

# Hospital Design and the 50% Advanced Energy Design Guide

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Graphics from the 50% Advanced Energy Design Guides for Large Hospitals, used by permission of ASHRAE. Download at www.ashrae.org/freeaedg

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## **Course Description**

Since 2002, ASHRAE, the Illuminating Engineering Society (IES), USGBC, and AIA, with support from the Department of Energy, have collaborated on a series of Advanced Energy Design Guides (AEDGs) that result in significant energy savings in the built environment beyond what is expected by using only ASHRAE Standard 90.1. The AEDG series of documents is now one of the most popular publications in ASHRAE's history with over 600,000 copies in circulation.

This program provides a brief history of the AEDG Series, and then focuses on the 50% Large Hospital AEDG which will be covered in detail including examples of recommendations, case studies, technologies, systems, and controls to reduce energy use by 50% or more (compared to ASHRAE 90.1-2004).

Recommended audience:

Hospital facility managers and environmental directors, ASHE members, consulting engineers, contractors, facilities managers, and students.

## **AIA Continuing Education Provider**

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- AIA Course Number / classification: AEDGH5019, 1 LU/HSW



## EDUCATION PARTNER

### 50% Hospital Advance Energy Design Guide

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## Learning Objectives

- Understand importance of, purpose for, and background of, the Advanced Energy Design Guide series
- Learn how to find and use the AEDG documents
- Identify integrated energy saving recommendations in the Large Hospital AEDGs to reduce energy costs
- Reap benefits of using AEDGs to achieve Optimize Energy Performance credits

### Advanced Energy Design Guides Goals

- Provide a two-page list of recommendations to reduce energy use in buildings
  - A way, but not the only way, to construct an energy-efficient building that uses significantly less energy than a code-compliant building
  - At least 50% energy savings as compared to ASHRAE/IESNA Standard 90.1-2004
    - 50% progress toward net-zero energy building
- Transfer energy dollars to other resources

## **AEDG Partnership**

Collaboration of professional organizations and DOE

- Specialized Project Committee for each guide
- Oversight is provided via AEDG Steering Committee
- Backed by DOE's national laboratory leadership, energy simulation, technical analysis and support
- Open peer review and commentary process



## Five 50% Guides Baseline: ASHRAE 90.1-2004



## **Guide Development**

- Meet all requirements of ANSI/ASHRAE Standards
  - 55 (comfort),
  - 62.1 (ventilation and indoor air quality), and
  - 90.1 (energy)
- Based on whole building energy savings
- Energy is independent variable and cost-effectiveness is dependent variable
- Off-the-shelf technology (must be available from at least two manufacturers)
- Building specific expertise for each guide

## **Specifically for Large Hospital AEDG**

- Guidelines for the Design and Construction of Healthcare Facilities – 2010 Edition
- Includes ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities



## Large Hospital Project Committee

- Shanti Pless (Chair)
- Merle McBride (Vice Chair)
- Mara Baum & Ray Pradinuk (AIA)
- Walt Vernon (ASHE)
- Jeff Boldt & Mick Schwedler (ASHRAE)
- John Gill & Joel Loveland (IES)
- John D'Angelo & Kim Shinn (USGBC)
- Tim Peglow (At-Large)
- Eric Bonnema (NREL) and Matt Leach (NREL)

## **Forward Excerpts**

- "Most important in AEDG for Hospitals is the recognition that patient outcomes, safety, and experience trump all cost- and energy-saving strategies."
- "The AEDG for Large Hospitals shows that existing reliable technologies and design philosophies can be used to reduce energy use in large hospitals by up to 50% of ANSI/ASHRAE/IESNA Standard 90.1-2004...."

