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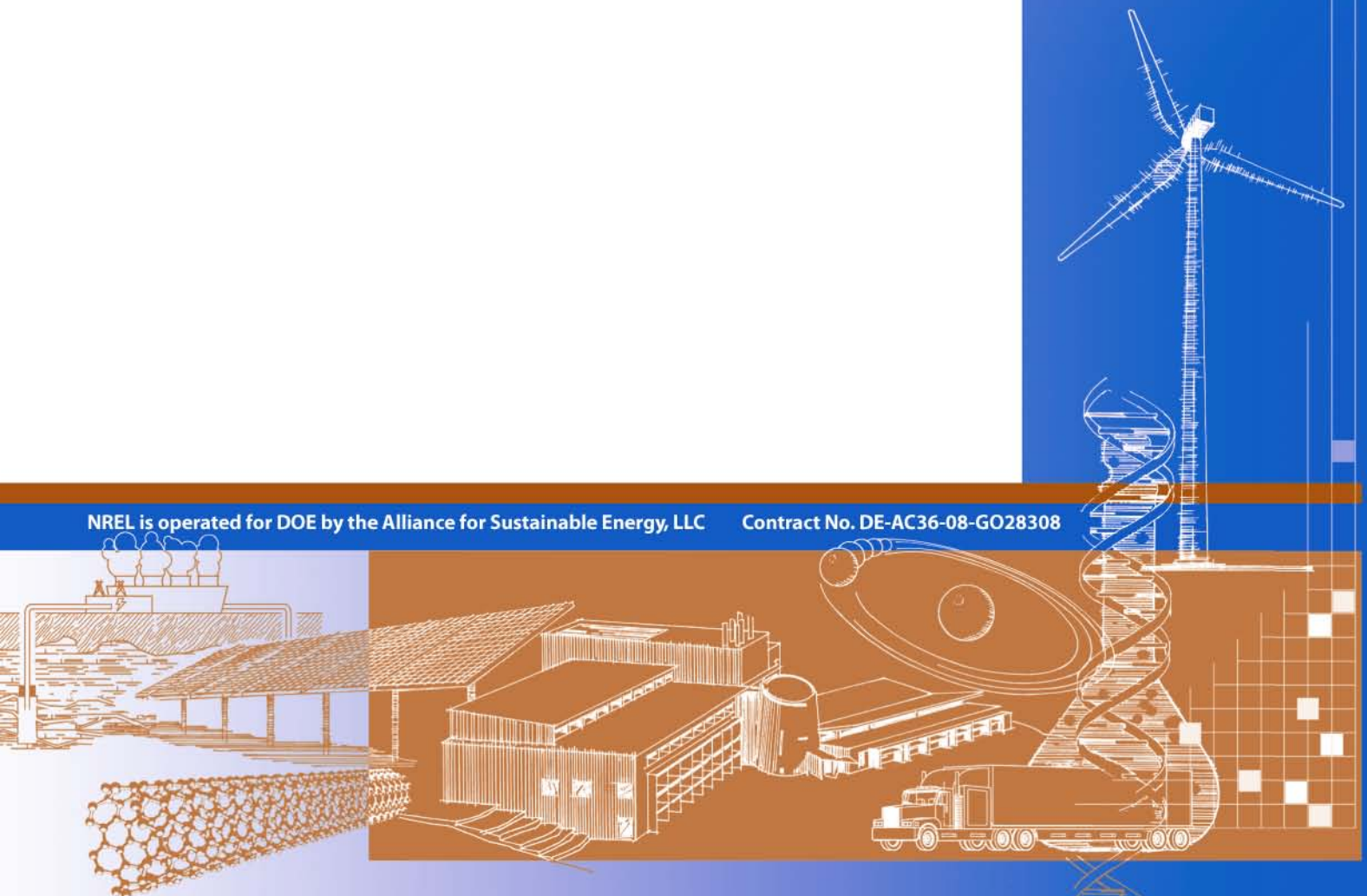
Large Hospital 50% Energy Savings: Technical Support Document

Eric Bonnema, Daniel Studer, Andrew Parker, Shanti Pless, and Paul Torcellini

Technical Report
NREL/TP-550-47867
September 2010



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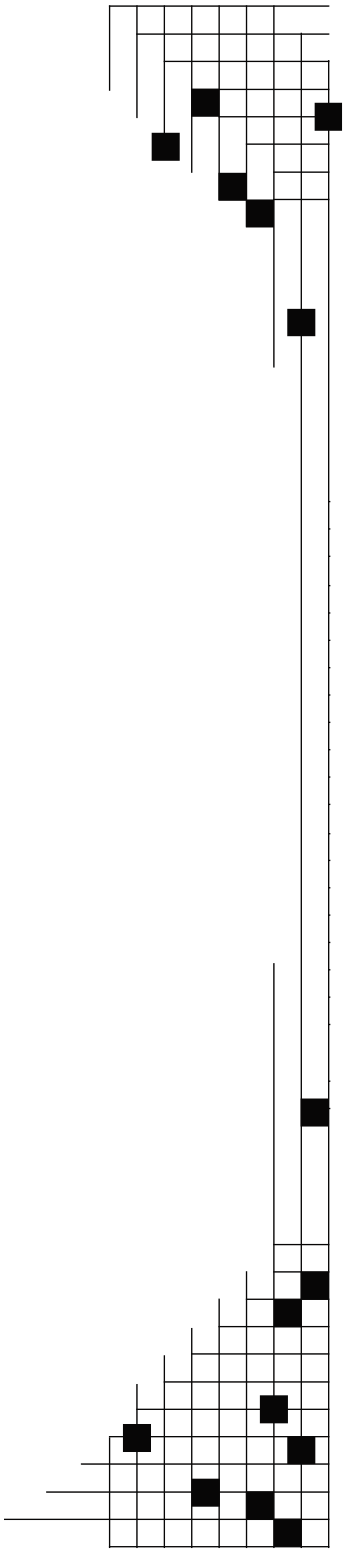
Prepared under Task No. BEC7.1309



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The authors are indebted to a number of building industry professionals for taking the time to review the analysis assumptions and earlier versions of this report. Jeff Boldt, Mike Lawless, Matt Slager, and Steve Mumm of KJWW Engineering Consultants commented on the prototype energy model and energy design measure model assumptions based on their experiences and standard practices. Jeff Boldt of KJWW Engineering Consultants, Brian Ball of NREL; Lam Vu of the U.S. Department of Veterans Affairs Office of Construction and Facilities Management; Drew Chidester and Sam McMahon of the University of Pittsburgh Medical Center; Michael Myer of the Pacific Northwest National Laboratory; John D'Angelo of the Cleveland Clinic; and Heather Burpee with the University of Washington's Integrated Design Lab reviewed an earlier draft of this report.

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Thousands of EnergyPlus simulations were run to fully debug and finalize the energy models referenced by this report. This would not have been possible without the support of the NREL High Performance Computing Center managed by Jim Albin and Wesley Jones. Additional thanks go to Torri Lopez of the NREL High Performance Computing Center for helping to install and maintain the software necessary to perform energy simulations on the Windows High Performance Computing cluster.

Finally, several other NREL colleagues provided valuable guidance and information during the modeling process, either directly or through their past work. Ian Doebber contributed insights, particularly heating, ventilation, and air conditioning insights, gained through his work on previous healthcare projects. Jennifer Scheib provided electric lighting data. Kyle Benne provided programming and automation assistance, and Brent Griffith contributed invaluable EnergyPlus modeling and debugging assistance.

Executive Summary

The Commercial Buildings Group at NREL developed this *Technical Support Document* under the direction of the U.S. Department of Energy Building Technologies Program. It documents the technical analysis performed and the resulting design guidance that will enable large hospitals to achieve whole-building energy savings of at least 50% over ANSI/ASHRAE/IESNA Standard 90.1-2004. This report also documents in detail the modeling methods used to demonstrate that the design recommendations meet or exceed the 50% energy savings goal.

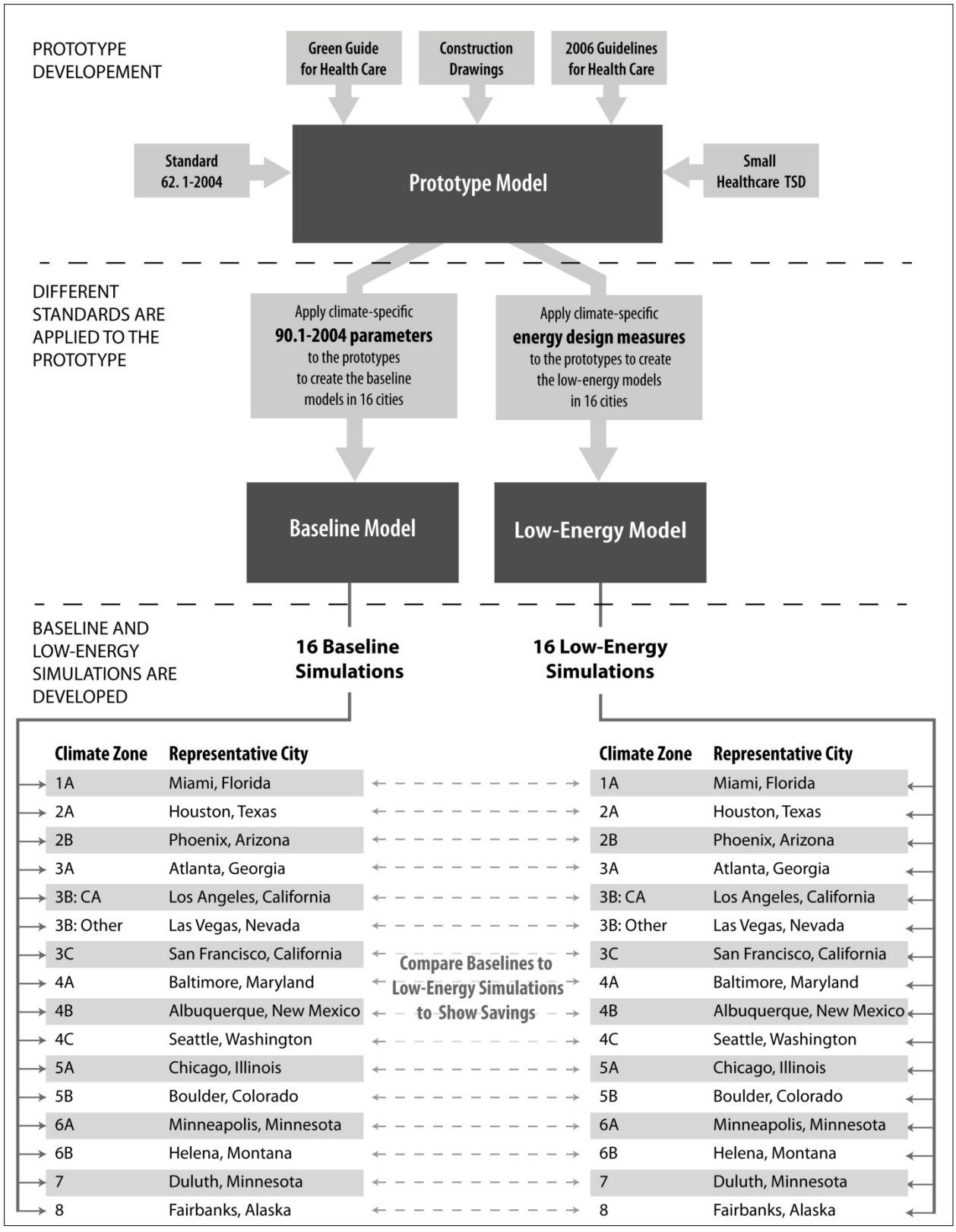
Methodology

To account for energy interactions between building subsystems, we used EnergyPlus (DOE 2010) to model the predicted energy performance of the baseline and low-energy buildings to verify that 50% energy savings are achievable in all climate zones. EnergyPlus computes building energy use based on the interactions between climate, building form and fabric, internal gains, and heating, ventilating, and air conditioning systems. The percent energy savings values presented in this document are based on a nominal minimally code-compliant building, as described in Standard 90.1-2004, and utilize a whole-building site energy use intensity metric (Torcellini et al. 2006).

The following steps were used to determine 50% savings:

1. Define architectural-program characteristics (design features not addressed by Standard 90.1-2004) for a typical large hospital, thereby defining a single prototype model.
2. Create baseline energy models for each climate zone that are elaborations of the prototype model and are compliant with Standard 90.1-2004, using industry feedback to strengthen the inputs for the baseline models.
3. Create low-energy models for each climate zone by applying a list of energy design measures to the prototype model. Utilize industry feedback to strengthen the energy design measures chosen for application.
4. Simulate the baseline and low-energy models in each climate zone to show that 50% (or greater) energy savings are achieved when the energy design measures are applied to the prototype model.

Figure ES-1 graphically shows the steps to determine 50% energy savings.



Climate Zone	Representative City	Climate Zone	Representative City
1A	Miami, Florida	1A	Miami, Florida
2A	Houston, Texas	2A	Houston, Texas
2B	Phoenix, Arizona	2B	Phoenix, Arizona
3A	Atlanta, Georgia	3A	Atlanta, Georgia
3B: CA	Los Angeles, California	3B: CA	Los Angeles, California
3B: Other	Las Vegas, Nevada	3B: Other	Las Vegas, Nevada
3C	San Francisco, California	3C	San Francisco, California
4A	Baltimore, Maryland	4A	Baltimore, Maryland
4B	Albuquerque, New Mexico	4B	Albuquerque, New Mexico
4C	Seattle, Washington	4C	Seattle, Washington
5A	Chicago, Illinois	5A	Chicago, Illinois
5B	Boulder, Colorado	5B	Boulder, Colorado
6A	Minneapolis, Minnesota	6A	Minneapolis, Minnesota
6B	Helena, Montana	6B	Helena, Montana
7	Duluth, Minnesota	7	Duluth, Minnesota
8	Fairbanks, Alaska	8	Fairbanks, Alaska

Figure ES-1 Flow diagram of modeling process
(Credit: Marjorie Schott/NREL)

The simulations supporting this work were conducted with the NREL commercial building energy analysis platform, Opt-E-Plus (NREL 2010). Opt-E-Plus is a software research tool that integrates with EnergyPlus and was used to coordinate the very large number of EnergyPlus simulations necessary for this study. Opt-E-Plus transforms user-specified, high-level building parameters stored in extensible markup language files into an EnergyPlus input file. Although Opt-E-Plus can perform whole-building optimizations, that functionality was forgone in this report because of the complexity of the large hospital energy model. Instead, Opt-E-Plus was used solely to manage the large batches of EnergyPlus simulations.

In this report, three types of models are referred to:

1. A prototype model that contains the architectural-program characteristics (design features not addressed by Standard 90.1-2004).
2. Baseline models that are created by taking the prototype model and distributing it across 16 U.S. climate zones while applying design features addressed by Standard 90.1-2004.
3. Low-energy models that are created by taking the prototype model and distributing it across 16 U.S. climate zones while applying energy design measures addressed by the TSD.

The prototype model is a 527,000 ft^2 (49,000 m^2), seven-story hospital. A 40% fraction of fenestration to gross wall area for the whole building was assumed. The prototype building has steel-frame construction and a roof with insulation above deck. Baseline heating, ventilation, and air conditioning equipment consists of central air handling units, chillers, boilers, chilled and hot water air handling unit coils, and constant air volume terminal units with hot water reheat coils.

Findings

The energy modeling results show that 50% energy savings can be achieved in large hospitals across all U.S. climate zones. Table ES-1 summarizes the percent savings for the 16 U.S. locations, which encompass all 15 U.S. climate zones, for which simulations were run.

Table ES-1 Low-Energy Model Performance

Climate Zone	Representative City	Savings
1A	Miami, Florida	50.8%
2A	Houston, Texas	52.9%
2B	Phoenix, Arizona	58.1%
3A	Atlanta, Georgia	53.0%
3B	Los Angeles, California	60.0%
3B	Las Vegas, Nevada	58.0%
3C	San Francisco, California	61.8%
4A	Baltimore, Maryland	53.6%
4B	Albuquerque, New Mexico	57.5%
4C	Seattle, Washington	58.6%
5A	Chicago, Illinois	52.2%
5B	Boulder, Colorado	56.2%
6A	Minneapolis, Minnesota	51.8%
6B	Helena, Montana	55.5%
7	Duluth, Minnesota	52.4%
8	Fairbanks, Alaska	52.6%

A comparison of energy use intensities across climate zones shows that the energy savings range from 50.6% to 61.3%. Energy savings were smallest in the humid climates (1A, 2A, 3A, 4A, 5A, and 6A) and in the extremely cold climates (7 and 8). The highest energy savings were achieved in the marine climates (3C and 4C), with relatively high energy savings achieved in the dry climates (2B, 3B, 4B, 5B, and 6B). In general, for each climate type (humid, marine, and arid) savings were seen to decrease as the climate became progressively colder.

The following energy design measures were used to attain 50% energy savings:

- Reduced lighting power densities.
- Daylighting sensors in applicable perimeter zones.
- Occupancy sensors in applicable zones.
- More insulative envelope (opaque exterior and fenestration).
- Overhangs on south-facing fenestrations.
- A multizone variable air volume dedicated outdoor air system with zone-level water-to-air heat pumps. The heat pumps shared a common condenser loop whose temperature was maintained though the use of a chiller and boiler.
- High-efficiency chillers, boilers, and water heaters.
- Demand controlled ventilation.
- More efficient pumps.
- Reduced infiltration through tighter envelope construction.
- Integration of subsystems to achieve whole-building performance.

Table ES-2 summarizes the energy design measures used to attain 50% energy savings.

Table ES-2 Recommendations to Achieve 50% Energy Savings

Item		Component	Recommendation
Envelope	Roofs	Insulation entirely above deck	R-25 c.i. to R-35 c.i., depending on climate zone
		SRI	Climate zone 1-3: 78, all other comply with Standard 90.1-2004
	Walls	Steel-framed	R-13 + R-7.5 c.i. to R-13 + R-21.6 c.i., depending on climate zone
	Slabs	Unheated	Comply with Standard 90.1
	Air Barrier	Infiltration	0.05 cfm/ft^2 of exterior wall and roof area
	Vertical fenestration	Total fenestration to gross wall area	40% max
		Thermal transmittance	U-0.20 to U-0.43, depending on climate zone
		SHGC – all types and orientations	SHGC-0.26 to SHGC-0.40, depending on climate zone
		Visible light transmittance	VLT-0.63 to VLT-0.69, depending on climate zone
		Exterior sun control (S, E, W only)	Projection factor of 0.5
Lighting	Interior lighting	Whole building interior LPD	0.88 W/ft^2
		Occupancy sensors	Installed in applicable zones
		Daylighting	400 lux continuous dimming in applicable perimeter zones
	Exterior lighting	Whole building exterior LPD	2.5 W/ft of exterior first floor façade perimeter
Operating Suite HVAC	Central air handling system	Water-cooled chiller	Variable speed, centrifugal, 7.0 COP, 44.0°F outlet temperature
		Cooling tower	Open tower, variable speed cooling tower fan
		Gas boiler	90% efficient condensing boiler, outdoor air temperature reset
		Pumps	Variable speed, 80% efficient
		Air-side economizer	Differential enthalpy controlled
HVAC	Water loop heat pump/dedicated outdoor air system	Water loop heat pump cooling efficiency	4.5 COP (15.4 EER) at 86°F
		Water loop heat pump heating efficiency	5.0 COP (17.1 EER) at 68°F
		Water loop heat pump fans	55% efficient, 0.30 in. w.c. pressure drop
		Condenser loop water-cooled chiller	Variable speed, centrifugal, 7.0 COP, 86.0°F outlet temperature
		Condenser loop cooling tower	Open tower, variable speed cooling tower fan
		Condenser loop gas boiler	90% efficient condensing boiler, 68.0°F outlet temperature
		Condenser loop economizer	Counterflow waterside economizer
		Condenser loop pumps	Variable speed, 80% efficient
		Dedicated outdoor air system fans	2.0 in. w.c. reduction over baseline central air handling system
		Dedicated outdoor air system boiler	90% efficient condensing boiler, outdoor air reset
		Dedicated outdoor air system chiller	Variable speed, centrifugal, 7.0 COP, 44.0°F outlet temperature
		Dedicated outdoor air system pumps	Variable speed, 80% efficient, 60 ft w.c.

Nomenclature

AEDG	Advanced Energy Design Guide
ACH	air changes per hour
AHU	air handling unit
AIA	American Institute of Architects
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
Btu	British thermal unit
C	Celsius, centigrade
CAV	constant air volume
CBECS	Commercial Buildings Energy Consumption Survey
CDD	cooling degree day
c.i.	continuous insulation
COP	coefficient of performance
DOAS	dedicated outdoor air system
DOE	U.S. Department of Energy
EDM	energy design measure
EER	energy efficiency ratio
EMS	energy management system
EUI	energy use intensity
F	Fahrenheit
ft	foot
gal	gallon
h	hour
HDD	heating degree day
HEA	Hospital Energy Alliance
HVAC	heating, ventilation, and air conditioning
IESNA	Illuminating Engineering Society of North America
in.	inch
LPD	lighting power density
m	meter
MOB	medical office building
NREL	National Renewable Energy Laboratory
NR	not regulated
OA	outside air
PLR	part-load ratio
RH	relative humidity
SHGC	solar heat gain coefficient
SRI	solar reflectance index
SWH	service water heating
TMY3	typical meteorological year 3
TSD	Technical Support Document
USGBC	U.S. Green Building Council
VAV	variable air volume

VLT	visible light transmittance
W	Watt
w.c.	water column
WLHP	water loop heat pump
XML	extensible markup language

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1. Introduction

This *Technical Support Document* (TSD) is a detailed compilation of the modeling assumptions, analysis techniques, and results that provide the technical basis for building design recommendations that achieve a desired level of energy savings compared to a baseline model. A series of TSDs is available for different building types and different energy savings levels; some of the TSDs have led to Advanced Energy Design Guides (AEDGs) jointly produced by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), American Institute of Architects (AIA), Illuminating Engineering Society of America (IESNA), U.S. Green Building Council (USGBC), and U.S. Department of Energy (DOE). The AEDGs are user-friendly books containing the design recommendations derived from the TSDs plus relevant case studies and best practices tips (Pless et al. 2007).

The TSDs are part of an effort to progressively facilitate the design, construction, and operation of energy-efficient buildings. The first phase concentrated on achieving 30% energy savings over Standard 90.1-2004 (ASHRAE 2004b). The second phase, which includes this TSD, provides design recommendations that architects, designers, contractors, developers, owners, and lessees of large hospitals can use to achieve whole-building site energy savings of at least 50% compared to the minimum requirements of Standard 90.1-2004. The energy reducing recommendations address building envelope (including infiltration through walls and doors); fenestration types; electrical lighting systems; daylighting; heating, ventilation, and air-conditioning (HVAC) systems; and outside air (OA) quantity and treatment. The recommendations should be used as a starting point for project-specific analyses and are not intended to be part of a code or standard. This work will also reach its intended audience through the DOE-sponsored Hospital Energy Alliance (HEA) (DOE 2008).

This TSD was developed by the Commercial Buildings Group at the National Renewable Energy Laboratory (NREL) under the direction of the DOE Building Technologies Program as Deliverable 10-2.2.4 under Task BEC7.1309 in the Commercial Buildings Statement of Work.

1.1 Objectives

The modeling and analysis described in this report are used to develop:

- A baseline building as a basis for evaluating energy savings measures.
- A set of recommendations that meet or exceed a goal of 50% site energy savings over Standard 90.1-2004.

1.2 Scope

This document provides recommendations to designers, developers, and owners of large hospitals to encourage the design and construction of energy-efficient buildings. To ease the burden of designing and constructing new energy-efficient large hospitals, this report describes a set of design measures that enable the 50% energy savings target to be met for each climate zone.

The TSD discusses energy savings and does not address other sustainability issues, such as acoustics, productivity, indoor environmental quality, water efficiency, landscaping, and transportation, except as they relate to operational energy consumption. It is also not intended to serve as any kind of design document—detailed design is left to the experts working on particular projects. The results are intended to demonstrate the advantages of integrated whole-building design and to show that 50% energy savings is possible independent of climate zone.

1.3 Report Organization

This report is organized into five sections. Section 1 provides background, overview, and scope information. Section 2 introduces the modeling methodology, including definitions, analysis framework and assumptions, prototype definition, the modeling process, and the external review process. Section 3 describes the model development process, starting with a description of the prototype model, followed by detailed input data for the climate-specific baseline and low-energy building models. Section 4 provides an overview of the validation work performed on the baseline and low-energy models to ensure that the results were reasonable and accurate. Section 5 contains the results of the modeling study, including the energy use intensities (EUIs) of the baseline and low-energy models.

2. Methodology and Assumptions

This section describes the methodology and assumptions used to develop this TSD. Our overall goal was to show, through energy modeling, that 50% energy savings are achievable in large hospitals across all U.S. climate zones.

2.1 Guiding Principles

The objective was to develop a set of recommendations to enable the design and construction of large hospitals that meet or exceed a goal of 50% energy savings over Standard 90.1-2004 and to develop a baseline building as a basis for evaluating energy savings measures. Achieving 50% energy savings requires integrated building design—an approach that analyzes buildings as holistic systems rather than as disconnected collections of individually engineered subsystems. Indeed, accounting for and taking advantage of interactions between subsystems is a paramount concern. As an example, a reduction in installed lighting power density (LPD) can often be accompanied by a smaller HVAC system, but only if an integrated design process allows for it.

The design was determined by applying energy design measures (EDMs) to a baseline building. We used the following guiding principles to develop a list of prospective EDMs:

- We considered only off-the-shelf technologies that were available from multiple sources, as opposed to technologies or techniques that were available only in limited quantities or from one manufacturer.
- The EDMs were limited to technologies that could be modeled with EnergyPlus.
- Verification was required that the measure saved energy as part of the integrated low-energy design during model development and simulation.

The recommended design is also expected to be reasonably cost effective, but not necessarily the most cost-effective design. Many EDMs involve cost reductions in other places, so we believe that the recommended design is reasonably cost effective. Given the difficulty of obtaining accurate and timely cost data on all the technologies required to reach 50% savings in all climate zones, we performed no economic analysis. However, the recommendations were based on strategies that have been shown to be cost effective in actual projects based on HEA and industry input.

2.2 Definitions

This section specifies how building energy use and the percent energy savings relative to Standard 90.1-2004 were calculated. It includes the site boundary used to calculate site energy use, approaches to energy demands not treated by the standards, and the application of Standard 90.1-2004 in this study.

2.2.1 Energy Use

Building energy use can be calculated a number of ways based on where the energy is assumed to originate and on which loads are included. Our assumptions follow.

2.2.1.1 Site Energy Use

The percent energy savings goal was based on site energy use, which is the amount of energy delivered to a building by the utility (typically in the form of electricity or natural gas) minus any renewable energy generated within its footprint. Other metrics, such as energy cost savings, source energy savings, and carbon savings, could be used (Torcellini et al. 2006). Each metric

has advantages and disadvantages in calculation and interpretation, and each favors different technologies and fuel types. This TSD used site energy savings to retain consistency with the previous TSDs and AEDGs.

2.2.1.2 Whole-Building Energy Use

Energy savings can be expressed in two ways: for regulated loads only or for all loads (the whole building). Regulated loads include lighting loads, HVAC loads, and any other load regulated by code. Non-regulated loads include plug and process loads that are not code regulated. Whole-building energy savings calculations include all loads, both regulated and non-regulated. In general, whole-building savings more accurately represent a building's impact.

The whole-building energy savings method was used to determine 50% energy savings, in line with Standard 90.1-2004 (ASHRAE 2004b) and the current Leadership in Energy and Environmental Design V3 (USGBC 2009).

2.2.2 Percent Energy Savings

Percent energy savings were based on the notion of a minimally code-compliant building as described in Standard 90.1-2004. The following steps were used to determine 50% savings:

1. Define architectural program characteristics (design aspects not addressed by Standard 90.1-2004) for typical large hospitals, thereby defining a prototype model.
2. Create baseline energy models for each climate zone that are elaborations of the prototype model and are minimally compliant with Standard 90.1-2004.
3. Create a list of EDMs that can be applied to the prototype model to create low-energy models that achieve 50% energy savings compared to the baseline models.

2.2.3 Standard 90.1-2004 Baseline

The 50% level of savings achieved by each low-energy building model was demonstrated in comparison with a baseline model that minimally satisfied the requirements of Standard 90.1-2004 (ASHRAE 2004b). Notable deviations from Standard 90.1-2004 included:

- Economizer high limit shutoff values ignored (due to enthalpy control)
- No pressure credits taken, as defined in the exception to Standard 90.1-2004 section G3.1.2.9
- Only one boiler was modeled, as opposed to two staged boilers as required by section G3.1.3.2
- Only one chiller was modeled, instead of more than one chiller as required by section G3.1.3.7 (very complex to apply this to all baseline models due to the varying cooling load experienced by the building in the different climate zones)
- Chilled water reset was not utilized (G3.1.3.9)
- The supply air temperature was not reset under minimum load conditions (G3.1.3.12)

2.3 Building Energy Modeling Methodology

This section describes in detail our building energy modeling methodology.

2.3.1 EnergyPlus

EnergyPlus Version 5.0 (DOE 2010), a publicly available building simulation engine, was used for all energy analyses. EnergyPlus was selected because it is a detailed DOE simulation tool that computes building energy use based on the interactions between climate, building form and

fabric, internal gains, HVAC systems, and renewable energy systems. The simulations were run on local personal computers and a 64-bit Linux cluster computer at NREL.

2.3.2 Opt-E-Plus

The simulations were managed with the NREL analysis platform, Opt-E-Plus (NREL 2010), which transforms user-specified, high-level building parameters (area, internal gains per zone, HVAC system configuration, etc.) stored in extensible markup language (XML) files. These XML files were expanded using the Opt-E-Plus capabilities into EnergyPlus input files. The advantage is that high-level variables can be changed and automatically mapped to several EnergyPlus inputs. Although Opt-E-Plus can perform whole-building optimizations, Opt-E-Plus was only used for managing the large number of simulations needed for the analysis. This is partly due to the complexity of hospitals.

2.3.3 Climate Zones

The TSDs contain a set of energy efficiency recommendations for each DOE climate zone examined. The eight zones and three subzones in the United States are depicted in Figure 2-1. The zones are defined primarily by heating degree days (HDDs) and cooling degree days (CDDs) (Briggs et al. 2003). The climate zones range from hot (zone 1) to cold (zone 8). Subzones indicate varying moisture conditions. Humid subzones are designated by the letter A, dry subzones by B, and marine subzones by C.

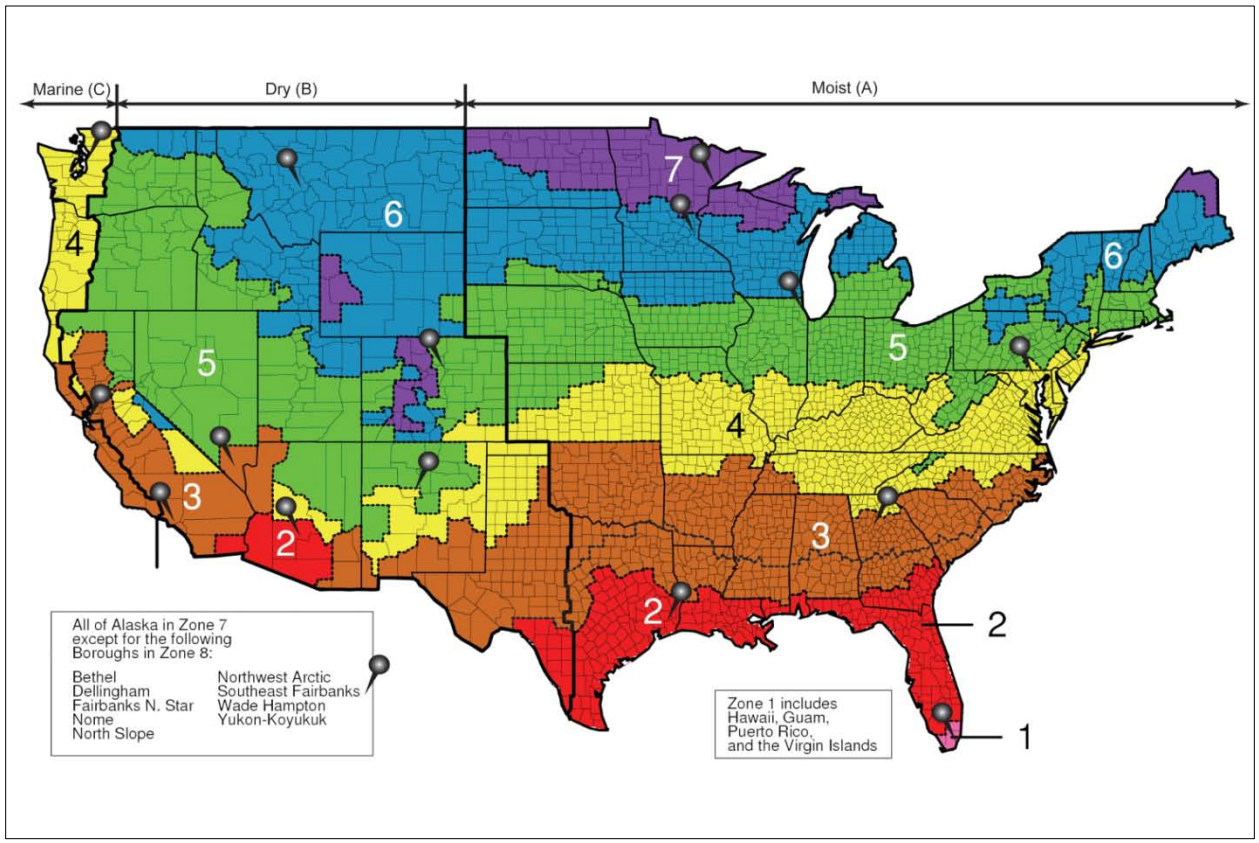


Figure 2-1 DOE climate zones and representative cities
(Credit: (DOE 2005)

The 16 specific locations (marked in Figure 2-1) for which analysis was performed are listed below and are designated as being representative of their climate zones. Large cities were chosen, as their weather data directly apply to a large fraction of the total U.S. building floor area. Energy savings were determined by running baseline and low-energy model simulations with the same typical meteorological year 3 (TMY3) weather file (one set of simulations for each city) (Deru et al. 2010).

- Zone 1A: Miami, Florida (very hot, humid)
- Zone 2A: Houston, Texas (hot, humid)
- Zone 2B: Phoenix, Arizona (hot, dry)
- Zone 3A: Atlanta, Georgia (hot, humid)
- Zone 3B: Las Vegas, Nevada (hot, dry) and Los Angeles, California (warm, dry)
- Zone 3C: San Francisco, California (marine)
- Zone 4A: Baltimore, Maryland (mild, humid)
- Zone 4B: Albuquerque, New Mexico (mild, dry)
- Zone 4C: Seattle, Washington (marine)
- Zone 5A: Chicago, Illinois (cold, humid)
- Zone 5B: Denver, Colorado (cold, dry)
- Zone 6A: Minneapolis, Minnesota (cold, humid)
- Zone 6B: Helena, Montana (cold, dry)
- Zone 7: Duluth, Minnesota (very cold)
- Zone 8: Fairbanks, Alaska (extremely cold)

2.4 Analysis Assumptions

We made the following assumptions:

- The models developed in this work represent typical large hospitals. They incorporate design features that yield climate-specific guidance.
- The models are controlled under ideal conditions. In actual buildings, the anticipated energy savings are often not achieved or erode over time because the buildings are not properly commissioned, operated, or maintained.

2.5 Defining a "Typical" Hospital

Each hospital building is unique and most do not follow a typical prototypical form or floor plan. Any large hospital is likely to differ significantly from another based on the services offered, owner preferences, and location. For this project, the geometry was based on actual project plans for a hospital similar in size to the target square footage for this report [500,000 ft^2 (46,450 m^2)]. The plans were provided by an engineering firm which specializes in hospital design.

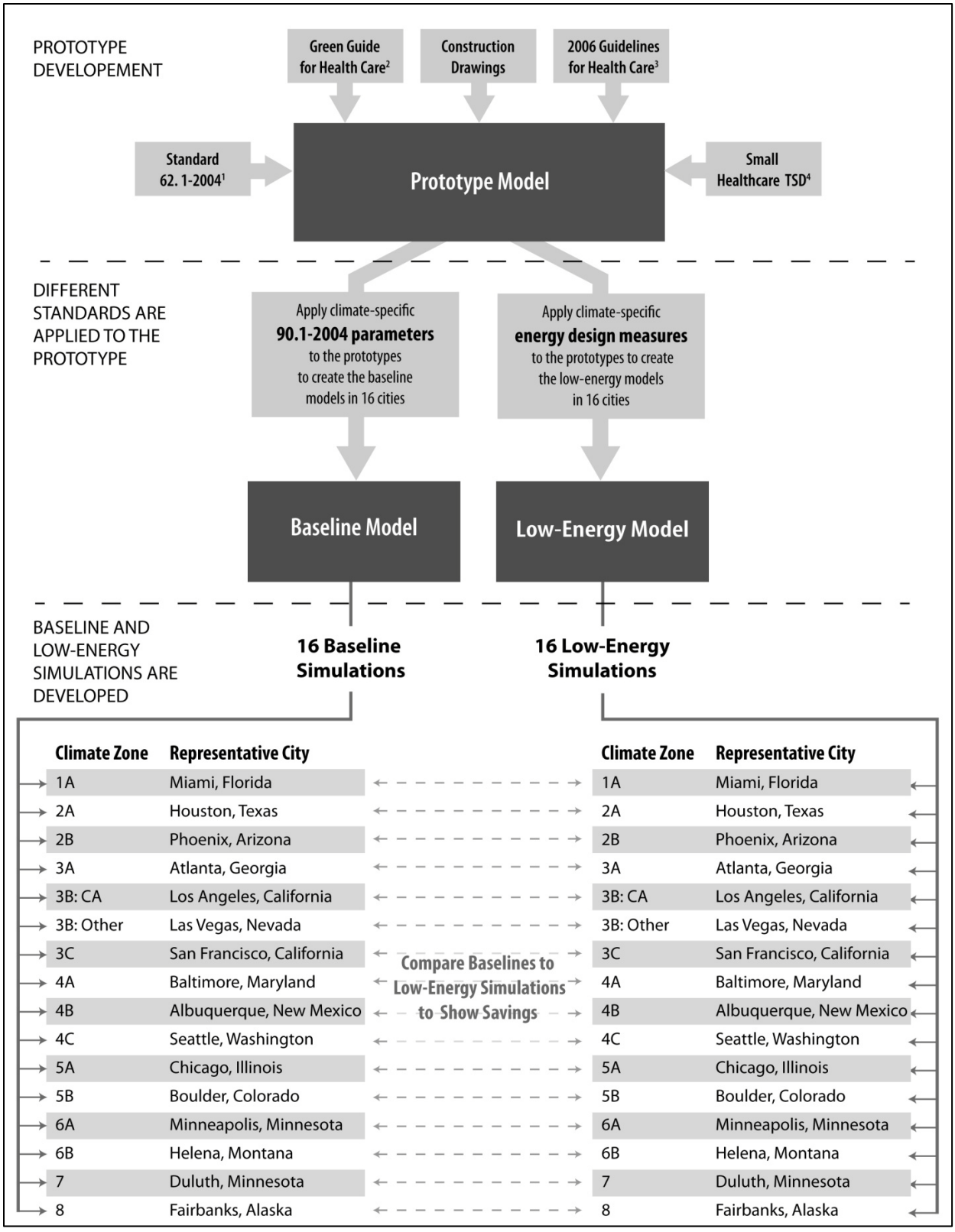
In addition, a number of reports and datasets were surveyed to develop typical large hospital characteristics and obtain energy performance estimates. These included the following:

- 2003 Commercial Buildings Energy Consumption Survey (CBECS) (EIA 2005)
- *U.S. Department of Energy Commercial Reference Building Models for Energy Simulation* (Deru et al. 2010)
- *Green Guide for Health Care*, V2.2 (GGHC 2007)
- *2006 Guidelines for Design and Construction of Health Care Facilities* (AIA et al. 2006)
- ANSI/ASHRAE Standard 62.1-2004 (ASHRAE 2004a)

- *Technical Support Document: Development of the Advanced Energy Design Guide for Small Hospitals and Healthcare Facilties—30% Guide* (Bonnema et al. 2010)
- Prototypical hospital plans from actual projects.

2.6 Modeling Process

Once a "typical" hospital was defined, it was used to create the initial EnergyPlus model known as the prototype. This prototype was taken in two separate directions: (1) applying Standard 90.1-2004 to generate the baseline model; and (2) applying EDMs to create the low-energy model. These two models were distributed across the climate zones, updated to include climate-specific parameters, and then simulated using EnergyPlus to generate percent energy savings comparisons. A diagram of this process is shown in Figure 2-2.



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3C	San Francisco, California	3C	San Francisco, California
4A	Baltimore, Maryland	4A	Baltimore, Maryland
4B	Albuquerque, New Mexico	4B	Albuquerque, New Mexico
4C	Seattle, Washington	4C	Seattle, Washington
5A	Chicago, Illinois	5A	Chicago, Illinois
5B	Boulder, Colorado	5B	Boulder, Colorado
6A	Minneapolis, Minnesota	6A	Minneapolis, Minnesota
6B	Helena, Montana	6B	Helena, Montana
7	Duluth, Minnesota	7	Duluth, Minnesota
8	Fairbanks, Alaska	8	Fairbanks, Alaska

[1](ASHRAE 2004a) [2](GGHC 2007) [3](AIA et al. 2006) [4](Bonnema et al. 2010)

Figure 2-2 Flow diagram of modeling process
(Credit: Marjorie Schott/NREL)

2.7 External Review Process

Building model inputs and assumptions were reviewed by several members of the HEA and by an engineering firm which specializes in large hospital design. All members of the HEA were invited to submit comments on an earlier draft of this document.

2.8 Energy Design Measures

The EDMs chosen for this analysis were:

- Reduced lighting power densities.
- Daylighting sensors in applicable perimeter zones.
- Occupancy sensors in applicable zones.
- More insulative envelope (opaque exterior and fenestration).
- Overhangs on south-facing fenestrations.
- A multizone variable air volume dedicated outdoor air system with zone-level water-to-air heat pumps. The heat pumps shared a common condenser loop whose temperature was maintained though the use of a chiller and boiler.
- High-efficiency chillers, boilers, and water heaters.
- Demand controlled ventilation.
- More efficient pumps.
- Reduced infiltration through tighter envelope construction

Table 2-1 summarizes the energy design measures used to attain 50% energy savings.

Table 2-1 Recommendations to Achieve 50% Energy Savings

Item		Component	Recommendation
Envelope	Roofs	Insulation entirely above deck	R-25 c.i. to R-35 c.i., depending on climate zone
		SRI	Climate zone 1-3: 78, all other comply with Standard 90.1-2004
	Walls	Steel-framed	R-13 + R-7.5 c.i. to R-13 + R-21.6 c.i., depending on climate zone
	Slabs	Unheated	Comply with Standard 90.1
	Air Barrier	Infiltration	0.05 cfm/ft^2 of exterior wall and roof area
	Vertical fenestration	Total fenestration to gross wall area	40% max
		Thermal transmittance	U-0.20 to U-0.43, depending on climate zone
		SHGC – all types and orientations	SHGC-0.26 to SHGC-0.40, depending on climate zone
		Visible light transmittance	VLT-0.63 to VLT-0.69, depending on climate zone
		Exterior sun control (S, E, W only)	Projection factor of 0.5
Lighting	Interior lighting	Whole building interior LPD	0.88 W/ft^2
		Occupancy sensors	Installed in applicable zones
		Daylighting	400 lux continuous dimming in applicable perimeter zones
	Exterior lighting	Whole building exterior LPD	2.5 W/ft of exterior first floor façade perimeter
Operating Suite HVAC	Central air handling system	Water-cooled chiller	Variable speed, centrifugal, 7.0 COP, 44.0°F outlet temperature
		Cooling tower	Open tower, variable speed cooling tower fan
		Gas boiler	90% efficient condensing boiler, outdoor air temperature reset
		Pumps	Variable speed, 80% efficient
		Air-side economizer	Differential enthalpy controlled
HVAC	Water loop heat pump/dedicated outdoor air system	Water loop heat pump cooling efficiency	4.5 COP (15.4 EER) at 86°F
		Water loop heat pump heating efficiency	5.0 COP (17.1 EER) at 68°F
		Water loop heat pump fans	55% efficient, 0.30 in. w.c. pressure drop
		Condenser loop water-cooled chiller	Variable speed, centrifugal, 7.0 COP, 86.0°F outlet temperature
		Condenser loop cooling tower	Open tower, variable speed cooling tower fan
		Condenser loop gas boiler	90% efficient condensing boiler, 68.0°F outlet temperature
		Condenser loop economizer	Counterflow waterside economizer
		Condenser loop pumps	Variable speed, 80% efficient
		Dedicated outdoor air system fans	2.0 in. w.c. reduction over baseline central air handling system
		Dedicated outdoor air system boiler	90% efficient condensing boiler, outdoor air reset
		Dedicated outdoor air system chiller	Variable speed, centrifugal, 7.0 COP, 44.0°F outlet temperature
		Dedicated outdoor air system pumps	Variable speed, 80% efficient, 60 ft w.c.

3. Model Development

This section describes the modeling inputs used to construct the baseline and low-energy models. Where the baseline and low-energy model inputs are identical, the inputs are listed with no subheadings. In sections where the baseline model and the low-energy model differ, subheadings of "Baseline Model" and "Low-Energy Model" are used. This layout was chosen to facilitate a quick comparison between the two models.

3.1 Form

The geometry for the energy models was based on actual hospital blueprints and includes a 427,000 ft^2 (39,670 m^2) seven-story hospital building and an attached 100,000 ft^2 (9,290 m^2) five-story medical office building (MOB). The MOB contains closed offices along the perimeter zones and open offices in the core.

The floor-to-floor height was modeled as 10 ft (3.05 m) (plenum spaces were ignored to simplify the energy model). Basic modeling parameters for the model are listed in Table 3-1. A rendering of the model is shown in Figure 3-1 (the MOB is shown on the left of the figure). Floor plans are shown in Figure 3-2 through Figure 3-6.

