blocks): 8 in. HW Concrete+Wall Insulation+0.5 in. Gym	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	1st, 2nd and 5th floors: Use nonresidential envelop requirement 3rd and 4th floors: Use residential envelope requirement since most of the spaces in the perimeter zones are patient rooms, which are residential spaces based on 90.1's definitions.	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Residential; Vertical Glazing, 10.1-20%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	0	
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Basement (conditioned)	

	Item	Descriptions	Data Source
	Construction	8" concrete wall; 8" concrete slab, 140 lbs heavy-weight aggregate	
	Thermal properties for ground level floor U-factor (Btu / h * ft2 * °F) and/or R-value (h * ft2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for basement walls	No insulation	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration (ACH)	25% of 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Gas boiler	2003 CBECS Data, PNNL's CBECS Study 2007, and 90.1 Mechanical Subcommittee input.
	Cooling type	Water cooled centrifugal chiller	
	Distribution and terminal units	Medical critical zones: five variable air volume (VAV) systems with hot water reheating and electric stream humidifiers. Non-critical zones: two VAV systems for general zones and one constant air volume (CAV) system for kitchen zone: VAV terminal box with damper and hot water reheating coil; minimum supply air at 30% of the zone design peak supply air.	AEDG for Small Healthcare Facilities
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Cooling	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Two water-cooled screw chillers, for each chiller with normal cooling capacity	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for hot water boiler	ASHRAE 90.1

	Item	Descriptions	Data Source
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	No setback	
	Supply air temperature	Maximum 110F, Minimum 52F	
	Chilled water supply temperatures	44 F	
	Hot water supply temperatures	180 F	
	Economizers	No economizer	Input from 90.1 Mechanical Subcommittee
	Ventilation	Both OA and TSA design air flowrate are derived from two sources: 1. Minimum OA and TSA air requirements specified by AIA Guidelines for Design and Construction of Health Care Facilities and 2. ASHRAE Standard 62.1-2004	AIA Guidelines; ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	60% to 62% depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	Chilled water (CHW), hot water (HW) and service hot water (SHW): variable speed Cooled water (CW): constant speed	
	Rated Pump Head	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	open cooling tower with two-speed fans	
	Cooling Tower Power	autosized	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	800	
	Water temperature setpoint	140 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		

	Item	Descriptions	Data Source
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method See Appendix B	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	8	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Motor type	Traction	
	Peak Motor Power (W/elevator)	20,370	
	Heat Gain to Building	Exterior	
	Peak Fan/lights Power (W/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See Appendix C	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Exterior Lighting		
	Peak Power (W)	16,636	ASHRAE 90.1
	Schedule	See Appendix C	

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

McGraw-Hill Companies, Inc. 2001. *Time-Saver Standards for Building Types.* New York, NY.

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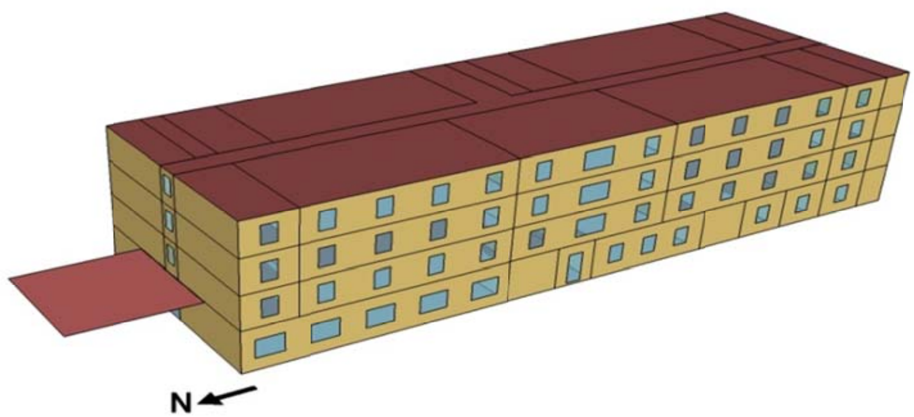
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

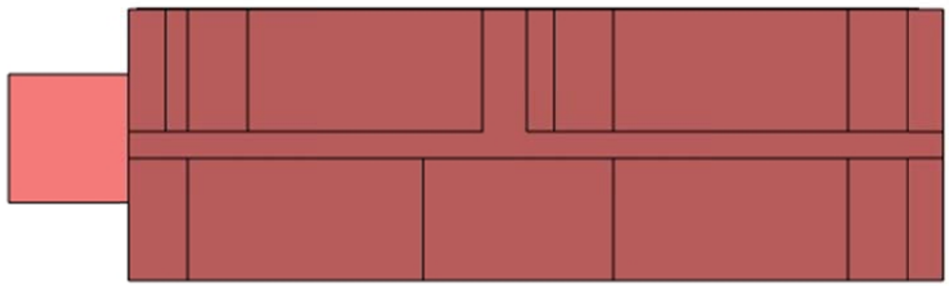
	Item	Descriptions	Data Source

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

A.9 Small Hotel Modeling Description

	Item	Input	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**Lodging**	
	Building Prototype	**Small Hotel**	
Form			
	Total Floor Area (sq. feet)	43200 (180 ft x 60 ft)	Hampton Inn Prototype from Hilton Hotels Corporation, Version 5.1, September 2004, referred as Hilton prototype; F.W.Dodge Database
	Building shape		Hilton prototype and CBECS 2003

	Item	Input	Data Source
	Aspect Ratio	3	Hilton prototype
	Number of Floors	4	
	Window Fraction (Window-to-Wall Ratio)	South: 3.1%, East: 11.4%, North: 4.0%, West: 15.2% Average Total: 10.9%	Hilton prototype
	Window Locations	One per guest room (4' x 5')	Hilton prototype
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	 *Ground Floor*: 19 zones including guest rooms, lobby, office space, meeting room, laundry room, employee lounge, restrooms, exercise room, mechanical room, corridor, stairs, storage; *2nd-4th Floor*: 16 zones per floor, including guest rooms, corridor, stairs and storage; Guest rooms accounts for 63% of total floor area.	
	Floor to floor height (feet)	Ground floor: 11 ft Upper floors: 9 ft	
	Floor to ceiling height (feet)	same as above	
	Glazing sill height (feet)	3 ft in ground floor, 2 ft. in upper floors	
Architecture			
	Exterior walls		
	Construction	Steel-Frame Walls (2x4 16 in. OC) 1 in. Stucco + 5/8 in. gypsum board + wall Insulation + 5/8 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Base Assembly from 90.1 Appendix A.
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	

	Item	Input	Data Source
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane + Roof insulation + metal decking	AEDG Highway Lodging Committee Recommendation
	U-factor (Btu / h * ft² * °F) and/or R-value (h * ft² * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft² * °F)	ASHRAE 90.1 Requirements Nonresidential for ground floor and residential for upper floors; Vertical Glazing, 10.1%-20.0%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	0.00%	
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft² * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth	
	Thermal properties for slab-on-grade floor F-factor (Btu / h * ft2 * °F) and/or R-value (h * ft2 * °F / Btu)	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		

	Item	Input	Data Source
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area, adjusted by wind (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898. *Infiltration Modeling Guidelines for Commercial Building Energy Analysis.*
HVAC			
	System Type		
	Heating type	Guest rooms: PTAC with electric resistance heating Public spaces (office, laundry, lobby, and meeting room): gas furnace inside the packaged air conditioning units Storage and stairs: electric cabinet heaters	2003 CBECS, NC3, Ducker report
	Cooling type	Guest rooms and corridors: PTAC and make-up air unit for outdoor air ventilation Public space: Split system with DX cooling Storage and stairs: No cooling	
	Distribution and terminal units	Constant air volume systems	
	HVAC Sizing		
	Air Conditioning	PTAC: 9,000 Btu/hr Split system and packaged MAU system: autosized to design day	PTAC: Ducker report
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	PTAC: EER = 10.58 Split system and packaged MAU system: varies by climate locations based on cooling capacity	ASHRAE 90.1
	Heating	PTAC and electric cabinet heater: Et = 100% Gas furnace: varies by climate locations based on heating capacity	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	70°F Cooling/Heating for rented guest rooms 74°F Cooling/66°F Heating for vacant guest rooms 75°F Cooling/70°F Heating for air conditioned public spaces (lobby, meeting room etc.) 45°F heating for stairs and storage rooms	AEDG Highway Lodging Committee Recommendation
	Thermostat Setback	74°F Cooling/66°F Heating for rented guest rooms	
	Supply air temperature	No seasonal supply air temperature reset.	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	
	Economizers	no economizer	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	No	ASHRAE 90.1
	Energy Recovery Ventilation	No	ASHRAE 90.1

	Item	Input	Data Source
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Mechanical Efficiency (%)	Varies by fan motor size	AEDG-SR Technical Support Document (Liu 2006)
	Supply Fan Pressure Drop	PTAC: 1.33 in. w.c. Cabinet Heater: 0.2 in w.c. Split DX units and MAU: 90.1 fan power limitation (depends on design flow rate)	PTAC Manufacture's Catalogs Split System: Wassmer and Brandemuehl, 2006,
	Pump		
	Pump Type	Constant speed (recirculating pump for DHW)	AEDG Highway Lodging Committee Recommendation
	Rated Pump Head	20 ft	
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Two Storage Tanks: one for laundry and the other for guest rooms	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	80%	ASHRAE 90.1-2004, Table7.8, Gas storage water heaters, >=75,000 Btu/h
	Tank Volume (gal)	200 gal for guest rooms and 100 gal for laundry	ASHRAE HandBook Application 2007, Ch. 49 Calculation is documented at PNNL's TSD for 30% AEDG Highway Lodging (Jiang et al 2008)
	Water temperature setpoint	120 F for guest rooms and 140 F for laundry	
	Water consumption	See Appendix C	Guest room: ASHRAE Handbook of Applications 2007, Chapter 49, Table 7 Laundry: AEDG Highway Lodging Committee Recommendation
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Space-by-Space Method	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	No	
	Occupancy Sensors	No	

	Item	Input	Data Source
	Plug load		
	Average power density (W/ft^2)	See Appendix B	AEDG Highway Lodging Committee Recommendation
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	Guest Room: AEDG Highway Lodging Committee Recommendation All other spaces: ASHRAE 62.1-1999
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	2	DOE Commercial Reference Building TSD (unpublished) and models (V1.3_5.0).
	Motor type	hydraulic	
	Peak Motor Power (W/elevator)	16055	
	Heat Gain to Building	Interior	
	Peak Fan/lights Power (W/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Exterior Lighting	See Appendix C	DOE Commercial Reference Building TSD (unpublished) and models (V1.3_5.0) and Appendix DF 2007
	Peak Power, kW	13.03	Derived based on ASHRAE 90.1-2004 and inputs from 90.1 Lighting Subcommittee
	Schedule	Astronomical Clock	

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

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PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

	Item	Input	Data Source

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Ducker International Standard. 2001. 2000 U.S. Market For Residential and Specialty Air Conditioning: PTAC.

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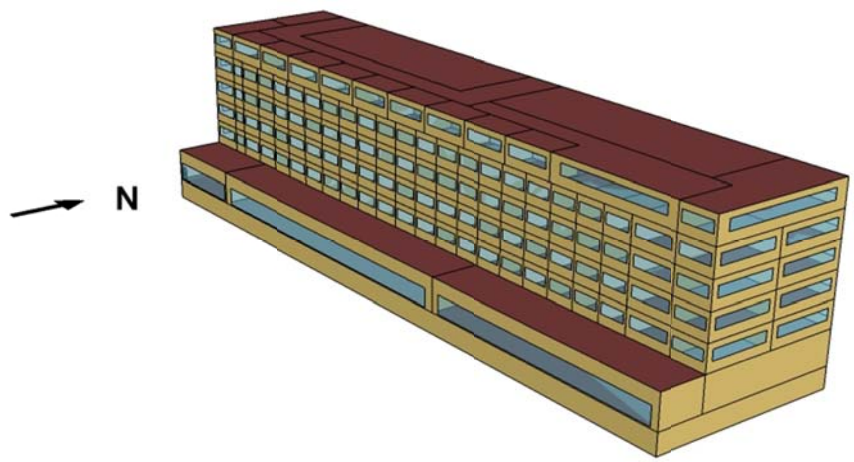
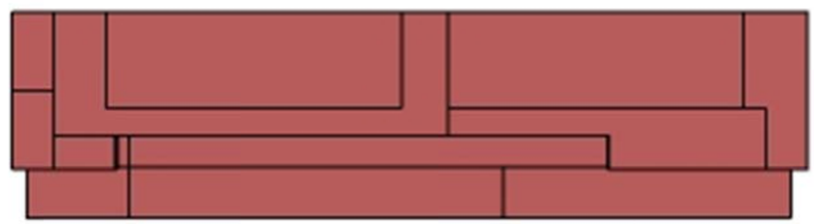
Jiang W, RE Jarnagin, K Gowri, M McBride, and B Liu. 2008. Technical Support Document: The Development of the Advanced Energy Design Guide for Highway Lodging Buildings . PNNL-17875, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/publications/abstracts.asp?report=246912

Liu B, RE Jarnagin, DW Winiarski, W Jiang, MF McBride, and C Crall. 2006. Technical Support Document: The Development of the Advanced Energy Design Guide for Small Retail Buildings. PNNL-16031, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/publications/abstracts.asp?report=221540

A.10 Large Hotel Modeling Description

	Item	Inputs	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**Lodging**	
	Building Prototype	**Large Hotel**	
Form			
	Total Floor Area (sq. feet)	122,132	
	Building shape		
	Aspect Ratio	Ground floor: 3.79 (284 ft x 75 ft) All other floors: 5.07 (284 ft x 56 ft)	

	Item	Inputs	Data Source
	Number of Floors	6 above-ground floors plus one basement (284 ft x 75 ft)	
	Window Fraction (Window-to-Wall Ratio)	South: 36.7%, East: 24.5%, North: 26.0%, West: 24.5% Total: 30.2%	
	Window Locations	For standard guest room, one per guest room (9.9' x 4')	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning		
		Basement: conditioned single zone; Ground Floor: 7 zones including retails, lobby, cafe, laundry, storage and mechanical rooms; 2nd to 5th Floor (guest-floor): 7 zones per floor, including guest rooms and corridor. Each floor has 42 guest rooms; 6th Floor: 7 zones including guest rooms, banquet room, dining, kitchen and corridor. Total 179 guest rooms, accounting for 41% of total floor area.	
	Floor to floor height (feet)	Basement: 8 ft Ground floor: 13 ft 2nd - 6th floors: 10 ft	
	Floor to ceiling height (feet)	same as above	
	Glazing sill height (feet)	6 in. in ground floor, 3.6 ft. in upper floors	
Architecture			
	Exterior walls		
	Construction	Mass Wall: 8 in. CMU, wall insulation and 0.5 in. gypsum board	2003 CBECS Database (Based on PNNL's Study)
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed for Ground Floor Residential:Walls, Above-Grade, Steel-Framed for remaining floors	ASHRAE 90.1

	Item	Inputs	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Insulation Entirely above Deck (Single-ply roof membrane, Steel deck with rigid insulation)	2003 CBECS Database (Based on PNNL's Study)
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential for ground floor and residential for upper floors; Vertical Glazing, 10.1%-20.0%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	22%	ASHRAE SSPC 90.1 (Fenestration Market Survey Data)
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Basement (conditioned)	
	Construction	8" heavy-weight Concrete with carpet for all walls and slabs in the model	
	Thermal properties for slab-on-grade floor F-factor (Btu / h * ft2 * °F) and/or R-value (h * ft2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Floors, Mass	ASHRAE 90.1
	Thermal properties for basement walls	No insulation	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	1 in. gypsum board	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		

	Item	Inputs	Data Source
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area, adjusted by wind (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	
HVAC			
	System Type		
	Heating type	One gas-fired boiler	
	Cooling type	One air-cooled chiller	ASHRAE 90.1
	Distribution and terminal units	Public spaces on ground floor and top floor: VAV with hot water reheating coils; Guest Rooms: dedicated outdoor air system + four-pipe fan-coil units.	2003 CBECS Database (Based on PNNL's Study)
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate locations based on cooling capacity	ASHRAE 90.1
	Heating	Various by climate locations based on heating capacity	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	Guest Rooms: 70°F Cooling/ 70°F Heating Public Area: 75°F cooling /70°F heating	
	Thermostat Setback	No setback	
	Supply air temperature	For the VAV system, the supply air temperature is set at 55 F; For the DOAS, the supply air temperature is reset according to the outdoor air temperature: Tsupply = 60 F when Toa < 60 F; Tsupply = 55 F when Toa > 70 F; Interpolation when Toa is between 60 and 70 F.	
	Chilled water supply temperatures	44 F	
	Hot water supply temperatures	140 F	
	Economizers	For the VAV system, air-side economizer only in all the zones except: 1a, 1b, 2a, 3a, and 4a.	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	No	ASHRAE 90.1
	Energy Recovery	No	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Fan Mechanical Efficiency (%)	65%	

	Item	Inputs	Data Source
	Fan Pressure Drop	Fan Coil Unit: 1.33 in. w.c. VAV and DOAS System: depends on CFM	
	Exhaust Fan		
	Fan schedules	See Appendix C	
	Fan Total Efficiency (%)	100%	
	Fan Pressure Drop	0.5 in. w.c.	
	Pump		
	Pump Type	Variable speed	
	Rated Pump Head	Use the pump power assumptions as specified in Appendix G, i.e., 22 W/gpm for chilled water pump, 19 W/gpm for hot water and condensing water pumps.	
	Pump Power	autosized	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	80%	ASHRAE 90.1
	Tank Volume (gal)	528	
	Water temperature setpoint	180 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using Space-by-Space Method	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	No	
	Occupancy Sensors	No	
	Plug load		
	Average power density (W/ft^2)	See Appendix B	
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	6	DOE Commercial

	Item	Inputs	Data Source
	Motor type	traction	Reference Building TSD (unpublished) and models (V1.3_5.0).
	Peak Motor Power (W/elevator)	20370	
	Heat Gain to Building	Exterior	
	Peak Fan/lights Power (W/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See Appendix C	DOE Commercial Reference Building TSD and models (V1.3_5.0) and Appendix DF 2007
	Exterior Lighting		
	Peak Power (W)	3,589.9	
	Schedule	Astronomical Clock	

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

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LBNL (1991). Huang, Joe, Akbari, H., Rainer, L. and Ritschard, R. 481 Prototypical Commercial Buildings for 20 Urban Market Areas, prepared for the Gas Research Institute, Chicago IL, also LBL-29798, Berkeley CA.

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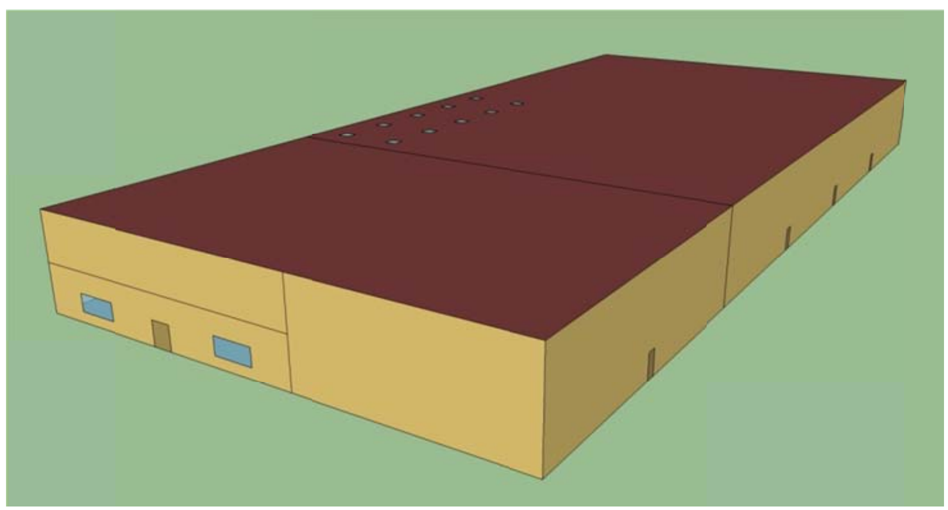
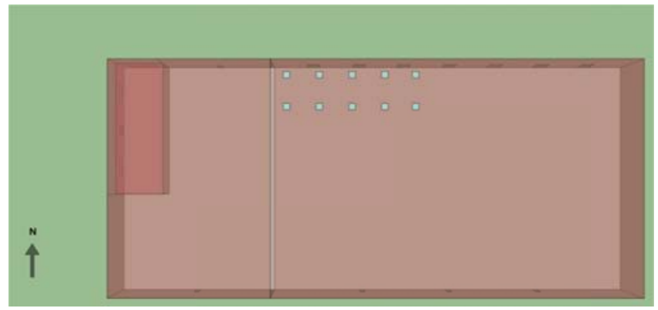
Wassmer and Brandemuehl, 2006, Effect of Data Availability on Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations

A.11 Warehouse Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**Non-refrigerated warehouse**	
	Building Prototype	**WAREHOUSE**	
Form			
	Total Floor Area (sq. feet)	49,495 (330 ft x 150 ft)	
	Building shape		

	Item	Descriptions	Data Source
	Aspect Ratio	2.2	
	Number of Floors	1	
	Window Fraction (Window-to-Wall Ratio)	0.71% Punched windows in Office Space	
	Window Locations	Only for Office Space	
	Shading Geometry	NA	
	Azimuth	non-directional	
	Thermal Zoning	Three zones: Bulk Storage, Fine Storage, and Office. The Office zone is enclosed on two sides and at the top by the Fine Storage zone. 	
	Floor to floor height (feet)	28	
	Floor to ceiling height (feet)	14 (Office)	
	Glazing sill height (feet)	3 (top of the window is 8 ft high with 5 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Metal Building Wall Metal Surface + Wall Insulation + Gypsum Board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Metal Building Semiheated; Walls, Above-Grade, Metal Building	ASHRAE 90.1

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Metal Building Roof Metal Surface + Roof Insulation	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Roofs, Metal Building Semiheated; Roofs, Metal Building	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with no frame and meeting ASHRAE 90.1 Requirements	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 0-10%, U_fixed	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with no frame and meeting ASHRAE 90.1 Requirements	
	Operable area	0	
	Skylight		
	Dimensions	Bulk Storage, Fine Storage Rectangular Skylights (4 ft x 4 ft) = 16 ft2 per skylight Number of skylights and total skylight area vary according to ASHRAE 90.1 Requirements	ASHRAE 90.1
	Glass-Type and frame	Hypothetical glass and frame meeting ASHRAE 90.1 Requirements below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Skylight with Curb, Glass	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-Grade	
	Construction	6" concrete slab	
	Thermal properties for ground level floor U-factor (Btu / h * ft2 * °F) and/or R-value (h * ft2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated Semiheated; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for	NA	

	Item	Descriptions	Data Source
	basement walls		
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated steel stud wall	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	Bulk Storage Material 12.5 lb/sf, 8ft thick, area of 64,890 ft2	
	Air Barrier System		
	Infiltration	office: 0.043346 cfm/ft2 of exterior surface area fine storage: 0.044442 cfm/ft2 of exterior surface area bulk storage: 3265 cfm (fixed)	
HVAC			
	System Type		
	Heating type	Gas furnace inside the packaged air conditioning unit	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Packaged air conditioning unit	
	Distribution and terminal units	Direct, uncontrolled air	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces	
	HVAC Control		
	Thermostat Setpoint	Fine storage: 80°F Cooling/ 60°F Heating; Office Area: 75°F Cooling/ 70°F Heating; Bulk Storage: 50°F Heating;	
	Thermostat Setback	85°F Cooling/60°F Heating	
	Supply air temperature	Minimum 55°F, maximum 110°F	
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	

	Item	Descriptions	Data Source
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	No	ASHRAE 90.1
	Energy Recovery	No	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	Varies depending on fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	NA	
	Rated Pump Head	NA	
	Pump Power	NA	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Electric storage water heater	
	Fuel type	Electricity	
	Thermal efficiency (%)	1	
	Tank Volume (gal)	20	
	Water temperature setpoint	120 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Space-By-Space Method See Appendix B	ASHRAE 90.1
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	
	Plug load		

	Item	Descriptions	Data Source
	Average power density (W/ft^2)	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	User's Manual for ASHRAE Standard 90.1-2004 (Appendix G)
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Peak Power	NA	
	Schedule	NA	
	Exterior Lighting		
	Peak Power	ASHRAE 90.1 Lighting Power Densities For Building Exteriors	ASHRAE 90.1
	Schedule	See Appendix C	

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

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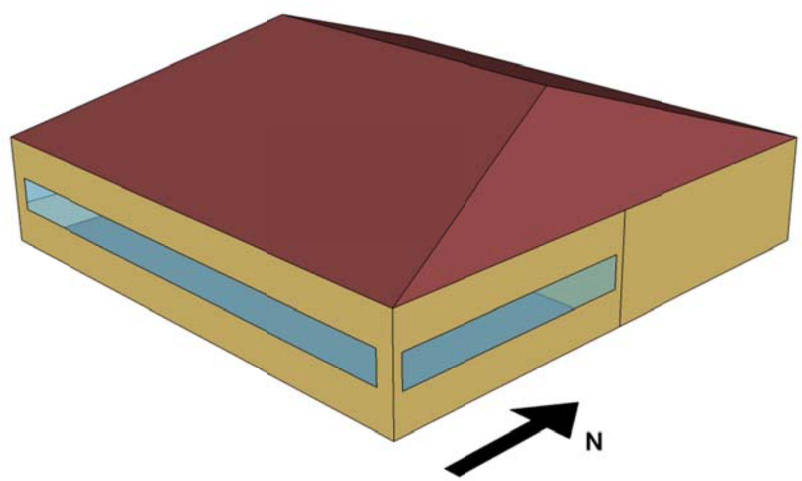
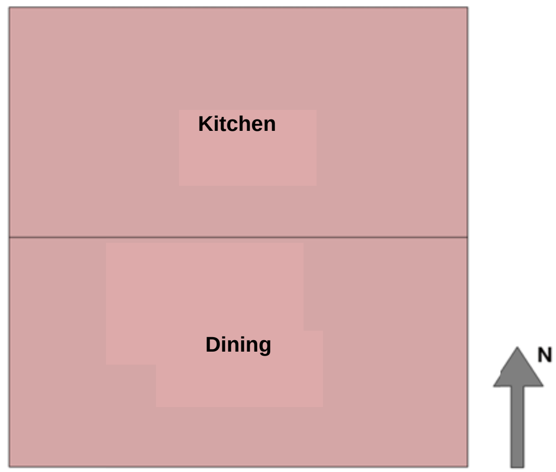
PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and, Mark Halverson. Pacific Northwest National Laboratory. December 2006.

A.12 Quick Service Restaurant Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**FOOD SERVICE**	
	Building Prototype	**Quick Service Restaurant**	
Form			
	Total Floor Area (sq. feet)	2,500 (50 ft x 50 ft)	
	Building shape		
	Aspect Ratio	1	
	Number of Floors	1	

	Item	Descriptions	Data Source
	Window Fraction (Window-to-Wall Ratio)	South: 28% East: 14% North: 0% West: 14% Total: 14%	
	Window Locations	East (23.3 ft x 3 ft), south (46.7 ft x 3 ft), and west (23.3 ft x 3 ft) sides of dining zone façade	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	 Kitchen, Dining, and Unconditioned Attic (See ZoneSummary tab)	
	Floor to floor height (feet)	NA	
	Floor to ceiling height (feet)	10	
	Glazing sill height (feet)	3.5 (top of the window is 6.5 ft high with 3 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Wood-framed wall: 1 in. stucco + 0.625 in. gypsum board + wall insulation + 0.625 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Wood-framed	ASHRAE 90.1

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	Vertical	
	Roof		
	Construction	Unconditioned attic roof modeled with asphalt shingles and 0.625 in. gypsum board (no insulation). Ceiling between attic and conditioned zones modeled with wood-joist attic roof consisting of the following layers: insulation and 0.625 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	Attic Roof (all zones): 0.071 - No Insulation Ceiling: ASHRAE 90.1 Requirements Nonresidential; Roofs, Attic and other	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	Insulated Ceiling - horizontal Attic Roof East & West - 45 deg. North & South - 18.44 deg.	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 20.1-30.0%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	Ducker Fenestration Market Data provided by the 90.1 envelope subcommittee
	Operable area	2% of total WWR	Ducker Fenestration Market Data provided by the envelope subcommittee
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth	
	Thermal properties for ground level floor	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1

	Item	Descriptions	Data Source
	U-factor (Btu / h * ft2 * °F) and/or R-value (h * ft2 * °F / Btu)		
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	0.5 in gypsum board + 0.5 in gypsum board	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Gas furnace inside the packaged air conditioning unit	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Packaged air conditioning unit	
	Distribution and terminal units	Single zone, constant air volume air distribution	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	Dining - 75°F Cooling/70°F Heating Kitchen - 79°F Cooling/66°F Heating	
	Thermostat Setback	Dining - 86°F Cooling/60°F Heating Kitchen - 86°F Cooling/60°F Heating	
	Supply air temperature	Maximum 104°F, Minimum 55°F	

	Item	Descriptions	Data Source
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	No	ASHRAE 90.1
	Energy Recovery	No	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	Various depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	Service hot water	
	Rated Pump Head	No	
	Pump Power	100% eff. motor. Negligible power consumption	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	52.8	
	Water temperature setpoint	140 F	
	Water consumption	BLDG_SWH_SCH See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method	
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	

	Item	Descriptions	Data Source
	Plug load		
	Average power density (W/ft^2)	See Appendix B	
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Peak Power	NA	
	Schedule	NA	
	Exterior Lighting		
	Peak Power (W)	1,743	ASHRAE 90.1
	Schedule	Astronomical Clock	

References

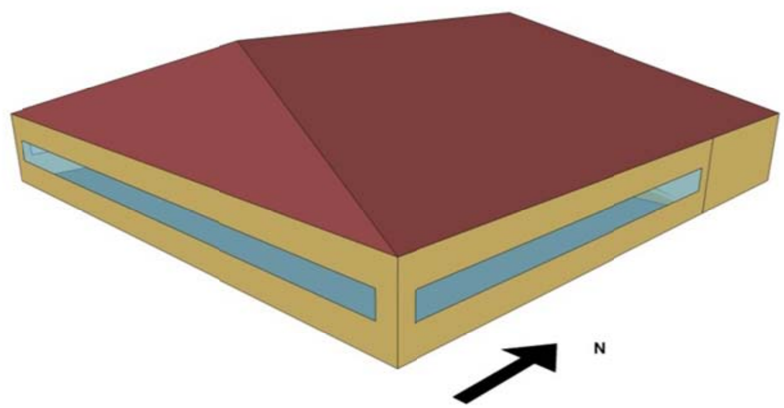
Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

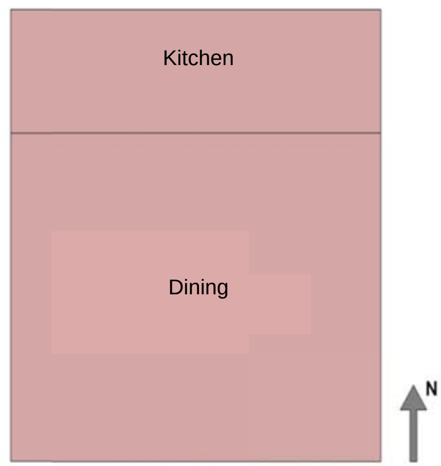
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

A.13 Full Service Restaurant Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**FOOD SERVICE**	
	Building Prototype	**Full Service Restaurant**	
Form			
	Total Floor Area (sq. feet)	5,502 (74.2 ft x 74.2 ft)	
	Building shape		
	Aspect Ratio	1	
	Number of Floors	Single floor plus attic	

	Item	Descriptions	Data Source
	Window Fraction (Window-to-Wall Ratio)	South: 28% East: 20.22% North: 0% West: 20.22% Total: 17.11%	
	Window Locations	All on dining-zone facade, none in kitchen. See above	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	 Kitchen, Dining, and Unconditioned Attic	
	Floor to floor height (feet)	N/A	
	Floor to ceiling height (feet)	10	
	Glazing sill height (feet)	3.5 ft (top of the window is 6.5 ft with 3 ft high glass)	
Architecture			
	Exterior walls		
	Construction	Steel-framed Wall: 1 in. Stucco + 0.625 in. gypsum board + wall insulation + 0.625 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Exterior wall layers: default 90.1 layering

	Item	Descriptions	Data Source
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Walls, Above-Grade, Steel-Framed	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Unconditioned attic roof modeled with asphalt shingles and 0.625 in. gypsum board (no insulation). Ceiling between attic and conditioned zones modeled with wood-joist attic roof consisting of the following layers: insulation and 0.625 in. gypsum board	Construction type: 2003 CBECS Data and PNNL's CBECS Study 2007. Roof layers: default 90.1 layering
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	Attic Roof (all zones): 0.071 - No Insulation Ceiling: ASHRAE 90.1 Requirements Nonresidential; Roofs, Attic and other	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	Insulated Ceiling - horizontal Attic Roof North & South - 45 deg. East & West - 18.44 deg.	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Nonresidential; Vertical Glazing, 20.1-30.0%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	Ducker Fenestration Market Data provided by the 90.1 envelope subcommittee
	Operable area	2% of total WWR	Ducker Fenestration Market Data provided by the envelope subcommittee
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	6" concrete slab poured directly on to the earth	

	Item	Descriptions	Data Source
	Thermal properties for ground level floor U-factor (Btu / h * ft2 * °F) and/or R-value (h * ft2 * °F / Btu)	ASHRAE 90.1 Requirements Nonresidential; Slab-on-Grade Floors, unheated	ASHRAE 90.1
	Thermal properties for basement walls	NA	
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	0.5 in gypsum board + 0.5 in gypsum board	
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	6 inches standard wood (16.6 lb/ft²)	
	Air Barrier System		
	Infiltration	Peak: 0.2016 cfm/sf of above grade exterior wall surface area (when fans turn off) Off Peak: 25% of peak infiltration rate (when fans turn on)	Reference: PNNL-18898: Infiltration Modeling Guidelines for Commercial Building Energy Analysis.
HVAC			
	System Type		
	Heating type	Gas furnace inside the packaged air conditioning unit	2003 CBECS Data, PNNL's CBECS Study 2006, and 90.1 Mechanical Subcommittee input.
	Cooling type	Packaged air conditioning unit	
	Distribution and terminal units	Single zone, constant air volume air distribution	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Various by climate location and design cooling capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	Various by climate location and design heating capacity ASHRAE 90.1 Requirements Minimum equipment efficiency for Warm Air Furnaces	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	Dining - 75°F Cooling/70°F Heating Kitchen - 79°F Cooling/66°F Heating	
	Thermostat Setback	Dining - 86°F Cooling/60°F Heating Kitchen - 86°F Cooling/60°F Heating	
	Supply air temperature	55°F cooling / 104°F heating	

	Item	Descriptions	Data Source
	Chilled water supply temperatures	NA	
	Hot water supply temperatures	NA	
	Economizers	Various by climate location and cooling capacity Control type: differential dry bulb	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	No	ASHRAE 90.1
	Energy Recovery	No	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	Various depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Various depending on the fan supply air cfm	
	Pump		
	Pump Type	Service hot water	
	Rated Pump Head	No	
	Pump Power	100% eff. motor. Negligible power consumption	
	Cooling Tower		
	Cooling Tower Type	NA	
	Cooling Tower Power	NA	
	Service Water Heating		
	SWH type	Storage Tank	
	Fuel type	Natural Gas	
	Thermal efficiency (%)	ASHRAE 90.1 Requirements Water Heating Equipment, Gas storage water heaters, >75,000 Btu/h input	ASHRAE 90.1
	Tank Volume (gal)	52.8	
	Water temperature setpoint	140 F	
	Water consumption	BLDG_SWH_SCH See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	ASHRAE 90.1 Lighting Power Densities Using the Building Area Method	
	Schedule	See Appendix C	
	Daylighting Controls	ASHRAE 90.1 Requirements	
	Occupancy Sensors	ASHRAE 90.1 Requirements	

	Item	Descriptions	Data Source
	Plug load		
	Average power density (W/ft^2)	See Appendix B	
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Peak Power	NA	
	Schedule	NA	
	Exterior Lighting		
	Peak Power (W)	3,695	ASHRAE 90.1
	Schedule	Astronomical Clock	

References

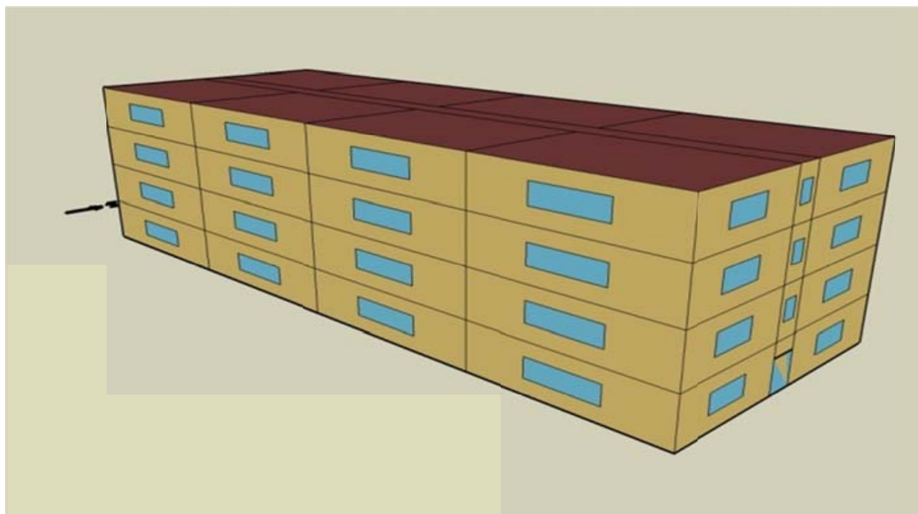
Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

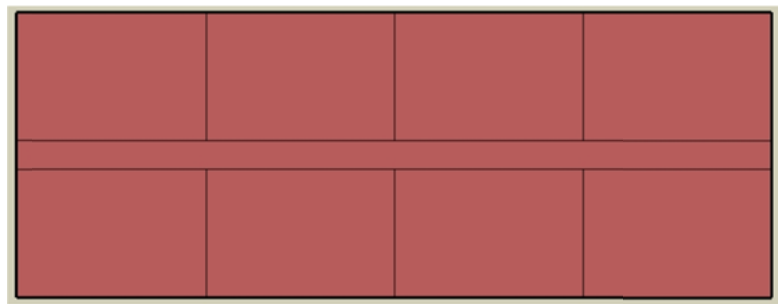
PNNL's CBECS Study. 2007. *Analysis of Building Envelope Construction in 2003 CBECS Buildings.* Dave Winiarski, Mark Halverson, and Wei Jiang. Pacific Northwest National Laboratory. March 2007.