## **1 - Introduction**

- Conditions to promote health and comfort
  - Ventilation and Indoor Air Quality (IAQ)
    - Refer to Indoor Air Quality Guide
  - Thermal comfort
    - Metabolic rate, clothing insulation, air temperature, radiant temperature, air speed, and humidity
  - Visual comfort
    - Daylighting
  - Acoustic comfort

## Scope

- Standard hospitals ≥ 100,000 ft2
- Space Types: reception/waiting, examination, treatment, OR, recovery, clean & soiled workrooms, nurses station, nursery, patient room, pharmacy, triage, trauma, ER, physical therapy, cafeteria, kitchen, conference, office, radiology/imaging, storage, mechanical & electrical rooms.
- Excludes: Atypical, special-use spaces

## **Integrated Design?**

• Do we really think we're going to get to 50% energy savings using our present practices?



• No, this is **<u>not</u>** good integrated design!

## **Integrated Design**

- Early involvement of <u>all</u> team members
- Agreed-upon, objective, and documented common goals
- Open communication about meeting the agreed upon metrics and goals
- Assessment of metrics and goals for a minimum of 3-5 years postoccupancy

### All working with reciprocal respect and trust

## **ASHRAE Digital Lighthouse**



Example BIM Output Reprinted with permission of HOK

## **Integrated Design**

#### CLEVELAND CLINIC A CASE STUDY



Cleveland Clinic Northeast Ohio Campus Photos courtesy of Cleveland Clinic



y (left) and Heliport Landing Area (right)

# Baseline Prototype Characteristics 50% Hospital AEDG

Model Parameter	Value
Total floor area	427,000 ft <sup>2</sup>
Floor-to-floor height	9 ft
Floor-to-ceiling height	14 ft D&T 13 ft IPU/other
Number of floors	7
WWR (floor-to-ceiling)	40%
WWR (floor-to-floor)	26% D&T 28% IPU/other
Glazing sill height	3.6 ft
Glazing height	3.7 ft
Exterior wall type	Mass
Roof type	IEAD
*Floor multiplier of 3 or	n patient tower





# Baseline Prototype HVAC Systems 50% Hospital AEDG

- Central VAV air-handlers
  - Terminal box minimum flow at required ACH for spaces in Standard 170
  - Terminal box minimum flow fraction of 0.3 for spaces not in Standard 170
- 55°F supply air temperature
- · Chilled water cooling coils
- Hot water preheat coils
- Variable speed fan
  - 60% static efficiency
  - 8 in w.c. pressure drop
- Electric steam humidifiers
  - Gas-fired humidifiers are not an option in EnergyPlus
  - 1,000,000 W at 354 gal/h
- Hot water terminal reheat



AHU-1	Floor 1	VAV	
AHU-2	Floor 2	VAV	
AHU-3	Floor 3	VAV	
AHU-4	Floor 4	VAV	
AHU-5	Floor 5	VAV	
AHU-6	Floor 6	VAV	
AHU-7	Floor 7	VAV	
SURG	Surgery Suite	VAV	

### • Groups climates into 8 zones



 Subcategorizes zones by humidity level



Look up climate zones by location ...

Miami = 1A Seattle = 4C Reykjavik = 7

## Recommendations by Climate Zone; Each CZ table fits on two pages

- Building envelope
  - insulation, fenestration, leakage

## Lighting

- interior, exterior, daylighting

### • HVAC

- design, equipment, controls
- Plug/process loads
  - equipment, controls, kitchens
- Service water heating
  - equipment, insulation
- Measurement & verification

