U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING ENERGY CODES PROGRAM

Impacts of Standard 90.1-2007 for Commercial Buildings at State Level

September 2009

Prepared by Pacific Northwest National Laboratory
for the U.S. Department of Energy Building Energy Codes Program

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Executive Summary

The Building Energy Codes Program (BECP) recently conducted a nationwide commercial energy code analysis for the U.S. Department of Energy (DOE). The analysis compares ANSI/ASHRAE/IESNA[1] Standard 90.1-2007 with the commercial code in each state as of June 2009. The results are provided in this report in chapters specific to each state.

Standard 90.1-2007 was chosen for this analysis because it is the baseline energy standard established in the American Recovery and Reinvestment Act of 2009 and the subject of DOE's forthcoming determination of energy savings for Standard 90.1. An overview of Standard 90.1-2007, as well as a brief comparison to previous versions, is provided as introductory information.

States with unique energy codes were not included in the analysis as the codes in these states would be difficult to appropriately compare to Standard 90.1 and most of these states have energy offices that routinely assess their codes against the national codes. In states with codes prior to and including the 2000 IECC or Standard 90.1-1999, those states with no statewide energy code, and home rule states which did not specifically request that another code be used, Standard 90.1-1999 was used as the baseline for comparison. Standard 90.1-1999 was chosen as the default baseline because BECP believes it fairly represents current construction practice in states with older codes or no codes.

Three DOE Benchmark buildings were used for the simulation used in this analysis: a medium office building (53,600 ft^2), a mid-rise apartment building (33,700 ft^2), and a non-refrigerated warehouse (49,500 ft^2)—representing the Standard 90.1 nonresidential, residential, and semiheated requirements, respectively. The buildings are described in further detail in the report, and in Appendix A.

Locations for the analysis were selected based on obtaining a sample representative of each climate zone in the state, where TMY2 weather file locations existed, making sure to include the state capital. In the absence of a TMY2 weather file for a particular climate zone in a state, a representative location in an adjacent state was used for the purposes of the simulation. These locations, and the full results of each state specific analysis completed by BECP, are provided in the following report.[2]

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

[2] DISCLAIMER: The results contained in these reports are complete and accurate to the best of BECP's knowledge, based on information available at the time it was written.

1.0 Introduction

This report describes the results of a nationwide commercial energy code analysis undertaken by the Building Energy Codes Program (BECP) for the U.S. Department of Energy (DOE). The task involved comparing each state's current commercial energy code[3] to ANSI/ASHRAE/IESNA[4] Standard 90.1-2007 (Standard 90.1-2007). State-specific results are provided in separate chapters.

The commercial comparison is made to Standard 90.1-2007 because that is the baseline commercial energy standard established in the American Recovery and Reinvestment Act of 2009. Standard 90.1-2007 will also soon be the subject of DOE's latest determination of energy savings for Standard 90.1.

2.0 Overview of Standard 90.1-2007

Standard 90.1-2007 sets requirements for the cost-effective use of energy in commercial buildings. Certain buildings that have very low energy use, such as buildings with no heating or cooling, are exempt. Standard 90.1-2007 applies to new buildings and to alterations and additions to existing buildings.

Table 1 shows the organization of Standard 90.1-2007. Most of the actual requirements are contained in Sections 5-10.

Table 1. Standard 90.1-2007 Table of Contents

1 – Purpose
2 – Scope
3 – Definitions, Abbreviations, and Acronyms
4 – Administration and Enforcement
5 – Building Envelope
6 – Heating, Ventilating, and Air Conditioning
7 – Service Water Heating
8 – Power
9 – Lighting
10 – Other Equipment
11 – Energy Cost Budget Method
12 – Normative References
Appendices

Sub-section numbers are standardized across the requirements sections. For example, sub-section 4 (x.4) is always the Mandatory Requirements. Table 2 shows the basic organization of the sub-sections used in Sections 5-10, although not all sub-sections are used in every Section.