PNNL's CBECS Study. 2006. *Review of Pre- and Post-1980 Buildings in CBECS – HVAC Equipment.* Dave Winiarski, Wei Jiang and Mark Halverson. Pacific Northwest National Laboratory. December 2006.

Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

A.14 Mid-Rise Apartment Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper. See Reference.
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**Multifamily**	
	Building Prototype	**Mid-rise Apartment**	
Form			
	Total Floor Area (sq. feet)	33,700 (152 ft x 55.5 ft)	Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Building shape		
	Aspect Ratio	2.74	

	Item	Descriptions	Data Source
	Number of Floors	4	90.1 Envelop Subcommittee
	Window Fraction (Window-to-Wall Ratio)	South: 14.7%, East: 16.3%, North: 14.7%, West: 15.1% Average Total: 15.0%	Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Window Locations	See pictures	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	 Each floor has 8 apartments except ground floor (7 apartments and 1 lobby with equivalent apartment area) Total 8 apartments per floor with corridor in center. Zone depth is 25 ft for each apartment from side walls and each apt is 25' x 38' (950 ft²).	Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Floor to floor height (ft)	10	
	Floor to ceiling height (ft)	10 (No drop-in ceiling plenum is modeled)	
	Glazing sill height (ft)	3 ft (14 ft wide x 4 ft high)	
Architecture			
	Exterior walls		
	Construction	Steel-Frame Walls (2X4 16IN OC) 0.4 in. Stucco+5/8 in. gypsum board + wall Insulation+5/8 in.	Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*. Base Assembly from 90.1 Appendix A.
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Residential; Walls, above grade, Steel Frame	ASHRAE 90.1

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Reference: PNNL-16770: Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York Base Assembly from 90.1 Appendix A.
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Residential; Roofs, Insulation entirely above deck	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Residential; Vertical Glazing, 10.1-20%	ASHRAE 90.1
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	100%	
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	8" concrete slab poured directly on to the earth	
	Slab-on-grade floor insulation level (F-factor)	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	

	Item	Descriptions	Data Source
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	8 lbs/ft2 of floor area	Reference: Building America Research Benchmark
	Air Barrier System		
	Infiltration (ACH)	0.2016 cfm/ft² of gross exterior wall area at all times (at 10 mph wind speed)	Reference: PNNL-18898. *Infiltration Modeling Guidelines for Commercial Building Energy Analysis.*
HVAC			
	System Type		
	Heating type	Gas Furnace	90.1 Mechanical Subcommittee
	Cooling type	Split system DX (1 per apt)	
	Distribution and terminal units	Constant volume	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	ASHRAE 90.1 Requirements Minimum Equipment Efficiency for Air Conditioners and Condensing Units	ASHRAE 90.1
	Heating	ASHRAE 90.1 Requirements Minimum Equipment Efficiency for Warm Air Furnaces	ASHRAE 90.1
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	No setback for apartments	
	Supply air temperature	Maximum 110F, Minimum 52F	
	Economizers	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	Depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Depending on the fan supply air cfm	
	Service Water Heating		
	SWH type	Individual Residential Water Heater with Storage Tank	

	Item	Descriptions	Data Source
	Fuel type	Electricity	Reference: RECS 2005
	Thermal efficiency (%)	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Tank Volume (gal)	20	Reference: Building America Research Benchmark
	Water temperature setpoint	120 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	Apartment units: 0.36 w/ft² (daily peak for hard-wired lighting) Other space types: meet maximum allowed Lighting Power Densities (LPD) by ASHRAE 90.1, using Space-by-Space Method	Apartment: Building America Research Benchmark Corridor: ASHRAE 90.1
	Schedule	See Appendix C	Reference: Building America Research Benchmark
	Daylighting Controls	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Occupancy Sensors	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Plug load		
	Average power density (W/ft^2)	0.62 W/ft² daily peak per apartment, including all the home appliances	Reference: Building America Research Benchmark
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	Reference: Building America Research Benchmark
	Schedule	See Appendix C	
Misc.			
	Elevator		
	Quantity	1	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Motor type	hydraulic	
	Peak Motor Power (watts/elevator)	16,055	
	Heat Gain to Building	Interior	
	Peak Fan/lights Power (watts/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See Appendix C	Reference: DOE Commercial Reference Building Models of the National Building Stock

	Item	Descriptions	Data Source
	Exterior Lighting		
	Peak Power (W)	4,642	ASHRAE 90.1
	Schedule	See Appendix C	

References

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons. ASHRAE Transactions 109(2).

Gowri K, MA Halverson, and EE Richman. 2007. Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for New York. PNNL-16770, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16770.pdf

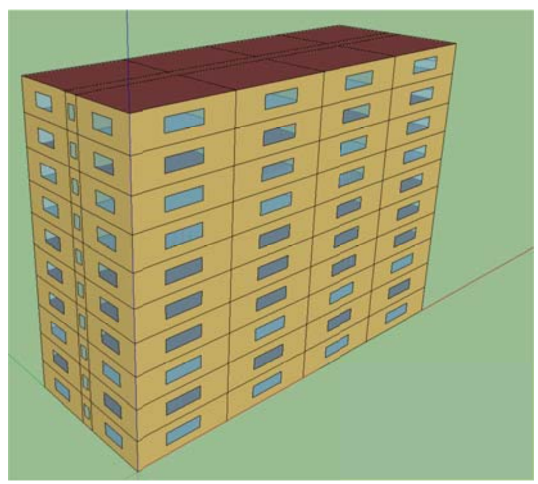
Gowri K, DW Winiarski, and RE Jarnagin. 2009. Infiltration modeling guidelines for commercial building energy analysis. PNNL-18898, Pacific Northwest National Laboratory, Richland, WA. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18898.pdf

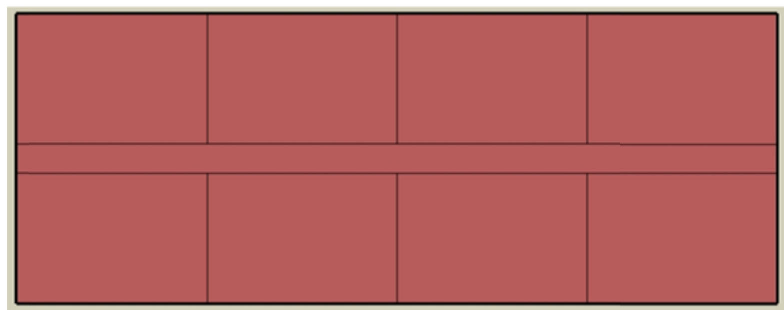
Building America Research Benchmark. http://www1.eere.energy.gov/buildings/building_america/index.html

DOE Commercial Reference Building Models of the National Building Stock: http://www.nrel.gov/docs/fy11osti/46861.pdf

RECS 2005. EIA's Residential Energy Consumption Survey. http://www.eia.doe.gov/emeu/recs/

A.15 High-Rise Apartment Modeling Description

	Item	Descriptions	Data Source
Program			
	Vintage	**NEW CONSTRUCTION**	
	Location (Representing 8 Climate Zones)	Zone 1A: Miami (very hot, humid) Zone 1B: Riyadh, Saudi Arabia (very hot, dry) Zone 2A: Houston (hot, humid) Zone 2B: Phoenix (hot, dry) Zone 3A: Memphis (warm, humid) Zone 3B: El Paso (warm, dry) Zone 3C: San Francisco (warm, marine) Zone 4A: Baltimore (mild, humid) Zone 4B: Albuquerque (mild, dry) Zone 4C: Salem (mild, marine) Zone 5A: Chicago (cold, humid) Zone 5B: Boise (cold, dry) Zone 5C: Vancouver, BC (cold, marine) Zone 6A: Burlington (cold, humid) Zone 6B: Helena (cold, dry) Zone 7: Duluth (very cold) Zone 8: Fairbanks (subarctic)	Selection of representative climates based on Briggs' paper
	Available fuel types	gas, electricity	
	Building Type (Principal Building Function)	**Multifamily**	
	Building Prototype	**High-rise Apartment**	
Form			
	Total Floor Area (sq. feet)	84,360 (152 ft x 55.5 ft)	Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Building shape		
	Aspect Ratio	2.75	

	Item	Descriptions	Data Source
	Number of Floors	10	90.1 Envelop Subcommittee
	Window Fraction (Window-to-Wall Ratio)	South: 14.7%, East: 15.8%, North: 14.7%, West: 15.**1**% Average Total: 14.9%	Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Window Locations	See pictures	
	Shading Geometry	none	
	Azimuth	non-directional	
	Thermal Zoning	 Each floor has 8 apartments except ground floor (7 apartments and 1 lobby with equivalent apartment area) Total 8 apartments per floor with corridor in center. Zone depth is 25 ft for each apartment from side walls and each apt is 25' x 38' (950 ft²).	Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Floor to floor height (ft)	10	
	Floor to ceiling height (ft)	10 (No drop-in ceiling plenum is modeled)	
	Glazing sill height (ft)	3 ft (14 ft wide x 4 ft high)	
Architecture			
	Exterior walls		
	Construction	Steel-Frame Walls (2X4 16IN OC) 0.4 in. Stucco+5/8 in. gypboard + wall Insulation+5/8 in. Gypboard	Reference: PNNL-16770: Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York Base Assembly from 90.1 Appendix A.
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Residential; Walls, above grade, Steel Frame	ASHRAE 90.1-2004

	Item	Descriptions	Data Source
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	vertical	
	Roof		
	Construction	Built-up Roof: Roof membrane+Roof insulation+metal decking	Reference: PNNL-16770: Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York Base Assembly from 90.1 Appendix A.
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	ASHRAE 90.1 Requirements Residential; Roofs, Insulation entirely above deck	ASHRAE 90.1-2004
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	horizontal	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown above	
	U-factor (Btu / h * ft^2 * °F)	ASHRAE 90.1 Requirements Residential; Vertical Glazing, 10.1-20%	ASHRAE 90.1-2004
	SHGC (all)		
	Visible transmittance	Hypothetical window with the exact U-factor and SHGC shown above	
	Operable area	100%	
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Slab-on-grade floors (unheated)	
	Construction	8" concrete slab poured directly on to the earth	
	Slab-on-grade floor insulation Level (F-factor)	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Dimensions	based on floor area and aspect ratio	
	Interior Partitions		
	Construction	2 x 4 uninsulated stud wall	

	Item	Descriptions	Data Source
	Dimensions	based on floor plan and floor-to-floor height	
	Internal Mass	8 lbs/ft^2 of floor area	Reference: Building America Research Benchmark
	Air Barrier System		
	Infiltration (ACH)	0.2016 cfm/ft^2 of gross exterior wall area at all times (at 10 mph wind speed)	Reference: PNNL-18898. *Infiltration Modeling Guidelines for Commercial Building Energy Analysis*.
HVAC			
	System Type		
	Heating type	Water Source Heat Pumps	90.1 Mechanical Subcommittee
	Cooling type		
	Distribution and terminal units	Constant volume	
	HVAC Sizing		
	Air Conditioning	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	ASHRAE 90.1 Requirements Minimum Equipment Efficiency for Electrically Operated Unitary and Applied Heat Pumps	ASHRAE 90.1
	Heating		
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	No setback for apartments	
	Supply air temperature	Maximum 110F, Minimum 52F	
	Economizers	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Ventilation	ASHRAE Ventilation Standard 62.1	ASHRAE Ventilation Standard 62.1
	Demand Control Ventilation	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Energy Recovery	ASHRAE 90.1 Requirements	ASHRAE 90.1

	Item	Descriptions	Data Source
	Supply Fan		
	Fan schedules	See Appendix C	
	Supply Fan Total Efficiency (%)	Depending on the fan motor size	ASHRAE 90.1 requirements for motor efficiency and fan power limitation
	Supply Fan Pressure Drop	Depending on the fan supply air cfm	
	Service Water Heating		
	SWH type	Individual Residential Water Heater with Storage Tank	
	Fuel type	Electricity	Reference: RECS 2005
	Thermal efficiency (%)	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Tank Volume (gal)	20	Reference: Building America Research Benchmark
	Water temperature setpoint	120 F	
	Water consumption	See Appendix C	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	Apartment units: 0.36 w/ft² (daily peak for hard-wired lighting) Corridor: 0.5 w/ft²	Apartment: Building America Research Benchmark Corridor: 90.1-2004
	Schedule	See Appendix C	Reference: Building America Research Benchmark
	Daylighting Controls	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Occupancy Sensors	ASHRAE 90.1 Requirements	ASHRAE 90.1
	Plug load		
	Average power density (W/ft^2)	0.62 W/ft² daily peak per apartment, including all the home appliances	Reference: Building America Research Benchmark
	Schedule	See Appendix C	
	Occupancy		
	Average people	See Appendix B	Reference: Building America Research Benchmark
	Schedule	See Appendix C	
Misc.			

	Item	Descriptions	Data Source
	Elevator		
	Quantity	1	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Motor type	Traction	
	Peak Motor Power (watts/elevator)	20,370	
	Heat Gain to Building	Interior	
	Peak Fan/lights Power (watts/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See Appendix C	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Exterior Lighting		
	Peak Power (W)	13,580	ASHRAE 90.1
	Schedule	See Appendix C	

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Building America Research Benchmark. http://www1.eere.energy.gov/buildings/building_america/index.html

DOE Commercial Reference Building Models of the National Building Stock: http://www.nrel.gov/docs/fy11osti/46861.pdf

RECS 2005. EIA's Residential Energy Consumption Survey. http://www.eia.doe.gov/emeu/recs/

Appendix B

Internal Load Zone Summary

B.1 Small Office Zone Summary

Zone	Area [ft^2]	Conditioned [Y/N]	Volume [ft^3]	Multipliers	Gross Wall Area [ft^2]	Window Glass Area [ft^2]	Lighting[b] [W/ft^2]	People [ft^2/person]	Number of People	Plug and Process [W/ft^2]
CORE_ZN	1,611.1	Yes	16,122.2	1	0	0	1.00	179	9.0	0.63
PERIMETER_ZN_1	1,221.3	Yes	12,221.4	1	909.1	222.2	1.00	179	6.8	0.63
PERIMETER_ZN_2	724.5	Yes	7,249.8	1	606.1	120.1	1.00	179	4.1	0.63
PERIMETER_ZN_3	1,221.3	Yes	12,221.4	1	909.1	180.1	1.00	179	6.8	0.63
PERIMETER_ZN_4	724.5	Yes	7,249.8	1	606.1	120.1	1.00	179	4.1	0.63
ATTIC	6,114.3	No	25,437.1	1	0	0	0	0	0	0
Total[a]	**5,502.6**		**80,501.7**		**3,030.3**	**642.6**			**30.8**	
Area Weighted Average							**1**	**179**		**0.63**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.2 Medium Office Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
CORE_BOTTOM	10,587.8	Yes	95,294.8	1	0	0	1	200	53	0.75
TOPFLOOR_PLENUM	17,877.8	Yes	71,514.5	1	2,183.6	0	0	0	0	0.75
MIDFLOOR_PLENUM	17,877.8	Yes	71,514.5	1	2,183.6	0	0	0	0	0.75
FIRSTFLOOR_PLENUM	17,877.8	Yes	71,514.5	1	2,183.6	0	0	0	0	0.75
CORE_MID	10,587.8	Yes	95,294.8	1	0	0	1	200	53	0.75
CORE_TOP	10,587.8	Yes	95,294.8	1	0	0	1	200	53	0.75
PERIMETER_TOP_ZN_3	2,232.0	Yes	20,089.0	1	1,473.9	702.7	1	200	11	0.75
PERIMETER_TOP_ZN_2	1,413.0	Yes	12,718.0	1	982.6	468.5	1	200	7	0.75
PERIMETER_TOP_ZN_1	2,232.0	Yes	20,089.0	1	1,473.9	702.7	1	200	11	0.75
PERIMETER_TOP_ZN_4	1,412.9	Yes	12,717.0	1	982.6	468.5	1	200	7	0.75
PERIMETER_BOT_ZN_3	2,232.0	Yes	20,089.0	1	1,473.9	702.7	1	200	11	0.75
PERIMETER_BOT_ZN_2	1,413.0	Yes	12,718.0	1	982.6	468.5	1	200	7	0.75
PERIMETER_BOT_ZN_1	2,232.0	Yes	20,089.0	1	1,473.9	702.7	1	200	11	0.75
PERIMETER_BOT_ZN_4	1,412.9	Yes	12,717.0	1	982.6	468.5	1	200	7	0.75
PERIMETER_MID_ZN_3	2,232.0	Yes	20,089.0	1	1,473.9	702.7	1	200	11	0.75
PERIMETER_MID_ZN_2	1,413.0	Yes	12,718.0	1	982.6	468.5	1	200	7	0.75
PERIMETER_MID_ZN_1	2,232.0	Yes	20,089.0	1	1,473.9	702.7	1	200	11	0.75
PERIMETER_MID_ZN_4	1,412.9	Yes	12,717.0	1	982.6	468.5	1	200	7	0.75
Total[a]	**53,633.3**		**697,266.6**		**21,290.2**	**7,027.4**			**268.2**	
Area Weighted Average							**1**	**200**		**0.75**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.3 Large Office Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
BASEMENT	38,339.1	Yes	306,709.3	1	0	0	1.0	199.9	192	0.45
CORE_BOTTOM	27,247.8	Yes	245,238.7	1	0	0	1.0	199.9	136	0.75
CORE_MID	27,247.8	Yes	245,238.7	10	0	0	1.0	199.9	136	0.75
CORE_TOP	27,247.8	Yes	245,238.7	1	0	0	1.0	199.9	136	0.75
PERIMETER_BOT_ZN_3	3,372.3	Yes	30,351.8	1	2,158.6	1,247.1	1.0	199.9	17	0.75
PERIMETER_BOT_ZN_2	2,173.3	Yes	19,560.0	1	1,439.0	831.4	1.0	199.9	11	0.75
PERIMETER_BOT_ZN_1	3,372.4	Yes	30,352.5	1	2,158.6	1,247.1	1.0	199.9	17	0.75
PERIMETER_BOT_ZN_4	2,173.3	Yes	19,560.0	1	1,439.0	831.4	1.0	199.9	11	0.75
PERIMETER_MID_ZN_3	3,372.3	Yes	30,351.8	10	2,158.6	1,247.1	1.0	199.9	17	0.75
PERIMETER_MID_ZN_2	2,173.3	Yes	19,560.0	10	1,439.0	831.4	1.0	199.9	11	0.75
PERIMETER_MID_ZN_1	3,372.4	Yes	30,352.5	10	2,158.6	1,247.1	1.0	199.9	17	0.75
PERIMETER_MID_ZN_4	2,173.3	Yes	19,560.0	10	1,439.0	831.4	1.0	199.9	11	0.75
PERIMETER_TOP_ZN_3	3,372.3	Yes	30,351.8	1	2,158.6	1,247.1	1.0	199.9	17	0.75
PERIMETER_TOP_ZN_2	2,173.3	Yes	19,560.0	1	1,439.0	831.4	1.0	199.9	11	0.75
PERIMETER_TOP_ZN_1	3,372.4	Yes	30,352.5	1	2,158.6	1,247.1	1.0	199.9	17	0.75
PERIMETER_TOP_ZN_4	2,173.3	Yes	19,560.0	1	1,439.0	831.4	1.0	199.9	11	0.75
GROUNDFLOOR_PLENUM	38,339.1	No	153,316.9	1	3,196.9	0	0	0	0	0
MIDFLOOR_PLENUM	38,339.1	No	153,316.9	10	3,196.9	0	0	0	0	0
TOPFLOOR_PLENUM	38,339.1	No	153,316.9	1	3,196.9	0	0	0	0	0
Total[a]	**498,407.8**		**6,287,267.6**		**124,705.4**	**49,884.2**			**2,493.0**	
Area Weighted Average							**1.0**	**199.9**		**0.727**

(a) Only volume, and gross wall area include unconditioned space. Total area and volume include multiplier of zone area and zone volume from Multipliers column
(b) 90.1-2004 baseline requirements for LPD

B.4 Stand-alone Retail Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
BACK_SPACE	4,089	Yes	81,836	1	4,480	0	0.8	66.6	61	0.7
CORE_RETAIL	17,227	Yes	344,775	1	3,841	0	1.7	66.6	259	0.3
POINT_OF_SALE	1,623	Yes	32,487	1	2,043	410	1.7	66.6	24	2.0
FRONT_RETAIL	1,623	Yes	32,487	1	2,043	410	1.7	66.6	24	0.3
FRONT_ENTRY	129	Yes	2,585	1	262	84	1.3	66.6	2	0
Total[a]	**24,692**		**494,171**		**12,669**				**371**	
Area Weighted Average							**179.5**	**66.6**		**0.5**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.5 Strip Mall Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
LGSTORE1	3,750	Yes	63,750	1	2,974	223	2.28	125	30	0.40
SMSTORE1	1,875	Yes	31,875	1	850	112	2.28	125	15	0.40
SMSTORE2	1,875	Yes	31,875	1	850	111	1.70	125	15	0.40
SMSTORE3	1,875	Yes	31,875	1	850	111	1.70	125	15	0.40
SMSTORE4	1,875	Yes	31,875	1	850	111	1.70	125	15	0.40
LGSTORE2	3,750	Yes	63,750	1	1,700	223	1.30	125	30	0.40
SMSTORE5	1,875	Yes	31,875	1	850	111	1.30	125	15	0.40
SMSTORE6	1,875	Yes	31,875	1	850	111	1.30	125	15	0.40
SMSTORE7	1,875	Yes	31,875	1	850	111	1.30	125	15	0.40
SMSTORE8	1,875	Yes	31,875	1	2,124	111	1.30	125	15	0.40
Total[a]	**22,500**		**382,500**		**12,746**	**1338**			**180**	
Area Weighted Average							**1.64**	**125**		**0.40**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.6 Primary School Zone Summary

Zone Name	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
CORNER_CLASS_1_POD_1_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.40	40	27	1.39
MULT_CLASS_1_POD_1_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.40	40	128	1.39
CORRIDOR_POD_1_ZN_1_FLR_1	2,067	Yes	27,126	1	129	45	0.50	0	0	0.37
CORNER_CLASS_2_POD_1_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.40	40	27	1.39
MULT_CLASS_2_POD_1_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.40	40	128	1.39
CORNER_CLASS_1_POD_2_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.40	40	27	1.39
MULT_CLASS_1_POD_2_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.40	40	128	1.39
CORRIDOR_POD_2_ZN_1_FLR_1	2,067	Yes	27,126	1	129	45	0.50	0	0	0.37
CORNER_CLASS_2_POD_2_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.40	40	27	1.39
MULT_CLASS_2_POD_2_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.40	40	128	1.39
CORNER_CLASS_1_POD_3_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.40	40	27	1.39
MULT_CLASS_1_POD_3_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.40	40	128	1.39
CORRIDOR_POD_3_ZN_1_FLR_1	2,067	Yes	27,126	1	129	45	0.50	0	0	0.37
CORNER_CLASS_2_POD_3_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.40	40	27	1.39
MULT_CLASS_2_POD_3_ZN_1_FLR_1	3,391	Yes	44,503	1	1,507	527	1.40	40	85	1.39
COMPUTER_CLASS_ZN_1_FLR_1	1,744	Yes	22,887	1	775	271	1.40	40	44	1.86
MAIN_CORRIDOR_ZN_1_FLR_1	5,878	Yes	77,139	1	388	136	0.50	0	0	0.37
LOBBY_ZN_1_FLR_1	1,841	Yes	24,159	1	818	286	1.30	0	0	0.37
MECH_ZN_1_FLR_1	2,713	Yes	35,602	1	0	0	1.50	0	0	0.93
BATH_ZN_1_FLR_1	2,045	Yes	26,843	1	431	151	0.90	0	0	0.37
OFFICES_ZN_1_FLR_1	4,747	Yes	62,304	1	1,809	633	1.10	200	24	1.00
GYM_ZN_1_FLR_1	3,843	Yes	50,437	1	732	400	1.40	33	115	0.46
KITCHEN_ZN_1_FLR_1	1,809	Yes	23,735	1	344	121	1.20	67	27	151.11
CAFETERIA_ZN_1_FLR_1	3,391	Yes	44,503	1	1,550	543	0.90	10	339	2.36
LIBRARY_MEDIA_CENTER_ZN_1_FLR_1	4,295	Yes	56,370	1	1,722	603	1.30	100	43	1.39
Total[a]	**73,966**		**970,730**		**27,042**	**9,609**			**1,477**	
Area Weighted Average							**1.19**	**42.62**		**4.80**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.7 Secondary School Zone Summary

Zone Name	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
CORNER_CLASS_1_POD_1_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
CORNER_CLASS_1_POD_1_ZN_1_FLR_2	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
MULT_CLASS_1_POD_1_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
MULT_CLASS_1_POD_1_ZN_1_FLR_2	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
CORRIDOR_POD_1_ZN_1_FLR_1	3,445	Yes	45,209	1	215	75	0.5	0	0	0.4
CORRIDOR_POD_1_ZN_1_FLR_2	3,445	Yes	45,209	1	215	75	0.5	0	0	0.4
CORNER_CLASS_2_POD_1_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
CORNER_CLASS_2_POD_1_ZN_1_FLR_2	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
MULT_CLASS_2_POD_1_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
MULT_CLASS_2_POD_1_ZN_1_FLR_2	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
CORNER_CLASS_1_POD_2_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
CORNER_CLASS_1_POD_2_ZN_1_FLR_2	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
MULT_CLASS_1_POD_2_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
MULT_CLASS_1_POD_2_ZN_1_FLR_2	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
CORRIDOR_POD_2_ZN_1_FLR_1	3,445	Yes	45,209	1	215	75	0.5	0	0	0.4
CORRIDOR_POD_2_ZN_1_FLR_2	3,445	Yes	45,209	1	215	75	0.5	0	0	0.4
CORNER_CLASS_2_POD_2_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
CORNER_CLASS_2_POD_2_ZN_1_FLR_2	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
MULT_CLASS_2_POD_2_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
MULT_CLASS_2_POD_2_ZN_1_FLR_2	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
CORNER_CLASS_1_POD_3_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
CORNER_CLASS_1_POD_3_ZN_1_FLR_2	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
MULT_CLASS_1_POD_3_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
MULT_CLASS_1_POD_3_ZN_1_FLR_2	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	1.9
CORRIDOR_POD_3_ZN_1_FLR_1	3,445	Yes	45,209	1	215	75	0.5	0	0	0.4
CORRIDOR_POD_3_ZN_1_FLR_2	3,445	Yes	45,209	1	215	75	0.5	0	0	0.4
CORNER_CLASS_2_POD_3_ZN_1_FLR_1	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
CORNER_CLASS_2_POD_3_ZN_1_FLR_2	1,066	Yes	13,987	1	861	301	1.4	28.5	37	0.9
MULT_CLASS_2_POD_3_ZN_1_FLR_1	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	0.9
MULT_CLASS_2_POD_3_ZN_1_FLR_2	5,135	Yes	67,390	1	2,282	799	1.4	28.5	180	1.9
MAIN_CORRIDOR_ZN_1_FLR_1	12,272	Yes	161,057	1	2,153	527	0.5	0	0	0.4
MAIN_CORRIDOR_ZN_1_FLR_2	12,272	Yes	161,057	1	2,153	527	0.5	0	0	0.4
LOBBY_ZN_1_FLR_1	2,261	Yes	29,668	1	646	226	1.3	0	0	0.4

Zone Name	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
LOBBY_ZN_1_FLR_2	2,261	Yes	29,668	1	646	226	1.3	0	0	0.4
BATHROOMS_ZN_1_FLR_1	2,261	Yes	29,668	1	1,249	271	0.9	0	0	0.4
BATHROOMS_ZN_1_FLR_2	2,261	Yes	29,668	1	1,249	271	0.9	0	0	0.4
OFFICES_ZN_1_FLR_1	5,727	Yes	75,160	1	2,239	784	1.1	200.0	29	1.0
OFFICES_ZN_1_FLR_2	5,727	Yes	75,160	1	2,239	784	1.1	200.0	29	1.0
GYM_ZN_1_FLR_1	21,272	Yes	558,330	1	0	864	1.4	33.4	637	0.5
AUX_GYM_ZN_1_FLR_1	13,435	Yes	352,630	1	6,545	2,867	1.4	33.4	403	0.5
AUDITORIUM_ZN_1_FLR_1	10,636	Yes	279,165	1	5,512	1,145	0.9	6.7	1,594	0.5
KITCHEN_ZN_1_FLR_1	2,325	Yes	30,516	1	388	136	1.2	66.4	35	177.0
LIBRARY_MEDIA_CENTER_ZN_1_FLR_2	9,043	Yes	118,673	1	2,541	894	1.3	100.0	90	0.9
CAFETERIA_ZN_1_FLR_1	6,717	Yes	88,157	1	2,153	754	0.9	10.0	671	7.1
MECH_ZN_1_FLR_1	3,682	Yes	48,317	1	0	0	1.5	0	0	9.2
MECH_ZN_1_FLR_2	3,682	Yes	48,317	1	0	0	1.5	0	0	0.4
Total[a]	210,907		3,362,978		68,723	23,931			6,096	
Area Weighted Average							1.13	32.09		3.01

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.8 Outpatient Healthcare Zone Summary

Zone	Area [ft^2]	Conditioned [Y/N]	Volume [ft^3]	Multipliers	Gross Wall Area [ft^2]	Window Glass Area [ft^2]	Lighting[b] [W/ft^2]	People[b] [ft^2/person]	Number of People	Plug and Process[2] [W/ft^2]
Floor 1 Anesthesia	108	Yes	1,080	1	90	24	1.50	50	2	2.0
Floor 1 Bio Haz	56	Yes	560	1	0	0	0.90	0	0	0.1
Floor 1 Café	420	Yes	4,200	1	200	96	0.90	10	42	1.0
Floor 1 Clean	126	Yes	1,260	1	0	0	1.50	50	3	2.0
Floor 1 Clean Work	165	Yes	1,650	1	0	0	1.50	50	3	2.0
Floor 1 Dictation	126	Yes	1,260	1	0	0	1.10	200	1	1.1
Floor 1 Dressing Room	45	Yes	450	1	90	25	1.10	200	0	1.1
Floor 1 Electrical Room	98	Yes	980	1	70	0	1.50	0	0	5.0
Floor 1 Elevator Pump Room	91	Yes	910	1	200	0	1.50	0	0	534.6
Floor 1 Humid	54	Yes	540	1	0	0	1.10	200	0	1.1
Floor 1 IT Hall	140	Yes	1,400	1	0	0	1.00	0	0	0.4
Floor 1 IT Room	112	Yes	1,120	1	0	0	1.10	200	1	1.1
Floor 1 Lobby	622	Yes	6,220	1	220	96	1.30	100	6	1.1
Floor 1 Lobby Hall	240	Yes	2,400	1	0	0	1.00	0	0	0.4
Floor 1 Lobby Toilet	54	Yes	540	1	60	0	0.90	0	0	0.4
Floor 1 Locker Room	660	Yes	6,600	1	220	60	0.80	67	10	3.0
Floor 1 Locker Room Hall	496	Yes	4,960	1	0	0	1.00	0	0	0.4
Floor 1 Lounge	360	Yes	3,600	1	0	0	0.80	67	5	3.0
Floor 1 Med Gas	56	Yes	560	1	150	0	0.90	0	0	0.1
Floor 1 MRI Control Room	168	Yes	1,680	1	50	0	0.40	50	3	10.0
Floor 1 MRI Hall	147	Yes	1,470	1	0	0	1.00	0	0	0.4
Floor 1 MRI Room	440	Yes	4,400	1	0	0	0.40	50	9	10.0
Floor 1 MRI Toilet	54	Yes	540	1	60	0	0.90	0	0	0.4
Floor 1 Nourishment	182	Yes	1,820	1	0	0	1.00	50	4	2.0
Floor 1 Nurse Hall	496	Yes	4,960	1	0	0	1.00	0	0	0.4
Floor 1 Nurse Janitor	54	Yes	540	1	0	0	0.90	0	0	0.1
Floor 1 Nurse Station	261	Yes	2,610	1	0	0	1.00	50	5	2.0
Floor 1 Nurse Toilet	54	Yes	540	1	0	0	0.90	0	0	0.4
Floor 1 Office	483	Yes	4,830	1	0	0	1.10	200	2	1.1
Floor 1 Operating Room 1	460	Yes	4,600	1	430	96	2.20	50	9	11.0
Floor 1 Operating Room 2	480	Yes	4,800	1	240	72	2.20	50	10	11.0
Floor 1 Operating Room 3	476	Yes	4,760	1	0	0	2.20	50	10	11.0
Floor 1 PACU	108	Yes	1,080	1	0	0	0.80	50	2	3.0

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[(b)] [W/ft²]	People[(b)] [ft²/person]	Number of People	Plug and Process[2] [W/ft²]
Floor 1 Pre-Op Hall	528	Yes	5,280	1	0	0	1.00	0	0	0.4
Floor 1 Pre-Op Room 1	189	Yes	1,890	1	40	0	0.70	100	2	2.0
Floor 1 Pre-Op Room 2	338	Yes	3,380	1	0	0	0.70	100	3	2.0
Floor 1 Pre-Op Toilet	54	Yes	540	1	60	0	0.90	0	0	0.4
Floor 1 Procedure Room	285	Yes	2,850	1	190	60	2.70	50	6	3.0
Floor 1 Reception	509	Yes	5,090	1	130	36	1.30	33	15	1.1
Floor 1 Reception Hall	128	Yes	1,280	1	0	0	1.00	0	0	0.4
Floor 1 Recovery Room	540	Yes	5,400	1	450	96	0.80	50	11	3.0
Floor 1 Scheduling	119	Yes	1,190	1	70	8	1.10	200	1	1.1
Floor 1 Scrub	84	Yes	840	1	0	0	1.00	0	0	0.4
Floor 1 Soil	126	Yes	1,260	1	0	0	1.50	50	3	2.0
Floor 1 Soil Hold	56	Yes	560	1	0	0	1.50	50	1	2.0
Floor 1 Soil Work	180	Yes	1,800	1	0	0	1.50	50	4	2.0
Floor 1 Step Down	300	Yes	3,000	1	370	72	0.80	50	6	3.0
Floor 1 Sterile Hall	616	Yes	6,160	1	80	24	1.00	0	0	0.4
Floor 1 Sterile Storage	396	Yes	3,960	1	0	0	0.90	0	0	0.1
Floor 1 Storage	920	Yes	9,200	1	630	90	0.90	0	0	0.1
Floor 1 Sub-Sterile	196	Yes	1,960	1	140	32	1.00	0	0	0.4
Floor 1 Utility Hall	256	Yes	2,560	1	160	0	1.00	0	0	0.4
Floor 1 Utility Janitor	42	Yes	420	1	0	0	0.90	0	0	0.1
Floor 1 Utility Room	360	Yes	3,600	1	180	24	0.90	0	0	0.1
Floor 1 Vestibule	72	Yes	720	1	80	0	1.00	0	0	0.4
Floor 2 Conference	336	Yes	3,360	1	400	96	1.30	20	17	1.0
Floor 2 Conference Toilet	64	Yes	640	1	0	0	0.90	0	0	0.4
Floor 2 Dictation	70	Yes	700	1	0	0	1.10	200	0	1.1
Floor 2 Exam 1	360	Yes	3,600	1	420	96	1.50	50	7	1.1
Floor 2 Exam 2	540	Yes	5,400	1	180	40	1.50	50	11	1.1
Floor 2 Exam 3	720	Yes	7,200	1	240	64	1.50	50	14	1.1
Floor 2 Exam 4	84	Yes	840	1	70	24	1.50	50	2	1.1
Floor 2 Exam 5	350	Yes	3,500	1	250	64	1.50	50	7	1.1
Floor 2 Exam 6	225	Yes	2,250	1	150	45	1.50	50	5	1.1
Floor 2 Exam 7	792	Yes	7,920	1	240	60	1.50	50	16	1.1
Floor 2 Exam 8	270	Yes	2,700	1	180	60	1.50	50	5	1.1
Floor 2 Exam 9	396	Yes	3,960	1	120	30	1.50	50	8	1.1
Floor 2 Exam Hall 1	180	Yes	1,800	1	60	0	1.00	0	0	0.4