	Component		Recc	mmendation r	iow-to lips		
Form/space planning	Proper zoning	Group	imilar spa	ce types within the building DL	.4-6		
	i teher sound	footprir	t.				
Roofs	Insulation entirely above deck	R-25.0	C.I.	En	42, 15-17		
	Solar reflectance index (SRI)	78		Ef	v1		
	Mass (HC > 7 Btu/tt*)	R-11.4	C.I.	E	13, 15-17		
Walls	Steel framed	R-13.0					
	Below-grade walls	R-7.5		Climate Zone 3	Recommendation Table for 1	able for Large Hospitals (Continu	ied)
Floors	Mass	R-12.5					
	Steel framed	R-30.0			Component	Recommendation	How-t
Slabs	Unheated	Comp			Cashing and smart	ENERGY STAR or California rebate-qualified	<b>DI 0</b> 0
chaos.	Heated	R-15.0			Cooking equipment	equipment	PL0-9
Deere	Swinging	U-0.70				6 in. insulation on low-temp walk-in	
DODIS	Nonswinging	U-0.50				equipment, insulated floor, LED lighting,	
Vestibules	At primary visitor building entrance	Comp	Kit	chen equipment	Refrigeration equipment	floating-head pressure controls, liquid	PL8-9, 1
Continuous air barriers	Continuous air barriers	Entire	5			refrigerant, evaporative condenser	
	Window-to-wall ratio	40% c	<b>a</b>			Side nanels, larger overhands, rear seal at	
		Nonm			Exhaust hoods	appliances, proximity hoods, VAV demand-	PL8, 10,
	Thermal transmittance	Metal				based exhaust	
(full assemblyNERC ration)	Solar heat gain coefficient (SHGC)	Nonm				Use traction elevators for all elevators, and	
(ion accountry-ion no raung)	occurricati gan openicient (3HOC)	Metal	Pro	cess loads	Elevators	use regenerative traction elevators for all	PL16
	Light-to-solar gain ratio (LSG)	All ori				nign-use elevators.	
	Exterior sun control	South			Gas water heater (condensing)	95% Efficiency	WH3, H
	All spaces	Comp	\$ Se	vice water heating	Point-of-use water heater	0.81 EF or 81% Et	PL11, W
	10000000000000000000000000000000000000	IEQ 8.	5		Electric-heat-pump water heater	2.33 EF	WH3
		Shape			Pipe insulation ( $d \le 1.5$ in $/d \ge 1.5$ in.)	1.0 in./1.5 in.	WH7
Interior f				lor			
Interior I				<b>le</b> r	nu		
Interior I		Manua		ler	าน		10/37
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Interior I Interior I Exterior I Equipment choices Controls Where the table says "Comply with States	Lighting controls—General Surgery task lights Exit signage Paulog and landscape lighting Paulog bas and drives All other extendr lighting Computers BURREY STAR <sup>18</sup> equipment Netforg machines Computer power control Occupancy sensors Timer availches	Manua possit Use L LPD = LPD = LPD = Auto f Auto f Auto f Colar Network Office Water context office bours corrections to the mest correct	WH Weinstrond	Fan-coll system with DOAS Mondeal WV system with Needeal WV system with heat recovery system ts and dampers	Cooling towers Boller efficiency Maximum fan power FOU fans Exhaust-air energy recovery in DOAS DOA's weathaition control Heat recovery water-cooled chiller Water-cooled chiller	VPD on tower fans 90% E <sub>0</sub> : 0.4 Workin Multiple speed = 47% total effectiveness 0.5 Workin 0.6 Wo	HV37 HV8 HV21-2 HV5 HV10-1 HV8,36 HV3,36 HV3,36 HV3,37 HV8 HV21-2 HV10-1 HV10-1 HV10-1 HV10-1 HV10-1 HV10-1 HV21-2 HV22-2 HV22 HV2