Table 3-1 Selected Modeling Assumptions

Model Parameters	Value
Total floor area	527,000 ft^2 (48,960 m^2)
Hospital floor area	427,000 ft^2 (39,670 m^2)
MOB floor area	100,000 ft^2 (9,290 m^2)
Floor-to-floor height (plenum spaces were ignored to simplify the energy model)	10 ft (3.05 m)
Number of floors (hospital)	7
Number of floors (MOB)	5
Glazing sill height (bottom of window to floor)	3.6 ft (1.1 m)
Glazing head height (top of window to ceiling)	2.4 ft (0.7 m)

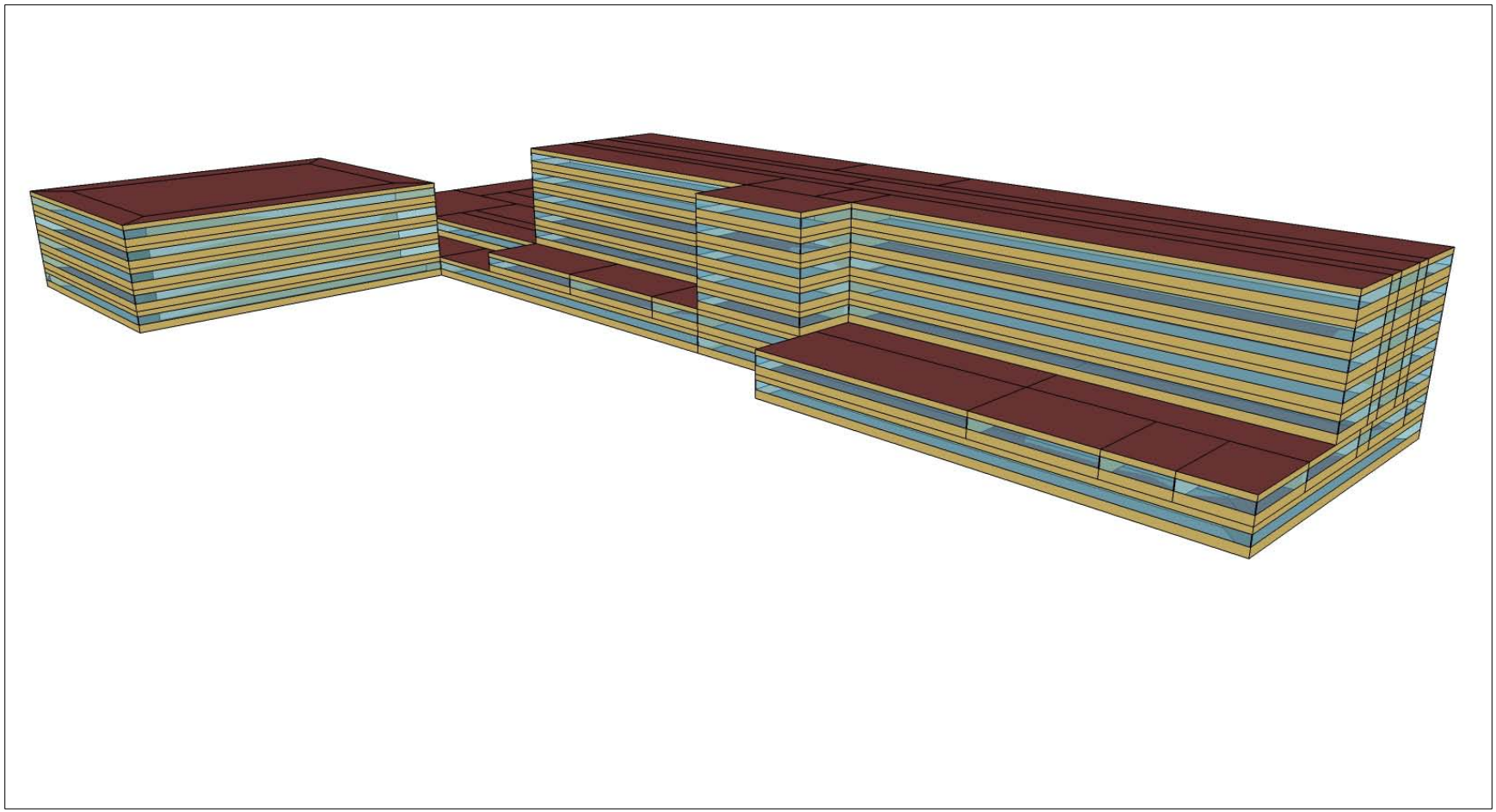

Figure 3-1 Baseline model rendering: View from southeast
(Credit: Eric Bonnema/NREL)

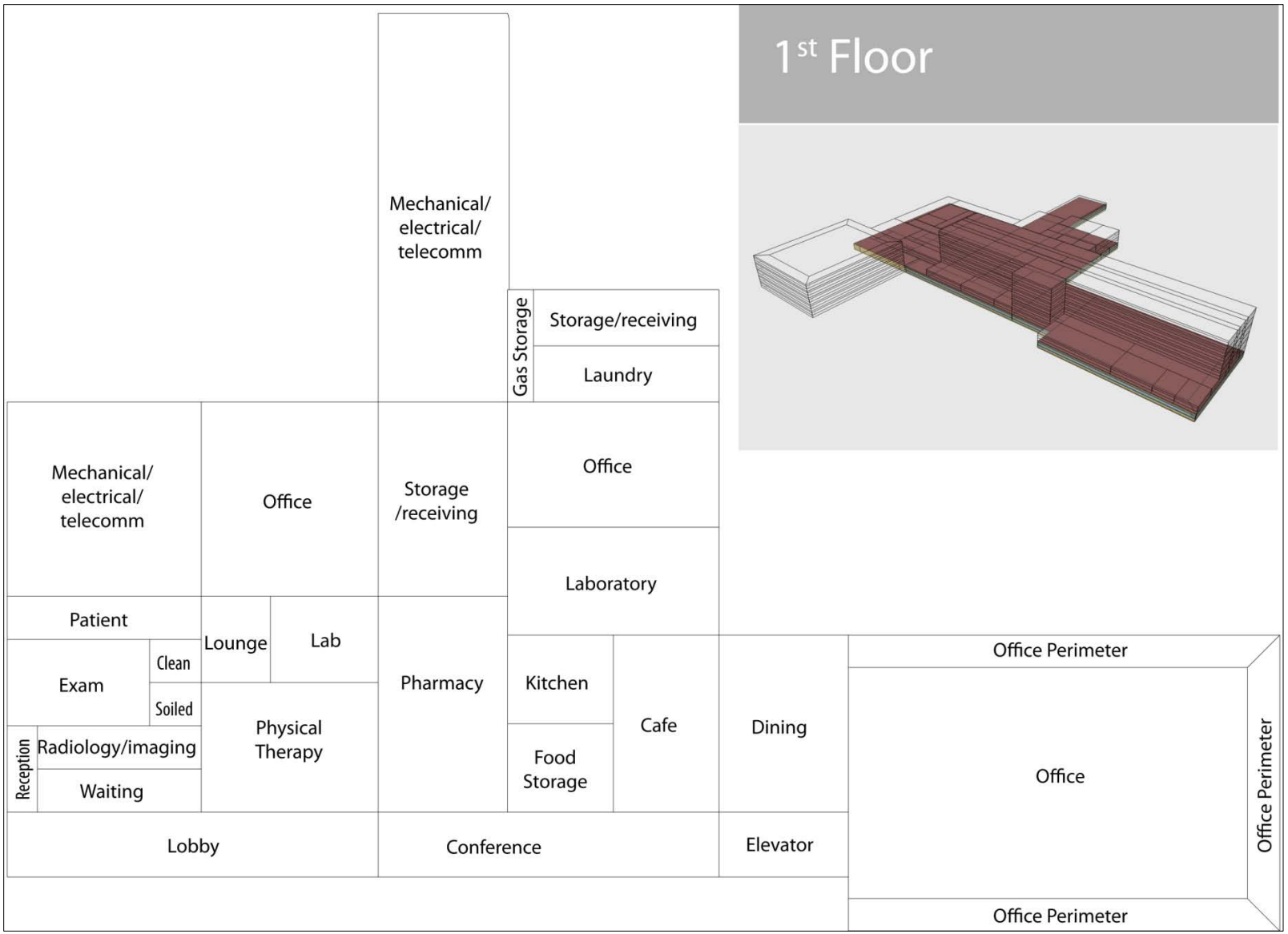

Figure 3-2 Large hospital prototype first floor plan
(Credit: Marjorie Schott/NREL)

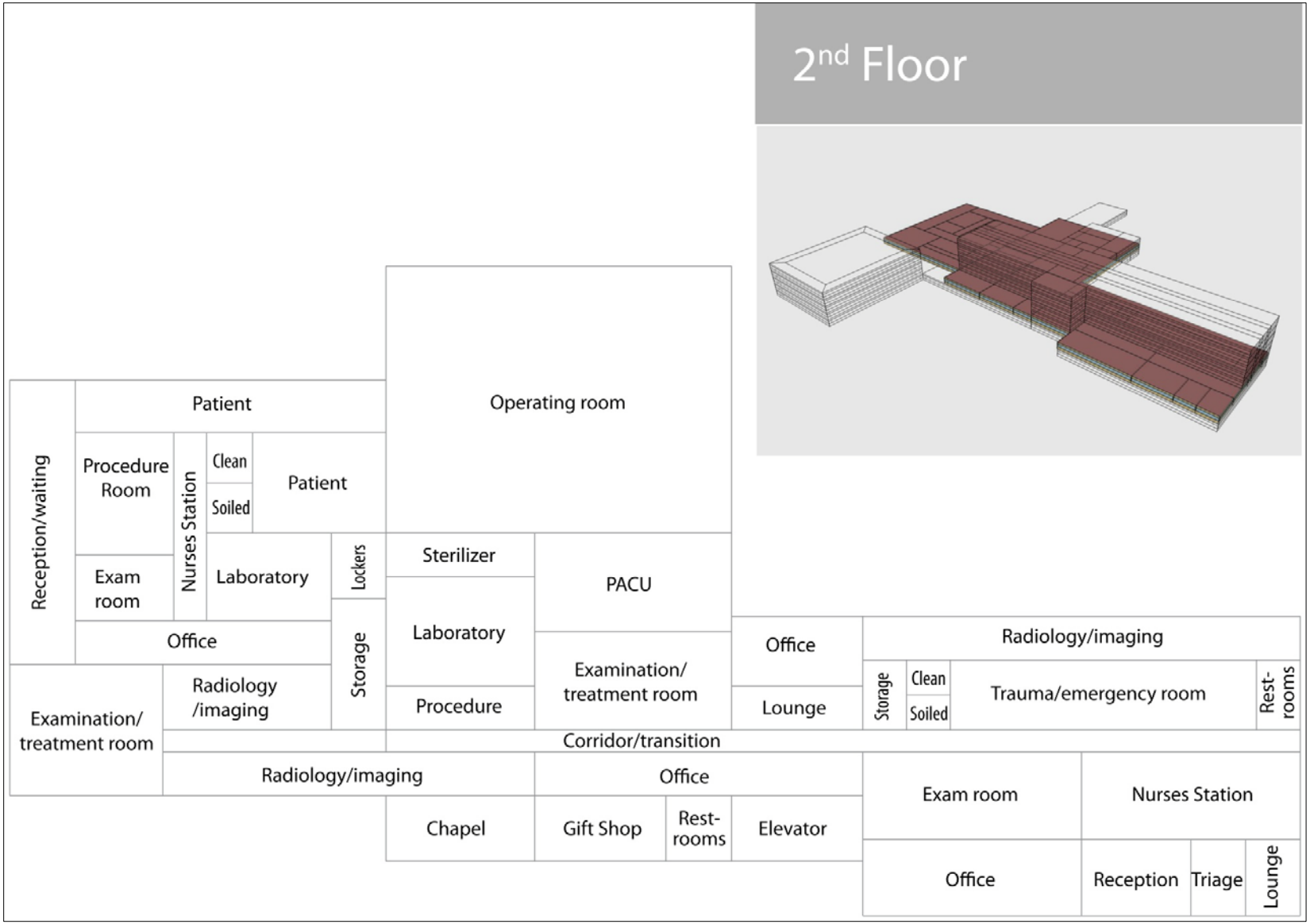

Figure 3-3 Large hospital prototype second floor plan
(Credit: Marjorie Schott/NREL)

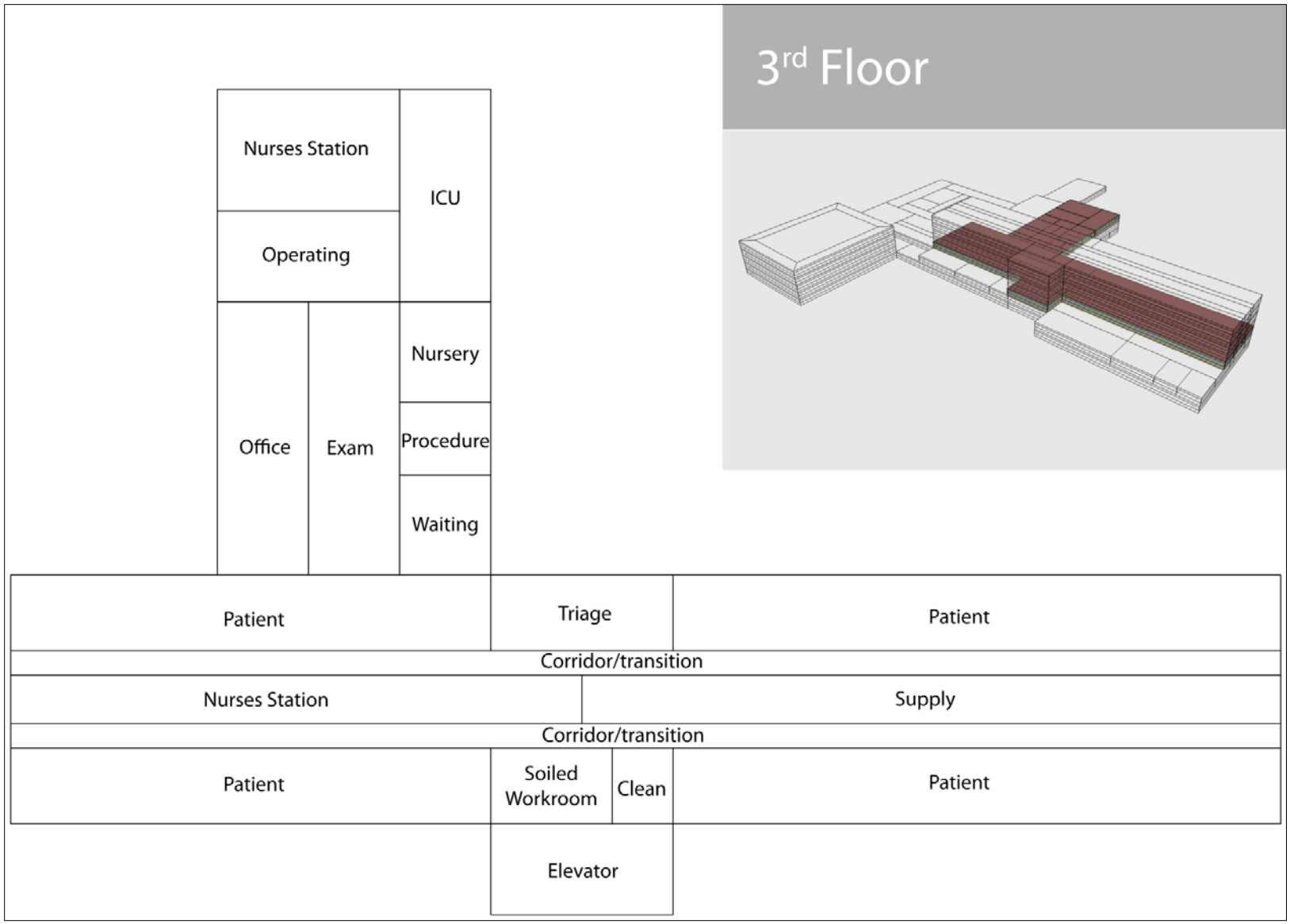

Figure 3-4 Large hospital prototype third floor plan
(Credit: Marjorie Schott/NREL)

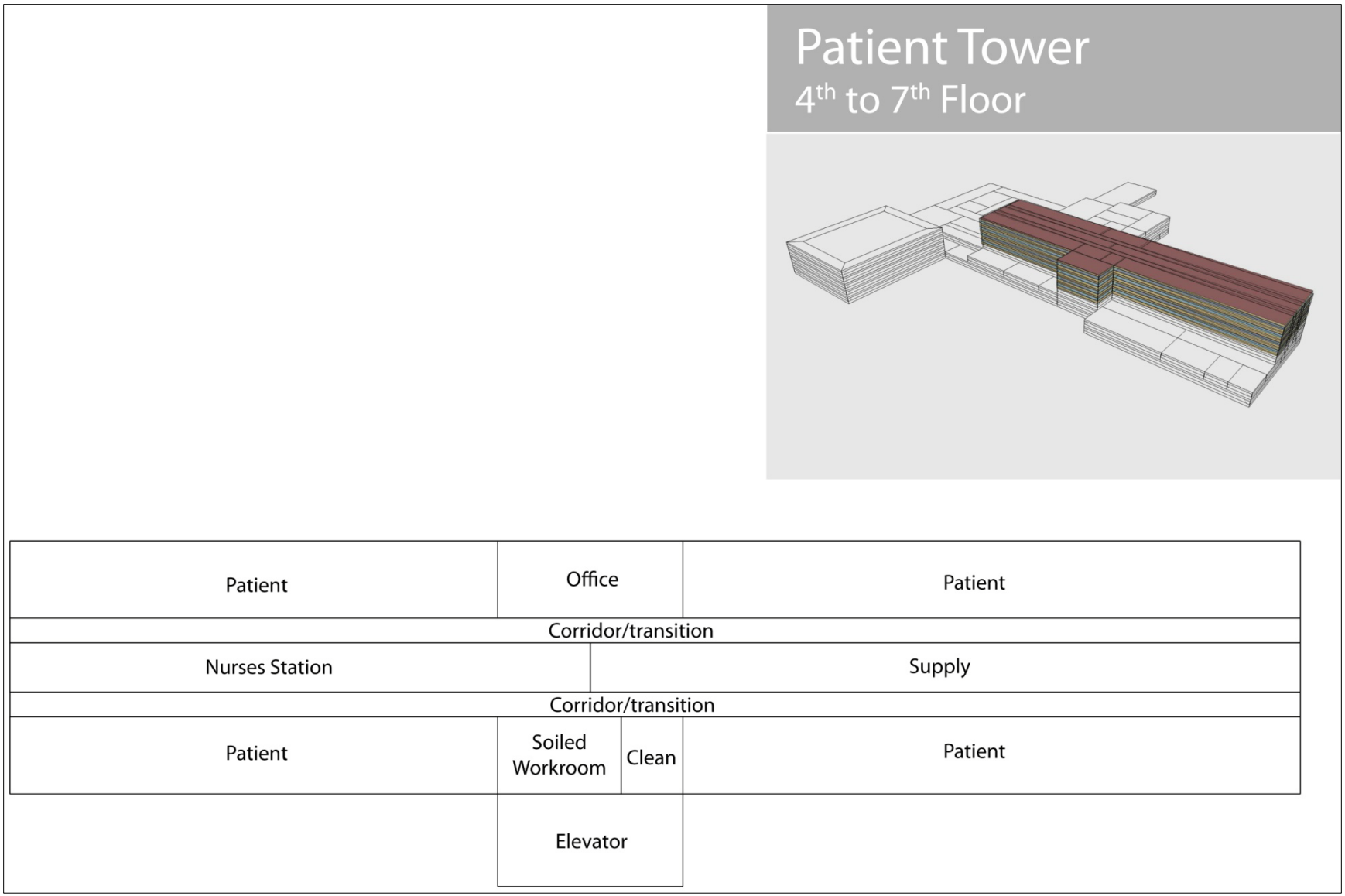

Figure 3-5 Large hospital prototype patient tower floor plan
(Credit: Marjorie Schott/NREL)

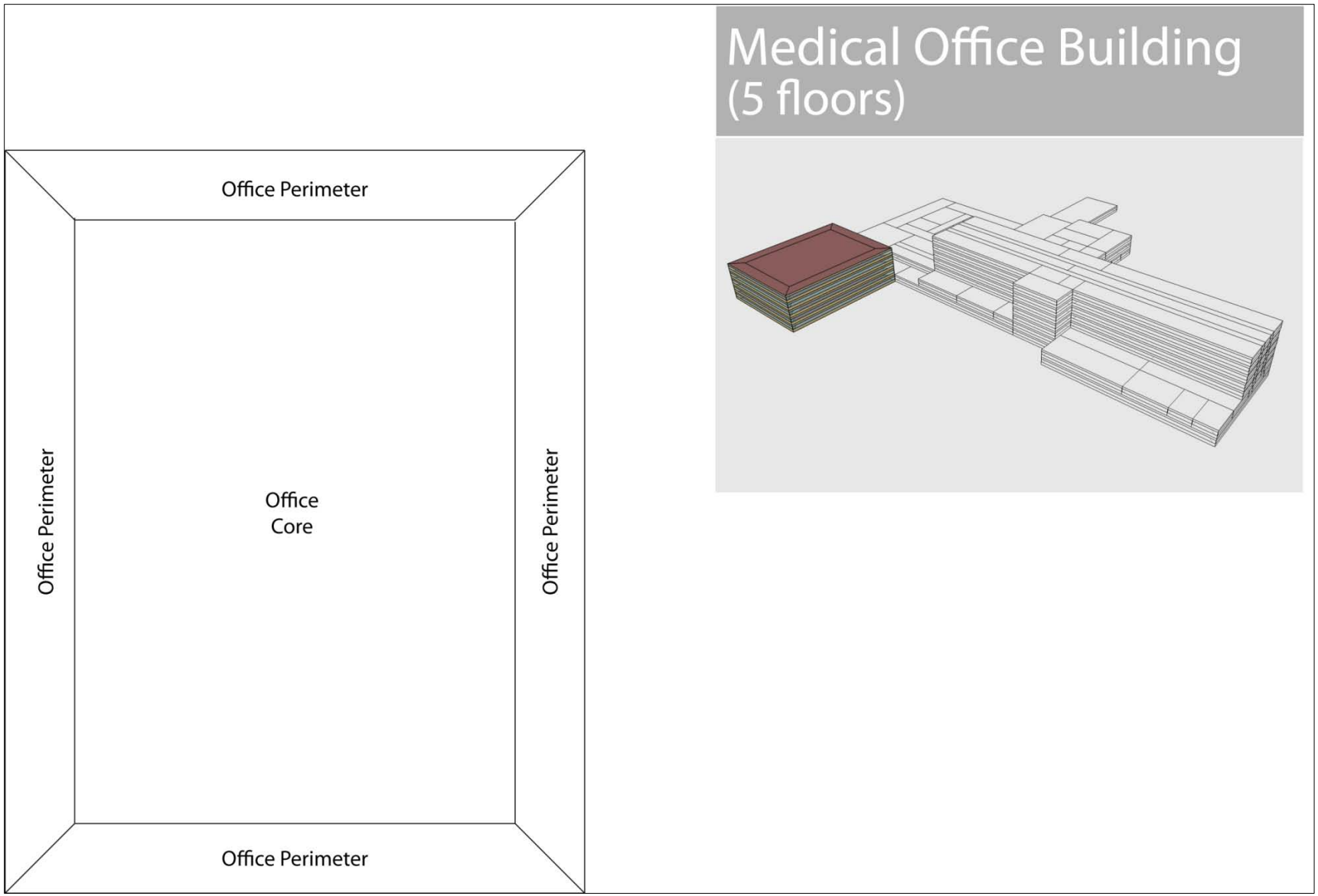

Figure 3-6 Large hospital prototype MOB floor plan
(Credit: Marjorie Schott/NREL)

3.1.1 Space Types

Every zone in the model was assigned to 1 of 32 space types, each of which had its own space conditioning and equipment requirements, which are discussed below. These space types corresponded to spaces listed in Standard 62.1-2004 (ASHRAE 2004a) and AIA et al. (2006). Table 3-2 lists these space types and gives an overview of their respective weighting in the model.

Table 3-2 Space Type Floor Areas in the Prototype Model

Space Type Name	Floor Area (ft^2)	Percent of Total
Anesthesia gas storage	624	0.1%
Cafeteria	4,018	0.8%
Clean workroom/holding	3,783	0.7%
Conference room	6,150	1.2%
Corridor/transition	38,640	7.3%
Dining room	4,920	0.9%
Examination/treatment room	18,940	3.6%
Food preparation center	4,018	0.8%
Laboratory	12,580	2.4%
Laundry	2,236	0.4%
Lobby area	3,750	0.7%
Locker	750	0.1%
Lounge	3,355	0.6%
Mechanical/electrical/telecomm room	18,900	3.6%
Medical supply/medication room	18,400	3.5%
Nurse station	22,730	4.3%
Nursery	990	0.2%
Office	163,766	31.1%
Operating suite	21,076	4.0%
Patient room	97,514	18.5%
Pharmacy	6,000	1.1%
Physical therapy	4,920	0.9%
Procedure room	4,600	0.9%
Radiology/imaging	11,230	2.1%
Reception/waiting	21,320	4.0%
Recovery room	6,150	1.2%
Restroom	1,540	0.3%
Soiled workroom/holding	6,283	1.2%
Sterilizer equipment room	1,360	0.3%
Storage/receiving	9,776	1.9%
Trauma/emergency room	4,480	0.8%
Triage	2,375	0.5%

3.2 Fabric

This section describes the building fabric, including materials comprising any part of the building's walls, floors, and roofs.

3.2.1 Exterior Walls

The baseline and low-energy walls were assumed to be steel framed. The material layers that made up the exterior wall construction consisted of a sheathing layer, a parallel steel stud/batt insulation layer, a layer of continuous insulation (c.i.) if necessary (c.i. is based on climate zone), and a 0.5-in. (0.0127-m) layer of gypsum board.

3.2.1.1 Baseline Model

Assembly U-factors for the baseline model varied based on the climate zone and were adjusted to account for standard film coefficients. Continuous insulation R-values were selected to meet the maximum U-factors required in Section 5 of Standard 90.1-2004 (ASHRAE 2004b). The baseline model exterior wall performance metrics are listed in Table 3-3.

Table 3-3 Baseline Exterior Wall Constructions

Climate Zone	Insulation R-values, Nominal	Assembly U-Factor (Btu/h·ft^2·°F)	Construction Type
1–4	R-13 batt	0.124	Steel framed
5–6	R-13 batt + R-3.8 c.i.	0.084	Steel framed
7–8	R-13 batt + R-7.5 c.i.	0.064	Steel framed

3.2.1.2 Low-Energy Model

The low-energy model exterior wall constructions were taken from the recommendations for steel-frame exterior wall constructions found in Bonnema et al. (2010). The low-energy model exterior wall performance metrics are listed in Table 3-4.

Table 3-4 Low-Energy Exterior Wall Constructions

Climate Zone	Insulation R-values, Nominal	Assembly U-Factor (Btu/h·ft^2·°F)	Construction Type
1–4	R-13 batt + R-7.5 c.i.	0.064	Steel framed
5	R-13 batt + R-15.6 c.i.	0.042	Steel framed
6–7	R-13 batt + R-18.8 c.i.	0.037	Steel framed
8	R-13 batt + R-21.6 c.i.	0.034	Steel framed

3.2.2 Roofs

The baseline and low-energy roof constructions were modeled as a roof with insulation entirely above deck, where the construction consisted of three layers: a roof membrane, insulation, and metal decking.

3.2.2.1 Baseline Model

Continuous insulation R-values were selected to meet the maximum U-values required in Section 5 of Standard 90.1-2004 (ASHRAE 2004b). The baseline roof performance metrics are listed in Table 3-5.

Table 3-5 Baseline Roof Constructions

Climate Zone	Insulation R-values, Nominal	Assembly U-Factor (Btu/h·ft^2·°F)	Construction Type
1–7	R-15.0 c.i.	0.063	Insulation entirely above deck
8	R-20.0 c.i.	0.048	Insulation entirely above deck

The prescriptive portion of Standard 90.1-2004 does not specify performance characteristics such as roof reflectance or absorption. However, Standard 90.1-2004 states that the baseline roof construction albedo shall be 0.30. As such, we assumed that the baseline roof membrane has a solar reflectivity of 0.30, a thermal absorptance of 0.90, and a visible absorptance of 0.70.

3.2.2.2 Low-Energy Model

The low-energy model roof constructions were taken from the recommendations for insulation entirely above deck roof types found in Bonnema et al. (2010). The thermal performance metrics for the low-energy roof constructions are listed by climate zone in Table 3-6.

Table 3-6 Low-Energy Roof Constructions

Climate Zone	Insulation R-values, Nominal	Assembly U-Factor (Btu/h·ft^2·°F)	Construction Type	Solar Reflectivity
1–3	R-25 c.i.	0.039	Insulation entirely above deck	0.70
4–6	R-30 c.i.	0.032	Insulation entirely above deck	0.30
7–8	R-35 c.i.	0.028	Insulation entirely above deck	0.30

The low-energy model roof membrane has a thermal absorptance of 0.9 and a visible absorptance of 0.7. The solar reflectivity of the roof membrane varies by climate zone (see Table 3-6).

3.2.3 Slab-on-Grade Floors

Both models had identical slab-on-grade floors, which were composed of a carpet pad layer over an 8-in. (0.2-m) thick heavyweight concrete layer. The average monthly temperatures used in EnergyPlus to calculate the ground heat transfer are listed in Table 3-7 through Table 3-9. These data were generated through the use of the Slab program, which is packaged with EnergyPlus.

Table 3-7 Simulated Monthly Ground Temperatures: Humid Climates

Month	Miami		Houston		Atlanta		Baltimore		Chicago		Minneapolis	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
January	72.5	22.5	69.0	20.5	67.9	20.0	67.5	19.7	67.1	19.5	66.8	19.3
February	72.8	22.6	68.6	20.3	67.8	19.9	67.4	19.7	67.1	19.5	66.8	19.3
March	73.0	22.8	69.4	20.8	67.9	19.9	67.5	19.7	67.2	19.5	66.9	19.4
April	73.3	23.0	71.8	22.1	68.8	20.5	67.5	19.7	67.3	19.6	67.1	19.5
May	73.5	23.1	73.0	22.8	71.7	22.0	68.9	20.5	68.0	20.0	68.3	20.2
June	73.5	23.1	73.2	22.9	72.6	22.5	71.8	22.1	71.0	21.6	70.8	21.6
July	73.6	23.1	73.3	22.9	72.8	22.7	72.4	22.5	72.0	22.2	71.8	22.1
August	73.6	23.1	73.3	23.0	73.0	22.8	72.6	22.6	72.3	22.4	72.1	22.3
September	73.6	23.1	73.4	23.0	73.1	22.8	71.9	22.2	70.6	21.4	69.2	20.6
October	73.7	23.1	73.1	22.8	70.1	21.2	69.1	20.6	68.2	20.1	67.8	19.9
November	73.5	23.1	70.9	21.6	68.5	20.3	68.1	20.0	67.6	19.8	67.4	19.6
December	73.2	22.9	69.2	20.6	68.1	20.0	67.6	19.8	67.3	19.6	67.1	19.5

Table 3-8 Simulated Monthly Ground Temperatures: Arid Climates

Month	Phoenix		Los Angeles		Las Vegas		Albuquerque		Boulder		Helena	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
January	66.7	19.3	68.2	20.1	66.0	18.9	66.6	19.2	66.6	19.2	66.4	19.1
February	66.6	19.2	68.2	20.1	66.0	18.9	66.6	19.2	66.5	19.2	66.5	19.1
March	68.7	20.4	68.2	20.1	66.0	18.9	66.5	19.2	66.6	19.2	66.5	19.1
April	70.5	21.4	68.4	20.2	68.6	20.3	66.6	19.2	66.7	19.3	66.6	19.2
May	70.7	21.5	69.0	20.6	69.6	20.9	68.8	20.4	66.9	19.4	66.7	19.3
June	70.1	21.2	69.7	21.0	69.7	20.9	70.5	21.4	68.8	20.4	68.1	20.0
July	69.9	21.1	72.3	22.4	69.4	20.8	70.8	21.6	70.7	21.5	70.4	21.3
August	70.3	21.3	72.9	22.7	69.5	20.8	71.1	21.7	71.2	21.8	69.8	21.0
September	70.6	21.4	73.0	22.8	69.8	21.0	71.3	21.8	68.8	20.4	67.7	19.8
October	70.9	21.6	71.5	22.0	69.6	20.9	67.7	19.8	67.2	19.5	66.9	19.4
November	68.6	20.3	69.1	20.6	66.6	19.2	66.9	19.4	66.8	19.3	66.7	19.3
December	66.9	19.4	68.4	20.2	66.1	18.9	66.7	19.3	66.6	19.2	66.5	19.2

Table 3-9 Simulated Monthly Ground Temperatures: Marine and Cold Climates

Month	San Francisco		Seattle		Duluth		Fairbanks	
	°F	°C	°F	°C	°F	°C	°F	°C
January	67.8	19.9	67.5	19.7	66.5	19.2	65.2	18.4
February	67.9	19.9	67.5	19.7	66.5	19.1	65.1	18.4
March	67.8	19.9	67.5	19.7	66.6	19.2	65.4	18.5
April	67.9	19.9	67.6	19.8	66.8	19.3	65.7	18.7
May	67.9	19.9	67.7	19.8	66.9	19.4	66.0	18.9
June	68.1	20.0	68.1	20.0	67.6	19.8	66.4	19.1
July	68.6	20.3	69.3	20.7	69.7	20.9	67.3	19.6
August	68.1	20.1	70.0	21.1	68.8	20.5	66.6	19.2
September	68.8	20.4	68.8	20.4	67.6	19.8	66.4	19.1
October	68.2	20.1	68.0	20.0	67.2	19.6	66.1	19.0
November	68.0	20.0	67.7	19.8	67.0	19.4	65.7	18.7
December	67.9	19.9	67.6	19.8	66.7	19.3	65.4	18.6

3.2.4 Fenestration

Building fenestration includes all envelope penetrations used for access and egress or lighting such as windows, doors, and skylights.

3.2.4.1 Baseline Model

Standard 90.1-2004 specifies window properties as window systems and not as window frame and glass separately; thus, window frames were not explicitly modeled and only one window was modeled per exterior surface. This reduced the complexity and increased the speed of the EnergyPlus simulations. The building had an overall fraction of fenestration to gross wall area of 40%, with individual fenestration objects distributed evenly on all exterior surfaces.

The U-factors and solar heat gain coefficients (SHGCs) that were applied to the fenestration objects were whole-assembly values and included framing effects. The performance criteria listed in Table 3-10 were set to match the requirements of Table 5.5-1 through Table 5.5-8 in Standard 90.1-2004 (ASHRAE 2004b). The multipliers from the visible light transmittance (VLT) table, Table C3.5 in Standard 90.1-2004 Appendix C (ASHRAE 2004b), were used to calculate VLT values for the baseline windows.

Table 3-10 Baseline Window Constructions

Climate Zone	SHGC (North)	SHGC (All Other)	VLT	U-Factor (Btu/h·ft^2·°F)
1 (A,B)	0.44	0.25	0.250	1.22
2 (A,B)	0.61	0.25	0.250	1.22
3 (A,B)	0.39	0.25	0.318	0.57
3 (C)	0.61	0.34	0.340	1.22
4 (A,B,C)	0.49	0.39	0.495	0.57
5 (A,B,C)	0.49	0.39	0.495	0.57
6 (A,B)	0.49	0.39	0.495	0.57
7	0.64	0.49	0.490	0.57
8	NR, 0.64 used	NR, 0.49 used	NR, 0.490 used	0.46

3.2.4.2 Low-Energy Model

The amount and distribution of glazing were identical in the low-energy and baseline energy models. For the low-energy model, window construction thermal property values were taken from Table 8-1 of Bonnema et al. (2010). The low-energy model window construction properties are summarized in Table 3-11.

Table 3-11 Low-Energy Window Constructions

Climate Zone	SHGC (All)	VLT	U-Factor (Btu/h·ft^2·°F)
1-3	0.26	0.63	0.43
4-8	0.34	0.69	0.29

Window overhangs were modeled on all south façades of the low-energy model. The fixed overhang started just above the window and extended out from the façade half the height of the window, providing a projection factor of 0.5. Our model had 4-ft (1.2-m) tall windows, meaning the overhangs projected 2 ft (0.6 m) outward from the top of the window.

3.3 Infiltration

Infiltration is the unintentional or accidental introduction of OA into a building, typically through cracks in the envelope and open doors. Infiltration is sometimes called *air leakage*.

3.3.1 Baseline Model

Baseline infiltration rates were calculated using an infiltration rate factor and total exterior wall areas for each zone. The calculated infiltration rate factor was assumed to be constant throughout the year. This is a good assumption for annual energy performance, but caution should be used in evaluating hour by hour loads with this method.

To determine the infiltration rate factor, we assumed that the building was constructed in such a manner that at a pressure differential of 75 Pa, the infiltration rate was equivalent to 0.4 cfm/ft^2 (2.0 L/s/m^2) of external wall area. Using a flow coefficient of 0.65 and an assumed pressure differential across the envelope of 4 Pa (a pressure likely to be encountered during normal building operation), we calculated the final infiltration rate factor to be 0.06 cfm/ft^2 (0.30 L/s/m^2). For zones with no external wall surfaces, the infiltration rate was set to zero. This methodology is consistent with that used by Deru et al. (2010).

Because a large amount of OA was brought into the building by the HVAC system, we modified the calculated zone infiltration rates via an infiltration schedule that was set to 0.50 during HVAC system operation. The infiltration schedule was a simple multiplier that in this case reduced the total infiltration by half. In many buildings, this schedule would be increased to 1.0 when the HVAC system was shut off for the night, to simulate the greater infiltration rate that would result from the building no longer being pressurized. But because of the unique space requirements of hospitals, the HVAC system operated 24/7, so the infiltration modification schedule was set to a constant value of 0.50.

3.3.2 Low-Energy Model

Infiltration in the low-energy model was treated in the same manner as in the baseline model, with two key exceptions:

- The infiltration rate factor was reduced by 15% to 0.05 cfm/ft^2 (0.26 L/s/m^2). This reduction was due to an assumed higher envelope construction quality (greater attention to detail was paid to the building envelope air barrier installation during construction).
- Because the individual zone DOAS VAV dampers in certain space types were allowed to close during unoccupied times (reducing the pressure in those zones), the infiltration rates for these zones were correspondingly increased via an infiltration schedule. Those infiltration schedules inversely mimicked the occupancy schedules for the space types to which they applied. A key showing the infiltration schedule used, by space type, is shown in Table E-13 in Appendix E. The infiltration schedules are shown in Table E-14 and Figure E-11.

3.4 Internal Load Densities

Internal loads include the heat generated by occupants, lights, appliances (plug and process loads), and water use equipment. This section addresses the aspects of these loads not addressed in Standard 90.1, including peak occupant and plug load densities.

3.4.1 Occupancy Density

Occupancy density values by space type were defined according to Standard 62.1-2004 (ASHRAE 2004a). The mapping from each space type to Standard 62.1-2004 and the resulting occupancy density values are presented in Table 3-12. Values for space types without direct mapping to the standard were estimated (denoted “Engineering judgment” in Table 3-12).

Table 3-12 Peak Occupancy Density Mapping

Space Type	Mapping to 62.1-2004	Occupancy Density	
		(#/1,000 ft^2)	(#/100 m^2)
Anesthesia gas storage	General::Storage rooms	0.00	0.00
Cafeteria	Food and beverage service:: Cafeteria/fast food dining	100.0	107.64
Clean workroom/holding	Office buildings::Office space	5.0	5.38
Conference room	General::Conference/meeting	50.0	53.82
Corridor/transition	General::Corridors	0.0	0.00
Dining room	Food and beverage service:: Restaurant dining rooms	70.0	75.35
Examination/treatment room	Office buildings::Office space	5.0	5.38
Food preparation center	Kitchen::commercial	5.0	5.38
Laboratory	Office buildings::Office space	5.0	5.38
Laundry	Retail::Coin operated laundries	20.0	21.53
Lobby area	Office buildings::Reception areas	30.0	32.29
Locker	Office buildings::Office space	5.0	5.38
Lounge	Office buildings::Office space	5.0	5.38
Mechanical/electrical/telecomm room	General::Storage rooms	0.0	0.00
Medical supply/medication room	General::Storage rooms	0.0	0.00
Nurse station	Office buildings::Office space	5.0	5.38
Nursery	Office buildings::Office space	5.0	5.38
Office	Office buildings::Office space	5.0	5.38
Operating suite	Engineering judgment	5.0	5.38
Patient room	Engineering judgment	5.0	5.38
Pharmacy	Miscellaneous Spaces::Pharmacy	10.0	10.76
Physical therapy	Sports and Entertainment:: Health club/weight rooms	10.0	10.76
Procedure room	Office buildings::Office space	5.0	5.38
Radiology/imaging	Office buildings::Office space	5.0	5.38
Reception/waiting	Office buildings::Reception areas	30.0	32.29
Recovery room	Office buildings::Office space	5.0	5.38
Restroom	Engineering judgment	5.0	5.38
Soiled workroom/holding	Engineering judgment	5.0	5.38
Sterilizer equipment room	Engineering judgment	0.0	0.00
Storage/receiving	Miscellaneous spaces::Shipping and receiving	0.0	0.00
Trauma/emergency room	Office buildings::Office space	5.0	5.38
Triage	Office buildings::Office space	5.0	5.38

3.4.2 Plug and Process Loads

Plug and process loads are notoriously difficult to estimate. When available, plug and process load densities were taken from the Green Guide for Health Care: Best Practices for Creating High Performance Healing Environments, Version 2.2 (GGHC) (GGHC 2007). The mapping from the space types in the model to the GGHC can be found in Table A-4 in Appendix A. The electricity and gas process loads for the food preparation space type were derived from an ASHRAE Transaction article regarding the estimation of food service loads and profiles

(ASHRAE 2001). Table 3-13 lists the peak plug and process loads used, for both the baseline and low-energy models, by space type.

Table 3-13 Peak Plug Loads

Space Type	Electric Plug Load (W/ft^2)	Electric Process Load (W/ft^2)	Gas Process Load (W/ft^2)
Anesthesia gas storage	1.00	0.00	0.00
Cafeteria	0.10	0.00	0.00
Clean workroom/holding	2.00	0.00	0.00
Conference room	0.10	0.00	0.00
Corridor/transition	0.10	0.00	0.00
Dining room	0.10	0.00	0.00
Examination/treatment room	1.00	0.00	0.00
Food preparation center	1.00	17.50	173.70
Laboratory	1.00	3.00	0.00
Laundry	0.00	0.50	10.00
Lobby area	0.10	0.00	0.00
Locker	0.25	0.00	0.00
Lounge	0.10	0.00	0.00
Mechanical/electrical/telecomm room	0.10	0.00	0.00
Medical supply/medication room	1.00	0.00	0.00
Nurse station	0.25	0.50	0.00
Nursery	1.00	0.00	0.00
Office	0.50	0.00	0.00
Operating suite	1.00	3.00	0.00
Patient room	1.00	0.00	0.00
Pharmacy	1.00	0.00	0.00
Physical therapy	1.00	0.00	0.00
Procedure room	1.00	3.00	0.00
Radiology/imaging	1.00	8.00	0.00
Reception/waiting	0.10	0.00	0.00
Recovery room	1.00	1.00	0.00
Restroom	0.10	0.00	0.00
Soiled workroom/holding	0.00	0.00	0.00
Sterilizer equipment room	1.00	5.00	7.00
Storage/receiving	1.00	0.00	0.00
Trauma/emergency room	1.00	3.00	0.00
Triage	1.00	0.00	0.00

3.4.3 Service Water Heating Loads

With the exception of the service water heating (SWH) flow rates in the kitchen and patient rooms, design flow rate values for SWH loads were taken from GGHC (2007). The GGHC does not explicitly provide flow rates, but it does provide design thermal loads by space type, in units of Btu/h/person. For this analysis, these design loads were converted to design flow rates based on the physical properties of water and an assumed temperature rise of 95ºF (35ºC) in the SWH

system. All SWH load schedules except those in the kitchens and patient room zones referenced their respective zone occupancy schedules.

The kitchen SWH design flow rate and schedule values were taken directly from the Full Service Restaurant Reference Building Model (Deru et al. 2010). The design flow rate and schedule for the patient room SWH loads were based on data for nursing homes found in Table 7 of Chapter 49 in the *2007 ASHRAE Handbook – HVAC Applications* (ASHRAE 2007). The schedule was developed such that the total and peak daily water use matched those found in the table. Table 3-14 provides an overview of the design (peak) flow rates by zone type. Table E-15 and Figure E-12 in Appendix E provide the SWH use schedules associated with the kitchen and patient room zones.

Table 3-14 SWH Design Flow Rates

Space Type	Design Flow Rate (gal/h/person)
Cafe	0.379
Conference room	0.190
Dining	0.379
Exam room	0.379
Intensive care	0.379
Imaging	0.758
Kitchen	133.0 (gal/h)
Laboratory	0.758
Laundry	0.758
Lobby	0.126
Nurse station	0.190
Nursery	0.379
Operating suite	1.263
PACU	0.379
Patient room	18.4 (gal/h)
Pharmacy	0.190
Physical therapy	0.190
Procedure room	0.758
Soiled linens	0.758
Sterilizing	0.758
Trauma	0.758
Triage	0.758

3.5 Schedules

As a whole, the hospital was assumed to be open 24 hours per day, 7 days per week. However, not all spaces were assumed to operate on this schedule. Generally, space type operating schedules were grouped into two categories: 24/7 and extended office hours. Extended office hours spanned from 5:00 a.m. until midnight; with the bulk of the occupancy occurring between 7:00 a.m. and 5:00 p.m. Because of the wide array of space types, however, five distinct operating schedules were developed. These are presented in Appendix E. Schedules were derived based on engineering judgment, except for the food area gas equipment schedule and the

food area electric equipment and lighting schedules, which were taken from the Full Service Restaurant Reference Building Model (Deru et al. 2010).

3.6 Lighting

This section describes the electric lighting modeled in the baseline and low-energy buildings.

3.6.1 Interior Lighting

Interior lighting includes all electric lighting inside the building envelope. It represents hard-wired light fixtures only; lighting from task lights or moveable fixtures was considered a plug or process load (see Section 3.4.2 for plug and process loads).

3.6.1.1 Baseline Model

The baseline interior LPDs for each space type were derived using the space-by-space method described in ASHRAE (2004b) and appear in Table 3-15. The mapping from each space type to the standard and the resulting baseline LPDs are presented in Table A-1 in Appendix A. For the location of each space type, refer to Figure 3-2 through Figure 3-6.

3.6.1.2 Low-Energy Model

The low-energy interior LPDs for each space type are provided in Table 3-15. The LPDs used were based on Bonnema et al. (2010). ASHRAE et al. (2009) explains how designers can achieve the LPD values listed in Table 3-15. Note that the LPD values given also take into account an additional 10% reduction for spaces, such as restrooms and offices, where occupancy sensors would be viable. Table 3-15 details which space types were assumed to incorporate occupancy sensors. For the location of each space type, see Figure 3-2 through Figure 3-6.

3.6.2 Exterior Lighting

Exterior lighting includes all electric lighting used to light the first floor of the façade. The model assumed no parking lot lighting because it is not within the building footprint. Exterior lighting was controlled in both models through the use of an astronomical clock (i.e. on at dusk, off at dawn).

3.6.2.1 Baseline Model

The baseline model had an installed exterior lighting capacity of 11,750 W. This number was derived using Standard 90.1-2004 Table 9.4.5 (ASHRAE 2004b), which specifies exterior façade lighting at a rate of 5.0 W/ft (3.28 W/m) of exterior first floor façade perimeter.

3.6.2.2 Low-Energy Model

The modeled low-energy exterior lighting power assumed a reduction of 50% from the baseline value for a total installed capacity of 5,875 W. This value was based on the lighting pollution section (Sustainable Sites Credit 8) of USGBC (2006). Such a large reduction was possible because most façade lighting is installed for aesthetic purposes only (except for that located near entrances and exits).

3.6.3 Daylighting Controls

Daylighting controls are specialty devices that measure the amount of daylight in a space and automatically dim the artificial electric lights to maintain a certain lighting level. No daylighting controls were modeled in the baseline building because they are an EDM—only applicable to the low-energy model. Continuous dimming daylighting controls were input into the low-energy model for appropriate space types (see Table 3-15). These controls consisted of one daylighting

reference point per zone, which controlled all of the lighting within that zone. The daylighting sensor was given a set point of 40 fc (400 lux) (Bonnema et al. 2010).

Table 3-15 Lighting by Space Type

Space Type	Baseline Model		Low-Energy Model			
	LPD (W/ft^2)	LPD (W/m^2)	LPD (W/ft^2)	LPD (W/m^2)	Occupancy Sensors (Yes/No)	Daylighting (Yes/No)
Anesthesia gas storage	0.90	9.69	0.80	8.61	Yes	No
Cafeteria	0.90	9.69	0.90	9.69	No	Yes
Clean workroom/holding	1.10	11.84	0.80	8.61	Yes	No
Conference room	1.30	13.99	1.10	11.84	Yes	Yes
Corridor/transition	1.00	10.76	0.70	7.53	No	Yes
Dining room	0.90	9.69	0.90	9.69	No	Yes
Examination/treatment room	1.50	16.15	1.10	11.84	Yes	No
Food preparation center	1.20	12.92	1.20	12.92	No	No
Laboratory	1.40	15.07	0.90	9.69	No	No
Laundry	0.60	6.46	0.60	6.46	No	Yes
Lobby area	1.30	13.99	0.80	8.61	No	Yes
Locker	0.60	6.46	0.60	6.46	No	No
Lounge	0.80	8.61	0.80	8.61	No	Yes
Mechanical/electrical/telecomm room	1.50	16.15	0.80	8.61	Yes	No
Medical supply/medication room	1.40	15.07	1.10	11.84	Yes	No
Nurse station	1.00	10.76	1.00	10.76	No	Yes
Nursery	0.60	6.46	0.60	6.46	No	No
Office	1.10	11.84	0.80	8.61	Yes	Yes
Operating suite	2.20	23.68	2.00	21.53	No	No
Patient room	0.70	7.53	0.70	7.53	No	No
Pharmacy	1.20	12.92	1.20	12.92	No	No
Physical therapy	0.90	9.69	0.90	9.69	No	No
Procedure room	2.70	29.06	2.00	21.53	No	No
Radiology/imaging	0.40	4.31	0.40	4.31	No	No
Reception/waiting	1.30	13.99	0.90	9.69	No	Yes
Recovery room	0.80	8.61	0.80	8.61	No	No
Restroom	0.90	9.69	0.80	8.61	Yes	No
Soiled workroom/holding	1.10	11.84	0.80	8.61	Yes	No
Sterilizer equipment room	0.90	9.69	0.90	9.69	Yes	No
Storage/receiving	0.90	9.69	0.70	7.53	Yes	No
Trauma/emergency room	2.70	29.06	1.20	12.92	No	No
Triage	2.70	29.06	2.00	21.53	No	No

Table 3-15 does not list patient rooms as available for daylighting. Although patient rooms may appear to be good candidates for daylighting based on room size and proximity to outside walls, in reality these often have the window shades drawn for sleeping and recovery. Patient room

lighting patterns are thus unpredictable, so they are not suitable candidates for daylighting. This is consistent with Bonnema et al. (2010) and ASHRAE et al. (2009).

3.7 Heating, Ventilating, and Air-Conditioning

Because of the substantial differences between the baseline and low-energy HVAC systems, a side-by-side comparison is difficult. As such, components that were modeled identically between the two models will be presented first, followed by a description of the remaining baseline HVAC components, and a similar description of the remaining low-energy HVAC system components.

3.7.1 Sizing

The equipment efficiencies and pressure rises and drops were specified separately in the baseline and low-energy models, but the equipment capacities and flow rates (on both the water and air systems) were allowed to autosize in EnergyPlus. This requirement was imposed because the models were swept across many climate zones; the building required a different heating and cooling capacity for the systems (and thus different water and airflow rates) in each climate. To avoid oversizing the systems (and thus overestimating energy use), we used a global sizing factor of 1.0 in both models. This multiplier was applied in EnergyPlus at the zone level to all zone heating and cooling loads and airflow rates, which were then used to calculate the system sizes. Note that zone sizing factors greater than 1.0 were used for a select few zones to ensure reasonable hours out of set point values. For zones where this was necessary, the same sizing factors were applied in both the baseline and low-energy models. Primary equipment sizing factors were also applied in such a manner as to ensure the boilers and chillers operated at reasonable part-load ratios (PLRs) throughout the year.

3.7.2 Humidification

Hospitals are unique among commercial buildings because they have minimum humidity requirements per AIA guidelines (AIA et al. 2006). All air handling units (AHUs), except the one serving the MOB, were equipped with electric, direct-injection steam humidifiers to maintain the control zone's interior relative humidity (RH) at 30% or higher (AIA et al. 2006). Although gas humidifiers are generally favored over electric devices in a hospital setting, electric humidifiers are the only option in EnergyPlus. For each AHU, a control zone with high OA requirements was chosen in an attempt to ensure that all zones served by that AHU met the required minimum RH set point throughout the year. Because of variations in latent loads caused by varying occupancy and SWH loads in each zone, the zone RH is unlikely to always be within the required tolerances.

Even though an electric humidifier is essentially 100% efficient—because all the electric power is transferred to the water as heat—a resultant efficiency of 93% (Bonnema et al. 2010) was used to account for occasional condensate blowdown. Modeled power draw and humidification parameters were based on data for a typical unit (Armstrong 2010). Individual capacity sizing multipliers were applied to meet the minimum humidity requirements in each AHU control zone.

3.7.3 Dehumidification

Section 5.10.1 of Standard 62.1-2004 (ASHRAE 2004a) states that an occupied space's RH shall be limited to 65% or less at either of the following design conditions: (1) the peak outdoor dew point design conditions and at the peak indoor design latent load; or (2) at the lowest space sensible heat ratio expected to occur and the concurrent outdoor condition. AIA et al. (2006)

lowers this requirement further by mandating a maximum humidity of 60%. Therefore, the cooling coils in all applicable AHUs were controlled in such a way as to prevent the RH of the control zones from rising higher than 60%.

3.7.4 Ventilation and Total Airflow

Ventilation rates by zone were defined according to—in order of priority—the *2006 Guidelines for Design and Construction of Health Care Facilities* (AIA et al. 2006), ASHRAE/ASHE Standard 170-2008 (ASHRAE 2008), and Standard 62.1-2004 (ASHRAE 2004a), depending on space type. Hospitals are unique among commercial buildings in that they have total airflow requirements as well as ventilation airflow requirements. Total airflow requirements are mandated by AIA et al. (2006) and apply only to hospital-specific space types. All total air requirements and some ventilation air requirements for the baseline and low-energy model zones were taken from this guide. If a zone did not have total air requirements listed in the guide, none were set. If a zone did not have ventilation air requirements listed in AIA et al. 2006 or Standard 170-2008, Standard 62.1-2004 was used.

The mapping from each space type to the respective standard along with the resulting required ventilation rates is presented in Table A-2 and Table A-3 in Appendix A. Table 3-16 presents the minimum ventilation rate for each space type.

Table 3-16 Minimum Ventilation Rates

Space Type	Ventilation per Person		Ventilation per Area		Required OA Changes	Required Total Air Changes
	cfm per person	L/s per person	cfm/ft^2	L/s·m^2	ACH	ACH
Anesthesia gas storage	0.0	0.0	0.12	0.61	0	8
Cafeteria	7.5	3.5	0.18	0.91	0	0
Clean workroom/holding	5.0	2.4	0.06	0.31	0	4
Conference room	5.0	2.4	0.06	0.31	0	0
Corridor/transition	0.0	0.0	0.06	0.31	0	2
Dining room	7.5	3.5	0.18	0.91	0	0
Examination/treatment room	5.0	2.4	0.06	0.31	0	6
Food preparation center	0.0	0.0	0.70	3.56	0	10
Laboratory	5.0	2.4	0.06	0.31	0	6
Laundry	7.5	3.5	0.06	0.31	0	10
Lobby area	5.0	2.4	0.06	0.31	0	0
Locker	0.0	0.0	0.50	2.54	0	10
Lounge	5.0	2.4	0.06	0.31	0	0
Mechanical/electrical/telecomm room	0.0	0.0	0.12	0.61	0	0
Medical supply/medication room	0.0	0.0	0.12	0.61	0	4
Nurse station	5.0	2.4	0.06	0.31	0	0
Nursery	0.0	0.0	0.00	0.00	2	6
Office	5.0	2.4	0.06	0.31	0	0
Operating suite	0.0	0.0	0.00	0.00	4	20
Patient room	0.0	0.0	0.00	0.00	2	6*
Pharmacy	5.0	2.4	0.18	0.91	0	4
Physical therapy	20.0	9.4	0.06	0.31	0	6
Procedure room	0.0	0.0	0.00	0.00	3	15
Radiology/imaging	5.0	2.4	0.06	0.31	0	6
Reception/waiting	5.0	2.4	0.06	0.31	0	0
Recovery room	0.0	0.0	0.00	0.00	2	6
Restroom	0.0	0.0	0.25	1.27	0	10
Soiled workroom/holding	5.0	2.4	0.06	0.31	0	10
Sterilizer equipment room	0.0	0.0	0.12	0.61	0	10
Storage/receiving	0.0	0.0	0.12	0.61	0	0
Trauma/emergency room	0.0	0.0	0.00	0.00	3	15
Triage	0.0	0.0	0.00	0.00	2	12

* Set to 4 ACH in the low energy model based on AIA et al. 2006 Table 2.1-2 Note 10

3.7.5 Baseline Model

The baseline HVAC system was modeled as a CAV system with hot water reheat at the zone terminal CAV boxes. Six AHUs served the building (one served the MOB, one served the operating suites, two served the patient tower, and two served the remainder of spaces on the first two floors). This air handler configuration was selected based on review of the mechanical plans on which the energy model geometry was based. The design deck air temperature was 45.0°F (7.2°C) for AHU 3 (which served the two operating suite zones), 55.0°F (12.8°C) for AHU 6 (which served the MOB), and 52.0°F (11.1°C) for the remaining four AHUs.

3.7.5.1 Fan Power Assumptions

To simplify the energy model, we combined discrete supply and return fans into a single equivalent fan component model in EnergyPlus. The calculated pressure drop, total fan efficiency, and motor efficiency values were based on the actual mechanical drawings for the modeled hospital. Table 3-17 lists the inputs and calculated outputs for the combined fans for the six AHUs.

Table 3-17 Baseline System Fan Calculation Results

Component	AHU 1	AHU 2	AHU 3	AHU 4	AHU 5	AHU 6
Supply fan internal pressure drop (in. w.c.)	2.7	2.7	4.3	2.2	2.2	2.2
Supply fan total efficiency (%)	67.0	67.5	66.7	60.7	60.4	52.8
Return fan internal pressure drop (in. w.c.)	0.3	0.3	4.5	3.0	3.3	0.3
Return fan total efficiency (%)	70.1	70.1	66.1	60.6	60.7	70.1
External pressure drop (in. w.c.)	6.8	6.5	3.3	4.0	4.3	5.7
Combined fan total pressure drop (in. w.c.)	10.0	9.5	12.1	9.2	9.7	8.1
Combined fan total efficiency (%)	74.4	75.2	70.2	68.1	68.3	64.0
Motor efficiency (%)	95.4	95.4	95.4	96.2	96.2	95.4

For simplicity, the inputs for AHUs serving similar space types and floor areas were then averaged to determine the modeled fan properties (see Table 3-18).