[3] Defined as the commercial energy code in effect on January 1, 2009, and referred to as the "base code". Exceptions to this definition are noted in the individual state chapters.
[4] The American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers/Illuminating Engineering Society of North America

Table 2. Organization of Sub-Sections

x.1 – General
x.2 – Compliance Paths
x.3 – Simple Buildings or Systems
x.4 – Mandatory Requirements
x.5 – Prescriptive Requirements
x.6 – Alternative Compliance Paths
x.7 – Submittals
x.8 – Products

3.0 Comparison to Previous Versions of Standard 90.1

The first Standard 90.1 was published in 1975, with revisions released in 1980, 1989, and 1999. Standard 90.1 was placed under continuous maintenance in 1999 which allowed the Standard to be updated with publication of approved addenda. Beginning with Standard 90.1-2001, the Standard moved to a three-year publication cycle.

Substantial revisions to the Standard have occurred since 1989. One major change was a complete revision of the climate zones in 2004. These revised climates zones are shown in Figure 1.

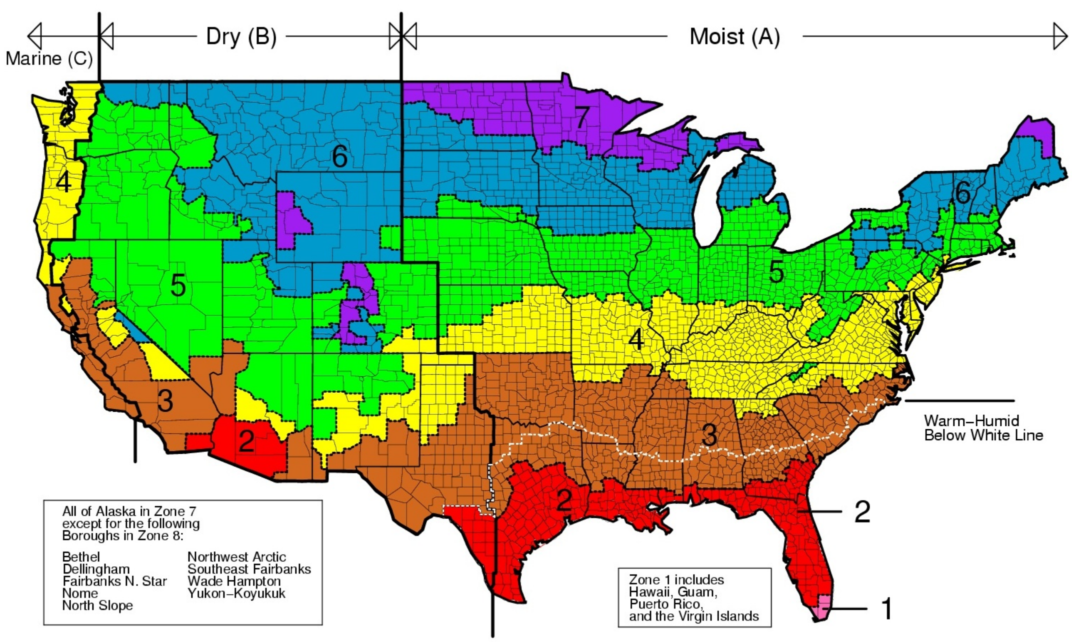

Figure 1. Climate Zones

Some of the significant requirements in Standard 90.1-2007 include:

- Stringent building insulation requirements
- Simplified fenestration requirements excluding orientation and window wall ratio
- Demand control ventilation requirements for spaces with an occupant density greater than 40 people per 1000 ft^2
- Separate simple and complex mechanical requirements.

4.0 Energy Analysis Assumptions

An energy analysis was conducted comparing each state's base code to Standard 90.1-2007. The EnergyPlus software was used to determine the energy impacts. EnergyPlus was developed by the U.S. Department of Energy[5] (DOE).

4.1 State Base Codes

States with unique energy codes (i.e., those that do not adopt/amend the International Energy Conservation Code® [IECC] or Standard 90.1) were not included in the analysis. This decision was made by DOE for two reasons: 1) these states generally have codes that have little resemblance to Standard 90.1, making a thorough comparison beyond the scope of this effort, and 2) most of these states have highly capable energy offices that routinely assess their codes against the national codes. However, states that were not included in the original analysis may request to be considered for a similar analysis by contacting BECP at techsupport@becp.pnl.gov.