Zone	Area [ft^2]	Conditioned [Y/N]	Volume [ft^3]	Multipliers	Gross Wall Area [ft^2]	Window Glass Area [ft^2]	Lighting[b] [W/ft^2]	People[b] [ft^2/person]	Number of People	Plug and Process[2] [W/ft^2]
Floor 2 Exam Hall 2	180	Yes	1,800	1	60	0	1.00	0	0	0.4
Floor 2 Exam Hall 3	180	Yes	1,800	1	60	0	1.00	0	0	0.4
Floor 2 Exam Hall 4	198	Yes	1,980	1	60	0	1.00	0	0	0.4
Floor 2 Exam Hall 5	198	Yes	1,980	1	60	0	1.00	0	0	0.4
Floor 2 Exam Hall 6	198	Yes	1,980	1	60	0	1.00	0	0	0.4
Floor 2 Janitor	63	Yes	630	1	160	0	0.90	0	0	0.1
Floor 2 Lounge	80	Yes	800	1	0	0	0.80	67	1	3.0
Floor 2 Nurse Station 1	150	Yes	1,500	1	0	0	1.00	50	3	2.0
Floor 2 Nurse Station 2	180	Yes	1,800	1	0	0	1.00	50	4	2.0
Floor 2 Office	560	Yes	5,600	1	400	96	1.10	200	3	1.1
Floor 2 Office Hall	444	Yes	4,440	1	0	0	1.00	0	0	0.4
Floor 2 Reception	984	Yes	9,840	1	490	180	1.30	33	29	1.1
Floor 2 Reception Hall	564	Yes	5,640	1	70	0	1.00	0	0	0.4
Floor 2 Reception Toilet	126	Yes	1,260	1	0	0	0.90	0	0	0.4
Floor 2 Scheduling 1	324	Yes	3,240	1	0	0	1.10	200	2	1.1
Floor 2 Scheduling 2	342	Yes	3,420	1	0	0	1.10	200	2	1.1
Floor 2 Storage 1	56	Yes	560	1	0	0	0.90	0	0	0.1
Floor 2 Storage 2	120	Yes	1,200	1	0	0	0.90	0	0	0.1
Floor 2 Storage 3	144	Yes	1,440	1	0	0	0.90	0	0	0.1
Floor 2 Utility	126	Yes	1,260	1	90	24	0.90	0	0	0.1
Floor 2 Work	1,690	Yes	16,900	1	260	60	1.10	200	8	0.9
Floor 2 Work Hall	834	Yes	8,340	1	60	0	1.00	0	0	0.4
Floor 2 Work Toilet	54	Yes	540	1	60	0	0.90	0	0	0.4
Floor 2 X-Ray	900	Yes	9,000	1	0	0	0.40	50	18	10.0
Floor 3 Dressing Room	42	Yes	420	1	0	0	1.10	200	0	1.1
Floor 3 Elevator Hall	370	Yes	3,700	1	40	0	1.00	0	0	0.4
Floor 3 Humid	108	Yes	1,080	1	0	0	1.10	200	1	1.1
Floor 3 Janitor	63	Yes	630	1	160	0	0.90	0	0	0.1
Floor 3 Locker	120	Yes	1,200	1	0	0	0.80	67	2	3.0
Floor 3 Lounge	759	Yes	7,590	1	230	60	0.80	67	11	3.0
Floor 3 Lounge Toilet	192	Yes	1,920	1	120	45	0.90	0	0	0.4
Floor 3 Mechanical	350	Yes	3,500	1	250	64	1.50	0	0	5.0
Floor 3 Mechanical Hall	300	Yes	3,000	1	0	0	1.00	0	0	0.4
Floor 3 Office	3,036	Yes	30,360	1	740	210	1.10	200	15	1.1
Floor 3 Office Hall	834	Yes	8,340	1	60	0	1.00	0	0	0.4

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting(b) [W/ft²]	People(b) [ft²/person]	Number of People	Plug and Process[2] [W/ft²]
Floor 3 Office Toilet	54	Yes	540	1	60	0	0.90	0	0	0.4
Floor 3 Physical Therapy 1	1,300	Yes	13,000	1	850	312	0.90	50	26	1.5
Floor 3 Physical Therapy 2	592	Yes	5,920	1	0	0	0.90	50	12	1.5
Floor 3 Physical Therapy Toilet	84	Yes	840	1	0	0	0.90	0	0	0.4
Floor 3 Storage 1	108	Yes	1,080	1	0	0	0.90	0	0	0.1
Floor 3 Storage 2	84	Yes	840	1	0	0	0.90	0	0	0.1
Floor 3 Treatment	476	Yes	4,760	1	0	0	1.50	50	10	1.1
Floor 3 Undeveloped 1	2,268	Yes	22,680	1	720	276	0.90	0	0	1.1
Floor 3 Undeveloped 2	1,152	Yes	11,520	1	560	144	0.90	0	0	1.1
Floor 3 Utility	216	Yes	2,160	1	0	0	0.90	0	0	0.1
Floor 3 Work	574	Yes	5,740	1	410	96	1.10	200	3	1.1
NE Stair	168	Yes	5,040	1	1050	129	1.00	0	0	0.4
NW Elevator	140	Yes	4,200	1	810	0	1.00	0	0	0.4
NW Stair	192	Yes	5,760	1	1200	120	1.00	0	0	0.4
SW Stair	96	Yes	2,880	1	600	12	1.00	0	0	0.4
Total(a)	**40,946**		**421,380**		**16,719**	**3,318**			**419**	
Area Weighted Average							**1.09**	**59.43**		**2.97**

(a) Only volume, and gross wall area include unconditioned space.
(b) Requirements from 90.1-2004 baseline, AEDG Small Healthcare and Green Guide for Healthcare

B.9 Hospital Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[(b)] [W/ft²]	People[2] [ft²/person]	Number of People	Plug and Process[2] [W/ft²]
BASEMENT	40,235.4	No	321,832.0	1	0	0	1.00	400	101	0.75
ER_EXAM1_MULT4_FLR_1	299.9	Yes	4,197.8	4	280	0	2.70	50	6	1.50
ER_TRAUMA1_FLR_1	299.9	Yes	4,197.8	1	490	0	2.70	50	6	4.00
ER_EXAM3_MULT4_FLR_1	299.9	Yes	4,197.8	4	210	0	2.70	50	6	1.50
ER_TRAUMA2_FLR_1	299.9	Yes	4,197.8	1	490	0	2.70	50	6	4.00
ER_TRIAGE_MULT4_FLR_1	299.9	Yes	4,197.8	4	280	0	2.70	50	6	2.00
OFFICE1_MULT4_FLR_1	150.0	Yes	2,099.6	5	140	32	1.10	143	1	1.10
LOBBY_RECORDS_FLR_1	15,869.0	Yes	222,132.3	1	4,409	674	1.27	750	21	0.10
CORRIDOR_FLR_1	6,122.8	Yes	85,706.1	1	980	0	1.00	1,000	6	0
ER_NURSESTN_LOBBY_FLR_1	13,295.2	Yes	186,104.8	1	1190	327	1.12	750	18	1.36
OR1_FLR_2	599.8	Yes	8,395.3	1	700	0	2.20	200	3	4.00
OR2_MULT5_FLR_2	599.8	Yes	8,395.3	5	280	0	2.20	200	3	4.00
OR3_FLR_2	599.8	Yes	8,395.3	1	420	0	2.20	200	3	4.00
OR4_FLR_2	2,399.2	Yes	33,583.2	1	0	0	2.20	200	12	4.00
IC_PATROOM1_MULT5_FLR_2	224.9	Yes	3,148.0	5	210	53	0.80	200	1	3.00
IC_PATROOM2_FLR_2	299.9	Yes	4,197.8	1	490	123	0.80	200	1	3.00
IC_PATROOM3_MULT6_FLR_2	224.9	Yes	3,148.0	6	210	53	0.80	200	1	3.00
ICU_FLR_2	6,649.2	Yes	93,075.5	1	2,310	269	0.80	200	33	3.00
ICU_NURSESTN_LOBBY_FLR_2	7,196.0	Yes	100,728.7	1	0	0	1.00	750	10	2.00
CORRIDOR_FLR_2	6,122.8	Yes	85,706.1	1	980	0	1.00	1,000	6	0
OR_NURSESTN_LOBBY_FLR_2	10,896.0	Yes	152,521.3	1	1,960	385	1.18	750	15	1.04
PATROOM1_MULT10_FLR_3	224.9	Yes	3,148.0	10	210	53	0.70	200	1	2.00
PATROOM2_FLR_3	374.9	Yes	5,247.6	1	560	141	0.70	200	2	2.00
PATROOM3_MULT10_FLR_3	217.5	Yes	3,043.9	10	203	51	0.70	200	1	2.00
PATROOM4_FLR_3	374.9	Yes	5,247.6	1	560	141	0.70	200	2	2.00
PATROOM5_MULT10_FLR_3	224.9	Yes	3,148.0	10	210	53	0.70	200	1	2.00
PHYSTHERAPY_FLR_3	5,248.1	Yes	73,462.3	1	0	0	0.90	200	26	1.50
PATROOM6_FLR_3	299.9	Yes	4,197.8	1	490	123	0.70	200	1	2.00
PATROOM7_MULT10_FLR_3	217.5	Yes	3,043.9	10	203	51	0.70	200	1	2.00
PATROOM8_FLR_3	299.9	Yes	4,197.8	1	490	123	0.70	200	1	2.00
NURSESTN_LOBBY_FLR_3	9,746.4	Yes	136,430.5	1	420	0	1.18	750	13	1.04
LAB_FLR_3	2,848.9	Yes	39,854.8	1	0	0	1.40	200	14	4.00
CORRIDOR_SE_FLR_3	6,097.8	Yes	85,356.4	1	490	0	1.00	1,000	6	0

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People[2] [ft²/person]	Number of People	Plug and Process[2] [W/ft²]
CORRIDOR_NW_FLR_3	6,097.8	Yes	85,356.4	1	907	0	1.00	1,000	6	0
PATROOM1_MULT10_FLR_4	224.9	Yes	3,148.0	10	210	53	0.70	200	1	2.00
PATROOM2_FLR_4	374.9	Yes	5,247.6	1	560	141	0.70	200	2	2.00
PATROOM3_MULT10_FLR_4	217.5	Yes	3,043.9	10	203	51	0.70	200	1	2.00
PATROOM4_FLR_4	374.9	Yes	5,247.6	1	560	141	0.70	200	2	2.00
PATROOM5_MULT10_FLR_4	224.9	Yes	3,148.0	10	210	53	0.70	200	1	2.00
RADIOLOGY_FLR_4	5,248.1	Yes	73,462.3	1	0	0	0.40	200	26	10.00
PATROOM6_FLR_4	299.9	Yes	4,197.8	1	490	123	0.70	200	1	2.00
PATROOM7_MULT10_FLR_4	217.5	Yes	3,043.9	10	203	51	0.70	200	1	2.00
PATROOM8_FLR_4	299.9	Yes	4,197.8	1	490	123	0.70	200	1	2.00
NURSESTN_LOBBY_FLR_4	9,746.4	Yes	136,429.4	1	420	0	1.18	750	13	1.04
LAB_FLR_4	2,848.9	Yes	39,854.8	1	0	0	1.40	200	14	4.00
CORRIDOR_SE_FLR_4	6,097.8	Yes	85,356.4	1	490	0	1.00	1,000	6	0
CORRIDOR_NW_FLR_4	6,097.8	Yes	85,356.4	1	907	0	1.00	1,000	6	0
DINING_FLR_5	7,497.2	Yes	104,946.6	1	2,450	385	0.90	100	75	1.00
NURSESTN_LOBBY_FLR_5	11,195.9	Yes	156,720.1	1	1,120	0	1.18	750	15	1.04
KITCHEN_FLR_5	9,996.4	Yes	139,928.2	1	2,800	0	1.20	200	50	22.63
OFFICE1_FLR_5	750.0	Yes	10,498.0	1	770	193	1.10	143	5	1.00
OFFICE2_MULT5_FLR_5	749.8	Yes	10,494.9	5	350	88	1.10	143	5	1.00
OFFICE3_FLR_5	749.8	Yes	10,494.9	1	770	193	1.10	143	5	1.00
OFFICE4_MULT6_FLR_5	150.0	Yes	2,099.6	6	140	32	1.10	143	1	1.00
CORRIDOR_FLR_5	5,398.1	Yes	75,561.9	1	840	0	1.00	1,000	5	0
Total[a]	**241,412.5**		**3,137,849.2**		**57,598**	**9,130**			**767**	
Area Weighted Average							**1.09**	**542.86**		**2.22**

(a) Only volume, and gross wall area include unconditioned space.
(b) Requirements from 90.1-2004 baseline, AEDG Small Healthcare and Green Guide for Healthcare

B.10 Small Hotel Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
REARSTAIRSFLR1	216	Yes	2,375	1	385	0	0.60	0	0	0
CORRIDORFLR1	1,620	Yes	17,809	1	352	106	0.50	0	0	0
REARSTORAGEFLR1	216	No	2,375	1	385	0	0.80	0	0	0
FRONTLOUNGEFLR1	1,755	Yes	19,295	1	1,012	160	1.10	33	53	2.42
RESTROOMFLR1	351	Yes	3,859	1	143	0	0.90	351	1	0
MEETINGROOMFLR1	864	Yes	9,499	1	352	53	1.30	20	43	0.57
MECHANICALROOMFLR1	351	Yes	3,859	1	143	0	1.50	0	0	0
GUESTROOM101	351	Yes	3,859	1	143	18	1.10	234	2	1.11
GUESTROOM102	351	Yes	3,859	1	143	18	1.10	234	2	1.11
GUESTROOM103	351	Yes	3,859	1	143	18	1.10	234	2	1.11
GUESTROOM104	351	Yes	3,859	1	143	18	1.10	234	2	1.11
GUESTROOM105	351	Yes	3,859	1	143	18	1.10	234	2	1.11
EMPLOYEELOUNGEFLR1	351	Yes	3,859	1	143	18	1.20	19	18	2.00
LAUNDRYROOMFLR1	1,053	No	11,576	1	429	53	0.60	96	11	40.67
ELEVATORCOREFLR1	162	No	1,781	1	66	0	0	0	0	200.28
EXERCISECENTERFLR1	351	Yes	3,859	1	143	18	0.90	50	7	1.73
FRONTOFFICEFLR1	1,404	Yes	15,435	1	572	71	1.10	140	10	1.28
FRONTSTAIRSFLR1	216	Yes	2,374	1	385	0	0.60	0	0	0
FRONTSTORAGEFLR1	135	No	1,484	1	55	0	0.80	0	0	0
REARSTAIRSFLR2	216	Yes	1,943	1	315	0	0.60	0	0	0
CORRIDORFLR2	1,350	Yes	12,142	1	198	28	0.50	0	0	0
REARSTORAGEFLR2	216	No	1,944	1	315	0	0.80	0	0	0
GUESTROOM201	351	Yes	3,157	1	360	18	1.10	234	2	1.11
GUESTROOM202_205	1,404	Yes	12,629	1	468	71	1.10	234	6	1.11
GUESTROOM206_208	1,134	Yes	10,200	1	378	72	1.10	252	5	1.11
GUESTROOM209_212	1,404	Yes	12,629	1	468	71	1.10	234	6	1.11
GUESTROOM213	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM214	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM215_218	1,404	Yes	12,628	1	468	71	1.10	234	6	1.11
ELEVATORCOREFLR2	162	No	1,457	1	54	0	0	0	0	0
GUESTROOM219	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM220_223	1,404	Yes	12,628	1	468	71	1.10	234	6	1.11
GUESTROOM224	351	Yes	3,157	1	117	18	1.10	234	2	1.11
FRONTSTORAGEFLR2	135	No	1,214	1	45	0	0.80	0	0	0
FRONTSTAIRSFLR2	216	Yes	1,943	1	315	0	0.60	0	0	0

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
REARSTAIRSFLR3	216	Yes	1,943	1	315	0	0.60	0	0	0
CORRIDORFLR3	1,350	Yes	12,142	1	198	28	0.50	0	0	0
REARSTORAGEFLR3	216	No	1,944	1	315	0	0.80	0	0	0
GUESTROOM301	351	Yes	3,157	1	360	18	1.10	234	2	1.11
GUESTROOM302_305	1,404	Yes	12,629	1	468	71	1.10	234	6	1.11
GUESTROOM306_308	1,134	Yes	10,200	1	378	72	1.10	252	5	1.11
GUESTROOM309_312	1,404	Yes	12,629	1	468	71	1.10	234	6	1.11
GUESTROOM313	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM314	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM315_318	1,404	Yes	12,628	1	468	71	1.10	234	6	1.11
ELEVATORCOREFLR3	162	No	1,457	1	54	0	0	0	0	0
GUESTROOM319	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM320_323	1,404	Yes	12,628	1	468	71	1.10	234	6	1.11
GUESTROOM324	351	Yes	3,157	1	117	18	1.10	234	2	1.11
FRONTSTORAGEFLR3	135	No	1,214	1	45	0	0.80	0	0	0
FRONTSTAIRSFLR3	216	Yes	1,943	1	315	0	0.60	0	0	0
REARSTAIRSFLR4	216	Yes	1,943	1	315	0	0.60	0	0	0
CORRIDORFLR4	1,350	Yes	12,142	1	198	28	0.50	0	0	0
REARSTORAGEFLR4	216	No	1,944	1	315	0	0.80	0	0	0
GUESTROOM401	351	Yes	3,157	1	360	18	1.10	234	2	1.11
GUESTROOM402_405	1,404	Yes	12,629	1	468	71	1.10	234	6	1.11
GUESTROOM406_408	1,134	Yes	10,200	1	378	72	1.10	252	5	1.11
GUESTROOM409_412	1,404	Yes	12,629	1	468	71	1.10	234	6	1.11
GUESTROOM413	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM414	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM415_418	1,404	Yes	12,628	1	468	71	1.10	234	6	1.11
ELEVATORCOREFLR4	162	No	1,457	1	54	0	0	0	0	0
GUESTROOM419	351	Yes	3,157	1	117	18	1.10	234	2	1.11
GUESTROOM420_423	1,404	Yes	12,628	1	468	71	1.10	234	6	1.11
GUESTROOM424	351	Yes	3,157	1	117	18	1.10	234	2	1.11
FRONTSTORAGEFLR4	135	No	1,214	1	45	0	0.80	0	0	0
FRONTSTAIRSFLR4	216	Yes	1,943	1	315	0	0.60	0	0	0
Total[a]	**40,101**		**410,163**		**18,235**	**1,983**			**259**	
Area Weighted Average							**1.04**	**173.6**		**2.82**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.11 Large Hotel Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
BASEMENT	21,300	Yes	170,442	1	0	0	1.00	400	106	0.50
RETAIL_1_FLR_1	722	Yes	9,385	1	741	251	1.50	125	11	1.00
RETAIL_2_FLR_1	836	Yes	10,868	1	286	0	1.50	125	13	1.00
MECH_FLR_1	1,768	Yes	22,983	1	676	0	1.50	0	0	0.50
STORAGE_FLR_1	1,020	Yes	13,259	1	390	0	0.90	501	0	0.25
LAUNDRY_FLR_1	840	Yes	10,920	1	923	0	0.60	250	8	55.53
CAFE_FLR_1	2,033	Yes	26,427	1	1,638	706	1.30	15	142	0.50
LOBBY_FLR_1	14,081	Yes	183,054	1	4,680	918	1.10	33	422	0.75
ROOM_1_FLR_3	420	Yes	4,200	4	430	142	1.10	280	2	0.63
ROOM_2_FLR_3	420	Yes	4,200	4	430	142	1.10	280	2	0.63
ROOM_3_MULT19_FLR_3	264	Yes	2,640	76	120	40	1.10	176	2	0.98
ROOM_4_MULT19_FLR_3	264	Yes	2,640	76	120	40	1.10	176	2	0.98
ROOM_5_FLR_3	420	Yes	4,200	4	430	142	1.10	280	2	0.63
ROOM_6_FLR_3	420	Yes	4,200	4	430	142	1.10	280	2	0.63
CORRIDOR_FLR_3	4,191	Yes	41,915	4	520	172	0.50	997	0	0
ROOM_1_FLR_6	420	Yes	4,200	1	430	142	1.10	280	2	0.63
ROOM_2_FLR_6	420	Yes	4,200	1	430	142	1.10	280	2	0.63
ROOM_3_MULT9_FLR_6	264	Yes	2,640	9	220	73	1.10	176	2	0.98
BANQUET_FLR_6	3,570	Yes	35,699	1	1,050	347	1.30	15	250	6.30
DINING_FLR_6	3,570	Yes	35,699	1	1,050	347	1.30	15	250	6.30
KITCHEN_FLR_6	1,112	Yes	11,119	1	940	284	1.20	200	22	272.68
CORRIDOR_FLR_6	4,436	Yes	44,360	1	920	304	0.50	997	0	0
Total[a]	**122,115**		**1,242,537**		**43,337**	**13,071**			**1,494**	
Area Weighted Average							**1.00**	**335.69**		**3.82**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.12 Warehouse Zone Summary

Zone	Area [ft^2]	Conditioned [Y/N]	Volume [ft^3]	Multipliers	Gross Wall Area [ft^2]	Window Glass Area [ft^2]	Lighting[b] [W/ft^2]	People [ft^2/person]	Number of People	Plug and Process [W/ft^2]
ZONE1 OFFICE	2,550	Yes	35,700	1	1,610	190	1.0	510	5.0	0.75
ZONE2 FINE STORAGE	15,000	Yes	384,300	1	8,190	0	0.8	0	0	0
ZONE3 BULK STORAGE	34,500	Yes	1,245,987	1	17,080	160	0.8	0	0	0.24
Total[a]	**52,050**		**1,665,987**		**26,880**	**350**			**5**	
Area Weighted Average							**0.8**	**25.0**		**0.19**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.13 Quick Service Restaurant Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
DINING	1,250	Yes	12,508	1	1,000	280	2.1	14.3	87	10.9
KITCHEN	1,250	Yes	12,508	1	1,000	0	1.2	199.3	6	98.8
ATTIC	2,501	No	9,264	1	0	0	0	0	0	0
Total[a]	**2,501**		**34,280**		**2,001**	**280**			**94**	**0**
Area Weighted Average							**1.6**	**106.8**		**54.8**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.14 Full Service Restaurant Zone Summary

Zone	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting[b] [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
DINING	4,001	Yes	40,025	1	1,821	508	2.1	14.3	280	6.0
KITCHEN	1,501	Yes	15,009	1	1,147	0	1.2	199.3	8	97.8
ATTIC	5,502	No	30,239	1	0	0	0	0	0	0
Total[a]	**5,502**		**85,273**		**2,968**	**508**			**287**	**0**
Area Weighted Average							**1.9**	**64.8**		**31.1**

(a) Only volume, and gross wall area include unconditioned space.
(b) 90.1-2004 baseline requirements for LPD

B.15 Mid-Rise Apartment Zone Summary

Zone[(a)]	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
G SW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
G NW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
OFFICE	950	Yes	9,499	1.0	630	92	1.1	950	1.0	0.6
G NE APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
G N1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
G N2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
G S1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
G S2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
M SW APARTMENT	950	Yes	9,499	2.0	630	92	0.4	380	2.5	0.6
M NW APARTMENT	950	Yes	9,499	2.0	630	92	0.4	380	2.5	0.6
M SE APARTMENT	950	Yes	9,499	2.0	630	92	0.4	380	2.5	0.6
M NE APARTMENT	950	Yes	9,499	2.0	630	92	0.4	380	2.5	0.6
M N1 APARTMENT	950	Yes	9,499	2.0	380	56	0.4	380	2.5	0.6
M N2 APARTMENT	950	Yes	9,499	2.0	380	56	0.4	380	2.5	0.6
M S1 APARTMENT	950	Yes	9,499	2.0	380	56	0.4	380	2.5	0.6
M S2 APARTMENT	950	Yes	9,499	2.0	380	56	0.4	380	2.5	0.6
T SW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T NW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T SE APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T NE APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T N1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T N2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T S1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T S2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T CORRIDOR	836	No	8,359	1.0	110	24	0.6	0	0.0	0.0
G CORRIDOR[(b)]	836	No	8,359	1.0	110	50	0.6	0	0.0	19.3
M CORRIDOR	836	No	8,359	2.0	110	24	0.6	0	0.0	0.0
Total[(c)]	**33,744**		**337,392**		**16,598**	**2,491**			**78.5**	
Area Weighted Average							**0.4**	**358**		**1.0**

(a) Each apartment zone contains one apartment with one bedroom, living room and bathroom.
(b) Elevator load is added in the ground floor corridor zone.
(c) Only volume, and gross wall area include unconditioned space.

B.16 High-Rise Apartment Zone Summary

Zone[a]	Area [ft²]	Conditioned [Y/N]	Volume [ft³]	Multipliers	Gross Wall Area [ft²]	Window Glass Area [ft²]	Lighting [W/ft²]	People [ft²/person]	Number of People	Plug and Process [W/ft²]
G SW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
G NW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
OFFICE	950	Yes	9,499	1.0	630	92	1.1	950	1.0	0.6
G NE APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
G N1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
G N2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
G S1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
G S2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
M SW APARTMENT	950	Yes	9,499	8.0	630	92	0.4	380	2.5	0.6
M NW APARTMENT	950	Yes	9,499	8.0	630	92	0.4	380	2.5	0.6
M SE APARTMENT	950	Yes	9,499	8.0	630	92	0.4	380	2.5	0.6
M NE APARTMENT	950	Yes	9,499	8.0	630	92	0.4	380	2.5	0.6
M N1 APARTMENT	950	Yes	9,499	8.0	380	56	0.4	380	2.5	0.6
M N2 APARTMENT	950	Yes	9,499	8.0	380	56	0.4	380	2.5	0.6
M S1 APARTMENT	950	Yes	9,499	8.0	380	56	0.4	380	2.5	0.6
M S2 APARTMENT	950	Yes	9,499	8.0	380	56	0.4	380	2.5	0.6
T SW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T NW APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T SE APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T NE APARTMENT	950	Yes	9,499	1.0	630	92	0.4	380	2.5	0.6
T N1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T N2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T S1 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T S2 APARTMENT	950	Yes	9,499	1.0	380	56	0.4	380	2.5	0.6
T CORRIDOR	836	No	8,359	1.0	110	24	0.6	0	0.0	24.6
G CORRIDOR[b]	836	No	8,359	1.0	110	50	0.6	0	0.0	0.0
M CORRIDOR	836	No	8,359	8.0	110	24	0.6	0	0.0	0.0
Total[c]	**84,360**		**843,481**		**41,495**	**6,187**			**198.5**	
Area Weighted Average							**0.4**	**349**		**0.8**

(a) Each apartment zone contains one apartment with one bedroom, living room and bathroom.
(b) Elevator load is added in the ground floor corridor zone.
(c) Only volume, and gross wall area include unconditioned space.

Appendix C

Simulation Schedules

C.1 Small Office Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD	0.18	0.18	0.18	0.18	0.18	0.23	0.23	0.42	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.61	0.42	0.42	0.32	0.32	0.23	0.18
	WEH	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_EQUIP_SCH	WD	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1	0.94	1	1	1	1	0.5	0.2	0.2	0.2	0.2	0.2	0.2
	WEH	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_OCC_SCH	WD	0	0	0	0	0	0	0.11	0.21	1	1	1	1	0.53	1	1	1	1	0.32	0.11	0.11	0.11	0.11	0.05	0
	WEH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_EXTERIOR_LIGHT	All Days	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD	0	0	0	0	0	0	0	0.27	0.55	0.64	0.64	0.82	1	0.91	0.55	0.55	0.73	0.37	0.37	0.18	0.27	0.09	0	0
	WEH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INFIL_SCH_PNNL	WD	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1	1	1
	WEH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HVACOperationSchd	WD	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
(Fan Schedule)	WEH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HTGSETP_SCH	WD	15.6	15.6	15.6	15.6	15.6	15.6	18.3	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	15.6	15.6	15.6	15.6	15.6
	WEH	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	WinterDesign	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
CLGSETP_SCH	WD	29.4	29.4	29.4	29.4	29.4	29.4	26.7	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	29.4	29.4	29.4	29.4	29.4	29.4
	WEH	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
	SummerDesign	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9
HTGSETP_SCH	WD	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60
	WEH	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	WinterDesign	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
CLGSETP_SCH	WD	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	75	85	85	85	85	85	85
	WEH	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
	SummerDesign	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
MinOA_Sched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C.2 Medium Office Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.3	0.3	0.2	0.2	0.1	0.05
	Saturday	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.3	0.3	0.3	0.3	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Sun, Hol, Other	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EQUIP_SCH	WD	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.5	0.4	0.4	0.4	0.4	0.4	0.4
	Saturday	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.35	0.35	0.35	0.35	0.35	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Sun, Hol, Other	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH	WD	0	0	0	0	0	0	0.1	0.2	0.95	0.95	0.95	0.95	0.5	0.95	0.95	0.95	0.95	0.3	0.1	0.1	0.1	0.1	0.05	0.05
	Saturday	0	0	0	0	0	0	0.1	0.1	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0	0
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_ELEVATORS	WD	0	0	0	0	0	0	0	0.35	0.69	0.43	0.37	0.43	0.58	0.48	0.37	0.37	0.46	0.62	0.12	0.04	0.04	0	0	0
	Saturday	0	0	0	0	0	0	0	0.16	0.14	0.21	0.18	0.25	0.21	0.13	0.08	0.04	0.05	0.06	0	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EXTERIOR_LIGHT	All Days	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.19	0.35	0.38	0.39	0.47	0.57	0.54	0.34	0.33	0.44	0.26	0.21	0.15	0.17	0.08	0.05	0.05
	Saturday	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.11	0.15	0.21	0.19	0.23	0.2	0.19	0.15	0.13	0.14	0.07	0.07	0.07	0.07	0.09	0.05	0.05
	Sun, Hol, Other	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.09	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04
INFIL_SCH_PNNL	WD, SummerDesign	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1
	Saturday, WinterDesign	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HVACOperationSchd	WD, SummerDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
(Fan Schedule)	Saturday, WinterDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HTGSETP_SCH	WD	15.6	15.6	15.6	15.6	15.6	17.6	19.6	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	15.6	15.6
	Saturday	15.6	15.6	15.6	15.6	15.6	17.6	19.6	21	21	21	21	21	21	21	21	21	21	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	Sun, Hol, Other	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	WinterDesign	15.6	15.6	15.6	15.6	15.6	17.6	19.6	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	15.6	15.6
CLGSETP_SCH	WD	26.7	26.7	26.7	26.7	26.7	25.7	25	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	26.7	26.7
	Saturday	26.7	26.7	26.7	26.7	26.7	25.7	25	24	24	24	24	24	24	24	24	24	24	26.7	26.7	26.7	26.7	26.7	26.7	26.7
	Sun, Hol, Other	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
	SummerDesign	26.7	26.7	26.7	26.7	26.7	25.7	25	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	26.7	26.7
HTGSETP_SCH	WD	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
	Saturday	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60	60	60
	Sun, Hol, Other	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	WinterDesign	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
CLGSETP_SCH	WD	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80
	Saturday	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	80	80	80	80	80	80	80
	Sun, Hol, Other	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
	SummerDesign	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
MinOA_MotorizedDamper_Sched	WD, SummerDesign	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
	Sat, WinterDesign	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MinOA_Sched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C.3 Large Office Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.3	0.3	0.2	0.2	0.1	0.05
	Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.3	0.3	0.3	0.3	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Sun, Hol, Other	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EQUIP_SCH	WD	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.5	0.4	0.4	0.4	0.4	0.4	0.4
	Sat	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.35	0.35	0.35	0.35	0.35	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Sun, Hol, Other	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH	WD	0	0	0	0	0	0	0.1	0.2	0.95	0.95	0.95	0.95	0.5	0.95	0.95	0.95	0.95	0.3	0.1	0.1	0.1	0.1	0.05	0.05
	Sat	0	0	0	0	0	0	0.1	0.1	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0	0
	SummerDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.05	0.05
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_ELEVATORS	WD	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	Sat	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	Sun	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	SummerDesign	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	WinterDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ELEV_LIGHT_FAN_SCH_ 24_7	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD, SummerDesign	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.19	0.35	0.38	0.39	0.47	0.57	0.54	0.34	0.33	0.44	0.26	0.21	0.15	0.17	0.08	0.05	0.05
	Sat, WinterDesign	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.11	0.15	0.21	0.19	0.23	0.2	0.19	0.15	0.13	0.14	0.07	0.07	0.07	0.07	0.09	0.05	0.05
	Sun, Hol, Other	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.09	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04
INFIL_SCH_PNNL	WD, SummerDesign	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1
	Sat, WinterDesign	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HVACOperationSchd	WD, SummerDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
(Fan Schedule)	Sat, WinterDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HTGSETP_SCH	WD	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
	SummerDesign	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Sat	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60	60	60
	WinterDesign	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
	Sun, Hol, Other	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CLGSETP_SCH	WD	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80
	SummerDesign	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80
	Sat	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	80	80	80	80	80	80	80
	WinterDesign	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
	Sun, Hol, Other	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Cool-Supply-Air-Temp-Sch	All	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
Heat-Supply-Air-Temp-Sch	All	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CW-Loop-Temp-Schedule	All	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
HW-Loop-Temp-Schedule	All	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
MinOA_Sched	WD, SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(Climate Zone 1-3)	Sat, WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_MotorizedDamper_ Sched	WD, SummerDesign	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
(Climate Zone 4-8)	Sat, WinterDesign	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