Table 3-18 Baseline System Fan Model Inputs

Component	AHU 1	AHU 2	AHU 3	AHU 4	AHU 5	AHU 6
Combined fan total pressure drop (in. w.c.)	9.7	9.7	12.1	9.5	9.5	8.1
Combined fan total efficiency (%)	74.8	74.8	70.2	68.2	68.2	64.0
Motor efficiency (%)	95.4	95.4	95.4	96.2	96.2	95.4

The motor efficiencies listed are for National Electrical Manufacturers Association premium efficiency, 4-pole, random wound enclosed electric motors rated at smaller than 600 volts. The efficiency level was selected based on what the fan total horsepower would have been had the flow rate through the fan been as listed in the mechanical drawings.

3.7.5.2 Economizers

Fixed minimum differential enthalpy controlled OA economizers were modeled in all climates. Differential enthalpy controlled economizers compare the return air enthalpy with the OA enthalpy. When the OA enthalpy is greater than the return air enthalpy, the OA flow rate is set to minimum. Enthalpy sensors for economizers are historically inaccurate (Taylor), so this

analysis assumed that the economizers used enthalpy data from a local weather station for control, significantly increasing the accuracy of the enthalpy measurements. This assumption did not affect the energy model but was the basis for choosing enthalpy control for the economizers over another type of control such as dry-bulb temperature control.

3.7.5.3 Heating Hot Water System

The hot water system was served by a non-condensing boiler that supplied water to the AHU heating coils and VAV box reheat coils according to an OA reset-based supply water temperature set point. The upper and lower bounds of this schedule were taken from Section G3.1.3.4 of Standard 90.1-2004 (ASHRAE 2004b) (see Table 3-19). For OA temperatures within this range, the supply water temperature value was linearly interpolated. For OA temperatures outside this bound, the upper or lower limit value was used. The design return water temperature difference was 20.0°F (11.1°C). Important performance metrics for the hot water system are listed in Table 3-20.

Table 3-19 Baseline Heating Hot Water System Outdoor Air Reset Values

Property	Value
Set point at outdoor low temperature	180.0°F (82.2°C)
Outdoor low temperature	20.0°F (-6.7°C)
Set point at outdoor high temperature	150.0°F (65.6°C)
Outdoor high temperature	50.0°F (10.0°C)

Table 3-20 Baseline Boiler Performance Metrics

Property	Value
Boiler type	Non-condensing
Fuel type	Natural gas
Boiler efficiency	80%
Boiler water design outlet temperature	Varies
Hot water pump type	Variable speed
Hot water pump efficiency	75%
Hot water pump head	60 ft w.c. (179 kPa)

The boiler efficiency was modeled strictly as a function of its operating PLR, which is the heating load divided by the steady-state heating capacity at any point in time. The cubic equation used to model the boiler PLR can be found in (3-1); its coefficients are listed in Table 3-21 and were taken from Bonnema et al. (2010).

$$\text{Boiler Efficiency} = C_1 + C_2 \cdot PLR + C_3 \cdot PLR^2 + C_4 \cdot PLR^3 \quad (3\text{-}1)$$

Table 3-21 Non-condensing Boiler Efficiency Curve Data

EnergyPlus Input Data	Value
Nominal E_t	0.80
Coefficient 1: constant (C_1 in (3-1))	0.626
Coefficient 2: PLR (C_2 in (3-1))	0.646
Coefficient 3: PLR^2 (C_3 in (3-1))	–0.777
Coefficient 4: PLR^3 (C_4 in (3-1))	0.314
Calculation PLR minimum	0.1
Calculation PLR maximum	1.0

3.7.5.4 Chilled Water System

The chilled water system was supplied by a water-cooled, variable-speed, centrifugal chiller. Its performance curves were taken from Richard Lord's Standard 90.1 Chiller Equipment Models (Lord 2010). Water was supplied to the AHU chilled water coils at 44.0°F (6.7°C) with a design return water temperature of 56.0°F (13.3°C). The cooling tower was modeled as a variable-speed cross-flow open cooling tower with a design approach temperature (outlet water temperature minus inlet air wet-bulb temperature) of 7.0°F (3.9°C) and a design range temperature (inlet water temperature minus outlet water temperature) of 10.0°F (5.6°C). Performance metrics are listed in Table 3-22.

Table 3-22 Baseline Chiller Performance Metrics

Property	Value
Chiller type	Centrifugal, water cooled, variable speed
Chiller fuel	Electricity
Chiller coefficient of performance	6.1
Tower type	Open, variable speed
Chiller design outlet temperature	44.0°F (6.7°C)
Chilled water design return temperature	56.0°F (13.3°C)
Chilled water pump type	Variable speed
Chilled water pump efficiency	75%
Chilled water pump head	60 ft w.c. (179 kPa)

3.7.6 Low-Energy Model

The low-energy model used zone-level water loop heat pumps (WLHPs) supplied by a common condenser loop for space conditioning and a VAV DOAS for ventilation. The only exception was the operating suite, which was conditioned and ventilated with a traditional CAV system, just as in the baseline model. The DOAS/WLHP system type was chosen because it had been proven to save energy and to function well in hospital environments ((KJWW 2000) and (KJWW 2009)). The large energy savings associated with this system type occur because it decouples the large ventilation air requirements (see Section 3.7.4) from the space conditioning requirements.

The WHLP portion of this system shared a common condenser loop for heat rejection, which allowed zones to "share" loads. That meant that if one zone was in cooling mode and another was in heating mode, both could reject their heat to the condenser loop and the loads would balance each other out. It is very common in hospitals to have some zones in cooling mode and

some in heating mode (because of the large plug and process loads in certain zones), so this system type was ideal.

However, care must be taken when utilizing a DOAS/WLHP system type in a hospital setting. Some important design considerations for installing heat pumps in hospitals include the following:

- Accessibility for maintenance, filter changing, and unit replacement are critical. One option is to have filters on the inlets to the heat pumps or filter-grilles. Another option is to mount the heat pumps in small closets near each patient room.
- The filter housings provided by the manufacturers are poorly constructed, and they may leak a lot. To minimize filter bypass some options include using strip magnets (inexpensive, but a little tacky looking), or manufactured slide-out filter sections with tight sealing doors (expensive, but much more professional looking).
- Adequate dehumidification must be available for densely occupied spaces. Sometimes it is impossible to locate heat pumps with an option for hot gas reheat, so electric coils may sometimes need to be added in the reheat position. There are few manufacturers who make a heat pump with an integral electric coil in the reheat position.
- Ducting the DOAS directly to the space can simplify balancing and eliminate the possibility that heat pump discharge temperature in heating season will exceed the Standard 62.1-2004 temperature limit, thus requiring additional OA. If the DOAS is connected to the heat pump supply duct there can be balancing issues, and the heat pump fans may spin backward when the heat pumps are off. If the DOAS is ducted to the heat pump inlets, some of the heat pump unit sizes may need to be increased because it may be necessary to warm the DOAS to satisfy the minimum inlet temperature requirements of the heat pumps. Keeping the DOAS cold after dehumidifying in warm weather saves energy, and not heating all the way to space neutral in cold weather often saves energy in zones that are in cooling mode.

In a normal installation, the WLHP system condenser loop would most likely contain some type of geothermal heat exchanger (ground- or pond-coupled) with a fluid cooler and boiler to handle the portion of the heat rejection load that the ground could not. EnergyPlus can model geothermal heat exchangers, but this can become an enormously complex task because EnergyPlus cannot autosize the ground heat exchangers or loop flows. Because the low-energy model was simulated in multiple climate zones, autosizing was a necessity.

Additionally, it would have been immensely difficult to hard-size the geothermal heat exchanger systems for all climate zones, because mixing autosizing and hard-sizing in EnergyPlus is not recommended; rather, all systems should be hard-sized or autosized exclusively.

In the low-energy model, the WLHP condenser loop temperature was maintained instead through the use of a traditional chiller and boiler, both of which can be autosized in EnergyPlus. The idea was to show that 50% energy savings were achievable even without the geothermal heat exchanger.

As in the baseline model, six AHUs served the building, and the areas served by each AHU were left the same between the two models. However, the AHU that served the two operating suite zones was specified as a CAV unit with hot water reheat, because the spaces it served were of the most critical nature. The five DOASs supplied 100% OA and had supply air temperature set

points of 55.0°F (12.8°C). AHU 3, which served the two operating suites, had a design deck air temperature of 45.0°F (7.2°C).

3.7.6.1 Fan Power Assumptions

The DOAS airflows were much smaller than those in the baseline HVAC system because the DOAS was only required to handle the ventilation air. As such, increasing the DOAS duct size slightly to reduce duct velocities and pressure drops would likely be an economical option (because of the smaller additional amount of material required to increase the duct size). Similar logic applies to slightly oversizing the DOAS AHUs and coils to reduce the velocity of the air across the coils.

A pressure drop reduction of 2.0 in. w.c. over the baseline values was applied to all five DOAS AHU fans. This assumed that 1.0 in. of pressure drop credit was realized because of smaller duct pressure losses, and that the remaining 1.0 in. was due to lower face velocities across the coils. The low-energy fan parameters, as modeled, are listed in Table 3-23. The motor efficiencies listed are for National Electrical Manufacturers Association premium efficiency, 4-pole, random wound enclosed electric motors rated at smaller than 600 volts.

Table 3-23 Low-Energy System Fan Model Inputs

Component	AHU 1	AHU 2	AHU 3	AHU 4	AHU 5	AHU 6
Combined fan total pressure drop (in. w.c.)	7.7	7.7	12.1	7.5	7.5	6.1
Combined fan total efficiency (%)	74.8	74.8	70.2	68.2	68.2	64.0
Motor efficiency (%)	95.4	95.4	95.4	96.2	96.2	95.4

3.7.6.2 Condenser Loop

The zone-level WLHPs were fed off of a single condenser loop. The loop temperature was allowed to float between 68.0°F (20.0°C) and 86.0°F (30.0°C) and was kept within this range by a water-side economizer, a water-cooled chiller, and a natural gas-fired boiler.

The water-side economizer was located upstream of the chiller on the condenser loop and was modeled as a simple counterflow heat exchanger. The chiller was modeled as a water-cooled, variable-speed, centrifugal chiller. Performance curves for the chiller were taken from Lord (2010). The water-side economizer and the chiller worked in series to maintain the water temperature at 86.0°F (30.0°C). Heat was rejected from both components to a secondary loop that was maintained via a variable-speed, cross-flow open cooling tower. This tower had a design approach temperature (outlet water temperature minus inlet air wet-bulb temperature) of 7.0°F (3.9°C) and a design range temperature (inlet water temperature minus outlet water temperature) of 10.0°F (5.6°C).

The final piece of primary equipment on the condenser loop was a natural gas-fired condensing boiler that kept the loop temperature from dropping below 68.0°F (20.0°C). The coefficients for the boiler PLR curve, which were taken from Bonnema et al. (2010), are listed in Table 3-27. The boiler efficiency curve used can be found in (3-1). Performance metrics for the condenser loop equipment are listed in Table 3-24.

Table 3-24 Condenser Loop Performance Metrics

Property	Value
Chiller type	Centrifugal, water cooled, variable speed
Chiller fuel type	Electricity
Chiller COP	7.0
Chiller design outlet temperature	86.0°F (30.0°C)
Boiler type	Condensing
Boiler fuel type	Natural gas
Boiler efficiency	90%
Boiler design outlet temperature	68.0°F (20.0°C)
Water-side economizer type	Counterflow
Tower type	Open, variable speed
Condenser loop pump type	Variable speed
Condenser loop pump efficiency	80%
Condenser pump head	60 ft w.c. (179 kPa)

3.7.6.3 Heating Hot Water System

The hot water system supplied water to the six AHUs and to the operating suite reheat coils. Note that it did not serve the condenser loop, as the water supply temperature requirements of the condenser loop were drastically different from those required by the AHU and OR heating coils. The hot water system was served by a natural gas-fired condensing boiler with an OA reset-based supply water temperature set point. The upper and lower bounds of this reset schedule are listed in Table 3-25. For OA temperatures within this range, the supply water temperature value was linearly interpolated. For OA temperatures outside this bound, the upper or lower limit value was used. Important performance metrics for the hot water system are listed in Table 3-26.

Table 3-25 Low-Energy Heating Hot Water System OA Reset Values

Property	Value
Set point at outdoor low temperature	180.0°F (82.2°C)
Outdoor low temperature	0.0°F (–17.8°C)
Set point at outdoor high temperature	140.0°F (60.0°C)
Outdoor high temperature	60.0°F (15.6°C)

Table 3-26 Low-Energy Heating Hot Water Loop Performance Metrics

Property	Value
Boiler type	Condensing
Fuel type	Natural gas
Boiler efficiency	90%
Hot water return design temperature difference	20.0°F (11.1°C)
Hot water pump type	Variable speed
Hot water pump efficiency	80%
Hot water pump head	60 ft w.c. (179 kPa)

Although the efficiency of a condensing boiler depends on the boiler PLR and the return water temperature, the boiler efficiency was modeled solely as a function of PLR because of

limitations within EnergyPlus. The coefficients for the PLR curve, which were taken from Bonnema et al. (2010), are listed in Table 3-27. The boiler efficiency curve used can be found in (3-1).

Table 3-27 Condensing Boiler Efficiency Curve Data

EnergyPlus Input Data	Value
Nominal E_t	0.90
Coefficient 1: constant (C_1 in (3-1))	0.9667
Coefficient 2: PLR (C_2 in (3-1))	–0.1667
Coefficient 3: PLR^2 (C_3 in (3-1))	0
Coefficient 4: PLR^3 (C_4 in (3-1))	0
Calculation PLR minimum	0.1
Calculation PLR maximum	1.0

3.7.6.4 Chilled Water System

The chilled water system, which was supplied by a water-cooled, variable-speed, centrifugal chiller, delivered chilled water to the six AHUs. Performance curves for the chiller were taken from Lord (2010). Water was supplied to the AHU chilled water coils at 44.0°F (6.7°C) and designed to return at a temperature of 56.0°F (13.3°C). The cooling tower was modeled as a variable-speed, cross-flow, open cooling tower with a design approach temperature (outlet water temperature minus inlet air wet-bulb temperature) of 7.0°F (3.9°C) and a design range temperature (inlet water temperature minus outlet water temperature) of 10.0°F (5.6°C). In reality, the condenser loop and chilled water loops would most likely share the same cooling tower; however, because of a modeling simplification, each loop was modeled with its own cooling tower (both have identical performance parameters, but not identical capacities). Performance metrics for the chilled water system are listed in Table 3-28.

Table 3-28 Low-Energy Chilled Water Loop Performance Metrics

Property	Value
Chiller type	Centrifugal, water cooled, variable speed
Chiller fuel	Electricity
Chiller coefficient of performance	7.0
Tower type	Open, variable speed
Chiller design outlet temperature	44.0°F (6.7°C)
Chilled water design return temperature	56.0°F (13.3°C)
Chilled water pump type	Variable speed
Chilled water pump efficiency	80%
Chilled water pump head	60 ft w.c. (179 kPa)

3.7.6.5 Water Loop Heat Pumps

Each zone in the model (except for the two operating suites), was conditioned via its own WLHP. Each WLHP used two direct-expansion coils, one for heating and the other for cooling. Both coils were fed from the condenser water loop described in section 3.7.6.2. A gas-fired heating coil provided backup heating in case the primary heating coil could not meet the zone load. Performance characteristics for the heat pumps are listed in Table 3-29. Heat pump

efficiency values were taken from a typical heat pump (ClimateMaster 2010). Fan pressure rise values are typical industry values for hospitals.

Table 3-29 Low-Energy WLHP Performance Metrics

Property	Value
Cooling coil type	Direct expansion
Cooling coil coefficient of performance	4.5 (15.4 EER)
Primary heating coil type	Direct expansion
Primary heating coil coefficient of performance	5.0 (17.1 EER)
Secondary heating coil type	Natural gas burner
Secondary heating coil efficiency	80%
Fan pressure rise	0.30 in. w.c. (74 Pa)
Fan total efficiency	55%
Motor efficiency	90%

3.7.6.6 Demand Controlled Ventilation

Demand controlled ventilation was modeled for zones in which the OA requirement was (at least in part) a function of occupancy. In these zones, the DOAS VAV terminal unit damper position was allowed to fluctuate as the occupancy in each eligible zone changed, so that these zones were not overventilated. The AHUs serving these zones used VAV fans, so as the dampers closed, the fans turned down, saving primary fan energy in addition to the energy that would otherwise have been necessary to condition the additional OA.

3.8 Service Water Heating

Service water heating (SWH) is the hot water supply that is used for purposes other than space heating.

3.8.1 Baseline Model

The SWH loads for the baseline models were met via an 80% efficient natural gas water heater. We ignored pumping energy, on the assumption that the water main pressure was strong enough to deliver service water to the building. SWH system parameters are listed in Table 3-30.

Table 3-30 SWH Performance Metrics

Properties	Value
Fuel type	Natural gas
Boiler efficiency	80%
Storage volume	793 gal (3.0 m^3)
Water heater capacity (kW)	845.0

3.8.2 Low-Energy Model

The low-energy model SWH had the same parameters as the baseline model (Table 3-30), except the natural gas water heater was modeled as 90% efficient.

4. Model Validation

This section describes our model validation work, which included analysis of both annual and subhourly results for certain key data. This data was checked both to assure that it was reasonable, as well as to ensure that, where applicable, it was within the proper tolerances.

4.1 Simulation Runtime

Because of the large number of zones (130) in the model, simulation runtime was a concern. To shorten the runtime we changed all interzone surface boundary conditions from adjacent zone to adiabatic. This eliminated the interzone heat transfer calculations performed within EnergyPlus. Because all zones were maintained at relatively the same temperature, the interzone heat transfer was small (small temperature gradient between zones) and could therefore be neglected. An analysis was performed to determine the simulation runtime and energy use effect of setting all interzone surface boundary conditions to adiabatic.

The first step was to set all interzone surface boundary conditions to adiabatic while keeping all interzone surfaces matched. The interzone surfaces were matched to allow for proper assignment of constructions. Simply changing the matched surface boundary condition from interzone to adiabatic resulted in negligible differences in simulation runtime and energy use (see Table 4-1).

Table 4-1 Simulation Runtime and Results Comparison

Simulation	Runtime (s)	Runtime Difference (%)	Energy Use (GJ)	Energy Use Difference (%)
Matched surfaces, adjacent zone interzone boundary conditions	2,973.72	0.00	133,320.95	0.00
Matched surfaces, adiabatic interzone boundary conditions	2,979.00	-0.18	133,507.65	–0.14
Aggregated surfaces, adiabatic interzone boundary conditions	1,955.55	34.24	134,007.69	–0.52

The next step was to aggregate the previously matched surfaces by deleting surface subdividing boundaries (essentially aggregating what had previously been multiple matched surfaces into one new adiabatic surface per zone). This resulted in significantly fewer surfaces within the model and led to an approximately one-third reduction in runtime without sacrificing energy consumption accuracy (see Table 4-1).

The results showed that aggregating subdivided surfaces and setting interzone boundary conditions to adiabatic significantly reduced simulation runtime while maintaining simulation accuracy.

4.2 Total and Ventilation Airflow Requirements

Nearly all commercial buildings have ventilation requirements that ensure that enough OA is provided. Hospitals differ from typical commercial buildings in that they also have total airflow (ventilation air mixed with return air) requirements in addition to ventilation air requirements. It was essential that the energy models satisfied total air and ventilation air requirements to properly model the energy consumption of the HVAC system. Table 2.1-2 in AIA et al. (2006) was first used to specify the OA and total air requirements. These tables list total air and ventilation air requirements for numerous hospital-specific space area designations. All total air requirements and some ventilation air requirements for the energy model zones were taken from this guide. If a zone in the energy model did not have total air requirements listed in the guide, none were set. If a zone in the energy model did not have ventilation air requirements listed in the guide, Standard 62.1-2004 (ASHRAE 2004a) was used.

4.2.1 Baseline Model

In the baseline model, the total airflow (where applicable) and ventilation airflow rates were set by sizing the minimum airflow rate to the CAV terminal box in each zone to match the requirement. The larger of the total airflow rate and the ventilation airflow rate divided by the AHU OA fraction was used to set the minimum airflow rate to the CAV terminal box in each zone. This ensured that every zone met the total and ventilation airflow requirements.

It is worthwhile to note that many zones were over ventilated due to this strategy, because the critical zone (the zone requiring the highest fraction of outdoor air) for each air handler determined the total minimum OA fraction for that air system. This led to excessive OA in zones that had less stringent OA requirements than the critical zone served by each AHU.

To confirm that this requirement was being met, we exported detailed simulation timestep airflow data from EnergyPlus and compared these to the calculated minimum requirements. Table 4-2 through Table 4-4 show that the zones met total airflow requirements (where applicable) and Table 4-5 through Table 4-7 show that the zones were never supplied with less than 97% of the required ventilation air. Because of the large number of zones (130), only 10 often-scrutinized zones are included in Table 4-2 through Table 4-7. Table D-1 and Table D-4 in Appendix D demonstrate that the total airflow and ventilation airflow requirements were met for all zones.

Table 4-2 Baseline Outdoor Airflow Validation: Humid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 1 Exam	224.4	871.2	871.2	871.2	871.2	871.2	871.2
Floor 2 Exam 1	357.0	1,658.9	1,752.7	1,758.8	1,861.5	1,852.1	1,864.6
Floor 2 Nurse Station 1	109.7	278.0	286.9	290.2	276.3	274.6	269.9
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,184.6	1,263.7	1,136.0	1,136.0	1,136.0	1,136.0
Floor 3 Operating	1,200.0	1,320.5	1,352.2	1,370.7	1,392.5	1,387.7	1,383.9
Floor 2 Trauma	2,240.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,701.6
Floor 3 Triage	500.0	990.0	990.0	990.0	990.0	990.0	990.0

Table 4-3 Baseline Outdoor Airflow Validation: Arid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4B Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 1 Exam	224.4	871.2	871.2	871.2	874.3	871.2	871.2
Floor 2 Exam 1	357.0	2,016.0	1,661.8	1,976.4	2,220.0	2,151.8	2,066.2
Floor 2 Nurse Station 1	109.7	309.8	262.5	310.8	333.0	322.1	297.9
Floor 2 Operating	12,850.7	13,165.0	12,850.7	13,171.3	14,616.5	14,403.4	13,392.5
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,462.8	1,136.0	1,346.4	1,361.9	1,248.9	1,136.0
Floor 3 Operating	1,200.0	1,460.7	1,279.8	1,465.3	1,684.6	1,646.8	1,537.1
Floor 2 Trauma	2,240.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0
Floor 3 Patient 1	1,666.7	1,750.3	1,666.7	1,666.7	1,790.5	1,845.2	1,896.6
Floor 3 Triage	500.0	990.0	990.0	990.0	990.0	990.0	990.0

Table 4-4 Baseline Outdoor Airflow Validation: Marine and Cold Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 1 Exam	224.4	871.2	871.2	871.2	871.2
Floor 2 Exam 1	357.0	1,754.5	1,882.6	1,929.0	1,715.8
Floor 2 Nurse Station 1	109.7	237.5	252.9	268.0	213.7
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,358.6	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 3 Operating	1,200.0	1,265.6	1,343.5	1,434.7	1,290.4
Floor 2 Trauma	2,240.0	3,719.4	3,696.0	3,696.0	3,696.0
Floor 3 Patient 1	1,666.7	1,689.5	1,840.6	1,802.5	2,107.0
Floor 3 Triage	500.0	990.0	990.0	990.0	990.0

Table 4-5 Baseline Total Airflow Validation: Humid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 1 Exam	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0
Floor 2 Exam 1	4,200.0	5,027.1	5,311.1	5,329.8	5,641.0	5,612.3	5,650.3
Floor 2 Nurse Station 1	2,280.0	3,211.2	3,263.1	3,339.3	3,205.8	3,227.4	3,212.8
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	4,050.0	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9
Floor 2 Patient 1	3,408.0	3,589.8	3,829.3	3,442.4	3,442.4	3,442.4	3,442.4
Floor 3 Operating	6,000.0	6,602.5	6,761.0	6,853.7	6,962.6	6,938.4	6,919.4
Floor 2 Trauma	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0
Floor 3 Patient 1	5,000.0	5,050.5	5,050.5	5,050.5	5,050.5	5,050.5	5,156.2
Floor 3 Triage	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0

Table 4-6 Baseline Total Airflow Validation: Arid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4B Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 1 Exam	2,640.0	2,640.0	2,640.0	2,640.0	2,649.4	2,640.0	2,640.0
Floor 2 Exam 1	4,200.0	6,109.1	5,035.8	5,989.2	6,727.3	6,520.7	6,261.3
Floor 2 Nurse Station 1	2,280.0	3,449.6	3,125.8	3,519.3	3,875.5	3,833.3	3,571.4
Floor 2 Operating	64,253.3	65,825.1	64,253.3	65,856.6	73,082.3	72,017.2	66,962.7
Floor 2 PACU	4,050.0	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9
Floor 2 Patient 1	3,408.0	4,432.7	3,442.4	4,080.1	4,126.9	3,784.6	3,442.4
Floor 3 Operating	6,000.0	7,303.6	6,399.2	7,326.5	8,423.1	8,234.0	7,685.4
Floor 2 Trauma	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0
Floor 3 Patient 1	5,000.0	5,304.1	5,050.5	5,050.5	5,425.9	5,591.4	5,747.4
Floor 3 Triage	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0

Table 4-7 Baseline Total Airflow Validation: Marine and Cold Climates

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 1 Exam	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0
Floor 2 Exam 1	4,200.0	5,316.7	5,704.8	5,845.6	5,199.3
Floor 2 Nurse Station 1	2,280.0	2,977.6	3,087.8	3,241.1	2,876.4
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	4,050.0	4,090.9	4,090.9	4,090.9	4,090.9
Floor 2 Patient 1	3,408.0	3,442.4	3,442.4	3,442.4	3,442.4
Floor 3 Operating	6,000.0	6,328.2	6,717.5	7,173.3	6,451.8
Floor 2 Trauma	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0
Floor 3 Patient 1	5,000.0	5,119.8	5,577.6	5,462.2	6,385.0
Floor 3 Triage	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0

4.2.2 Low-Energy Model

In the low-energy model, the ventilation airflow rates were set by sizing the minimum airflow rates to the VAV terminal boxes in each zone to match the ventilation air requirements. The total airflow rates (where applicable) were set at the zone WLHP fan by specifying a 24/7 fan operation schedule and a minimum flow rate for the unit equivalent to the total airflow requirement for the zone minus the ventilation airflow rate being delivered via the VAV terminal box.

To verify that this requirement was being met, we exported detailed simulation timestep airflow data from EnergyPlus and compared these to the calculated minimum requirements to demonstrate that the model always met airflow requirements. Table 4-8 through Table 4-10 show that the zones met total airflow requirements (where applicable) and Table 4-11 through Table 4-13 show that the zones were never supplied with less than 97% of the required ventilation air. Because of the large number of zones (130), only 10 often-scrutinized zones are included in Table 4-8 through Table 4-13. Table D-7 through Table D-12 demonstrate that the total airflow and ventilation airflow requirements were met for all zones.

Table 4-8 Low-Energy Outdoor Airflow Validation: Humid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 1 Exam	158.4	159.5	158.2	158.2	156.7	156.4	155.6
Floor 2 Exam 1	252.0	253.7	251.7	251.6	249.3	248.8	247.5
Floor 2 Nurse Station 1	77.4	90.9	90.2	90.1	89.6	89.2	88.7
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 3 Operating	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0
Floor 2 Trauma	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Triage	500.0	500.0	500.0	500.0	500.0	500.0	500.0

Table 4-9 Low-Energy Outdoor Airflow Validation: Arid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4B Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 1 Exam	158.4	158.7	157.4	158.4	158.5	159.1	157.3
Floor 2 Exam 1	252.0	252.5	250.5	252.0	252.1	253.1	250.3
Floor 2 Nurse Station 1	77.4	90.6	89.9	90.3	90.4	90.7	89.7
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	13,210.6	13,124.4	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 3 Operating	1,200.0	1,207.6	1,200.0	1,244.0	1,413.1	1,398.6	1,307.3
Floor 2 Trauma	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Triage	500.0	500.0	500.0	500.0	500.0	500.0	500.0

Table 4-10 Low-Energy Outdoor Airflow Validation: Marine and Cold Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 1 Exam	158.4	158.5	156.5	156.1	154.6
Floor 2 Exam 1	252.0	252.2	248.9	248.4	246.0
Floor 2 Nurse Station 1	77.4	90.4	89.0	89.0	88.1
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 3 Operating	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0
Floor 2 Trauma	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Triage	500.0	500.0	500.0	500.0	500.0

Table 4-11 Low-Energy Total Airflow Validation: Humid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 1 Exam	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6
Floor 2 Exam 1	3,843.0	3,843.0	3,843.0	3,843.0	3,939.8	3,910.4	3,896.5
Floor 2 Nurse Station 1	2,086.2	2,550.7	2,563.2	2,634.1	2,587.3	2,626.0	2,631.4
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	2,700.0	2,875.7	2,886.7	2,967.8	2,914.6	2,924.6	2,937.9
Floor 2 Patient 1	1,136.0	2,497.4	2,504.9	2,425.2	2,470.9	2,444.0	2,357.1
Floor 3 Operating	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0
Floor 2 Trauma	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0
Floor 3 Patient 1	1,666.7	2,925.3	3,053.7	3,084.5	3,054.0	2,986.0	2,984.7
Floor 3 Triage	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0

Table 4-12 Low-Energy Total Airflow Validation: Arid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4B Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 1 Exam	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6
Floor 2 Exam 1	3,843.0	4,155.9	3,843.0	4,259.9	4,721.2	4,561.2	4,241.8
Floor 2 Nurse Station 1	2,086.2	2,704.4	2,511.3	2,794.3	3,110.3	3,107.0	2,902.4
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	66,053.1	65,622.1	64,253.3
Floor 2 PACU	2,700.0	3,046.6	2,777.6	3,116.9	3,534.3	3,492.4	3,256.4
Floor 2 Patient 1	1,136.0	2,821.2	1,945.9	2,926.3	3,009.6	2,806.6	2,491.7
Floor 3 Operating	6,000.0	6,038.1	6,000.0	6,220.0	7,065.6	6,993.1	6,536.5
Floor 2 Trauma	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0
Floor 3 Patient 1	1,666.7	3,542.2	2,753.0	3,596.9	3,662.9	3,481.4	3,255.3
Floor 3 Triage	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0

Table 4-13 Low-Energy Total Airflow Validation: Marine and Cold Climates

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 1 Exam	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6
Floor 2 Exam 1	3,843.0	3,843.0	3,843.0	3,843.0	3,843.0
Floor 2 Nurse Station 1	2,086.2	2,459.4	2,546.4	2,644.5	2,531.7
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	2,700.0	2,700.0	2,780.5	2,962.2	2,870.6
Floor 2 Patient 1	1,136.0	1,703.7	1,949.1	2,226.6	2,116.2
Floor 3 Operating	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0
Floor 2 Trauma	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0
Floor 3 Patient 1	1,666.7	3,172.9	3,349.9	2,886.8	3,951.5
Floor 3 Triage	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0

4.3 Determination of Reheat Energy

Initial energy simulations showed that a large portion of the building's total energy use was devoted to heating, even in hot climates. This, coupled with anecdotal evidence that reheat energy in hospitals accounted for a significant fraction of total energy use, led to the pursuit of EDMs that would reduce the need for reheat. However, in order to choose energy design strategies that effectively reduced reheat energy, we first needed to better understand the fraction of building heating energy that was classified as reheat for each climate zone. We therefore wrote customized EnergyPlus Runtime Language code into the large hospital TSD model using the Energy Management System (EMS) feature of EnergyPlus.

4.3.1 Methodology

For this analysis, energy used by the AHU heating coils and the zone-level reheat coils was broken up into two categories, *primary heating energy* and *reheat energy*.

Primary heating energy included:

- Heating energy used by the AHU heating coils.
- Energy used by the zone reheat coil to directly increase the space temperature of a zone that was requesting heating. This did *not* include the energy used to counteract the AHU if that AHU was in cooling mode.

Reheat energy included all other energy used by the zone reheat coil.

To see how the zone-level reheat coil energy was apportioned between primary heating and reheat energy on a case-by-case basis, refer to Table 4-14.

Table 4-14 Summary of Reheat Assignment by AHU Coil Activity and Zone State

Active AHU Heating Coil	Active AHU Cooling Coil	Zone State	Reheat Coil* Energy Assignment	Notes
Yes	Yes	Cooling	None – AHU control problem	This will trigger a flag in the EMS code
		Deadband		
		Heating		
	No	Cooling	100% reheat energy	
		Deadband		
		Heating	100% primary heating energy	
No	Yes	Cooling	100% reheat energy	
		Deadband		
		Heating	X% reheat energy (1 - X)% primary heating energy	See (4-1), (4-3), (4-4)
	No	Cooling	100% reheat energy	Economizing
		Deadband		
		Heating	100% primary heating energy	

* With this HVAC system configuration, zone level reheat coils perform the primary heating.

As an operational note, the AHU heating coils raised the air temperature (when necessary) to the required deck temperature, which was much lower than the heating supply air temperature (the temperature at which air is supplied to a zone that is calling for heating). If required, the zone reheat coils raised the supplied air temperature to the heating supply air temperature set point.

For the unique case in which the zone called for heating and the AHU actively cooled the incoming airstream, the zone reheat coil energy had to be distributed between primary heating energy, which the zone called for, and reheat energy, which the zone reheat coil provided to combat the cooling provided by the AHU. To determine the fraction of reheat coil energy that was labeled as reheat energy, we applied a simple temperature ratio in which the difference between the AHU cooling coil inlet air temperature and the AHU fan outlet air temperature was divided by the reheat coil outlet to inlet air temperature difference (see (4-1) and Figure 4-1).

$$ReheatEnergyRatio = Min\left[Max\left(\frac{CC_{InTemp} - Fan_{OutTemp}}{ZRC_{OutTemp} - ZRC_{InTemp}}, 0 \right), 1 \right] \quad (4\text{-}1)$$

where

ReheatEnergyRatio: The fraction of zone reheat coil energy appropriated to reheat
CC_{InTemp}: AHU cooling coil inlet air temperature
$Fan_{OutTemp}$: AHU fan outlet air temperature
$ZRC_{OutTemp}$: Zone reheat coil outlet air temperature
ZRC_{InTemp}: Zone reheat coil inlet air temperature

Figure 4-1 provides a graphical representation of the temperatures experienced by the HVAC system points referenced in (4-1).

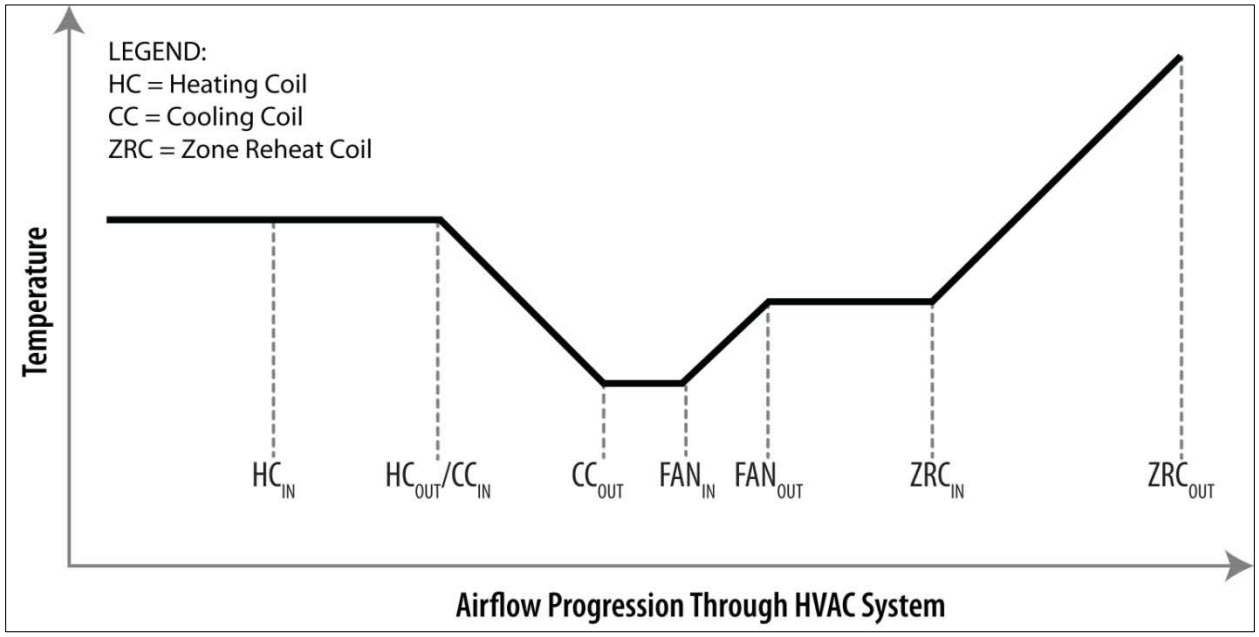

Figure 4-1 HVAC system temperature diagram
(Credit: Marjorie Schott/NREL)

A temperature ratio (instead of an energy ratio) was used to simplify and reduce the required EMS code. This was appropriate for two reasons:

- The mass flow rate of air destined for a specific zone that passes through the AHU is equal to the mass flow rate of air that passes through that zone's reheat coil.
- The specific heat capacity of air does not change appreciably over the range of temperatures experienced by the airstream in a typical HVAC system (Moran 2004).

Had an energy ratio been used, the equation would have been:

$$ReheatEnergyRatio = Min\left[Max\left(\frac{Mass_{Air} \cdot C_{p_{Air}} \cdot \left(CC_{InTemp} - Fan_{OutTemp} \right)}{Mass_{Air} \cdot C_{p_{Air}} \cdot \left(ZRC_{OutTemp} - ZRC_{InTemp} \right)}, 0 \right), 1 \right] \quad (4\text{-}2)$$

With the above assumptions, the mass flow rate and specific heat terms would have dropped out, leaving only the ratio of the temperature differences, and the equation would have simplified to (4-1).

In (4-1), the maximum of this reheat energy ratio and zero was taken to guard against air entering the cooling coil at a temperature lower than that of the fan outlet but higher than the cooling coil outlet set point (which would lead to a ratio less than zero). In this case, the cooling coil must still remove heat from the airstream to meet the cold deck temperature set point, which is set downstream of the fan (i.e. after the fan heat is added). However, because the heat removed by the cooling coil is added back for "free" by the system fan, no additional load is imposed on the zone reheat coil and all the zone reheat coil energy should be apportioned to primary heating.

The minimum statement in (4-1) was necessary to guard against the possibility that the temperature rise across the reheat coil was smaller than the temperature decrease from the cooling coil inlet to the supply fan outlet. In that case, the reheat energy ratio would have exceeded a value of 1.0. Were this scenario to occur in the model, the heating energy that the zone reheat coil provided to the airstream would be categorized as 100% reheat. This is because the reheat coil would not be actively raising the zone temperature, but would instead be counteracting the AHU cooling coil.

To calculate the actual amount of reheat coil energy that was assigned as reheat energy, we multiplied the reheat energy ratio by the amount of energy the zone reheat coil transferred to the airstream, which is an available reporting variable in EnergyPlus (see (4-3)). A similar approach was applied to determine the amount of primary heating energy that the zone reheat coil supplied to the zone, except that a value of 1 minus the reheat energy ratio was used (see (4-4)).

$$ReheatEnergy = ReheatEnergyRatio \cdot ZoneReheatCoilEnergy \quad (4\text{-}3)$$

$$PrimaryHeatingEnergy = \left(1 - ReheatEnergyRatio\right) \cdot ZoneReheatCoilEnergy \quad (4\text{-}4)$$

where

ZoneReheatCoilEnergy: Energy transferred from the zone reheat coil to the zone supply air

For more details, refer to the representative EMS code in Appendix C.

4.3.2 Reheat Energy Results

The fraction of building heating energy that was categorized as primary heating energy and the fraction that was categorized as reheat energy (as defined according to Table 4-14 and Section 4.3.1) in the baseline simulations is detailed in Table 4-15. Because the DOAS allowed ventilation air to be supplied independent of the space thermal loads, reheat energy in the low-energy model was essentially non-existent (there was some reheat energy attributable to the CAV system that served the operating suite, but it was minimal) and is therefore not reported.

Table 4-15 Baseline Reheat Energy Percentage

Climate Zone	Primary Heating Energy Percentage (%)	Reheat Energy Percentage (%)
1A	1.0	99.0
2A	7.0	93.0
2B	5.8	94.2
3A	8.4	91.6
3B:CA	3.6	96.4
3B:Other	7.2	92.8
3C	8.9	91.1
4A	12.6	87.4
4B	11.4	88.6
4C	11.3	88.7
5A	16.2	83.8
5B	14.3	85.7
6A	19.9	80.1
6B	18.0	82.0
7A	22.0	78.0
7B	29.6	70.4

4.4 Hours Set Point Not Met

To determine whether the simulated HVAC systems adequately met the thermal loads, we reported the hours that the heating and cooling set points were not met during occupied hours (defined as people being in the zone) for each model in all locations. The simulations used 10-minute time steps, leading to the possibility of fractional hours where the set point was not met. For a time step to be counted as "out of set point," the difference between the zone temperature and the current zone set point had to be greater than 1.8°F (1.0°C). If multiple zones were out of set point for the same time step, that time step was not counted as being out of set point twice (the maximum number of hours that the model could be out of set point was 8,760). Hours out of set point for the baseline and low-energy models, by location, are listed in Table 4-16.

Table 4-16 Hours Set Point Not Met During Occupied Hours

Climate Zone	Baseline			Low-Energy		
	Heating	Cooling	Total	Heating	Cooling	Total
1A	0.00	0.00	0.00	0.00	0.00	0.00
2A	0.00	0.00	0.00	0.00	0.00	0.00
2B	0.00	0.00	0.00	0.00	0.00	0.00
3A	0.00	0.00	0.00	0.00	0.00	0.00
3B:CA	0.00	0.00	0.00	0.00	0.00	0.00
3B:Other	0.00	0.00	0.00	0.00	0.00	0.00
3C	0.00	0.00	0.00	0.00	0.00	0.00
4A	0.00	0.00	0.00	0.00	0.00	0.00
4B	0.00	0.00	0.00	0.00	33.17	33.17
4C	0.00	0.00	0.00	0.00	0.00	0.00
5A	0.00	0.00	0.00	0.00	0.00	0.00
5B	0.00	0.50	0.50	0.00	25.67	25.67
6A	0.00	0.00	0.00	0.00	0.00	0.00
6B	0.00	0.00	0.00	2.50	0.00	2.50
7A	0.00	0.50	0.50	0.00	0.00	0.00
7B	2.33	0.00	2.33	0.00	1.83	1.83

4.5 Zone Relative Humidity Levels

Hospitals are required to maintain space RH values between 30% and 60% (AIA et al. 2006). To ensure this requirement was being met, we reported the RH values for the five humidity control zones (one per AHU; AHU/DOAS 6 serving the MOB did not have a humidifier) at detailed time steps for each location. The 5^{th} and 95^{th} percentile RH values experienced by each zone are reported in Table 4-17 (baseline model) and Table 4-18 (low-energy model).

Table 4-17 Baseline Annual 5th and 95th Percentile RH Values

Climate Zone	Floor 2 Lab 1 RH (%)		Floor 2 Trauma RH (%)		Floor 2 Operating Suite RH (%)		Floor 3 ICU RH (%)		Floor 3 Triage RH (%)	
	5th Percentile	95th Percentile	5th Percentile	95th Percentile	5th Percentile	95th Percentile	5th Percentile	95th Percentile	5th Percentile	95th Percentile
1A	44.2	46.4	48.8	51.3	43.7	46.1	43.6	46.0	43.5	45.6
2A	30.0	46.3	30.0	51.4	30.0	45.8	30.0	45.7	30.0	45.4
2B	30.0	46.2	30.0	52.0	30.0	45.4	30.0	45.0	30.0	45.2
3A	30.0	45.9	30.0	51.4	30.0	45.5	30.0	45.3	30.0	45.0
3B:CA	30.2	46.8	34.9	52.6	30.1	46.2	30.1	46.5	30.1	46.2
3B:Other	30.0	45.3	30.0	51.4	30.0	44.9	30.0	44.3	30.0	44.4
3C	31.5	46.6	36.6	52.0	31.0	46.2	31.2	45.9	31.0	45.4
4A	30.0	46.3	30.0	51.3	30.0	45.7	30.0	45.4	30.0	45.2
4B	28.8	46.4	30.0	52.5	29.9	46.9	30.0	45.8	30.0	46.1
4C	30.0	46.1	30.0	51.5	30.0	45.5	30.0	45.1	30.0	44.9
5A	30.0	46.0	30.0	51.1	30.0	45.5	30.0	45.2	30.0	45.0
5B	30.0	45.4	30.0	51.8	30.0	45.8	30.0	44.8	30.0	44.9
6A	30.0	45.9	30.0	51.2	30.0	45.5	30.0	45.1	30.0	45.0
6B	30.0	44.6	30.0	51.1	30.0	44.5	30.0	43.8	30.0	43.8
7A	30.0	45.7	30.0	51.4	30.0	45.2	30.0	44.8	30.0	44.7
7B	30.0	46.2	30.0	51.9	30.0	45.9	30.0	45.3	30.0	45.4

Table 4-18 Low-Energy Annual 5th and 95th Percentile RH Values

Climate Zone	Floor 2 Lab 1 RH (%)		Floor 2 Trauma RH (%)		Floor 2 Operating Suite RH (%)		Floor 3 ICU RH (%)		Floor 3 Triage RH (%)	
	5th Percentile	95th Percentile	5th Percentile	95th Percentile	5th Percentile	95th Percentile	5th Percentile	95th Percentile	5th Percentile	95th Percentile
1A	44.7	47.3	48.9	51.7	40.7	52.2	41.0	50.6	41.9	48.5
2A	41.5	48.2	30.0	51.8	33.3	53.1	32.0	51.2	33.8	49.1
2B	43.7	51.0	30.0	52.3	34.1	53.3	31.9	49.4	34.0	50.2
3A	40.3	47.3	30.0	51.8	32.5	52.5	31.6	50.2	33.1	48.5
3B:CA	47.2	53.6	35.0	53.0	36.5	57.1	32.5	52.1	36.3	53.1
3B:Other	43.4	50.0	30.0	51.7	33.8	51.5	31.6	48.6	33.7	49.5
3C	47.8	54.3	36.7	52.5	36.0	56.9	32.9	52.4	35.9	53.5
4A	41.2	48.5	30.0	51.6	32.6	52.1	31.8	49.8	33.2	48.6
4B	40.7	46.7	30.0	52.8	33.6	53.0	31.8	49.0	33.5	50.4
4C	44.9	52.3	30.0	52.0	34.5	54.6	32.0	50.8	34.3	51.4
5A	40.4	47.6	30.0	51.4	32.5	51.4	31.5	49.2	32.9	47.9
5B	40.2	45.3	30.0	52.0	33.8	50.1	31.8	47.5	33.6	48.4
6A	40.8	48.0	30.0	51.6	32.8	51.4	31.5	48.8	33.1	47.7
6B	42.0	47.4	30.0	51.4	33.6	47.6	31.6	46.6	33.4	47.8
7A	41.0	48.4	30.0	51.7	33.3	52.3	31.3	49.4	33.2	48.4
7B	43.3	53.4	30.0	52.3	33.4	53.6	31.2	50.8	33.2	52.1

5. Results

This section describes simulation results for both models in each climate zone. Section 5.1 describes the baseline models, and Section 5.2 describes the low-energy models and compares their energy performance to the baseline.

Performance is reported using the following metrics:

- Site EUI is the whole-building site yearly energy use (Section 2.2.1) divided by the building floor area and is reported in MJ/m^2·yr and kBtu/ft^2·yr.
- Electricity intensity is the yearly electricity consumption divided by the building floor area and is reported in MJ/m^2·yr and kBtu/ft^2·yr.
- Natural gas intensity is the yearly natural gas consumption divided by the building floor area and is reported in MJ/m^2·yr and kBtu/ft^2·yr.

5.1 Baseline Models

The energy intensities of the Standard 90.1-2004 baseline models are shown in Table 5-1 through Table 5-3. The EUIs vary across the climate zones; thus the difficulty in achieving 50% energy savings and the amount of energy saved in doing so vary by climate zone.

Table 5-1 Baseline Model Performance: Humid Climates

Units	Metric	Humid Climate Zones					
		1A	2A	3A	4A	5A	6A
SI	EUI (MJ/m^2·yr)	4,787.6	4,697.5	4,474.5	4,544.0	4,409.4	4,397.0
	Electricity intensity (MJ/m^2·yr)	3,218.1	2,956.3	2,748.8	2,623.5	2,448.3	2,383.7
	Natural gas intensity (MJ/m^2·yr)	1,569.5	1,741.2	1,725.7	1,920.5	1,961.1	2,013.3
IP	EUI (kBtu/ft^2·yr)	421.6	413.6	394.0	400.1	388.3	387.2
	Electricity intensity (kBtu/ft^2·yr)	283.4	260.3	242.0	231.0	215.6	209.9
	Natural gas intensity (kBtu/ft^2·yr)	138.2	153.3	152.0	169.1	172.7	177.3

Table 5-2 Baseline Model Performance: Arid Climates

Units	Metric	Arid Climate Zones					
		2C	3B:CA	3B:Other	4B	5B	6B
SI	EUI ($MJ/m^2 \cdot yr$)	4,602.7	4,131.0	4,465.4	4,254.8	4,077.5	4,077.7
	Electricity intensity ($MJ/m^2 \cdot yr$)	2,896.8	2,461.6	2,829.7	2,671.2	2,408.7	2,224.4
	Natural gas intensity ($MJ/m^2 \cdot yr$)	1,705.9	1,669.4	1,635.6	1,583.6	1,668.8	1,853.3
IP	EUI ($kBtu/ft^2 \cdot yr$)	405.3	363.8	393.2	374.7	359.0	359.1
	Electricity intensity ($kBtu/ft^2 \cdot yr$)	255.1	216.8	249.2	235.2	212.1	195.9
	Natural gas intensity ($kBtu/ft^2 \cdot yr$)	150.2	147.0	144.0	139.4	146.9	163.2

Table 5-3 Baseline Model Performance: Marine and Cold Climates

Units	Metric	Marine Climate Zones		Cold Climate Zones	
		3C	4C	7	8
SI	EUI ($MJ/m^2 \cdot yr$)	4,072.6	4,003.9	4,290.6	4,417.3
	Electricity intensity ($MJ/m^2 \cdot yr$)	2,258.3	2,075.2	2,233.9	2,108.8
	Natural gas intensity ($MJ/m^2 \cdot yr$)	1,814.3	1,928.7	2,056.8	2,308.5
IP	EUI ($kBtu/ft^2 \cdot yr$)	358.6	352.6	377.8	389.0
	Electricity intensity ($kBtu/ft^2 \cdot yr$)	198.9	182.7	196.7	185.7
	Natural gas intensity ($kBtu/ft^2 \cdot yr$)	159.8	169.8	181.1	203.3

A comparison of the baseline model results shows that the most energy intensive climate zone is 1A, represented by Miami, Florida, and the least energy intensive is 4C, represented by Seattle, Washington. However, the baseline model energy intensity results are similar across most of the modeled climate zones.

5.2 Low-Energy Models

The energy performance of the selected low-energy models is summarized in Table 5-4 through Table 5-6. The tables report several whole-building metrics.