In some cases, decisions about base codes needed to be made. For example, all versions of the IECC include two compliance options for commercial buildings: the commercial requirements in the IECC and Standard 90.1. Since there can only be one base code in the analysis, if a state specifically adopts the IECC as its commercial code, the commercial requirements from the applicable IECC were used in the analysis. There are several states with older commercial codes[6]. For states with codes prior to and including the 2000 IECC or Standard 90.1-1999, Standard 90.1-1999 was used as the base code.

Standard 90.1-1999 was chosen as the baseline construction for states with older codes because it has been around long enough (about 10 years) to allow many of the concepts and requirements embodied in it to become common practice in the construction industry. Standard 90.1-1999 also represents a major change in ASHRAE standards, coming ten years after the previous version of Standard 90.1. Standard 90.1-1999 is old enough that states considering adoption of Standard 90.1-2007 will still see significant savings, but not so old that states will be misled by the savings shown in this report. Keeping with the concept of Standard 90.1-1999 as "common practice" in the construction industry, Standard 90.1-1999 was also used as the base code for states with no state-wide commercial energy code. Some home rule states[7] requested a specific code be used in the analysis; for all other home rule states Standard 90.1-1999 was used as the base code.

[5] EnergyPlus is available and discussed in more detail at http://apps1.eere.energy.gov/buildings/energyplus/
[6] Examples include codes based on 90A90B, 90.1-1989, and the 1992 Model Energy Code.
[7] In home rule states, codes are adopted and enforced on a local level.

4.2 Benchmark Buildings

Three DOE Benchmark buildings[8] were used for the simulation: a medium office building, a mid-rise apartment building, and a non-refrigerated warehouse (semiheated). These three building types represent the Standard 90.1 nonresidential, residential, and semiheated requirements, respectively. For states that have adopted a newer version of Standard 90.1 (1999 or later), the three types of envelope requirements were compared directly. For states that have adopted a version of the IECC that contains only a single set of commercial envelope requirements (any version prior to the 2009 IECC), the medium office and mid-rise apartment buildings were modeled using the single set of IECC requirements. The warehouse building was modeled using the semiheated envelope requirements from the reference standard version of Standard 90.1 incorporated in the version of the IECC under consideration. DOE assumes that any designer of a warehouse that would truly be considered semiheated within Standard 90.1 would be motivated to use the Standard 90.1 semiheated envelope requirements as allowed by the IECC.

Use of the IECC requirements for semiheated values in a comparison with Standard 90.1-2007 would lead to the awkward conclusion that the IECC is more stringent. This is true in the sense that use of more insulation in semiheated buildings will save some energy. However, because Standard 90.1-2007 is the designated comparison and it has separate semiheated envelope requirements, DOE chose to compare those semiheated requirements in the ASHRAE reference standard to the IECC.

The medium office has a gross area of 53,600 ft^2, three floors, and a window-to-wall ratio (WWR) of 33%. The HVAC systems are assumed to be a gas furnace and a packaged DX unit. The walls are modeled as steel frame walls, and the roof as insulation entirely above deck.

The mid-rise apartment building has a gross area of 33,700 ft^2, four floors, and a WWR of 15%. The assumed heating system is a gas furnace, with one split DX system assumed to provide cooling for each apartment. The walls are modeled as steel frame walls, and the roof as insulation entirely above deck.

The semiheated warehouse has a gross area of 49,500 ft^2, one floor, and no windows in the storage area. Limited heating is provided by unit heaters and no cooling is provided. The walls and roof are modeled as metal building walls and roof.

The DOE Benchmark buildings are also further described in Appendix A.

Equipment efficiencies are assumed to be the current Federal requirements for all codes. While older codes may have older (lower) equipment efficiencies listed in them, equipment that meets the requirements of these old codes may no longer be manufactured or imported into the United States. Thus, this equipment is typically not available. There are some pieces of HVAC equipment that are not covered by the Federal requirements (notably, chillers), but the HVAC equipment modeled in the three benchmark buildings used in the analysis is covered by the Federal requirements.