C.4 Stand-alone Retail Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5	0.5	0.2	0.05	0.05
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sat.	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.3	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.3	0.3	0.1	0.05	0.05
	Sun, Hol, Other	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.4	0.2	0.05	0.05	0.05	0.05	0.05
BLDG_EQUIP_SCH	WD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.2	0.2	0.2
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sat.	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.3	0.5	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.3	0.15	0.15
	Sun, Hol, Other	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.3	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.6	0.4	0.15	0.15	0.15	0.15	0.15
BLDG_OCC_SCH	WD	0	0	0	0	0	0	0	0.1	0.2	0.5	0.5	0.7	0.7	0.7	0.7	0.8	0.7	0.5	0.5	0.3	0.3	0	0	0
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sat.	0	0	0	0	0	0	0	0.1	0.2	0.5	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.2	0.2	0.2	0.1	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0.1	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.2	0.1	0	0	0	0	0
BLDG_EXTERIOR_LIGHT	WD, SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat, WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD, SummerDesign	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.15	0.23	0.32	0.41	0.57	0.62	0.61	0.5	0.45	0.46	0.47	0.42	0.34	0.33	0.04	0.04	0.04
	Sat, WinterDesign	0.11	0.1	0.08	0.06	0.06	0.06	0.06	0.2	0.24	0.27	0.42	0.54	0.59	0.6	0.49	0.48	0.47	0.46	0.44	0.36	0.29	0.22	0.06	0.06
	Sun, Hol, Other	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.14	0.29	0.31	0.36	0.36	0.34	0.35	0.37	0.34	0.25	0.06	0.06	0.06	0.06	0.06
INFIL_SCH_PNNL	WD, SummerDesign	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1
	Sat, WinterDesign	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1	1	1
HVACOperationSchd	WD, SummerDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
(FAN_SCH)	Sat, WinterDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
HTGSETP_SCH	WD, WinterDesign	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56
	SummerDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56
	Sat	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56
	Sun, Hol, Other	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56	15.56	15.56
HTGSETP_SCH	WD, WinterDesign	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60
	SummerDesign	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Sat	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
	Sun, Hol, Other	60	60	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60
CLGSETP_SCH	WD, SummerDesign	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44
	WinterDesign	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44
	Sat	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44
	Sun, Hol, Other	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44	29.44	29.44
CLGSETP_SCH	WD, SummerDesign	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	85	85	85
	WinterDesign	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
	Sat	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	85	85
	Sun, Hol, Other	85	85	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	85	85	85	85	85
OA_DAMPER_SCH	WD, SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat, WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dual Zone Control Type Sched	All	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
MinOA_Sched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C.5 Strip Mall Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Type1_LIGHT_SCH	Monday-Thursday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.5
	Fri-Sat	0.5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.5
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Type2_LIGHT_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.5	0.05	0.05	0.05
	Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.5	0.05	0.05	0.05	0.05	0.05
	Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.5	0.05	0.05	0.05	0.05	0.05	0.05
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Type3_LIGHT_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.5	0.05	0.05	0.05
	Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.5	0.05	0.05	0.05	0.05	0.05
	Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.95	0.95	0.95	0.95	0.95	0.95	0.5	0.05	0.05	0.05	0.05	0.05	0.05
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Type1_OCC_SCH	Monday-Thursday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.10	0.10	0.20	0.40	0.40	0.25	0.25	0.50	0.50	0.50	0.30	0.30	0.30	0.05
	Fri-Sat	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.20	0.60	0.40	0.25	0.25	0.50	0.50	0.50	0.30	0.30	0.30	0.20
	Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.10	0.20	0.40	0.60	0.40	0.40	0.30	0.60	0.60	0.40	0.40	0.30	0.20	0.05
	SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WinterDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type2_OCC_SCH	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.10	0.20	0.40	0.30	0.20	0.20	0.50	0.50	0.20	0.05	0.00	0.00	0.00
	Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.20	0.40	0.60	0.40	0.30	0.30	0.30	0.05	0.00	0.00	0.00	0.00	0.00
	Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.20	0.40	0.40	0.30	0.20	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00
	SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WinterDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type3_OCC_SCH	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.43	0.46	0.71	0.50	0.69	0.54	0.71	0.34	0.26	0.11	0.00	0.00	0.00
	Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.58	0.71	0.74	0.77	0.80	0.74	0.54	0.11	0.00	0.00	0.00	0.00	0.00
	Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.43	0.46	0.50	0.69	0.34	0.11	0.00	0.00	0.00	0.00	0.00	0.00
	SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WinterDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type1_EQUIP_SCH	Monday-Thursday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.50	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50
	Fri-Sat	0.50	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.50	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
	Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.50	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50
	SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WinterDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type2_EQUIP_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.50	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.05	0.05	0.05
	Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.50	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.05	0.05	0.05	0.05	0.05
	Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.50	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.05	0.05	0.05	0.05	0.05	0.05
	SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WinterDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type3_EQUIP_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.05	0.05	0.05
	Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.05	0.05	0.05	0.05	0.05
	Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.05	0.05	0.05	0.05	0.05	0.05
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALWAYS_ON	WD, SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(AstronomicalClock control)	Sat, WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Type1_SWH_SCH	Mon-Thurs, SummerDesign	0.08	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.15	0.23	0.32	0.41	0.62	0.60	0.55	0.45	0.50	0.46	0.47	0.34	0.33	0.23	0.13
	Fri-Sat, WinterDesign	0.13	0.10	0.08	0.06	0.06	0.06	0.06	0.07	0.10	0.20	0.23	0.32	0.41	0.65	0.60	0.55	0.45	0.50	0.46	0.47	0.34	0.33	0.23	0.13
	Sun	0.06	0.07	0.07	0.06	0.06	0.06	0.06	0.07	0.10	0.14	0.29	0.31	0.36	0.36	0.34	0.35	0.37	0.34	0.25	0.27	0.21	0.16	0.16	0.10
Type2_SWH_SCH	WD, SummerDesign	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.15	0.23	0.32	0.41	0.57	0.62	0.61	0.50	0.45	0.46	0.47	0.42	0.34	0.13	0.10	0.08
	Sat, WinterDesign	0.04	0.10	0.08	0.06	0.06	0.06	0.06	0.07	0.20	0.24	0.27	0.42	0.54	0.62	0.60	0.50	0.48	0.47	0.34	0.13	0.10	0.08	0.08	0.04
	Sun	0.04	0.07	0.07	0.06	0.06	0.06	0.06	0.07	0.10	0.12	0.14	0.29	0.33	0.40	0.36	0.37	0.35	0.37	0.13	0.10	0.10	0.08	0.08	0.04
Type3_SWH_SCH	WD, SummerDesign	0.08	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.15	0.25	0.41	0.57	0.62	0.61	0.50	0.45	0.46	0.47	0.42	0.34	0.13	0.10	0.10
	Sat, WinterDesign	0.08	0.10	0.08	0.06	0.06	0.06	0.06	0.07	0.07	0.20	0.27	0.42	0.54	0.59	0.60	0.49	0.48	0.47	0.46	0.13	0.10	0.10	0.10	0.08
	Sun	0.06	0.07	0.07	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.12	0.29	0.31	0.36	0.36	0.34	0.35	0.37	0.13	0.10	0.10	0.10	0.08	0.07
Type1_Infil_SCH	Mon-Thurs, SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Fri-Sat, WinterDesign	0.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Type2_Infil_SCH	WD, SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00
	Sat, WinterDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00
	Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00	1.00
Type3_Infil_SCH	WD, SummerDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00
	Sat, WinterDesign	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00
	Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00	1.00
Type1_FAN_SCH	Mon-Thurs, SummerDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Fri-Sat, WinterDesign	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Type2_FAN_SCH	WD, SummerDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
	Sat, WinterDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
	Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Type3_FAN_SCH	WD, SummerDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
	Sat, WinterDesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
	Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Type1_HTGSETP_SCH	Mon-Thurs, WinterDesign	21.11	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
	Fri-Sat	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
	Sun	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
	SummerDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56
Type2_HTGSETP_SCH	WD, WinterDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56
	Sat	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56	15.56	15.56
	Sun	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56	15.56	15.56	15.56
	SummerDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56
Type3_HTGSETP_SCH	WD, WinterDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56
	Sat	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56	15.56	15.56
	Sun	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	15.56	15.56	15.56	15.56	15.56	15.56
	SummerDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Type1_CLGSETP_SCH	Mon-Thurs, SummerDesign	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89
	Fri-Sat	23.89	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89
	Sun	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89
	WinterDesign	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44
Type2_CLGSETP_SCH	WD, SummerDesign	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44	29.44
	Sat	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44	29.44	29.44	29.44
	Sun	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44	29.44	29.44	29.44	29.44
	WinterDesign	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44
Type3_CLGSETP_SCH	WD, SummerDesign	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44
	Sat	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44	29.44	29.44	29.44
	Sun	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	29.44	29.44	29.44	29.44	29.44	29.44	29.44
	WinterDesign	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44	29.44
Type1_HTGSETP_SCH	Mon-Thurs, WinterDesign	70.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
	Fri-Sat	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
	Sun	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
	SummerDesign	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Type2_HTGSETP_SCH	WD, WinterDesign	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	60.00	60.00	60.00
	Sat	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	60.00	60.00	60.00	60.00	60.00	60.00
	Sun	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	60.00	60.00	60.00	60.00	60.00	60.00
	SummerDesign	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Type3_HTGSETP_SCH	WD, WinterDesign	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	60.00	60.00	60.00
	Sat	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	60.00	60.00	60.00	60.00	60.00
	Sun	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	60.00	60.00	60.00	60.00	60.00	60.00
	SummerDesign	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Type1_CLGSETP_SCH	Mon-Thurs, SummerDesign	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
	Fri-Sat	75.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
	Sun	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
	WinterDesign	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Type2_CLGSETP_SCH	WD, SummerDesign	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	85.00	85.00	85.00	85.00
	Sat	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	85.00	85.00	85.00	85.00	85.00	85.00
	Sun	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
	WinterDesign	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Type3_CLGSETP_SCH	WD, SummerDesign	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	85.00	85.00	85.00
	Sat	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	85.00	85.00	85.00	85.00	85.00	85.00
	Sun	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	80.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
	WinterDesign	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
MinOA_Sched	All	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

C.6 Primary School Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD, SummerDesign	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.18	0.18	0.18
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
BLDG_LIGHT_SCH	WD, SummerDesign	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.18	0.18	0.18	0.18
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
BLDG_EQUIP_SCH	WD, SummerDesign	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.35	0.35	0.35	0.35	0.35	0.35	0.35
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
BLDG_EQUIP_SCH	WD, SummerDesign	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.25	0.25	0.25
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Kitchen_Elec_EQUIP_SCH	WD, SummerDesign	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.15	0.25	0.25	0.25	0.15	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Kitchen_Elec_EQUIP_SCH	WD, SummerDesign	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.15	0.25	0.25	0.25	0.15	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Kitchen_Gas_EQUIP_SCH	WD, SummerDesign	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.15	0.15	0.2	0.2	0.2	0.1	0.1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Kitchen_Gas_EQUIP_SCH	WD, SummerDesign	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.15	0.15	0.2	0.2	0.2	0.1	0.1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BLDG_OCC_SCH	WD, SummerDesign	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.15	0.15	0.15	0.15	0.15	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH	WD, SummerDesign	0	0	0	0	0	0	0	0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_Extend	WD, SummerDesign	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_Extend	WD, SummerDesign	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_OCC_SCH_Offices	WD, SummerDesign	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.15	0.15	0.15	0.15	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Offices	WD, SummerDesign	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.15	0.15	0.15	0.15	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Gym	WD, SummerDesign	0	0	0	0	0	0	0	0	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.95	0.95	0.95	0.95	0.95	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Gym	WD, SummerDesign	0	0	0	0	0	0	0	0	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Cafeteria	WD, SummerDesign	0	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.35	0.35	0.35	0.35	0.35	0	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Cafeteria	WD, SummerDesign	0	0	0	0	0	0	0	0	0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.35	0	0	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_ELEVATORS	WD, SummerDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sat, WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_SWH_SCH	WD, SummerDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.34	0.6	0.63	0.72	0.79	0.83	0.61	0.65	0.1	0.1	0.19	0.25	0.22	0.22	0.12	0.09
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
BLDG_SWH_SCH	WD, SummerDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.19	0.25	0.22	0.22	0.12	0.09
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
INFIL_SCH_PNNL	WD, SummerDesign	1	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1
	Sat, Sun, Hol, WinterDesign, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HVACOperationSchd	WD, SummerDesign, WinterDesign	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
	Sat, Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAN_SCH	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dual Zone Control Type Sched	All	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
ReheatCoilAvailSched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CoolingCoilAvailSched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_MotorizedDamper_ Sched	WD, SummerDesign, WinterDesign	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Sat, Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MinOA_Sched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HTGSETP_SCH	WD	15.6	15.6	15.6	15.6	15.6	15.6	15.6	21	21	21	21	21	21	21	21	21	21	21	21	21	21	15.6	15.6	15.6
	SummerDesign, Sat, Sun, Hol, Other	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	WinterDesign	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
CLGSETP_SCH	WD	26.7	26.7	26.7	26.7	26.7	26.7	26.7	24	24	24	24	24	24	24	24	24	24	24	24	24	24	26.7	26.7	26.7
	SummerDesign	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	WinterDesign, Sat, Sun, Hol, Other	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
HTGSETP_SCH_SETBACk	WD	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
(For mechanical room and bathroom)	SummerDesign, Sat, Sun, Hol, Other	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	WinterDesign	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
CLGSETP_SCH_SETUP	WD	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
(For mechanical room and bathroom)	SummerDesign	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
	WinterDesign, Sat, Sun, Hol, Other	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
VAV-Supply-Air-Temp-Sch	All	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
HW-Loop-Temp-Schedule	All	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82
Heating-Supply-Air-Temp-Sch	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
HTGSETP_SCH	WD	60	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60
	SummerDesign, Sat, Sun, Hol, Other	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	WinterDesign	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
CLGSETP_SCH	WD	80	80	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80	80
	SummerDesign	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	WinterDesign, Sat, Sun, Hol, Other	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
HTGSETP_SCH_SETBACk	WD	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
(For mechanical room and bathroom)	SummerDesign, Sat, Sun, Hol, Other	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	WinterDesign	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
CLGSETP_SCH_SETUP	WD	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
(For mechanical room and bathroom)	SummerDesign	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	WinterDesign, Sat, Sun, Hol, Other	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
VAV-Supply-Air-Temp-Sch	All	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
HW-Loop-Temp-Schedule	All	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
Heat-Supply-Air-Temp-Sch	All	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61

C.7 Secondary School Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD, SummerDesign	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.18	0.18	0.18
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
BLDG_LIGHT_SCH	WD, SummerDesign	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.18	0.18	0.18	0.18
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
BLDG_EQUIP_SCH_Base	WD, SummerDesign	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.35	0.35	0.35	0.35	0.35	0.35	0.35
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
BLDG_EQUIP_SCH_BASE	WD, SummerDesign	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.25	0.25	0.25
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Kitchen_Elec_EQUIP_SCH	WD, SummerDesign	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.15	0.25	0.25	0.25	0.15	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Kitchen_Elec_EQUIP_SCH	WD, SummerDesign	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.15	0.25	0.25	0.25	0.15	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Kitchen_Gas_EQUIP_SCH	WD, SummerDesign	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.15	0.15	0.2	0.2	0.2	0.1	0.1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Kitchen_Gas_EQUIP_SCH	WD, SummerDesign	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.15	0.15	0.2	0.2	0.2	0.1	0.1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BLDG_ELEVATORS	WD	0	0	0	0	0	0	0	0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.15	0	0	0	0	0	0	0	0
	Sat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesign	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ELEV_LIGHT_FAN_SCH_24_7	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_OCC_SCH	WD, SummerDesign	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.15	0.15	0.15	0.15	0.15	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH	WD, SummerDesign	0	0	0	0	0	0	0	0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0	0	0

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_Extend	WD, SummerDesign	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_Extend	WD, SummerDesign	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Offices	WD, SummerDesign	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.15	0.15	0.15	0.15	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Offices	WD, SummerDesign	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.15	0.15	0.15	0.15	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Gym	WD, SummerDesign	0	0	0	0	0	0	0	0	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.95	0.95	0.95	0.95	0.95	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Gym	WD, SummerDesign	0	0	0	0	0	0	0	0	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Auditorium	WD, SummerDesign	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.95	0.95	0.95	0.95	0.95	0	0	0	0
(Study Periods)	Sat, WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Auditorium	WD, SummerDesign	0	0	0	0	0	0	0	0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.35	0	0	0	0	0
(Summer Holiday)	Sat, WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Cafeteria	WD, SummerDesign	0	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.35	0.35	0.35	0.35	0.35	0	0	0	0
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH_Cafeteria	WD, SummerDesign	0	0	0	0	0	0	0	0	0	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.35	0.35	0.35	0.35	0	0	0	0
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_SWH_SCH	WD, SummerDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.34	0.6	0.63	0.72	0.79	0.83	0.61	0.65	0.1	0.1	0.19	0.25	0.22	0.22	0.12	0.09
(Study Periods)	Sat, Sun, Hol, WinterDesign, Other	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
BLDG_SWH_SCH	WD, SummerDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.19	0.25	0.22	0.22	0.12	0.09
(Summer Holiday)	Sat, Sun, Hol, WinterDesign, Other	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
INFIL_SCH_PNNL	WD, SummerDesign	1	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1
	Sat, WinterDesign	1	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
HVACOperationSchd	WD, SummerDesign, WinterDesign	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
	Sat, Sun, Hol, Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAN_SCH	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dual Zone Control Type Sched	All	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
ReheatCoilAvailSched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CoolingCoilAvailSched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_MotorizedDamper_ Sched	WD, SummerDesign	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
	Sat, Sun, Hol, WinterDesign, Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MinOA_Sched	All	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
HTGSETP_SCH	WD	15.6	15.6	15.6	15.6	15.6	15.6	15.6	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	15.6	15.6	15.6
	SummerDesign, Sat, Sun, Hol, Other	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	WinterDesign	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
CLGSETP_SCH	WD	29.4	29.4	29.4	29.4	29.4	29.4	29.4	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	29.4	29.4	29.4
	SummerDesign	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
	WinterDesign, Sat, Sun, Hol, Other	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
HTGSETP_SCH_SETBACk	WD	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
(For mechanical room and bathroom)	SummerDesign, Sat, Sun, Hol, Other	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	WinterDesign	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
CLGSETP_SCH_SETUP	WD	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
(For mechanical room and bathroom)	SummerDesign	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
	WinterDesign, Sat, Sun, Hol, Other	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
Seasonal-Reset-Supply-Air-Temp-Sch	All	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
	All	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
	All	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
VAV-Supply-Air-Temp-Sch	All	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
CW-Loop-Temp-Schedule	All	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
HW-Loop-Temp-Schedule	All	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0
Heating-Supply-Air-Temp-Sch	All	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
HTGSETP_SCH	WD	60	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60
	SummerDesign, Sat, Sun, Hol, Other	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	WinterDesign	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
CLGSETP_SCH	WD	85	85	85	85	85	85	85	75	75	75	75	75	75	75	75	75	75	75	75	75	75	85	85	85
	SummerDesign	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	WinterDesign, Sat, Sun, Hol, Other	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
HTGSETP_SCH_SETBACk	WD	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
(For mechanical room and bathroom)	SummerDesign, Sat, Sun, Hol, Other	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	WinterDesign	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
CLGSETP_SCH_SETUP	WD	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
(For mechanical room and bathroom)	SummerDesign	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	WinterDesign, Sat, Sun, Hol, Other	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
Seasonal-Reset-Supply-Air-Temp-Sch	All	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
	All	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
	All	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
VAV-Supply-Air-Temp-Sch	All	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
CW-Loop-Temp-Schedule	All	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
HW-Loop-Temp-Schedule	All	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
Heating-Supply-Air-Temp-Sch	All	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61

C.8 Outpatient Hourly Operation Healthcare Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Critical Light Schedule	All	0.5	0.5	0.5	0.5	0.7	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.7	0.7	0.5	0.5
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesign	0.5	0.5	0.5	0.5	0.7	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.7	0.7	0.5	0.5
Admin Light Schedule	WD	0.1	0.1	0.1	0.1	0.3	0.3	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.6	0.3	0.3	0.1	0.1
	Sat	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1
	SummerDesign	0.1	0.1	0.1	0.1	0.3	0.3	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.6	0.3	0.3	0.1	0.1
	WinterDesign	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1
	Sun, Hol	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Critical Equip Schedule	All Days	0.5	0.5	0.5	0.5	0.8	0.8	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	0.5	0.5	0.5	0.5
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesign	0.5	0.5	0.5	0.5	0.8	0.8	1	1	1	1	1	1	1	1	1	1	1	1	0.8	0.8	0.5	0.5	0.5	0.5
Admin Equip Schedule	WD	0.3	0.3	0.3	0.3	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	0.5	0.5	0.3	0.3	0.3	0.3
	Sat	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3
	SummerDesign	0.3	0.3	0.3	0.3	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	0.5	0.5	0.3	0.3	0.3	0.3
	WinterDesign	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3
	Sun, Hol	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3
BLDG_ELEVATORS	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.75	1	1	1	0.75	1	1	1	1	1	0.52	0.52	0.52	0.28	0.05	0.05
	Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.4	0.46	0.7	0.7	0.7	0.51	0.51	0.51	0.51	0.51	0.25	0.05	0.05	0.05	0.05	0.05	0.05
	Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ELEV_LIGHT_FAN_SCH_24_7	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Critical Occ Schedule	All Days	0.4	0.4	0.4	0.4	0.65	0.65	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.65	0.65	0.65	0.65	0.4	0.4
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesign	0.4	0.4	0.4	0.4	0.65	0.65	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.65	0.65	0.65	0.65	0.4	0.4
Admin Occ Schedule	WD	0.05	0.05	0.05	0.05	0.2	0.2	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5	0.2	0.2	0.05	0.05
	Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.05	0.05	0.05	0.05
	SummerDesign	0.05	0.05	0.05	0.05	0.2	0.2	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5	0.2	0.2	0.05	0.05
	WinterDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.05	0.05	0.05	0.05
	Sun, Hol	0	0	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0	0	0
BLDG_SWH_SCH	WD	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.17	0.58	0.66	0.78	0.82	0.71	0.82	0.78	0.74	0.63	0.41	0.18	0.18	0.18	0.1	0.01	0.01
	Sat	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.2	0.28	0.3	0.3	0.24	0.24	0.23	0.23	0.23	0.1	0.01	0.01	0.01	0.01	0.01	0.01
	SummerDesign	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.17	0.58	0.66	0.78	0.82	0.71	0.82	0.78	0.74	0.63	0.41	0.18	0.18	0.18	0.1	0.01	0.01
	WinterDesign	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.2	0.28	0.3	0.3	0.24	0.24	0.23	0.23	0.23	0.1	0.01	0.01	0.01	0.01	0.01	0.01
	Sun, Hol	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
INFIL_SCH	WD, Sat	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Critical Heating Schedule	All Days	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
	WinterDesign	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
	SummerDesign	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Critical Cooling Schedule	All Days	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
	WinterDesign	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	SummerDesign	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
OR Heating Schedule	All Days	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
	WinterDesign	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
	SummerDesign	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
OR Cooling Schedule	All Days	72	72	72	72	72	72	65	65	65	65	65	65	65	65	65	65	65	72	72	72	72	72	72	72
	WinterDesign	72	72	72	72	72	72	65	65	65	65	65	65	65	65	65	65	65	72	72	72	72	72	72	72
	SummerDesign	72	72	72	72	72	72	65	65	65	65	65	65	65	65	65	65	65	72	72	72	72	72	72	72
Admin Heating Schedule	WD	65	65	65	65	65	70	70	70	70	70	70	70	70	70	70	70	70	70	65	65	65	65	65	65
	Sat	65	65	65	65	65	65	65	70	70	70	70	70	70	70	70	65	65	65	65	65	65	65	65	65
	SummerDesign	65	65	65	65	65	70	70	70	70	70	70	70	70	70	70	70	70	70	65	65	65	65	65	65
	WinterDesign	65	65	65	65	65	65	65	70	70	70	70	70	70	70	70	65	65	65	65	65	65	65	65	65
	Sun, Hol	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Admin Cooling Schedule	WD	77	77	77	77	77	72	72	72	72	72	72	72	72	72	72	72	72	72	77	77	77	77	77	77
	Sat	77	77	77	77	77	77	77	72	72	72	72	72	72	72	72	77	77	77	77	77	77	77	77	77
	SummerDesign	77	77	77	77	77	72	72	72	72	72	72	72	72	72	72	72	72	72	77	77	77	77	77	77
	WinterDesign	77	77	77	77	77	77	77	72	72	72	72	72	72	72	72	77	77	77	77	77	77	77	77	77
	Sun, Hol	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
HVACOperationSchd	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(AHU-1 Fan; AHU-2 Fan)	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hours_of_operation	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(Exhaust Fans)	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_OA_SCH	WD	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	Sat	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	SummerDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	WinterDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	Sun, Hol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OR_MinSA_Sched	WD	0.2	0.2	0.2	0.2	0.2	0.2	1	1	1	1	1	1	1	1	1	1	1	1	0.2	0.2	0.2	0.2	0.2	0.2
	Sat	0.2	0.2	0.2	0.2	0.2	0.2	1	1	1	1	1	1	1	1	1	1	1	1	0.2	0.2	0.2	0.2	0.2	0.2
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Sun, Hol	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

C.9 Hospital Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD, SummerDesign	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1
(Office, Lobby, Clinic, OR)	Sat, WinterDesign	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1
	Sun, Hol, Other	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
BLDG_LIGHT_EXTD_SCH	WD, SummerDesign	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
(ER, Patient Rm, ICU, Nurse Station, Dinning, Kitchen)	Sat, WinterDesign	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.5
	Sun, Hol, Other	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
BLDG_EQUIP_SCH	WD, SummerDesign	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4
	Sat, WinterDesign	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.4	0.4	0.4	0.4	0.4	0.4
	Sun, Hol, Other	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
BLDG_EQUIP_EXTD_SCH	WD, SummerDesign	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4
	Sat	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.4	0.4	0.4	0.4	0.4	0.4
	Sun, Hol, Other	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
BLDG_OCC_SCH	WD	0	0	0	0	0	0	0	0.1	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.3	0.3	0.2	0.2	0	0
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat, WinterDesign	0	0	0	0	0	0	0	0.1	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0	0	0	0	0
	Sun, Hol, Other	0	0	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0	0	0	0
BLDG_OCC_EXTD_SCH	WD	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.5	0.5	0.4	0.4	0.4	0.4
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat, WinterDesign	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4
	Sun, Hol, Other	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
BLDG_ELEVATORS	WD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.75	1	1	1	0.75	1	1	1	1	1	0.52	0.52	0.52	0.28	0.2	0.2
	Sat	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.46	0.7	0.7	0.7	0.51	0.51	0.51	0.51	0.51	0.25	0.2	0.2	0.2	0.2	0.2	0.2
	Sun	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
ELEV_LIGHT_FAN_SCH_24_7	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD, SummerDesign	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.17	0.58	0.66	0.78	0.82	0.71	0.82	0.78	0.74	0.63	0.41	0.18	0.18	0.18	0.1	0.01	0.01
	Sat, WinterDesign	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.2	0.28	0.3	0.3	0.24	0.24	0.23	0.23	0.23	0.1	0.01	0.01	0.01	0.01	0.01	0.01
	Sun, Hol, Other	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
BLDG_SWH_EXTD_SCH	WD, SummerDesign	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.58	0.66	0.78	0.82	0.71	0.82	0.78	0.74	0.63	0.41	0.35	0.35	0.35	0.3	0.3	0.3
	Sat, WinterDesign	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.3
	Sun, Hol, Other	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.3
INFIL_SCH_PNNL	WD, SummerDesign	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sat, WinterDesign	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sun, Hol, Other	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
HVACOperationSchd	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(fan schedule)																									
HTGSETP_SCH	All	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
CLGSETP_SCH	All	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Dual Zone Control Type Sched	All	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
CW-Loop-Temp-Schedule	All	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
HW-Loop-Temp-Schedule	All	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Heat-Supply-Air-Temp-Sch	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
HTGSETP_SCH	All	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
CLGSETP_SCH	All	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
CW-Loop-Temp-Schedule	All	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
HW-Loop-Temp-Schedule	All	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Heat-Supply-Air-Temp-Sch	All	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
ReheatCoilAvailSched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CoolingCoilAvailSched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Humidity Setpoint Schedule	WD, SummerDesign	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	Sat, WinterDesign	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	Sun, Hol, Other	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
MinOA_Sched	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
VAV_ER_OAminOA FracSchedule	All	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
VAV_OR_OAminOA FracSchedule	All	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
VAV_ICU_OAminOA FracSchedule	All	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
VAV_PATRMS_OAminOA FracSchedule	All	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
VAV_LABS_OAminOA FracSchedule	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Kitchen_SAT_SCH	All	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
VAV_SAT_SCH	All	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
MinRelHumSetSch	All	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
MaxRelHumSetSch	All	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60

C.10 Small Hotel Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
GuestRoom_Ltg_Sch_Base	WD	0.22	0.17	0.11	0.11	0.11	0.22	0.44	0.56	0.44	0.44	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.67	0.89	1	0.89	0.67	0.33
	Sat, Sun, Hol	0.26	0.26	0.11	0.11	0.11	0.11	0.41	0.41	0.56	0.56	0.41	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.85	1	1	1	0.85	0.41
GUESTROOM_ EQUIP_SCH	WD	0.11	0.11	0.11	0.11	0.11	0.11	0.62	0.9	0.43	0.43	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.51	0.51	0.49	0.66	0.7	0.35	0.11
	Sat, Sun, Hol	0.11	0.11	0.11	0.11	0.11	0.11	0.3	0.62	0.9	0.62	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.43	0.51	0.49	0.66	0.7	0.35	0.11
GuestRoom_Occ_Sch	WD	1	1	1	1	1	1	0.77	0.43	0.43	0.2	0.2	0.2	0.2	0.2	0.2	0.31	0.54	0.54	0.54	0.77	0.77	0.89	1	1
	Sat, Sun, Hol	1	1	1	1	1	1	0.77	0.53	0.53	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.53	0.54	0.65	0.65	0.77	0.77	0.77
LOBBY_ LIGHT_SCH	WD	0.5	0.5	0.5	0.5	0.5	0.6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.6	0.5	0.5
	Sat, Sun, Hol	0.5	0.5	0.5	0.5	0.5	0.6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.6	0.5	0.5
LOBBY_ EQUIP_SCH	WD	0.21	0.21	0.21	0.21	0.21	0.68	1	1	1	1	0.32	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.21
	Sat, Sun, Hol	0.21	0.21	0.21	0.21	0.21	0.68	1	1	1	1	0.32	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.21
Lobby_Occ_Sch	WD	0.1	0.1	0.1	0.1	0.1	0.3	0.7	0.7	0.7	0.7	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.2	0.2	0.2	0.2	0.1	0.1
	Sat, Sun, Hol	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.7	0.7	0.7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Office_Ltg_Sch_Base	WD	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.61	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.61	0.5	0.5	0.5	0.5	0.5	0.5
	Sat, Sun, Hol	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.61	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.61	0.5	0.5	0.5	0.5	0.5	0.5
OFFICE_ EQUIP_SCH	WD	0.33	0.33	0.33	0.33	0.33	0.38	0.38	0.43	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	0.75	0.63	0.63	0.48	0.48	0.33	0.33
	Sat, Sun, Hol	0.33	0.33	0.33	0.33	0.33	0.38	0.38	0.43	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.48	0.48	0.48	0.48	0.33	0.33
Office_Occ_Sch	WD	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	1	1	1	1	0.5	1	1	1	1	0.4	0.3	0.2	0.2	0.2	0.2	0.2
	Sat, Sun, Hol	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.2
MeetingRoom_Ltg_Sch_Base	WD	0	0	0	0	0	0.2	0.3	0.5	1	1	1	1	1	1	1	1	1	1	0.5	0.3	0.2	0.05	0	0
	Sat, Sun, Hol	0	0	0	0	0	0.2	0.3	0.5	1	1	1	1	1	1	1	1	1	1	0.5	0.3	0.2	0.05	0	0
MEETINGROOM_ EQUIP_SCH	WD	0	0	0	0	0	0	0	0.05	0.54	0.54	0.26	0.26	0.05	0.54	0.54	0.26	0.26	0.26	0.05	0.05	0	0	0	0
	Sat, Sun, Hol	0	0	0	0	0	0	0	0.05	0.54	0.54	0.26	0.26	0.05	0.54	0.54	0.26	0.26	0.26	0.05	0.05	0	0	0	0
MeetingRoom_Occ_Sch	WD	0	0	0	0	0	0	0	0.05	0.5	0.5	0.2	0.2	0.05	0.5	0.5	0.2	0.2	0.2	0.05	0.05	0	0	0	0
	Sat, Sun, Hol	0	0	0	0	0	0	0	0.05	0.5	0.5	0.2	0.2	0.05	0.5	0.5	0.2	0.2	0.2	0.05	0.05	0	0	0	0
LaundryRoom_Ltg_Sch	WD	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
	Sat, Sun, Hol	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
LAUNDRY_ ELE_SCH	WD	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	Sat, Sun, Hol	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
LAUNDRY_ GAS_SCH	WD	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
	Sat, Sun, Hol	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
LaundryRoom_Occ_Sch	WD	0	0	0	0	0	0	0	0	0.09	0.09	0.18	0.18	0	0.18	0.18	0.18	0.09	0	0	0	0	0	0	0
	Sat, Sun, Hol	0	0	0	0	0	0	0	0	0.09	0.09	0.18	0.18	0	0.18	0.18	0.18	0.09	0	0	0	0	0	0	0
ExerciseCenter_Ltg_Sch_Base	WD	0	0	0	0	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.5	0
	Sat, Sun, Hol	0	0	0	0	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.5	0
ExerciseCenter_Eqp_Sch	WD	0	0	0	0	0	0	0.5	1	1	0.5	0.5	0.5	0	0.5	0.5	0.5	1	0.5	0.5	1	1	0.5	0.5	0
	Sat, Sun, Hol	0	0	0	0	0	0	0.5	1	1	0.5	0.5	0.5	0	0.5	0.5	0.5	1	0.5	0.5	1	1	0.5	0.5	0
ExerciseCenter_Occ_Sch	WD	0	0	0	0	0	0	0.5	1	1	1	1	0.5	0	1	1	1	1	1	1	1	1	1	0.5	0
	Sat, Sun, Hol	0	0	0	0	0	0	0.5	1	1	1	1	0.5	0	1	1	1	1	1	1	1	1	1	0.5	0
EMPLOYEELOUNGE_ LIGHT_SCH	WD	0.05	0.05	0.05	0.05	0.05	0.15	0.4	0.5	1	1	1	1	1	1	1	1	1	1	0.5	0.4	0.15	0.15	0.05	0.05
	Sat, Sun, Hol	0.05	0.05	0.05	0.05	0.05	0.15	0.3	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.3	0.15	0.15	0.05	0.05
EmployeeLounge_Eqp_Sch	WD	0.11	0.11	0.11	0.11	0.11	0.19	0.19	0.25	1	1	0.86	0.86	1	0.86	0.86	0.86	0.86	0.86	0.25	0.19	0.11	0.11	0.11	0.11
	Sat, Sun, Hol	0.11	0.11	0.11	0.11	0.11	0.19	0.19	0.25	1	1	0.86	0.86	1	0.86	0.86	0.86	0.86	0.86	0.25	0.19	0.11	0.11	0.11	0.11
EmployeeLounge_Occ_Sch	WD	0	0	0	0	0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.7	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0	0	0	0
	Sat, Sun, Hol	0	0	0	0	0	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0	0	0	0
GuestRoom_SHW_Sch	WD	0.2	0.15	0.15	0.15	0.2	0.35	0.6	0.8	0.55	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.55	0.4	0.4	0.6	0.45	0.25
	Sat, Sun, Hol	0.2	0.15	0.15	0.15	0.2	0.25	0.35	0.6	0.8	0.55	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.25	0.3	0.4	0.4	0.4	0.6	0.35
LaundryRoom_SHW_Sch	WD	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Sat, Sun, Hol	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
GUESTROOM_INFIL_SCH	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sat, Sun, Hol	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
COMMONAREA_INFIL_SCH	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sat, Sun, Hol	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
GUESTROOM_FAN_SCH	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(HVAC Operation)	Sat, Sun, Hol	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
COMMONAREA_FAN_SCH	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(HVAC Operation)	Sat, Sun, Hol	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
VacGuestRoom_HtgSP_Sch	WD	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00
(Vacant)	Sat, Sun, Hol	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00
VacGuestRoom_ClgSP_Sch	WD	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00
(Vacant)	Sat, Sun, Hol	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00	74.00
Base_OccGuestRoom_HtgSP_Sch	WD	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
(Rented)	Sat, Sun, Hol	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Base_OccGuestRoom_ClgSP_Sch	WD	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
(Rented)	Sat, Sun, Hol	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
CommonArea_HtgSP_Sch	WD	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
	Sat, Sun, Hol	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
CommonArea_ClgSP_Sch	WD	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
	Sat, Sun, Hol	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
SemiHeated_HtgSP_Sch	WD	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
(for storage rooms and stairs)	Sat, Sun, Hol	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
GUESTROOM_OA_SCH	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Sat, Sun, Hol	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
COMMONAREA_OA_SCH	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Sat, Sun, Hol	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BLDG_ELEVATORS	WD	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	Sat	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	Sun	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	SummerDesign	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	WinterDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ELEV_LIGHT_FAN_SCH_24_7	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
VacGuestRoom_HtgSP_Sch	WD	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89
(Vacant)	Sat, Sun, Hol	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89
VacGuestRoom_ClgSP_Sch	WD	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33
(Vacant)	Sat, Sun, Hol	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33
Base_OccGuestRoom_HtgSP_Sch	WD	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
(Rented)	Sat, Sun, Hol	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
Base_OccGuestRoom_ClgSP_Sch	WD	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
(Rented)	Sat, Sun, Hol	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
CommonArea_HtgSP_Sch	WD	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
	Sat, Sun, Hol	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
CommonArea_ClgSP_Sch	WD	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Sat, Sun, Hol	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89
SemiHeated_HtgSP_Sch	WD	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22
(for storage rooms and stairs)	Sat, Sun, Hol	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22

C.11 Large Hotel Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD	0.2	0.15	0.1	0.1	0.1	0.2	0.4	0.5	0.4	0.4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.6	0.8	0.9	0.8	0.6	0.3
(for public spaces)	Sat	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.6	0.7	0.7	0.7	0.6	0.3
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sun, Hol, and Other	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.5	0.7	0.8	0.6	0.5	0.3
GuestRoom_Ltg_Sch_Base	WD	0.22	0.17	0.11	0.11	0.11	0.22	0.44	0.56	0.44	0.44	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.67	0.89	1	0.89	0.67	0.33
(for guest rooms)	Sat, Sun, Hol	0.26	0.26	0.11	0.11	0.11	0.11	0.41	0.41	0.56	0.56	0.41	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.85	1	1	1	0.85	0.41
	SummerDesign CustomDay1 CustomDay2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EQUIP_SCH	WD	0.3	0.25	0.2	0.2	0.2	0.3	0.5	0.6	0.5	0.5	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.7	0.9	0.95	0.9	0.7	0.4
(for public spaces on the ground floor)	Sat	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.4	0.5	0.5	0.4	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.7	0.8	0.8	0.8	0.7	0.4
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sun, Hol, and Other	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.6	0.8	0.9	0.7	0.6	0.4
GuestRoom_Eqp_Sch	WD	0.2	0.2	0.2	0.2	0.2	0.2	0.62	0.9	0.43	0.43	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.51	0.51	0.49	0.66	0.7	0.35	0.2
(for guest rooms)	Sat, Sun, Hol	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.62	0.9	0.62	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.43	0.51	0.49	0.66	0.7	0.35	0.2
	SummerDesign CustomDay1 CustomDay2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kitchen_Elec_Equip_SCH	WD	0.1	0.1	0.1	0.1	0.1	0.1	0.25	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
(for kitchen, dining and banquet)	Sat, Sun, Hol, Others	0.1	0.1	0.1	0.1	0.1	0.1	0.25	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	SummerDesign	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kitchen_Gas_Equip_SCH	WD, Sat	0.02	0.02	0.02	0.02	0.02	0.05	0.1	0.15	0.2	0.15	0.25	0.25	0.25	0.2	0.15	0.2	0.3	0.3	0.3	0.2	0.2	0.15	0.1	0.05
(for kitchen)	Sun, Hol, Others	0.02	0.02	0.02	0.02	0.02	0.05	0.1	0.15	0.2	0.15	0.25	0.25	0.25	0.2	0.15	0.2	0.3	0.3	0.3	0.2	0.2	0.15	0.1	0.05
	SummerDesign	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH	WD	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.7	0.7	0.8	0.9	0.9
(for public spaces)	Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.6	0.6	0.6	0.7	0.7	0.7
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sun, Hol, and Other	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.3	0.4	0.4	0.6	0.6	0.8	0.8	0.8
GUESTROOM_ OCC_SCH	WD	0.65	0.65	0.65	0.65	0.65	0.65	0.5	0.28	0.28	0.13	0.13	0.13	0.13	0.13	0.13	0.2	0.35	0.35	0.35	0.5	0.5	0.58	0.65	0.65
(for guest rooms)	Sat, Sun, Hol, others	0.65	0.65	0.65	0.65	0.65	0.65	0.5	0.34	0.34	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.34	0.35	0.65	0.65	0.5	0.5	0.5
	SummerDesign CustomDay1 CustomDay2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_ELEVATORS	WD	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	Sat	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	Sun	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
	SummerDesign	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	WinterDesign	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ELEV_LIGHT_FAN_SCH_24_7	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Sun, Hol, Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Kitchen_Exhaust_SCH (for plug load)	All	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD,SummerDesign	0.2	0.15	0.15	0.15	0.2	0.25	0.5	0.6	0.55	0.45	0.4	0.45	0.4	0.35	0.3	0.3	0.3	0.4	0.55	0.6	0.5	0.55	0.45	0.25
(for laundry)	Sat, WinterDesign	0.2	0.15	0.15	0.15	0.2	0.25	0.4	0.5	0.5	0.5	0.45	0.5	0.5	0.45	0.4	0.4	0.35	0.4	0.55	0.55	0.5	0.55	0.4	0.3
	Sun, Hol, Others	0.25	0.2	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.55	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.4	0.5	0.5	0.4	0.5	0.4	0.2
GuestRoom_SWH_Sch	WD	0.2	0.15	0.15	0.15	0.2	0.35	0.6	0.8	0.55	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.55	0.4	0.4	0.6	0.45	0.25
	Others	0.2	0.15	0.15	0.15	0.2	0.25	0.35	0.6	0.8	0.55	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.25	0.3	0.4	0.4	0.4	0.6	0.35
LaundryRoom_SWH_Sch	All	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
INFIL_QUARTER_ON_SCH	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
(for all zones)	Sat, Sun, Hol	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
GUESTROOM_FAN_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(HVAC Operation)																									
COMMONAREA_FAN_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(HVAC Operation)																									
HtgSetP_Sch	All	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
ClgSetP_Sch	All	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
MinOA_MotorizedDamper_ Sched	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hours_of_operation	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