Table 5-4 Low-Energy Model Performance: Humid Climate Zones

Building Type and Units	Metric	Humid Climate Zones					
		1A	2A	3A	4A	5A	6A
Low-energy	Percent energy savings	50.9%	54.2%	54.3%	54.7%	53.0%	52.4%
Baseline (SI units)	EUI ($MJ/m^2 \cdot yr$)	4,787.6	4,697.5	4,474.5	4,544.0	4,409.4	4,397.0
Low-energy (SI units)	EUI ($MJ/m^2 \cdot yr$)	2,352.1	2,149.8	2,043.1	2,059.3	2,072.2	2,095.1
Baseline (SI units)	Electricity intensity ($MJ/m^2 \cdot yr$)	3,218.1	2,956.3	2,748.8	2,623.5	2,448.3	2,383.7
Low-energy (SI units)	Electricity intensity ($MJ/m^2 \cdot yr$)	2,152.5	1,915.9	1,772.7	1,708.4	1,648.7	1,610.5
Baseline (SI units)	Natural gas intensity ($MJ/m^2 \cdot yr$)	1,569.5	1,741.2	1,725.7	1,920.5	1,961.1	2,013.3
Low-energy (SI Units)	Natural gas intensity ($MJ/m^2 \cdot yr$)	199.6	233.9	270.5	350.9	423.4	484.7
Baseline (IP units)	EUI ($kBtu/ft^2 yr$)	421.6	413.6	394.0	400.1	388.3	387.2
Low-energy (IP units)	EUI ($kBtu/ft^2 yr$)	207.1	189.3	179.9	181.3	182.5	184.5
Baseline (IP units)	Electricity intensity ($kBtu/ft^2 yr$)	283.4	260.3	242.0	231.0	215.6	209.9
Low-energy (IP units)	Electricity intensity ($kBtu/ft^2 yr$)	189.5	168.7	156.1	150.4	145.2	141.8
Baseline (IP units)	Natural gas intensity ($kBtu/ft^2 yr$)	138.2	153.3	152.0	169.1	172.7	177.3
Low-energy (IP units)	Natural gas intensity ($kBtu/ft^2 yr$)	17.6	20.6	23.8	30.9	37.3	42.7

Table 5-5 Low-Energy Model Performance: Arid Climate Zones

Building Type and Units	Metric	Arid Climate Zones					
		2B	3B:CA	3B:Other	4B	5B	6B
Low-energy	Percent energy savings	59.5%	59.8%	59.7%	59.3%	58.0%	57.2%
Baseline (SI units)	EUI ($MJ/m^2 \cdot yr$)	4,602.7	4,131.0	4,465.4	4,254.8	4,077.5	4,077.7
Low-energy (SI units)	EUI ($MJ/m^2 \cdot yr$)	1,861.9	1,659.2	1,799.2	1,730.0	1,713.7	1,745.9
Baseline (SI units)	Electricity intensity ($MJ/m^2 \cdot yr$)	2,896.8	2,461.6	2,829.7	2,671.2	2,408.7	2,224.4
Low-energy (SI units)	Electricity intensity ($MJ/m^2 \cdot yr$)	1,660.0	1,452.2	1,573.7	1,463.9	1,388.4	1,334.3
Baseline (SI units)	Natural gas intensity ($MJ/m^2 \cdot yr$)	1,705.9	1,669.4	1,635.6	1,583.6	1,668.8	1,853.3
Low-energy (SI units)	Natural gas intensity ($MJ/m^2 \cdot yr$)	201.9	207.0	225.5	266.1	325.3	411.7
Baseline (IP units)	EUI ($kBtu/ft^2 yr$)	405.3	363.8	393.2	374.7	359.0	359.1
Low-energy (IP units)	EUI ($kBtu/ft^2 yr$)	164.0	146.1	158.4	152.3	150.9	153.7
Baseline (IP units)	Electricity intensity ($kBtu/ft^2 yr$)	255.1	216.8	249.2	235.2	212.1	195.9
Low-energy (IP units)	Electricity intensity ($kBtu/ft^2 yr$)	146.2	127.9	138.6	128.9	122.3	117.5
Baseline (IP units)	Natural gas intensity ($kBtu/ft^2 yr$)	150.2	147.0	144.0	139.4	146.9	163.2
Low-energy (IP units)	Natural gas intensity ($kBtu/ft^2 yr$)	17.8	18.2	19.9	23.4	28.6	36.2

Table 5-6 Low-Energy Model Performance: Marine and Cold Climate Zones

Building Type and Units	Metric	Marine Climate Zones		Cold Climate Zone	
		1A	3B	4C	7A
Low-energy	Percent energy savings	62.7%	59.8%	52.6%	52.5%
Baseline (SI units)	EUI ($MJ/m^2 \cdot yr$)	4,072.6	4,003.9	4,290.6	4,417.3
Low-energy (SI units)	EUI ($MJ/m^2 \cdot yr$)	1,519.2	1,610.2	2,033.7	2,096.9
Baseline (SI units)	Electricity intensity ($MJ/m^2 \cdot yr$)	2,258.3	2,075.2	2,233.9	2,108.8
Low-energy (SI units)	Electricity Intensity ($MJ/m^2 \cdot yr$)	1,284.5	1,298.2	1,486.3	1,343.4
Baseline (SI units)	Natural gas intensity ($MJ/m^2 \cdot yr$)	1,814.3	1,928.7	2,056.8	2,308.5
Low-energy (SI units)	Natural gas intensity ($MJ/m^2 \cdot yr$)	234.7	312.0	547.4	753.6
Baseline (IP units)	EUI ($kBtu/ft^2 yr$)	358.6	352.6	377.8	389.0
Low-energy (IP units)	EUI ($kBtu/ft^2 yr$)	133.8	141.8	179.1	184.6
Baseline (IP units)	Electricity intensity ($kBtu/ft^2 yr$)	198.9	182.7	196.7	185.7
Low-energy (IP units)	Electricity intensity ($kBtu/ft^2 yr$)	113.1	114.3	130.9	118.3
Baseline (IP units)	Natural gas intensity ($kBtu/ft^2 yr$)	159.8	169.8	181.1	203.3
Low-energy (IP units)	Natural gas intensity ($kBtu/ft^2 yr$)	20.7	27.5	48.2	66.4

All climate zones met the 50% energy savings goal. A comparison of the baseline model results shows that the most energy intensive climate zone is 1A, represented by Miami, Florida, and the least energy intensive is 4C, represented by Seattle, Washington. However, the baseline model energy intensity results are similar across most of the modeled climate zones.

5.3 Comparison

Figure 5-1 shows the energy use of the baseline and low-energy models broken down by end use. Tabular end use energy consumption data are detailed in Appendix B. As Figure 5-1 and Table 5-4 show, the biggest source of energy savings was natural gas, which is due to the change in HVAC systems types between the baseline and low-energy models. This almost completely eliminated the wasteful reheat energy and saved a tremendous amount of natural gas while still maintaining the space airflow, temperature, and humidity requirements. The biggest electricity savings came from reducing fan energy, a direct result of changing the HVAC system type in the low-energy model thereby reducing the required airflow rates and pressure drops seen by the system.

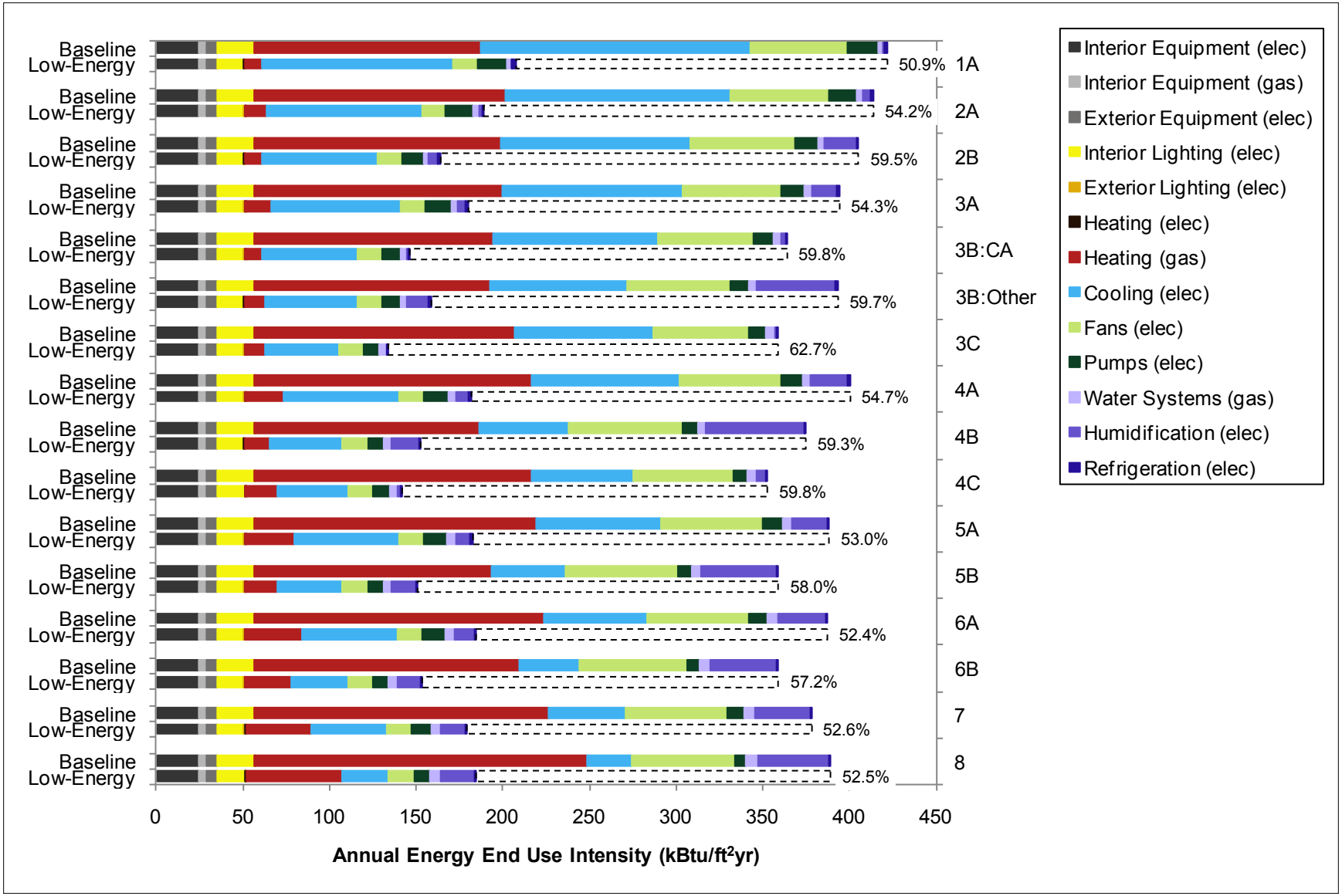

Figure 5-1 EUI by end use for baseline and low-energy models
(Credit: Eric Bonnema/NREL)

5.4 Bundle Analysis

During the modeling process, baseline and low-energy models were created and compared to provide the percent energy savings numbers. The low-energy model was created by starting with the prototype model and applying the design recommendations. However, it is difficult to determine which recommendations provided the largest energy savings, because all EDMs were all applied in a single operation. To better understand how each recommendation affected energy performance, we performed a study in which each group of similar recommendations was incrementally and aggregately applied to the baseline model until the low-energy model was obtained. A similar study was performed by Bonnema et al. (2010) and was termed a *bundled energy efficiency measure analysis*. The same terminology, or the *bundle analysis*, will be used here. The bundle analysis in this report includes four steps, chosen in no particular order:

1. Apply envelope efficiency measures, which included adding overhangs to the south windows and upgrading the building materials in accordance with Section 3.2.
2. Reduce infiltration in the exterior zones from 0.3 ACH to 0.25 ACH, representing a tighter envelope construction (see Section 3.3).
3. Reduce interior and exterior LPDs and add daylighting controls and occupancy sensors to applicable zones (see Section 3.6).
4. Change HVAC system type from CAV AHUs to a DOAS/WLHP system (see Section 3.7).

Figure 5-2 shows the bundle analysis results for the humid climate zones, Figure 5-3 shows the results for the arid climate zones, and Figure 5-4 shows the results for the marine and cold climate zones.

The results show that the biggest energy saver (by far) is the change of HVAC system type. Moving from the CAV AHUs to a DOAS/WLHP system decoupled the space conditioning loads from the ventilation loads. This eliminated the largest energy use (reheat energy). This type of system also shares a common condenser loop for heat rejection, which allowed zones to share loads. This meanstthat if one zone was in cooling mode and another was in heating mode, they could reject their heat to the common condenser loop and the loads would balance each other out. During the winter, hospitals typically have some zones in cooling mode (because of the large plug and process loads in certain zones) and some in heating mode so this system type is ideal.

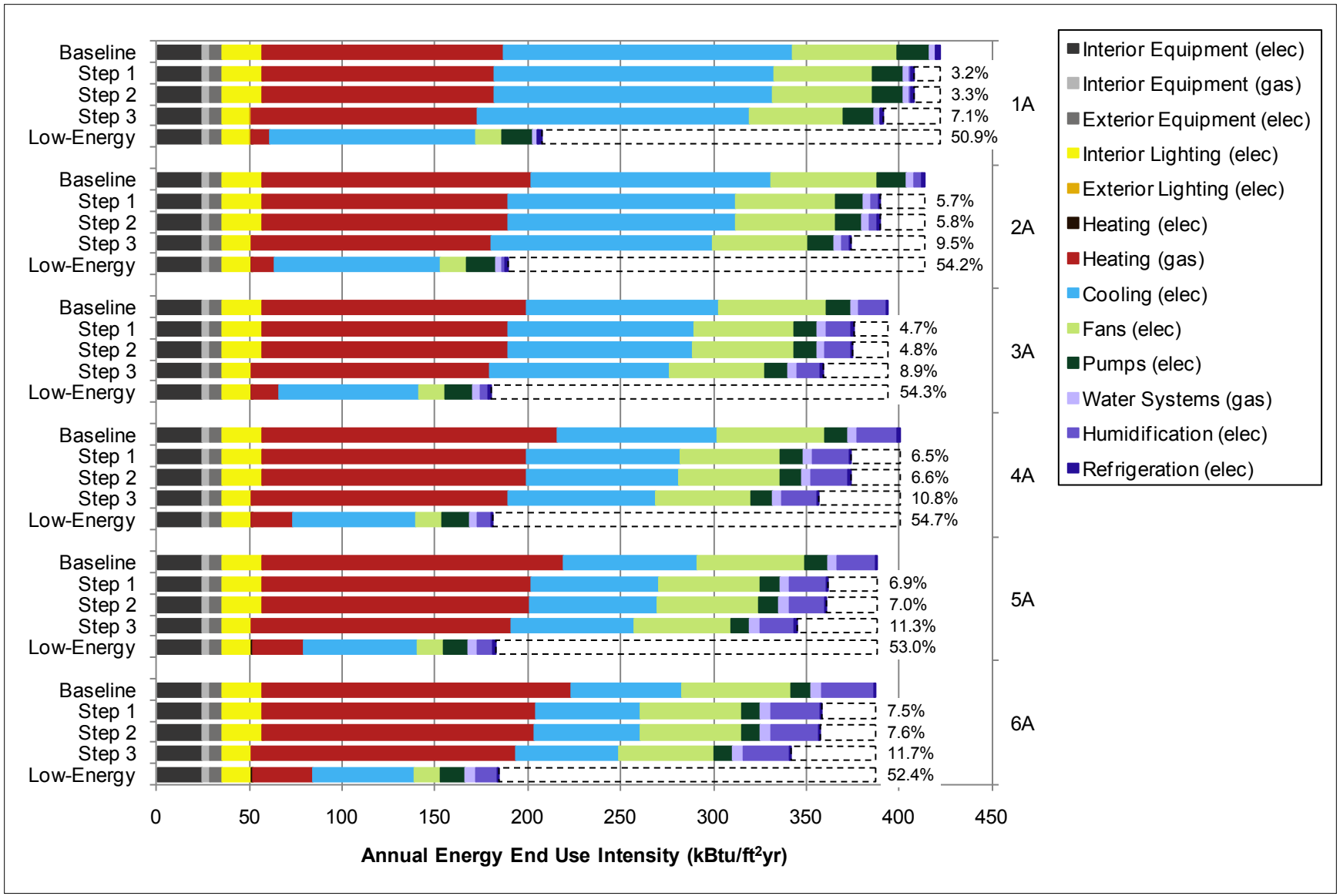

Figure 5-2 Bundle analysis results for humid climate zones
(Credit: Eric Bonnema/NREL)

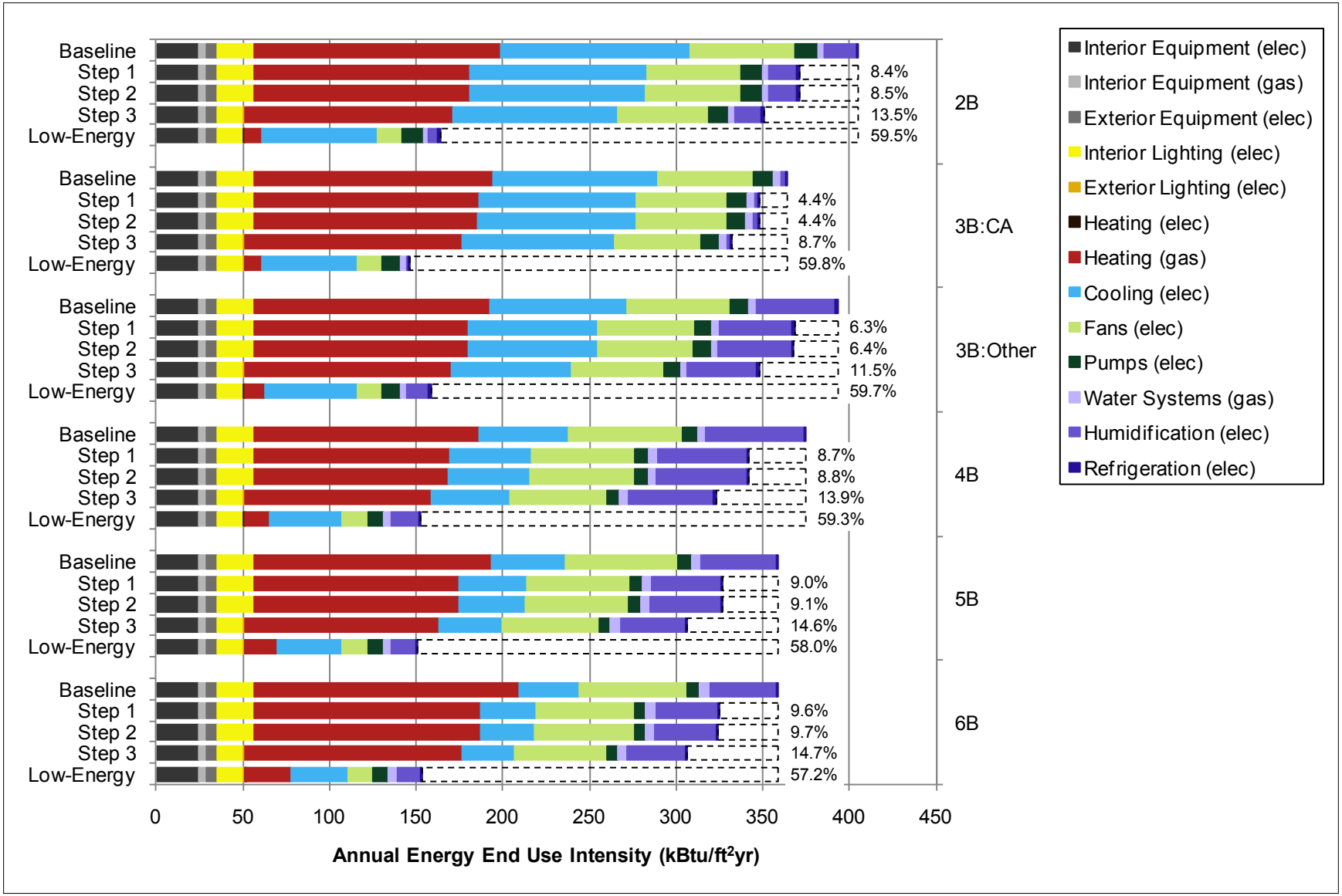

Figure 5-3 Bundle analysis results for arid climate zones
(Credit: Eric Bonnema/NREL)

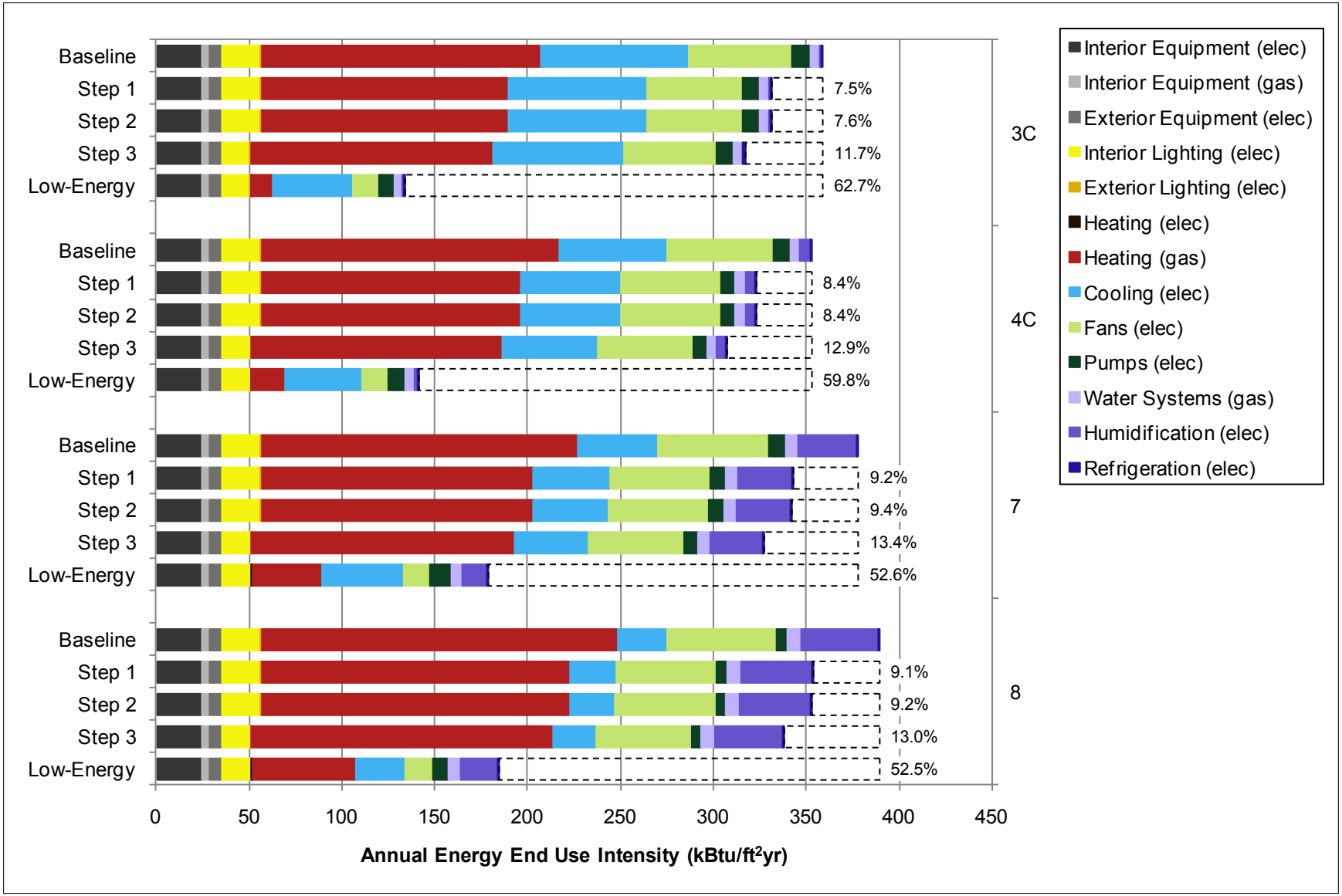

Figure 5-4 Bundle analysis results for marine and cold climate zones
(Credit: Eric Bonnema/NREL)

6. Conclusion

This TSD describes the methodology and process behind demonstrating 50% energy savings in large hospitals compared to Standard 90.1-2004, and it demonstrates that 50% energy savings in large hospitals is achievable in all U.S. climate zones.

Hospitals are enormously complex buildings with many unique requirements. Architects, designers, contractors, developers, owners, and lessees of large hospitals thus often overlook energy usage because they are so focused on meeting the hospital's numerous other requirements. We have demonstrated that 50% energy savings is achievable with conventional technologies while still maintaining all of the requirements necessary for hospital accreditation.

Our ultimate goal is to empower architects and engineers to design the most energy-efficient commercial buildings possible. Unfortunately, design solutions are not identical across all commercial building types because of inherent program differences, so a separate analysis must be run for each commercial building category.

A series of TSDs is available for different building types and different energy savings levels; some of the TSDs have led to the production of volumes in the first stage of the ASHRAE, AIA, IESNA, USGBC, and DOE AEDG series. These represent designs that achieve 30% energy savings over Standard 90.1. The next generation of TSDs target 50% energy savings over Standard 90.1, and it is our hope that the results of this study will influence the creation of an AEDG for large hospitals. The AEDG would be built around the analysis performed in this TSD but would address other building related items not covered in this TSD and provide alternative design recommendations, relevant case studies, and best practices tips.

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Appendix A. Space Types and Standards Mapping

This section documents the mapping from the space types in the energy model to the various references used to determine model input parameters.

A.1 Mapping for LPD

The mapping from each space type to Standard 90.1-2004 for LPDs is listed in Table A-1.

Table A-1 Standard 90.1-2004 Space Type Mapping

Space Type	Mapping to Standard 90.1-2004 Table 9.6.1
Anesthesia gas storage	Active storage::For hospital
Cafeteria	Dining area
Clean workroom/holding	Office-enclosed
Conference room	Conference/meeting/multipurpose
Corridor/transition	Corridor/transition::For hospital
Dining room	Dining area
Examination/treatment room	Hospital::Exam/treatment
Food preparation center	Food preparation
Laboratory	Laboratory
Laundry	Hospital::Laundry-washing
Lobby area	Lobby
Locker	Dressing/locker/fitting room
Lounge	Lounge/recreation::For hospital
Mechanical/electrical/telecomm room	Electrical/mechanical
Medical supply/medication room	Hospital::Medical supply
Nurse station	Hospital::Nurse station
Nursery	Hospital::Nursery
Office	Office-enclosed
Operating suite	Hospital::Operating suite
Patient room	Hospital::Patient room
Pharmacy	Hospital::Pharmacy
Physical therapy	Hospital::Physical therapy
Procedure room	Hospital::Emergency room
Radiology/imaging	Hospital::Radiology
Reception/waiting	Lobby
Recovery room	Hospital::Recovery
Restroom	Restrooms
Soiled workroom/holding	Office-enclosed
Sterilizer equipment room	Active storage::For hospital
Storage/receiving	Active storage::For hospital
Trauma/emergency room	Hospital::Emergency room
Triage	Hospital::Exam/treatment

A.2 Mapping for Airflow

The mapping from each space type to AIA Guidelines Table 2.1-2 and to Standard 170-2007 for air change rates is listed in Table A-3.

Table A-2 AIA Guidelines and Standard 170 Space Type Mapping

Space Type	Mapping to AIA Guidelines Table 2.1-2	Mapping to Standard 170-2008 Table 7-1
Anesthesia gas storage	Emergency, surgery, and critical care::Anesthesia gas storage	
Cafeteria		
Clean workroom/holding	Support areas::Clean workroom or clean holding	
Conference room		
Corridor/transition	Nursing units::Patient corridor	
Dining room		
Examination/treatment room	Diagnostic and treatment areas::Examination room	
Food preparation center	Service areas::Food preparation center	
Laboratory	Diagnostic and treatment areas::Laboratory: General	
Laundry	Service areas::Laundry, general	
Lobby area		
Locker	Service areas::Bathroom	
Lounge		
Mechanical/electrical/telecomm room		
Medical supply/medication room	Support areas::Medication room	
Nurse station		
Nursery	Nursing units::Newborn nursery suite	
Office		
Operating suite		Operating/surgical cytoscopic rooms
Patient room	Nursing units::Patient room	
Pharmacy	Service areas::Pharmacy	
Physical therapy	Diagnostic and treatment areas::Physical therapy and hydrotherapy	
Procedure room	Emergency, surgery, and critical care::Procedure room	
Radiology/imaging	Diagnostic and treatment areas::Imaging::X-ray (diagnostic & treatment)	
Reception/waiting		
Recovery room	Emergency, surgery, and critical care::Recovery room	
Restroom	Service areas::Bathroom	
Soiled workroom/holding	Soiled workroom or soiled holding	
Sterilizer equipment room	Sterilizing and supply::ETO-sterilizer room	
Storage/receiving		
Trauma/emergency room	Emergency, surgery, and critical care::Trauma room	
Triage	Emergency, surgical, and critical care::Triage	

The mapping from each space type to ASHRAE Standard 62.1-2004 Table 6-1 for ventilation rates and to Table 6-4 for exhaust rates is listed in Table A-3.

Table A-3 Standard 62.1-2004 Space Type Mapping

Space Type	Mapping to Standard 62.1-2004 Table 6-1	Mapping to Standard 62.1-2004 Table 6-4
Anesthesia gas storage	General::Storage rooms	
Cafeteria	Food and beverage service::Cafeteria/fast food dining	
Clean workroom/holding	Office buildings::Office space	
Conference room	General::Conference/meeting	
Corridor/transition	General::Corridors	
Dining room	Food and beverage service::Restaurant dining rooms	
Examination/treatment room	Office buildings::Office space	
Food preparation center		Kitchen - commercial
Laboratory	Office buildings::Office space	
Laundry	Retail::Coin-operated laundries	
Lobby area	Office buildings::Reception areas	
Locker	Office buildings::Office space	Locker rooms
Lounge	Office buildings::Office space	
Mechanical/electrical/telecomm room	General::Storage rooms	
Medical supply/medication room	General::Storage rooms	
Nurse station	Office buildings::Office space	
Nursery	Office buildings::Office space	
Office	Office buildings::Office space	
Operating suite		
Patient room		
Pharmacy	Miscellaneous Spaces::Pharmacy	
Physical therapy	Sports and Entertainment:: Health club/weight rooms	
Procedure room	Office buildings::Office space	
Radiology/imaging	Office buildings::Office space	
Reception/waiting	Office buildings::Reception areas	
Recovery room	Office buildings::Office space	
Restroom		Locker/dressing rooms
Soiled workroom/holding		
Sterilizer equipment room	General::Storage rooms	
Storage/receiving	Miscellaneous spaces:: Shipping/receiving	
Trauma/emergency room	Office buildings::Office space	
Triage	Office buildings::Office space	

A.3 Mapping for Plug and Process Loads

The mapping from each space type to GGHC Table OCC-1 for electric plug loads and to Table P-1 for electric and natural gas process loads is listed in Table A-4.

Table A-4 GGHC Space Type Mapping

Space Type	Mapping to GGHC Table OCC-1	Mapping to GGHC Table P-1
Anesthesia gas storage	Anesthesia storage	
Cafeteria		
Clean workroom/holding	Clean utility/workroom	
Conference room	Conference rooms	
Corridor/transition	Corridors	
Dining room	Dining room	
Examination/treatment room	Treatment/examination	
Food preparation center	Kitchen, food preparation	Full service kitchen
Laboratory	Laboratory	Labs
Laundry		Laundry
Lobby area	Waiting areas/lounges	
Locker	Lockers	
Lounge	Waiting areas/lounges	
Mechanical/electrical/telecomm room	Janitors closet/utility	
Medical supply/medication room	Surgical supply	
Nurse station	Nursing stations general	Nursing units
Nursery	Nursery, general	
Office		
Operating suite	Operating suite	Surgical suite
Patient room	Patient room	
Pharmacy	Pharmacy/medicine room	
Physical therapy	Physical therapy and hydrotherapy	
Procedure room	Trauma	Emergency department
Radiology/imaging	X-ray, diagnostic and treatment	Imaging department or area
Reception/waiting	Waiting areas/lounges	
Recovery room	Recovery	ICU/CCU
Restroom	Bathroom/public	
Soiled workroom/holding		
Sterilizer equipment room	Sterilizer room	Central sterile
Storage/receiving	Unsterile supply	
Trauma/emergency room	Trauma	Emergency department
Triage		

Appendix B. Energy Use Data by End Use

This section contains detailed simulation data by end use in both inch-pound (IP) and international (SI) units.

B.1 IP Units

Table B-1 shows the detailed energy use information of the energy models by end use in IP units.

Table B-1 Large Hospital End Uses (IP Units)

Climate	Model	Electricity (kBtu/ft^{2}yr)										Gas (kBtu/ft^{2}yr)			Total End Uses	Percent Savings
		Heating	Cooling	Interior Lights	Exterior Lights	Interior Equipment	Exterior Equipment	Fans	Pumps	Humidifiers	Refrigeration	Heating	Interior Equipment	Water Systems		
1A	Baseline	0.0	155.6	21.1	0.3	24.1	6.6	56.1	17.3	0.4	2.0	130.3	24.1	3.3	431.8	N/A
	Low-energy	0.0	110.7	15.2	0.2	24.1	6.6	14.1	16.5	0.1	2.0	10.1	24.1	2.9	211.8	51.0%
2A	Baseline	0.0	129.5	21.1	0.3	24.1	6.6	57.3	15.5	4.5	1.6	144.8	24.1	3.9	422.8	N/A
	Low-energy	0.2	89.5	15.3	0.2	24.1	6.6	14.1	15.7	1.4	1.7	12.5	24.1	3.5	199.5	52.8%
2B	Baseline	0.0	109.0	21.1	0.3	24.1	6.6	61.1	13.3	18.0	1.6	142.1	24.1	3.5	413.3	N/A
	Low-energy	0.1	66.9	15.2	0.2	24.1	6.6	14.2	12.1	5.1	1.7	10.0	24.1	3.1	171.6	58.5%
3A	Baseline	0.0	103.7	21.1	0.3	24.1	6.6	57.3	13.4	14.4	1.3	142.8	24.1	4.6	401.5	N/A
	Low-energy	0.4	75.0	15.3	0.2	24.1	6.6	14.1	14.6	4.5	1.4	15.1	24.1	4.1	189.1	52.9%
3B:CA	Baseline	0.0	94.6	21.1	0.3	24.1	6.6	55.3	11.7	2.0	1.1	137.9	24.1	4.4	370.4	N/A
	Low-energy	0.2	55.9	15.3	0.2	24.1	6.6	14.1	10.0	0.5	1.2	9.7	24.1	3.9	148.2	60.0%
3B:Other	Baseline	0.0	79.1	21.1	0.3	24.1	6.6	60.0	10.9	45.7	1.4	135.4	24.1	4.0	399.2	N/A
	Low-energy	0.3	53.2	15.2	0.2	24.1	6.6	14.2	10.7	12.6	1.5	11.7	24.1	3.6	165.0	58.7%
3C	Baseline	0.0	79.8	21.1	0.3	24.1	6.6	55.3	10.0	0.8	0.9	150.2	24.1	5.0	364.7	N/A
	Low-energy	0.4	42.8	15.3	0.2	24.1	6.6	14.1	8.5	0.2	1.0	11.6	24.1	4.4	138.8	61.9%
4A	Baseline	0.0	85.5	21.1	0.3	24.1	6.6	58.4	12.5	21.3	1.2	159.4	24.1	5.1	406.5	N/A
	Low-energy	0.4	66.8	15.3	0.2	24.1	6.6	14.1	14.3	7.4	1.3	21.8	24.1	4.5	190.1	53.2%

Climate	Model	Electricity (kBtu/ft^{2}yr)										Gas (kBtu/ft^{2}yr)			Total End Uses	Percent Savings
		Heating	Cooling	Interior Lights	Exterior Lights	Interior Equipment	Exterior Equipment	Fans	Pumps	Humidifiers	Refrigeration	Heating	Interior Equipment	Water Systems		
4B	Baseline	0.0	51.5	21.1	0.3	24.1	6.6	65.6	8.7	56.3	1.1	129.9	24.1	5.0	378.6	N/A
	Low-energy	0.2	41.9	15.2	0.2	24.1	6.6	14.7	9.1	15.9	1.2	14.4	24.1	4.4	157.6	58.4%
4C	Baseline	0.0	58.1	21.1	0.3	24.1	6.6	57.8	8.5	5.4	0.9	159.9	24.1	5.3	357.6	N/A
	Low-energy	0.5	41.4	15.4	0.2	24.1	6.6	14.1	9.3	1.8	1.0	18.1	24.1	4.7	147.3	58.8%
5A	Baseline	0.0	72.0	21.1	0.3	24.1	6.6	58.3	11.6	20.6	1.1	162.6	24.1	5.5	393.6	N/A
	Low-energy	0.6	60.8	15.3	0.2	24.1	6.6	14.1	13.9	8.4	1.2	27.8	24.1	4.9	190.6	51.6%
5B	Baseline	0.0	42.8	21.1	0.3	24.1	6.6	64.8	7.9	43.7	1.0	136.8	24.1	5.5	362.5	N/A
	Low-energy	0.3	37.1	15.3	0.2	24.1	6.6	14.7	8.8	14.3	1.1	19.1	24.1	4.9	155.7	57.0%
6A	Baseline	0.0	59.8	21.1	0.3	24.1	6.6	58.5	10.8	27.7	1.1	166.8	24.1	5.9	391.7	N/A
	Low-energy	0.7	54.7	15.3	0.2	24.1	6.6	14.1	13.2	11.8	1.1	32.8	24.1	5.2	192.0	51.0%
6B	Baseline	0.0	35.0	21.1	0.3	24.1	6.6	62.2	7.1	38.7	0.9	152.6	24.1	6.0	361.9	N/A
	Low-energy	0.5	33.1	15.3	0.2	24.1	6.6	14.3	8.6	13.8	1.0	26.3	24.1	5.3	158.2	56.3%
7	Baseline	0.0	43.6	21.1	0.3	24.1	6.6	59.4	9.0	31.7	0.9	170.0	24.1	6.5	381.3	N/A
	Low-energy	0.9	43.6	15.3	0.2	24.1	6.6	14.1	11.4	13.8	1.0	37.8	24.1	5.8	185.2	51.4%
8	Baseline	0.0	26.6	21.1	0.3	24.1	6.6	58.8	6.2	41.2	0.8	191.4	24.1	7.3	391.1	N/A
	Low-energy	1.1	26.7	15.6	0.2	24.1	6.6	14.3	8.9	19.9	0.9	55.3	24.1	6.5	188.5	51.8%

B.2 SI Units

Table B-2 shows the detailed energy use information of the energy models by end use in SI units.

Table B-2 Large Hospital End Uses (SI Units)

Climate	Model	Electricity (MJ/m^2·yr)										Gas (MJ/m^2·yr)			Total End Uses	Percent Savings
		Heating	Cooling	Interior Lights	Exterior Lights	Interior Equipment	Exterior Equipment	Fans	Pumps	Humidifiers	Refrigeration	Heating	Interior Equipment	Water Systems		
1A	Baseline	0.0	1,767.4	239.1	3.8	273.5	74.5	637.0	196.0	4.6	22.2	1,480.1	273.5	37.0	4,904.2	N/A
	Low-energy	0.4	1,257.4	172.9	1.9	273.5	74.5	160.6	187.0	1.3	22.9	114.2	273.5	32.8	2,405.1	51.0%
2A	Baseline	0.0	1,470.4	239.1	3.8	273.5	74.5	650.3	175.7	51.1	18.0	1,644.2	273.5	44.5	4,801.2	N/A
	Low-energy	2.6	1,016.3	173.4	1.9	273.5	74.5	160.4	178.7	15.7	18.9	141.9	273.5	39.6	2,265.6	52.8%
2B	Baseline	0.0	1,237.8	239.1	3.8	273.5	74.5	693.5	151.5	204.6	18.4	1,613.3	273.5	40.2	4,693.2	N/A
	Low-energy	1.7	759.5	172.4	1.9	273.5	74.5	161.2	137.9	57.9	19.5	113.7	273.5	35.7	1,949.3	58.5%
3A	Baseline	0.0	1,177.4	239.1	3.8	273.5	74.5	650.2	152.2	163.0	15.1	1,621.5	273.5	51.8	4,559.7	N/A
	Low-energy	4.5	851.2	173.5	1.9	273.5	74.5	160.5	165.5	51.5	16.1	172.0	273.5	46.0	2,147.1	52.9%
3B:CA	Baseline	0.0	1,074.6	239.1	3.8	273.5	74.5	628.1	133.0	22.7	12.3	1,566.6	273.5	50.4	4,206.9	N/A
	Low-energy	2.2	634.5	173.2	1.9	273.5	74.5	159.8	113.0	6.1	13.6	109.8	273.5	44.8	1,682.6	60.0%
3B:Other	Baseline	0.0	898.0	239.1	3.8	273.5	74.5	681.7	124.3	519.1	15.8	1,537.8	273.5	45.4	4,533.8	N/A
	Low-energy	3.0	604.2	172.8	1.9	273.5	74.5	161.7	121.8	143.3	16.9	132.7	273.5	40.3	1,873.8	58.7%
3C	Baseline	0.0	905.7	239.1	3.8	273.5	74.5	628.3	113.7	9.6	10.1	1,705.2	273.5	56.6	4,141.5	N/A
	Low-energy	4.5	485.9	173.5	1.9	273.5	74.5	159.9	97.1	2.7	11.1	131.9	273.5	50.3	1,576.1	61.9%
4A	Baseline	0.0	971.3	239.1	3.8	273.5	74.5	663.8	142.4	241.6	13.6	1,810.5	273.5	57.5	4,616.2	N/A
	Low-energy	5.1	758.5	173.8	1.9	273.5	74.5	160.4	161.8	84.4	14.5	247.4	273.5	51.1	2,158.5	53.2%

Climate	Model	Electricity (MJ/m^2·yr)										Gas (MJ/m^2·yr)			Total End Uses	Percent Savings
		Heating	Cooling	Interior Lights	Exterior Lights	Interior Equipment	Exterior Equipment	Fans	Pumps	Humidifiers	Refrigeration	Heating	Interior Equipment	Water Systems		
4B	Baseline	0.0	585.2	239.1	3.8	273.5	74.5	745.5	98.3	639.3	12.1	1,474.7	273.5	56.4	4,299.6	N/A
	Low-energy	2.0	475.9	172.6	1.9	273.5	74.5	166.5	103.5	180.3	13.2	163.5	273.5	50.1	1,790.0	58.4%
4C	Baseline	0.0	660.3	239.1	3.8	273.5	74.5	656.3	96.1	61.4	10.2	1,815.8	273.5	60.5	4,061.3	N/A
	Low-energy	5.2	469.7	175.1	1.9	273.5	74.5	160.1	106.2	20.7	11.2	205.8	273.5	53.7	1,673.2	58.8%
5A	Baseline	0.0	817.4	239.1	3.8	273.5	74.5	662.0	131.9	233.6	12.5	1,846.2	273.5	62.5	4,469.7	N/A
	Low-energy	6.9	690.9	174.0	1.9	273.5	74.5	160.3	157.5	95.8	13.4	315.4	273.5	55.6	2,164.7	51.6%
5B	Baseline	0.0	485.7	239.1	3.8	273.5	74.5	735.5	89.3	496.4	11.0	1,554.1	273.5	62.2	4,116.3	N/A
	Low-energy	3.2	420.9	173.7	1.9	273.5	74.5	166.9	99.5	162.5	12.0	217.5	273.5	55.3	1,768.4	57.0%
6A	Baseline	0.0	678.6	239.1	3.8	273.5	74.5	664.9	122.3	315.1	12.0	1,894.0	273.5	66.8	4,448.5	N/A
	Low-energy	8.3	621.3	174.1	1.9	273.5	74.5	160.4	149.9	133.7	13.0	372.8	273.5	59.4	2,180.2	51.0%
6B	Baseline	0.0	397.2	239.1	3.8	273.5	74.5	706.1	80.9	439.1	10.2	1,733.2	273.5	67.6	4,109.4	N/A
	Low-energy	5.4	376.4	173.9	1.9	273.5	74.5	162.3	98.2	156.9	11.3	299.1	273.5	60.1	1,796.1	56.3%
7	Baseline	0.0	495.6	239.1	3.8	273.5	74.5	674.0	102.7	360.5	10.1	1,930.3	273.5	74.0	4,329.8	N/A
	Low-energy	9.7	495.0	174.3	1.9	273.5	74.5	160.3	129.0	157.2	10.9	429.2	273.5	65.8	2,103.6	51.4%
8	Baseline	0.0	301.9	239.1	3.7	273.5	74.5	667.7	70.5	468.4	9.4	2,173.4	273.5	82.6	4,441.6	N/A
	Low-energy	13.0	303.1	177.4	1.9	273.5	74.5	162.9	100.8	225.9	10.5	627.6	273.5	73.4	2,140.3	51.8%

Appendix C. Reheat EMS Code

This section contains representative EnergyPlus Runtime Language code that apportioned reheat energy from primary heating energy in the baseline model.

C.1 Output Variables

These output variables contain the heating and reheat energy for the energy model, the goal of this program. The AHU heating coil energy output variables are repeated for every AHU.

```
Output:Variable,
  *,
  Building Reheat Total Energy,
  Detailed;

Output:Variable,
  *,
  Building Heating Total Energy,
  Detailed;

Output:Variable,
  AHU_HeatCoil,
  Total Water Heating Coil Energy,
  Detailed;
```

C.2 EMS Sensors

These EMS sensors are repeated for every zone in the energy model and represent various building model sensors used in the reheat program.

```
EnergyManagementSystem:Sensor,
  ZoneName_Load,
  Zone Name,
  Zone/Sys Sensible Load Predicted;

EnergyManagementSystem:Sensor,
  ZoneName_Coil_Energy,
  Zone Name VAV Box Reheat Coil,
  Total Water Heating Coil Energy;

EnergyManagementSystem:Sensor,
  ZoneName_Coil_Inlet_Air_Temp,
```

```
  ZoneName VAV Box Inlet Node Name,
  System Node Temp;

EnergyManagementSystem:Sensor,
  ZoneName_Coil_Outlet_Air_Temp,
  Zone Name VAV Box Outlet Node Name,
  System Node Temp;
```

The following EMS sensors are repeated for every AHU in the energy model.

```
EnergyManagementSystem:Sensor,
  AHU_HeatCoil_Energy,
  AHU Heat Coil Name,
  Total Water Heating Coil Energy;

EnergyManagementSystem:Sensor,
  AHU_CoolCoil_Energy,
  AHU Cool Coil Name,
  Total Water Heating Coil Energy;

EnergyManagementSystem:Sensor,
  AHU_CoolCoil_Inlet_Node_Temp,
  AHU Cool Coil Inlet Node Name,
  System Node Temp;

EnergyManagementSystem:Sensor,
  AHU_Out,
  AHU Supply Equipment Outlet Node,
  System Node Temp;
```

C.3 EMS Program Calling Manager

This is the initialization program calling manager; it is used to initialize the variables to zero.

```
EnergyManagementSystem:ProgramCallingManager,
  InitializeVariables,
  BeginTimestepBeforePredictor,
  Initialize;
```

These EMS program calling managers are repeated for every zone in the energy model.

```
EnergyManagementSystem:ProgramCallingManager,
  ZoneName_Call,
```

```
  EndofZoneTimestepAfterZoneReporting,
  Flr_1_Cafe_Coil_Reheat_Energy_Program;
```

The following are the AHU program calling managers, repeated for every AHU in the energy model.

```
EnergyManagementSystem:ProgramCallingManager,
  Reheat_Sum_Call,
  EndofZoneTimestepAfterZoneReporting,
  Reheat_Sum_Program;

EnergyManagementSystem:ProgramCallingManager,
  Heat_Sum_Call,
  EndofZoneTimestepAfterZoneReporting,
  Heat_Sum_Program;

EnergyManagementSystem:ProgramCallingManager,
  AHU_Heat_Sum_Call,
  EndofZoneTimestepAfterZoneReporting,
  AHU_Heat_Energy_Program;
```

C.4 EMS Program

This program initializes all variables to zero and the 'set' line is repeated for every variable.

```
EnergyManagementSystem:Program,
  Initialize,
  IF (DayOfYear == 1 && Hour == 0 && DayOfMonth == 1),
    SET VariableName = 0,
  ENDIF;
```

This is the main reheat energy calculation program and it is repeated for every zone in the energy model.

```
EnergyManagementSystem:Program,
  ZoneName_Coil_Reheat_Energy_Program,
  IF (AHU_CoolCoil_Energy > 0 && AHU_HeatCoil_Energy > 0),
   SET AHU_Problem = AHU_Problem + 1,
  ELSEIF (ZoneName_Load <= 0),
    SET ZoneName_ReheatEnergy = ZoneName_ReheatEnergy + ZoneName_Coil_Energy,
  ELSEIF (AHU_HeatCoil_Energy > 0 && AHU_CoolCoil_Energy == 0),
    SET ZoneName_Heat = ZoneName_Heat + ZoneName_Coil_Energy,
  ELSEIF (AHU_CoolCoil_Energy > 0 && AHU_HeatCoil_Energy == 0),
    SET ZoneName_DryBulbTemp1 = ZoneName_Coil_Outlet_Air_Temp - ZoneName_Coil_Inlet_Air_Temp,
    SET ZoneName_DryBulbTemp2 = @Max (AHU_CoolCoil_Inlet_Node_Temp - AHU_Out) 0,
```

```
    SET ZoneName_Ratio = @Min (ZoneName_DryBulbTemp2 / ZoneName_DryBulbTemp1) 1,
    SET ZoneName_ReheatEnergy = ZoneName_ReheatEnergy + (ZoneName_Ratio * ZoneName_Coil_Energy),
    SET ZoneName_Heat = ZoneName_Heat + ((1-ZoneName_Ratio) * ZoneName_Coil_Energy),
  ELSEIF (AHU_CoolCoil_Energy == 0 && AHU_HeatCoil_Energy == 0),
    SET AHU_Economize = AHU_Economize + 1,
    SET ZoneName_Heat = ZoneName_Heat + ZoneName_Coil_Energy,
  ENDIF;
```

This program sums the AHU heating energy. The "set" line sums the previous "AHU_Heat" value with the "AHU_HeatCoil_Energy" values for each AHU.

```
EnergyManagementSystem:Program,
  AHU_Heat_Energy_Program,
  SET AHU_Heat = AHU_Heat + AHU_HeatCoil_Energy;
```

These two programs sum the primary heating and reheat energy. The 'set' lines include the variables for every zone.

```
EnergyManagementSystem:Program,
  Heat_Sum_Program,
  SET Heat = ZoneName_Heat + ZoneName_Heat;

EnergyManagementSystem:Program,
  Reheat_Sum_Program,
  SET Reheat = ZoneName_Reheat_Energy + ZoneName_Reheat_Energy;
```

C.5 EMS Global Variables

This EMS object contains the names of all the global variables in the program.

```
EnergyManagementSystem:GlobalVariable,
  VariableName,
```

C.6 EMS Output Variables

The following EMS output variables are repeated for every zone.

```
EnergyManagementSystem:OutputVariable,
  Zone Name Reheat Energy,
  ZoneName_ReheatEnergy,
  Summed,
  ZoneTimestep,
  ZoneName_Coil_Reheat_Energy_Program;
```

These EMS output variables sum the primary heating and reheat energy values reported inside the energy model.

```
EnergyManagementSystem:OutputVariable,
  Building Reheat Total Energy,
  Reheat,
  Summed,
  ZoneTimestep,
  Reheat_Sum_Program;

EnergyManagementSystem:OutputVariable,
  Building Heating Total Energy,
  Heat,
  Summed,
  ZoneTimestep,
  Heat_Sum_Program;
```

The following EMS output variables are AHU indicators and are repeated for every AHU.

```
EnergyManagementSystem:OutputVariable,
  AHU Problem Indicator,
  AHU_Problem,
  Summed,
  ZoneTimestep,
  ZoneName_Coil_Reheat_Energy_Program;

EnergyManagementSystem:OutputVariable,
  AHU Economize Indicator,
  AHU_Economize,
  Summed,
  ZoneTimestep,
  ZoneName_Coil_Reheat_Energy_Program;
```

Appendix D. Total and Ventilation Airflow Requirements

This section documents that all zones in the baseline and low-energy model meet the total and ventilation airflow requirements. Not all zones have minimum total airflow requirements and are represented with "N/A" in the tables. See Section 4.2 for more details on total and ventilation airflow requirements.

D.1 Baseline Model

Table D-1 through Table D-3 demonstrate that all the zones in the baseline model are supplied with at least 97% of the minimum ventilation air required by the standards; Table D-4 through Table D-6 show that all zones in the baseline model are supplied with at least 97% of the minimum total air (where applicable) required by the standards.