The HVAC system for the medium office building is simulated with an economizer when required by the code. By default, the economizer requirements are based on Table 6.5.1 in Standard 90.1-2004. A design day simulation was done in all climate zones to determine the cooling capacity and the economizer requirement. The typical cooling capacity in the medium office building exceeds 135,000 Btu/h in all climate zones. Table 3 shows the economizer requirement for representative locations in the various climate zones. The building

[8] The Benchmark buildings are available at and discussed in more detail at http://www1.eere.energy.gov/buildings/commercial_initiative/benchmark_models.html.

simulation assumes that the economizer high limit shutoff will be controlled by differential dry bulb temperature, a control option allowed by the Standard. Under this control scenario, when the outdoor air temperature is below both the return air temperature and the high ambient shutoff temperature, the economizer is enabled.

Table 3. Economizer Requirements in Standard 90.1-2004

Climate Zone	Representative City	Economizer Requirement
1A	Miami	No
2A	Houston	No
2B	Phoenix	Yes
3A	Atlanta	No
3B	Los Angeles	Yes
3C	San Francisco	Yes
4A	Baltimore	No
4B	Albuquerque	Yes
4C	Seattle	Yes
5A	Chicago	Yes
5B	Denver	Yes
6A	Minneapolis	Yes
6B	Helena	Yes
7	Duluth	Yes
8	Fairbanks	Yes

4.3 The 2003 IECC and Lighting Power Density

Over the two decades of commercial energy code development, changes in allowable lighting power density have been one of the most important drivers of energy efficiency. As an example, Table 4 shows the allowable interior lighting power densities for the three buildings used in this analysis. Similar differences in requirements for other building types can also be listed.

Table 4. Comparison of Lighting Power Density Requirements

Standard/Code Version	Allowable Interior Lighting Power Density (whole building) – watts per square foot		
	Office	Mid-Rise Apartment	Warehouse
Standard 90.1.1989, 1998 IECC, 2000 IECC	1.5 to 1.9	Apartment lighting not covered, Multifamily not listed	0.4 to 0.8
Standard 90.1-1999, Standard 90.1-2001	1.3	Apartment lighting not covered, Multifamily 1.0	1.2
Standard 90.1-2004, Standard 90.1-2007, 2003 IECC, 2006 IECC, 2009 IECC	1.0	Apartment lighting not covered, Multifamily 0.7	0.8

The issue with the 2003 IECC is that it uses Standard 90.1-2001 as its reference standard. The 2003 IECC contains the low lighting power densities exemplified by the 1.0 watt per square foot value in the actual text of Chapter 8. But the 2003 IECC also allows the use of Standard 90.1-2001 under the provisions of Chapter 7. And Standard 90.1-2001 has the mid-range interior lighting power densities exemplified by the 1.3 watts per square foot value. No other version of the IECC has as significant a discontinuity between the requirements of the IECC and the requirements of the ASHRAE reference standard.

For this analysis, the requirements of the 2003 IECC were used. While lighting designers may very well have discovered this discontinuity, the use of the 2003 requirements provide a conservative estimate of the savings associated with adoption of Standard 90.1-2007. Use of Standard 90.1-2001 lighting densities as the baseline would simply increase the savings.

The simulation models for nonresidential and semiheated buildings use the lighting power density requirements for office and warehouse, depending on the activity type of the thermal zone. In the case of the residential building model, the lighting power density is not regulated in older codes and is assumed to be 0.36 W/sf in apartment units based on the Building America benchmark model. The office area and corridor lighting requirements in the residential building model are based on Standard 90.1-2004 requirements.

4.4 Selected Locations

The approach used to select representative locations for the analysis first focused on the goal of having one location to represent each climate zone within a state, with one of the locations being the state capital. TMY2 weather file locations were used. When a climate zone in a state was not represented by a TMY2 weather file location in that state, a representative location in an adjacent state was selected to represent the climate zone for purposes of the simulation. However, a representative city within the actual state is referenced in the report tables. A listing of the selected locations is shown below.