C.12 Warehouse Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD (Office Light WD Sensor)	0.18	0.18	0.18	0.18	0.18	0.18	0.23	0.42	0.77	0.77	0.77	0.77	0.68	0.77	0.77	0.77	0.77	0.61	0.18	0.18	0.18	0.18	0.18	0.18
	WEH (Office Light WEH)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	WD (Storage Light WD)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.60	0.75	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.75	0.60	0.10	0.10	0.10	0.10	0.10	0.10
	WEH (Storage Light WEH)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
BLDG_EQUIP_SCH	WD (Office_Plug_WD_BASE)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.50	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	0.50	0.30	0.30	0.30	0.30	0.30	0.30
	WEH (Office_Plug_WEH_BASE)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	WD (Bulk Storage Plug WD)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	0.25	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	WEH (Bulk Storage Plug WEH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BLDG_OCC_SCH	WD (Office Occ WD)	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.21	1.00	1.00	1.00	1.00	0.53	1.00	1.00	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
	WEH (Office Occ WEH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BLDG_SWH_SCH	WD (Office DHW WD)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.40	0.50	0.50	0.70	0.90	0.80	0.70	0.80	0.30	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	WEH (Office DHW WEH)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
INFIL_SCH_PNNL	WD (Office Infiltration WD)	1	1	1	1	1	1	1	1.25	1.25	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.25	1.25	1	1	1	1	1	1
	WEH (Office infiltration WEH)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WD (Fine Storage INFIL WD)	1	1	1	1	1	1	1	1.25	1.25	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.25	1.25	1	1	1	1	1	1
	WEH (Fine Storage INFIL WEH)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WD (Bulk Storage INFIL_Base WD)	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	1	1	1	1	0.77	1	1	1	1	0.77	0.77	0.77	0.77	0.77	0.77	0.77
	WEH (Bulk Storage INFIL_Base WEH)	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
HVACOperationSchd	Compact HVAC-Always 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fan Schedule	WD (FanSched)	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	WEH (FanSched)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SummerDesignDay (FanSched)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesignDay (FanSched)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_Sched	AllDays	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_MotorizedDamper_Sched	WD, Sat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sun, Hol, Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SummerDesign, WinterDesign	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
HTGSETP_SCH	WD (Office Heating WD)	15.6	15.6	15.6	15.6	15.6	15.6	18.3	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	15.6	15.6	15.6	15.6	15.6	15.6
	WEH (Office Heating WEH)	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
CLGSETP_SCH	WD (Office Cooling WD)	29.4	29.4	29.4	29.4	29.4	29.4	26.7	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	29.4	29.4	29.4	29.4	29.4	29.4
	WEH (Office Cooling WEH)	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
Bulk Storage Heating Setpoint Schedule	AllDays	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Hot Water Setpoint Temp Schedule (SWH)	AllDays	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9	48.9
Fine Storage Heating Setpoint Schedule	AllDays	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Fine Storage Cooling Setpoint Schedule	AllDays	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
HTGSETP_SCH	WD (Office Heating WD)	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60	60

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	WEH (Office Heating WEH)	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CLGSETP_SCH	WD (Office Cooling WD)	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	75	85	85	85	85	85	85
	WEH (Office Cooling WEH)	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
Bulk Storage Heating Setpoint Schedule	AllDays	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Hot Water Setpoint Temp Schedule	AllDays	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
Fine Storage Heating Setpoint Schedule	AllDays	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Fine Storage Cooling Setpoint Schedule	AllDays	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80

C.13 Quick Service Restaurant Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD	0.15	0.15	0.15	0.15	0.15	0.2	0.4	0.4	0.6	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.3
	Sat	0.2	0.15	0.15	0.15	0.15	0.15	0.3	0.3	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.5	0.3
	Sun, Hol, Other	0.2	0.15	0.15	0.15	0.15	0.15	0.3	0.3	0.5	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.3
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EQUIP_SCH	WD	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	Sat	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	Sun, Hol, Other	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	SummerDesign	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FF_GAS_EQUIP_SCH	WD, Sat	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	Sun, Hol, Other	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	SummerDesign	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH	WD	0.05	0	0	0	0	0.05	0.1	0.4	0.4	0.4	0.2	0.5	0.8	0.7	0.4	0.2	0.25	0.5	0.8	0.8	0.8	0.5	0.35	0.2
	Sat	0.05	0	0	0	0	0	0.05	0.5	0.5	0.4	0.2	0.45	0.5	0.5	0.35	0.3	0.3	0.3	0.7	0.9	0.7	0.65	0.55	0.35
	Sun, Hol, Other	0.05	0	0	0	0	0	0.05	0.5	0.5	0.2	0.2	0.3	0.5	0.5	0.3	0.2	0.25	0.35	0.55	0.65	0.7	0.35	0.2	0.2
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EXTERIOR_LIGHT	WD, SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(AstronomicalClock control)	Sat, WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD, SummerDesign	0.2	0	0	0	0	0	0.15	0.6	0.55	0.45	0.4	0.45	0.4	0.35	0.3	0.3	0.3	0.4	0.55	0.6	0.5	0.55	0.45	0.25
	Sat, WinterDesign	0.2	0	0	0	0	0	0.15	0.15	0.15	0.5	0.45	0.5	0.5	0.45	0.4	0.4	0.35	0.4	0.55	0.55	0.5	0.55	0.4	0.3
	Sun, Hol, Other	0.25	0	0	0	0	0	0.15	0.15	0.15	0.15	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.4	0.5	0.5	0.4	0.5	0.4	0.2
INFIL_SCH_PNNL	WD, SummerDesign	0.25	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sat, WinterDesign	0.25	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sun, Hol, Other	0.25	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
HVACOperationSchd	WD, SummerDesign	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(FAN_SCH)	Sat, WinterDesign	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HTGSETP_SCH	WD	13	13	13	13	13	13	21	21	21	21	21	21	21	21	21	21	21	21	21	13	13	13	13	13
	SummerDesign	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	Sat	13	13	13	13	13	13	21	21	21	21	21	21	21	13	13	13	13	13	13	13	13	13	13	13
	WinterDesign	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	Sun, Hol, Other	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
CLGSETP_SCH	WD	33	33	33	33	33	33	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	33	33
	SummerDesign	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	Sat	33	33	33	33	33	33	24	24	24	24	24	24	24	24	24	24	24	24	33	33	33	33	33	33
	WinterDesign	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
	Sun, Hol, Other	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Dual Zone Control Type Sched	All	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Seasonal-Reset-Supply-Air-Temp-Sch	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	All	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
CW-Loop-Temp-Schedule	All	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
HW-Loop-Temp-Schedule	All	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Heating-Supply-Air-Temp-Sch	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
HTGSETP_DINING_SCH	WD, Winter Design	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
	SummerDesign	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Sat, Sun, Hol, Other	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
HTGSETP_KITCHEN_SCH	WD, Winter Design	60	60	60	60	60	63	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
	SummerDesign	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Sat, Sun, Hol, Other	60	60	60	60	60	63	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
CLGSETP_DINING_SCH	WD, SummerDesign	86	86	86	86	86	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	WinterDesign	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86
	Sat, Sun, Hol, Other	86	86	86	86	86	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
CLGSETP_KITCHEN_SCH	WD, SummerDesign	86	86	86	86	86	83	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
	WinterDesign	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86
	Sat, Sun, Hol, Other	86	86	86	86	86	83	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
HTGSETP_DINING_SCH	WD, Winter Design	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
	SummerDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56
	Sat, Sun, Hol, Other	15.56	15.56	15.56	15.56	15.56	18.33	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11	21.11
HTGSETP_KITCHEN_SCH	WD, Winter Design	15.56	15.56	15.56	15.56	15.56	17.22	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89
	SummerDesign	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56	15.56
	Sat, Sun, Hol, Other	15.56	15.56	15.56	15.56	15.56	17.22	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89
CLGSETP_DINING_SCH	WD, SummerDesign	30.00	30.00	30.00	30.00	30.00	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89
	WinterDesign	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Sat, Sun, Hol, Other	30.00	30.00	30.00	30.00	30.00	26.67	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89
CLGSETP_KITCHEN_SCH	WD, SummerDesign	30.00	30.00	30.00	30.00	30.00	28.33	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11
	WinterDesign	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Sat, Sun, Hol, Other	30.00	30.00	30.00	30.00	30.00	28.33	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11
MinOA_FFKitch_Sched (for kichen)	WD, SummerDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sat	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_Sched (for dining)	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C.14 Full Service Restaurant Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BLDG_LIGHT_SCH	WD	0.15	0.15	0.15	0.15	0.15	0.2	0.4	0.4	0.6	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.3
	Sat	0.2	0.15	0.15	0.15	0.15	0.15	0.3	0.3	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.5	0.3
	Sun, Hol, Other	0.2	0.15	0.15	0.15	0.15	0.15	0.3	0.3	0.5	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.3
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EQUIP_SCH	WD	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
Used for Electric Equipment	Sat	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	Sun, Hol, Other	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	SummerDesign	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rest_GAS_EQUIP_SCH	WD, Sat	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
Used for Gas Cooking Equipment	Sun, Hol, Other	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.2	0.18	0.09	0.03
	SummerDesign	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_OCC_SCH	WD	0.05	0	0	0	0	0.05	0.1	0.4	0.4	0.4	0.2	0.5	0.8	0.7	0.4	0.2	0.25	0.5	0.8	0.8	0.8	0.5	0.35	0.2
	Sat	0.05	0	0	0	0	0	0.05	0.5	0.5	0.4	0.2	0.45	0.5	0.5	0.35	0.3	0.3	0.3	0.7	0.9	0.7	0.65	0.55	0.35
	Sun, Hol, Other	0.05	0	0	0	0	0	0.05	0.5	0.5	0.2	0.2	0.3	0.5	0.5	0.3	0.2	0.25	0.35	0.55	0.65	0.7	0.35	0.2	0.2
	SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLDG_EXTERIOR_LIGHT	WD, SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(AstronomicalClock control)	Sat, WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_SWH_SCH	WD, SummerDesign	0.2	0	0	0	0	0	0.15	0.6	0.55	0.45	0.4	0.45	0.4	0.35	0.3	0.3	0.3	0.4	0.55	0.6	0.5	0.55	0.45	0.25
	Sat, WinterDesign	0.2	0	0	0	0	0	0.15	0.15	0.15	0.5	0.45	0.5	0.5	0.45	0.4	0.4	0.35	0.4	0.55	0.55	0.5	0.55	0.4	0.3
	Sun, Hol, Other	0.25	0	0	0	0	0	0.15	0.15	0.15	0.15	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.4	0.5	0.5	0.4	0.5	0.4	0.2
INFIL_SCH_PNNL	WD, SummerDesign	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sat, WinterDesign	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Sun, Hol, Other	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
HVACOperationSchd	WD, SummerDesign	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(FAN_SCH)	Sat, WinterDesign	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HTGSETP_SCH	WD,	16	16	16	16	16	18	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
(Dining)	SummerDesign	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	WinterDesign	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	Sat	16	16	16	16	16	18	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	Sun, Hol, Other	16	16	16	16	16	18	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
HTGSETP_KITCHEN_SCH	WD, Winter Design	19	16	16	16	16	17	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
(Kitchen)	SummerDesign	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	WinterDesign	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
	Sat	19	16	16	16	16	17	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
	Sun, Hol, Other	19	16	16	16	16	17	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
CLGSETP_SCH	WD, SummerDesign	30	30	30	30	30	26	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
(Dining)	Sat	30	30	30	30	30	26	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	WinterDesign	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Sun, Hol, Other	30.00	30.00	30.00	30.00	30.00	26.11	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89	23.89
CLGSETP_KITCHEN_SCH	WD,	26.11	30.00	30.00	30.00	30.00	28.33	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	SummerDesign																								
(Kitchen)	Sat	26.11	30.00	30.00	30.00	30.00	28.33	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11
	WinterDesign	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Sun, Hol, Other	26.11	30.00	30.00	30.00	30.00	28.33	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11	26.11
HTGSETP_SCH	WD,	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
(Dining)	SummerDesign	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
	WinterDesign	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
	Sat	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
	Sun, Hol, Other	60.00	60.00	60.00	60.00	60.00	65.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
HTGSETP_KITCHEN_SCH	WD, Winter Design	66.00	60.00	60.00	60.00	60.00	63.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00
(Kitchen)	SummerDesign	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	WinterDesign	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
	Sat	66	60	60	60	60	63	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
	Sun, Hol, Other	66	60	60	60	60	63	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
CLGSETP_SCH	WD, SummerDesign	86	86	86	86	86	79	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
(Dining)	Sat	86	86	86	86	86	79	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	WinterDesign	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86
	Sun, Hol, Other	86	86	86	86	86	79	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
CLGSETP_KITCHEN_SCH	WD, SummerDesign	79	86	86	86	86	83	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
(Kitchen)	Sat	79	86	86	86	86	83	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
	WinterDesign	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86
	Sun, Hol, Other	79	86	86	86	86	83	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
MinOA_MotorizedDamper_ Sched	WD, SummerDesign	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(Dining)	Sat	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_SDKitch_Sched	WD, SummerDesign	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
(Kitchen)	Sat	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WinterDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sun, Hol, Other	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C.15 Mid-Rise Apartment Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
OCC_APT_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.85	0.39	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.30	0.52	0.87	0.87	0.87	1.00	1.00	1.00
LTG_APT_SCH	All	0.067	0.067	0.067	0.067	0.187	0.394	0.440	0.393	0.172	0.119	0.119	0.119	0.119	0.119	0.119	0.206	0.439	0.616	0.829	0.986	1.000	0.692	0.384	0.160
EQP_APT_SCH	All	0.45	0.41	0.39	0.38	0.38	0.43	0.54	0.65	0.66	0.67	0.69	0.70	0.69	0.66	0.65	0.68	0.80	1.00	1.00	0.93	0.89	0.85	0.71	0.58
INF_APT_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CLGSETP_APT_SCH	All	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
HTGSETP_APT_SCH	All	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
APT_DHW_SCH	All	0.08	0.04	0.01	0.01	0.04	0.27	0.94	1.00	0.96	0.84	0.76	0.61	0.53	0.47	0.41	0.47	0.55	0.73	0.86	0.82	0.75	0.61	0.53	0.29
Fan	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OCC_OFF_SCH	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	WEH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LTG_OFF_SCH	WD	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.90	0.90	0.90	0.90	0.80	0.90	0.90	0.90	0.90	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	WEH	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
EQP_OFF_SCH_BASE	WD	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.50	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	0.50	0.33	0.33	0.33	0.33	0.33	0.33
	WEH	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
INF_OFF_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
HTGSETP_OFF_SCH	WD	60	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	65	60	60	60	60	60	60
	WEH	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CLGSETP_OFF_SCH	WD	85	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	80	85	85	85	85	85	85
	WEH	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
Elevator Motor	All	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
ELEV_LIGHT_FAN_SCH_24_7	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LTG_COR_SCH	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C.16 High-Rise Apartment Hourly Operation Schedules

Schedule	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
OCC_APT_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.85	0.39	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.30	0.52	0.87	0.87	0.87	1.00	1.00	1.00
LTG_APT_SCH	All	0.067	0.067	0.067	0.067	0.187	0.394	0.440	0.393	0.172	0.119	0.119	0.119	0.119	0.119	0.119	0.206	0.439	0.616	0.829	0.986	1.000	0.692	0.384	0.160
EQP_APT_SCH	All	0.45	0.41	0.39	0.38	0.38	0.43	0.54	0.65	0.66	0.67	0.69	0.70	0.69	0.66	0.65	0.68	0.80	1.00	1.00	0.93	0.89	0.85	0.71	0.58
INF_APT_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CLGSETP_APT_SCH	All	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
HTGSETP_APT_SCH	All	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
APT_DHW_SCH	All	0.08	0.04	0.01	0.01	0.04	0.27	0.94	1.00	0.96	0.84	0.76	0.61	0.53	0.47	0.41	0.47	0.55	0.73	0.86	0.82	0.75	0.61	0.53	0.29
Fan	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OCC_OFF_SCH	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	WEH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LTG_OFF_SCH	WD	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.90	0.90	0.90	0.90	0.80	0.90	0.90	0.90	0.90	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	WEH	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
EQP_OFF_SCH_BASE	WD	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.50	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	0.50	0.33	0.33	0.33	0.33	0.33	0.33
	WEH	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
INF_OFF_SCH	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
HTGSETP_OFF_SCH	WD	60	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	65	60	60	60	60	60	60
	WEH	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CLGSETP_OFF_SCH	WD	85	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	80	85	85	85	85	85	85
	WEH	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
Elevator Motor	All	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.5	0.5	0.35	0.15	0.15	0.15	0.15	0.15	0.15	0.35	0.5	0.5	0.4	0.4	0.3	0.2	0.1
ELEV_LIGHT_FAN_SCH_24_7	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LTG_COR_SCH	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Appendix D

Prototype Building HVAC System List

D.1 Small Office HVAC System List

Zone	HVAC System Name
CORE_ZN	PSZ-AC:1
PERIMETER_ZN_1	PSZ-AC:2
PERIMETER_ZN_2	PSZ-AC:3
PERIMETER_ZN_3	PSZ-AC:4
PERIMETER_ZN_4	PSZ-AC:5
ATTIC	NA

D.2 Medium Office HVAC System List

Zone	HVAC System Name
CORE_BOTTOM	PACU_VAV_bot
TOPFLOOR_PLENUM	NA
MIDFLOOR_PLENUM	NA
FIRSTFLOOR_PLENUM	NA
CORE_MID	PACU_VAV_mid
CORE_TOP	PACU_VAV_top
PERIMETER_TOP_ZN_3	PACU_VAV_top
PERIMETER_TOP_ZN_2	PACU_VAV_top
PERIMETER_TOP_ZN_1	PACU_VAV_top
PERIMETER_TOP_ZN_4	PACU_VAV_top
PERIMETER_BOT_ZN_3	PACU_VAV_bot
PERIMETER_BOT_ZN_2	PACU_VAV_bot
PERIMETER_BOT_ZN_1	PACU_VAV_bot
PERIMETER_BOT_ZN_4	PACU_VAV_bot
PERIMETER_MID_ZN_3	PACU_VAV_mid
PERIMETER_MID_ZN_2	PACU_VAV_mid
PERIMETER_MID_ZN_1	PACU_VAV_mid
PERIMETER_MID_ZN_4	PACU_VAV_mid

D.3 Large Office HVAC System List

Zone	HVAC System Name
BASEMENT	CAV_bas
CORE_BOTTOM	VAV_bot WITH REHEAT
CORE_MID	VAV_mid WITH REHEAT
CORE_TOP	VAV_top WITH REHEAT
PERIMETER_BOT_ZN_3	VAV_bot WITH REHEAT
PERIMETER_BOT_ZN_2	VAV_bot WITH REHEAT
PERIMETER_BOT_ZN_1	VAV_bot WITH REHEAT
PERIMETER_BOT_ZN_4	VAV_bot WITH REHEAT
PERIMETER_MID_ZN_3	VAV_mid WITH REHEAT
PERIMETER_MID_ZN_2	VAV_mid WITH REHEAT
PERIMETER_MID_ZN_1	VAV_mid WITH REHEAT
PERIMETER_MID_ZN_4	VAV_mid WITH REHEAT
PERIMETER_TOP_ZN_3	VAV_top WITH REHEAT
PERIMETER_TOP_ZN_2	VAV_top WITH REHEAT
PERIMETER_TOP_ZN_1	VAV_top WITH REHEAT
PERIMETER_TOP_ZN_4	VAV_top WITH REHEAT
GROUNDFLOOR_PLENUM	NA
MIDFLOOR_PLENUM	NA
TOPFLOOR_PLENUM	NA

D.4 Stand-alone Retail HVAC System List

Zone	HVAC System Name
BACK_SPACE	PSZ-AC:1
CORE_RETAIL	PSZ-AC:2
POINT_OF_SALE	PSZ-AC:3
FRONT_RETAIL	PSZ-AC:4
FRONT_ENTRY	Front_Entry Unit Heater

D.5 Strip Mall HVAC System List

Zone	HVAC System Name
LGSTORE1	PSZ-AC_1:1
SMSTORE1	PSZ-AC_2:2
SMSTORE2	PSZ-AC_3:3
SMSTORE3	PSZ-AC_4:4
SMSTORE4	PSZ-AC_5:5
LGSTORE2	PSZ-AC_6:6
SMSTORE5	PSZ-AC_7:7
SMSTORE6	PSZ-AC_8:8
SMSTORE7	PSZ-AC_9:9
SMSTORE8	PSZ-AC_10:10

D.6 Primary School HVAC System List

Zone	HVAC System Name
CORNER_CLASS_1_POD_1_ZN_1_FLR_1	VAV_POD_1
MULT_CLASS_1_POD_1_ZN_1_FLR_1	VAV_POD_1
CORRIDOR_POD_1_ZN_1_FLR_1	VAV_POD_1
CORNER_CLASS_2_POD_1_ZN_1_FLR_1	VAV_POD_1
MULT_CLASS_2_POD_1_ZN_1_FLR_1	VAV_POD_1
CORNER_CLASS_1_POD_2_ZN_1_FLR_1	VAV_POD_2
MULT_CLASS_1_POD_2_ZN_1_FLR_1	VAV_POD_2
CORRIDOR_POD_2_ZN_1_FLR_1	VAV_POD_2
CORNER_CLASS_2_POD_2_ZN_1_FLR_1	VAV_POD_2
MULT_CLASS_2_POD_2_ZN_1_FLR_1	VAV_POD_2
CORNER_CLASS_1_POD_3_ZN_1_FLR_1	VAV_POD_3
MULT_CLASS_1_POD_3_ZN_1_FLR_1	VAV_POD_3
CORRIDOR_POD_3_ZN_1_FLR_1	VAV_POD_3
CORNER_CLASS_2_POD_3_ZN_1_FLR_1	VAV_POD_3
MULT_CLASS_2_POD_3_ZN_1_FLR_1	VAV_POD_3
COMPUTER_CLASS_ZN_1_FLR_1	VAV_OTHER
MAIN_CORRIDOR_ZN_1_FLR_1	VAV_OTHER
LOBBY_ZN_1_FLR_1	VAV_OTHER
MECH_ZN_1_FLR_1	VAV_OTHER
BATH_ZN_1_FLR_1	VAV_OTHER; Bath_ZN_1_FLR_1 Exhaust Fan
OFFICES_ZN_1_FLR_1	VAV_OTHER
GYM_ZN_1_FLR_1	PSZ-AC_2:5
KITCHEN_ZN_1_FLR_1	PSZ-AC_1:6; Kitchen_ZN_1_FLR_1 Exhaust Fan
CAFETERIA_ZN_1_FLR_1	PSZ-AC_2:7
LIBRARY_MEDIA_CENTER_ZN_1_FLR_1	VAV_OTHER

D.7 Secondary School HVAC System List

Zone	HVAC System Name
CORNER_CLASS_1_POD_1_ZN_1_FLR_1	VAV_POD_1
CORNER_CLASS_1_POD_1_ZN_1_FLR_2	VAV_POD_1
MULT_CLASS_1_POD_1_ZN_1_FLR_1	VAV_POD_1
MULT_CLASS_1_POD_1_ZN_1_FLR_2	VAV_POD_1
CORRIDOR_POD_1_ZN_1_FLR_1	VAV_POD_1
CORRIDOR_POD_1_ZN_1_FLR_2	VAV_POD_1
CORNER_CLASS_2_POD_1_ZN_1_FLR_1	VAV_POD_1
CORNER_CLASS_2_POD_1_ZN_1_FLR_2	VAV_POD_1
MULT_CLASS_2_POD_1_ZN_1_FLR_1	VAV_POD_1
MULT_CLASS_2_POD_1_ZN_1_FLR_2	VAV_POD_1
CORNER_CLASS_1_POD_2_ZN_1_FLR_1	VAV_POD_2
CORNER_CLASS_1_POD_2_ZN_1_FLR_2	VAV_POD_2
MULT_CLASS_1_POD_2_ZN_1_FLR_1	VAV_POD_2
MULT_CLASS_1_POD_2_ZN_1_FLR_2	VAV_POD_2
CORRIDOR_POD_2_ZN_1_FLR_1	VAV_POD_2
CORRIDOR_POD_2_ZN_1_FLR_2	VAV_POD_2
CORNER_CLASS_2_POD_2_ZN_1_FLR_1	VAV_POD_2
CORNER_CLASS_2_POD_2_ZN_1_FLR_2	VAV_POD_2
MULT_CLASS_2_POD_2_ZN_1_FLR_1	VAV_POD_2
MULT_CLASS_2_POD_2_ZN_1_FLR_2	VAV_POD_2
CORNER_CLASS_1_POD_3_ZN_1_FLR_1	VAV_POD_3
CORNER_CLASS_1_POD_3_ZN_1_FLR_2	VAV_POD_3
MULT_CLASS_1_POD_3_ZN_1_FLR_1	VAV_POD_3
MULT_CLASS_1_POD_3_ZN_1_FLR_2	VAV_POD_3
CORRIDOR_POD_3_ZN_1_FLR_1	VAV_POD_3
CORRIDOR_POD_3_ZN_1_FLR_2	VAV_POD_3
CORNER_CLASS_2_POD_3_ZN_1_FLR_1	VAV_POD_3
CORNER_CLASS_2_POD_3_ZN_1_FLR_2	VAV_POD_3
MULT_CLASS_2_POD_3_ZN_1_FLR_1	VAV_POD_3
MULT_CLASS_2_POD_3_ZN_1_FLR_2	VAV_POD_3
MAIN_CORRIDOR_ZN_1_FLR_1	VAV_OTHER
MAIN_CORRIDOR_ZN_1_FLR_2	VAV_OTHER
LOBBY_ZN_1_FLR_1	VAV_OTHER
LOBBY_ZN_1_FLR_2	VAV_OTHER
BATHROOMS_ZN_1_FLR_1	VAV_OTHER; Bathrooms_ZN_1_FLR_1 Exhaust Fan
BATHROOMS_ZN_1_FLR_2	VAV_OTHER; Bathrooms_ZN_1_FLR_2 Exhaust Fan
OFFICES_ZN_1_FLR_1	VAV_OTHER
OFFICES_ZN_1_FLR_2	VAV_OTHER
GYM_ZN_1_FLR_1	PSZ-AC_1:5
AUX_GYM_ZN_1_FLR_1	PSZ-AC_2:6
AUDITORIUM_ZN_1_FLR_1	PSZ-AC_3:7
KITCHEN_ZN_1_FLR_1	PSZ-AC_4:8
LIBRARY_MEDIA_CENTER_ZN_1_FLR_2	VAV_OTHER
CAFETERIA_ZN_1_FLR_1	PSZ-AC_5:9
MECH_ZN_1_FLR_1	VAV_OTHER
MECH_ZN_1_FLR_2	VAV_OTHER

D.8 Outpatient Healthcare HVAC System List

Zone	HVAC System Name
Floor 1 Anesthesia	AHU-1; Floor 1 Anesthesia Exhaust Fan
Floor 1 Bio Haz	AHU-1
Floor 1 Café	AHU-1
Floor 1 Clean	AHU-1
Floor 1 Clean Work	AHU-1
Floor 1 Dictation	AHU-1
Floor 1 Dressing Room	AHU-1
Floor 1 Electrical Room	AHU-1
Floor 1 Elevator Pump Room	AHU-1
Floor 1 Humid	AHU-1
Floor 1 IT Hall	AHU-1
Floor 1 IT Room	AHU-1
Floor 1 Lobby	AHU-1
Floor 1 Lobby Hall	AHU-1
Floor 1 Lobby Toilet	AHU-1; Floor 1 Lobby Toilet Exhaust Fan
Floor 1 Locker Room	AHU-1
Floor 1 Locker Room Hall	AHU-1
Floor 1 Lounge	AHU-1
Floor 1 Med Gas	AHU-1
Floor 1 MRI Control Room	AHU-1; Floor 1 MRI Control Room Exhaust Fan
Floor 1 MRI Hall	AHU-1
Floor 1 MRI Room	AHU-1; Floor 1 MRI Room Exhaust Fan
Floor 1 MRI Toilet	AHU-1; Floor 1 MRI Toilet Exhaust Fan
Floor 1 Nourishment	AHU-1
Floor 1 Nurse Hall	AHU-1
Floor 1 Nurse Janitor	AHU-1
Floor 1 Nurse Station	AHU-1
Floor 1 Nurse Toilet	AHU-1; Floor 1 Nurse Toilet Exhaust Fan
Floor 1 Office	AHU-1
Floor 1 Operating Room 1	AHU-1
Floor 1 Operating Room 2	AHU-1
Floor 1 Operating Room 3	AHU-1
Floor 1 PACU	AHU-1
Floor 1 Pre-Op Hall	AHU-1
Floor 1 Pre-Op Room 1	AHU-1
Floor 1 Pre-Op Room 2	AHU-1
Floor 1 Pre-Op Toilet	AHU-1; Floor 1 Pre-Op Toilet Exhaust Fan
Floor 1 Procedure Room	AHU-1
Floor 1 Reception	AHU-1
Floor 1 Reception Hall	AHU-1
Floor 1 Recovery Room	AHU-1
Floor 1 Scheduling	AHU-1
Floor 1 Scrub	AHU-1
Floor 1 Soil	AHU-1; Floor 1 Soil Exhaust Fan
Floor 1 Soil Hold	AHU-1; Floor 1 Soil Hold Exhaust Fan
Floor 1 Soil Work	AHU-1; Floor 1 Soil Work Exhaust Fan
Floor 1 Step Down	AHU-1
Floor 1 Sterile Hall	AHU-1
Floor 1 Sterile Storage	AHU-1

Zone	HVAC System Name
Floor 1 Storage	AHU-1
Floor 1 Sub-Sterile	AHU-1
Floor 1 Utility Hall	AHU-1
Floor 1 Utility Janitor	AHU-1
Floor 1 Utility Room	AHU-1
Floor 1 Vestibule	AHU-1
Floor 2 Conference	AHU-2
Floor 2 Conference Toilet	AHU-2; Floor 2 Conference Toilet Exhaust Fan
Floor 2 Dictation	AHU-2
Floor 2 Exam 1	AHU-2
Floor 2 Exam 2	AHU-2
Floor 2 Exam 3	AHU-2
Floor 2 Exam 4	AHU-2
Floor 2 Exam 5	AHU-2
Floor 2 Exam 6	AHU-2
Floor 2 Exam 7	AHU-2
Floor 2 Exam 8	AHU-2
Floor 2 Exam 9	AHU-2
Floor 2 Exam Hall 1	AHU-2
Floor 2 Exam Hall 2	AHU-2
Floor 2 Exam Hall 3	AHU-2
Floor 2 Exam Hall 4	AHU-2
Floor 2 Exam Hall 5	AHU-2
Floor 2 Exam Hall 6	AHU-2
Floor 2 Janitor	AHU-2
Floor 2 Lounge	AHU-2
Floor 2 Nurse Station 1	AHU-2
Floor 2 Nurse Station 2	AHU-2
Floor 2 Office	AHU-2
Floor 2 Office Hall	AHU-2
Floor 2 Reception	AHU-2
Floor 2 Reception Hall	AHU-2
Floor 2 Reception Toilet	AHU-2; Floor 2 Reception Toilet Exhaust Fan
Floor 2 Scheduling 1	AHU-2
Floor 2 Scheduling 2	AHU-2
Floor 2 Storage 1	AHU-2
Floor 2 Storage 2	AHU-2
Floor 2 Storage 3	AHU-2
Floor 2 Utility	AHU-2
Floor 2 Work	AHU-2
Floor 2 Work Hall	AHU-2
Floor 2 Work Toilet	AHU-2; Floor 2 Work Toilet Exhaust Fan
Floor 2 X-Ray	AHU-2; Floor 2 X-Ray Exhaust Fan
Floor 3 Dressing Room	AHU-2
Floor 3 Elevator Hall	AHU-2
Floor 3 Humid	AHU-2
Floor 3 Janitor	AHU-2
Floor 3 Locker	AHU-2
Floor 3 Lounge	AHU-2
Floor 3 Lounge Toilet	AHU-2; Floor 3 Lounge Toilet Exhaust Fan
Floor 3 Mechanical	AHU-2
Floor 3 Mechanical Hall	AHU-2

Zone	HVAC System Name
Floor 3 Office	AHU-2
Floor 3 Office Hall	AHU-2
Floor 3 Office Toilet	AHU-2; Floor 3 Office Toilet Exhaust Fan
Floor 3 Physical Therapy 1	AHU-2
Floor 3 Physical Therapy 2	AHU-2
Floor 3 Physical Therapy Toilet	AHU-2; Floor 3 Physical Therapy Toilet Exhaust Fan
Floor 3 Storage 1	AHU-2
Floor 3 Storage 2	AHU-2
Floor 3 Treatment	AHU-2
Floor 3 Undeveloped 1	AHU-2
Floor 3 Undeveloped 2	AHU-2
Floor 3 Utility	AHU-2
Floor 3 Work	AHU-2
NE Stair	AHU-2
NW Elevator	AHU-2
NW Stair	AHU-2
SW Stair	AHU-2

D.9 Hospital HVAC System List

Zone	HVAC System Name
BASEMENT	VAV_1
ER_EXAM1_MULT4_FLR_1	VAV_ER
ER_TRAUMA1_FLR_1	VAV_ER
ER_EXAM3_MULT4_FLR_1	VAV_ER
ER_TRAUMA2_FLR_1	VAV_ER
ER_TRIAGE_MULT4_FLR_1	VAV_ER
OFFICE1_MULT4_FLR_1	VAV_1
LOBBY_RECORDS_FLR_1	VAV_1
CORRIDOR_FLR_1	VAV_1
ER_NURSESTN_LOBBY_FLR_1	VAV_1
OR1_FLR_2	VAV_OR
OR2_MULT5_FLR_2	VAV_OR
OR3_FLR_2	VAV_OR
OR4_FLR_2	VAV_OR
IC_PATROOM1_MULT5_FLR_2	VAV_ICU
IC_PATROOM2_FLR_2	VAV_ICU
IC_PATROOM3_MULT6_FLR_2	VAV_ICU
ICU_FLR_2	VAV_ICU
ICU_NURSESTN_LOBBY_FLR_2	VAV_1
CORRIDOR_FLR_2	VAV_1
OR_NURSESTN_LOBBY_FLR_2	VAV_1
PATROOM1_MULT10_FLR_3	VAV_PATRMS
PATROOM2_FLR_3	VAV_PATRMS
PATROOM3_MULT10_FLR_3	VAV_PATRMS
PATROOM4_FLR_3	VAV_PATRMS
PATROOM5_MULT10_FLR_3	VAV_PATRMS
PHYSTHERAPY_FLR_3	VAV_2
PATROOM6_FLR_3	VAV_PATRMS
PATROOM7_MULT10_FLR_3	VAV_PATRMS
PATROOM8_FLR_3	VAV_PATRMS
NURSESTN_LOBBY_FLR_3	VAV_2
LAB_FLR_3	VAV_LABS
CORRIDOR_SE_FLR_3	VAV_2
CORRIDOR_NW_FLR_3	VAV_2
PATROOM1_MULT10_FLR_4	VAV_PATRMS
PATROOM2_FLR_4	VAV_PATRMS
PATROOM3_MULT10_FLR_4	VAV_PATRMS
PATROOM4_FLR_4	VAV_PATRMS
PATROOM5_MULT10_FLR_4	VAV_PATRMS
RADIOLOGY_FLR_4	VAV_2
PATROOM6_FLR_4	VAV_PATRMS
PATROOM7_MULT10_FLR_4	VAV_PATRMS
PATROOM8_FLR_4	VAV_PATRMS
NURSESTN_LOBBY_FLR_4	VAV_2
LAB_FLR_4	VAV_LABS
CORRIDOR_SE_FLR_4	VAV_2
CORRIDOR_NW_FLR_4	VAV_2
DINING_FLR_5	VAV_2
NURSESTN_LOBBY_FLR_5	VAV_2