Table D-1 Baseline Model Ventilation Airflow Validation: Humid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 1 Cafe	3,736.7	3,736.7	3,736.7	3,736.7	3,736.7	3,736.7	3,736.7
Floor 1 Clean	40.8	105.6	105.6	105.6	105.6	105.6	105.6
Floor 1 Conference	1,906.5	2,703.8	2,879.1	2,963.7	3,071.5	3,092.7	3,149.3
Floor 1 Dining	3,468.6	3,468.6	3,468.6	3,468.6	3,468.6	3,468.6	3,468.6
Floor 1 Elevator	378.0	496.5	543.9	556.7	594.8	595.9	611.8
Floor 1 Exam	224.4	871.2	871.2	871.2	871.2	871.2	871.2
Floor 1 Food Storage	1,406.3	6,965.8	6,975.4	7,212.9	6,971.9	7,099.8	7,143.7
Floor 1 Gas Storage	74.9	274.6	274.6	274.6	274.6	274.6	274.6
Floor 1 Imaging	129.2	942.7	941.3	967.9	934.0	947.0	951.1
Floor 1 Kitchen	1,406.3	7,789.4	7,789.4	7,789.4	7,789.4	7,789.4	7,789.4
Floor 1 Lab 1	170.0	710.5	707.7	724.9	697.4	704.7	706.6
Floor 1 Lab 2	416.5	1,856.7	1,855.1	1,887.4	1,849.2	1,839.3	1,843.8
Floor 1 Laundry	469.6	2,568.8	2,578.8	2,640.9	2,564.7	2,594.5	2,608.0
Floor 1 Lobby	787.5	1,248.1	1,265.2	1,262.9	1,241.4	1,216.1	1,198.6
Floor 1 Lounge	108.8	108.8	108.8	108.8	108.8	108.8	108.8
Floor 1 Mech 1	972.0	1,539.1	1,580.0	1,501.2	1,567.7	1,512.5	1,494.3
Floor 1 Mech 2	1,296.0	2,912.8	3,044.2	2,919.8	3,109.8	2,976.6	2,923.5
Floor 1 Office 1	627.3	1,251.8	1,234.7	1,218.4	1,217.9	1,212.8	1,204.9
Floor 1 Office 2	483.1	1,081.0	1,078.0	1,081.1	1,105.6	1,084.4	1,080.6
Floor 1 Office 3	1,682.6	3,185.9	3,133.2	3,129.4	2,987.3	2,970.4	2,958.2
Floor 1 Office 3 Perimeter 1	245.5	943.2	1,008.5	866.3	842.8	803.5	787.4
Floor 1 Office 3 Perimeter 2	155.6	792.8	813.8	820.3	971.9	918.2	927.6
Floor 1 Office 3 Perimeter 3	245.5	851.5	1,027.0	1,057.9	1,248.3	1,249.7	1,303.6
Floor 1 Patient	600.0	600.0	600.0	600.0	600.0	600.0	600.0
Floor 1 Pharmacy	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0
Floor 1 Physical Therapy	1,279.2	1,623.6	1,623.6	1,623.6	1,623.6	1,623.6	1,623.6
Floor 1 Receiving	268.3	575.4	608.7	549.5	558.3	534.0	534.3
Floor 1 Reception	117.6	307.7	320.6	317.5	372.6	357.8	357.4

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 1 Soil	40.8	264.0	264.0	264.0	264.0	264.0	264.0
Floor 1 Storage	648.0	996.1	981.7	985.5	941.9	939.5	936.8
Floor 1 Waiting	319.2	328.8	326.3	332.4	319.2	320.1	320.3
Floor 2 Chapel	173.4	736.4	806.4	815.0	916.0	917.7	937.8
Floor 2 Clean 1	41.1	148.1	151.5	154.3	147.6	147.8	146.3
Floor 2 Clean 2	27.2	72.5	72.6	75.1	72.8	74.1	74.6
Floor 2 Corridor	312.0	572.0	572.0	572.0	572.0	572.0	572.0
Floor 2 Elevator	378.0	532.6	592.2	617.2	671.6	683.8	706.9
Floor 2 Exam 1	357.0	1,658.9	1,752.7	1,758.8	1,861.5	1,852.1	1,864.6
Floor 2 Exam 2	114.8	445.5	445.5	445.5	445.5	445.5	445.5
Floor 2 Exam 3	344.3	1,336.5	1,336.5	1,336.5	1,336.5	1,336.5	1,336.5
Floor 2 Exam 4	340.0	1,320.0	1,320.0	1,320.0	1,320.0	1,320.0	1,320.0
Floor 2 Gift Shop	153.0	512.5	581.1	604.1	664.8	672.7	690.9
Floor 2 Imaging 1	196.4	1,716.8	1,735.6	1,782.8	1,718.0	1,737.6	1,737.0
Floor 2 Imaging 2	289.0	2,655.0	2,856.6	2,992.1	3,119.8	3,175.0	3,249.7
Floor 2 Imaging 3	340.0	3,231.1	3,312.5	3,217.0	3,167.5	3,193.3	3,145.1
Floor 2 Lab 1	193.8	1,059.7	1,076.8	1,102.0	1,057.9	1,065.0	1,060.2
Floor 2 Lab 2	289.0	1,393.8	1,397.6	1,431.8	1,374.6	1,392.3	1,396.3
Floor 2 Lockers	375.0	412.5	412.5	412.5	412.5	412.5	412.5
Floor 2 Lounge 1	102.0	102.0	102.0	102.0	102.0	102.0	102.0
Floor 2 Lounge 2	74.4	281.9	313.9	318.4	375.6	364.6	375.9
Floor 2 Nurse Station 1	109.7	278.0	286.9	290.2	276.3	274.6	269.9
Floor 2 Nurse Station 2	340.0	781.6	809.1	810.7	799.9	795.7	792.3
Floor 2 Office 1	198.9	565.6	566.9	580.4	557.2	558.7	562.6
Floor 2 Office 2	163.2	459.2	483.6	452.3	449.8	451.1	452.3
Floor 2 Office 3	255.0	644.8	646.1	666.2	647.2	658.5	662.3
Floor 2 Office 4	297.5	1,135.7	1,245.9	1,270.4	1,402.7	1,407.7	1,435.8
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 2 Patient 1	1,136.0	1,184.6	1,263.7	1,136.0	1,136.0	1,136.0	1,136.0
Floor 2 Patient 2	935.3	935.3	935.3	935.3	935.3	935.3	935.3
Floor 2 Procedure 1	1,260.0	2,079.0	2,079.0	2,079.0	2,079.0	2,079.0	2,079.0
Floor 2 Procedure 2	680.0	1,122.0	1,122.0	1,122.0	1,122.0	1,122.0	1,122.0
Floor 2 Reception	367.5	625.8	676.3	701.8	742.5	750.4	767.3
Floor 2 Restroom 1	160.0	352.0	352.0	352.0	352.0	352.0	352.0
Floor 2 Restroom 2	225.0	495.0	495.0	495.0	495.0	495.0	495.0
Floor 2 Soil 1	41.1	265.7	265.7	265.7	265.7	265.7	265.7
Floor 2 Soil 2	27.2	176.0	176.0	176.0	176.0	176.0	176.0
Floor 2 Sterilizing	163.2	1,387.4	1,399.8	1,440.3	1,389.8	1,406.5	1,402.5
Floor 2 Storage 1	180.0	391.8	393.0	402.3	386.5	387.9	390.3
Floor 2 Storage 2	76.8	155.6	155.9	160.8	156.2	158.9	159.9
Floor 2 Trauma	2,240.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0
Floor 2 Triage	291.7	577.5	577.5	577.5	577.5	577.5	577.5
Floor 2 Waiting	819.0	2,023.4	2,113.6	2,093.5	2,291.4	2,238.0	2,219.4
Floor 3 Clean	42.5	113.1	113.4	117.2	113.6	115.7	116.4
Floor 3 Elevator	378.0	716.9	787.1	795.1	894.9	898.3	922.3
Floor 3 Exam	229.5	891.0	891.0	891.0	891.0	891.0	891.0
Floor 3 ICU	700.0	830.8	877.6	856.2	918.2	889.9	898.7
Floor 3 Nurse Station 1	255.7	493.5	500.1	509.8	522.3	524.5	527.3
Floor 3 Nurse Station 2	204.0	923.1	978.1	917.4	969.3	941.9	914.6
Floor 3 Nursery	330.0	330.0	330.0	330.0	333.0	330.0	330.0
Floor 3 Office	229.5	1,109.2	1,162.9	1,155.1	1,288.0	1,248.0	1,230.2
Floor 3 Operating	1,200.0	1,320.5	1,352.2	1,370.7	1,392.5	1,387.7	1,383.9
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,701.6
Floor 3 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient 4	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,332.9	1,389.7
Floor 3 Patient Corridor 1	200.6	367.8	367.8	367.8	367.8	367.8	367.8

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 3 Patient Corridor 2	200.6	367.8	367.8	367.8	367.8	367.8	367.8
Floor 3 Procedure	360.0	594.0	594.0	594.0	594.0	594.0	594.0
Floor 3 Soil	85.0	550.0	550.0	550.0	550.0	550.0	550.0
Floor 3 Supply	441.6	809.6	809.6	809.6	809.6	809.6	809.6
Floor 3 Triage	500.0	990.0	990.0	990.0	990.0	990.0	990.0
Floor 3 Waiting	207.9	385.5	392.6	391.1	410.9	396.3	395.2
Floor 4-6 Clean	42.5	339.4	340.1	351.6	340.8	347.1	349.3
Floor 4-6 Elevator	378.0	2,160.6	2,365.9	2,384.6	2,682.5	2,694.5	2,765.4
Floor 4-6 Nurse Station	255.7	1,480.5	1,500.6	1,529.3	1,567.2	1,574.4	1,582.6
Floor 4-6 Office	127.5	1,266.7	1,349.8	1,216.5	1,206.5	1,187.8	1,178.9
Floor 4-6 Patient 1	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,118.7
Floor 4-6 Patient 2	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 3	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient 4	1,316.7	3,950.0	3,950.0	3,950.0	3,952.1	4,014.9	4,186.1
Floor 4-6 Patient Corridor 1	200.6	1,103.5	1,103.5	1,103.5	1,103.5	1,103.5	1,103.5
Floor 4-6 Patient Corridor 2	200.6	1,103.5	1,103.5	1,103.5	1,103.5	1,103.5	1,103.5
Floor 4-6 Soil	85.0	1,650.0	1,650.0	1,650.0	1,650.0	1,650.0	1,650.0
Floor 4-6 Supply	441.6	2,428.8	2,428.8	2,428.8	2,428.8	2,428.8	2,428.8
Floor 7 Clean	42.5	148.9	153.4	155.9	148.4	148.1	146.3
Floor 7 Elevator	378.0	861.0	938.3	938.1	1,036.6	1,034.1	1,051.9
Floor 7 Nurse Station	255.7	712.6	745.3	746.7	740.7	728.0	715.4
Floor 7 Office	127.5	520.1	561.6	511.5	495.4	481.5	470.2
Floor 7 Patient 1	1,666.7	1,666.7	1,699.2	1,747.1	1,956.1	1,969.0	2,030.9
Floor 7 Patient 2	1,666.7	1,718.3	1,847.2	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 3	1,316.7	1,457.6	1,562.8	1,408.5	1,419.5	1,378.0	1,325.7
Floor 7 Patient 4	1,316.7	1,316.7	1,394.4	1,431.3	1,610.5	1,620.9	1,670.2
Floor 7 Patient Corridor 1	200.6	528.6	563.3	556.7	541.0	524.6	509.3
Floor 7 Patient Corridor 2	200.6	528.6	563.3	556.7	541.0	524.6	509.3
Floor 7 Soil	85.0	550.0	550.0	550.0	550.0	550.0	550.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 7 Supply	441.6	855.6	893.4	896.8	856.2	846.1	831.9
MOB Floor 1 Core	1,170.9	1,350.8	1,328.2	1,328.4	1,267.2	1,260.4	1,255.1
MOB Floor 1 Perimeter 1	194.5	644.6	675.4	664.9	801.4	764.4	761.0
MOB Floor 1 Perimeter 2	140.3	354.7	431.9	448.3	533.4	535.0	560.0
MOB Floor 1 Perimeter 3	194.5	569.4	583.9	586.1	686.5	648.6	654.3
MOB Floor 2-4 Core	1,049.8	4,493.7	4,502.1	4,642.0	4,510.1	4,588.3	4,614.7
MOB Floor 2-4 Perimeter 1	184.9	2,135.0	2,249.2	2,236.3	2,729.2	2,640.3	2,636.0
MOB Floor 2-4 Perimeter 2	140.3	1,179.5	1,452.7	1,533.8	1,845.5	1,886.0	1,980.4
MOB Floor 2-4 Perimeter 3	184.9	1,878.7	1,946.4	1,974.5	2,347.0	2,260.0	2,280.7
MOB Floor 2-4 Perimeter 4	140.3	1,169.3	1,270.0	1,097.3	1,092.7	1,059.9	1,046.3
MOB Floor 5 Core	1,049.8	1,663.5	1,669.5	1,706.9	1,637.6	1,639.9	1,649.3
MOB Floor 5 Perimeter 1	184.9	836.3	888.2	883.0	1,055.1	1,018.2	1,009.4
MOB Floor 5 Perimeter 2	140.3	526.2	652.3	686.1	810.8	823.9	859.1
MOB Floor 5 Perimeter 3	184.9	661.5	688.8	695.4	829.5	796.0	802.3
MOB Floor 5 Perimeter 4	140.3	463.7	506.3	444.9	434.6	418.9	408.5

Table D-2 Baseline Model Ventilation Airflow Validation: Arid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 1 Cafe	3,736.7	3,736.7	3,736.7	3,736.7	3,736.7	3,736.7	3,736.7
Floor 1 Clean	40.8	105.6	105.6	105.6	113.3	113.9	105.6
Floor 1 Conference	1,906.5	3,143.4	2,895.2	3,117.5	3,487.4	3,528.5	3,427.0
Floor 1 Dining	3,468.6	3,468.6	3,468.6	3,468.6	3,468.6	3,468.6	3,468.6
Floor 1 Elevator	378.0	606.1	549.2	584.8	657.2	668.3	661.5
Floor 1 Exam	224.4	871.2	871.2	871.2	874.3	871.2	871.2
Floor 1 Food Storage	1,406.3	7,179.2	6,967.6	7,453.5	8,465.9	8,537.3	7,982.3
Floor 1 Gas Storage	74.9	274.6	274.6	274.6	274.6	274.6	274.6
Floor 1 Imaging	129.2	939.8	937.0	969.2	1,109.3	1,117.6	1,044.3
Floor 1 Kitchen	1,406.3	7,789.4	7,789.4	7,994.7	9,025.3	9,101.0	8,532.5
Floor 1 Lab 1	170.0	687.2	702.0	705.2	817.3	822.8	766.6
Floor 1 Lab 2	416.5	1,853.4	1,780.8	1,853.0	2,174.0	2,141.6	1,987.6
Floor 1 Laundry	469.6	2,636.2	2,533.1	2,689.0	3,056.7	3,064.9	2,869.3
Floor 1 Lobby	787.5	1,281.3	1,143.1	1,263.8	1,462.6	1,401.4	1,276.3
Floor 1 Lounge	108.8	108.8	108.8	108.8	108.8	108.8	108.8
Floor 1 Mech 1	972.0	1,600.9	1,332.7	1,486.3	1,791.3	1,684.6	1,529.8
Floor 1 Mech 2	1,296.0	3,309.4	2,534.8	3,081.0	3,619.5	3,344.1	3,046.9
Floor 1 Office 1	627.3	1,203.4	1,154.2	1,168.1	1,334.8	1,318.8	1,204.5
Floor 1 Office 2	483.1	1,024.5	1,033.7	1,006.6	1,236.8	1,202.3	1,109.5
Floor 1 Office 3	1,682.6	2,813.4	3,042.5	2,820.9	3,441.8	3,450.1	3,174.7
Floor 1 Office 3 Perimeter 1	245.5	1,140.7	647.8	966.4	991.6	888.6	792.5
Floor 1 Office 3 Perimeter 2	155.6	926.8	737.1	866.7	1,114.3	1,021.1	965.7
Floor 1 Office 3 Perimeter 3	245.5	1,295.9	1,066.3	1,217.7	1,327.5	1,364.5	1,413.9
Floor 1 Patient	600.0	600.0	600.0	600.0	600.0	600.0	600.0
Floor 1 Pharmacy	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0
Floor 1 Physical Therapy	1,279.2	1,623.6	1,623.6	1,623.6	1,623.6	1,623.6	1,623.6
Floor 1 Receiving	268.3	673.0	474.0	585.3	628.5	577.0	537.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 1 Reception	117.6	358.0	290.3	344.6	441.4	413.8	385.3
Floor 1 Soil	40.8	264.0	264.0	264.0	264.0	264.0	264.0
Floor 1 Storage	648.0	857.2	958.1	858.3	1,036.0	1,039.5	962.0
Floor 1 Waiting	319.2	319.2	322.1	319.2	365.9	367.9	341.2
Floor 2 Chapel	173.4	998.2	799.4	965.0	1,045.9	1,043.8	1,041.9
Floor 2 Clean 1	41.1	161.8	142.4	163.8	178.2	174.5	162.2
Floor 2 Clean 2	27.2	75.3	72.6	78.2	88.0	88.8	83.3
Floor 2 Corridor	312.0	572.0	572.0	572.0	572.0	572.0	572.0
Floor 2 Elevator	378.0	711.5	615.7	701.2	764.7	788.1	790.4
Floor 2 Exam 1	357.0	2,016.0	1,661.8	1,976.4	2,220.0	2,151.8	2,066.2
Floor 2 Exam 2	114.8	446.2	445.5	453.7	480.1	472.4	445.5
Floor 2 Exam 3	344.3	1,336.5	1,336.5	1,336.5	1,349.7	1,361.2	1,336.5
Floor 2 Exam 4	340.0	1,320.0	1,320.0	1,320.0	1,365.7	1,358.0	1,320.0
Floor 2 Gift Shop	153.0	724.6	596.2	708.9	746.1	759.8	766.4
Floor 2 Imaging 1	196.4	1,822.4	1,691.1	1,871.5	2,077.5	2,070.5	1,934.4
Floor 2 Imaging 2	289.0	3,275.0	2,943.1	3,299.9	3,620.5	3,700.2	3,633.5
Floor 2 Imaging 3	340.0	3,619.6	2,895.8	3,585.1	3,864.9	3,766.8	3,432.2
Floor 2 Lab 1	193.8	1,138.4	1,031.5	1,161.4	1,278.9	1,265.0	1,178.6
Floor 2 Lab 2	289.0	1,456.6	1,355.4	1,500.3	1,671.2	1,662.0	1,552.4
Floor 2 Lockers	375.0	412.5	412.5	412.5	412.5	412.5	412.5
Floor 2 Lounge 1	102.0	102.0	102.0	103.0	115.9	116.9	109.7
Floor 2 Lounge 2	74.4	412.2	288.4	376.4	421.5	400.4	400.8
Floor 2 Nurse Station 1	109.7	309.8	262.5	310.8	333.0	322.1	297.9
Floor 2 Nurse Station 2	340.0	905.6	735.1	887.5	964.1	933.4	872.2
Floor 2 Office 1	198.9	616.6	533.5	622.8	646.3	629.7	592.7
Floor 2 Office 2	163.2	568.3	400.7	520.4	531.7	507.5	472.3
Floor 2 Office 3	255.0	668.4	646.1	691.9	772.7	779.3	733.6
Floor 2 Office 4	297.5	1,531.2	1,239.8	1,488.4	1,602.0	1,601.3	1,593.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 2 Operating	12,850.7	13,165.0	12,850.7	13,171.3	14,616.5	14,403.4	13,392.5
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,462.8	1,136.0	1,346.4	1,361.9	1,248.9	1,136.0
Floor 2 Patient 2	935.3	935.3	935.3	935.3	935.3	935.3	935.3
Floor 2 Procedure 1	1,260.0	2,079.0	2,079.0	2,079.0	2,079.0	2,079.0	2,079.0
Floor 2 Procedure 2	680.0	1,122.0	1,122.0	1,122.0	1,122.0	1,122.0	1,122.0
Floor 2 Reception	367.5	805.2	683.3	793.6	848.6	859.7	853.6
Floor 2 Restroom 1	160.0	352.0	352.0	352.0	352.0	352.0	352.0
Floor 2 Restroom 2	225.0	495.0	495.0	495.0	495.0	495.0	495.0
Floor 2 Soil 1	41.1	265.7	265.7	265.7	265.7	265.7	265.7
Floor 2 Soil 2	27.2	176.0	176.0	176.0	176.0	176.0	176.0
Floor 2 Sterilizing	163.2	1,465.4	1,370.9	1,508.9	1,681.6	1,681.2	1,559.8
Floor 2 Storage 1	180.0	426.8	372.1	431.9	451.0	440.1	413.9
Floor 2 Storage 2	76.8	161.3	155.9	167.1	186.7	188.3	177.2
Floor 2 Trauma	2,240.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0	3,696.0
Floor 2 Triage	291.7	577.5	577.5	577.5	577.5	577.5	577.5
Floor 2 Waiting	819.0	2,392.4	1,876.6	2,334.4	2,777.4	2,633.5	2,433.0
Floor 3 Clean	42.5	117.6	113.4	122.1	137.4	138.6	130.0
Floor 3 Elevator	378.0	982.5	770.7	936.7	1,032.7	1,032.3	1,023.2
Floor 3 Exam	229.5	891.0	891.0	894.0	945.6	928.6	891.0
Floor 3 ICU	700.0	1,038.1	748.1	959.5	1,078.8	1,006.6	955.8
Floor 3 Nurse Station 1	255.7	536.6	486.1	543.6	631.4	624.8	585.2
Floor 3 Nurse Station 2	204.0	1,129.1	764.8	1,060.8	1,185.1	1,097.0	987.1
Floor 3 Nursery	330.0	357.3	330.0	334.4	388.6	360.1	343.1
Floor 3 Office	229.5	1,327.7	1,025.1	1,290.6	1,566.5	1,468.6	1,352.9
Floor 3 Operating	1,200.0	1,460.7	1,279.8	1,465.3	1,684.6	1,646.8	1,537.1
Floor 3 Patient 1	1,666.7	1,750.3	1,666.7	1,666.7	1,790.5	1,845.2	1,896.6
Floor 3 Patient 2	1,666.7	1,672.5	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 3 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient 4	1,316.7	1,428.8	1,316.7	1,360.4	1,462.5	1,509.0	1,550.9
Floor 3 Patient Corridor 1	200.6	367.8	367.8	367.8	369.7	367.8	367.8
Floor 3 Patient Corridor 2	200.6	367.8	367.8	367.8	369.5	367.8	367.8
Floor 3 Procedure	360.0	594.0	594.0	594.0	639.7	622.7	594.0
Floor 3 Soil	85.0	550.0	550.0	550.0	550.0	550.0	550.0
Floor 3 Supply	441.6	809.6	809.6	809.6	809.6	809.6	809.6
Floor 3 Triage	500.0	990.0	990.0	990.0	990.0	990.0	990.0
Floor 3 Waiting	207.9	450.7	336.1	427.5	491.8	454.8	418.3
Floor 4-6 Clean	42.5	352.8	340.2	366.2	412.2	415.7	390.0
Floor 4-6 Elevator	378.0	2,958.1	2,305.7	2,811.7	3,098.1	3,097.4	3,068.8
Floor 4-6 Nurse Station	255.7	1,610.8	1,457.6	1,630.6	1,894.7	1,875.3	1,756.6
Floor 4-6 Office	127.5	1,577.2	954.0	1,415.1	1,469.6	1,379.9	1,265.0
Floor 4-6 Patient 1	1,666.7	5,283.0	5,000.0	5,000.8	5,380.2	5,552.0	5,711.3
Floor 4-6 Patient 2	1,666.7	5,043.5	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 3	1,316.7	4,280.0	3,950.0	3,950.0	4,069.6	3,950.0	3,950.0
Floor 4-6 Patient 4	1,316.7	4,308.3	3,950.0	4,092.8	4,401.0	4,547.1	4,675.6
Floor 4-6 Patient Corridor 1	200.6	1,103.5	1,103.5	1,103.5	1,109.0	1,103.5	1,103.5
Floor 4-6 Patient Corridor 2	200.6	1,103.5	1,103.5	1,103.5	1,109.0	1,103.5	1,103.5
Floor 4-6 Soil	85.0	1,650.0	1,650.0	1,650.0	1,650.0	1,650.0	1,650.0
Floor 4-6 Supply	441.6	2,428.8	2,428.8	2,428.8	2,428.8	2,428.8	2,428.8
Floor 7 Clean	42.5	163.8	143.5	164.9	179.6	175.2	163.0
Floor 7 Elevator	378.0	1,155.9	890.7	1,097.9	1,203.2	1,187.2	1,169.9
Floor 7 Nurse Station	255.7	820.0	671.3	805.9	896.5	855.5	793.4
Floor 7 Office	127.5	654.4	391.8	588.7	606.6	559.2	509.8
Floor 7 Patient 1	1,666.7	2,190.0	1,693.7	2,070.9	2,183.0	2,215.0	2,262.8
Floor 7 Patient 2	1,666.7	2,170.0	1,666.7	1,967.7	1,987.8	1,811.7	1,666.7
Floor 7 Patient 3	1,316.7	1,828.0	1,316.7	1,669.4	1,746.6	1,596.6	1,418.2

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 7 Patient 4	1,316.7	1,791.8	1,402.9	1,699.8	1,803.7	1,827.8	1,865.1
Floor 7 Patient Corridor 1	200.6	634.7	480.6	608.3	654.6	610.0	564.2
Floor 7 Patient Corridor 2	200.6	634.7	480.6	608.3	654.6	610.0	564.2
Floor 7 Soil	85.0	550.0	550.0	550.0	550.0	550.0	550.0
Floor 7 Supply	441.6	979.8	809.6	962.7	1,035.6	993.9	924.7
MOB Floor 1 Core	1,170.9	1,185.9	1,292.4	1,191.4	1,456.8	1,461.6	1,345.0
MOB Floor 1 Perimeter 1	194.5	760.7	601.3	727.1	946.3	878.5	814.4
MOB Floor 1 Perimeter 2	140.3	548.2	454.3	516.4	563.5	582.7	608.4
MOB Floor 1 Perimeter 3	194.5	663.0	528.4	617.5	785.9	720.7	679.0
MOB Floor 2-4 Core	1,049.8	4,657.1	4,502.5	4,819.6	5,379.1	5,425.0	5,108.3
MOB Floor 2-4 Perimeter 1	184.9	2,651.9	2,024.2	2,567.3	3,296.7	3,098.2	2,888.3
MOB Floor 2-4 Perimeter 2	140.3	1,951.8	1,575.4	1,880.6	2,007.6	2,111.2	2,215.2
MOB Floor 2-4 Perimeter 3	184.9	2,331.6	1,776.3	2,221.4	2,767.1	2,579.5	2,449.6
MOB Floor 2-4 Perimeter 4	140.3	1,531.4	794.5	1,322.9	1,335.4	1,216.2	1,104.5
MOB Floor 5 Core	1,049.8	1,822.7	1,569.2	1,838.1	1,899.1	1,844.2	1,734.8
MOB Floor 5 Perimeter 1	184.9	1,039.9	787.7	1,004.3	1,279.4	1,196.9	1,112.9
MOB Floor 5 Perimeter 2	140.3	871.9	690.2	835.4	884.8	921.0	962.5
MOB Floor 5 Perimeter 3	184.9	832.5	615.4	786.9	971.2	895.0	850.9
MOB Floor 5 Perimeter 4	140.3	604.9	313.4	528.2	534.3	483.4	436.7

Table D-3 Baseline Model Ventilation Airflow Validation: Marine and Cold Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 1 Cafe	3,736.7	3,760.4	3,736.7	3,736.7	3,736.7
Floor 1 Clean	40.8	105.6	105.6	105.6	105.6
Floor 1 Conference	1,906.5	2,961.9	3,153.2	3,151.4	3,188.5
Floor 1 Dining	3,468.6	3,490.6	3,468.6	3,468.6	3,468.6
Floor 1 Elevator	378.0	575.9	621.7	608.0	636.2
Floor 1 Exam	224.4	871.2	871.2	871.2	871.2
Floor 1 Food Storage	1,406.3	6,906.1	6,989.1	7,260.9	6,945.0
Floor 1 Gas Storage	74.9	276.3	274.6	274.6	274.6
Floor 1 Imaging	129.2	891.4	916.4	948.2	889.5
Floor 1 Kitchen	1,406.3	7,838.8	7,789.4	7,799.6	7,789.4
Floor 1 Lab 1	170.0	660.0	670.2	691.9	660.0
Floor 1 Lab 2	416.5	1,627.3	1,698.1	1,810.2	1,649.9
Floor 1 Laundry	469.6	2,443.0	2,508.4	2,610.1	2,464.3
Floor 1 Lobby	787.5	963.4	1,067.2	1,159.5	932.3
Floor 1 Lounge	108.8	108.8	108.8	108.8	108.8
Floor 1 Mech 1	972.0	1,122.0	1,293.1	1,421.4	1,193.6
Floor 1 Mech 2	1,296.0	2,125.7	2,539.3	2,849.1	2,225.3
Floor 1 Office 1	627.3	910.5	1,018.3	1,081.1	929.6
Floor 1 Office 2	483.1	851.2	966.5	1,022.8	889.6
Floor 1 Office 3	1,682.6	2,530.6	2,609.4	2,796.1	2,236.4
Floor 1 Office 3 Perimeter 1	245.5	552.8	606.5	718.8	621.4
Floor 1 Office 3 Perimeter 2	155.6	671.3	858.7	971.8	943.0
Floor 1 Office 3 Perimeter 3	245.5	1,256.8	1,403.4	1,330.0	1,534.0
Floor 1 Patient	600.0	600.0	600.0	600.0	600.0
Floor 1 Pharmacy	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0
Floor 1 Physical Therapy	1,279.2	1,623.6	1,623.6	1,623.6	1,623.6
Floor 1 Receiving	268.3	384.7	445.4	494.4	444.4
Floor 1 Reception	117.6	298.3	344.5	380.7	344.9

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 1 Soil	40.8	264.0	264.0	264.0	264.0
Floor 1 Storage	648.0	773.5	839.1	855.2	734.7
Floor 1 Waiting	319.2	319.2	319.2	319.2	319.2
Floor 2 Chapel	173.4	893.3	980.9	976.4	998.6
Floor 2 Clean 1	41.1	133.0	139.4	146.6	124.6
Floor 2 Clean 2	27.2	72.9	73.4	76.2	73.5
Floor 2 Corridor	312.0	572.0	572.0	572.0	572.0
Floor 2 Elevator	378.0	714.3	752.0	741.3	823.6
Floor 2 Exam 1	357.0	1,754.5	1,882.6	1,929.0	1,715.8
Floor 2 Exam 2	114.8	445.5	445.5	445.5	445.5
Floor 2 Exam 3	344.3	1,345.0	1,336.5	1,336.5	1,336.5
Floor 2 Exam 4	340.0	1,328.4	1,320.0	1,320.0	1,320.0
Floor 2 Gift Shop	153.0	679.6	729.9	716.9	760.1
Floor 2 Imaging 1	196.4	1,643.2	1,687.5	1,760.9	1,616.6
Floor 2 Imaging 2	289.0	3,188.2	3,359.9	3,371.2	3,327.4
Floor 2 Imaging 3	340.0	2,860.0	2,949.8	3,168.7	3,004.1
Floor 2 Lab 1	193.8	982.6	1,019.0	1,069.6	949.2
Floor 2 Lab 2	289.0	1,330.7	1,355.5	1,416.5	1,339.7
Floor 2 Lockers	375.0	412.5	412.5	412.5	412.5
Floor 2 Lounge 1	102.0	102.6	102.0	102.0	102.0
Floor 2 Lounge 2	74.4	315.4	372.1	391.2	421.5
Floor 2 Nurse Station 1	109.7	237.5	252.9	268.0	213.7
Floor 2 Nurse Station 2	340.0	698.7	742.8	799.9	779.0
Floor 2 Office 1	198.9	511.0	524.1	546.4	554.0
Floor 2 Office 2	163.2	389.9	386.9	443.0	446.7
Floor 2 Office 3	255.0	648.2	652.7	675.6	653.5
Floor 2 Office 4	297.5	1,384.3	1,494.3	1,488.0	1,509.6
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,358.6	1,350.0	1,350.0	1,350.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 2 Patient 2	935.3	935.3	935.3	935.3	935.3
Floor 2 Procedure 1	1,260.0	2,079.0	2,079.0	2,079.0	2,079.0
Floor 2 Procedure 2	680.0	1,122.0	1,122.0	1,122.0	1,122.0
Floor 2 Reception	367.5	746.1	792.2	790.5	811.9
Floor 2 Restroom 1	160.0	354.2	352.0	352.0	352.0
Floor 2 Restroom 2	225.0	498.1	495.0	495.0	495.0
Floor 2 Soil 1	41.1	265.7	265.7	265.7	265.7
Floor 2 Soil 2	27.2	177.1	176.0	176.0	176.0
Floor 2 Sterilizing	163.2	1,314.7	1,351.5	1,421.7	1,315.5
Floor 2 Storage 1	180.0	357.4	366.2	380.8	382.5
Floor 2 Storage 2	76.8	156.4	157.5	163.1	157.7
Floor 2 Trauma	2,240.0	3,719.4	3,696.0	3,696.0	3,696.0
Floor 2 Triage	291.7	581.2	577.5	577.5	577.5
Floor 2 Waiting	819.0	1,868.7	2,107.5	2,356.7	2,037.3
Floor 3 Clean	42.5	113.0	114.6	119.0	114.8
Floor 3 Elevator	378.0	873.6	952.9	964.5	1,029.4
Floor 3 Exam	229.5	891.0	891.0	891.0	891.0
Floor 3 ICU	700.0	716.1	822.3	922.2	909.7
Floor 3 Nurse Station 1	255.7	493.5	517.6	549.6	522.9
Floor 3 Nurse Station 2	204.0	732.4	823.1	942.3	806.9
Floor 3 Nursery	330.0	330.0	330.0	337.8	337.2
Floor 3 Office	229.5	971.8	1,147.2	1,319.1	1,145.9
Floor 3 Operating	1,200.0	1,265.6	1,343.5	1,434.7	1,290.4
Floor 3 Patient 1	1,666.7	1,689.5	1,840.6	1,802.5	2,107.0
Floor 3 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient 4	1,316.7	1,396.5	1,509.1	1,466.9	1,696.1
Floor 3 Patient Corridor 1	200.6	367.8	367.8	367.8	367.8

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 3 Patient Corridor 2	200.6	367.8	367.8	367.8	367.8
Floor 3 Procedure	360.0	594.0	594.0	594.0	594.0
Floor 3 Soil	85.0	550.0	550.0	550.0	550.0
Floor 3 Supply	441.6	809.6	809.6	809.6	809.6
Floor 3 Triage	500.0	990.0	990.0	990.0	990.0
Floor 3 Waiting	207.9	289.9	334.8	402.4	373.5
Floor 4-6 Clean	42.5	339.0	343.9	356.9	344.3
Floor 4-6 Elevator	378.0	2,610.7	2,851.6	2,892.9	3,086.9
Floor 4-6 Nurse Station	255.7	1,479.3	1,552.6	1,650.5	1,570.6
Floor 4-6 Office	127.5	967.2	1,008.6	1,178.7	1,157.3
Floor 4-6 Patient 1	1,666.7	5,075.5	5,539.5	5,426.5	6,314.9
Floor 4-6 Patient 2	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 3	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient 4	1,316.7	4,193.8	4,547.1	4,425.3	5,114.6
Floor 4-6 Patient Corridor 1	200.6	1,103.5	1,103.5	1,103.5	1,103.5
Floor 4-6 Patient Corridor 2	200.6	1,103.5	1,103.5	1,103.5	1,103.5
Floor 4-6 Soil	85.0	1,650.0	1,650.0	1,650.0	1,650.0
Floor 4-6 Supply	441.6	2,428.8	2,428.8	2,428.8	2,428.8
Floor 7 Clean	42.5	133.5	140.6	146.8	127.3
Floor 7 Elevator	378.0	973.7	1,073.9	1,093.2	1,109.7
Floor 7 Nurse Station	255.7	622.8	681.9	728.9	608.1
Floor 7 Office	127.5	364.5	387.9	464.4	392.5
Floor 7 Patient 1	1,666.7	1,951.3	2,152.3	2,122.1	2,325.9
Floor 7 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 3	1,316.7	1,316.7	1,316.7	1,323.3	1,316.7
Floor 7 Patient 4	1,316.7	1,622.4	1,780.6	1,743.6	1,891.7
Floor 7 Patient Corridor 1	200.6	420.8	473.9	508.6	402.2
Floor 7 Patient Corridor 2	200.6	420.8	473.9	508.6	402.2
Floor 7 Soil	85.0	550.0	550.0	550.0	550.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 7 Supply	441.6	809.6	809.6	829.1	809.6
MOB Floor 1 Core	1,170.9	1,170.9	1,170.9	1,183.9	1,170.9
MOB Floor 1 Perimeter 1	194.5	605.8	717.8	813.8	740.3
MOB Floor 1 Perimeter 2	140.3	542.1	610.6	575.9	678.2
MOB Floor 1 Perimeter 3	194.5	478.5	607.4	679.9	646.1
MOB Floor 2-4 Core	1,049.8	4,488.9	4,548.3	4,706.9	4,553.8
MOB Floor 2-4 Perimeter 1	184.9	2,171.7	2,548.3	2,926.1	2,780.9
MOB Floor 2-4 Perimeter 2	140.3	2,017.0	2,221.8	2,128.7	2,576.8
MOB Floor 2-4 Perimeter 3	184.9	1,754.2	2,157.6	2,481.7	2,472.8
MOB Floor 2-4 Perimeter 4	140.3	774.6	817.9	1,034.0	936.2
MOB Floor 5 Core	1,049.8	1,498.8	1,538.2	1,598.6	1,621.6
MOB Floor 5 Perimeter 1	184.9	821.7	971.7	1,116.5	1,022.7
MOB Floor 5 Perimeter 2	140.3	854.6	950.0	917.5	1,069.7
MOB Floor 5 Perimeter 3	184.9	602.6	747.3	868.6	867.9
MOB Floor 5 Perimeter 4	140.3	296.2	314.7	401.2	339.9

Table D-4 Baseline Model Total Airflow Validation: Humid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 1 Cafe	N/A	11,323.5	11,323.5	11,323.5	11,323.5	11,323.5	11,323.5
Floor 1 Clean	320.0	320.0	320.0	320.0	320.0	320.0	320.0
Floor 1 Conference	N/A	8,193.4	8,724.6	8,980.8	9,307.7	9,371.8	9,543.4
Floor 1 Dining	N/A	10,510.9	10,510.9	10,510.9	10,510.9	10,510.9	10,510.9
Floor 1 Elevator	N/A	1,504.5	1,648.3	1,687.0	1,802.5	1,805.6	1,853.9
Floor 1 Exam	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0
Floor 1 Food Storage	3,348.3	21,108.4	21,137.7	21,857.2	21,127.0	21,514.4	21,647.6
Floor 1 Gas Storage	832.0	832.0	832.0	832.0	832.0	832.0	832.0
Floor 1 Imaging	1,520.0	2,856.7	2,852.5	2,933.1	2,830.4	2,869.7	2,882.0
Floor 1 Kitchen	3,348.3	23,604.3	23,604.3	23,604.3	23,604.3	23,604.3	23,604.3
Floor 1 Lab 1	2,000.0	2,153.2	2,144.5	2,196.8	2,113.4	2,135.4	2,141.4
Floor 1 Lab 2	4,900.0	5,626.2	5,621.6	5,719.3	5,603.6	5,573.5	5,587.2
Floor 1 Laundry	3,726.7	7,784.1	7,814.4	8,002.6	7,771.7	7,862.0	7,903.1
Floor 1 Lobby	N/A	3,782.1	3,833.8	3,826.9	3,761.9	3,685.1	3,632.0
Floor 1 Lounge	N/A	329.7	329.7	329.7	329.7	329.7	329.7
Floor 1 Mech 1	N/A	4,664.0	4,787.9	4,549.2	4,750.7	4,583.2	4,528.1
Floor 1 Mech 2	N/A	8,826.5	9,224.8	8,847.9	9,423.5	9,020.0	8,859.0
Floor 1 Office 1	N/A	3,793.2	3,741.6	3,692.0	3,690.7	3,675.1	3,651.1
Floor 1 Office 2	N/A	3,275.6	3,266.6	3,276.0	3,350.2	3,286.1	3,274.4
Floor 1 Office 3	N/A	9,654.2	9,494.5	9,483.0	9,052.4	9,001.2	8,964.2
Floor 1 Office 3 Perimeter 1	N/A	2,858.2	3,055.9	2,625.0	2,553.9	2,434.9	2,386.0
Floor 1 Office 3 Perimeter 2	N/A	2,402.4	2,466.0	2,485.8	2,945.1	2,782.4	2,811.1
Floor 1 Office 3 Perimeter 3	N/A	2,580.3	3,112.0	3,205.7	3,782.6	3,786.9	3,950.4
Floor 1 Patient	1,800.0	1,818.2	1,818.2	1,818.2	1,818.2	1,818.2	1,818.2
Floor 1 Pharmacy	4,000.0	4,181.8	4,181.8	4,181.8	4,181.8	4,181.8	4,181.8
Floor 1 Physical Therapy	4,920.0	4,920.0	4,920.0	4,920.0	4,920.0	4,920.0	4,920.0
Floor 1 Receiving	N/A	1,743.7	1,844.5	1,665.0	1,691.8	1,618.2	1,619.0
Floor 1 Reception	N/A	932.4	971.5	962.2	1,129.1	1,084.1	1,082.9

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 1 Soil	800.0	800.0	800.0	800.0	800.0	800.0	800.0
Floor 1 Storage	N/A	3,018.6	2,974.7	2,986.3	2,854.1	2,847.1	2,838.8
Floor 1 Waiting	N/A	996.5	988.9	1,007.4	967.3	969.9	970.5
Floor 2 Chapel	N/A	2,231.7	2,443.6	2,469.7	2,775.9	2,780.9	2,841.9
Floor 2 Clean 1	322.0	448.7	459.2	467.6	447.2	447.7	443.3
Floor 2 Clean 2	213.3	219.6	220.1	227.5	220.5	224.6	226.1
Floor 2 Corridor	1,733.3	1,733.3	1,733.3	1,733.3	1,733.3	1,733.3	1,733.3
Floor 2 Elevator	N/A	1,614.0	1,794.6	1,870.2	2,035.1	2,072.2	2,142.2
Floor 2 Exam 1	4,200.0	5,027.1	5,311.1	5,329.8	5,641.0	5,612.3	5,650.3
Floor 2 Exam 2	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Exam 3	4,050.0	4,050.0	4,050.0	4,050.0	4,050.0	4,050.0	4,050.0
Floor 2 Exam 4	4,000.0	4,000.0	4,000.0	4,000.0	4,000.0	4,000.0	4,000.0
Floor 2 Gift Shop	N/A	1,553.1	1,761.0	1,830.6	2,014.5	2,038.6	2,093.5
Floor 2 Imaging 1	2,310.0	5,202.3	5,259.5	5,402.3	5,206.0	5,265.4	5,263.5
Floor 2 Imaging 2	3,400.0	8,045.5	8,656.5	9,067.0	9,453.9	9,621.2	9,847.5
Floor 2 Imaging 3	4,000.0	9,791.2	10,037.9	9,748.4	9,598.5	9,676.7	9,530.6
Floor 2 Lab 1	2,280.0	3,211.2	3,263.1	3,339.3	3,205.8	3,227.4	3,212.8
Floor 2 Lab 2	3,400.0	4,223.7	4,235.1	4,338.7	4,165.4	4,219.0	4,231.3
Floor 2 Lockers	1,250.0	1,250.0	1,250.0	1,250.0	1,250.0	1,250.0	1,250.0
Floor 2 Lounge 1	N/A	309.1	309.1	309.1	309.1	309.1	309.1
Floor 2 Lounge 2	N/A	854.3	951.3	964.8	1,138.1	1,104.7	1,139.0
Floor 2 Nurse Station 1	N/A	842.5	869.3	879.5	837.2	832.1	818.0
Floor 2 Nurse Station 2	N/A	2,368.6	2,451.7	2,456.6	2,423.9	2,411.3	2,400.8
Floor 2 Office 1	N/A	1,713.9	1,717.9	1,758.8	1,688.5	1,693.1	1,704.9
Floor 2 Office 2	N/A	1,391.4	1,465.4	1,370.6	1,362.9	1,367.1	1,370.5
Floor 2 Office 3	N/A	1,954.1	1,957.8	2,018.9	1,961.3	1,995.4	2,007.0
Floor 2 Office 4	N/A	3,441.5	3,775.4	3,849.7	4,250.5	4,265.7	4,351.0
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	4,050.0	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 2 Patient 1	3,408.0	3,589.8	3,829.3	3,442.4	3,442.4	3,442.4	3,442.4
Floor 2 Patient 2	2,806.0	2,834.3	2,834.3	2,834.3	2,834.3	2,834.3	2,834.3
Floor 2 Procedure 1	6,300.0	6,300.0	6,300.0	6,300.0	6,300.0	6,300.0	6,300.0
Floor 2 Procedure 2	3,400.0	3,400.0	3,400.0	3,400.0	3,400.0	3,400.0	3,400.0
Floor 2 Reception	N/A	1,896.3	2,049.5	2,126.6	2,250.0	2,274.1	2,325.3
Floor 2 Restroom 1	1,066.7	1,066.7	1,066.7	1,066.7	1,066.7	1,066.7	1,066.7
Floor 2 Restroom 2	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0
Floor 2 Soil 1	805.0	805.0	805.0	805.0	805.0	805.0	805.0
Floor 2 Soil 2	533.3	533.3	533.3	533.3	533.3	533.3	533.3
Floor 2 Sterilizing	2,266.7	4,204.3	4,241.7	4,364.4	4,211.5	4,262.1	4,249.9
Floor 2 Storage 1	N/A	1,187.1	1,190.8	1,219.2	1,171.1	1,175.4	1,182.8
Floor 2 Storage 2	N/A	471.5	472.4	487.3	473.3	481.6	484.4
Floor 2 Trauma	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0
Floor 2 Triage	1,750.0	1,750.0	1,750.0	1,750.0	1,750.0	1,750.0	1,750.0
Floor 2 Waiting	N/A	6,131.4	6,404.7	6,344.1	6,943.6	6,781.7	6,725.4
Floor 3 Clean	333.3	342.8	343.5	355.1	344.2	350.6	352.9
Floor 3 Elevator	N/A	2,172.3	2,385.1	2,409.4	2,711.8	2,722.1	2,794.7
Floor 3 Exam	2,700.0	2,700.0	2,700.0	2,700.0	2,700.0	2,700.0	2,700.0
Floor 3 ICU	2,100.0	2,517.5	2,659.3	2,594.5	2,782.5	2,696.6	2,723.2
Floor 3 Nurse Station 1	N/A	1,495.5	1,515.6	1,544.9	1,582.8	1,589.5	1,597.8
Floor 3 Nurse Station 2	N/A	2,797.3	2,963.8	2,780.1	2,937.3	2,854.3	2,771.6
Floor 3 Nursery	990.0	1,000.0	1,000.0	1,000.0	1,009.1	1,000.0	1,000.0
Floor 3 Office	N/A	3,361.3	3,523.8	3,500.3	3,903.2	3,781.8	3,727.9
Floor 3 Operating	6,000.0	6,602.5	6,761.0	6,853.7	6,962.6	6,938.4	6,919.4
Floor 3 Patient 1	5,000.0	5,050.5	5,050.5	5,050.5	5,050.5	5,050.5	5,156.2
Floor 3 Patient 2	5,000.0	5,050.5	5,050.5	5,050.5	5,050.5	5,050.5	5,050.5
Floor 3 Patient 3	3,950.0	3,989.9	3,989.9	3,989.9	3,989.9	3,989.9	3,989.9
Floor 3 Patient 4	3,950.0	3,989.9	3,989.9	3,989.9	3,989.9	4,039.0	4,211.1
Floor 3 Patient Corridor 1	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 3 Patient Corridor 2	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7
Floor 3 Procedure	1,800.0	1,800.0	1,800.0	1,800.0	1,800.0	1,800.0	1,800.0
Floor 3 Soil	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Supply	2,453.3	2,453.3	2,453.3	2,453.3	2,453.3	2,453.3	2,453.3
Floor 3 Triage	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0
Floor 3 Waiting	N/A	1,168.1	1,189.7	1,185.1	1,245.0	1,200.9	1,197.5
Floor 4-6 Clean	333.3	1,028.4	1,030.6	1,065.4	1,032.6	1,051.9	1,058.6
Floor 4-6 Elevator	N/A	6,547.3	7,169.3	7,226.1	8,128.9	8,165.2	8,380.0
Floor 4-6 Nurse Station	N/A	4,486.3	4,547.2	4,634.3	4,749.0	4,770.9	4,795.7
Floor 4-6 Office	N/A	3,838.5	4,090.3	3,686.4	3,656.2	3,599.5	3,572.5
Floor 4-6 Patient 1	5,000.0	15,151.5	15,151.5	15,151.5	15,151.5	15,151.5	15,511.2
Floor 4-6 Patient 2	5,000.0	15,151.5	15,151.5	15,151.5	15,151.5	15,151.5	15,151.5
Floor 4-6 Patient 3	3,950.0	11,969.7	11,969.7	11,969.7	11,969.7	11,969.7	11,969.7
Floor 4-6 Patient 4	3,950.0	11,969.7	11,969.7	11,969.7	11,976.2	12,166.2	12,685.3
Floor 4-6 Patient Corridor 1	1,114.7	3,344.0	3,344.0	3,344.0	3,344.0	3,344.0	3,344.0
Floor 4-6 Patient Corridor 2	1,114.7	3,344.0	3,344.0	3,344.0	3,344.0	3,344.0	3,344.0
Floor 4-6 Soil	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Supply	2,453.3	7,360.0	7,360.0	7,360.0	7,360.0	7,360.0	7,360.0
Floor 7 Clean	333.3	451.2	464.9	472.3	449.8	448.8	443.2
Floor 7 Elevator	N/A	2,609.1	2,843.3	2,842.8	3,141.2	3,133.7	3,187.5
Floor 7 Nurse Station	N/A	2,159.4	2,258.6	2,262.9	2,244.4	2,206.1	2,167.9
Floor 7 Office	N/A	1,576.1	1,701.8	1,550.0	1,501.1	1,459.1	1,424.8
Floor 7 Patient 1	5,000.0	5,050.5	5,149.0	5,294.3	5,927.4	5,966.8	6,154.2
Floor 7 Patient 2	5,000.0	5,207.0	5,597.5	5,050.5	5,050.5	5,050.5	5,050.5
Floor 7 Patient 3	3,950.0	4,417.0	4,735.6	4,268.3	4,301.5	4,175.8	4,017.3
Floor 7 Patient 4	3,950.0	3,989.9	4,225.4	4,337.1	4,880.4	4,911.9	5,061.2
Floor 7 Patient Corridor 1	1,114.7	1,601.7	1,706.8	1,687.1	1,639.3	1,589.7	1,543.4
Floor 7 Patient Corridor 2	1,114.7	1,601.7	1,706.8	1,687.1	1,639.3	1,589.7	1,543.4
Floor 7 Soil	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 7 Supply	2,453.3	2,592.7	2,707.2	2,717.5	2,594.5	2,563.9	2,520.9
MOB Floor 1 Core	N/A	6,754.2	6,641.2	6,642.0	6,336.0	6,302.0	6,275.4
MOB Floor 1 Perimeter 1	N/A	3,223.1	3,377.1	3,324.5	4,007.0	3,821.9	3,805.2
MOB Floor 1 Perimeter 2	N/A	1,773.6	2,159.7	2,241.4	2,667.1	2,675.1	2,800.1
MOB Floor 1 Perimeter 3	N/A	2,847.2	2,919.5	2,930.3	3,432.4	3,242.9	3,271.6
MOB Floor 2-4 Core	N/A	22,468.6	22,510.4	23,209.8	22,550.3	22,941.6	23,073.4
MOB Floor 2-4 Perimeter 1	N/A	10,675.1	11,245.8	11,181.3	13,646.1	13,201.7	13,180.2
MOB Floor 2-4 Perimeter 2	N/A	5,897.7	7,263.6	7,669.2	9,227.3	9,429.9	9,902.1
MOB Floor 2-4 Perimeter 3	N/A	9,393.4	9,731.8	9,872.4	11,734.9	11,299.8	11,403.5
MOB Floor 2-4 Perimeter 4	N/A	5,846.6	6,350.0	5,486.7	5,463.6	5,299.5	5,231.6
MOB Floor 5 Core	N/A	8,317.6	8,347.5	8,534.5	8,188.1	8,199.5	8,246.4
MOB Floor 5 Perimeter 1	N/A	4,181.6	4,440.9	4,414.8	5,275.6	5,091.2	5,047.2
MOB Floor 5 Perimeter 2	N/A	2,631.2	3,261.4	3,430.7	4,054.0	4,119.3	4,295.7
MOB Floor 5 Perimeter 3	N/A	3,307.3	3,443.9	3,476.9	4,147.7	3,980.0	4,011.6
MOB Floor 5 Perimeter 4	N/A	2,318.3	2,531.6	2,224.3	2,173.1	2,094.6	2,042.6