State	Location	Climate Zone	State	Location	Climate Zone
AL	Mobile	2A	NE	Omaha	5A
AL	Montgomery	3A	NV	Las Vegas	3B
AK	Anchorage	7	NV	Reno	5B
AK	Fairbanks	8	NH	Manchester	5A
AR	Little Rock	3A	NH	Concord	6A
AR	Fayetteville	4A	NJ	Newark	4A
AZ	Phoenix	2B	NJ	Paterson	5A
AZ	Sierra Vista	3B	NM	Las Cruces	3B
AZ	Prescott	4B	NM	Albuquerque	4B
AZ	Flagstaff	5B	NY	New York City	4A
CO	La Junta	4B	NY	Albany	5A
CO	Boulder	5B	NY	Binghamton	6A
CO	Eagle	6B	NM	Santa Fe	5B
CO	Alamosa	7B	NC	Charlotte	3A
CT	Hartford	5A	NC	Raleigh	4A
DE	Wilmington	4A	NC	Boone	5A
DC	Washington DC	4A	ND	Bismarck	6A
GA	Savannah	2A	ND	Minot	7
GA	Atlanta	3A	OH	Cincinnati	4A
GA	Rome	4A	OH	Columbus	5A
HI	Honolulu	1A	OK	Oklahoma City	3A
ID	Boise	5B	OK	Guymon	4A
ID	Pocatello	6B	PA	Philadelphia	4A
IL	Belleville	4A	PA	Harrisburg	5A
IL	Springfield	5A	PA	Bradford	6A
IN	Evansville	4A	RI	Providence	5A
IN	Indianapolis	5A	SC	Columbia	3A
IA	Des Moines	5A	SD	Yankton	5A
IA	Mason City	6A	SD	Pierre	6A
KS	Topeka	4A	TN	Memphis	3A
KS	Goodland	5A	TN	Nashville	4A
KY	Lexington	4A	TX	Austin	2A
LA	Baton Rouge	2A	TX	Houston	2B
LA	Shreveport	3A	TX	El Paso	3A
ME	Portland	6A	TX	Fort Worth	3B
ME	Caribou	7	TX	Amarillo	4B
MD	Baltimore	4A	UT	Saint George	3B
MD	Mtn. Lake Park	5A	UT	Salt Lake City	5B
MA	Boston	5	UT	Logan	6B
MI	Lansing	5A	VT	Burlington	6A
MI	Alpena	6A	VA	Richmond	4A
MI	Sault Ste. Marie	7	WV	Charleston	4A
MN	St. Paul	6A	WV	Elkins	5A
MN	Duluth	7	WI	Madison	6A
MS	Biloxi	2A	WI	Superior	7
MS	Jackson	3A	WY	Torrington	5B
MO	Saint Louis	4A	WY	Cheyenne	6B
MO	St. Joseph	5A	WY	Rock Springs	7B
MT	Helena	6B			

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Impacts of Standard 90.1-2007 on Commercial Buildings in Maryland

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Maryland

Summary

Standard 90.1-2007 contains improvements in energy efficiency over the current state code, the 2006 International Energy Conservation Code (IECC)[1]. Standard 90.1-2007 would improve energy efficiency in commercial buildings in Maryland. The analysis of the impact of Standard 90.1-2007 resulted in energy and cost savings.

Main Differences Between the Current State Code and Standard 90.1-2007

The 2006 IECC is the most commonly adopted commercial building energy code at the time this report was written. The reference standard for the 2006 IECC is Standard 90.1-2004 and the 2006 IECC shares many features with Standard 90.1-2004. However, the 2006 IECC was created slightly later than Standard 90.1-2004 and thus was able to benefit from changes to Standard 90.1 being contemplated for Standard 90.1-2007. The 2006 IECC is widely considered to be slightly more stringent due to the later creation date in addition to the differences in the development process at ASHRAE and ICC.

- Less strict requirements for vestibules in cold climates in Standard 90.1-2007.
- A requirement for demand controlled ventilation in high occupancy spaces in Standard 90.1-2007.
- Fan power limitation in Standard 90.1-2007.
- Revision of the additional lighting power allowance for retail displays to lower the allowance for some categories of merchandise in Standard 90.1-2007.
- Lack of residential and semiheated space requirements in the 2006 IECC. (However, these are available by way of the ASHRAE reference standard, Standard 90.1-2004.)
- Lack of a detailed space-by-space lighting design method in the 2006 IECC. (However, this is available by way of the ASHRAE reference standard, Standard 90.1-2004).
- More stringent economizer requirements in colder climates in Standard 90.1-2007.