Zone	HVAC System Name
KITCHEN_FLR_5	CAV_KITCHEN; Kitchen_Flr_5 Exhaust Fan
OFFICE1_FLR_5	VAV_2
OFFICE2_MULT5_FLR_5	VAV_2
OFFICE3_FLR_5	VAV_2
OFFICE4_MULT6_FLR_5	VAV_2
CORRIDOR_FLR_5	VAV_2

D.10 Small Hotel HVAC System List

Zone	HVAC System Name
REARSTAIRSFLR1	RearStairsFlr1 UnitHeater
CORRIDORFLR1	CorridorFlr1 PTAC; MAU
REARSTORAGEFLR1	NA
FRONTLOUNGEFLR1	SAC_FrontLounge
RESTROOMFLR1	SAC_Exc_EmpLge_RestRm
MEETINGROOMFLR1	SAC_MeetingRoom
MECHANICALROOMFLR1	MechRm UnitHeater
GUESTROOM101	101 PTAC; MAU
GUESTROOM102	102 PTAC; MAU
GUESTROOM103	103 PTAC; MAU
GUESTROOM104	104 PTAC; MAU
GUESTROOM105	105 PTAC; MAU
EMPLOYEELOUNGEFLR1	SAC_Exc_EmpLge_RestRm
LAUNDRYROOMFLR1	NA
ELEVATORCOREFLR1	NA
EXERCISECENTERFLR1	SAC_Exc_EmpLge_RestRm
FRONTOFFICEFLR1	SAC_FrontOffice
FRONTSTAIRSFLR1	FrontStairsFlr1 UnitHeater
FRONTSTORAGEFLR1	NA
REARSTAIRSFLR2	RearStairsFlr2 UnitHeater
CORRIDORFLR2	CorridorFlr2 PTAC; MAU
REARSTORAGEFLR2	NA
GUESTROOM201	201 PTAC; MAU
GUESTROOM202_205	202_205 PTAC; MAU
GUESTROOM206_208	206_208 PTAC; MAU
GUESTROOM209_212	209_212 PTAC; MAU
GUESTROOM213	213 PTAC; MAU
GUESTROOM214	214 PTAC; MAU
GUESTROOM215_218	215_218 PTAC; MAU
ELEVATORCOREFLR2	NA
GUESTROOM219	219 PTAC; MAU
GUESTROOM220_223	220_223 PTAC; MAU
GUESTROOM224	224 PTAC; MAU
FRONTSTORAGEFLR2	NA
FRONTSTAIRSFLR2	FrontStairsFlr2 UnitHeater
REARSTAIRSFLR3	RearStairsFlr3 UnitHeater
CORRIDORFLR3	CorridorFlr3 PTAC; MAU
REARSTORAGEFLR3	NA
GUESTROOM301	301 PTAC; MAU
GUESTROOM302_305	302_305 PTAC; MAU
GUESTROOM306_308	306_308 PTAC; MAU
GUESTROOM309_312	309_312 PTAC; MAU
GUESTROOM313	313 PTAC; MAU
GUESTROOM314	314 PTAC; MAU
GUESTROOM315_318	315_318 PTAC; MAU
ELEVATORCOREFLR3	NA
GUESTROOM319	319 PTAC; MAU
GUESTROOM320_323	320_323 PTAC; MAU
GUESTROOM324	324 PTAC; MAU

Zone	HVAC System Name
FRONTSTORAGEFLR3	NA
FRONTSTAIRSFLR3	FrontStairsFlr3 UnitHeater
REARSTAIRSFLR4	RearStairsFlr4 UnitHeater
CORRIDORFLR4	CorridorFlr4 PTAC; MAU
REARSTORAGEFLR4	NA
GUESTROOM401	401 PTAC; MAU
GUESTROOM402_405	402_405 PTAC; MAU
GUESTROOM406_408	406_408 PTAC; MAU
GUESTROOM409_412	409_412 PTAC; MAU
GUESTROOM413	413 PTAC; MAU
GUESTROOM414	414 PTAC; MAU
GUESTROOM415_418	415_418 PTAC; MAU
ELEVATORCOREFLR4	NA
GUESTROOM419	419 PTAC; MAU
GUESTROOM420_423	420_423 PTAC; MAU
GUESTROOM424	424 PTAC; MAU
FRONTSTORAGEFLR4	NA
FRONTSTAIRSFLR4	FrontStairsFlr4 UnitHeater

D.11 Large Hotel HVAC System List

Zone	HVAC System Name
BASEMENT	VAV WITH REHEAT
RETAIL_1_FLR_1	VAV WITH REHEAT
RETAIL_2_FLR_1	VAV WITH REHEAT
MECH_FLR_1	VAV WITH REHEAT
STORAGE_FLR_1	VAV WITH REHEAT
LAUNDRY_FLR_1	VAV WITH REHEAT; Laundry_Flr_1 Exhaust Fan
CAFE_FLR_1	VAV WITH REHEAT
LOBBY_FLR_1	VAV WITH REHEAT
ROOM_1_FLR_3	Room_1_Flr_3 fan coil; FLR_3_DOAS
ROOM_2_FLR_3	Room_2_Flr_3 fan coil; FLR_3_DOAS
ROOM_3_MULT19_FLR_3	Room_3_Mult19_Flr_3 fan coil; FLR_3_DOAS
ROOM_4_MULT19_FLR_3	Room_4_Mult19_Flr_3 fan coil; FLR_3_DOAS
ROOM_5_FLR_3	Room_5_Flr_3 fan coil; FLR_3_DOAS
ROOM_6_FLR_3	Room_6_Flr_3 fan coil; FLR_3_DOAS
CORRIDOR_FLR_3	VAV WITH REHEAT
ROOM_1_FLR_6	Room_1_Flr_6 fan coil; FLR_6_DOAS
ROOM_2_FLR_6	Room_2_Flr_6 fan coil; FLR_3_DOAS
ROOM_3_MULT9_FLR_6	Room_3_Mult9_Flr_6 fan coil; FLR_3_DOAS
BANQUET_FLR_6	VAV WITH REHEAT
DINING_FLR_6	VAV WITH REHEAT
KITCHEN_FLR_6	VAV WITH REHEAT; Kitchen_Flr_6 Exhaust Fan
CORRIDOR_FLR_6	VAV WITH REHEAT

D.12 Warehouse HVAC System List

Zone	HVAC System Name
ZONE1 OFFICE	PSZ-Office
ZONE2 FINE STORAGE	PSZ-Fine
ZONE3 BULK STORAGE	Zone3UnitHeater; Zone3HiRadiant

D.13 Quick Service Restaurant HVAC System List

Zone	HVAC System Name
DINING	PSZ-AC_1:1; Dining Exhaust Fan
KITCHEN	PSZ-AC_2:2; Kitchen Exhaust Fan
ATTIC	NA

D.14 Full Service Restaurant HVAC System List

Zone	HVAC System Name
DINING	PSZ-AC_1:1; Dining Exhaust Fan
KITCHEN	PSZ-AC_2:2; Kitchen Exhaust Fan
ATTIC	NA

D.15 Mid-Rise Apartment HVAC System List

Zone	HVAC System Name
G SW APARTMENT	Split GSW Furnace with DX Cooling
G NW APARTMENT	Split GNW Furnace with DX Cooling
OFFICE	Split Office Furnace with DX Cooling
G NE APARTMENT	Split GNE Furnace with DX Cooling
G N1 APARTMENT	Split GN1 Furnace with DX Cooling
G N2 APARTMENT	Split GN2 Furnace with DX Cooling
G S1 APARTMENT	Split GS1 Furnace with DX Cooling
G S2 APARTMENT	Split GS2 Furnace with DX Cooling
M SW APARTMENT	Split MSW Furnace with DX Cooling
M NW APARTMENT	Split MNW Furnace with DX Cooling
M SE APARTMENT	Split MSE Furnace with DX Cooling
M NE APARTMENT	Split MNE Furnace with DX Cooling
M N1 APARTMENT	Split MN1 Furnace with DX Cooling
M N2 APARTMENT	Split MN2 Furnace with DX Cooling
M S1 APARTMENT	Split MS1 Furnace with DX Cooling
M S2 APARTMENT	Split MS2 Furnace with DX Cooling
T SW APARTMENT	Split TSW Furnace with DX Cooling
T NW APARTMENT	Split TNW Furnace with DX Cooling
T SE APARTMENT	Split TSE Furnace with DX Cooling
T NE APARTMENT	Split TNE Furnace with DX Cooling
T N1 APARTMENT	Split TN1 Furnace with DX Cooling
T N2 APARTMENT	Split TN2 Furnace with DX Cooling
T S1 APARTMENT	Split TS1 Furnace with DX Cooling
T S2 APARTMENT	Split TS2 Furnace with DX Cooling
T CORRIDOR	NA
G CORRIDOR	NA
M CORRIDOR	NA

D.16 High-Rise Apartment HVAC System List

Zone	HVAC System Name
G SW APARTMENT	AirLoop G SW DXAC Heat Pump
G NW APARTMENT	AirLoop G NW DXAC Heat Pump
OFFICE	AirLoop Office DXAC Heat Pump
G NE APARTMENT	AirLoop G NE DXAC Heat Pump
G N1 APARTMENT	AirLoop G N1 DXAC Heat Pump
G N2 APARTMENT	AirLoop G N2 DXAC Heat Pump
G S1 APARTMENT	AirLoop G S1 DXAC Heat Pump
G S2 APARTMENT	AirLoop G S2 DXAC Heat Pump
M SW APARTMENT[(a)]	AirLoop M SW DXAC Heat Pump
M NW APARTMENT[(a)]	AirLoop M NW DXAC Heat Pump
M SE APARTMENT[(a)]	AirLoop M SE DXAC Heat Pump
M NE APARTMENT[(a)]	AirLoop M NE DXAC Heat Pump
M N1 APARTMENT[(a)]	AirLoop M N1 DXAC Heat Pump
M N2 APARTMENT[(a)]	AirLoop M N2 DXAC Heat Pump
M S1 APARTMENT[(a)]	AirLoop M S1 DXAC Heat Pump
M S2 APARTMENT[(a)]	AirLoop M S2 DXAC Heat Pump
T SW APARTMENT	AirLoop T SW DXAC Heat Pump
T NW APARTMENT	AirLoop T NW DXAC Heat Pump
T SE APARTMENT	AirLoop T SE DXAC Heat Pump
T NE APARTMENT	AirLoop T NE DXAC Heat Pump
T N1 APARTMENT	AirLoop T N1 DXAC Heat Pump
T N2 APARTMENT	AirLoop T N2 DXAC Heat Pump
T S1 APARTMENT	AirLoop T S1 DXAC Heat Pump
T S2 APARTMENT	AirLoop T S2 DXAC Heat Pump
T CORRIDOR	NA
G CORRIDOR	NA
M CORRIDOR	NA

(a) Note that the HVAC system names for middle floors correspond to their zone names, e.g., for the south-west apaprtment unit in the second floor (F2 SW Apartment), the HVAC system name is AirLoop F2 SW DXAC Heat Pump

Appendix E

Building Envelope Requirements

Appendix E

Building Envelope Requirements

E.1 Envelope Requirements – Roof

		90.1-2004						90.1-2010					
	Roofs	Non-Residential		Residential		Semiheated		Non-Residential		Residential		Semiheated	
Climate Zone	Opaque Elements	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value
1	Insulation Entirely above Deck	U-0.063	R-15.0 c.i.	U-0.063	R-15.0 c.i.	U-1.282	R-0	U-0.063	R-15.0 c.i.	U-0.048	R-20.0 c.i.	U-0.218	R-3.8 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-1.280	R-0	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
	Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	R-0	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
2	Insulation Entirely above Deck	U-0.063	R-15.0 c.i.	U-0.063	R-15.0 c.i.	U-0.218	R-3.8 c.i.	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.218	R-3.8 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.097	R-10.0
	Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0	U-0.027	R-38.0	U-0.027	R-38.0	U-0.081	R-13.0
3	Insulation Entirely above Deck	U-0.063	R-15.0 c.i.	U-0.063	R-15.0 c.i.	U-0.218	R-3.8 c.i.	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.173	R-5.0 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.097	R-10.0
	Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
4	Insulation Entirely above Deck	U-0.063	R-15.0 c.i.	U-0.063	R-15.0 c.i.	U-0.218	R-3.8 c.i.	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.173	R-5.0 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.097	R-10.0
	Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
5	Insulation Entirely above Deck	U-0.063	R-15.0 c.i.	U-0.063	R-15.0 c.i.	U-0.173	R-5.0 c.i.	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.083	R-13.0
	Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.053	R-19.0	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0

	Roofs	90.1-2004						90.1-2010					
		Non-Residential		Residential		Semiheated		Non-Residential		Residential		Semiheated	
6	Insulation Entirely above Deck	U-0.063	R-15.0 c.i.	U-0.063	R-15.0 c.i.	U-0.173	R-5.0 c.i.	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.093	R-10.0 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0	U-0.049	R-13.0 + R-19.0	U-0.049	R-13.0 + R-19.0	U-0.072	R-16.0
	Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0	U-0.027	R-38.0	U-0.027	R-38.0	U-0.034	R-30.0
7	Insulation Entirely above Deck	U-0.063	R-15.0 c.i.	U-0.063	R-15.0 c.i.	U-0.173	R-5.0 c.i.	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.093	R-10.0 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0	U-0.049	R-13.0 + R-19.0	U-0.049	R-13.0 + R-19.0	U-0.072	R-16.0
	Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0	U-0.027	R-38.0	U-0.027	R-38.0	U-0.034	R-30.0
8	Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.093	R-10.0 c.i.	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.063	R-15.0 c.i.
	Metal Building[(a)]	U-0.049	R-13.0 + R-19.0	U-0.049	R-13.0 + R-19.0	U-0.072	R-16.0	U-0.035	R-11.0 + R-19.0Ls	U-0.035	R-11.0 + R-19.0Ls	U-0.065	R-19.0
	Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.034	R-30.0	U-0.021	R-49.0	U-0.021	R-49.0	U-0.034	R-30.0

(a) Metal building roof Ls refers to liner system (see 90.1-2010 Section A.2.3.2.4)

E.2 Envelope Requirements – Walls Above Grade

Walls, Above-Grade		90.1-2004						90.1-2010					
		Non-Residential		Residential		Semiheated		Non-Residential		Residential		Semiheated	
Climate Zone	Opaque Elements	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value
1	Mass	U-0.580	R-0	U-0.151	R-5.7 ci	U-0.580	R-0	U-0.580	R-0	U-0.151	R-5.7 c.i.[a]	U-0.580	R-0
	Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	R-0	U-0.093	R-16.0	U-0.093	R-16.0	U-0.113	R-13.0
	Steel-Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	R-0	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	R-0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	R-0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	R-0
2	Mass	U-0.580	R-0	U-0.151	R-5.7 ci	U-0.580	R-0	U-0.151	R5.7 c.i.	U-0.123	R-7.6 c.i.	U-0.580	R-0
	Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0	U-0.093	R-16.0	U-0.093	R-16.0	U-0.113	R-13.0
	Steel-Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	R-0	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	R-0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0
3	Mass	U-0.151	R-5.7 ci	U-0.123	R-7.6 ci	U-0.580	R-0	U-0.123	R-7.6 c.i.	U-0.104	R-9.5 c.i.	U-0.580	R-0
	Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0	U-0.084	R-19.0	U-0.084	R-19.0	U-0.113	R-13.0
	Steel-Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	R-0	U-0.084	R-13.0 + R-3.8 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0
4	Mass	U-0.151	R-5.7 ci	U-0.104	R-9.5 ci	U-0.580	R-0	U-0.104	R-9.5 c.i.	U-0.090	R-11.4 c.i.	U-0.580	R-0
	Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0	U-0.084	R-19.0	U-0.084	R-19.0	U-0.113	R-13.0
	Steel-Framed	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.064	R-13.0 + R-3.8 c.i.	U-0.089	R-13.0
5	Mass	U-0.123	R-7.6 ci	U-0.090	R-11.4 ci	U-0.580	R-0	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151	R-5.7 c.i.
	Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0	U-0.069	R-13.0 + R-5.6 c.i.	U-0.069	R-13.0 + R-5.6 c.i.	U-0.113	R-13.0
	Steel-Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0

Walls, Above-Grade		90.1-2004						90.1-2010					
		Non-Residential		Residential		Semiheated		Non-Residential		Residential		Semiheated	
Climate Zone	Opaque Elements	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value
6	Mass	U-0.104	R-9.5 ci	U-0.090	R-11.4 ci	U-0.580	R-0	U-0.080	R-13.3 c.i.	U-0.071	R-15.2 c.i.	U-0.151	R-5.7 c.i.
	Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0	U-0.069	R-13.0 + R-5.6 c.i.	U-0.069	R-13.0 + R-5.6 c.i.	U-0.113	R-13.0
	Steel-Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.064	R-13.0 + R-3.8 ci	U-0.089	R-13.0	U-0.051	R-13.0 + R-7.5 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
7	Mass	U-0.090	R-11.4 ci	U-0.080	R-13.3 ci	U-0.580	R-0	U-0.071	R-15.2 c.i.	U-0.071	R-15.2 c.i.	U-0.123	R-7.6 c.i.
	Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0	U-0.057	R-19.0 + R-5.6 c.i.	U-0.057	R-19.0 + R-5.6 c.i.	U-0.113	R-13.0
	Steel-Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.042	R-13.0 + R-15.6 c.i.	U-0.124	R-13.0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0	U-0.051	R-13.0 + R-7.5 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
8	Mass	U-0.080	R-13.3 ci	U-0.071	R-15.2 ci	U-0.151	R-5.7 ci	U-0.071	R-15.2 c.i.	U-0.052	R-25.0 c.i.	U-0.104	R-9.5 c.i.
	Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0	U-0.057	R-19.0 + R-5.6 c.i.	U-0.057	R-19.0 + R-5.6 c.i.	U-0.113	R-13.0
	Steel-Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.037	R-13.0 + R-18.8 c.i.	U-0.084	R-13.0 + R-3.8 c.i.
	Wood-Framed and Other	U-0.051	R-13.0 + R-7.5 ci	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0	U-0.036	R-13.0 + R-15.6 c.i.	U-0.036	R-13.0 + R-15.6 c.i.	U-0.089	R-13.0

E.3 Envelope Requirements – Walls Below Grade

Walls, Below-Grade		90.1-2004 Non-Residential		90.1-2004 Residential		90.1-2004 Semiheated		90.1-2010 Non-Residential		90.1-2010 Residential		90.1-2010 Semiheated	
Climate Zone	Opaque Elements	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value
1	Below-Grade Walls	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0
2	Below-Grade Walls	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0
3	Below-Grade Walls	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0
4	Below-Grade Walls	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-0.119	R-7.5 c.i.	C-1.140	R-0
5	Below-Grade Walls	C-1.140	R-0	C-1.140	R-0	C-1.140	R-0	C-0.119	R-7.5 c.i.	C-0.119	R-7.5 c.i.	C-1.140	R-0
6	Below-Grade Walls	C-1.140	R-0	C-0.119	R-7.5 ci	C-1.140	R-0	C-0.119	R-7.5 c.i.	C-0.119	R-7.5 c.i.	C-1.140	R-0
7	Below-Grade Walls	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	R-0	C-0.119	R-7.5 c.i.	C-0.092	R-10.0 c.i.	C-1.140	R-0
8	Below-Grade Walls	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	R-0	C-0.119	R-7.5 c.i.	C-0.075	R-12.5 c.i.	C-1.140	R-0

E.4 Envelope Requirements – Floors

		90.1-2004						90.1-2010					
Floors		Non-Residential		Residential		Semiheated		Non-Residential		Residential		Semiheated	
Climate Zone	Opaque Elements	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value
1	Mass	U-0.322	R-0	U-0.322	R-0	U-0.322	R-0	U-0.322	R-0	U-0.322	R-0	U-0.322	R-0
	Steel-Joist	U-0.350	R-0	U-0.350	R-0	U-0.350	R-0	U-0.350	R-0	U-0.350	R-0	U-0.350	R-0
	Wood-Framed and Other	U-0.282	R-0	U-0.282	R-0	U-0.282	R-0	U-0.282	R-0	U-0.282	R-0	U-0.282	R-0
2	Mass	U-0.137	R-4.2 ci	U-0.107	R-6.3 ci	U-0.322	R-0	U-0.107	R-6.3 c.i.	U-0.087	R-8.3 c.i.	U-0.322	R-0
	Steel-Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.350	R-0	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
	Wood-Framed and Other	U-0.051	R-19.0	U-0.051	R-19.0	U-0.282	R-0	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
3	Mass	U-0.107	R-6.3 ci	U-0.087	R-8.3 ci		R-0	U-0.107	R-6.3 c.i.	U-0.087	R-8.3 c.i.	U-0.322	R-0
	Steel-Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
	Wood-Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.282	R-0	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
4	Mass	U-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	R-0	U-0.087	R-8.3 c.i.	U-0.074	R-10.4 c.i.	U-0.137	R-4.2 c.i.
	Steel-Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0	U-0.038	R-30.0	U-0.038	R-30.0	U-0.069	R-13.0
	Wood-Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
5	Mass	U-0.087	R-8.3 ci	U-0.074	R-10.4 ci	U-0.322	R-0	U-0.074	R-10.4 c.i.	U-0.064	R-12.5 c.i.	U-0.137	R-4.2 c.i.
	Steel-Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0
	Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
6	Mass	U-0.087	R-8.3 ci	U-0.064	R-12.5 ci	U-0.322	R-0	U-0.064	R-12.5 c.i.	U-0.057	R-14.6 c.i.	U-0.137	R-4.2 c.i.
	Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.069	R-13.0	U-0.038	R-30.0	U-0.032	R-38.0	U-0.052	R-19.0
	Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-.0066	R-13.0	U-0.033	R-30.0	U-0.033	R-30.0	U-.0051	R-19.0
7	Mass	U-0.087	R-8.3 ci	U-0.064	R-12.5 ci	U-0.137	R-4.2 ci	U-0.064	R-12.5 c.i.	U-0.051	R-16.7 c.i.	U-0.107	R-6.3 c.i.
	Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0	U-0.038	R-30.0	U-0.032	R-38.0	U-0.052	R-19.0
	Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
8	Mass	U-0.064	R-12.5 ci	U-0.057	R-14.6 ci	U-0.137	R-4.2 ci	U-0.057	R-14.6 c.i.	U-0.051	R-16.7 c.i.	U-0.087	R-8.3 c.i.
	Steel-Joist	U-0.038	R-30.0	U-0.032	R-38.0	U-0.052	R-19.0	U-0.032	R-38.0	U-0.032	R-38.0	U-0.052	R-19.0
	Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0	U-0.033	R-30.0	U-0.033	R-30.0	U-0.033	R-30.0

E.5 Envelope Requirements – Slab-On-Grade Floors

Floors, Slab-On-Grade		90.1-2004						90.1-2010					
		Non-Residential		Residential		Semiheated		Non-Residential		Residential		Semiheated	
Climate Zone	Opaque Elements	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value
1	Unheated	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0
	Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
2	Unheated	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0
	Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
3	Unheated	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0
	Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-0.900	R-10 for 24 in.	F-0.900	R-10 for 24 in.	F-1.020	R-7.5 for 12 in.
4	Unheated	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.540	R-10 for 24 in.	F-0.730	R-0
	Heated	F-0.950	R-7.5 for 24 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24in.	F-1.020	R-7.5 for 12 in.
5	Unheated	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.540	R-10 for 24 in.	F-0.730	R-0
	Heated	F-0.840	R-10 for 36 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24 in.	F-1.020	R-7.5 for 12 in.
6	Unheated	F-0.730	R-0	F-0.730	R-0	F-0.730	R-0	F-0.540	R-10 for 24 in.	F-0.520	R-15 for 24 in.	F-0.730	R-0
	Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.	F-0.860	R-15 for 24 in.	F-0.688	R-20 for 48 in.	F-1.020	R-7.5 for 12 in.
7	Unheated	F-0.730	R-0	F-0.540	R-10 for 24 in.	F-0.730	R-0	F-0.520	R-15 for 24 in.	F-0.520	R-15 for 24 in.	F-0.730	R-0
	Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.	F-0.843	R-20 for 24in.	F-0.688	R-20 for 48 in.	F-0.900	R-10 for 24 in.
8	Unheated	F-0.540	R-10 for 24 in.	F-0.520	R-15 for 24 in.	F-0.730	R-0	F-0.520	R-15 for 24 in.	F-0.510	R-20 for 24 in.	F-0.730	R-0
	Heated	F-0.780	R-10 for 48 in.	F-0.780	R-10 for 48 in.	F-0.950	R-7.5 for 24 in.	F-0.688	R-20 for 48 in.	F-0.688	R-20 for 48 in.	F-0.900	R-10.0 for 24 in.

E.6 Envelope Requirements – Doors

		90.1-2004						90.1-2010					
Opaque Doors		Non-Residential		Residential		Semiheated		Non-Residential		Residential		Semiheated	
Climate Zone	Opaque Elements	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value	U-Value	R-Value
1	Swinging	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429
	Non-Swinging	U-1.450	R-0.69	U-1.450	R-0.69	U-1.450	R-0.69	U-1.450	R-0.69	U-1.450	R-0.69	U-1.450	R-0.69
2	Swinging	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429
	Non-Swinging	U-1.450	R-0.69	U-1.450	R-0.69	U-1.450	R-0.69	U-1.450	R-0.69	U-0.500	R-2	U-1.450	R-0.69
3	Swinging	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429
	Non-Swinging	U-1.450	R-0.69	U-0.500	R-2	U-1.450	R-0.69	U-1.450	R-0.69	U-0.500	R-2	U-1.450	R-0.69
4	Swinging	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429
	Non-Swinging	U-1.450	R-0.69	U-0.500	R-2	U-1.450	R-0.69	U-1.500	R-0.667	U-0.500	R-2	U-1.450	R-0.69
5	Swinging	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.700	R-1.429	U-0.500	R-2	U-0.700	R-1.429
	Non-Swinging	U-1.450	R-0.69	U-0.500	R-2	U-1.450	R-0.69	U-0.500	R-2	U-0.500	R-2	U-1.450	R-0.69
6	Swinging	U-0.700	R-1.429	U-0.500	R-2	U-0.700	R-1.429	U-0.700	R-1.429	U-0.500	R-2	U-0.700	R-1.429
	Non-Swinging	U-0.500	R-2	U-0.500	R-2	U-1.450	R-0.69	U-0.500	R-2	U-0.500	R-2	U-1.450	R-0.69
7	Swinging	U-0.700	R-1.429	U-0.500	R-2	U-0.700	R-1.429	U-0.500	R-2	U-0.500	R-2	U-0.700	R-1.429
	Non-Swinging	U-0.500	R-2	U-0.500	R-2	U-1.450	R-0.69	U-0.500	R-2	U-0.500	R-2	U-1.450	R-0.69
8	Swinging	U-0.500	R-2	U-0.500	R-2	U-0.700	R-1.429	U-0.500	R-2	U-0.500	R-2	U-0.700	R-1.429
	Non-Swinging	U-0.500	R-2	U-0.500	R-2	U-1.450	R-0.69	U-0.500	R-2	U-0.500	R-2	U-0.500	R-2

E.7 Envelope Requirements – 90.1-2004 Vertical Glazing[(a)]

Vertical Glazing		Non-Residential				Residential				Semiheated			
ASHRAE Zone	WWR (%)	U-Value Fixed	U-Value Opererable	SHGC (all)	SHGC (North)	U-Value Fixed	U-Value Opererable	SHGC (all)	SHGC (North)	U-Value Fixed	U-Value Opererable	SHGC (all)	SHGC (North)
1	10	1.22	1.27	0.25	0.61	1.22	1.27	0.25	0.61	1.22	1.27	NR	NR
	20	1.22	1.27	0.25	0.61	1.22	1.27	0.25	0.61	1.22	1.27	NR	NR
	30	1.22	1.27	0.25	0.61	1.22	1.27	0.25	0.61	1.22	1.27	NR	NR
	40	1.22	1.27	0.25	0.44	1.22	1.27	0.25	0.44	1.22	1.27	NR	NR
	50	1.22	1.27	0.19	0.33	1.22	1.27	0.19	0.33	0.98	1.02	NR	NR
2	10	1.22	1.27	0.25	0.61	1.22	1.27	0.39	0.61	1.22	1.27	NR	NR
	20	1.22	1.27	0.25	0.61	1.22	1.27	0.25	0.61	1.22	1.27	NR	NR
	30	1.22	1.27	0.25	0.61	1.22	1.27	0.25	0.61	1.22	1.27	NR	NR
	40	1.22	1.27	0.25	0.61	1.22	1.27	0.25	0.61	1.22	1.27	NR	NR
	50	1.22	1.27	0.17	0.44	1.22	1.27	0.17	0.43	0.98	1.02	NR	NR
3	10	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	20	0.57	0.67	0.25	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	30	0.57	0.67	0.25	0.39	0.57	0.67	0.25	0.39	1.22	1.27	NR	NR
	40	0.57	0.67	0.25	0.39	0.57	0.67	0.25	0.39	1.22	1.27	NR	NR
	50	0.46	0.47	0.19	0.26	0.46	0.47	0.19	0.26	0.98	1.02	NR	NR
3C	10	1.22	1.27	0.61	0.82	1.22	1.27	0.61	0.82	1.22	1.27	NR	NR
	20	1.22	1.27	0.39	0.61	1.22	1.27	0.61	0.61	1.22	1.27	NR	NR
	30	1.22	1.27	0.39	0.61	1.22	1.27	0.39	0.61	1.22	1.27	NR	NR
	40	1.22	1.27	0.34	0.61	1.22	1.27	0.34	0.61	1.22	1.27	NR	NR
	50	1.22	1.27	0.2	0.3	0.73	0.81	0.25	0.61	0.98	1.02	NR	NR
4	10	0.57	0.67	0.39	0.49	0.57	0.61	0.39	0.49	1.22	1.27	NR	NR
	20	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	30	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	40	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	50	0.46	0.47	0.25	0.36	0.46	0.47	0.25	0.36	0.98	1.02	NR	NR
5	10	0.57	0.67	0.49	0.49	0.57	0.67	0.49	0.49	1.22	1.27	NR	NR
	20	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	30	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	40	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	50	0.46	0.47	0.26	0.36	0.46	0.47	0.26	0.49	0.98	1.02	NR	NR

Vertical Glazing		Non-Residential				Residential				Semiheated			
ASHRAE Zone	WWR (%)	U-Value Fixed	U-Value Opererable	SHGC (all)	SHGC (North)	U-Value Fixed	U-Value Opererable	SHGC (all)	SHGC (North)	U-Value Fixed	U-Value Opererable	SHGC (all)	SHGC (North)
6	10	0.57	0.67	0.49	0.49	0.57	0.67	0.49	0.64	1.22	1.27	NR	NR
	20	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	30	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	40	0.57	0.67	0.39	0.49	0.57	0.67	0.39	0.49	1.22	1.27	NR	NR
	50	0.46	0.47	0.26	0.49	0.46	0.47	0.26	0.49	0.98	1.02	NR	NR
7	10	0.57	0.67	0.49	0.64	0.57	0.67	0.49	0.64	1.22	1.27	NR	NR
	20	0.57	0.67	0.49	0.64	0.57	0.67	0.49	0.64	1.22	1.27	NR	NR
	30	0.57	0.67	0.49	0.64	0.57	0.67	0.49	0.64	1.22	1.27	NR	NR
	40	0.57	0.67	0.49	0.64	0.57	0.67	0.49	0.64	1.22	1.27	NR	NR
	50	0.46	0.47	0.36	0.64	0.46	0.47	0.36	0.64	0.98	1.02	NR	NR
8	10	0.46	0.47	NR	NR	0.46	0.47	NR	NR	1.22	1.27	NR	NR
	20	0.46	0.47	NR	NR	0.46	0.47	NR	NR	1.22	1.27	NR	NR
	30	0.46	0.47	NR	NR	0.46	0.47	NR	NR	1.22	1.27	NR	NR
	40	0.46	0.47	NR	NR	0.46	0.47	NR	NR	1.22	1.27	NR	NR
	50	0.35	0.39	NR	NR	0.35	0.39	NR	NR	0.98	1.02	NR	NR

(a) 90.1-2004 shown separately from 90.1-2010 because of space constraints on page due to different vertical glazing categories

E.8 Envelope Requirements – 90.1-2010 Vertical Glazing[(a)]

Vertical Glazing		Non-Residential		Residential		Semiheated	
ASHRAE Zone	Frame Type	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)
1	Non-Metal Framing	1.20	0.25	1.20	0.25	1.20	NR
	Metal Framing (Curtainwall)	1.20	0.25	1.20	0.25	1.20	NR
	Metal Framing (Entrance)	1.20	0.25	1.20	0.25	1.20	NR
	Metal Framing (All Other)	1.20	0.25	1.20	0.25	1.20	NR
2	Non-Metal Framing	0.75	0.25	0.75	0.25	1.20	NR
	Metal Framing (Curtainwall)	0.70	0.25	0.70	0.25	1.20	NR
	Metal Framing (Entrance)	1.10	0.25	1.10	0.25	1.20	NR
	Metal Framing (All Other)	0.75	0.25	0.75	0.25	1.20	NR
3	Non-Metal Framing	0.65	0.25	0.65	0.25	1.20	NR
	Metal Framing (Curtainwall)	0.60	0.25	0.60	0.25	1.20	NR
	Metal Framing (Entrance)	0.90	0.25	0.90	0.25	1.20	NR
	Metal Framing (All Other)	0.65	0.25	0.65	0.25	1.20	NR
4	Non-Metal Framing	0.40	0.40	0.40	0.40	1.20	NR
	Metal Framing (Curtainwall)	0.50	0.40	0.50	0.40	1.20	NR
	Metal Framing (Entrance)	0.85	0.40	0.85	0.40	1.20	NR
	Metal Framing (All Other)	0.55	0.40	0.55	0.40	1.20	NR
5	Non-Metal Framing	0.35	0.40	0.35	0.40	1.20	NR
	Metal Framing (Curtainwall)	0.45	0.40	0.45	0.40	1.20	NR
	Metal Framing (Entrance)	0.80	0.40	0.80	0.40	1.20	NR
	Metal Framing (All Other)	0.55	0.40	0.55	0.40	1.20	NR
6	Non-Metal Framing	0.35	0.40	0.35	0.40	0.65	NR
	Metal Framing (Curtainwall)	0.45	0.40	0.45	0.40	0.60	NR
	Metal Framing (Entrance)	0.80	0.40	0.80	0.40	0.90	NR
	Metal Framing (All Other)	0.55	0.40	0.55	0.40	0.65	NR
7	Non-Metal Framing	0.35	0.45	0.35	NR	0.65	NR
	Metal Framing (Curtainwall)	0.40	0.45	0.40	NR	0.60	NR
	Metal Framing (Entrance)	0.80	0.45	0.80	NR	0.90	NR
	Metal Framing (All Other)	0.45	0.45	0.45	NR	0.65	NR
8	Non-Metal Framing	0.35	0.45	0.35	NR	0.65	NR
	Metal Framing (Curtainwall)	0.40	0.45	0.40	NR	0.60	NR
	Metal Framing (Entrance)	0.80	0.45	0.80	NR	0.90	NR
	Metal Framing (All Other)	0.45	0.45	0.45	NR	0.65	NR

(a) 90.1-2004 shown separately from 90.1-2010 because of space constraints on page due to different vertical glazing categories