Table D-5 Baseline Model Total Airflow Validation: Arid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 1 Cafe	N/A	11,323.5	11,323.5	11,323.5	11,323.5	11,323.5	11,323.5
Floor 1 Clean	320.0	320.0	320.0	320.0	343.3	345.2	320.0
Floor 1 Conference	N/A	9,525.5	8,773.2	9,447.1	10,567.8	10,692.5	10,384.8
Floor 1 Dining	N/A	10,510.9	10,510.9	10,510.9	10,510.9	10,510.9	10,510.9
Floor 1 Elevator	N/A	1,836.7	1,664.4	1,772.0	1,991.5	2,025.0	2,004.6
Floor 1 Exam	2,640.0	2,640.0	2,640.0	2,640.0	2,649.4	2,640.0	2,640.0
Floor 1 Food Storage	3,348.3	21,755.0	21,114.1	22,586.3	25,654.1	25,870.7	24,188.8
Floor 1 Gas Storage	832.0	832.0	832.0	832.0	832.0	832.0	832.0
Floor 1 Imaging	1,520.0	2,847.9	2,839.2	2,936.9	3,361.4	3,386.8	3,164.4
Floor 1 Kitchen	3,348.3	23,604.3	23,604.3	24,226.4	27,349.3	27,578.7	25,856.0
Floor 1 Lab 1	2,000.0	2,082.4	2,127.3	2,136.9	2,476.8	2,493.4	2,322.9
Floor 1 Lab 2	4,900.0	5,616.3	5,396.4	5,615.1	6,587.7	6,489.6	6,023.2
Floor 1 Laundry	3,726.7	7,988.5	7,676.1	8,148.6	9,262.7	9,287.4	8,694.7
Floor 1 Lobby	N/A	3,882.8	3,463.9	3,829.7	4,432.0	4,246.7	3,867.6
Floor 1 Lounge	N/A	329.7	329.7	329.7	329.7	329.7	329.7
Floor 1 Mech 1	N/A	4,851.4	4,038.4	4,504.0	5,428.2	5,104.7	4,635.8
Floor 1 Mech 2	N/A	10,028.4	7,681.2	9,336.4	10,968.2	10,133.7	9,232.9
Floor 1 Office 1	N/A	3,646.6	3,497.6	3,539.7	4,044.8	3,996.3	3,650.0
Floor 1 Office 2	N/A	3,104.7	3,132.3	3,050.3	3,748.0	3,643.4	3,362.2
Floor 1 Office 3	N/A	8,525.5	9,219.6	8,548.2	10,429.7	10,454.7	9,620.3
Floor 1 Office 3 Perimeter 1	N/A	3,456.7	1,963.1	2,928.5	3,004.7	2,692.8	2,401.4
Floor 1 Office 3 Perimeter 2	N/A	2,808.4	2,233.8	2,626.4	3,376.7	3,094.3	2,926.4
Floor 1 Office 3 Perimeter 3	N/A	3,927.0	3,231.3	3,689.9	4,022.9	4,135.0	4,284.5
Floor 1 Patient	1,800.0	1,818.2	1,818.2	1,818.2	1,818.2	1,818.2	1,818.2
Floor 1 Pharmacy	4,000.0	4,181.8	4,181.8	4,181.8	4,181.8	4,181.8	4,181.8
Floor 1 Physical Therapy	4,920.0	4,920.0	4,920.0	4,920.0	4,920.0	4,920.0	4,920.0
Floor 1 Receiving	N/A	2,039.3	1,436.4	1,773.6	1,904.7	1,748.5	1,627.2

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 1 Reception	N/A	1,084.9	879.7	1,044.2	1,337.6	1,253.9	1,167.6
Floor 1 Soil	800.0	800.0	800.0	800.0	800.0	800.0	800.0
Floor 1 Storage	N/A	2,597.6	2,903.5	2,600.8	3,139.3	3,150.0	2,915.3
Floor 1 Waiting	N/A	967.3	976.1	967.3	1,108.7	1,114.8	1,034.0
Floor 2 Chapel	N/A	3,024.9	2,422.4	2,924.2	3,169.5	3,162.9	3,157.2
Floor 2 Clean 1	322.0	490.2	431.4	496.3	540.0	528.9	491.5
Floor 2 Clean 2	213.3	228.3	220.1	237.0	266.7	269.0	252.4
Floor 2 Corridor	1,733.3	1,733.3	1,733.3	1,733.3	1,733.3	1,733.3	1,733.3
Floor 2 Elevator	N/A	2,156.2	1,865.6	2,124.7	2,317.3	2,388.1	2,395.2
Floor 2 Exam 1	4,200.0	6,109.1	5,035.8	5,989.2	6,727.3	6,520.7	6,261.3
Floor 2 Exam 2	1,350.0	1,352.0	1,350.0	1,374.7	1,454.8	1,431.4	1,350.0
Floor 2 Exam 3	4,050.0	4,050.0	4,050.0	4,050.0	4,089.9	4,124.9	4,050.0
Floor 2 Exam 4	4,000.0	4,000.0	4,000.0	4,000.0	4,138.5	4,115.0	4,000.0
Floor 2 Gift Shop	N/A	2,195.8	1,806.6	2,148.3	2,260.9	2,302.3	2,322.3
Floor 2 Imaging 1	2,310.0	5,522.3	5,124.5	5,671.4	6,295.5	6,274.2	5,861.8
Floor 2 Imaging 2	3,400.0	9,924.3	8,918.3	9,999.5	10,971.4	11,212.9	11,010.7
Floor 2 Imaging 3	4,000.0	10,968.5	8,775.3	10,863.9	11,711.8	11,414.6	10,400.6
Floor 2 Lab 1	2,280.0	3,449.6	3,125.8	3,519.3	3,875.5	3,833.3	3,571.4
Floor 2 Lab 2	3,400.0	4,413.9	4,107.3	4,546.3	5,064.3	5,036.4	4,704.3
Floor 2 Lockers	1,250.0	1,250.0	1,250.0	1,250.0	1,250.0	1,250.0	1,250.0
Floor 2 Lounge 1	N/A	309.1	309.1	312.1	351.2	354.3	332.3
Floor 2 Lounge 2	N/A	1,249.0	873.8	1,140.6	1,277.3	1,213.3	1,214.6
Floor 2 Nurse Station 1	N/A	938.9	795.5	941.8	1,009.1	975.9	902.7
Floor 2 Nurse Station 2	N/A	2,744.3	2,227.6	2,689.2	2,921.6	2,828.4	2,642.9
Floor 2 Office 1	N/A	1,868.6	1,616.5	1,887.1	1,958.4	1,908.2	1,795.9
Floor 2 Office 2	N/A	1,722.1	1,214.1	1,576.9	1,611.1	1,537.8	1,431.1
Floor 2 Office 3	N/A	2,025.5	1,957.9	2,096.6	2,341.6	2,361.6	2,223.1
Floor 2 Office 4	N/A	4,640.1	3,757.1	4,510.4	4,854.4	4,852.4	4,827.4

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 2 Operating	64,253.3	65,825.1	64,253.3	65,856.6	73,082.3	72,017.2	66,962.7
Floor 2 PACU	4,050.0	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9	4,090.9
Floor 2 Patient 1	3,408.0	4,432.7	3,442.4	4,080.1	4,126.9	3,784.6	3,442.4
Floor 2 Patient 2	2,806.0	2,834.3	2,834.3	2,834.3	2,834.3	2,834.3	2,834.3
Floor 2 Procedure 1	6,300.0	6,300.0	6,300.0	6,300.0	6,300.0	6,300.0	6,300.0
Floor 2 Procedure 2	3,400.0	3,400.0	3,400.0	3,400.0	3,400.0	3,400.0	3,400.0
Floor 2 Reception	N/A	2,440.1	2,070.6	2,405.0	2,571.4	2,605.2	2,586.7
Floor 2 Restroom 1	1,066.7	1,066.7	1,066.7	1,066.7	1,066.7	1,066.7	1,066.7
Floor 2 Restroom 2	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0
Floor 2 Soil 1	805.0	805.0	805.0	805.0	805.0	805.0	805.0
Floor 2 Soil 2	533.3	533.3	533.3	533.3	533.3	533.3	533.3
Floor 2 Sterilizing	2,266.7	4,440.6	4,154.2	4,572.4	5,095.8	5,094.4	4,726.6
Floor 2 Storage 1	N/A	1,293.3	1,127.5	1,308.7	1,366.8	1,333.6	1,254.3
Floor 2 Storage 2	N/A	488.9	472.5	506.2	565.9	570.7	537.0
Floor 2 Trauma	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0
Floor 2 Triage	1,750.0	1,750.0	1,750.0	1,750.0	1,750.0	1,750.0	1,750.0
Floor 2 Waiting	N/A	7,249.8	5,686.5	7,074.0	8,416.3	7,980.2	7,372.8
Floor 3 Clean	333.3	356.4	343.6	369.9	416.3	419.9	393.9
Floor 3 Elevator	N/A	2,977.3	2,335.5	2,838.6	3,129.4	3,128.3	3,100.5
Floor 3 Exam	2,700.0	2,700.0	2,700.0	2,708.9	2,865.4	2,813.8	2,700.0
Floor 3 ICU	2,100.0	3,145.7	2,267.0	2,907.6	3,269.2	3,050.2	2,896.3
Floor 3 Nurse Station 1	N/A	1,626.0	1,473.0	1,647.1	1,913.4	1,893.2	1,773.3
Floor 3 Nurse Station 2	N/A	3,421.5	2,317.6	3,214.7	3,591.2	3,324.3	2,991.2
Floor 3 Nursery	990.0	1,082.7	1,000.0	1,013.4	1,177.5	1,091.3	1,039.7
Floor 3 Office	N/A	4,023.3	3,106.3	3,910.9	4,746.9	4,450.3	4,099.6
Floor 3 Operating	6,000.0	7,303.6	6,399.2	7,326.5	8,423.1	8,234.0	7,685.4
Floor 3 Patient 1	5,000.0	5,304.1	5,050.5	5,050.5	5,425.9	5,591.4	5,747.4
Floor 3 Patient 2	5,000.0	5,068.2	5,050.5	5,050.5	5,050.5	5,050.5	5,050.5

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 3 Patient 3	3,950.0	3,989.9	3,989.9	3,989.9	3,989.9	3,989.9	3,989.9
Floor 3 Patient 4	3,950.0	4,329.7	3,989.9	4,122.5	4,431.8	4,572.6	4,699.6
Floor 3 Patient Corridor 1	1,114.7	1,114.7	1,114.7	1,114.7	1,120.2	1,114.7	1,114.7
Floor 3 Patient Corridor 2	1,114.7	1,114.7	1,114.7	1,114.7	1,119.6	1,114.7	1,114.7
Floor 3 Procedure	1,800.0	1,800.0	1,800.0	1,800.0	1,938.6	1,886.8	1,800.0
Floor 3 Soil	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Supply	2,453.3	2,453.3	2,453.3	2,453.3	2,453.3	2,453.3	2,453.3
Floor 3 Triage	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0
Floor 3 Waiting	N/A	1,365.7	1,018.4	1,295.3	1,490.3	1,378.1	1,267.5
Floor 4-6 Clean	333.3	1,069.1	1,030.8	1,109.8	1,248.9	1,259.8	1,181.7
Floor 4-6 Elevator	N/A	8,964.0	6,986.9	8,520.3	9,388.3	9,386.1	9,299.4
Floor 4-6 Nurse Station	N/A	4,881.3	4,417.0	4,941.2	5,741.5	5,682.7	5,323.1
Floor 4-6 Office	N/A	4,779.4	2,890.9	4,288.2	4,453.5	4,181.5	3,833.2
Floor 4-6 Patient 1	5,000.0	16,009.1	15,151.5	15,154.1	16,303.5	16,824.3	17,307.1
Floor 4-6 Patient 2	5,000.0	15,283.4	15,151.5	15,151.5	15,151.5	15,151.5	15,151.5
Floor 4-6 Patient 3	3,950.0	12,969.7	11,969.7	11,969.7	12,332.2	11,969.7	11,969.7
Floor 4-6 Patient 4	3,950.0	13,055.5	11,969.7	12,402.3	13,336.3	13,779.2	14,168.4
Floor 4-6 Patient Corridor 1	1,114.7	3,344.0	3,344.0	3,344.0	3,360.7	3,344.0	3,344.0
Floor 4-6 Patient Corridor 2	1,114.7	3,344.0	3,344.0	3,344.0	3,360.7	3,344.0	3,344.0
Floor 4-6 Soil	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Supply	2,453.3	7,360.0	7,360.0	7,360.0	7,360.0	7,360.0	7,360.0
Floor 7 Clean	333.3	496.5	434.9	499.6	544.4	531.0	494.0
Floor 7 Elevator	N/A	3,502.9	2,699.1	3,327.0	3,646.0	3,597.6	3,545.0
Floor 7 Nurse Station	N/A	2,484.9	2,034.4	2,442.1	2,716.6	2,592.6	2,404.1
Floor 7 Office	N/A	1,983.0	1,187.4	1,784.0	1,838.1	1,694.4	1,544.8
Floor 7 Patient 1	5,000.0	6,636.3	5,132.4	6,275.4	6,615.2	6,712.1	6,856.8
Floor 7 Patient 2	5,000.0	6,575.7	5,050.5	5,962.7	6,023.6	5,490.1	5,050.5
Floor 7 Patient 3	3,950.0	5,539.3	3,989.9	5,058.6	5,292.7	4,838.3	4,297.6

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 7 Patient 4	3,950.0	5,429.6	4,251.3	5,150.8	5,465.7	5,538.9	5,651.7
Floor 7 Patient Corridor 1	1,114.7	1,923.4	1,456.3	1,843.3	1,983.6	1,848.5	1,709.8
Floor 7 Patient Corridor 2	1,114.7	1,923.4	1,456.3	1,843.3	1,983.6	1,848.5	1,709.8
Floor 7 Soil	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Supply	2,453.3	2,969.2	2,453.3	2,917.3	3,138.2	3,011.9	2,802.2
MOB Floor 1 Core	N/A	5,929.6	6,462.1	5,957.2	7,284.1	7,308.0	6,725.2
MOB Floor 1 Perimeter 1	N/A	3,803.6	3,006.6	3,635.3	4,731.7	4,392.6	4,071.8
MOB Floor 1 Perimeter 2	N/A	2,740.8	2,271.3	2,582.0	2,817.6	2,913.6	3,042.2
MOB Floor 1 Perimeter 3	N/A	3,315.0	2,641.9	3,087.5	3,929.3	3,603.3	3,394.9
MOB Floor 2-4 Core	N/A	23,285.3	22,512.6	24,097.9	26,895.3	27,124.8	25,541.3
MOB Floor 2-4 Perimeter 1	N/A	13,259.4	10,121.2	12,836.5	16,483.6	15,490.8	14,441.4
MOB Floor 2-4 Perimeter 2	N/A	9,759.1	7,877.1	9,402.8	10,038.0	10,556.2	11,075.9
MOB Floor 2-4 Perimeter 3	N/A	11,658.0	8,881.5	11,107.0	13,835.7	12,897.6	12,247.8
MOB Floor 2-4 Perimeter 4	N/A	7,657.1	3,972.4	6,614.6	6,677.1	6,080.9	5,522.4
MOB Floor 5 Core	N/A	9,113.6	7,845.9	9,190.6	9,495.7	9,221.1	8,674.2
MOB Floor 5 Perimeter 1	N/A	5,199.7	3,938.3	5,021.7	6,397.0	5,984.3	5,564.6
MOB Floor 5 Perimeter 2	N/A	4,359.7	3,450.8	4,176.8	4,424.0	4,605.2	4,812.4
MOB Floor 5 Perimeter 3	N/A	4,162.5	3,076.8	3,934.7	4,856.0	4,475.0	4,254.3
MOB Floor 5 Perimeter 4	N/A	3,024.7	1,567.1	2,641.2	2,671.5	2,417.0	2,183.6

Table D-6 Baseline Model Total Airflow Validation: Marine and Cold Climates

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 1 Cafe	N/A	11,323.5	11,323.5	11,323.5	11,323.5
Floor 1 Clean	320.0	320.0	320.0	320.0	320.0
Floor 1 Conference	N/A	8,918.9	9,555.0	9,549.6	9,662.2
Floor 1 Dining	N/A	10,510.9	10,510.9	10,510.9	10,510.9
Floor 1 Elevator	N/A	1,734.2	1,884.0	1,842.5	1,927.8
Floor 1 Exam	2,640.0	2,640.0	2,640.0	2,640.0	2,640.0
Floor 1 Food Storage	3,348.3	20,795.8	21,179.0	22,002.8	21,045.4
Floor 1 Gas Storage	832.0	832.0	832.0	832.0	832.0
Floor 1 Imaging	1,520.0	2,701.2	2,776.9	2,873.2	2,695.5
Floor 1 Kitchen	3,348.3	23,604.3	23,604.3	23,635.3	23,604.3
Floor 1 Lab 1	2,000.0	2,000.0	2,031.0	2,096.8	2,000.0
Floor 1 Lab 2	4,900.0	4,900.0	5,145.8	5,485.4	4,999.8
Floor 1 Laundry	3,726.7	7,356.4	7,601.3	7,909.4	7,467.5
Floor 1 Lobby	N/A	2,919.4	3,234.0	3,513.6	2,825.3
Floor 1 Lounge	N/A	329.7	329.7	329.7	329.7
Floor 1 Mech 1	N/A	3,400.0	3,918.4	4,307.1	3,617.1
Floor 1 Mech 2	N/A	6,441.4	7,695.0	8,633.7	6,743.4
Floor 1 Office 1	N/A	2,759.2	3,085.8	3,276.0	2,816.9
Floor 1 Office 2	N/A	2,563.0	2,928.8	3,099.5	2,695.8
Floor 1 Office 3	N/A	7,620.1	7,907.2	8,473.0	6,777.1
Floor 1 Office 3 Perimeter 1	N/A	1,664.5	1,838.0	2,178.3	1,882.9
Floor 1 Office 3 Perimeter 2	N/A	2,021.3	2,602.1	2,944.8	2,857.7
Floor 1 Office 3 Perimeter 3	N/A	3,784.6	4,252.6	4,030.4	4,648.5
Floor 1 Patient	1,800.0	1,818.2	1,818.2	1,818.2	1,818.2
Floor 1 Pharmacy	4,000.0	4,181.8	4,181.8	4,181.8	4,181.8
Floor 1 Physical Therapy	4,920.0	4,920.0	4,920.0	4,920.0	4,920.0
Floor 1 Receiving	N/A	1,158.4	1,349.6	1,498.3	1,346.6
Floor 1 Reception	N/A	904.0	1,043.8	1,153.6	1,045.1

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 1 Soil	800.0	800.0	800.0	800.0	800.0
Floor 1 Storage	N/A	2,343.9	2,542.8	2,591.4	2,226.4
Floor 1 Waiting	N/A	967.3	967.3	967.3	967.3
Floor 2 Chapel	N/A	2,706.9	2,972.6	2,958.7	3,026.1
Floor 2 Clean 1	322.0	403.0	422.3	444.2	377.4
Floor 2 Clean 2	213.3	219.4	222.5	231.0	222.8
Floor 2 Corridor	1,733.3	1,733.3	1,733.3	1,733.3	1,733.3
Floor 2 Elevator	N/A	2,150.8	2,278.8	2,246.2	2,495.7
Floor 2 Exam 1	4,200.0	5,316.7	5,704.8	5,845.6	5,199.3
Floor 2 Exam 2	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Exam 3	4,050.0	4,050.0	4,050.0	4,050.0	4,050.0
Floor 2 Exam 4	4,000.0	4,000.0	4,000.0	4,000.0	4,000.0
Floor 2 Gift Shop	N/A	2,046.5	2,211.9	2,172.6	2,303.4
Floor 2 Imaging 1	2,310.0	4,979.5	5,113.7	5,336.0	4,898.8
Floor 2 Imaging 2	3,400.0	9,661.3	10,181.6	10,215.8	10,083.1
Floor 2 Imaging 3	4,000.0	8,612.0	8,938.7	9,602.0	9,103.4
Floor 2 Lab 1	2,280.0	2,977.6	3,087.8	3,241.1	2,876.4
Floor 2 Lab 2	3,400.0	4,032.6	4,107.5	4,292.5	4,059.8
Floor 2 Lockers	1,250.0	1,250.0	1,250.0	1,250.0	1,250.0
Floor 2 Lounge 1	N/A	309.1	309.1	309.1	309.1
Floor 2 Lounge 2	N/A	949.7	1,127.5	1,185.4	1,277.3
Floor 2 Nurse Station 1	N/A	719.6	766.3	812.1	647.6
Floor 2 Nurse Station 2	N/A	2,103.8	2,251.0	2,424.1	2,360.6
Floor 2 Office 1	N/A	1,548.4	1,588.0	1,655.8	1,678.8
Floor 2 Office 2	N/A	1,174.1	1,172.4	1,342.5	1,353.6
Floor 2 Office 3	N/A	1,952.0	1,978.0	2,047.2	1,980.4
Floor 2 Office 4	N/A	4,168.3	4,528.1	4,509.2	4,574.6
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	4,050.0	4,090.9	4,090.9	4,090.9	4,090.9

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 2 Patient 1	3,408.0	3,442.4	3,442.4	3,442.4	3,442.4
Floor 2 Patient 2	2,806.0	2,834.3	2,834.3	2,834.3	2,834.3
Floor 2 Procedure 1	6,300.0	6,300.0	6,300.0	6,300.0	6,300.0
Floor 2 Procedure 2	3,400.0	3,400.0	3,400.0	3,400.0	3,400.0
Floor 2 Reception	N/A	2,246.6	2,400.6	2,395.3	2,460.2
Floor 2 Restroom 1	1,066.7	1,066.7	1,066.7	1,066.7	1,066.7
Floor 2 Restroom 2	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0
Floor 2 Soil 1	805.0	805.0	805.0	805.0	805.0
Floor 2 Soil 2	533.3	533.3	533.3	533.3	533.3
Floor 2 Sterilizing	2,266.7	3,983.9	4,095.3	4,308.2	3,986.3
Floor 2 Storage 1	N/A	1,082.9	1,109.8	1,153.8	1,159.0
Floor 2 Storage 2	N/A	471.0	477.4	494.2	478.0
Floor 2 Trauma	11,200.0	11,200.0	11,200.0	11,200.0	11,200.0
Floor 2 Triage	1,750.0	1,750.0	1,750.0	1,750.0	1,750.0
Floor 2 Waiting	N/A	5,662.7	6,386.2	7,141.4	6,173.7
Floor 3 Clean	333.3	342.4	347.4	360.5	347.8
Floor 3 Elevator	N/A	2,647.2	2,887.7	2,922.6	3,119.3
Floor 3 Exam	2,700.0	2,700.0	2,700.0	2,700.0	2,700.0
Floor 3 ICU	2,100.0	2,170.0	2,491.9	2,794.6	2,756.6
Floor 3 Nurse Station 1	N/A	1,495.6	1,568.4	1,665.5	1,584.4
Floor 3 Nurse Station 2	N/A	2,219.4	2,494.3	2,855.5	2,445.2
Floor 3 Nursery	990.0	1,000.0	1,000.0	1,023.6	1,022.0
Floor 3 Office	N/A	2,944.7	3,476.3	3,997.4	3,472.3
Floor 3 Operating	6,000.0	6,328.2	6,717.5	7,173.3	6,451.8
Floor 3 Patient 1	5,000.0	5,119.8	5,577.6	5,462.2	6,385.0
Floor 3 Patient 2	5,000.0	5,050.5	5,050.5	5,050.5	5,050.5
Floor 3 Patient 3	3,950.0	3,989.9	3,989.9	3,989.9	3,989.9
Floor 3 Patient 4	3,950.0	4,231.7	4,573.0	4,445.0	5,139.7
Floor 3 Patient Corridor 1	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 3 Patient Corridor 2	1,114.7	1,114.7	1,114.7	1,114.7	1,114.7
Floor 3 Procedure	1,800.0	1,800.0	1,800.0	1,800.0	1,800.0
Floor 3 Soil	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Supply	2,453.3	2,453.3	2,453.3	2,453.3	2,453.3
Floor 3 Triage	3,000.0	3,000.0	3,000.0	3,000.0	3,000.0
Floor 3 Waiting	N/A	878.4	1,014.6	1,219.5	1,132.0
Floor 4-6 Clean	333.3	1,027.3	1,042.1	1,081.5	1,043.5
Floor 4-6 Elevator	N/A	7,911.3	8,641.2	8,766.5	9,354.3
Floor 4-6 Nurse Station	N/A	4,482.8	4,705.0	5,001.4	4,759.4
Floor 4-6 Office	N/A	2,930.9	3,056.4	3,571.7	3,507.1
Floor 4-6 Patient 1	5,000.0	15,380.4	16,786.2	16,444.0	19,136.2
Floor 4-6 Patient 2	5,000.0	15,151.5	15,151.5	15,151.5	15,151.5
Floor 4-6 Patient 3	3,950.0	11,969.7	11,969.7	11,969.7	11,969.7
Floor 4-6 Patient 4	3,950.0	12,708.4	13,779.2	13,410.0	15,498.8
Floor 4-6 Patient Corridor 1	1,114.7	3,344.0	3,344.0	3,344.0	3,344.0
Floor 4-6 Patient Corridor 2	1,114.7	3,344.0	3,344.0	3,344.0	3,344.0
Floor 4-6 Soil	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Supply	2,453.3	7,360.0	7,360.0	7,360.0	7,360.0
Floor 7 Clean	333.3	404.6	426.1	445.0	385.9
Floor 7 Elevator	N/A	2,950.7	3,254.4	3,312.8	3,362.7
Floor 7 Nurse Station	N/A	1,887.4	2,066.3	2,208.7	1,842.7
Floor 7 Office	N/A	1,104.4	1,175.4	1,407.3	1,189.3
Floor 7 Patient 1	5,000.0	5,913.0	6,522.0	6,430.7	7,048.3
Floor 7 Patient 2	5,000.0	5,050.5	5,050.5	5,050.5	5,050.5
Floor 7 Patient 3	3,950.0	3,989.9	3,989.9	4,010.0	3,989.9
Floor 7 Patient 4	3,950.0	4,916.3	5,395.8	5,283.5	5,732.4
Floor 7 Patient Corridor 1	1,114.7	1,275.2	1,436.2	1,541.1	1,218.7
Floor 7 Patient Corridor 2	1,114.7	1,275.2	1,436.2	1,541.1	1,218.7
Floor 7 Soil	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 7 Supply	2,453.3	2,453.3	2,453.3	2,512.5	2,453.3
MOB Floor 1 Core	N/A	5,854.4	5,854.4	5,919.6	5,854.4
MOB Floor 1 Perimeter 1	N/A	3,029.1	3,589.1	4,069.2	3,701.5
MOB Floor 1 Perimeter 2	N/A	2,710.7	3,052.9	2,879.7	3,391.0
MOB Floor 1 Perimeter 3	N/A	2,392.5	3,037.2	3,399.3	3,230.3
MOB Floor 2-4 Core	N/A	22,444.3	22,741.3	23,534.5	22,768.9
MOB Floor 2-4 Perimeter 1	N/A	10,858.5	12,741.6	14,630.3	13,904.5
MOB Floor 2-4 Perimeter 2	N/A	10,085.2	11,109.2	10,643.6	12,884.1
MOB Floor 2-4 Perimeter 3	N/A	8,771.0	10,788.1	12,408.4	12,363.9
MOB Floor 2-4 Perimeter 4	N/A	3,873.0	4,089.5	5,170.1	4,681.2
MOB Floor 5 Core	N/A	7,494.2	7,690.8	7,993.0	8,108.1
MOB Floor 5 Perimeter 1	N/A	4,108.3	4,858.4	5,582.7	5,113.4
MOB Floor 5 Perimeter 2	N/A	4,273.2	4,750.2	4,587.3	5,348.5
MOB Floor 5 Perimeter 3	N/A	3,013.1	3,736.3	4,343.1	4,339.5
MOB Floor 5 Perimeter 4	N/A	1,480.9	1,573.6	2,005.9	1,699.4

D.2 Low-Energy Model

Table D-7 through Table D-9 demonstrate that all the zones in the baseline model are supplied with at least 97% of the required ventilation air required by the standards, while Table D-10 through Table D-12 show that all zones in the baseline model are supplied with at least 97% of the total air (where applicable) required by the standards.

Table D-7 Low-Energy Model Ventilation Airflow Validation: Humid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 1 Cafe	723.2	726.8	720.9	720.7	719.8	713.3	709.2
Floor 1 Clean	28.8	33.8	33.6	33.5	33.3	33.2	33.0
Floor 1 Conference	369.0	371.2	368.2	368.1	364.6	364.3	362.2
Floor 1 Dining	885.6	889.9	882.7	882.5	881.3	873.5	868.4
Floor 1 Elevator	108.0	217.2	215.5	215.4	214.1	213.3	212.0
Floor 1 Exam	158.4	159.5	158.2	158.2	156.7	156.4	155.6
Floor 1 Food Storage	1,406.3	1,406.3	1,402.4	1,399.0	1,388.7	1,387.6	1,379.5
Floor 1 Gas Storage	74.9	74.9	74.9	74.9	74.9	74.9	74.9
Floor 1 Imaging	91.2	107.1	106.2	106.2	105.6	105.1	104.5
Floor 1 Kitchen	1,406.3	1,413.8	1,402.4	1,399.0	1,388.7	1,387.6	1,379.5
Floor 1 Lab 1	120.0	140.9	139.8	139.8	138.9	138.3	137.5
Floor 1 Lab 2	294.0	345.0	342.2	342.1	340.1	338.7	336.8
Floor 1 Laundry	134.2	469.7	469.7	469.7	469.7	469.7	469.7
Floor 1 Lobby	225.0	452.9	449.3	449.2	446.4	444.3	441.9
Floor 1 Lounge	76.8	90.2	89.5	89.4	88.9	88.5	88.0
Floor 1 Mech 1	972.0	972.6	970.8	968.6	961.5	959.7	954.5
Floor 1 Mech 2	1,296.0	1,296.9	1,294.3	1,291.4	1,282.0	1,279.6	1,272.7
Floor 1 Office 1	442.8	445.8	442.2	442.1	438.0	437.2	434.8
Floor 1 Office 2	341.0	343.1	340.3	340.2	337.0	336.7	334.8
Floor 1 Office 3	1,187.7	1,194.8	1,185.2	1,184.8	1,173.6	1,172.7	1,165.9
Floor 1 Office 3 Perimeter 1	173.3	174.3	172.9	172.8	171.2	171.1	170.1
Floor 1 Office 3 Perimeter 2	109.8	110.5	109.6	109.5	108.5	108.4	107.8
Floor 1 Office 3 Perimeter 3	173.3	174.3	172.9	172.8	171.2	171.1	170.1
Floor 1 Patient	600.0	600.0	600.0	600.0	600.0	600.0	600.0
Floor 1 Pharmacy	1,080.0	1,206.9	1,197.2	1,196.8	1,189.5	1,183.9	1,177.6
Floor 1 Physical Therapy	295.2	297.2	294.8	294.7	292.0	291.5	289.9
Floor 1 Receiving	268.3	268.5	267.7	267.1	265.1	264.9	263.4
Floor 1 Reception	33.6	67.6	67.1	67.1	66.7	66.3	66.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 1 Soil	28.8	40.8	40.8	40.8	40.8	40.8	40.8
Floor 1 Storage	648.0	648.4	647.2	645.7	641.0	639.8	636.4
Floor 1 Waiting	91.2	183.6	182.1	182.1	180.9	180.1	179.1
Floor 2 Chapel	122.4	123.2	122.2	122.2	121.1	120.9	120.2
Floor 2 Clean 1	29.0	34.0	33.8	33.8	33.5	33.4	33.2
Floor 2 Clean 2	19.2	22.5	22.3	22.3	22.2	22.1	22.0
Floor 2 Corridor	312.0	312.2	311.6	310.9	308.6	308.1	306.4
Floor 2 Elevator	108.0	217.2	215.5	215.4	214.1	213.3	212.0
Floor 2 Exam 1	252.0	253.7	251.7	251.6	249.3	248.8	247.5
Floor 2 Exam 2	81.0	81.6	80.9	80.9	80.1	80.0	79.5
Floor 2 Exam 3	243.0	244.5	242.5	242.4	240.1	239.9	238.5
Floor 2 Exam 4	240.0	241.4	239.5	239.4	237.2	237.0	235.6
Floor 2 Gift Shop	108.0	108.6	107.8	107.7	106.7	106.6	106.0
Floor 2 Imaging 1	138.6	162.8	161.5	161.4	160.4	159.7	158.8
Floor 2 Imaging 2	204.0	239.6	237.7	237.6	236.1	235.0	233.8
Floor 2 Imaging 3	240.0	281.6	279.4	279.3	277.6	276.5	274.9
Floor 2 Lab 1	136.8	160.7	159.4	159.3	158.4	157.6	156.8
Floor 2 Lab 2	204.0	239.6	237.7	237.6	236.1	235.0	233.8
Floor 2 Lockers	375.0	375.0	375.0	375.0	375.0	375.0	375.0
Floor 2 Lounge 1	72.0	84.5	83.8	83.8	83.3	83.0	82.5
Floor 2 Lounge 2	52.5	61.6	61.1	61.1	60.7	60.5	60.1
Floor 2 Nurse Station 1	77.4	90.9	90.2	90.1	89.6	89.2	88.7
Floor 2 Nurse Station 2	240.0	281.6	279.4	279.3	277.6	276.5	274.9
Floor 2 Office 1	140.4	141.4	140.2	140.2	138.9	138.6	137.9
Floor 2 Office 2	115.2	115.9	115.0	114.9	113.8	113.7	113.1
Floor 2 Office 3	180.0	181.1	179.6	179.6	177.9	177.7	176.7
Floor 2 Office 4	210.0	211.3	209.6	209.5	207.5	207.3	206.1
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 2 Patient 2	935.3	935.3	935.3	935.3	935.3	935.3	935.3
Floor 2 Procedure 1	1,260.0	1,260.0	1,260.0	1,260.0	1,260.0	1,260.0	1,260.0
Floor 2 Procedure 2	680.0	680.0	680.0	680.0	680.0	680.0	680.0
Floor 2 Reception	105.0	211.2	209.5	209.4	208.2	207.3	206.2
Floor 2 Restroom 1	160.0	160.0	160.0	160.0	160.0	160.0	160.0
Floor 2 Restroom 2	225.0	225.0	225.0	225.0	225.0	225.0	225.0
Floor 2 Soil 1	29.0	41.1	41.1	41.1	41.1	41.1	41.1
Floor 2 Soil 2	19.2	27.2	27.2	27.2	27.2	27.2	27.2
Floor 2 Sterilizing	163.2	163.3	163.3	163.3	163.3	163.3	163.3
Floor 2 Storage 1	180.0	180.1	179.8	179.4	178.1	177.7	176.8
Floor 2 Storage 2	76.8	76.9	76.6	76.5	75.9	75.8	75.4
Floor 2 Trauma	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0
Floor 2 Triage	291.7	291.7	291.7	291.7	291.7	291.7	291.7
Floor 2 Waiting	234.0	471.1	467.3	467.1	464.3	462.1	459.6
Floor 3 Clean	30.0	35.3	35.0	35.0	34.7	34.6	34.4
Floor 3 Elevator	108.0	217.5	215.7	215.7	214.4	213.3	212.3
Floor 3 Exam	162.0	163.2	161.9	161.8	160.3	160.0	159.2
Floor 3 ICU	700.0	700.0	700.0	700.0	700.0	700.0	700.0
Floor 3 Nurse Station 1	180.5	212.1	210.3	210.3	209.0	207.9	207.0
Floor 3 Nurse Station 2	144.0	169.2	167.8	167.8	166.8	165.9	165.2
Floor 3 Nursery	330.0	330.0	330.0	330.0	330.0	330.0	330.0
Floor 3 Office	162.0	163.2	161.9	161.8	160.3	160.0	159.2
Floor 3 Operating	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient 4	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient Corridor 1	200.6	200.8	200.5	200.0	198.5	198.1	197.2

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 3 Patient Corridor 2	200.6	200.8	200.5	200.0	198.6	198.1	197.0
Floor 3 Procedure	360.0	360.0	360.0	360.0	360.0	360.0	360.0
Floor 3 Soil	60.0	85.0	85.0	85.0	85.0	85.0	85.0
Floor 3 Supply	441.6	441.9	441.3	440.3	437.0	436.0	433.5
Floor 3 Triage	500.0	500.0	500.0	500.0	500.0	500.0	500.0
Floor 3 Waiting	59.4	119.6	118.7	118.6	117.9	117.3	116.8
Floor 4-6 Clean	30.0	105.8	104.9	104.9	104.2	103.7	103.1
Floor 4-6 Elevator	108.0	652.5	647.2	647.1	643.1	639.8	637.0
Floor 4-6 Nurse Station	180.5	636.2	631.0	630.9	627.0	623.8	621.1
Floor 4-6 Office	90.0	272.0	269.8	269.7	267.2	266.6	265.1
Floor 4-6 Patient 1	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 2	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 3	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient 4	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient Corridor 1	200.6	602.3	601.4	600.0	595.6	594.3	591.6
Floor 4-6 Patient Corridor 2	200.6	602.3	601.5	600.1	595.7	594.3	590.9
Floor 4-6 Soil	60.0	255.1	255.1	255.1	255.1	255.1	255.1
Floor 4-6 Supply	441.6	1,325.7	1,323.9	1,320.8	1,311.0	1,308.1	1,300.6
Floor 7 Clean	30.0	35.3	35.0	35.0	34.7	34.6	34.4
Floor 7 Elevator	108.0	217.5	215.7	215.7	214.4	213.3	212.3
Floor 7 Nurse Station	180.5	212.1	210.3	210.3	209.0	207.9	207.0
Floor 7 Office	90.0	90.7	89.9	89.9	89.1	88.9	88.4
Floor 7 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 7 Patient 4	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 7 Patient Corridor 1	200.6	200.8	200.5	200.0	198.5	198.1	197.2
Floor 7 Patient Corridor 2	200.6	200.8	200.5	200.0	198.6	198.1	197.0
Floor 7 Soil	60.0	85.0	85.0	85.0	85.0	85.0	85.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 1A Ventilation Air (cfm)	Climate Zone 2A Ventilation Air (cfm)	Climate Zone 3A Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5A Ventilation Air (cfm)	Climate Zone 6A Ventilation Air (cfm)
Floor 7 Supply	441.6	441.9	441.3	440.3	437.0	436.0	433.5
MOB Floor 1 Core	826.5	831.8	825.1	824.9	817.1	816.1	813.8
MOB Floor 1 Perimeter 1	137.3	138.1	137.0	137.0	135.7	135.5	135.1
MOB Floor 1 Perimeter 2	99.0	99.6	98.8	98.8	97.9	97.7	97.5
MOB Floor 1 Perimeter 3	137.3	138.1	137.0	137.0	135.7	135.5	135.1
MOB Floor 2-4 Core	741.0	2,237.3	2,219.3	2,218.6	2,197.6	2,194.9	2,189.0
MOB Floor 2-4 Perimeter 1	130.5	394.0	390.8	390.7	387.0	386.6	385.5
MOB Floor 2-4 Perimeter 2	99.0	298.9	296.5	296.4	293.6	293.2	292.5
MOB Floor 2-4 Perimeter 3	130.5	394.0	390.8	390.7	387.0	386.6	385.5
MOB Floor 2-4 Perimeter 4	99.0	298.9	296.5	296.4	293.6	293.2	292.5
MOB Floor 5 Core	741.0	745.8	739.8	739.5	732.5	731.6	729.7
MOB Floor 5 Perimeter 1	130.5	131.3	130.3	130.2	129.0	128.9	128.5
MOB Floor 5 Perimeter 2	99.0	99.6	98.8	98.8	97.9	97.7	97.5
MOB Floor 5 Perimeter 3	130.5	131.3	130.3	130.2	129.0	128.9	128.5
MOB Floor 5 Perimeter 4	99.0	99.6	98.8	98.8	97.9	97.7	97.5

Table D-8 Low-Energy Model Ventilation Airflow Validation: Arid Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 1 Cafe	723.2	723.7	717.3	722.3	722.9	725.6	717.7
Floor 1 Clean	28.8	33.7	33.4	33.6	33.6	33.7	33.4
Floor 1 Conference	369.0	369.6	366.4	368.9	369.2	370.4	366.4
Floor 1 Dining	885.6	886.2	878.4	884.5	885.1	888.5	878.8
Floor 1 Elevator	108.0	216.5	214.7	215.9	216.2	216.9	214.5
Floor 1 Exam	158.4	158.7	157.4	158.4	158.5	159.1	157.3
Floor 1 Food Storage	1,406.3	1,406.3	1,394.0	1,403.9	1,406.2	1,404.9	1,395.5
Floor 1 Gas Storage	74.9	74.9	74.9	74.9	74.9	74.9	74.9
Floor 1 Imaging	91.2	106.8	105.9	106.4	106.5	106.8	105.7
Floor 1 Kitchen	1,406.3	1,407.0	1,394.0	1,403.9	1,406.2	1,411.3	1,395.5
Floor 1 Lab 1	120.0	140.5	139.3	140.0	140.1	140.6	139.1
Floor 1 Lab 2	294.0	343.9	341.0	342.9	343.3	344.5	340.8
Floor 1 Laundry	134.2	469.7	469.7	469.7	469.7	469.7	469.7
Floor 1 Lobby	225.0	451.5	447.7	449.9	450.3	451.8	446.9
Floor 1 Lounge	76.8	89.9	89.2	89.6	89.7	90.0	89.0
Floor 1 Mech 1	972.0	972.6	965.1	971.0	972.5	972.1	965.4
Floor 1 Mech 2	1,296.0	1,296.9	1,286.8	1,294.6	1,296.6	1,296.2	1,287.2
Floor 1 Office 1	442.8	443.6	440.1	442.8	443.0	444.6	439.8
Floor 1 Office 2	341.0	341.6	338.6	341.0	341.2	342.3	338.6
Floor 1 Office 3	1,187.7	1,189.8	1,179.3	1,187.5	1,188.4	1,192.1	1,179.4
Floor 1 Office 3 Perimeter 1	173.3	173.6	172.0	173.2	173.4	173.9	172.0
Floor 1 Office 3 Perimeter 2	109.8	110.0	109.0	109.8	109.9	110.2	109.0
Floor 1 Office 3 Perimeter 3	173.3	173.6	172.0	173.2	173.4	173.9	172.0
Floor 1 Patient	600.0	600.0	600.0	600.0	600.0	600.0	600.0
Floor 1 Pharmacy	1,080.0	1,203.0	1,193.0	1,198.7	1,199.8	1,203.8	1,190.9
Floor 1 Physical Therapy	295.2	295.8	293.4	295.2	295.3	296.4	293.2
Floor 1 Receiving	268.3	268.5	266.1	268.0	268.5	268.2	266.4

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 1 Reception	33.6	67.4	66.9	67.2	67.2	67.5	66.7
Floor 1 Soil	28.8	40.8	40.8	40.8	40.8	40.8	40.8
Floor 1 Storage	648.0	648.4	643.4	647.3	648.3	648.1	643.6
Floor 1 Waiting	91.2	183.0	181.5	182.3	182.5	183.1	181.2
Floor 2 Chapel	122.4	122.6	121.6	122.4	122.5	122.9	121.6
Floor 2 Clean 1	29.0	33.9	33.6	33.8	33.8	33.9	33.6
Floor 2 Clean 2	19.2	22.5	22.3	22.4	22.4	22.5	22.3
Floor 2 Corridor	312.0	312.2	309.8	311.7	312.1	312.0	309.9
Floor 2 Elevator	108.0	216.5	214.7	215.9	216.2	216.9	214.5
Floor 2 Exam 1	252.0	252.5	250.5	252.0	252.1	253.1	250.3
Floor 2 Exam 2	81.0	81.2	80.5	81.0	81.0	81.3	80.4
Floor 2 Exam 3	243.0	243.4	241.3	243.0	243.1	243.9	241.3
Floor 2 Exam 4	240.0	240.4	238.3	240.0	240.1	240.9	238.3
Floor 2 Gift Shop	108.0	108.2	107.2	108.0	108.1	108.4	107.2
Floor 2 Imaging 1	138.6	162.3	160.9	161.7	161.8	162.4	160.6
Floor 2 Imaging 2	204.0	238.8	236.8	238.0	238.2	239.0	236.4
Floor 2 Imaging 3	240.0	280.7	278.4	279.9	280.3	281.2	278.2
Floor 2 Lab 1	136.8	160.2	158.8	159.6	159.7	160.3	158.5
Floor 2 Lab 2	204.0	238.8	236.8	238.0	238.2	239.0	236.4
Floor 2 Lockers	375.0	375.0	375.0	375.0	375.0	375.0	375.0
Floor 2 Lounge 1	72.0	84.2	83.5	84.0	84.1	84.4	83.4
Floor 2 Lounge 2	52.5	61.4	60.9	61.2	61.3	61.5	60.8
Floor 2 Nurse Station 1	77.4	90.6	89.9	90.3	90.4	90.7	89.7
Floor 2 Nurse Station 2	240.0	280.7	278.4	279.9	280.3	281.2	278.2
Floor 2 Office 1	140.4	140.7	139.5	140.4	140.5	141.0	139.4
Floor 2 Office 2	115.2	115.4	114.4	115.2	115.3	115.6	114.4
Floor 2 Office 3	180.0	180.3	178.7	180.0	180.1	180.7	178.7
Floor 2 Office 4	210.0	210.4	208.5	210.0	210.1	210.8	208.5

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	13,210.6	13,124.4	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 2 Patient 2	935.3	935.3	935.3	935.3	935.3	935.3	935.3
Floor 2 Procedure 1	1,260.0	1,260.0	1,260.0	1,260.0	1,260.0	1,260.0	1,260.0
Floor 2 Procedure 2	680.0	680.0	680.0	680.0	680.0	680.0	680.0
Floor 2 Reception	105.0	210.5	208.8	209.9	210.2	210.9	208.6
Floor 2 Restroom 1	160.0	160.0	160.0	160.0	160.0	160.0	160.0
Floor 2 Restroom 2	225.0	225.0	225.0	225.0	225.0	225.0	225.0
Floor 2 Soil 1	29.0	41.1	41.1	41.1	41.1	41.1	41.1
Floor 2 Soil 2	19.2	27.2	27.2	27.2	27.2	27.2	27.2
Floor 2 Sterilizing	163.2	163.3	163.3	163.3	163.3	163.3	163.3
Floor 2 Storage 1	180.0	180.1	178.7	179.8	180.1	180.0	178.8
Floor 2 Storage 2	76.8	76.8	76.2	76.7	76.8	76.8	76.3
Floor 2 Trauma	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0
Floor 2 Triage	291.7	291.7	291.7	291.7	291.7	291.7	291.7
Floor 2 Waiting	234.0	469.5	465.6	467.9	468.3	469.8	464.8
Floor 3 Clean	30.0	35.1	34.8	35.0	35.0	35.2	34.8
Floor 3 Elevator	108.0	216.8	215.0	215.9	216.3	217.0	214.7
Floor 3 Exam	162.0	162.4	161.1	162.0	162.2	162.7	161.0
Floor 3 ICU	700.0	700.0	700.0	700.0	700.0	700.0	700.0
Floor 3 Nurse Station 1	180.5	211.4	209.6	210.5	210.9	211.6	209.3
Floor 3 Nurse Station 2	144.0	168.7	167.2	168.0	168.3	168.8	167.0
Floor 3 Nursery	330.0	330.0	330.0	330.0	330.0	330.0	330.0
Floor 3 Office	162.0	162.4	161.1	162.0	162.2	162.7	161.0
Floor 3 Operating	1,200.0	1,207.6	1,200.0	1,244.0	1,413.1	1,398.6	1,307.3
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 3 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient 4	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient Corridor 1	200.6	200.8	199.3	200.4	200.8	200.8	199.4
Floor 3 Patient Corridor 2	200.6	200.8	199.3	200.4	200.8	200.7	199.2
Floor 3 Procedure	360.0	360.0	360.0	360.0	360.0	360.0	360.0
Floor 3 Soil	60.0	85.0	85.0	85.0	85.0	85.0	85.0
Floor 3 Supply	441.6	441.9	438.7	441.1	441.9	441.8	438.5
Floor 3 Triage	500.0	500.0	500.0	500.0	500.0	500.0	500.0
Floor 3 Waiting	59.4	119.3	118.2	118.8	119.0	119.4	118.1
Floor 4-6 Clean	30.0	105.4	104.5	105.0	105.1	105.5	104.3
Floor 4-6 Elevator	108.0	650.5	645.0	647.8	648.9	651.1	644.1
Floor 4-6 Nurse Station	180.5	634.2	628.8	631.6	632.6	634.8	627.9
Floor 4-6 Office	90.0	270.5	268.5	269.9	270.2	271.0	268.1
Floor 4-6 Patient 1	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 2	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 3	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient 4	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient Corridor 1	200.6	602.3	597.9	601.3	602.3	602.3	598.2
Floor 4-6 Patient Corridor 2	200.6	602.3	597.9	601.3	602.3	602.2	597.7
Floor 4-6 Soil	60.0	255.1	255.1	255.1	255.1	255.1	255.1
Floor 4-6 Supply	441.6	1,325.7	1,316.0	1,323.4	1,325.6	1,325.4	1,315.5
Floor 7 Clean	30.0	35.1	34.8	35.0	35.0	35.2	34.8
Floor 7 Elevator	108.0	216.8	215.0	215.9	216.3	217.0	214.7
Floor 7 Nurse Station	180.5	211.4	209.6	210.5	210.9	211.6	209.3
Floor 7 Office	90.0	90.2	89.5	90.0	90.1	90.3	89.4
Floor 7 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7

Zone Name	Required Ventilation Air (cfm)	Climate Zone 2B Ventilation Air (cfm)	Climate Zone 3B:CA Ventilation Air (cfm)	Climate Zone 3B:Other Ventilation Air (cfm)	Climate Zone 4A Ventilation Air (cfm)	Climate Zone 5B Ventilation Air (cfm)	Climate Zone 6B Ventilation Air (cfm)
Floor 7 Patient 4	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 7 Patient Corridor 1	200.6	200.8	199.3	200.4	200.8	200.8	199.4
Floor 7 Patient Corridor 2	200.6	200.8	199.3	200.4	200.8	200.7	199.2
Floor 7 Soil	60.0	85.0	85.0	85.0	85.0	85.0	85.0
Floor 7 Supply	441.6	441.9	438.7	441.1	441.9	441.8	438.5
MOB Floor 1 Core	826.5	829.5	821.0	827.1	829.8	832.5	822.9
MOB Floor 1 Perimeter 1	137.3	137.8	136.3	137.3	137.8	138.2	136.7
MOB Floor 1 Perimeter 2	99.0	99.4	98.3	99.1	99.4	99.7	98.6
MOB Floor 1 Perimeter 3	137.3	137.8	136.3	137.3	137.8	138.2	136.7
MOB Floor 2-4 Core	741.0	2,231.1	2,208.2	2,224.5	2,231.8	2,239.1	2,213.3
MOB Floor 2-4 Perimeter 1	130.5	392.9	388.9	391.8	393.0	394.3	389.8
MOB Floor 2-4 Perimeter 2	99.0	298.1	295.0	297.2	298.2	299.2	295.7
MOB Floor 2-4 Perimeter 3	130.5	392.9	388.9	391.8	393.0	394.3	389.8
MOB Floor 2-4 Perimeter 4	99.0	298.1	295.0	297.2	298.2	299.2	295.7
MOB Floor 5 Core	741.0	743.7	736.1	741.5	743.9	746.4	737.8
MOB Floor 5 Perimeter 1	130.5	131.0	129.6	130.6	131.0	131.4	129.9
MOB Floor 5 Perimeter 2	99.0	99.4	98.3	99.1	99.4	99.7	98.6
MOB Floor 5 Perimeter 3	130.5	131.0	129.6	130.6	131.0	131.4	129.9
MOB Floor 5 Perimeter 4	99.0	99.4	98.3	99.1	99.4	99.7	98.6

Table D-9 Low-Energy Model Ventilation Airflow Validation: Marine and Cold Climates