A comparison of the thermal envelope requirements is provided in Table 1.

[1] Maryland's new code, the 2009 IECC, becomes effective October 2009.

Table 1. Comparison of Envelope Requirements (U-factors in Btu/hr.ft2.°F)

	Climate Zone 4A		Climate Zone 5A	
	IECC 2006	90.1-2007	IECC 2006	90.1-2007
Nonresidential				
Exterior Wall	0.125	0.064	0.085	0.064
Roof	0.063	0.048	0.048	0.048
Slab	NR	NR	NR	NR
Window*	0.57 (0.39)	0.52 (0.40)	0.57 (0.39)	0.48 (0.40)
Residential				
Exterior Wall	0.125	0.064	0.085	0.064
Roof	0.063	0.048	0.048	0.048
Slab	NR	R-10/2ft.	NR	R-10/2ft.
Window*	0.57 (0.39)	0.52 (0.40)	0.57 (0.39)	0.48 (0.40)
Semiheated				
Exterior Wall	0.134	0.134	0.123	0.123
Roof	0.097	0.097	0.097	0.097
Slab	NR	NR	NR	NR
*Window SHGC shown in parentheses next to the U-factor				

Energy Analysis

An energy analysis was conducted comparing each state's base code to Standard 90.1-2007. The EnergyPlus software was used to determine the energy impacts. Summary savings results are shown below by building type. Results are shown for the electricity and natural gas energy use intensity (in kWh/sf-year and kBtu/sf-year, respectively) for both the base code and Standard 90.1-2007. Results are also shown for the percent reduction of overall site energy usage and energy cost from the base case to Standard 90.1-2007. The energy cost savings are estimated using national average energy costs of $0.0939 per kWh for electricity and $1.2201 per therm for natural gas. Presentation of the individual results for electricity and natural gas usage allows interested parties to calculate source energy or energy cost savings based on state (rather than national average) fuel prices. Total annual energy usage for the three building prototypes may be calculated by multiplying the energy use intensity numbers by the square footage of the prototype building.

Maryland Energy End Use and Percentage Savings							
		Energy Use Intensity				***Savings 90.1-2007 vs. IECC 2006***	
		IECC 2006		**90.1-2007**			
Building Prototype	**Location**	Electricity (kWh/sf/yr)	Natural Gas (kBtu/sf/yr)	Electricity (kWh/sf/yr)	Natural Gas (kBtu/sf/yr)	Energy	Cost
Nonresidential	Baltimore	12.46	5.19	11.86	4.62	5.5%	5.1%
Residential	Baltimore	9.24	15.40	9.03	11.36	10.2%	6.6%
Semiheated	Baltimore	4.34	13.69	4.33	13.54	0.5%	0.3%
Nonresidential	Mountain Lake Park	11.55	6.42	11.23	5.58	4.2%	3.5%
Residential	Mountain Lake Park	8.81	14.97	8.79	12.63	5.3%	3.0%
Semiheated	Mountain Lake Park	4.32	15.29	4.32	15.17	0.4%	0.3%

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Appendix A – Prototype Building Descriptions

Table A-1: Nonresidential Prototype Building Characteristics

Characteristic		Prototype Building Model Description
GENERAL		
	Building Type	Medium Office
	Gross Floor Area	53,600 ft^2
	Building Shape	Rectangle
	Aspect Ratio	1.5 (164 ft x 109 ft)
	Number of Floors	3
	Window-to-Wall Ratio	33% (modeled as strip windows of 5 ft. high)
	Floor Height	13 ft
	Floor-to-Ceiling Height	9 ft
	Exterior Wall	Steel-framed wall
	Roof	Insulation entirely above deck, metal deck roof
	Floor	8” Slab-on-grade
INTERNAL LOADS		
	Occupancy	
	Number of People	5 persons / 1000 sf
	Lighting	
	Power Density	1.0 w/sf
	Plug Load	
	Average Power Density	0.75 w/sf
HVAC		
	Heating Type	Gas furnace
	Cooling Type	Packaged DX Unit
	Fan Control	Variable air volume
	Distribution/Terminal Units	VAV terminal box with electric reheating coil
	Cooling T-stat	75°F (80°F setback)
	Heating T-stat	70°F (60°F setback)
SERVICE WATER HEATER		
	Water Heater Type	Electric storage water heater
	Tank Capacity, gallons	260
	Supply Temperature, °F	120