Interior I Interior I Exterior Synthys Equipment choices Controls Where the table says "Comply with State	Lighting controls—General Surgery task fights Exit signage Papela and landscape lighting Parking lists and drives All other esterior lighting Computers EMERGY STAPF exployment Vending machines Computer power control Occupancy sensors Timer switches	Manua possit Use L UPD = LPD = Auto r Lepto = Auto r Delarr Netwo a enterp Office Water applia hours crite the mest curren	MM Notestanda	Fan-coil system with DOAS	Cooling towns Bolier efficiency Maximum fan power FoU ans Exhaustaal energy recovery in DOAS DOAS mentaliain control Haat recovery revision cooled chiller Valder-cooled chiller	VPD on tower fans           90% Fig.           90% Fig.           0.4 Wich           Multiple speed           A (hundit 20x8) = 60% total effectiveness           B (dry 20x9) = 70% senable effectiveness           B (dry 20x9) = 70% senable effectiveness           C (not hower taris)           VPD and NEMA premium           VPD on tower taris           90% Fig.           B (dry 20x9) = 9% senable effectiveness           Compt with standard 90.1*           A (hundit 20x8) = 60% total effectiveness           B (dry 20x9) = 60% total effectiveness           C (dry and 10% senable effectiveness           C (drash A)           Roi           Design and ciccul for sepanal submets submets on where on whe	HV37 HV8 HV21-22 HV9, 15- HV10-11 HV8, 35 HV33 HV35 HV73 HV70-11 HV10-11 HV10-11 HV10-11 HV10-11 HV10-12 HV10-
Interior I Interior I Exterior I Equipment choices Controls Where the table says "Comply with State	Lighting controls—General Surgery task lights Exit signage Pauking loss and drives All other extenor righting Computers BURRGY STAR <sup>®</sup> equipment Vending machines Computer power control Occupancy sensors Timer switches	Manue possibility Use Li LPD = LPD = LPD = LPD = LAttor Lattor Lattor Lattor All of Delarr Netwo and or Police Septia hours: of the next current	MH Date Meridian Me	Pan-coli system with DOAS Pan-coli system with DOAS Weinde air VAV system with near recovery system ets and dempers assurement and verification	Cooling towers Boole efficiency Maximum fan power Fo'U hans Exhaust-air energy recovery in DOAS DOA's weathaition control Heat recovery water-cooled chiller Water-cooled chiller	VPD on tower fans 90% 6 <sub>C</sub> 0.4 Workin Multiple speed = 67% total effectiveness Comparison of the speed = 67% total effectiveness Comparison of the speed = 67% total effectiveness Comparison of the speed = 67% total effectiveness CV WI VPD and VERAA permittin VPD and VPD and V	HV37 HV8 HV21-2 HV9, 15 HV10-1 HV6, 36 HV35 HV35 HV35 HV37 HV35 HV37 HV32 HV21-2 HV19 HV10-1 HV10-1 HV10-1 HV10-2