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 1 Cafe	723.2	722.7	713.4	711.5	705.6
Floor 1 Clean	28.8	33.6	33.1	33.1	32.8
Floor 1 Conference	369.0	369.1	364.4	363.4	360.4
Floor 1 Dining	885.6	884.9	873.5	871.2	864.0
Floor 1 Elevator	108.0	216.1	212.6	212.7	210.9
Floor 1 Exam	158.4	158.5	156.5	156.1	154.6
Floor 1 Food Storage	1,406.3	1,404.7	1,376.3	1,381.6	1,366.0
Floor 1 Gas Storage	74.9	74.9	74.9	74.9	74.9
Floor 1 Imaging	91.2	106.5	104.9	104.9	103.8
Floor 1 Kitchen	1,406.3	1,405.6	1,376.3	1,381.6	1,372.5
Floor 1 Lab 1	120.0	140.1	138.0	138.0	136.6
Floor 1 Lab 2	294.0	343.2	337.7	337.8	334.9
Floor 1 Laundry	134.2	469.7	469.7	469.7	469.7
Floor 1 Lobby	225.0	450.4	443.4	443.5	439.1
Floor 1 Lounge	76.8	89.7	88.3	88.3	87.5
Floor 1 Mech 1	972.0	972.5	951.9	958.2	948.8
Floor 1 Mech 2	1,296.0	1,296.7	1,269.2	1,277.5	1,265.1
Floor 1 Office 1	442.8	443.2	437.4	436.5	432.2
Floor 1 Office 2	341.0	341.2	336.8	335.9	333.1
Floor 1 Office 3	1,187.7	1,188.1	1,172.8	1,169.7	1,160.0
Floor 1 Office 3 Perimeter 1	173.3	173.3	171.1	170.6	169.2
Floor 1 Office 3 Perimeter 2	109.8	109.8	108.4	108.1	107.2
Floor 1 Office 3 Perimeter 3	173.3	173.3	171.1	170.6	169.2
Floor 1 Patient	600.0	600.0	600.0	600.0	600.0
Floor 1 Pharmacy	1,080.0	1,200.0	1,181.5	1,181.6	1,170.1
Floor 1 Physical Therapy	295.2	295.5	291.6	291.0	288.2
Floor 1 Receiving	268.3	268.2	262.8	263.8	260.8
Floor 1 Reception	33.6	67.3	66.2	66.2	65.6

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 1 Soil	28.8	40.8	40.8	40.8	40.8
Floor 1 Storage	648.0	648.3	634.6	638.8	632.5
Floor 1 Waiting	91.2	182.5	179.7	179.7	178.0
Floor 2 Chapel	122.4	122.5	120.9	120.7	119.5
Floor 2 Clean 1	29.0	33.8	33.3	33.3	33.0
Floor 2 Clean 2	19.2	22.4	22.1	22.1	21.9
Floor 2 Corridor	312.0	312.2	305.6	307.6	304.6
Floor 2 Elevator	108.0	216.1	212.6	212.7	210.9
Floor 2 Exam 1	252.0	252.2	248.9	248.4	246.0
Floor 2 Exam 2	81.0	81.1	80.0	79.8	79.1
Floor 2 Exam 3	243.0	243.1	240.0	239.3	237.3
Floor 2 Exam 4	240.0	240.1	237.0	236.4	234.4
Floor 2 Gift Shop	108.0	108.0	106.6	106.4	105.5
Floor 2 Imaging 1	138.6	161.9	159.4	159.4	157.8
Floor 2 Imaging 2	204.0	238.2	234.5	234.6	232.3
Floor 2 Imaging 3	240.0	280.2	275.7	275.7	273.4
Floor 2 Lab 1	136.8	159.8	157.3	157.3	155.8
Floor 2 Lab 2	204.0	238.2	234.5	234.6	232.3
Floor 2 Lockers	375.0	375.0	375.0	375.0	375.0
Floor 2 Lounge 1	72.0	84.1	82.7	82.7	82.0
Floor 2 Lounge 2	52.5	61.3	60.3	60.3	59.8
Floor 2 Nurse Station 1	77.4	90.4	89.0	89.0	88.1
Floor 2 Nurse Station 2	240.0	280.2	275.7	275.7	273.4
Floor 2 Office 1	140.4	140.5	138.7	138.4	137.0
Floor 2 Office 2	115.2	115.2	113.8	113.5	112.5
Floor 2 Office 3	180.0	180.1	177.7	177.3	175.8
Floor 2 Office 4	210.0	210.1	207.4	206.8	205.1
Floor 2 Operating	12,850.7	12,850.7	12,850.7	12,850.7	12,850.7
Floor 2 PACU	1,350.0	1,350.0	1,350.0	1,350.0	1,350.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 2 Patient 1	1,136.0	1,136.0	1,136.0	1,136.0	1,136.0
Floor 2 Patient 2	935.3	935.3	935.3	935.3	935.3
Floor 2 Procedure 1	1,260.0	1,260.0	1,260.0	1,260.0	1,260.0
Floor 2 Procedure 2	680.0	680.0	680.0	680.0	680.0
Floor 2 Reception	105.0	210.1	206.7	206.8	205.0
Floor 2 Restroom 1	160.0	160.0	160.0	160.0	160.0
Floor 2 Restroom 2	225.0	225.0	225.0	225.0	225.0
Floor 2 Soil 1	29.0	41.1	41.1	41.1	41.1
Floor 2 Soil 2	19.2	27.2	27.2	27.2	27.2
Floor 2 Sterilizing	163.2	163.3	163.3	163.3	163.3
Floor 2 Storage 1	180.0	180.1	176.3	177.4	175.7
Floor 2 Storage 2	76.8	76.8	75.2	75.5	74.6
Floor 2 Trauma	2,240.0	2,240.0	2,240.0	2,240.0	2,240.0
Floor 2 Triage	291.7	291.7	291.7	291.7	291.7
Floor 2 Waiting	234.0	468.4	461.1	461.2	456.7
Floor 3 Clean	30.0	35.0	34.5	34.5	34.2
Floor 3 Elevator	108.0	216.2	212.9	212.7	211.1
Floor 3 Exam	162.0	162.2	160.2	159.6	158.3
Floor 3 ICU	700.0	700.0	700.0	700.0	700.0
Floor 3 Nurse Station 1	180.5	210.8	207.6	207.4	205.8
Floor 3 Nurse Station 2	144.0	168.2	165.6	165.5	164.2
Floor 3 Nursery	330.0	330.0	330.0	330.0	330.0
Floor 3 Office	162.0	162.2	160.2	159.6	158.3
Floor 3 Operating	1,200.0	1,200.0	1,200.0	1,200.0	1,200.0
Floor 3 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 3 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient 4	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 3 Patient Corridor 1	200.6	200.8	196.5	197.3	195.2

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 3 Patient Corridor 2	200.6	200.8	196.5	197.2	195.0
Floor 3 Procedure	360.0	360.0	360.0	360.0	360.0
Floor 3 Soil	60.0	85.0	85.0	85.0	85.0
Floor 3 Supply	441.6	441.9	432.5	434.1	429.2
Floor 3 Triage	500.0	500.0	500.0	500.0	500.0
Floor 3 Waiting	59.4	118.9	117.1	117.0	116.1
Floor 4-6 Clean	30.0	105.1	103.4	103.4	102.5
Floor 4-6 Elevator	108.0	648.6	638.8	638.2	633.2
Floor 4-6 Nurse Station	180.5	632.4	622.8	622.3	617.3
Floor 4-6 Office	90.0	270.3	266.6	265.8	263.6
Floor 4-6 Patient 1	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 2	1,666.7	5,000.0	5,000.0	5,000.0	5,000.0
Floor 4-6 Patient 3	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient 4	1,316.7	3,950.0	3,950.0	3,950.0	3,950.0
Floor 4-6 Patient Corridor 1	200.6	602.3	589.5	591.9	585.6
Floor 4-6 Patient Corridor 2	200.6	602.3	589.5	591.7	585.0
Floor 4-6 Soil	60.0	255.1	255.1	255.1	255.1
Floor 4-6 Supply	441.6	1,325.7	1,297.4	1,302.4	1,287.6
Floor 7 Clean	30.0	35.0	34.5	34.5	34.2
Floor 7 Elevator	108.0	216.2	212.9	212.7	211.1
Floor 7 Nurse Station	180.5	210.8	207.6	207.4	205.8
Floor 7 Office	90.0	90.1	88.9	88.6	87.9
Floor 7 Patient 1	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 2	1,666.7	1,666.7	1,666.7	1,666.7	1,666.7
Floor 7 Patient 3	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 7 Patient 4	1,316.7	1,316.7	1,316.7	1,316.7	1,316.7
Floor 7 Patient Corridor 1	200.6	200.8	196.5	197.3	195.2
Floor 7 Patient Corridor 2	200.6	200.8	196.5	197.2	195.0
Floor 7 Soil	60.0	85.0	85.0	85.0	85.0

Zone Name	Required Ventilation Air (cfm)	Climate Zone 3C Ventilation Air (cfm)	Climate Zone 4C Ventilation Air (cfm)	Climate Zone 7 Ventilation Air (cfm)	Climate Zone 8 Ventilation Air (cfm)
Floor 7 Supply	441.6	441.9	432.5	434.1	429.2
MOB Floor 1 Core	826.5	827.2	817.5	816.1	813.0
MOB Floor 1 Perimeter 1	137.3	137.4	135.8	135.5	135.0
MOB Floor 1 Perimeter 2	99.0	99.1	97.9	97.8	97.4
MOB Floor 1 Perimeter 3	137.3	137.4	135.8	135.5	135.0
MOB Floor 2-4 Core	741.0	2,224.8	2,198.9	2,195.2	2,186.8
MOB Floor 2-4 Perimeter 1	130.5	391.8	387.2	386.6	385.1
MOB Floor 2-4 Perimeter 2	99.0	297.2	293.8	293.3	292.2
MOB Floor 2-4 Perimeter 3	130.5	391.8	387.2	386.6	385.1
MOB Floor 2-4 Perimeter 4	99.0	297.2	293.8	293.3	292.2
MOB Floor 5 Core	741.0	741.6	733.0	731.7	728.9
MOB Floor 5 Perimeter 1	130.5	130.6	129.1	128.9	128.4
MOB Floor 5 Perimeter 2	99.0	99.1	97.9	97.8	97.4
MOB Floor 5 Perimeter 3	130.5	130.6	129.1	128.9	128.4
MOB Floor 5 Perimeter 4	99.0	99.1	97.9	97.8	97.4

Table D-10 Low-Energy Model Total Airflow Validation: Humid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 1 Cafe	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Clean	279.2	285.9	283.4	288.3	280.2	281.7	283.0
Floor 1 Conference	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Dining	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Elevator	N/A	264.5	34.3	0.0	6.6	0.0	0.0
Floor 1 Exam	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6
Floor 1 Food Storage	1,942.0	21,108.4	21,137.7	21,857.1	21,268.5	21,661.0	21,951.8
Floor 1 Gas Storage	757.1	757.1	757.1	757.1	757.1	757.1	757.1
Floor 1 Imaging	1,390.8	2,856.7	2,852.5	2,933.1	2,857.1	2,898.0	2,930.5
Floor 1 Kitchen	1,942.0	23,604.3	23,604.3	23,604.3	23,604.3	23,604.3	23,604.3
Floor 1 Lab 1	1,830.0	1,990.3	1,981.5	2,028.3	1,976.4	1,997.3	2,017.6
Floor 1 Lab 2	4,483.5	5,146.2	5,129.3	5,234.5	5,138.0	5,138.0	5,195.0
Floor 1 Laundry	3,257.1	7,625.7	7,638.2	7,849.5	7,629.4	7,731.2	7,770.6
Floor 1 Lobby	N/A	428.5	108.7	47.9	75.0	0.0	0.0
Floor 1 Lounge	N/A	72.9	14.4	7.5	9.2	7.3	11.7
Floor 1 Mech 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Mech 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Patient	600.0	929.0	928.7	934.1	958.1	947.4	947.8
Floor 1 Pharmacy	2,620.0	3,197.9	3,166.7	3,215.5	3,133.0	3,145.2	3,168.2
Floor 1 Physical Therapy	3,640.8	3,640.8	3,640.8	3,640.8	3,640.8	3,640.8	3,640.8
Floor 1 Receiving	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Reception	N/A	33.7	0.0	0.0	0.0	0.0	0.0

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 1 Soil	759.2	759.2	759.2	759.2	759.2	759.2	759.2
Floor 1 Storage	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Waiting	N/A	220.6	148.5	152.6	145.4	150.8	157.4
Floor 2 Chapel	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Clean 1	280.9	325.3	327.4	335.3	332.2	336.5	336.4
Floor 2 Clean 2	186.1	201.5	201.9	208.7	202.3	206.1	207.4
Floor 2 Corridor	1,421.3	1,421.3	1,421.3	1,421.3	1,421.3	1,421.3	1,421.3
Floor 2 Elevator	N/A	280.3	173.8	73.9	168.2	70.8	56.2
Floor 2 Exam 1	3,843.0	3,843.0	3,843.0	3,843.0	3,939.8	3,910.4	3,896.5
Floor 2 Exam 2	1,235.3	1,235.2	1,235.2	1,235.2	1,235.2	1,235.2	1,235.2
Floor 2 Exam 3	3,705.8	3,705.8	3,705.8	3,705.8	3,705.8	3,705.8	3,705.8
Floor 2 Exam 4	3,660.0	3,660.0	3,660.0	3,660.0	3,660.0	3,660.0	3,660.0
Floor 2 Gift Shop	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Imaging 1	2,113.7	4,752.5	4,769.6	4,914.7	4,796.3	4,876.9	4,896.8
Floor 2 Imaging 2	3,111.0	7,437.0	7,551.0	7,741.3	7,590.1	7,620.2	7,646.9
Floor 2 Imaging 3	3,660.0	9,322.7	9,344.2	9,420.8	9,270.3	9,375.7	9,245.3
Floor 2 Lab 1	2,086.2	2,550.7	2,563.2	2,634.1	2,587.3	2,626.0	2,631.4
Floor 2 Lab 2	3,111.0	3,698.2	3,707.0	3,820.8	3,710.6	3,772.0	3,792.3
Floor 2 Lockers	875.0	875.0	875.0	875.0	875.0	875.0	875.0
Floor 2 Lounge 1	N/A	106.7	104.9	122.8	110.0	119.8	126.5
Floor 2 Lounge 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Nurse Station 1	N/A	180.3	124.1	123.1	119.0	93.5	72.2
Floor 2 Nurse Station 2	N/A	661.4	501.4	485.9	507.7	442.4	360.4
Floor 2 Office 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Office 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Office 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Office 4	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	2,700.0	2,875.7	2,886.7	2,967.8	2,914.6	2,924.6	2,937.9

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 2 Patient 1	1,136.0	2,497.4	2,504.9	2,425.2	2,470.9	2,444.0	2,357.1
Floor 2 Patient 2	935.3	1,275.8	1,286.9	1,311.9	1,314.6	1,327.7	1,323.5
Floor 2 Procedure 1	5,040.0	5,040.0	5,040.0	5,040.0	5,040.0	5,040.0	5,040.0
Floor 2 Procedure 2	2,720.0	2,720.0	2,720.0	2,720.0	2,720.0	2,720.0	2,720.0
Floor 2 Reception	N/A	247.8	57.5	0.0	22.6	0.0	0.0
Floor 2 Restroom 1	906.7	906.7	906.7	906.7	906.7	906.7	906.7
Floor 2 Restroom 2	1,275.0	1,275.0	1,275.0	1,275.0	1,275.0	1,275.0	1,275.0
Floor 2 Soil 1	763.9	763.9	763.9	763.9	763.9	763.9	763.9
Floor 2 Soil 2	506.1	506.1	506.1	506.1	506.1	506.1	506.1
Floor 2 Sterilizing	2,103.5	3,938.2	3,951.4	4,075.2	3,968.9	4,036.6	4,052.1
Floor 2 Storage 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Storage 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Trauma	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0
Floor 2 Triage	1,458.3	1,458.3	1,458.3	1,458.3	1,458.3	1,458.3	1,458.3
Floor 2 Waiting	N/A	291.9	0.0	0.0	0.0	0.0	0.0
Floor 3 Clean	290.8	314.5	315.1	325.8	315.7	321.7	323.7
Floor 3 Elevator	N/A	123.4	0.0	0.0	0.0	0.0	0.0
Floor 3 Exam	2,470.5	2,470.5	2,470.5	2,470.5	2,470.5	2,470.5	2,470.5
Floor 3 ICU	1,400.0	2,238.3	2,276.0	2,320.9	2,491.3	2,460.6	2,483.0
Floor 3 Nurse Station 1	N/A	481.6	435.0	467.1	449.0	459.4	468.8
Floor 3 Nurse Station 2	N/A	85.1	0.0	0.0	0.0	0.0	0.0
Floor 3 Nursery	660.0	765.5	781.7	798.0	888.2	875.0	883.7
Floor 3 Office	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 3 Operating	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0
Floor 3 Patient 1	1,666.7	2,925.3	3,053.7	3,084.5	3,054.0	2,986.0	2,984.7
Floor 3 Patient 2	1,666.7	3,423.8	3,437.6	3,345.3	3,347.2	3,325.5	3,224.0
Floor 3 Patient 3	1,316.7	2,358.1	2,374.7	2,371.4	2,400.4	2,400.6	2,357.4
Floor 3 Patient 4	1,316.7	2,485.9	2,587.9	2,614.6	2,633.5	2,581.5	2,579.0
Floor 3 Patient Corridor 1	914.0	914.0	914.0	914.0	914.0	914.0	914.0

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 3 Patient Corridor 2	914.0	914.0	914.0	914.0	914.0	914.0	914.0
Floor 3 Procedure	1,440.0	1,440.0	1,440.0	1,440.0	1,461.9	1,479.1	1,483.4
Floor 3 Soil	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7
Floor 3 Supply	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7
Floor 3 Triage	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0
Floor 3 Waiting	N/A	79.8	0.0	0.0	0.0	0.0	0.0
Floor 4-6 Clean	290.8	943.4	945.4	977.4	947.2	965.0	971.1
Floor 4-6 Elevator	N/A	363.3	0.0	0.0	0.0	0.0	0.0
Floor 4-6 Nurse Station	N/A	1,438.6	1,300.6	1,397.3	1,344.0	1,376.7	1,399.8
Floor 4-6 Office	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 4-6 Patient 1	1,666.7	8,780.0	9,165.1	9,252.9	9,152.8	8,957.1	8,955.2
Floor 4-6 Patient 2	1,666.7	10,273.4	10,317.5	10,044.6	10,043.7	9,979.8	9,677.3
Floor 4-6 Patient 3	1,316.7	8,795.1	8,839.5	8,638.9	8,797.6	8,720.2	8,480.8
Floor 4-6 Patient 4	1,316.7	7,482.7	7,788.6	7,867.2	7,927.1	7,778.6	7,774.0
Floor 4-6 Patient Corridor 1	914.0	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1
Floor 4-6 Patient Corridor 2	914.0	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1
Floor 4-6 Soil	1,581.7	4,745.0	4,745.0	4,745.0	4,745.0	4,745.0	4,745.0
Floor 4-6 Supply	2,011.7	6,035.2	6,035.2	6,035.2	6,035.2	6,035.2	6,035.2
Floor 7 Clean	290.8	335.4	338.0	346.1	341.3	345.3	345.1
Floor 7 Elevator	N/A	39.6	0.0	0.0	0.0	0.0	0.0
Floor 7 Nurse Station	N/A	376.5	233.2	203.7	215.1	144.0	76.3
Floor 7 Office	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 7 Patient 1	1,666.7	3,153.4	3,296.6	3,308.2	3,334.1	3,242.3	3,226.4
Floor 7 Patient 2	1,666.7	3,725.1	3,753.9	3,634.7	3,685.5	3,637.4	3,509.9
Floor 7 Patient 3	1,316.7	3,206.5	3,233.3	3,147.1	3,249.5	3,201.9	3,099.2
Floor 7 Patient 4	1,316.7	2,715.8	2,834.3	2,844.7	2,916.4	2,845.8	2,829.9
Floor 7 Patient Corridor 1	914.0	914.0	914.0	914.0	914.0	914.0	914.0
Floor 7 Patient Corridor 2	914.0	914.0	914.0	914.0	914.0	914.0	914.0
Floor 7 Soil	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7

Zone Name	Required Total Air (cfm)	Climate Zone 1A Total Air (cfm)	Climate Zone 2A Total Air (cfm)	Climate Zone 3A Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5A Total Air (cfm)	Climate Zone 6A Total Air (cfm)
Floor 7 Supply	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7
MOB Floor 1 Core	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Core	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 4	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Core	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 4	N/A	0.0	0.0	0.0	0.0	0.0	0.0

Table D-11 Low-Energy Model Total Airflow Validation: Arid Climates

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 1 Cafe	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Clean	279.2	279.2	279.4	279.2	321.8	323.6	303.3
Floor 1 Conference	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Dining	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Elevator	N/A	15.1	92.6	0.0	75.1	0.0	0.0
Floor 1 Exam	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6
Floor 1 Food Storage	1,942.0	21,755.0	21,114.1	22,586.3	25,835.5	26,054.4	24,550.4
Floor 1 Gas Storage	757.1	757.1	757.1	757.1	757.1	757.1	757.1
Floor 1 Imaging	1,390.8	2,847.9	2,839.2	2,936.9	3,398.9	3,424.8	3,229.6
Floor 1 Kitchen	1,942.0	23,604.3	23,604.3	24,226.5	27,530.2	27,761.8	26,216.3
Floor 1 Lab 1	1,830.0	1,914.2	1,964.3	1,962.5	2,318.0	2,333.6	2,198.9
Floor 1 Lab 2	4,483.5	5,033.3	4,958.4	5,104.1	6,044.8	5,996.0	5,638.9
Floor 1 Laundry	3,257.1	7,742.1	7,564.5	7,986.7	9,103.7	9,144.8	8,572.6
Floor 1 Lobby	N/A	105.9	208.0	69.8	277.0	111.6	46.8
Floor 1 Lounge	N/A	0.0	12.5	0.0	17.5	18.7	26.2
Floor 1 Mech 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Mech 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Patient	600.0	863.1	893.0	873.3	1,090.5	1,071.7	1,000.4
Floor 1 Pharmacy	2,620.0	2,877.5	3,116.7	2,917.0	3,579.4	3,597.7	3,381.6
Floor 1 Physical Therapy	3,640.8	3,640.8	3,640.8	3,640.8	3,640.8	3,640.8	3,640.8
Floor 1 Receiving	N/A	0.0	0.0	0.0	0.0	0.0	0.0

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 1 Reception	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Soil	759.2	759.2	759.2	759.2	759.2	759.2	759.2
Floor 1 Storage	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 1 Waiting	N/A	135.5	176.5	136.4	243.7	250.3	242.7
Floor 2 Chapel	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Clean 1	280.9	349.3	317.0	359.9	397.4	394.7	368.1
Floor 2 Clean 2	186.1	209.5	201.9	217.4	244.7	246.8	231.5
Floor 2 Corridor	1,421.3	1,421.3	1,421.3	1,421.3	1,421.3	1,421.3	1,421.3
Floor 2 Elevator	N/A	199.7	277.4	244.8	351.4	223.5	172.6
Floor 2 Exam 1	3,843.0	4,155.9	3,843.0	4,259.9	4,721.2	4,561.2	4,241.8
Floor 2 Exam 2	1,235.3	1,235.2	1,235.2	1,241.3	1,409.1	1,400.0	1,316.6
Floor 2 Exam 3	3,705.8	3,705.8	3,705.8	3,705.8	3,705.8	3,705.8	3,705.8
Floor 2 Exam 4	3,660.0	3,660.0	3,660.0	3,660.0	3,777.5	3,778.7	3,660.0
Floor 2 Gift Shop	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Imaging 1	2,113.7	4,994.6	4,719.6	5,172.3	5,781.4	5,801.4	5,430.0
Floor 2 Imaging 2	3,111.0	8,161.2	7,286.8	8,394.1	9,138.6	9,028.3	8,458.7
Floor 2 Imaging 3	3,660.0	9,927.7	8,611.0	10,315.4	11,297.4	11,114.5	10,105.2
Floor 2 Lab 1	2,086.2	2,704.4	2,511.3	2,794.3	3,110.3	3,107.0	2,902.4
Floor 2 Lab 2	3,111.0	3,869.6	3,667.9	4,005.8	4,485.7	4,499.8	4,214.9
Floor 2 Lockers	875.0	875.0	875.0	875.0	875.0	875.0	875.0
Floor 2 Lounge 1	N/A	135.9	157.2	142.5	195.9	196.6	205.4
Floor 2 Lounge 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Nurse Station 1	N/A	160.2	181.3	175.7	236.1	182.1	146.3
Floor 2 Nurse Station 2	N/A	663.9	748.1	691.2	917.2	753.9	669.8
Floor 2 Office 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Office 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Office 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Office 4	N/A	0.0	0.0	0.0	0.0	0.0	0.0

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	66,053.1	65,622.1	64,253.3
Floor 2 PACU	2,700.0	3,046.6	2,777.6	3,116.9	3,534.3	3,492.4	3,256.4
Floor 2 Patient 1	1,136.0	2,821.2	1,945.9	2,926.3	3,009.6	2,806.6	2,491.7
Floor 2 Patient 2	935.3	1,391.4	1,225.7	1,428.4	1,565.4	1,543.2	1,435.6
Floor 2 Procedure 1	5,040.0	5,040.0	5,040.0	5,040.0	5,131.3	5,140.3	5,040.0
Floor 2 Procedure 2	2,720.0	2,720.0	2,720.0	2,720.0	2,720.0	2,739.4	2,720.0
Floor 2 Reception	N/A	108.0	190.4	118.2	216.2	0.0	0.0
Floor 2 Restroom 1	906.7	906.7	906.7	906.7	906.7	906.7	906.7
Floor 2 Restroom 2	1,275.0	1,275.0	1,275.0	1,275.0	1,275.0	1,275.0	1,275.0
Floor 2 Soil 1	763.9	763.9	763.9	763.9	763.9	763.9	763.9
Floor 2 Soil 2	506.1	506.1	506.1	506.1	506.1	506.1	506.1
Floor 2 Sterilizing	2,103.5	4,127.5	3,920.7	4,276.7	4,789.8	4,813.1	4,501.2
Floor 2 Storage 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Storage 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 2 Trauma	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0
Floor 2 Triage	1,458.3	1,458.3	1,458.3	1,458.3	1,458.3	1,458.3	1,458.3
Floor 2 Waiting	N/A	12.3	150.7	0.0	93.8	0.0	0.0
Floor 3 Clean	290.8	326.9	315.2	339.3	381.9	385.2	361.3
Floor 3 Elevator	N/A	0.0	41.8	0.0	4.3	0.0	0.0
Floor 3 Exam	2,470.5	2,470.5	2,470.5	2,470.5	2,755.9	2,732.4	2,565.5
Floor 3 ICU	1,400.0	2,561.1	2,079.5	2,568.0	2,962.1	2,852.5	2,696.3
Floor 3 Nurse Station 1	N/A	492.4	540.8	544.3	712.7	696.1	661.8
Floor 3 Nurse Station 2	N/A	0.0	11.8	0.0	0.0	0.0	0.0
Floor 3 Nursery	660.0	886.3	716.7	888.9	1,052.1	1,010.9	958.5
Floor 3 Office	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 3 Operating	6,000.0	6,038.1	6,000.0	6,220.0	7,065.6	6,993.1	6,536.5
Floor 3 Patient 1	1,666.7	3,542.2	2,753.0	3,596.9	3,662.9	3,481.4	3,255.3
Floor 3 Patient 2	1,666.7	3,827.8	2,757.3	3,974.8	4,108.1	3,870.4	3,425.5

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 3 Patient 3	1,316.7	2,579.0	2,114.4	2,673.0	2,927.2	2,830.0	2,552.8
Floor 3 Patient 4	1,316.7	2,989.2	2,352.0	3,045.2	3,160.4	3,009.5	2,809.0
Floor 3 Patient Corridor 1	914.0	914.0	914.0	914.0	914.0	914.0	914.0
Floor 3 Patient Corridor 2	914.0	914.0	914.0	914.0	914.0	914.0	914.0
Floor 3 Procedure	1,440.0	1,465.0	1,440.0	1,515.4	1,750.7	1,738.8	1,629.4
Floor 3 Soil	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7
Floor 3 Supply	2,011.7	2,011.7	2,011.7	2,011.7	2,020.1	2,019.0	2,011.7
Floor 3 Triage	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0
Floor 3 Waiting	N/A	32.1	54.7	3.1	47.1	0.0	0.0
Floor 4-6 Clean	290.8	980.8	945.6	1,018.0	1,145.7	1,155.6	1,084.0
Floor 4-6 Elevator	N/A	0.0	116.3	0.0	13.7	0.0	0.0
Floor 4-6 Nurse Station	N/A	1,472.8	1,615.9	1,629.9	2,141.0	2,082.2	1,974.3
Floor 4-6 Office	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 4-6 Patient 1	1,666.7	10,641.4	8,248.5	10,806.4	10,985.8	10,443.2	9,765.8
Floor 4-6 Patient 2	1,666.7	11,506.2	8,275.2	11,943.1	12,331.7	11,620.8	10,284.6
Floor 4-6 Patient 3	1,316.7	9,834.2	7,166.9	10,205.1	10,795.3	10,182.6	9,029.8
Floor 4-6 Patient 4	1,316.7	9,001.5	7,067.9	9,171.9	9,519.7	9,071.2	8,468.5
Floor 4-6 Patient Corridor 1	914.0	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1
Floor 4-6 Patient Corridor 2	914.0	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1	2,742.1
Floor 4-6 Soil	1,581.7	4,745.0	4,745.0	4,745.0	4,745.0	4,745.0	4,745.0
Floor 4-6 Supply	2,011.7	6,035.2	6,035.2	6,035.2	6,059.3	6,057.0	6,035.2
Floor 7 Clean	290.8	361.2	327.2	371.7	409.0	405.5	378.4
Floor 7 Elevator	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 7 Nurse Station	N/A	321.9	372.9	333.3	482.1	297.5	231.5
Floor 7 Office	N/A	0.0	0.0	0.0	0.0	0.0	0.0
Floor 7 Patient 1	1,666.7	3,903.6	2,874.4	3,932.4	3,975.3	3,721.7	3,466.4
Floor 7 Patient 2	1,666.7	4,263.0	2,916.8	4,398.6	4,499.9	4,185.3	3,699.2
Floor 7 Patient 3	1,316.7	3,658.2	2,550.3	3,773.0	3,967.6	3,699.0	3,272.8

Zone Name	Required Total Air (cfm)	Climate Zone 2B Total Air (cfm)	Climate Zone 3B:CA Total Air (cfm)	Climate Zone 3B:Other Total Air (cfm)	Climate Zone 4A Total Air (cfm)	Climate Zone 5B Total Air (cfm)	Climate Zone 6B Total Air (cfm)
Floor 7 Patient 4	1,316.7	3,331.4	2,499.9	3,369.4	3,482.6	3,274.8	3,045.1
Floor 7 Patient Corridor 1	914.0	914.0	914.0	914.0	922.3	914.0	914.0
Floor 7 Patient Corridor 2	914.0	914.0	914.0	914.0	922.3	914.0	914.0
Floor 7 Soil	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7
Floor 7 Supply	2,011.7	2,011.7	2,011.7	2,011.7	2,209.6	2,161.6	2,029.7
MOB Floor 1 Core	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Core	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 4	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Core	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 1	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 2	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 3	N/A	0.0	0.0	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 4	N/A	0.0	0.0	0.0	0.0	0.0	0.0

Table D-12 Low-Energy Model Total Airflow Validation: Marine and Cold Climates

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 1 Cafe	N/A	0.0	0.0	0.0	0.0
Floor 1 Clean	279.2	279.2	279.2	279.2	279.2
Floor 1 Conference	N/A	0.0	0.0	0.0	0.0
Floor 1 Dining	N/A	0.0	0.0	0.0	0.0
Floor 1 Elevator	N/A	50.9	50.9	0.0	0.0
Floor 1 Exam	2,415.6	2,415.6	2,415.6	2,415.6	2,415.6
Floor 1 Food Storage	1,942.0	20,795.8	21,335.6	22,343.8	21,407.5
Floor 1 Gas Storage	757.1	757.1	757.1	757.1	757.1
Floor 1 Imaging	1,390.8	2,701.2	2,810.4	2,937.6	2,773.5
Floor 1 Kitchen	1,942.0	23,604.3	23,604.3	23,975.1	23,604.3
Floor 1 Lab 1	1,830.0	1,830.0	1,901.6	1,989.3	1,841.8
Floor 1 Lab 2	4,483.5	4,483.5	4,780.4	5,080.5	4,735.3
Floor 1 Laundry	3,257.1	7,248.1	7,510.1	7,793.8	7,417.4
Floor 1 Lobby	N/A	132.1	143.5	0.0	0.0
Floor 1 Lounge	N/A	6.4	13.7	11.9	0.0
Floor 1 Mech 1	N/A	0.0	0.0	0.0	0.0
Floor 1 Mech 2	N/A	0.0	0.0	0.0	0.0
Floor 1 Office 1	N/A	0.0	0.0	0.0	0.0
Floor 1 Office 2	N/A	0.0	0.0	0.0	0.0
Floor 1 Office 3	N/A	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 1	N/A	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 2	N/A	0.0	0.0	0.0	0.0
Floor 1 Office 3 Perimeter 3	N/A	0.0	0.0	0.0	0.0
Floor 1 Patient	600.0	729.1	863.6	889.6	811.3
Floor 1 Pharmacy	2,620.0	2,636.7	2,892.9	3,028.0	2,697.6
Floor 1 Physical Therapy	3,640.8	3,640.8	3,640.8	3,640.8	3,640.8
Floor 1 Receiving	N/A	0.0	0.0	0.0	0.0
Floor 1 Reception	N/A	0.0	0.0	0.0	0.0

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 1 Soil	759.2	759.2	759.2	759.2	759.2
Floor 1 Storage	N/A	0.0	0.0	0.0	0.0
Floor 1 Waiting	N/A	171.4	178.8	182.2	167.0
Floor 2 Chapel	N/A	0.0	0.0	0.0	0.0
Floor 2 Clean 1	280.9	307.6	322.9	334.3	319.4
Floor 2 Clean 2	186.1	201.3	204.2	211.9	204.4
Floor 2 Corridor	1,421.3	1,421.3	1,421.3	1,421.3	1,421.3
Floor 2 Elevator	N/A	251.1	237.0	48.1	27.6
Floor 2 Exam 1	3,843.0	3,843.0	3,843.0	3,843.0	3,843.0
Floor 2 Exam 2	1,235.3	1,235.2	1,235.2	1,235.2	1,235.2
Floor 2 Exam 3	3,705.8	3,705.8	3,705.8	3,705.8	3,705.8
Floor 2 Exam 4	3,660.0	3,660.0	3,660.0	3,660.0	3,660.0
Floor 2 Gift Shop	N/A	0.0	0.0	0.0	0.0
Floor 2 Imaging 1	2,113.7	4,664.5	4,781.0	4,960.1	4,767.4
Floor 2 Imaging 2	3,111.0	7,703.1	7,930.0	7,666.4	8,120.8
Floor 2 Imaging 3	3,660.0	8,343.1	8,721.9	9,274.3	8,841.9
Floor 2 Lab 1	2,086.2	2,459.4	2,546.4	2,644.5	2,531.7
Floor 2 Lab 2	3,111.0	3,637.3	3,707.2	3,854.3	3,709.4
Floor 2 Lockers	875.0	875.0	875.0	875.0	875.0
Floor 2 Lounge 1	N/A	156.6	157.7	147.0	175.9
Floor 2 Lounge 2	N/A	0.0	0.0	0.0	0.0
Floor 2 Nurse Station 1	N/A	164.6	159.3	96.6	39.9
Floor 2 Nurse Station 2	N/A	698.4	685.6	462.9	339.5
Floor 2 Office 1	N/A	0.0	0.0	0.0	0.0
Floor 2 Office 2	N/A	0.0	0.0	0.0	0.0
Floor 2 Office 3	N/A	0.0	0.0	0.0	0.0
Floor 2 Office 4	N/A	0.0	0.0	0.0	0.0
Floor 2 Operating	64,253.3	64,253.3	64,253.3	64,253.3	64,253.3
Floor 2 PACU	2,700.0	2,700.0	2,780.5	2,962.2	2,870.6

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 2 Patient 1	1,136.0	1,703.7	1,949.1	2,226.6	2,116.2
Floor 2 Patient 2	935.3	1,173.9	1,255.4	1,298.3	1,234.2
Floor 2 Procedure 1	5,040.0	5,040.0	5,040.0	5,040.0	5,040.0
Floor 2 Procedure 2	2,720.0	2,720.0	2,720.0	2,720.0	2,720.0
Floor 2 Reception	N/A	134.9	105.6	0.0	0.0
Floor 2 Restroom 1	906.7	906.7	906.7	906.7	906.7
Floor 2 Restroom 2	1,275.0	1,275.0	1,275.0	1,275.0	1,275.0
Floor 2 Soil 1	763.9	763.9	763.9	763.9	763.9
Floor 2 Soil 2	506.1	506.1	506.1	506.1	506.1
Floor 2 Sterilizing	2,103.5	3,867.8	3,954.8	4,114.5	3,950.8
Floor 2 Storage 1	N/A	0.0	0.0	0.0	0.0
Floor 2 Storage 2	N/A	0.0	0.0	0.0	0.0
Floor 2 Trauma	8,960.0	8,960.0	8,960.0	8,960.0	8,960.0
Floor 2 Triage	1,458.3	1,458.3	1,458.3	1,458.3	1,458.3
Floor 2 Waiting	N/A	1.4	0.0	0.0	0.0
Floor 3 Clean	290.8	314.1	318.6	330.7	319.1
Floor 3 Elevator	N/A	0.0	0.0	0.0	0.0
Floor 3 Exam	2,470.5	2,470.5	2,470.5	2,470.5	2,470.5
Floor 3 ICU	1,400.0	1,937.6	2,313.4	2,444.3	2,561.5
Floor 3 Nurse Station 1	N/A	564.7	550.1	503.9	618.5
Floor 3 Nurse Station 2	N/A	0.0	0.0	0.0	0.0
Floor 3 Nursery	660.0	661.9	825.8	869.5	930.7
Floor 3 Office	N/A	0.0	0.0	0.0	0.0
Floor 3 Operating	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0
Floor 3 Patient 1	1,666.7	3,172.9	3,349.9	2,886.8	3,951.5
Floor 3 Patient 2	1,666.7	2,529.3	2,798.9	3,122.4	3,006.2
Floor 3 Patient 3	1,316.7	2,006.0	2,184.9	2,336.8	2,228.5
Floor 3 Patient 4	1,316.7	2,667.8	2,767.8	2,504.0	3,191.5
Floor 3 Patient Corridor 1	914.0	914.0	914.0	914.0	914.0

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 3 Patient Corridor 2	914.0	914.0	914.0	914.0	914.0
Floor 3 Procedure	1,440.0	1,440.0	1,440.0	1,495.7	1,502.0
Floor 3 Soil	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7
Floor 3 Supply	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7
Floor 3 Triage	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0
Floor 3 Waiting	N/A	18.4	21.2	0.0	0.0
Floor 4-6 Clean	290.8	942.4	955.9	992.1	957.2
Floor 4-6 Elevator	N/A	0.0	0.0	0.0	0.0
Floor 4-6 Nurse Station	N/A	1,690.5	1,606.3	1,509.3	1,853.6
Floor 4-6 Office	N/A	0.0	0.0	0.0	0.0
Floor 4-6 Patient 1	1,666.7	9,556.4	10,060.1	8,657.4	11,851.6
Floor 4-6 Patient 2	1,666.7	7,595.1	8,399.4	9,369.2	9,018.2
Floor 4-6 Patient 3	1,316.7	6,513.5	7,319.6	8,239.2	8,036.5
Floor 4-6 Patient 4	1,316.7	8,032.6	8,337.8	7,546.7	9,626.6
Floor 4-6 Patient Corridor 1	914.0	2,742.1	2,742.1	2,742.1	2,742.1
Floor 4-6 Patient Corridor 2	914.0	2,742.1	2,742.1	2,742.1	2,742.1
Floor 4-6 Soil	1,581.7	4,745.0	4,745.0	4,745.0	4,745.0
Floor 4-6 Supply	2,011.7	6,035.2	6,035.2	6,035.2	6,035.2
Floor 7 Clean	290.8	317.8	332.5	343.6	329.2
Floor 7 Elevator	N/A	0.0	0.0	0.0	0.0
Floor 7 Nurse Station	N/A	329.0	321.4	114.3	0.0
Floor 7 Office	N/A	0.0	0.0	0.0	0.0
Floor 7 Patient 1	1,666.7	3,301.4	3,596.9	3,074.2	4,271.1
Floor 7 Patient 2	1,666.7	2,597.6	2,978.8	3,315.8	3,142.9
Floor 7 Patient 3	1,316.7	2,260.4	2,624.0	2,946.3	2,837.1
Floor 7 Patient 4	1,316.7	2,795.7	2,987.4	2,696.6	3,460.9
Floor 7 Patient Corridor 1	914.0	914.0	914.0	914.0	914.0
Floor 7 Patient Corridor 2	914.0	914.0	914.0	914.0	914.0
Floor 7 Soil	1,581.7	1,581.7	1,581.7	1,581.7	1,581.7

Zone Name	Required Total Air (cfm)	Climate Zone 3C Total Air (cfm)	Climate Zone 4C Total Air (cfm)	Climate Zone 7 Total Air (cfm)	Climate Zone 8 Total Air (cfm)
Floor 7 Supply	2,011.7	2,011.7	2,011.7	2,011.7	2,011.7
MOB Floor 1 Core	N/A	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 1	N/A	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 2	N/A	0.0	0.0	0.0	0.0
MOB Floor 1 Perimeter 3	N/A	0.0	0.0	0.0	0.0
MOB Floor 2-4 Core	N/A	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 1	N/A	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 2	N/A	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 3	N/A	0.0	0.0	0.0	0.0
MOB Floor 2-4 Perimeter 4	N/A	0.0	0.0	0.0	0.0
MOB Floor 5 Core	N/A	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 1	N/A	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 2	N/A	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 3	N/A	0.0	0.0	0.0	0.0
MOB Floor 5 Perimeter 4	N/A	0.0	0.0	0.0	0.0

Appendix E. Schedules

This section contains the schedules used in the energy models.

E.1 24/7 Schedules

The 24/7 occupancy, lighting, and equipment schedules are presented in Table E-1 and Figure E-1. The 24/7 set point schedules are presented in Table E-2. No figure is included for Table E-2 because of its simplicity.

Table E-1 24/7 Occupancy, Lighting, and Equipment Schedules

Hour	Occupancy All Days	Lighting All Days	Equipment All Days
1	0.4	0.8	0.5
2	0.4	0.8	0.5
3	0.4	0.8	0.5
4	0.4	0.8	0.5
5	0.65	0.8	0.8
6	0.65	0.8	0.8
7	0.9	0.9	1.0
8	0.9	0.9	1.0
9	0.9	0.9	1.0
10	0.9	0.9	1.0
11	0.9	0.9	1.0
12	0.9	0.9	1.0
13	0.9	0.9	1.0
14	0.9	0.9	1.0
15	0.9	0.9	1.0
16	0.9	0.9	1.0
17	0.9	0.9	1.0
18	0.9	0.9	1.0
19	0.65	0.9	0.8
20	0.65	0.9	0.8
21	0.65	0.9	0.5
22	0.65	0.9	0.5
23	0.4	0.8	0.5
24	0.4	0.8	0.5
Total Hours/Day	17.1	20.8	19.2

Table E-2 24/7 Set Point Schedules

Hour	Heating Set Point (°C)	Heating Set Point (°F)	Cooling Set Point (°C)	Cooling Set Point (°F)
1–24	21.1	70.0	22.2	72.0

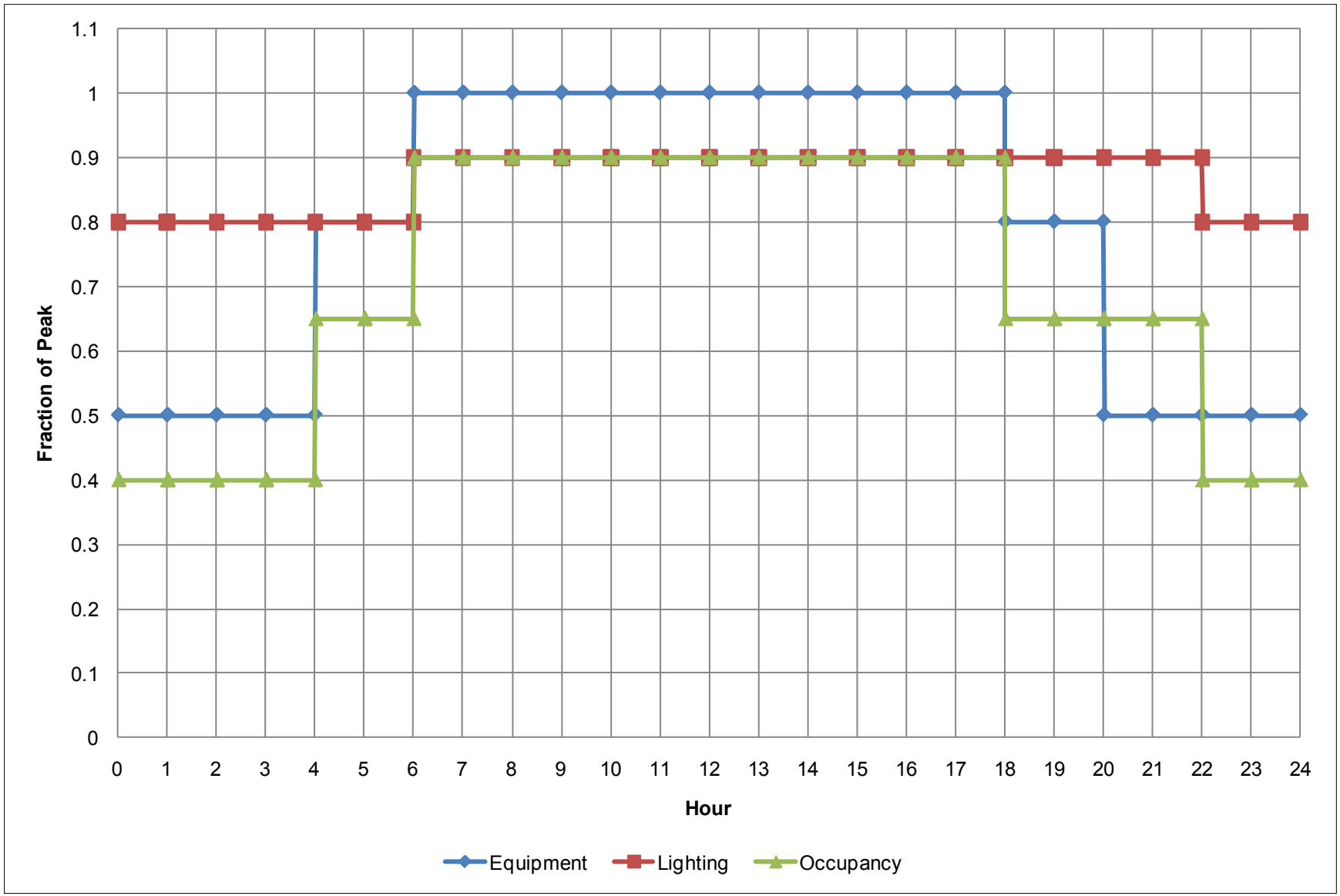

Figure E-1 24/7 occupancy, equipment, and lighting schedules
(Credit: Daniel Studer/NREL)

E.2 Patient Schedules

Patient area occupancy and lighting schedules are presented in Table E-3 and Figure E-2. Patient areas use 24/7 equipment and set point schedules (see Section E.1).

Table E-3 Patient Area Lighting and Occupancy Schedules

Hour	Lighting, All Days	Occupancy, All Days
1	0.5	0.7
2	0.5	0.7
3	0.5	0.7
4	0.5	0.7
5	0.7	0.7
6	0.7	0.7
7	0.9	0.7
8	0.9	0.7
9	0.9	0.7
10	0.9	0.7
11	0.9	0.8
12	0.9	0.8
13	0.9	0.8
14	0.9	0.8
15	0.9	0.8
16	0.9	0.8
17	0.9	0.8
18	0.9	0.8
19	0.7	0.7
20	0.7	0.7
21	0.7	0.7
22	0.7	0.7
23	0.5	0.7
24	0.5	0.7
Total Hours/Day	18.0	17.6

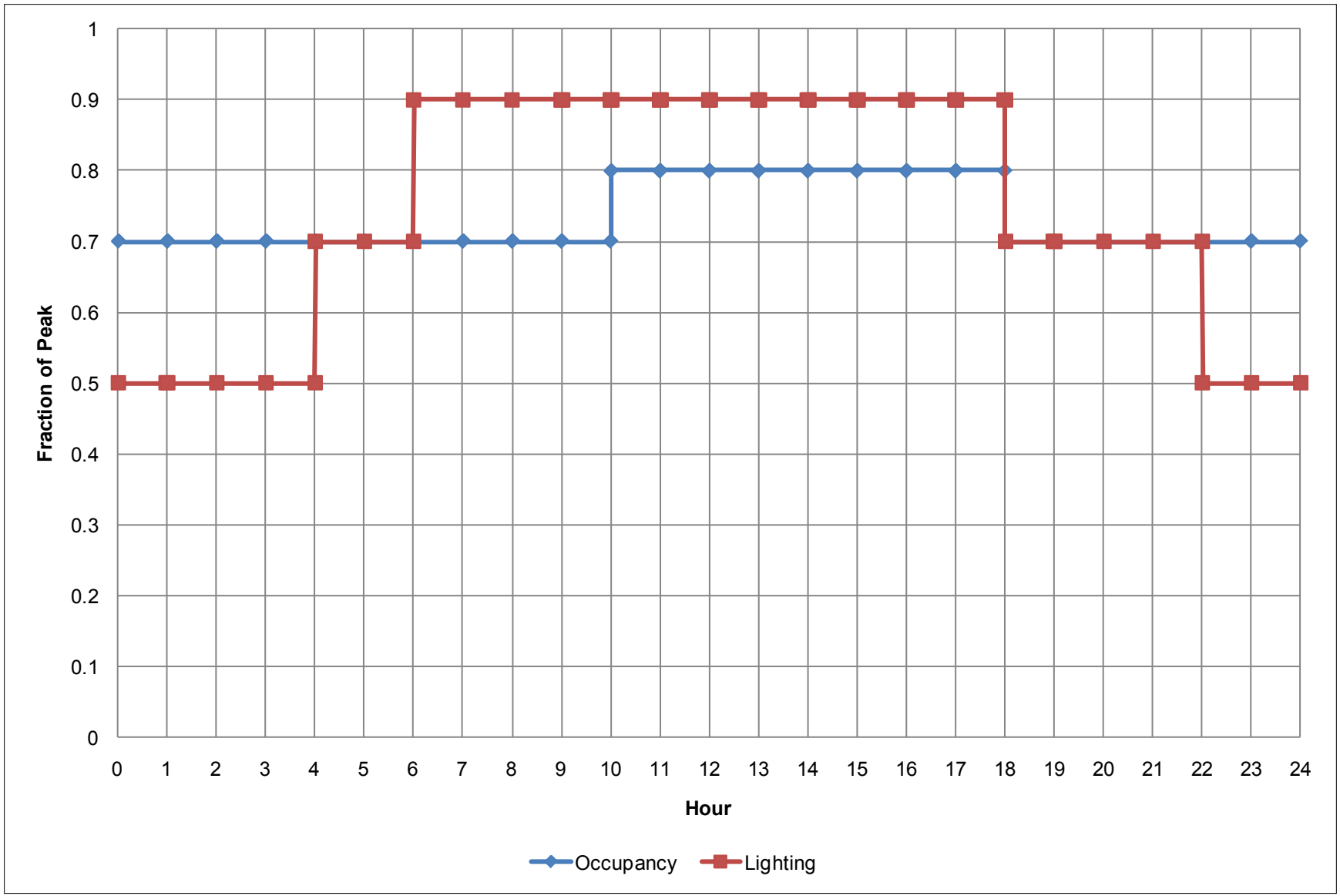

Figure E-2 Patient area occupancy and lighting schedules
(Credit: Daniel Studer/NREL)

E.3 Office Schedules

Office occupancy, lighting, equipment, and set point schedules are presented in Table E-4 through Table E-7 and Figure E-3 through Figure E-6.