E.9 Envelope Requirements –Skylights

		90.1-2004						90.1-2010					
Skylights		Non-Residential		Residental		Semi-Heated		Non-Residential		Residental		Semi-Heated	
Climate Zone	Type and % of Roof Area	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)
1	Glass with curb 0%-2%	1.98	0.36	1.98	0.19	1.98	NR	1.98	0.36	1.98	0.19	1.98	NR
	Glass with curb 2.1%-5%	1.98	0.19	1.98	0.16	1.98	NR	1.98	0.19	1.98	0.16	1.98	NR
	Plastic with curb 0%-2%	1.90	0.34	1.90	0.27	1.90	NR	1.90	0.34	1.90	0.27	1.90	NR
	Plastic with curb 2.1%-5%	1.90	0.27	1.90	0.27	1.90	NR	1.90	0.27	1.90	0.27	1.90	NR
	All without curb 0%-2%	1.36	0.36	1.36	0.19	1.36	NR	1.36	0.36	1.36	0.19	1.36	NR
	All without curb 2.1%-5%	1.36	0.19	1.36	0.19	1.36	NR	1.36	0.19	1.36	0.19	1.36	NR
2	Glass with curb 0%-2%	1.98	0.36	1.98	0.19	1.98	NR	1.98	0.36	1.98	0.19	1.98	NR
	Glass with curb 2.1%-5%	1.98	0.19	1.98	0.19	1.98	NR	1.98	0.19	1.98	0.19	1.98	NR
	Plastic with curb 0%-2%	1.90	0.39	1.90	0.27	1.90	NR	1.90	0.39	1.90	0.27	1.90	NR
	Plastic with curb 2.1%-5%	1.90	0.34	1.90	0.27	1.90	NR	1.90	0.34	1.90	0.27	1.90	NR
	All without curb 0%-2%	1.36	0.36	1.36	0.19	1.36	NR	1.36	0.36	1.36	0.19	1.36	NR
	All without curb 2.1%-5%	1.36	0.19	1.36	0.19	1.36	NR	1.36	0.19	1.36	0.19	1.36	NR
3	Glass with curb 0%-2%	1.17	0.39	1.17	0.36	1.98	NR	1.17	0.39	1.17	0.36	1.98	NR
	Glass with curb 2.1%-5%	1.17	0.19	1.17	0.19	1.98	NR	1.17	0.19	1.17	0.19	1.98	NR
	Plastic with curb 0%-2%	1.30	0.65	1.30	0.27	1.90	NR	1.30	0.65	1.30	0.27	1.90	NR
	Plastic with curb 2.1%-5%	1.30	0.34	1.30	0.27	1.90	NR	1.30	0.34	1.30	0.27	1.90	NR
	All without curb 0%-2%	0.69	0.39	0.69	0.36	1.36	NR	0.69	0.39	0.69	0.36	1.36	NR
	All without curb 2.1%-5%	0.69	0.19	0.69	0.19	1.36	NR	0.69	0.19	0.69	0.19	1.36	NR
3C	Glass with curb 0%-2%	1.98	0.61	1.98	0.39	1.98	NR	1.17	0.39	1.17	0.36	1.98	NR
	Glass with curb 2.1%-5%	1.98	0.39	1.98	0.19	1.98	NR	1.17	0.19	1.17	0.19	1.98	NR
	Plastic with curb 0%-2%	1.90	0.65	1.90	0.65	1.90	NR	1.30	0.65	1.30	0.27	1.90	NR
	Plastic with curb 2.1%-5%	1.90	0.39	1.90	0.34	1.90	NR	1.30	0.34	1.30	0.27	1.90	NR
	All without curb 0%-2%	1.36	0.61	1.36	0.39	1.36	NR	0.69	0.39	0.69	0.36	1.36	NR
	All without curb 2.1%-5%	1.36	0.39	1.36	0.19	1.36	NR	0.69	0.19	0.69	0.19	1.36	NR
4	Glass with curb 0%-2%	1.17	0.49	0.98	0.36	1.98	NR	1.17	0.49	0.98	0.36	1.98	NR
	Glass with curb 2.1%-5%	1.17	0.39	0.98	0.19	1.98	NR	1.17	0.39	0.98	0.19	1.98	NR
	Plastic with curb 0%-2%	1.30	0.65	1.30	0.62	1.90	NR	1.30	0.65	1.30	0.62	1.90	NR
	Plastic with curb 2.1%-5%	1.30	0.34	1.30	0.27	1.90	NR	1.30	0.34	1.30	0.27	1.90	NR
	All without curb 0%-2%	0.69	0.49	0.58	0.36	1.36	NR	0.69	0.49	0.58	0.36	1.36	NR
	All without curb 2.1%-5%	0.69	0.39	0.58	0.19	1.36	NR	0.69	0.39	0.58	0.19	1.36	NR

	Skylights	90.1-2004						90.1-2010					
		Non-Residential		Residental		Semi-Heated		Non-Residential		Residental		Semi-Heated	
Climate Zone	Type and % of Roof Area	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)	U-Value	SHGC (all)
5	Glass with curb 0%-2%	1.17	0.49	1.17	0.49	1.98	NR	1.17	0.49	1.17	0.49	1.98	NR
	Glass with curb 2.1%-5%	1.17	0.39	1.17	0.39	1.98	NR	1.17	0.39	1.17	0.39	1.98	NR
	Plastic with curb 0%-2%	1.10	0.77	1.10	0.77	1.90	NR	1.10	0.77	1.10	0.77	1.90	NR
	Plastic with curb 2.1%-5%	1.10	0.62	1.10	0.62	1.90	NR	1.10	0.62	1.10	0.62	1.90	NR
	All without curb 0%-2%	0.69	0.49	0.69	0.49	1.36	NR	0.69	0.49	0.69	0.49	1.36	NR
	All without curb 2.1%-5%	0.69	0.39	0.69	0.39	1.36	NR	0.69	0.39	0.69	0.39	1.36	NR
6	Glass with curb 0%-2%	1.17	0.49	0.98	0.46	1.98	NR	1.17	0.49	0.98	0.46	1.98	NR
	Glass with curb 2.1%-5%	1.17	0.49	0.98	0.36	1.98	NR	1.17	0.49	0.98	0.36	1.98	NR
	Plastic with curb 0%-2%	0.87	0.71	0.74	0.65	1.90	NR	0.87	0.71	0.74	0.65	1.90	NR
	Plastic with curb 2.1%-5%	0.87	0.58	0.74	0.55	1.90	NR	0.87	0.58	0.74	0.55	1.90	NR
	All without curb 0%-2%	0.69	0.49	0.58	0.49	1.36	NR	0.69	0.49	0.58	0.49	1.36	NR
	All without curb 2.1%-5%	0.69	0.49	0.58	0.39	1.36	NR	0.69	0.49	0.58	0.39	1.36	NR
7	Glass with curb 0%-2%	1.17	0.68	1.17	0.64	1.98	NR	1.17	0.68	1.17	0.64	1.98	NR
	Glass with curb 2.1%-5%	1.17	0.64	1.17	0.64	1.98	NR	1.17	0.64	1.17	0.64	1.98	NR
	Plastic with curb 0%-2%	0.87	0.77	0.61	0.77	1.90	NR	0.87	0.77	0.61	0.77	1.90	NR
	Plastic with curb 2.1%-5%	0.87	0.71	0.61	0.77	1.90	NR	0.87	0.71	0.61	0.77	1.90	NR
	All without curb 0%-2%	0.69	0.68	0.69	0.64	1.36	NR	0.69	0.68	0.69	0.64	1.36	NR
	All without curb 2.1%-5%	0.69	0.64	0.69	0.64	1.36	NR	0.69	0.64	0.69	0.64	1.36	NR
8	Glass with curb 0%-2%	0.98	NR	0.98	NR	1.30	NR	0.98	NR	0.98	NR	1.30	NR
	Glass with curb 2.1%-5%	0.98	NR	0.98	NR	1.30	NR	0.98	NR	0.98	NR	1.30	NR
	Plastic with curb 0%-2%	0.61	NR	0.61	NR	1.10	NR	0.61	NR	0.61	NR	1.10	NR
	Plastic with curb 2.1%-5%	0.61	NR	0.61	NR	1.10	NR	0.61	NR	0.61	NR	1.10	NR
	All without curb 0%-2%	0.58	NR	0.58	NR	0.81	NR	0.58	NR	0.58	NR	0.81	NR
	All without curb 2.1%-5%	0.58	NR	0.58	NR	0.81	NR	0.58	NR	0.58	NR	0.81	NR

Appendix F

90.1-2010 Energy Savings Results by End-Uses

F.1 Small Office Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	0	53	67	24	50	0	24	0	0	0	0	9	0	227	41.2	20%	26%
	90.1-2010	0	39	57	9	46	0	22	0	0	0	0	9	0	182	33.0		
1B Riyadh	90.1-2004	1	57	67	24	50	0	30	0	0	0	0	8	0	238	43.3	19%	25%
	90.1-2010	1	43	57	9	46	0	27	0	0	0	0	8	0	192	34.8		
2A Houston	90.1-2004	7	40	67	24	50	0	24	0	0	0	0	9	0	222	40.4	19%	25%
	90.1-2010	6	29	57	9	46	0	22	0	0	0	0	9	0	179	32.5		
2B Phoenix	90.1-2004	4	47	67	24	50	0	29	0	0	0	0	9	0	230	41.9	20%	25%
	90.1-2010	4	35	57	9	46	0	26	0	0	0	0	9	0	185	33.7		
3A Memphis	90.1-2004	13	30	67	24	50	0	23	0	0	0	0	10	0	218	39.5	19%	25%
	90.1-2010	12	22	56	9	46	0	20	0	0	0	0	10	0	176	32.0		
3B El Paso	90.1-2004	9	30	67	24	50	0	26	0	0	0	0	10	0	217	39.4	19%	25%
	90.1-2010	9	22	56	9	46	0	23	0	0	0	0	10	0	176	31.9		
3C San Francisco	90.1-2004	8	12	67	24	50	0	21	0	0	0	0	10	0	194	35.2	20%	27%
	90.1-2010	7	8	56	9	46	0	17	0	0	0	0	10	0	155	28.2		
4A Baltimore	90.1-2004	29	21	67	24	50	0	23	0	0	0	0	10	0	225	40.9	20%	26%
	90.1-2010	21	16	56	9	46	0	20	0	0	0	0	10	0	179	32.6		
4B Albuquerque	90.1-2004	19	23	67	24	50	0	27	0	0	0	0	10	0	221	40.2	19%	25%
	90.1-2010	16	18	56	9	46	0	24	0	0	0	0	10	0	179	32.5		
4C Salem	90.1-2004	22	12	67	24	50	0	22	0	0	0	0	11	0	208	37.9	19%	24%
	90.1-2010	19	9	56	9	46	0	20	0	0	0	0	11	0	170	30.8		
5A Chicago	90.1-2004	50	18	67	24	50	0	24	0	0	0	0	11	0	244	44.4	23%	29%
	90.1-2010	32	13	56	9	46	0	20	0	0	0	0	11	0	187	34.1		
5B Boise	90.1-2004	32	15	67	24	50	0	26	0	0	0	0	11	0	226	41.0	20%	26%
	90.1-2010	24	12	56	9	46	0	22	0	0	0	0	11	0	180	32.7		
5C Vancouver	90.1-2004	25	9	67	24	50	0	21	0	0	0	0	11	0	206	37.5	19%	25%
	90.1-2010	20	7	56	9	46	0	18	0	0	0	0	11	0	168	30.5		
6A Burlington	90.1-2004	69	13	67	24	50	0	23	0	0	0	0	11	0	258	47.0	25%	31%
	90.1-2010	42	10	56	9	46	0	20	0	0	0	0	11	0	194	35.2		
6B Helena	90.1-2004	60	12	67	24	50	0	26	0	0	0	0	11	0	251	45.6	23%	29%
	90.1-2010	39	9	56	9	46	0	22	0	0	0	0	11	0	192	35.0		
7 Duluth	90.1-2004	109	10	67	24	50	0	27	0	0	0	0	12	0	299	54.4	28%	34%
	90.1-2010	64	7	56	9	46	0	20	0	0	0	0	12	0	214	39.0		
8 Fairbanks	90.1-2004	178	7	67	24	50	0	30	0	0	0	0	12	0	368	66.9	28%	33%
	90.1-2010	113	5	56	9	46	0	22	0	0	0	0	12	0	264	48.0		

F.2 Medium Office Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	19	929	525	215	805	0	131	0	0	0	0	117	0	2,740	51.1	24%	34%
	90.1-2010	8	691	368	77	723	0	96	0	0	0	0	117	0	2,080	38.8		
1B Riyadh	90.1-2004	58	935	525	214	805	0	225	0	0	0	0	103	0	2,865	53.4	24%	34%
	90.1-2010	21	729	371	77	723	0	144	0	0	0	0	103	0	2,169	40.4		
2A Houston	90.1-2004	227	736	525	214	805	0	118	0	0	0	0	147	0	2,772	51.7	26%	37%
	90.1-2010	114	527	372	77	723	0	83	0	0	0	0	147	0	2,043	38.1		
2B Phoenix	90.1-2004	142	769	525	214	805	0	166	0	0	0	0	129	0	2,750	51.3	25%	35%
	90.1-2010	57	586	375	77	723	0	116	0	0	0	0	129	0	2,062	38.5		
3A Memphis	90.1-2004	326	541	525	214	805	0	108	0	0	0	0	171	0	2,690	50.2	28%	40%
	90.1-2010	149	377	363	77	723	0	74	0	0	0	0	171	0	1,934	36.1		
3B El Paso	90.1-2004	139	472	525	215	805	0	131	0	0	0	0	163	0	2,448	45.7	25%	38%
	90.1-2010	64	343	363	77	723	0	95	0	0	0	0	163	0	1,828	34.1		
3C San Francisco	90.1-2004	236	223	525	214	805	0	90	0	0	0	0	197	0	2,290	42.7	32%	49%
	90.1-2010	55	91	365	77	723	0	60	0	0	0	0	197	0	1,568	29.2		
4A Baltimore	90.1-2004	567	392	525	214	805	0	107	0	0	0	0	200	0	2,810	52.4	30%	42%
	90.1-2010	283	262	358	77	723	0	74	0	0	0	0	200	0	1,977	36.9		
4B Albuquerque	90.1-2004	282	354	525	214	805	0	132	0	0	0	0	195	0	2,507	46.7	27%	40%
	90.1-2010	128	252	357	77	723	0	101	0	0	0	0	195	0	1,833	34.2		
4C Salem	90.1-2004	474	214	525	214	805	0	94	0	0	0	0	212	0	2,538	47.3	30%	44%
	90.1-2010	206	134	360	78	723	0	68	0	0	0	0	212	0	1,780	33.2		
5A Chicago	90.1-2004	826	296	525	214	805	0	104	0	0	0	0	220	0	2,990	55.8	28%	38%
	90.1-2010	482	220	359	78	723	0	72	0	0	0	0	220	0	2,155	40.2		
5B Boise	90.1-2004	570	244	525	214	805	0	113	0	0	0	0	217	0	2,687	50.1	28%	40%
	90.1-2010	306	170	360	77	723	0	83	0	0	0	0	217	0	1,935	36.1		
5C Vancouver	90.1-2004	545	153	525	214	805	0	89	0	0	0	0	221	0	2,551	47.6	29%	43%
	90.1-2010	267	78	370	78	723	0	67	0	0	0	0	221	0	1,802	33.6		
6A Burlington	90.1-2004	1,061	226	525	214	805	0	100	0	0	0	0	238	0	3,169	59.1	28%	37%
	90.1-2010	664	159	359	78	723	0	70	0	0	0	0	238	0	2,292	42.7		
6B Helena	90.1-2004	844	187	525	214	805	0	108	0	0	0	0	241	0	2,923	54.5	27%	38%
	90.1-2010	520	121	360	77	723	0	79	0	0	0	0	241	0	2,121	39.6		
7 Duluth	90.1-2004	1,394	161	525	214	805	0	110	0	0	0	0	267	0	3,475	64.8	27%	35%
	90.1-2010	939	96	360	78	723	0	69	0	0	0	0	267	0	2,532	47.2		
8 Fairbanks	90.1-2004	2,234	104	525	213	805	0	110	0	0	0	0	302	0	4,292	80.0	21%	26%
	90.1-2010	1,787	52	375	80	723	0	70	0	0	0	0	302	0	3,389	63.2		

F.3 Large Office Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	156	4,916	4,877	937	5,931	1,855	1,145	1,374	2,928	0	0	199	0	24,318	48.8	26%	34%
	90.1-2010	60	3,495	3,646	516	5,223	1,806	953	789	1,356	0	19	199	0	18,062	36.2		
1B Riyadh	90.1-2004	532	4,107	4,877	936	5,931	1,855	1,436	1,813	1,189	0	0	176	0	22,853	45.8	22%	30%
	90.1-2010	180	3,266	3,655	516	5,223	1,806	1,242	1,184	445	0	19	176	0	17,711	35.5		
2A Houston	90.1-2004	2,430	3,779	4,877	935	5,931	1,855	1,032	1,222	2,145	0	0	251	0	24,456	49.1	30%	39%
	90.1-2010	762	2,558	3,672	515	5,223	1,806	808	685	919	0	15	251	0	17,215	34.5		
2B Phoenix	90.1-2004	1,395	3,354	4,877	935	5,931	1,855	1,290	1,723	1,629	0	0	220	0	23,208	46.5	27%	37%
	90.1-2010	314	2,427	3,683	515	5,223	1,806	1,060	947	655	0	0	220	0	16,850	33.8		
3A Memphis	90.1-2004	2,588	2,662	4,877	936	5,931	1,855	934	1,061	1,452	0	0	292	0	22,587	45.3	27%	37%
	90.1-2010	1,067	1,873	3,621	517	5,223	1,806	733	661	654	0	15	292	0	16,464	33.0		
3B El Paso	90.1-2004	972	1,912	4,877	936	5,931	1,855	1,181	712	647	0	0	278	0	19,301	38.7	22%	31%
	90.1-2010	394	1,604	3,615	516	5,223	1,806	998	417	278	0	0	278	0	15,129	30.3		
3C San Francisco	90.1-2004	1,685	803	4,877	935	5,931	1,855	811	790	73	0	0	336	0	18,095	36.3	26%	39%
	90.1-2010	275	515	3,630	516	5,223	1,806	644	387	25	0	0	336	0	13,357	26.8		
4A Baltimore	90.1-2004	4,636	1,955	4,877	935	5,931	1,855	945	983	904	0	0	342	0	23,362	46.9	29%	38%
	90.1-2010	2,163	1,297	3,596	518	5,223	1,806	767	532	400	0	15	342	0	16,658	33.4		
4B Albuquerque	90.1-2004	2,231	1,437	4,877	935	5,931	1,855	1,178	793	328	0	0	334	0	19,899	39.9	24%	33%
	90.1-2010	888	1,171	3,586	516	5,223	1,806	1,067	485	145	0	0	334	0	15,221	30.5		
4C Salem	90.1-2004	3,598	773	4,877	935	5,931	1,855	857	448	228	0	0	363	0	19,865	39.8	26%	37%
	90.1-2010	1,439	648	3,607	520	5,223	1,806	727	244	101	0	0	363	0	14,678	29.4		
5A Chicago	90.1-2004	7,137	1,379	4,877	934	5,931	1,855	925	637	676	0	0	377	0	24,727	49.6	28%	37%
	90.1-2010	3,714	1,060	3,602	523	5,223	1,806	736	503	293	0	14	377	0	17,851	35.8		
5B Boise	90.1-2004	4,729	1,062	4,877	934	5,931	1,855	1,072	452	249	0	0	370	0	21,531	43.2	26%	36%
	90.1-2010	2,206	820	3,601	514	5,223	1,806	930	269	103	0	0	370	0	15,842	31.8		
5C Vancouver	90.1-2004	4,415	471	4,877	933	5,931	1,855	837	346	108	0	0	377	0	20,149	40.4	27%	38%
	90.1-2010	1,813	346	3,666	523	5,223	1,806	724	187	44	0	0	377	0	14,709	29.5		
6A Burlington	90.1-2004	8,981	1,049	4,877	934	5,931	1,855	908	507	429	0	0	408	0	25,878	51.9	27%	35%
	90.1-2010	5,279	785	3,603	525	5,223	1,806	729	417	182	0	14	408	0	18,970	38.0		
6B Helena	90.1-2004	6,827	844	4,877	934	5,931	1,855	996	541	133	0	0	412	0	23,350	46.8	26%	35%
	90.1-2010	3,859	591	3,606	517	5,223	1,806	895	335	66	0	15	412	0	17,324	34.7		
7 Duluth	90.1-2004	12,082	712	4,877	934	5,931	1,855	986	402	239	0	0	457	0	28,474	57.1	27%	34%
	90.1-2010	7,409	476	3,605	521	5,223	1,806	743	374	92	0	15	457	0	20,722	41.6		
8 Fairbanks	90.1-2004	18,961	442	4,877	928	5,931	1,855	998	310	72	0	0	517	0	34,890	70.0	22%	26%
	90.1-2010	14,129	240	3,703	538	5,223	1,806	759	313	20	0	16	517	0	27,265	54.7		

F.4 Stand-alone Retail Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	8	597	465	109	185	0	336	0	0	0	0	22	0	1,722	69.7	27%	30%
	90.1-2010	9	394	411	45	185	0	188	0	0	0	0	22	0	1,254	50.8		
1B Riyadh	90.1-2004	26	635	465	109	185	0	406	0	0	0	0	21	0	1,847	74.8	24%	26%
	90.1-2010	32	468	421	45	185	0	239	0	0	0	0	21	0	1,411	57.1		
2A Houston	90.1-2004	195	454	465	109	185	0	359	0	0	0	0	25	0	1,793	72.6	35%	39%
	90.1-2010	64	233	417	45	185	0	183	0	0	0	20	25	0	1,171	47.4		
2B Phoenix	90.1-2004	89	516	465	109	185	0	413	0	0	0	0	23	0	1,800	72.9	31%	34%
	90.1-2010	58	300	422	45	185	0	213	0	0	0	0	23	0	1,247	50.5		
3A Memphis	90.1-2004	279	323	465	109	185	0	339	0	0	0	0	28	0	1,728	70.0	34%	38%
	90.1-2010	96	173	418	45	185	0	180	0	0	0	19	28	0	1,144	46.3		
3B El Paso	90.1-2004	114	274	465	109	185	0	371	0	0	0	0	27	0	1,545	62.6	25%	28%
	90.1-2010	84	188	424	45	185	0	211	0	0	0	0	27	0	1,164	47.1		
3C San Francisco	90.1-2004	178	47	465	109	185	0	314	0	0	0	0	31	0	1,328	53.8	24%	28%
	90.1-2010	123	33	423	45	185	0	170	0	0	0	0	31	0	1,010	40.9		
4A Baltimore	90.1-2004	561	212	465	109	185	0	343	0	0	0	0	31	0	1,907	77.2	37%	41%
	90.1-2010	172	129	416	45	185	0	206	0	0	0	19	31	0	1,203	48.7		
4B Albuquerque	90.1-2004	260	175	465	109	185	0	390	0	0	0	0	31	0	1,614	65.4	24%	28%
	90.1-2010	176	135	415	45	185	0	234	0	0	0	0	31	0	1,220	49.4		
4C Salem	90.1-2004	440	81	465	109	185	0	332	0	0	0	0	33	0	1,644	66.6	25%	28%
	90.1-2010	293	60	417	45	185	0	201	0	0	0	0	33	0	1,233	49.9		
5A Chicago	90.1-2004	740	166	465	109	185	0	396	0	0	0	0	34	0	2,095	84.8	39%	43%
	90.1-2010	259	103	419	46	185	0	215	0	0	0	18	33	0	1,278	51.7		
5B Boise	90.1-2004	488	130	465	109	185	0	411	0	0	0	0	33	0	1,821	73.7	25%	28%
	90.1-2010	363	89	424	45	185	0	229	0	0	0	0	33	0	1,367	55.3		
5C Vancouver	90.1-2004	531	33	465	109	185	0	323	0	0	0	0	34	0	1,678	68.0	24%	27%
	90.1-2010	364	26	423	46	185	0	191	0	0	0	0	34	0	1,268	51.3		
6A Burlington	90.1-2004	955	115	465	109	185	0	402	0	0	0	0	36	0	2,266	91.8	41%	45%
	90.1-2010	324	72	440	46	185	0	214	0	0	0	18	35	0	1,333	54.0		
6B Helena	90.1-2004	687	88	465	109	185	0	446	0	0	0	0	36	0	2,015	81.6	37%	40%
	90.1-2010	254	64	440	45	185	0	239	0	0	0	18	36	0	1,279	51.8		
7 Duluth	90.1-2004	1,257	71	465	109	185	0	446	0	0	0	0	39	0	2,571	104.1	44%	47%
	90.1-2010	440	45	423	45	185	0	254	0	0	0	18	38	0	1,450	58.7		
8 Fairbanks	90.1-2004	2,018	39	465	108	185	0	479	0	0	0	0	42	0	3,335	135.1	38%	40%
	90.1-2010	1,017	25	445	47	185	0	296	0	0	0	19	42	0	2,076	84.1		

F.5 Strip Mall Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	5	517	544	137	122	0	221	0	0	0	0	36	0	1,581	70.3	25%	28%
	90.1-2010	4	369	424	52	122	0	172	0	0	0	0	36	0	1,180	52.4		
1B Riyadh	90.1-2004	9	535	544	137	122	0	304	0	0	0	0	35	0	1,684	74.9	23%	25%
	90.1-2010	8	401	424	52	122	0	247	0	0	0	0	35	0	1,290	57.3		
2A Houston	90.1-2004	147	405	544	136	122	0	244	0	0	0	0	39	0	1,637	72.7	24%	26%
	90.1-2010	112	288	424	52	122	0	200	0	0	0	0	39	0	1,237	55.0		
2B Phoenix	90.1-2004	51	450	544	136	122	0	307	0	0	0	0	37	0	1,648	73.2	25%	28%
	90.1-2010	38	315	424	52	122	0	240	0	0	0	0	37	0	1,228	54.6		
3A Memphis	90.1-2004	326	303	544	136	122	0	245	0	0	0	0	41	0	1,717	76.3	31%	33%
	90.1-2010	204	182	424	52	122	0	161	0	0	0	0	41	0	1,187	52.7		
3B El Paso	90.1-2004	99	250	544	136	122	0	281	0	0	0	0	40	0	1,473	65.5	27%	29%
	90.1-2010	72	168	424	52	122	0	201	0	0	0	0	40	0	1,079	47.9		
3C San Francisco	90.1-2004	182	39	544	136	122	0	193	0	0	0	0	43	0	1,259	56.0	27%	30%
	90.1-2010	117	22	424	52	122	0	140	0	0	0	0	43	0	921	40.9		
4A Baltimore	90.1-2004	664	193	544	136	122	0	240	0	0	0	0	43	0	1,942	86.3	32%	34%
	90.1-2010	377	123	424	52	122	0	180	0	0	0	0	43	0	1,322	58.8		
4B Albuquerque	90.1-2004	268	160	544	136	122	0	277	0	0	0	0	43	0	1,550	68.9	28%	30%
	90.1-2010	154	115	424	52	122	0	209	0	0	0	0	43	0	1,120	49.8		
4C Salem	90.1-2004	549	77	544	136	122	0	230	0	0	0	0	45	0	1,702	75.6	30%	32%
	90.1-2010	322	56	424	52	122	0	176	0	0	0	0	44	0	1,197	53.2		
5A Chicago	90.1-2004	941	146	544	136	122	0	243	0	0	0	0	45	0	2,176	96.7	31%	33%
	90.1-2010	589	92	424	53	122	0	179	0	0	0	0	45	0	1,504	66.8		
5B Boise	90.1-2004	607	115	544	136	122	0	263	0	0	0	0	45	0	1,831	81.4	28%	30%
	90.1-2010	390	80	424	52	122	0	203	0	0	0	0	45	0	1,316	58.5		
5C Vancouver	90.1-2004	701	29	544	136	122	0	171	0	0	0	0	45	0	1,748	77.7	29%	31%
	90.1-2010	430	24	424	53	122	0	145	0	0	0	0	45	0	1,243	55.2		
6A Burlington	90.1-2004	1220	94	544	136	122	0	256	0	0	0	0	47	0	2,419	107.5	33%	34%
	90.1-2010	755	61	424	53	122	0	171	0	0	0	0	46	0	1,631	72.5		
6B Helena	90.1-2004	854	70	544	136	122	0	285	0	0	0	0	47	0	2,058	91.4	28%	30%
	90.1-2010	578	54	424	52	122	0	197	0	0	0	0	46	0	1,473	65.5		
7 Duluth	90.1-2004	1,573	56	544	136	122	0	299	0	0	0	0	49	0	2,778	123.5	33%	35%
	90.1-2010	982	31	424	52	122	0	192	0	0	0	0	49	0	1,852	82.3		
8 Fairbanks	90.1-2004	2,456	29	544	135	122	0	364	0	0	0	0	51	0	3,701	164.5	30%	31%
	90.1-2010	1,673	12	424	54	122	0	255	0	0	0	0	51	0	2,591	115.2		

F.6 Primary School Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	35	1,718	1,148	81	1,576	0	579	0	0	0	0	43	74	5,254	71.0	22%	32%
	90.1-2010	18	1,157	782	33	1,548	0	359	0	0	0	80	43	74	4,094	55.4		
1B Riyadh	90.1-2004	106	1,808	1,148	81	1,576	0	702	0	0	0	0	40	72	5,533	74.8	21%	30%
	90.1-2010	61	1,315	792	33	1,548	0	490	0	0	0	0	40	74	4,353	58.9		
2A Houston	90.1-2004	461	1,377	1,148	81	1,576	0	544	1	0	0	0	57	73	5,317	71.9	26%	38%
	90.1-2010	141	860	792	33	1,548	0	341	0	0	0	66	57	74	3,911	52.9		
2B Phoenix	90.1-2004	245	1,435	1,148	81	1,576	0	644	0	0	0	0	50	72	5,251	71.0	23%	33%
	90.1-2010	111	978	800	33	1,548	0	435	0	0	0	0	50	73	4,029	54.5		
3A Memphis	90.1-2004	780	1,015	1,148	81	1,576	0	497	1	0	0	0	67	72	5,237	70.8	31%	44%
	90.1-2010	184	584	773	34	1,548	0	304	0	0	0	66	67	73	3,633	49.1		
3B El Paso	90.1-2004	353	890	1,148	81	1,576	0	554	1	0	0	0	64	71	4,736	64.0	24%	36%
	90.1-2010	173	584	775	33	1,548	0	355	1	0	0	0	64	73	3,606	48.8		
3C San Francisco	90.1-2004	475	356	1,148	81	1,576	0	413	1	0	0	0	76	71	4,195	56.7	26%	41%
	90.1-2010	165	169	779	33	1,548	0	271	1	0	0	0	76	74	3,115	42.1		
4A Baltimore	90.1-2004	1,613	696	1,148	80	1,576	0	475	3	0	0	0	79	72	5,742	77.6	37%	52%
	90.1-2010	246	451	758	34	1,548	0	336	1	0	0	66	79	73	3,590	48.5		
4B Albuquerque	90.1-2004	747	613	1,148	81	1,576	0	551	2	0	0	0	77	71	4,865	65.8	25%	37%
	90.1-2010	385	402	757	33	1,548	0	381	2	0	0	0	77	73	3,658	49.5		
4C Salem	90.1-2004	1,106	365	1,148	80	1,576	0	427	2	0	0	0	83	71	4,857	65.7	27%	40%
	90.1-2010	531	229	761	34	1,548	0	294	2	0	0	0	83	74	3,555	48.1		
5A Chicago	90.1-2004	1,819	531	1,148	81	1,576	0	466	4	0	0	0	87	71	5,782	78.2	36%	50%
	90.1-2010	388	377	759	34	1,548	0	341	1	0	0	69	87	73	3,677	49.7		
5B Boise	90.1-2004	1,403	435	1,148	80	1,576	0	486	3	0	0	0	86	71	5,288	71.5	26%	37%
	90.1-2010	767	297	762	33	1,548	0	339	3	0	0	0	86	73	3,908	52.8		
5C Vancouver	90.1-2004	1,237	224	1,148	80	1,576	0	386	2	0	0	0	86	71	4,811	65.0	29%	43%
	90.1-2010	533	126	779	34	1,548	0	253	2	0	0	0	86	74	3,435	46.4		
6A Burlington	90.1-2004	2,395	390	1,148	80	1,576	0	462	5	0	0	0	94	71	6,221	84.1	40%	54%
	90.1-2010	520	284	760	34	1,548	0	340	2	0	0	72	94	72	3,726	50.4		
6B Helena	90.1-2004	1,954	302	1,148	80	1,576	0	479	5	0	0	0	95	70	5,710	77.2	37%	51%
	90.1-2010	444	205	763	34	1,548	0	355	1	0	0	67	95	72	3,584	48.5		
7 Duluth	90.1-2004	3,295	260	1,148	80	1,576	0	503	7	0	0	0	106	71	7,046	95.3	43%	56%
	90.1-2010	860	173	757	34	1,548	0	371	3	0	0	80	106	71	4,001	54.1		
8 Fairbanks	90.1-2004	5,231	143	1,148	80	1,576	0	489	13	0	0	0	119	70	8,869	119.9	36%	44%
	90.1-2010	2,496	100	785	35	1,548	0	397	8	0	0	91	119	71	5,650	76.4		

F.7 Secondary School Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	71	5,593	3,125	210	3,041	0	1,594	212	0	0	0	57	154	14,057	66.7	27%	34%
	90.1-2010	38	3,600	2,066	84	2,961	0	1,013	64	0	0	268	57	154	10,304	48.9		
1B Riyadh	90.1-2004	195	5,401	3,125	210	3,041	0	1,856	187	0	0	0	53	152	14,220	67.4	22%	29%
	90.1-2010	123	4,159	2,094	84	2,963	0	1,272	63	0	0	65	53	153	11,029	52.3		
2A Houston	90.1-2004	1,176	4,362	3,125	210	3,041	0	1,579	181	0	0	0	76	153	13,903	65.9	31%	40%
	90.1-2010	280	2,713	2,095	84	2,961	0	963	53	0	0	197	76	153	9,577	45.4		
2B Phoenix	90.1-2004	453	4,488	3,125	210	3,041	0	1,781	175	0	0	0	67	151	13,492	64.0	26%	34%
	90.1-2010	172	3,102	2,117	84	2,963	0	1,160	58	0	0	114	67	152	9,989	47.4		
3A Memphis	90.1-2004	2,014	3,241	3,125	209	3,041	0	1,525	151	0	0	0	90	152	13,550	64.3	35%	45%
	90.1-2010	310	2,011	2,058	84	2,961	0	886	44	0	0	185	90	153	8,782	41.6		
3B El Paso	90.1-2004	641	2,657	3,125	210	3,041	0	1,628	125	0	0	0	86	151	11,663	55.3	25%	34%
	90.1-2010	327	1,955	2,061	84	2,963	0	1,013	40	0	0	43	86	152	8,724	41.4		
3C San Francisco	90.1-2004	855	838	3,125	209	3,041	0	1,375	79	0	0	0	102	151	9,777	46.4	28%	41%
	90.1-2010	122	622	2,074	84	2,963	0	769	20	0	0	94	102	153	7,003	33.2		
4A Baltimore	90.1-2004	4,121	2,156	3,125	209	3,041	0	1,539	115	0	0	0	107	152	14,565	69.1	44%	55%
	90.1-2010	388	1,373	2,013	84	2,961	0	926	30	0	0	190	107	152	8,224	39.0		
4B Albuquerque	90.1-2004	1,536	1,727	3,125	209	3,041	0	1,693	94	0	0	0	104	150	11,681	55.4	27%	36%
	90.1-2010	710	1,372	2,008	84	2,963	0	1,093	32	0	0	41	104	152	8,559	40.6		
4C Salem	90.1-2004	2,604	896	3,125	209	3,041	0	1,439	61	0	0	0	112	151	11,639	55.2	33%	45%
	90.1-2010	722	737	2,024	85	2,963	0	861	20	0	0	104	112	153	7,780	36.9		
5A Chicago	90.1-2004	4,900	1,617	3,125	209	3,041	0	1,589	88	0	0	0	118	151	14,839	70.4	44%	55%
	90.1-2010	677	1,147	2,015	85	2,961	0	946	26	0	0	196	118	152	8,323	39.5		
5B Boise	90.1-2004	3,348	1,307	3,125	209	3,041	0	1,592	76	0	0	0	116	150	12,966	61.5	30%	39%
	90.1-2010	1,670	1,017	2,025	84	2,963	0	1,006	28	0	0	45	116	152	9,106	43.2		
5C Vancouver	90.1-2004	3,053	471	3,125	209	3,041	0	1,382	42	0	0	0	116	151	11,591	55.0	29%	40%
	90.1-2010	1,513	440	2,076	85	2,963	0	810	16	0	0	40	116	153	8,212	38.9		
6A Burlington	90.1-2004	6,286	1,138	3,125	209	3,041	0	1,582	72	0	0	0	128	150	15,732	74.6	47%	58%
	90.1-2010	977	850	2,019	85	2,961	0	936	22	0	0	195	128	151	8,324	39.5		
6B Helena	90.1-2004	5,102	887	3,125	209	3,041	0	1,621	64	0	0	0	129	150	14,329	67.9	43%	55%
	90.1-2010	849	689	2,029	84	2,961	0	1,028	26	0	0	197	129	151	8,144	38.6		
7 Duluth	90.1-2004	8,731	693	3,125	209	3,041	0	1,767	59	0	0	0	144	150	17,918	85.0	51%	61%
	90.1-2010	1,733	520	1,967	85	2,961	0	1,022	17	0	0	229	144	151	8,829	41.9		
8 Fairbanks	90.1-2004	14,746	376	3,125	208	3,041	0	1,725	61	0	0	0	162	149	23,594	111.9	46%	53%
	90.1-2010	5,587	294	2,101	87	2,961	0	1,093	25	0	0	263	162	150	12,722	60.3		