## **Recommendation Table Contents**

known problems

ltem

• H

			Climate Z	one 3 Recommendation Table f	or Table for Large Hospitals		
			ltem	Component	Recommendation	How-to Tips 🗸	
			Form/space planning	Proper zoning	Group similar space types within the building footprint.	DL46	
			Rods	Insulation entirely above deck	R-25.0 c.i.	EN2, 15-17	
				Solar reflectance index (SRI) Mass (HC > 7 Btufft <sup>2</sup> )	78 R-11.4 c.i.	EN1 EN3. 15-17	
			Walls	Steel framed	R-13.0 + R-7.5 c.i.	EN4, 15-17	
				Below-grade walls	R-7.5 c.i. (Comply with Standard 90.1" in 3A	EN5, 15-17	
	Component	Recomme	ndatic	on	How	-to <sup>-</sup>	Tips
			Continuous air barriers	Continuous air barriers Window-to-wall ratio	Entire building envelope 40% of net wall (floor-ceiling)	EN13 DL7, EN20	
				Thermal transmittance	Nonmetal framing windows = 0.56	EN18-20, 22-25	
			Vertical fenestration (full assembly—NFRC rating)	Solar heat gain coefficient (SHGC)	Nonmetal framing windows = 0.65 Nonmetal framing windows = 0.41	EN19-20, 23-25	
				Light-to-solar gain ratio (LSG)	All orientations ≥ 1.5	EN24	
	$\mathbf{w}$ to line of	ntoin		Exterior sun control	South orientation only - PF = 0.5	EN21, DL13-14	
( )	VV = (0) + (0) S (10)			All spaces	IEQ 8.1 (daylighting) and IEQ 8.2 (views)	DL3-6	
		mann		Diagnostic and treatment block	Shape the building tootprint and form such that the area within 15 ft of the perimeter exceeds 40% of the floorplate.	DL6	
			Form-driven daylighting option	Inpatient units	Ensure that 75% of the occupied space not including patient rooms lies within 20 ft of the parimeter.	DL6	
Ś	Specific			Staff areas (exam rooms, nurse stations, offices, corridors); public spaces (waiting, reception); and other regularly occupied spaces as applicable	Design the building form to maximize access to natural light, through sidelighting and toplighting.	DL8-14, 20-23	
			Nonform-driven daylighting option	Staff areas (exam rooms, nurse stations, offices, comdors) and public spaces (waiting, reception)	Add daylight controls to any space within 15 ft of a perimeter window.	DL20-23	
10	aaammandati	000	Interior finishes	Room interior surface average reflectance	Ceilings ≥ 80% Walls ≥ 70%	DL17	
	ecommenuali	ONS	10 III	Lighting power density (LPD)	Whole building = 0.9 W/th <sup>2</sup> Space-by-space per Table 5-4 T8 & T5 > 2 ft = 92	EL1, 12-20	
				Light source efficacy (mean lumens per watt)	T8&T5<2ft=85	EL2-5	
			5		All other >50		
- (	Luidanco on c	boor	Interior lighting	Ballasts-4 ft T8 Lamps	Dimming= NEMA Premium Dimming= NEMA Premium Program Start	EL2	
' \				Ballasts—Fluorescent and HID Dimming controls daylight harvesting	Electronic Dim all fixtures in daylighted zones.	EL2-5 DL20-23, EL11	
		,		Lighting controls-General	Manual ON, auto/timed OFF in all areas as possible.	EL6,21	
	(* K			Surgery task lights	Use LED lights exclusively.	EL14	
r	vractica tor			Exit signage	0.1-0.2 W Light Emitting Capacitor (LEC) exit signs exclusively	EL22	
	חמטווטס וטו			Façade and landscape lighting	LPD = 0.15 W/# <sup>2</sup>	EL23	
			Exterior lighting	All other exterior lighting	LPD = 0.1 W/ft <sup>-</sup> LPD = Comply with Standard 90.1*	EL23 EL23	
1.				Computers	Auto reduce to 25% (12 am-6 am) Laptops = minimum 2/3 of total computers All others = mini dealton computers	PL2	
	nnementatio		Equipment choices	ENERGY STAR® equipment	All computers, equipment, appliances	PL5	
				Vending machines	Delamp and specify best in class efficiency.	PL3, 7	
			Ē	Computer power control	and control during unoccupied hours or IT enterprise power management software	PL2	
			Controls	Occupancy sensors	Office plug occupancy sensors Water coolers, coffee makers, small	PL3	
(	Ve of another's			Timer switches	appliances = auto OFF during unoccupied	PL3	

## How-to Tips

Туре	Abbreviation	Number of Tips
Envelope	EN	29
Daylighting	DL	23
Electric lighting	EL	24
Plug and process loads	PL	17
Water heating	WH	7
HVAC	HV	40
Quality Assurance	QA	15
Add	itional Bonus Savin	gs
Additional HVAC	HV	5
Renewable energy	RE	4
Electrical distribution	ED	3

## **How-to Tip Examples**



## More How-to Tips

#### **Tables of Information**

Table 5-5 Efficacy Values for Different Linear Fluorescent Lamp/Ballast Combinations (with Two Lamps)