Table A-2: Residential Prototype Building Characteristics

Characteristic		Prototype Building Model Description
GENERAL		
	Building Type	Multifamily residential building
	Gross Floor Area	33,700 ft^2
	Building Shape	Rectangle
	Aspect Ratio	2.75 (152 ft x 56 ft)
	Number of Floors	4
	Activity Area	Each floor has 8 (25'x38') apartments, except ground floor which has 7 apartments and one lobby/office
	Window-to-Wall Ratio	15% (4ft high view windows)
	Floor Height	10 ft
	Floor-to-Ceiling Height	10 ft (for the office area only)
	Exterior Wall	Steel-framed wall
	Roof	Insulation entirely above deck, metal deck roof
	Floor	8" Slab-on-grade
INTERNAL LOADS		
	Occupancy	
	Number of People	78 persons total (average 2.5 persons per apartment unit)
	Lighting	
	Average Power Density	• Apartment units: 0.36 w/sf • Corridors: 0.5 w/sf • Office area: 1.1 w/sf
	Plug Load	
	Average Power Density	0.62 w/sf
HVAC		
	Heating Type	Gas furnace
	Cooling Type	Split system DX (one per apartment)
	Fan Control	Constant volume
	Distribution/Terminal Units	Single zone/direct air
	Cooling T-stat	75°F (no setback assumed)
	Heating T-stat	70°F (no setback assumed)
SERVICE WATER HEATER		
	Water Heater Type	Individual residential electric storage water heater
	Tank Capacity, gallons	20 (per apartment unit)
	Supply Temperature, °F	120

Table A-3: Semiheated Prototype Building Characteristics

Characteristic	Prototype Building Model Description
GENERAL	
Building Type	Non-refrigerated warehouse
Gross Floor Area	49,500 ft²
Building Shape	Wide rectangle
Aspect Ratio	2.2 (330 ft x 150 ft)
Number of Floors	1
Activity Area (percentage of gross floor area)	• Bulk storage area: 34,500 ft² (70%) • Fine storage area: 12,450 ft² (25%) • Office area: 2,550 ft² (5%)
Window-to-Wall Ratio	• Storage area: No windows • Office area: 12% view windows
Floor Height	28 ft
Floor-to-Ceiling Height	14 ft (for the office area only)
Exterior Wall	Metal building wall
Roof	Metal building roof
Floor	6" Slab-on-grade
Door	7 opaque doors (3'x7'), 7 roll-up dock doors (8'x10')
INTERNAL LOADS	
Occupancy	
Number of People	5 (in the office area)
Lighting	
Average Power Density	• Bulk storage area: 0.8 w/sf • Fine storage area: 0.8 w/sf • Office area: 1.0 w/sf
Plug Load	
Average Power Density	Office: 0.75 w/sf Bulk storage: 0.24 w/sf
HVAC	
Heating Type	• Bulk storage area: Unit heater • Fine storage area: Gas furnace • Office area: Gas furnace
Cooling Type	• Bulk storage area: No cooling • Fine storage area: Direct expansion • Office area: Direct expansion
Fan Control	Constant volume
Distribution/Terminal Units	Single zone/Direct air

Characteristic		Prototype Building Model Description
	Cooling T-stat	• Fine storage area: 80°F • Office area: 75°F (85°F setback)
	Heating T-stat	• Bulk storage area: 50°F • Fine storage area: 60°F • Office area: 70°F (60°F setback)
SERVICE WATER HEATER		
	Water Heater Type	Electric storage water heater
	Tank Capacity, gallons	20
	Supply Temperature, °F	120