F.8 Outpatient Hourly Operation Healthcare Schedules

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	1,391	2,051	580	215	1,936	0	583	16	0	3	0	34	0	6,807	166.2	20%	27%
	90.1-2010	837	1,650	505	125	1,902	0	400	16	0	1	0	34	0	5,470	133.6		
1B Riyadh	90.1-2004	1,424	1,716	580	215	1,936	0	640	17	0	333	0	31	0	6,892	168.3	23%	32%
	90.1-2010	730	1,328	505	125	1,902	0	445	16	0	206	0	31	0	5,289	129.2		
2A Houston	90.1-2004	1,710	1,740	580	215	1,936	0	569	16	0	45	0	39	0	6,850	167.3	22%	30%
	90.1-2010	1,071	1,312	505	125	1,902	0	384	16	0	19	0	39	0	5,373	131.2		
2B Phoenix	90.1-2004	1,633	1,523	580	215	1,936	0	605	16	0	161	0	36	0	6,705	163.8	24%	34%
	90.1-2010	847	1,155	505	125	1,902	0	413	16	0	84	0	36	0	5,083	124.1		
3A Memphis	90.1-2004	1,813	1,417	580	215	1,936	0	557	18	0	123	0	43	0	6,702	163.7	23%	32%
	90.1-2010	1,155	984	505	125	1,902	0	374	18	0	63	0	43	0	5,168	126.2		
3B El Paso	90.1-2004	1,451	1,093	580	215	1,936	0	594	16	0	410	0	41	0	6,337	154.8	25%	36%
	90.1-2010	723	796	505	125	1,902	0	412	16	0	250	0	41	0	4,770	116.5		
3C San Francisco	90.1-2004	1,907	799	580	215	1,936	0	553	16	0	44	0	47	0	6,096	148.9	29%	42%
	90.1-2010	897	454	505	125	1,902	0	387	18	0	11	0	47	0	4,345	106.1		
4A Baltimore	90.1-2004	2,127	1,140	580	215	1,936	0	553	20	0	202	0	48	0	6,820	166.6	27%	38%
	90.1-2010	1,193	704	505	125	1,902	0	381	18	0	110	0	48	0	4,984	121.7		
4B Albuquerque	90.1-2004	1,602	867	580	215	1,936	0	609	16	0	497	0	47	0	6,369	155.6	26%	38%
	90.1-2010	767	603	505	125	1,902	0	429	16	0	309	0	47	0	4,702	114.8		
4C Salem	90.1-2004	2,111	667	580	215	1,936	0	548	17	0	88	0	50	0	6,212	151.7	28%	40%
	90.1-2010	1,060	427	505	125	1,902	0	379	17	0	26	0	50	0	4,491	109.7		
5A Chicago	90.1-2004	2,292	768	580	215	1,936	0	551	21	0	248	0	51	0	6,661	162.7	24%	33%
	90.1-2010	1,401	570	505	125	1,902	0	376	20	0	139	0	51	0	5,089	124.3		
5B Boise	90.1-2004	1,954	637	580	215	1,936	0	570	19	0	402	0	50	0	6,362	155.4	25%	37%
	90.1-2010	1,092	443	505	125	1,902	0	394	18	0	215	0	50	0	4,744	115.9		
5C Vancouver	90.1-2004	2,068	570	580	215	1,936	0	549	19	0	97	0	51	0	6,084	148.6	27%	39%
	90.1-2010	1,079	357	505	125	1,902	0	387	17	0	31	0	51	0	4,454	108.8		
6A Burlington	90.1-2004	2,624	641	580	215	1,936	0	549	22	0	298	0	54	0	6,918	169.0	24%	33%
	90.1-2010	1,639	459	505	125	1,902	0	377	20	0	180	0	54	0	5,260	128.5		
6B Helena	90.1-2004	2,248	536	580	215	1,936	0	578	21	0	500	0	54	0	6,668	162.8	26%	36%
	90.1-2010	1,294	359	505	125	1,902	0	395	20	0	296	0	54	0	4,950	120.9		
7 Duluth	90.1-2004	2,980	466	580	215	1,936	0	565	24	0	393	0	59	0	7,217	176.2	25%	34%
	90.1-2010	1,869	306	505	125	1,902	0	379	21	0	241	0	59	0	5,406	132.0		
8 Fairbanks	90.1-2004	4,284	334	580	213	1,936	0	578	30	0	574	0	65	0	8,594	209.9	23%	30%
	90.1-2010	3,005	207	505	124	1,902	0	376	26	0	371	0	65	0	6,581	160.7		

F.9 Hospital Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	7,792	6,603	4,018	248	9,564	2,408	4,204	1,489	3,087	0	0	168	200	39,782	164.7	26%	35%
	90.1-2010	3,727	4,485	3,435	195	9,446	2,382	2,736	917	1,497	0	144	168	200	29,334	121.5		
1B Riyadh	90.1-2004	7,660	4,979	4,018	248	9,564	2,408	4,476	1,743	1,303	12	0	149	196	36,756	152.2	25%	34%
	90.1-2010	3,601	3,624	3,435	195	9,446	2,382	2,970	1,063	460	11	0	149	197	27,535	114.0		
2A Houston	90.1-2004	9,572	5,409	4,018	248	9,564	2,408	4,189	1,438	2,304	2	0	212	193	39,556	163.8	25%	33%
	90.1-2010	5,037	3,905	3,435	195	9,446	2,382	2,693	888	1,052	1	144	212	193	29,585	122.5		
2B Phoenix	90.1-2004	8,937	4,159	4,018	248	9,564	2,408	4,384	1,788	1,424	7	0	187	192	37,315	154.5	25%	34%
	90.1-2010	4,432	3,090	3,436	195	9,446	2,382	2,825	1,115	635	6	0	187	193	27,943	115.7		
3A Memphis	90.1-2004	10,467	4,308	4,018	248	9,564	2,408	4,122	1,410	1,608	4	0	246	188	38,591	159.8	25%	33%
	90.1-2010	5,682	2,868	3,434	195	9,446	2,382	2,675	885	729	3	144	246	188	28,879	119.6		
3B El Paso	90.1-2004	7,643	2,913	4,018	248	9,564	2,408	4,383	1,269	779	11	0	235	186	33,657	139.4	22%	31%
	90.1-2010	4,091	2,173	3,434	195	9,446	2,382	2,944	707	340	10	0	235	187	26,145	108.3		
3C San Francisco	90.1-2004	10,730	2,048	4,018	248	9,564	2,408	4,082	1,384	183	2	0	283	181	35,131	145.5	24%	33%
	90.1-2010	5,577	1,552	3,434	195	9,446	2,382	2,715	854	55	1	0	283	181	26,676	110.5		
4A Baltimore	90.1-2004	12,003	3,456	4,018	248	9,564	2,408	4,110	1,295	1,037	7	0	288	182	38,616	159.9	26%	34%
	90.1-2010	6,451	2,151	3,433	195	9,446	2,382	2,726	822	432	4	144	288	182	28,657	118.7		
4B Albuquerque	90.1-2004	9,047	2,585	4,018	248	9,564	2,408	4,484	1,354	441	12	0	282	181	34,623	143.4	23%	32%
	90.1-2010	4,804	1,863	3,433	195	9,446	2,382	3,050	872	154	11	0	282	181	26,674	110.5		
4C Salem	90.1-2004	11,475	1,768	4,018	248	9,564	2,408	4,078	1,010	294	3	0	306	178	35,350	146.4	23%	32%
	90.1-2010	6,530	1,225	3,434	195	9,446	2,382	2,735	621	116	3	0	306	179	27,172	112.5		
5A Chicago	90.1-2004	13,257	2,610	4,018	248	9,564	2,408	4,114	1,211	769	8	0	318	179	38,702	160.3	25%	33%
	90.1-2010	7,250	1,845	3,434	195	9,446	2,382	2,741	814	323	5	144	318	179	29,075	120.4		
5B Boise	90.1-2004	11,146	2,047	4,018	248	9,564	2,408	4,279	1,224	251	10	0	312	177	35,685	147.8	23%	31%
	90.1-2010	6,408	1,326	3,434	195	9,446	2,382	2,889	797	85	9	0	312	177	27,461	113.7		
5C Vancouver	90.1-2004	11,978	1,560	4,018	247	9,564	2,408	4,042	936	215	4	0	318	177	35,466	146.9	23%	32%
	90.1-2010	6,900	1,014	3,436	195	9,446	2,382	2,731	569	70	3	0	318	177	27,240	112.8		
6A Burlington	90.1-2004	14,485	2,135	4,018	248	9,564	2,408	4,076	1,036	531	9	0	344	176	39,028	161.6	25%	33%
	90.1-2010	8,042	1,523	3,434	195	9,446	2,382	2,729	718	223	5	144	344	177	29,361	121.6		
6B Helena	90.1-2004	12,208	1,726	4,018	247	9,564	2,408	4,307	1,195	161	12	0	347	174	36,368	150.6	23%	31%
	90.1-2010	6,824	1,279	3,434	195	9,446	2,382	2,933	859	53	8	144	347	175	28,078	116.3		
7 Duluth	90.1-2004	16,055	1,559	4,018	247	9,564	2,408	4,165	905	286	11	0	385	173	39,776	164.7	25%	33%
	90.1-2010	9,054	1,097	3,434	195	9,446	2,382	2,779	655	110	7	144	385	173	29,859	123.6		
8 Fairbanks	90.1-2004	21,767	1,042	4,018	246	9,564	2,408	4,068	610	127	14	0	436	170	44,470	184.1	24%	31%
	90.1-2010	13,397	708	3,436	193	9,446	2,382	2,722	537	32	8	144	436	170	33,613	139.2		

F.10 Small Hotel Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	9	823	472	90	970	0	380	1	0	0	0	345	0	3,090	71.5	11%	16%
	90.1-2010	5	634	391	62	960	0	343	1	0	0	0	345	0	2,741	63.5		
1B Riyadh	90.1-2004	35	743	472	90	970	0	396	1	0	0	0	321	0	3,028	70.1	11%	17%
	90.1-2010	19	573	391	62	960	0	357	1	0	0	0	321	0	2,684	62.1		
2A Houston	90.1-2004	193	638	472	90	970	0	381	1	0	0	0	401	0	3,146	72.8	13%	19%
	90.1-2010	94	485	391	62	960	0	344	1	0	0	0	401	0	2,738	63.4		
2B Phoenix	90.1-2004	115	636	472	90	970	0	389	1	0	0	0	368	0	3,041	70.4	13%	19%
	90.1-2010	51	470	391	62	960	0	352	1	0	0	0	368	0	2,655	61.5		
3A Memphis	90.1-2004	349	500	472	90	970	0	379	1	0	0	0	444	0	3,205	74.2	14%	20%
	90.1-2010	183	372	389	62	960	0	342	1	0	0	0	444	0	2,753	63.7		
3B El Paso	90.1-2004	186	450	472	90	970	0	390	1	0	0	0	430	0	2,989	69.2	12%	18%
	90.1-2010	93	343	389	62	960	0	351	1	0	0	0	430	0	2,629	60.9		
3C San Francisco	90.1-2004	208	247	472	90	970	0	378	1	0	0	0	491	0	2,858	66.2	12%	18%
	90.1-2010	75	200	391	62	960	0	339	1	0	0	0	491	0	2,520	58.3		
4A Baltimore	90.1-2004	653	357	472	90	970	0	378	1	0	0	0	498	0	3,419	79.1	16%	22%
	90.1-2010	349	286	388	62	960	0	341	1	0	0	0	498	0	2,884	66.8		
4B Albuquerque	90.1-2004	373	331	472	90	970	0	395	1	0	0	0	490	0	3,122	72.3	13%	19%
	90.1-2010	191	274	388	62	960	0	353	1	0	0	0	490	0	2,719	62.9		
4C Salem	90.1-2004	519	230	472	90	970	0	377	1	0	0	0	520	0	3,179	73.6	15%	21%
	90.1-2010	243	199	388	62	960	0	341	1	0	0	0	520	0	2,714	62.8		
5A Chicago	90.1-2004	955	293	472	90	970	0	377	1	0	0	0	535	0	3,693	85.5	17%	23%
	90.1-2010	543	236	388	62	960	0	342	1	0	0	0	535	0	3,066	71.0		
5B Boise	90.1-2004	665	252	472	90	970	0	383	1	0	0	0	528	0	3,362	77.8	15%	21%
	90.1-2010	356	209	389	62	960	0	348	1	0	0	0	528	0	2,852	66.0		
5C Vancouver	90.1-2004	600	194	472	90	970	0	372	1	0	0	0	536	0	3,234	74.9	15%	21%
	90.1-2010	295	168	389	62	960	0	339	1	0	0	0	536	0	2,750	63.7		
6A Burlington	90.1-2004	1,210	242	472	90	970	0	375	1	0	0	0	568	0	3,928	90.9	18%	24%
	90.1-2010	710	201	388	62	960	0	341	1	0	0	0	568	0	3,230	74.8		
6B Helena	90.1-2004	945	206	472	90	970	0	385	1	0	0	0	573	0	3,642	84.3	16%	22%
	90.1-2010	539	174	389	62	960	0	349	1	0	0	0	573	0	3,047	70.5		
7 Duluth	90.1-2004	1,602	188	472	90	970	0	379	1	0	0	0	621	0	4,323	100.1	20%	26%
	90.1-2010	918	155	388	62	960	0	342	1	0	0	0	621	0	3,447	79.8		
8 Fairbanks	90.1-2004	2,383	138	472	90	970	0	375	1	0	0	0	686	0	5,114	118.4	20%	24%
	90.1-2010	1,552	117	389	62	960	0	342	1	0	0	0	686	0	4,108	95.1		

F.11 Large Hotel Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	990	7,408	1,379	291	3,397	927	1,050	451	0	0	0	3,699	70	19,662	161.0	24%	30%
	90.1-2010	225	4,055	1,292	223	3,373	903	620	109	0	0	286	3,699	73	14,858	121.7		
1B Riyadh	90.1-2004	873	5,530	1,379	291	3,397	927	867	343	0	0	0	3,293	69	16,968	138.9	13%	16%
	90.1-2010	419	4,404	1,292	223	3,373	903	739	106	0	0	0	3,293	72	14,825	121.4		
2A Houston	90.1-2004	2,310	5,074	1,379	290	3,397	927	750	374	0	0	0	4,633	70	19,204	157.3	22%	26%
	90.1-2010	563	3,082	1,293	223	3,373	903	587	100	0	0	243	4,633	73	15,072	123.4		
2B Phoenix	90.1-2004	1,832	4,753	1,379	290	3,397	927	853	348	0	0	0	4,089	69	17,938	146.9	18%	23%
	90.1-2010	465	3,437	1,293	223	3,373	903	678	108	0	0	0	4,089	71	14,640	119.9		
3A Memphis	90.1-2004	3,004	3,577	1,379	290	3,397	927	698	338	0	0	0	5,366	69	19,045	156.0	20%	24%
	90.1-2010	704	2,449	1,291	223	3,373	903	572	98	0	0	228	5,366	72	15,280	125.1		
3B El Paso	90.1-2004	2,071	2,711	1,379	290	3,397	927	750	258	0	0	0	5,125	69	16,977	139.0	14%	17%
	90.1-2010	691	2,231	1,291	223	3,373	903	680	91	0	0	0	5,125	71	14,679	120.2		
3C San Francisco	90.1-2004	2,214	1,119	1,379	290	3,397	927	678	187	0	0	0	6,160	70	16,423	134.5	13%	17%
	90.1-2010	653	885	1,292	223	3,373	903	605	74	0	0	0	6,160	72	14,238	116.6		
4A Baltimore	90.1-2004	4,934	2,408	1,379	290	3,397	927	702	280	0	0	0	6,265	69	20,651	169.1	26%	31%
	90.1-2010	471	1,727	1,290	223	3,373	903	614	88	0	0	226	6,265	72	15,252	124.9		
4B Albuquerque	90.1-2004	3,582	1,846	1,379	290	3,397	927	761	226	0	0	0	6,129	70	18,606	152.4	16%	19%
	90.1-2010	1,239	1,606	1,290	223	3,373	903	728	88	0	0	0	6,129	71	15,650	128.2		
4C Salem	90.1-2004	4,518	1,084	1,379	290	3,397	927	699	184	0	0	0	6,645	69	19,193	157.2	17%	21%
	90.1-2010	1,747	926	1,290	223	3,373	903	637	73	0	0	0	6,645	71	15,887	130.1		
5A Chicago	90.1-2004	6,669	1,828	1,379	290	3,397	927	705	265	0	0	0	6,893	69	22,421	183.6	29%	35%
	90.1-2010	727	1,429	1,290	223	3,373	903	638	89	0	0	217	6,893	71	15,852	129.8		
5B Boise	90.1-2004	5,687	1,396	1,379	290	3,397	927	747	220	0	0	0	6,781	69	20,893	171.1	19%	23%
	90.1-2010	2,198	1,202	1,290	223	3,373	903	692	91	0	0	0	6,781	71	16,823	137.8		
5C Vancouver	90.1-2004	4,714	823	1,379	290	3,397	927	681	158	0	0	0	6,900	69	19,338	158.4	22%	26%
	90.1-2010	778	728	1,291	222	3,373	903	637	62	0	0	171	6,900	72	15,137	124.0		
6A Burlington	90.1-2004	8,073	1,365	1,379	290	3,397	927	703	228	0	0	0	7,450	69	23,880	195.5	31%	37%
	90.1-2010	1,039	1,122	1,290	223	3,373	903	634	79	0	0	213	7,450	71	16,397	134.3		
6B Helena	90.1-2004	7,536	1,037	1,379	290	3,397	927	757	206	0	0	0	7,531	69	23,130	189.4	29%	34%
	90.1-2010	941	999	1,290	222	3,373	903	708	81	0	0	225	7,531	71	16,344	133.8		
7 Duluth	90.1-2004	10,486	929	1,379	290	3,397	927	747	219	0	0	0	8,332	68	26,774	219.2	34%	39%
	90.1-2010	1,750	806	1,290	222	3,373	903	661	76	0	0	235	8,332	71	17,719	145.1		
8 Fairbanks	90.1-2004	15,940	634	1,379	288	3,397	927	774	225	0	0	0	9,420	67	33,051	270.6	32%	36%
	90.1-2010	5,574	585	1,290	221	3,373	903	680	95	0	0	244	9,420	70	22,455	183.9		

F.12 Warehouse Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	53	95	457	117	132	0	68	0	0	0	0	5	0	927	17.8	33%	39%
	90.1-2010	0	69	306	60	127	0	49	0	0	0	0	5	0	617	11.9		
1B Riyadh	90.1-2004	86	337	457	117	132	0	262	0	0	0	0	5	0	1,396	26.8	27%	30%
	90.1-2010	17	277	319	60	127	0	210	0	0	0	0	5	0	1,015	19.5		
2A Houston	90.1-2004	220	54	457	117	132	0	53	0	0	0	0	6	0	1,039	20.0	32%	36%
	90.1-2010	116	42	313	60	127	0	47	0	0	0	0	6	0	711	13.7		
2B Phoenix	90.1-2004	125	164	457	117	132	0	169	0	0	0	0	6	0	1,169	22.5	24%	27%
	90.1-2010	78	143	328	60	127	0	152	0	0	0	0	6	0	894	17.2		
3A Memphis	90.1-2004	423	38	457	117	132	0	47	0	0	0	0	7	0	1,222	23.5	30%	34%
	90.1-2010	272	27	317	60	127	0	42	0	0	0	0	7	0	853	16.4		
3B El Paso	90.1-2004	259	40	457	117	132	0	64	0	0	0	0	7	0	1,077	20.7	26%	29%
	90.1-2010	193	31	323	60	127	0	58	0	0	0	0	7	0	799	15.4		
3C San Francisco	90.1-2004	379	0	457	117	132	0	18	0	0	0	0	8	0	1,111	21.3	23%	26%
	90.1-2010	314	0	329	60	127	0	16	0	0	0	0	8	0	855	16.4		
4A Baltimore	90.1-2004	730	13	457	117	132	0	35	0	0	0	0	8	0	1,492	28.7	29%	31%
	90.1-2010	516	8	316	60	127	0	30	0	0	0	0	8	0	1,066	20.5		
4B Albuquerque	90.1-2004	513	13	457	117	132	0	41	0	0	0	0	8	0	1,281	24.6	26%	29%
	90.1-2010	386	9	319	60	127	0	36	0	0	0	0	8	0	945	18.2		
4C Salem	90.1-2004	544	1	457	117	132	0	23	0	0	0	0	9	0	1,282	24.6	24%	27%
	90.1-2010	437	0	321	60	127	0	21	0	0	0	0	9	0	976	18.8		
5A Chicago	90.1-2004	1,036	7	457	117	132	0	43	0	0	0	0	9	0	1,800	34.6	26%	28%
	90.1-2010	791	4	314	61	127	0	34	0	0	0	0	9	0	1,340	25.8		
5B Boise	90.1-2004	723	6	457	117	132	0	37	0	0	0	0	9	0	1,481	28.5	26%	28%
	90.1-2010	542	4	329	60	127	0	32	0	0	0	0	9	0	1,102	21.2		
5C Vancouver	90.1-2004	631	0	457	117	132	0	24	0	0	0	0	9	0	1,371	26.3	23%	25%
	90.1-2010	502	0	335	61	127	0	22	0	0	0	0	9	0	1,056	20.3		
6A Burlington	90.1-2004	1,258	2	457	117	132	0	38	0	0	0	0	10	0	2,013	38.7	31%	33%
	90.1-2010	785	1	384	61	127	0	26	0	0	0	0	10	0	1,394	26.8		
6B Helena	90.1-2004	1,074	1	457	117	132	0	38	0	0	0	0	10	0	1,829	35.1	30%	33%
	90.1-2010	660	1	386	60	127	0	28	0	0	0	0	10	0	1,272	24.4		
7 Duluth	90.1-2004	1,804	0	457	117	132	0	49	0	0	0	0	10	0	2,569	49.4	27%	29%
	90.1-2010	1,255	0	377	60	127	0	35	0	0	0	0	10	0	1,866	35.9		
8 Fairbanks	90.1-2004	1,959	0	457	116	132	0	36	0	0	0	0	12	0	2,712	52.1	24%	25%
	90.1-2010	1,436	0	390	62	127	0	28	0	0	0	0	12	0	2,055	39.5		

F.13 Quick Service Restaurant Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	35	191	71	26	687	0	75	0	0	0	0	40	66	1,191	476.0	7%	16%
	90.1-2010	26	162	34	11	686	0	82	0	0	0	0	40	66	1,107	442.8		
1B Riyadh	90.1-2004	33	189	71	26	687	0	110	0	0	0	0	37	63	1,217	486.6	6%	13%
	90.1-2010	33	168	34	11	686	0	113	0	0	0	0	37	63	1,146	458.3		
2A Houston	90.1-2004	158	142	71	26	687	0	82	0	0	0	0	49	64	1,279	511.6	8%	17%
	90.1-2010	128	116	35	11	686	0	89	0	0	0	0	49	64	1,178	471.1		
2B Phoenix	90.1-2004	91	151	71	26	687	0	107	0	0	0	0	44	63	1,241	496.0	6%	15%
	90.1-2010	82	129	34	11	686	0	111	0	0	0	0	44	63	1,160	463.8		
3A Memphis	90.1-2004	258	102	71	26	687	0	81	0	0	0	0	56	63	1,344	537.5	7%	14%
	90.1-2010	231	83	34	11	686	0	87	0	0	0	0	56	62	1,251	500.2		
3B El Paso	90.1-2004	156	82	71	26	687	0	96	0	0	0	0	54	62	1,233	493.2	6%	13%
	90.1-2010	146	71	34	11	686	0	97	0	0	0	0	54	62	1,161	464.1		
3C San Francisco	90.1-2004	229	4	71	26	687	0	62	0	0	0	0	63	61	1,204	481.4	8%	19%
	90.1-2010	180	3	34	11	686	0	69	0	0	0	0	63	60	1,107	442.5		
4A Baltimore	90.1-2004	423	60	71	26	687	0	77	0	0	0	0	64	61	1,470	587.8	10%	18%
	90.1-2010	353	45	34	11	686	0	74	0	0	0	0	64	61	1,328	531.1		
4B Albuquerque	90.1-2004	277	48	71	26	687	0	91	0	0	0	0	63	61	1,324	529.6	9%	18%
	90.1-2010	237	37	33	11	686	0	82	0	0	0	0	63	61	1,210	483.9		
4C Salem	90.1-2004	407	18	71	26	687	0	75	0	0	0	0	68	61	1,412	564.5	11%	21%
	90.1-2010	313	14	34	11	686	0	73	0	0	0	0	68	60	1,258	503.2		
5A Chicago	90.1-2004	589	42	71	26	687	0	75	0	0	0	0	70	61	1,621	648.0	10%	18%
	90.1-2010	486	31	34	11	686	0	72	0	0	0	0	70	60	1,451	580.3		
5B Boise	90.1-2004	461	34	71	26	687	0	87	0	0	0	0	69	60	1,495	597.8	10%	19%
	90.1-2010	379	25	33	11	686	0	80	0	0	0	0	69	60	1,343	537.2		
5C Vancouver	90.1-2004	476	3	71	26	687	0	53	0	0	0	0	70	60	1,447	578.5	11%	21%
	90.1-2010	362	2	34	11	686	0	58	0	0	0	0	70	60	1,284	513.4		
6A Burlington	90.1-2004	738	25	71	26	687	0	69	0	0	0	0	75	60	1,751	700.2	11%	18%
	90.1-2010	606	18	34	11	686	0	70	0	0	0	0	75	60	1,560	623.9		
6B Helena	90.1-2004	608	18	71	26	687	0	79	0	0	0	0	76	60	1,625	649.8	10%	18%
	90.1-2010	505	14	34	11	686	0	75	0	0	0	0	76	59	1,461	584.0		
7 Duluth	90.1-2004	934	13	71	26	687	0	67	0	0	0	0	84	59	1,940	775.7	11%	17%
	90.1-2010	774	9	34	11	686	0	68	0	0	0	0	84	59	1,724	689.3		
8 Fairbanks	90.1-2004	1,425	4	71	26	687	0	61	0	0	0	0	94	59	2,426	970.1	10%	14%
	90.1-2010	1,225	3	34	11	686	0	64	0	0	0	0	94	58	2,176	870.0		

F.14 Full Service Restaurant Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	19	353	176	55	867	0	143	0	0	0	0	115	64	1,792	325.7	16%	31%
	90.1-2010	25	251	75	23	864	0	85	0	0	0	0	115	64	1,503	273.2		
1B Riyadh	90.1-2004	39	367	176	55	867	0	269	0	0	0	0	102	62	1,938	352.2	19%	34%
	90.1-2010	37	266	76	23	864	0	145	0	0	0	0	102	62	1,575	286.3		
2A Houston	90.1-2004	188	283	176	55	867	0	224	0	0	0	0	144	63	2,000	363.4	20%	35%
	90.1-2010	160	182	76	23	864	0	88	0	0	0	0	144	62	1,599	290.7		
2B Phoenix	90.1-2004	141	300	176	55	867	0	260	0	0	0	0	127	62	1,989	361.5	20%	36%
	90.1-2010	90	206	76	23	864	0	139	0	0	0	0	127	61	1,587	288.4		
3A Memphis	90.1-2004	364	204	176	55	867	0	221	0	0	0	0	167	62	2,115	384.4	20%	33%
	90.1-2010	297	129	74	23	864	0	86	0	0	0	0	167	61	1,701	309.2		
3B El Paso	90.1-2004	240	172	176	55	867	0	249	0	0	0	0	159	61	1,980	360.0	19%	34%
	90.1-2010	166	119	74	23	864	0	131	0	0	0	0	159	60	1,597	290.3		
3C San Francisco	90.1-2004	395	10	176	55	867	0	124	0	0	0	0	191	61	1,879	341.5	20%	37%
	90.1-2010	213	8	74	23	864	0	74	0	0	0	0	191	59	1,508	274.1		
4A Baltimore	90.1-2004	683	114	176	55	867	0	142	0	0	0	0	195	61	2,293	416.8	19%	30%
	90.1-2010	495	75	74	23	864	0	79	0	0	0	0	195	60	1,865	339.0		
4B Albuquerque	90.1-2004	427	99	176	55	867	0	248	0	0	0	0	190	61	2,123	385.8	21%	36%
	90.1-2010	307	62	73	23	864	0	92	0	0	0	0	190	60	1,671	303.7		
4C Salem	90.1-2004	687	35	176	55	867	0	134	0	0	0	0	206	60	2,221	403.7	20%	34%
	90.1-2010	439	25	74	24	864	0	77	0	0	0	0	206	59	1,767	321.2		
5A Chicago	90.1-2004	949	78	176	55	867	0	139	0	0	0	0	214	60	2,539	461.5	19%	29%
	90.1-2010	695	53	74	24	864	0	79	0	0	0	0	214	59	2,063	374.9		
5B Boise	90.1-2004	705	71	176	55	867	0	232	0	0	0	0	211	60	2,376	431.9	21%	33%
	90.1-2010	526	41	73	23	864	0	86	0	0	0	0	211	59	1,884	342.3		
5C Vancouver	90.1-2004	788	7	176	55	867	0	114	0	0	0	0	214	60	2,282	414.7	20%	33%
	90.1-2010	502	8	75	24	864	0	70	0	0	0	0	214	59	1,816	330.0		
6A Burlington	90.1-2004	1,172	52	176	55	867	0	130	0	0	0	0	231	60	2,744	498.7	18%	27%
	90.1-2010	880	31	74	24	864	0	75	0	0	0	0	231	59	2,238	406.8		
6B Helena	90.1-2004	919	42	176	55	867	0	222	0	0	0	0	234	60	2,575	468.0	19%	29%
	90.1-2010	711	25	73	23	864	0	85	0	0	0	0	234	58	2,075	377.1		
7 Duluth	90.1-2004	1,461	29	176	55	867	0	130	0	0	0	0	259	59	3,037	552.0	16%	23%
	90.1-2010	1,169	17	74	24	864	0	75	0	0	0	0	259	58	2,540	461.6		
8 Fairbanks	90.1-2004	2,220	12	176	55	867	0	122	0	0	0	0	293	58	3,803	691.2	16%	21%
	90.1-2010	1,800	7	75	24	864	0	72	0	0	0	0	293	57	3,193	580.3		

F.15 Mid-Rise Apartment Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	2	401	95	69	491	0	200	0	0	0	0	175	0	1,433	42.5	10%	15%
	90.1-2010	1	314	99	38	485	0	182	0	0	0	0	175	0	1,294	38.4		
1B Riyadh	90.1-2004	6	430	95	69	491	0	290	0	0	0	0	161	0	1,542	45.7	11%	16%
	90.1-2010	4	332	99	38	485	0	253	0	0	0	0	161	0	1,373	40.7		
2A Houston	90.1-2004	117	286	95	69	491	0	212	0	0	0	0	207	0	1,477	43.8	14%	20%
	90.1-2010	62	216	99	38	485	0	170	0	0	0	0	207	0	1,277	37.8		
2B Phoenix	90.1-2004	44	346	95	69	491	0	264	0	0	0	0	188	0	1,497	44.4	14%	21%
	90.1-2010	20	248	99	38	485	0	207	0	0	0	0	188	0	1,286	38.1		
3A Memphis	90.1-2004	192	218	95	69	491	0	194	0	0	0	0	232	0	1,491	44.2	12%	18%
	90.1-2010	134	161	99	38	485	0	160	0	0	0	0	232	0	1,309	38.8		
3B El Paso	90.1-2004	72	214	95	69	491	0	218	0	0	0	0	223	0	1,383	41.0	11%	17%
	90.1-2010	48	155	99	38	485	0	181	0	0	0	0	223	0	1,229	36.4		
3C San Francisco	90.1-2004	103	58	95	69	491	0	190	0	0	0	0	259	0	1,265	37.5	12%	20%
	90.1-2010	59	37	99	38	485	0	131	0	0	0	0	259	0	1,108	32.8		
4A Baltimore	90.1-2004	397	137	95	69	491	0	181	0	0	0	0	263	0	1,632	48.4	12%	17%
	90.1-2010	270	114	99	38	485	0	167	0	0	0	0	263	0	1,435	42.5		
4B Albuquerque	90.1-2004	191	144	95	69	491	0	211	0	0	0	0	258	0	1,458	43.2	10%	15%
	90.1-2010	119	121	99	38	485	0	194	0	0	0	0	258	0	1,314	38.9		
4C Salem	90.1-2004	295	67	95	69	491	0	176	0	0	0	0	276	0	1,468	43.5	10%	15%
	90.1-2010	198	59	99	38	485	0	163	0	0	0	0	276	0	1,318	39.1		
5A Chicago	90.1-2004	634	106	95	69	491	0	180	0	0	0	0	284	0	1,859	55.1	13%	18%
	90.1-2010	448	89	99	38	485	0	166	0	0	0	0	284	0	1,610	47.7		
5B Boise	90.1-2004	387	96	95	69	491	0	202	0	0	0	0	280	0	1,619	48.0	11%	16%
	90.1-2010	268	82	99	38	485	0	186	0	0	0	0	280	0	1,439	42.6		
5C Vancouver	90.1-2004	388	43	95	69	491	0	155	0	0	0	0	284	0	1,526	45.2	11%	16%
	90.1-2010	270	42	99	38	485	0	145	0	0	0	0	284	0	1,364	40.4		
6A Burlington	90.1-2004	762	74	95	69	491	0	172	0	0	0	0	303	0	1,966	58.3	13%	17%
	90.1-2010	563	65	99	38	485	0	159	0	0	0	0	303	0	1,713	50.8		
6B Helena	90.1-2004	560	67	95	69	491	0	198	0	0	0	0	306	0	1,785	52.9	11%	16%
	90.1-2010	412	59	99	38	485	0	184	0	0	0	0	306	0	1,583	46.9		
7 Duluth	90.1-2004	1,044	51	95	69	491	0	191	0	0	0	0	333	0	2,273	67.4	18%	22%
	90.1-2010	720	42	99	38	485	0	155	0	0	0	0	333	0	1,873	55.5		
8 Fairbanks	90.1-2004	1,276	38	95	69	491	0	187	0	0	0	0	370	0	2,525	74.8	11%	13%
	90.1-2010	1,069	32	99	38	485	0	159	0	0	0	0	370	0	2,251	66.7		

F.16 High-Rise Apartment Energy Saving Results

Zone	Standard	Heating [MMBtu]	Cooling [MMBtu]	Interior Lights [MMBtu]	Exterior Lights [MMBtu]	Interior Equipment [MMBtu]	Exterior Equipment [MMBtu]	Fans [MMBtu]	Pumps [MMBtu]	Heat Rejection [MMBtu]	Humidifi-cation [MMBtu]	Heat Recovery [MMBtu]	Water Heater [MMBtu]	Refrigera-tion [MMBtu]	Total Energy [MMBtu]	EUI [kBtu/sf]	Energy Savings [%]	Energy Savings w/o PlugLoad [%]
1A Miami	90.1-2004	1	1,455	222	193	1,113	0	479	69	62	0	0	463	0	4,057	48.1	4%	5%
	90.1-2010	0	1,400	228	148	1,093	0	450	54	60	0	0	463	0	3,896	46.2		
1B Riyadh	90.1-2004	1	1,477	222	190	1,113	0	742	71	42	0	0	428	0	4,288	50.8	6%	8%
	90.1-2010	1	1,398	228	145	1,093	0	648	53	40	0	0	428	0	4,034	47.8		
2A Houston	90.1-2004	264	1,009	222	192	1,113	0	508	69	43	0	0	546	0	3,965	47.0	10%	14%
	90.1-2010	110	948	228	146	1,093	0	415	49	40	0	0	545	0	3,574	42.4		
2B Phoenix	90.1-2004	60	1,143	222	190	1,113	0	633	73	37	0	0	498	0	3,970	47.1	10%	13%
	90.1-2010	14	1,022	228	145	1,093	0	504	49	33	0	0	498	0	3,585	42.5		
3A Memphis	90.1-2004	470	766	222	189	1,113	0	463	65	31	0	0	610	0	3,929	46.6	10%	14%
	90.1-2010	279	703	228	144	1,093	0	392	47	28	0	0	609	0	3,524	41.8		
3B El Paso	90.1-2004	111	764	222	191	1,113	0	521	53	23	0	0	588	0	3,586	42.5	8%	12%
	90.1-2010	51	691	228	145	1,093	0	442	37	21	0	0	588	0	3,295	39.1		
3C San Francisco	90.1-2004	164	171	222	189	1,113	0	467	47	6	0	0	679	0	3,058	36.2	11%	18%
	90.1-2010	59	145	228	144	1,093	0	329	27	5	0	0	678	0	2,708	32.1		
4A Baltimore	90.1-2004	1,028	491	222	188	1,113	0	432	59	19	0	0	689	0	4,240	50.3	12%	16%
	90.1-2010	616	503	228	143	1,093	0	406	46	19	0	0	688	0	3,742	44.4		
4B Albuquerque	90.1-2004	411	509	222	189	1,113	0	504	47	15	0	0	676	0	3,687	43.7	8%	11%
	90.1-2010	199	539	228	144	1,093	0	474	37	16	0	0	675	0	3,404	40.4		
4C Salem	90.1-2004	689	243	222	185	1,113	0	424	49	8	0	0	722	0	3,655	43.3	10%	14%
	90.1-2010	399	269	228	141	1,093	0	400	38	9	0	0	721	0	3,297	39.1		
5A Chicago	90.1-2004	1,680	387	222	185	1,113	0	445	60	14	0	0	743	0	4,851	57.5	14%	19%
	90.1-2010	1,078	402	228	141	1,093	0	408	46	15	0	0	743	0	4,153	49.2		
5B Boise	90.1-2004	934	340	222	185	1,113	0	484	49	10	0	0	733	0	4,070	48.3	11%	15%
	90.1-2010	566	365	228	141	1,093	0	455	38	11	0	0	733	0	3,629	43.0		
5C Vancouver	90.1-2004	919	158	222	182	1,113	0	383	43	5	0	0	744	0	3,769	44.7	11%	15%
	90.1-2010	565	195	228	139	1,093	0	363	34	6	0	0	744	0	3,367	39.9		
6A Burlington	90.1-2004	1,962	270	222	184	1,113	0	419	53	10	0	0	792	0	5,026	59.6	14%	18%
	90.1-2010	1,330	295	228	140	1,093	0	393	42	11	0	0	791	0	4,323	51.2		
6B Helena	90.1-2004	1,325	240	222	183	1,113	0	481	45	7	0	0	799	0	4,417	52.4	11%	15%
	90.1-2010	888	268	228	140	1,093	0	454	35	8	0	0	798	0	3,912	46.4		
7 Duluth	90.1-2004	2,756	192	222	183	1,113	0	503	59	7	0	0	869	0	5,904	70.0	20%	25%
	90.1-2010	1,741	196	228	140	1,093	0	386	38	7	0	0	868	0	4,697	55.7		
8 Fairbanks	90.1-2004	3,000	142	222	159	1,113	0	477	48	4	0	0	963	0	6,128	72.6	13%	16%
	90.1-2010	2,315	148	228	121	1,093	0	405	33	4	0	0	962	0	5,310	62.9		

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