Table E-4 Office Occupancy Schedule

Hour	Weekdays	Saturdays	Sundays
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.10	0.00	0.00
7	0.20	0.10	0.00
8	0.95	0.10	0.00
9	0.95	0.30	0.00
10	0.95	0.30	0.00
11	0.95	0.30	0.00
12	0.95	0.30	0.00
13	0.50	0.10	0.00
14	0.95	0.10	0.00
15	0.95	0.10	0.00
16	0.95	0.10	0.00
17	0.95	0.10	0.00
18	0.30	0.00	0.00
19	0.30	0.00	0.00
20	0.10	0.00	0.00
21	0.05	0.00	0.00
22	0.05	0.00	0.00
23	0.05	0.00	0.00
24	0.05	0.00	0.00
Total Hours/Day	10.25	1.90	0.00

Table E-5 Office Lighting Schedule

Hour	Weekdays	Saturdays	Sundays
1	0.05	0.05	0.05
2	0.05	0.05	0.05
3	0.05	0.05	0.05
4	0.05	0.05	0.05
5	0.05	0.05	0.05
6	0.10	0.05	0.05
7	0.30	0.10	0.05
8	0.90	0.10	0.05
9	0.90	0.30	0.05
10	0.90	0.30	0.05
11	0.90	0.30	0.05
12	0.90	0.30	0.05
13	0.90	0.15	0.05
14	0.90	0.15	0.05
15	0.90	0.15	0.05
16	0.90	0.15	0.05
17	0.90	0.15	0.05
18	0.90	0.05	0.05
19	0.90	0.05	0.05
20	0.50	0.05	0.05
21	0.30	0.05	0.05
22	0.20	0.05	0.05
23	0.10	0.05	0.05
24	0.05	0.05	0.05
Total Hours/Day	12.60	2.80	1.20

Table E-6 Office Equipment Schedule

Hour	Weekdays	Saturdays	Sundays
1	0.40	0.30	0.30
2	0.40	0.30	0.30
3	0.40	0.30	0.30
4	0.40	0.30	0.30
5	0.40	0.30	0.30
6	0.40	0.30	0.30
7	0.40	0.40	0.30
8	0.90	0.40	0.30
9	0.90	0.50	0.30
10	0.90	0.50	0.30
11	0.90	0.50	0.30
12	0.90	0.50	0.30
13	0.80	0.35	0.30
14	0.90	0.35	0.30
15	0.90	0.35	0.30
16	0.90	0.35	0.30
17	0.90	0.35	0.30
18	0.65	0.30	0.30
19	0.50	0.30	0.30
20	0.40	0.30	0.30
21	0.40	0.30	0.30
22	0.40	0.30	0.30
23	0.40	0.30	0.30
24	0.40	0.30	0.30
Total Hours/Day	14.85	8.45	7.20

Table E-7 Office Set Point Schedule

Hour	Weekdays				Saturdays				Sundays			
	Heating		Cooling		Heating		Cooling		Heating		Cooling	
	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)
1	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
2	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
3	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
4	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
5	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
6	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
7	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
8	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
9	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
10	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
11	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
12	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
13	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
14	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
15	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
16	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
17	21.1	70.0	22.2	72.0	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0
18	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
19	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
20	21.1	70.0	22.2	72.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
21	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
22	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
23	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0
24	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0	18.3	64.9	25.0	77.0

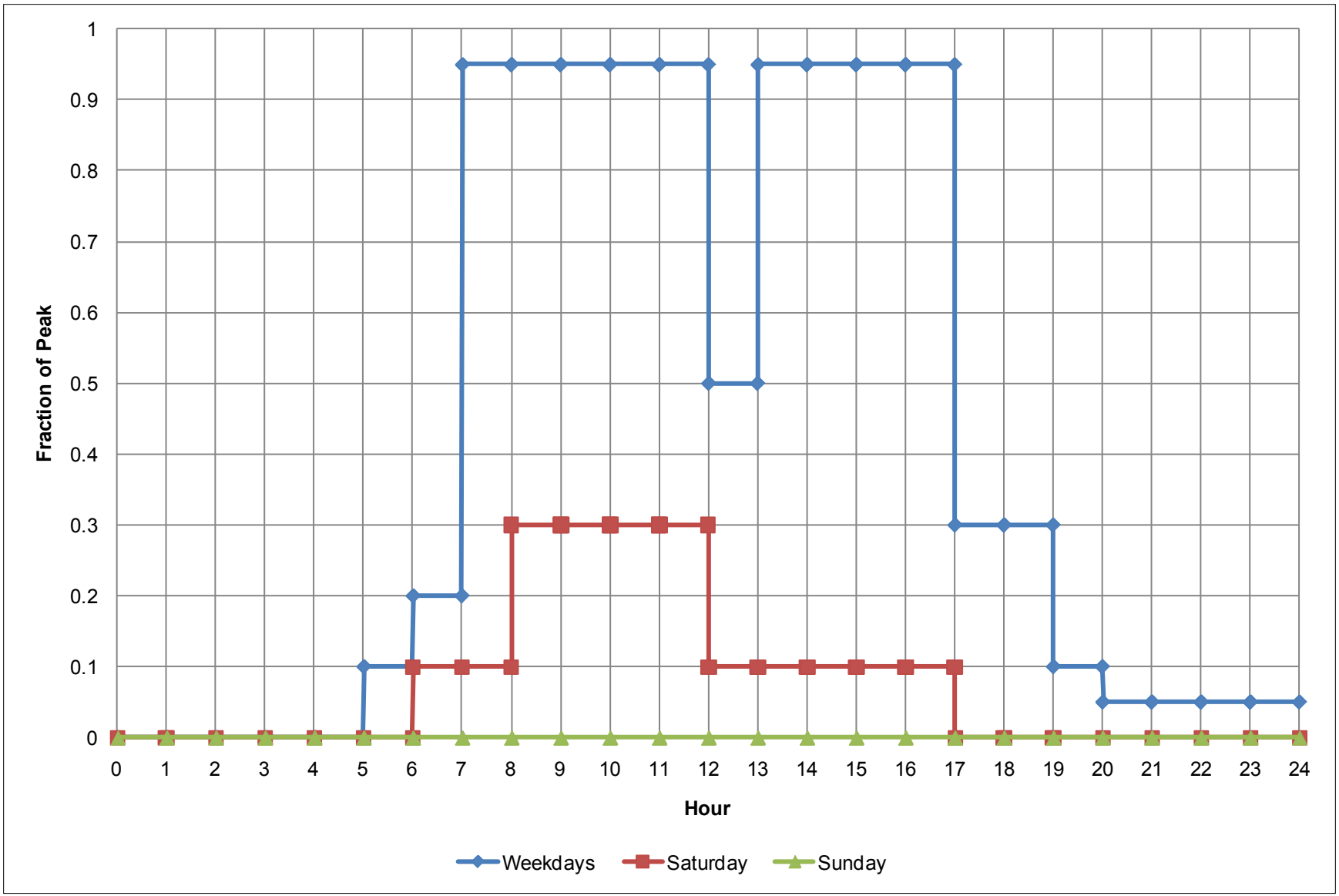

Figure E-3 Office occupancy schedules
(Credit: Daniel Studer/NREL)

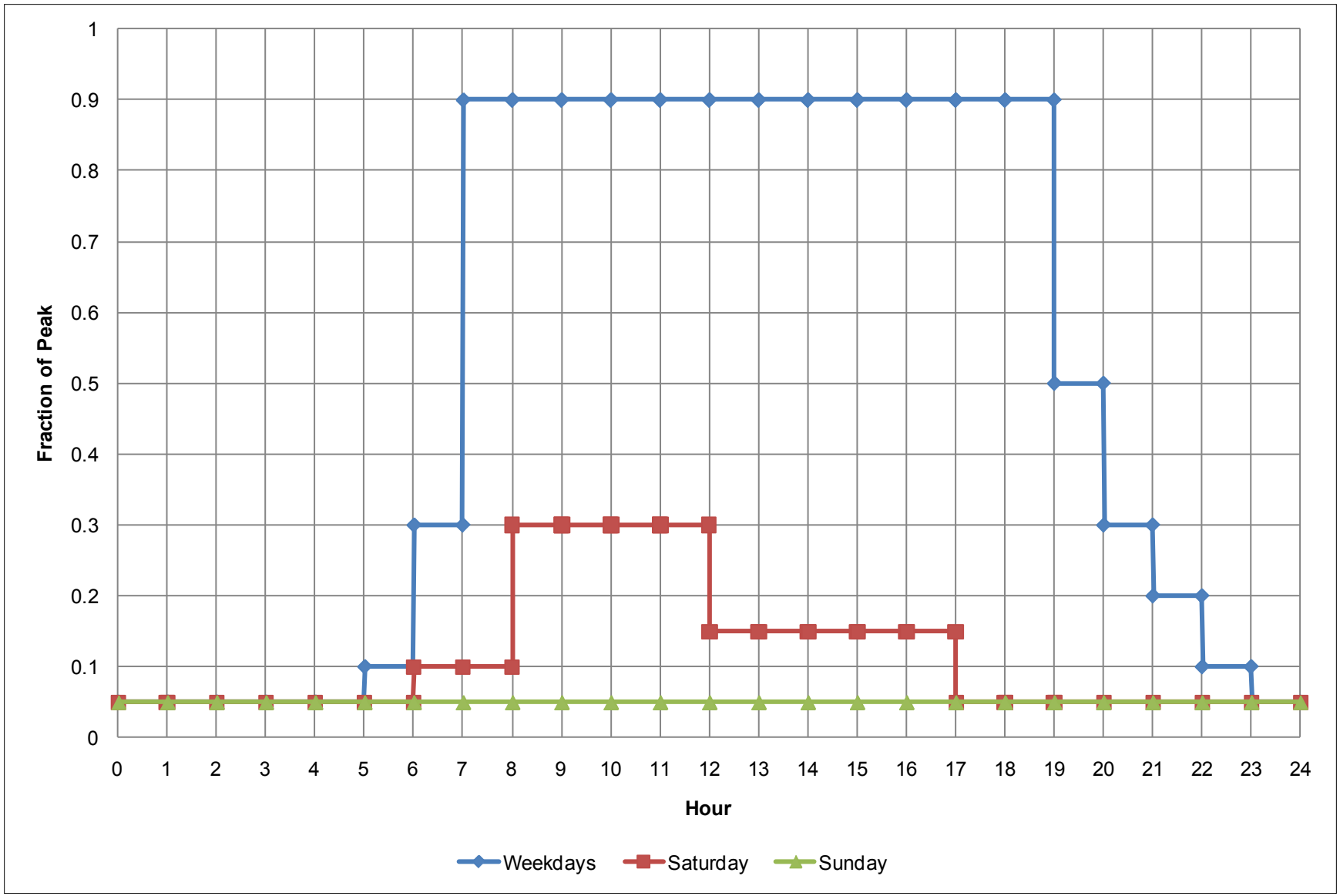

Figure E-4 Office lighting schedules
(Credit: Daniel Studer/NREL)

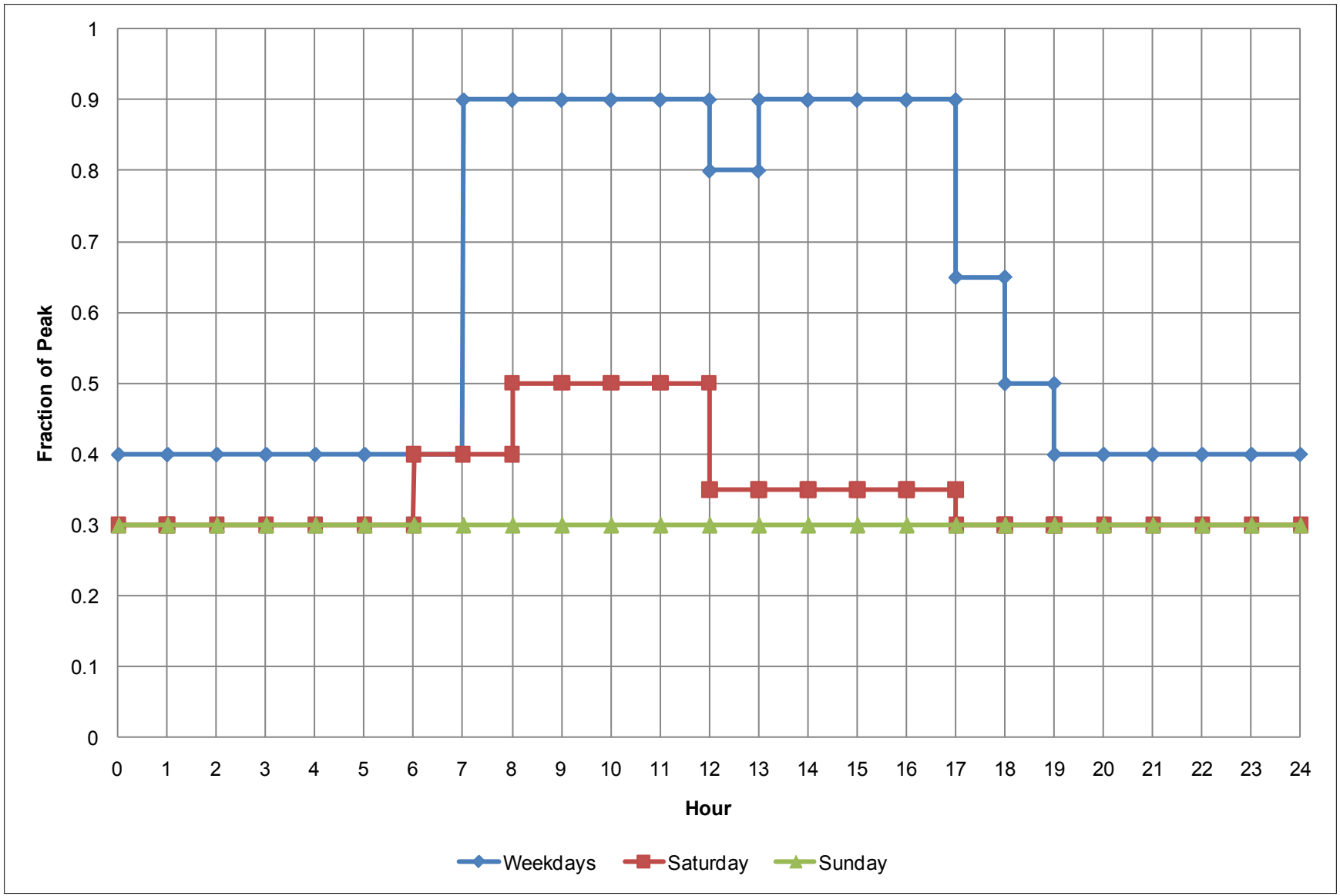

Figure E-5 Office equipment schedules
(Credit: Daniel Studer/NREL)

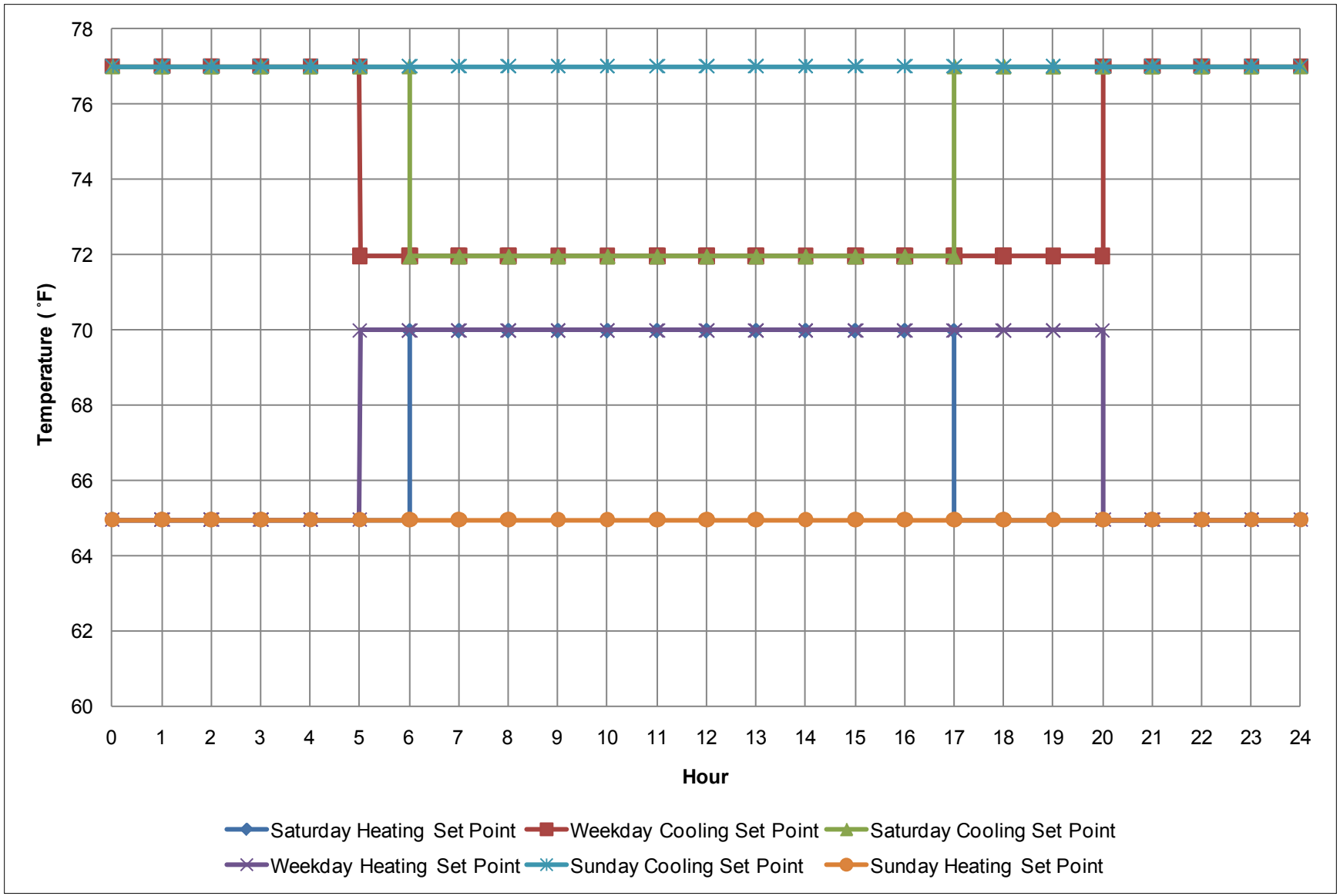

Figure E-6 Office set point schedules
(Credit: Daniel Studer/NREL)

E.4 Food Service-Related Area Schedules

Occupancy, lighting, equipment, and set point schedules for food service related areas are presented in Table E-8, Table E-9, Figure E-7, and Figure E-8.

Table E-8 Food Service-Related Area Occupancy, Lighting, and Equipment Schedules

Hour	Kitchen Occupancy, All Days	Dining Occupancy, All Days	Lighting, All Days	Gas Equipment, All Days	Electric Equipment, All Days
1	0.45	0.05	0.45	0.01	0.10
2	0.15	0.00	0.15	0.01	0.10
3	0.15	0.00	0.15	0.01	0.10
4	0.15	0.00	0.15	0.01	0.10
5	0.15	0.00	0.15	0.01	0.10
6	0.45	0.05	0.45	0.12	0.10
7	0.90	0.10	0.90	0.14	0.25
8	0.90	0.40	0.90	0.13	0.35
9	0.90	0.40	0.90	0.14	0.35
10	0.90	0.20	0.90	0.18	0.25
11	0.90	0.50	0.90	0.20	0.35
12	0.90	0.80	0.90	0.15	0.35
13	0.90	0.80	0.90	0.13	0.35
14	0.90	0.70	0.90	0.19	0.25
15	0.90	0.40	0.90	0.20	0.25
16	0.90	0.20	0.90	0.16	0.25
17	0.90	0.50	0.90	0.14	0.35
18	0.90	0.80	0.90	0.10	0.35
19	0.90	0.80	0.90	0.07	0.35
20	0.90	0.50	0.90	0.04	0.25
21	0.90	0.50	0.90	0.04	0.25
22	0.90	0.35	0.90	0.02	0.25
23	0.60	0.20	0.90	0.01	0.25
24	0.60	0.20	0.90	0.01	0.25
Total Hours/Day	17.10	8.45	17.70	2.22	5.9

Table E-9 Food Service-Related Area Set Point Schedules

Hour	Heating Set Point (°C)	Heating Set Point (°F)	Cooling Set Point (°C)	Cooling Set Point (°F)
1	18.3	64.9	25.0	77.0
2	18.3	64.9	25.0	77.0
3	18.3	64.9	25.0	77.0
4	18.3	64.9	25.0	77.0
5	18.3	64.9	25.0	77.0
6	21.1	70.0	22.2	72.0
7	21.1	70.0	22.2	72.0
8	21.1	70.0	22.2	72.0
9	21.1	70.0	22.2	72.0
10	21.1	70.0	22.2	72.0
11	21.1	70.0	22.2	72.0
12	21.1	70.0	22.2	72.0
13	21.1	70.0	22.2	72.0
14	21.1	70.0	22.2	72.0
15	21.1	70.0	22.2	72.0
16	21.1	70.0	22.2	72.0
17	21.1	70.0	22.2	72.0
18	21.1	70.0	22.2	72.0
19	21.1	70.0	22.2	72.0
20	21.1	70.0	22.2	72.0
21	21.1	70.0	22.2	72.0
22	21.1	70.0	22.2	72.0
23	21.1	70.0	22.2	72.0
24	21.1	70.0	22.2	72.0

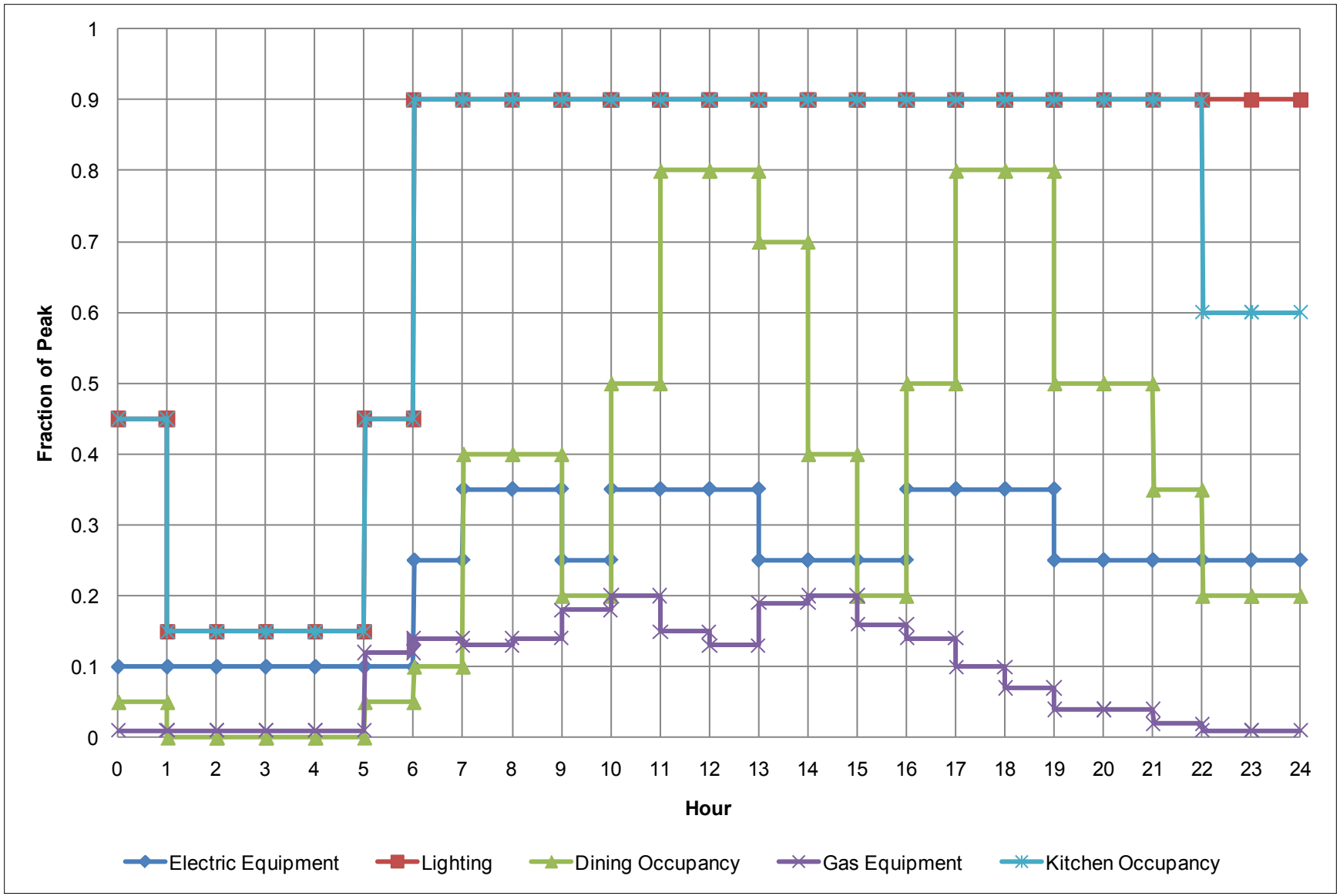

Figure E-7 Food service-related area occupancy, lighting, and equipment schedules
(Credit: Daniel Studer/NREL)

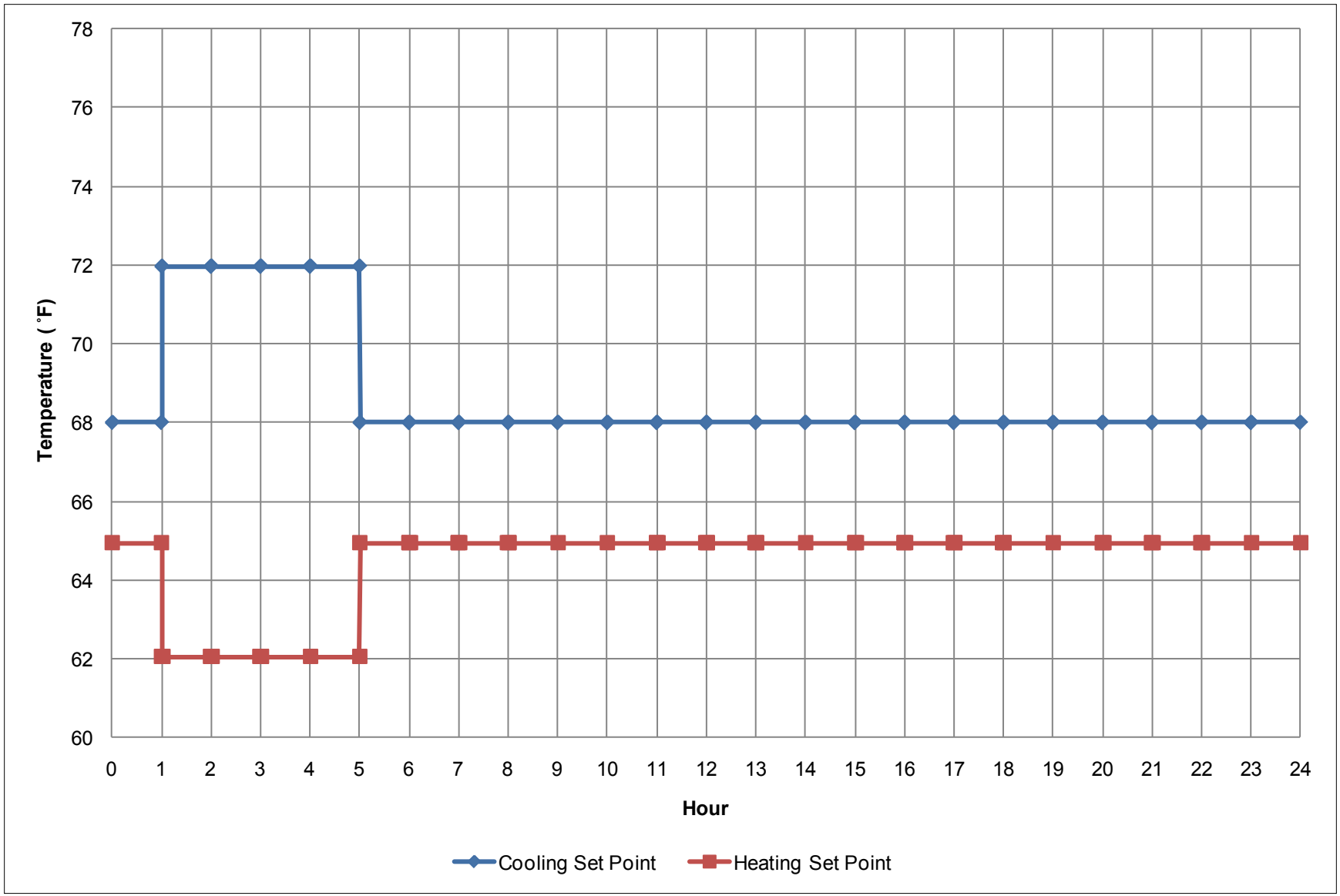

Figure E-8 Food service-related area set point schedules
(Credit: Daniel Studer/NREL)

E.5 Laundry Schedules

Occupancy, lighting, equipment, and set point schedules for the laundry room zones are presented in Table E-10, Table E-11, Figure E-9, and Figure E-10. The gas equipment schedule is also used to modify the electric equipment load.

Table E-10 Laundry Zone Occupancy, Lighting, and Equipment Schedules

Hour	Occupancy, All Days	Lighting, All Days	Gas Equipment, All Days
1	0.00	0.05	0.00
2	0.00	0.05	0.00
3	0.00	0.05	0.00
4	0.00	0.05	0.00
5	0.00	0.05	0.00
6	0.10	0.10	0.00
7	0.20	0.30	0.00
8	0.95	0.90	0.00
9	0.95	0.90	1.00
10	0.95	0.90	1.00
11	0.95	0.90	1.00
12	0.95	0.90	1.00
13	0.50	0.90	1.00
14	0.95	0.90	1.00
15	0.95	0.90	1.00
16	0.95	0.90	1.00
17	0.95	0.90	1.00
18	0.30	0.90	1.00
19	0.30	0.90	0.00
20	0.10	0.50	0.00
21	0.05	0.30	0.00
22	0.05	0.20	0.00
23	0.05	0.10	0.00
24	0.05	0.05	0.00
Total Hours/Day	10.25	12.60	10.00

Table E-11 Laundry Zone Set Point Schedules

Hour	Heating Set Point (°C)	Heating Set Point (°F)	Cooling Set Point (°C)	Cooling Set Point (°F)
1	16.7	62.1	22.2	72.0
2	16.7	62.1	22.2	72.0
3	16.7	62.1	22.2	72.0
4	16.7	62.1	22.2	72.0
5	16.7	62.1	22.2	72.0
6	18.3	64.9	20.0	68.0
7	18.3	64.9	20.0	68.0
8	18.3	64.9	20.0	68.0
9	18.3	64.9	20.0	68.0
10	18.3	64.9	20.0	68.0
11	18.3	64.9	20.0	68.0
12	18.3	64.9	20.0	68.0
13	18.3	64.9	20.0	68.0
14	18.3	64.9	20.0	68.0
15	18.3	64.9	20.0	68.0
16	18.3	64.9	20.0	68.0
17	18.3	64.9	20.0	68.0
18	18.3	64.9	20.0	68.0
19	18.3	64.9	20.0	68.0
20	18.3	64.9	20.0	68.0
21	16.7	62.1	22.2	72.0
22	16.7	62.1	22.2	72.0
23	16.7	62.1	22.2	72.0
24	16.7	62.1	22.2	72.0

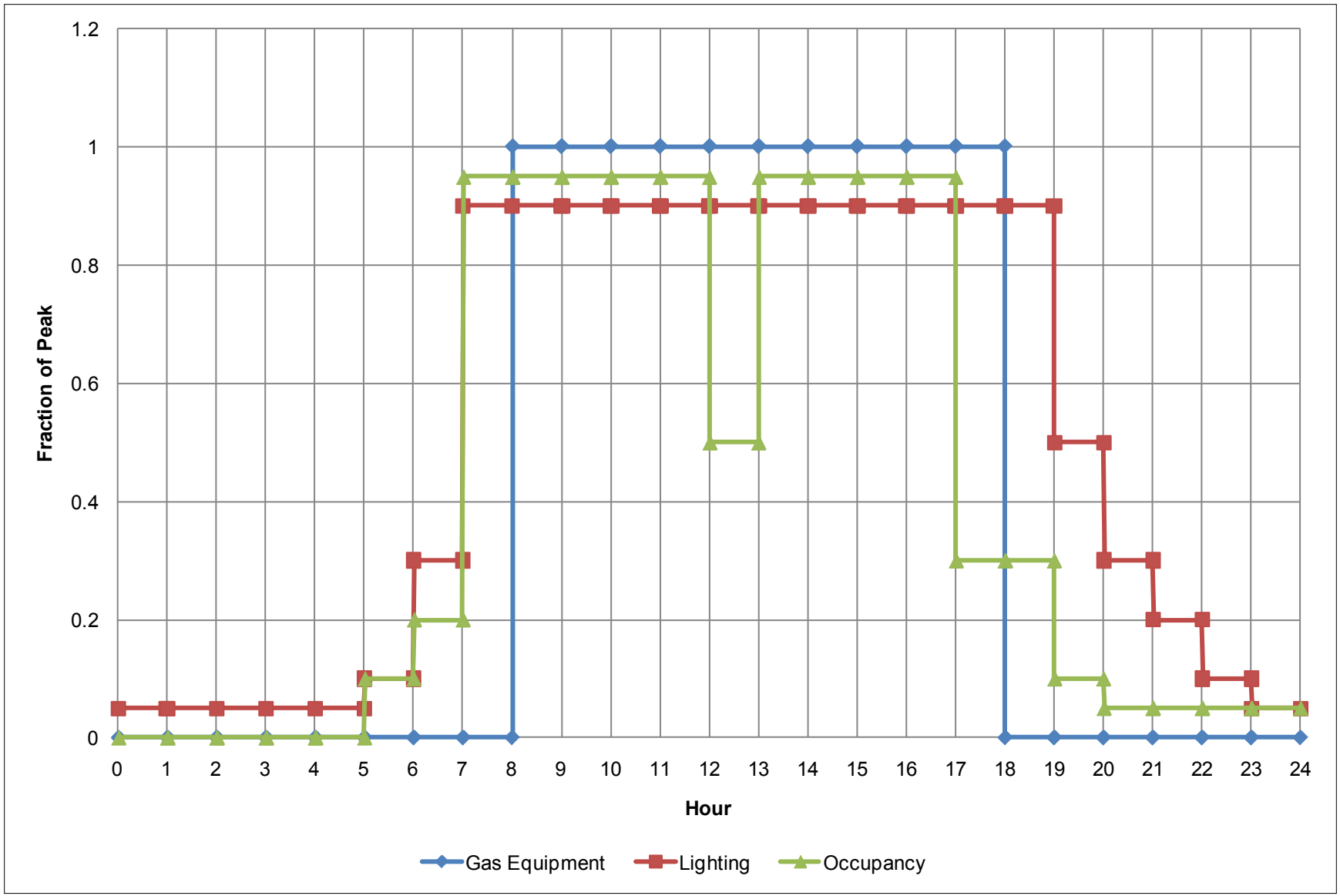

Figure E-9 Laundry zone occupancy, lighting, and equipment schedules
(Credit: Daniel Studer/NREL)

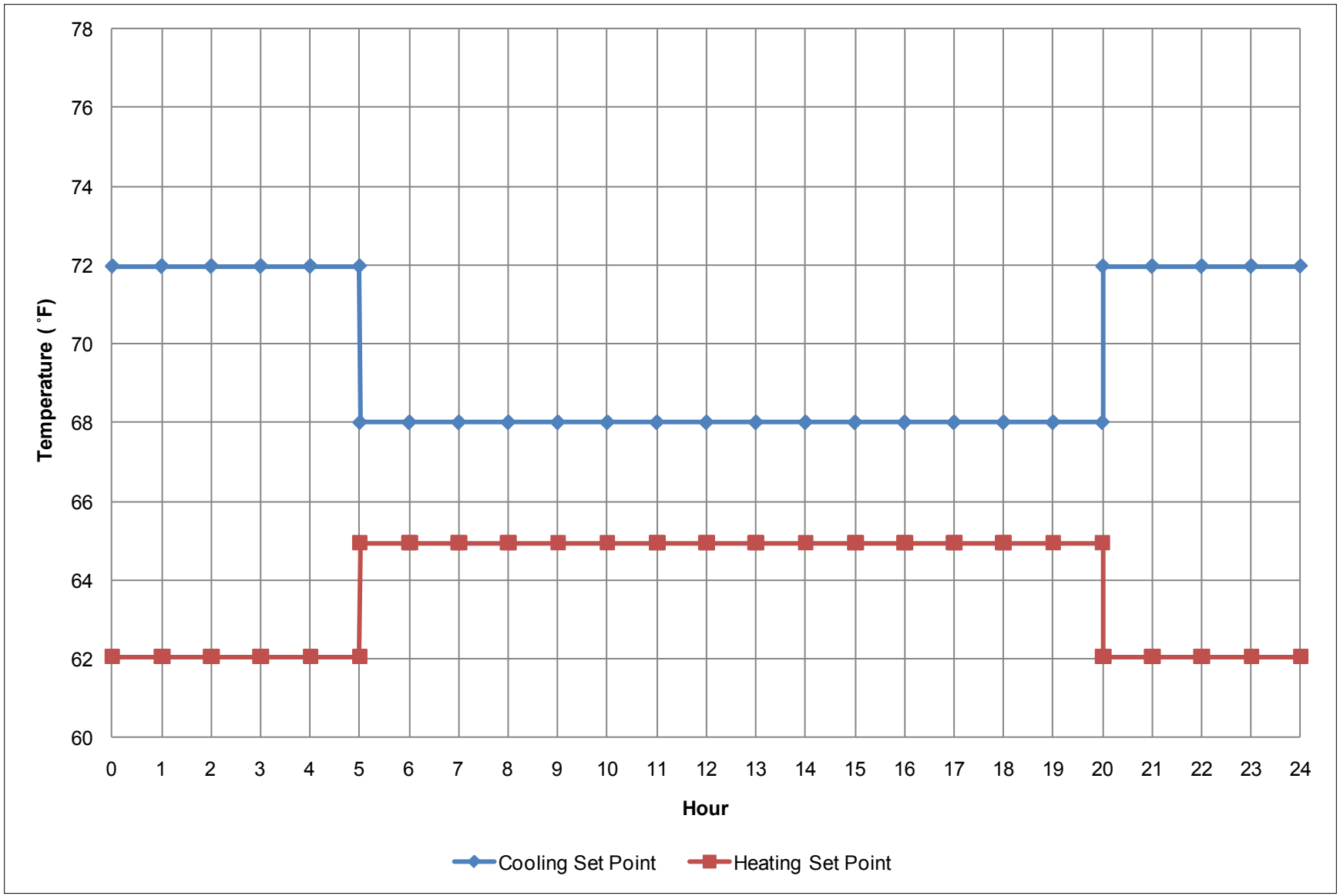

Figure E-10 Laundry zone set point schedules
(Credit: Daniel Studer/NREL)

E.6 Operating Suite Schedules

The operating suites were assumed to be available 24 hours per day, 7 days per week and, except for the set point schedule, utilized the 24/7 schedules presented in Section E.1. The operating suite set point schedules can be found in Table E-12. No figure is included for Table E-12 because of its simplicity.

Table E-12 Operating Suite Set Point Schedules

Hour	Heating Set Point (°C)	Heating Set Point (°F)	Cooling Set Point (°C)	Cooling Set Point (°F)
1–24	18.3	64.9	18.3	64.9

E.7 Infiltration Schedules

The infiltration schedules used in the energy models are shown in Table E-13 with visual representations of the data in Figure E-11. Table E-14 shows which space types in which models used which infiltration schedules.

Table E-13 Infiltration Schedule Names by Space Type

Space Type	Baseline Model Infiltration Schedule	Low-Energy Model Infiltration Schedule
Anesthesia gas storage	Always on infiltration schedule	Always on infiltration schedule
Cafeteria	Always on infiltration schedule	Dining infiltration schedule
Clean workroom/holding	Always on infiltration schedule	Always on infiltration schedule
Conference room	Always on infiltration schedule	Office infiltration schedule
Corridor/transition	Always on infiltration schedule	Always on infiltration schedule
Dining room	Always on infiltration schedule	Dining infiltration schedule
Examination/treatment room	Always on infiltration schedule	Office infiltration schedule
Food preparation center	Always on infiltration schedule	Always on infiltration schedule
Laboratory	Always on infiltration schedule	Always on infiltration schedule
Laundry	Always on infiltration schedule	Laundry infiltration schedule
Lobby area	Always on infiltration schedule	Always on infiltration schedule
Locker	Always on infiltration schedule	Always on infiltration schedule
Lounge	Always on infiltration schedule	Always on infiltration schedule
Mechanical/electrical/telecomm room	Always on infiltration schedule	Office infiltration schedule
Medical supply/medication room	Always on infiltration schedule	Always on infiltration schedule
Nurse station	Always on infiltration schedule	Always on infiltration schedule
Nursery	Always on infiltration schedule	Always on infiltration schedule
Office	Always on infiltration schedule	Office infiltration schedule
Operating suite	Always on infiltration schedule	Always on infiltration schedule
Patient room	Always on infiltration schedule	Always on infiltration schedule
Pharmacy	Always on infiltration schedule	Always on infiltration schedule
Physical therapy	Always on infiltration schedule	Office infiltration schedule
Procedure room	Always on infiltration schedule	Office infiltration schedule
Radiology/imaging	Always on infiltration schedule	Always on infiltration schedule
Reception/waiting	Always on infiltration schedule	Always on infiltration schedule
Recovery room	Always on infiltration schedule	Always on infiltration schedule
Restroom	Always on infiltration schedule	Always on infiltration schedule
Soiled workroom/holding	Always on infiltration schedule	Always on infiltration schedule
Sterilizer equipment room	Always on infiltration schedule	Always on infiltration schedule
Storage/receiving	Always on infiltration schedule	Office infiltration schedule
Trauma/emergency room	Always on infiltration schedule	Always on infiltration schedule
Triage	Always on infiltration schedule	Always on infiltration schedule

Table E-14 Low-Energy Infiltration Schedules

Hour	Always On Infiltration All Days	Dining All Days	Laundry All Days	Office Weekdays	Office Saturday	Office Sunday
1	0.5	1.0	1.0	1.0	1.0	1.0
2	0.5	1.0	1.0	1.0	1.0	1.0
3	0.5	1.0	1.0	1.0	1.0	1.0
4	0.5	1.0	1.0	1.0	1.0	1.0
5	0.5	1.0	1.0	1.0	1.0	1.0
6	0.5	0.5	0.5	0.5	1.0	1.0
7	0.5	0.5	0.5	0.5	0.5	1.0
8	0.5	0.5	0.5	0.5	0.5	1.0
9	0.5	0.5	0.5	0.5	0.5	1.0
10	0.5	0.5	0.5	0.5	0.5	1.0
11	0.5	0.5	0.5	0.5	0.5	1.0
12	0.5	0.5	0.5	0.5	0.5	1.0
13	0.5	0.5	0.5	0.5	0.5	1.0
14	0.5	0.5	0.5	0.5	0.5	1.0
15	0.5	0.5	0.5	0.5	0.5	1.0
16	0.5	0.5	0.5	0.5	0.5	1.0
17	0.5	0.5	0.5	0.5	0.5	1.0
18	0.5	0.5	0.5	0.5	1.0	1.0
19	0.5	0.5	0.5	0.5	1.0	1.0
20	0.5	0.5	0.5	0.5	1.0	1.0
21	0.5	0.5	1.0	1.0	1.0	1.0
22	0.5	0.5	1.0	1.0	1.0	1.0
23	0.5	0.5	1.0	1.0	1.0	1.0
24	0.5	0.5	1.0	1.0	1.0	1.0
Total Hours/Day	12.0	14.5	16.5	16.5	18.5	24.0

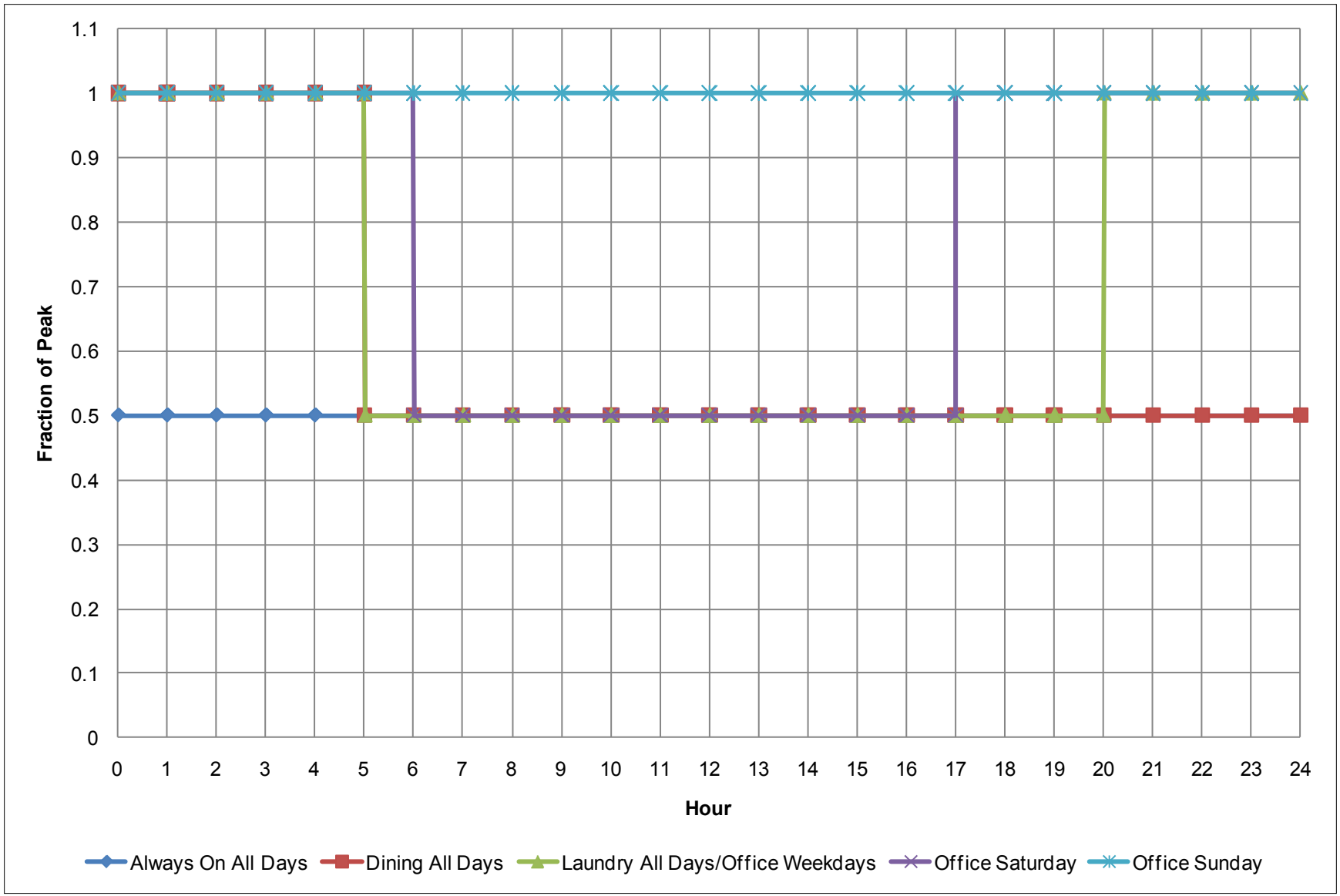

Figure E-11 Infiltration schedules
(Credit: Daniel Studer/NREL)

E.8 Service Water Heating Schedules

The SWH schedules are listed in Table E-15 with a visual representation in Figure E-12.

Table E-15 SWH Schedules

Hour	Kitchen All Days	Patient Rooms All Days
1	0.20	0.013
2	0.00	0.013
3	0.00	0.013
4	0.00	0.013
5	0.00	0.013
6	0.00	0.017
7	0.15	0.020
8	0.60	0.027
9	0.55	0.027
10	0.45	0.150
11	0.40	0.150
12	0.45	0.027
13	0.40	0.033
14	0.35	0.033
15	0.30	0.033
16	0.30	0.033
17	0.30	0.150
18	0.40	0.053
19	0.55	0.047
20	0.60	0.033
21	0.50	0.030
22	0.55	0.027
23	0.45	0.023
24	0.25	0.020
Total Hours/Day	7.75	1.000

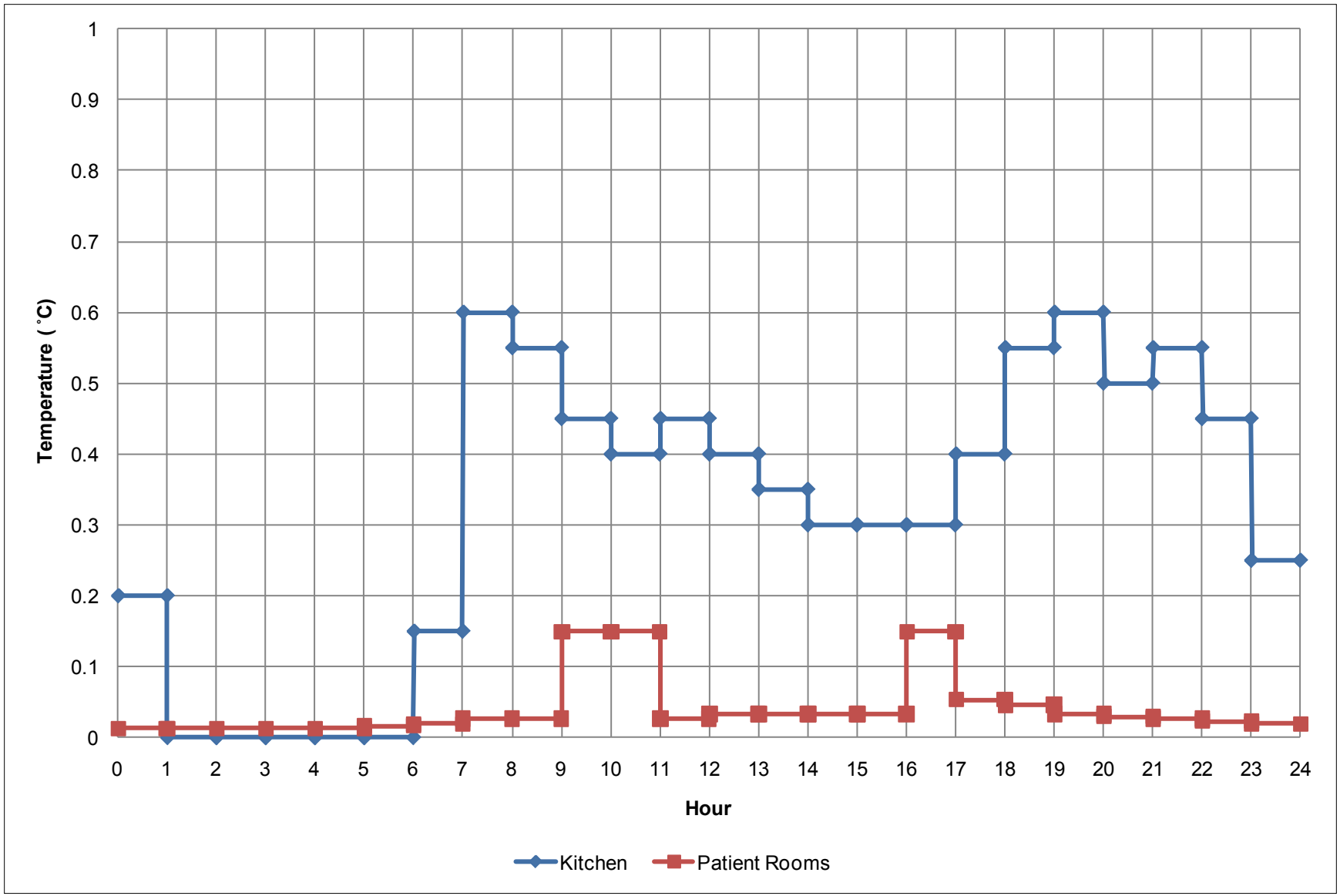

Figure E-12 SWH schedules
(Credit: Daniel Studer/NREL)

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14. ABSTRACT *(Maximum 200 Words)*
This Technical Support Document documents the technical analysis and design guidance for large hospitals to achieve whole-building energy savings of at least 50% over ANSI/ASHRAE/IESNA Standard 90.1-2004 and represents a step toward determining how to provide design guidance for aggressive energy savings targets. This report documents the modeling methods used to demonstrate that the design recommendations meet or exceed the 50% goal. EnergyPlus was used to model the predicted energy performance of the baseline and low-energy buildings to verify that 50% energy savings are achievable. Percent energy savings are based on a nominal minimally code-compliant building and whole-building, net site energy use intensity. The report defines architectural-program characteristics for typical large hospitals, thereby defining a prototype model; creates baseline energy models for each climate zone that are elaborations of the prototype models and are minimally compliant with Standard 90.1-2004; creates a list of energy design measures that can be applied to the prototype model to create low-energy models; uses industry feedback to strengthen inputs for baseline energy models and energy design measures; and simulates low-energy models for each climate zone to show that when the energy design measures are applied to the prototype model, 50% energy savings (or more) are achieved.

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