Pallast	Lamp Selection						
Dallast	F32T8 Standard	F32T8 Premium	F32T8 High Performance	F28T5 Standard	F28T5 Premiun		
Generic Standard Instant Start (59 W, 0.87 BF-T8/1.0 T5)	77	80	87	NA	NA		
Standard Instant Start Low Light Level (54 W, 0.78 BF)	75	78	85	NA	NA		
Standard Instant Start High Light Level (74 W, 1.15 BF)	81	84	92	NA	NA		
Standard Program Start Normal Light Level (60 W, 0.88 BF)	78	82	88	95	100		
Program Start Low Light Level (56 W, 0.78 BF)	73	75	82	NA	NA		
Dimming Rapid Start (64 W max, 0.88 BF-T8/1.0 T5)	72	75	81	NA			
High-Performance Normal Light Level (55 W, 0.88 BF-T8/	85	90	95	95	с		
High-Per Leve ENI	Cool Roof:	(Climate Zor	nes: 0 0 0)		ca pa		
High-Per Leve	For a roof to be considered a cool roof, a Solar Reflectance Index (S) ormended. A high effectance keeps much of the surgements from						
High-Pe Step (54 W,	high therma roof to cool cial roof pro and metal p	d emissivity sur- more rapidly. Co ducts that qualif anels. Examples	ool roofs are typicall y as cool roofs fall in are presented in Tabl	y solar energy t y white and hav to three categor e 5-1.	hat so c a i liç ies: tu		

#### Table 5-1 Examples of Cool Roofs

Category	Product	Reflectance	higher	quality lig
()	White polyvinyl chloride (PVC)	0.86	"safer"	feeling for
Circula alte	White chlorinated polyethylene (CPE)	0.86	1.0000000	
Single ply	White chlorosulfonated polyethylene (CPSE)	0.85		199
	White thermoplastic polyolefin (TSO)	0.77	0.87	95
tionid position	White elastomeric, polyurethane, acrylic coating	0.71	0.86	86
Liquid applied	White paint (on metal or concrete)	0.71	0.85	86
Metal panels	Factory-coated white finish	0.90	0.87	113

#### **Climate Zones Specified**

#### EN7 Floors, Metal Joist, or Steel Framed (Climate Zones: all)

ulation should be installed parallel to the framing members and in intimate contact with the oring system supported by the framing member in order to avoid the potential thermal shortuiting associated with open or exposed air spaces. Nonrigid insulation should be supported m below and no less frequently than 24 in. on center.

#### tb-on-Grade Floors, Unheated (Climate Zones: 📀 🐵 🙃 🕢 🕲)

jid c.i. should be used around the perimeter of the slab and should reach the depth listed in recommendation or to the bottom of the footing, whichever is less,

#### ub-on-Grade Floors, Heated (Climate Zones: all)

ntinuous rigid insulation should be used around the perimeter of the slab and should reach to depth listed or to the frost line, whichever is deeper. Additionally, in climate zone 8, continis insulation should be placed below the slab as well.

Note: In areas where termites are a concern and rigid insulation is not recommended for under the slab, a different heating system should be used.

#### **Cleveland Clinic 100th Street Garage**

eveland Clinic is a large, multispecialty, not-for-profit, academic medical center whose main npus is located in Cleveland, Ohio. In 2011, Cleveland Clinic used the CBEA high-efficiency rking structure lighting specification as the basis of award for conversion of their 100th Street age from high-pressure sodium to LED. The garage is 970,250 ft<sup>2</sup> with over 1500 parking ices on six partially closed floors and a rooftop level. There are 830 main garage fixtures, 28 lighting fixtures on the roof, and 65 stairwell fixtures. In addition to being a lower wattage urce, LED allowed step dimming not possible with the existing lights. 620 of the replacement hts used occupancy sensors to toggle between a high and low power setting, and the 218 fixes closest to the perimeter used photo and occupancy sensors.

The energy savings per year is 1,276,583 kWh per year, yielding a 4.2 year simple payback. With ility incentives, the payback was reduced to 3.2 years. In addition to the energy savings, the igher quality light allowed a better performance for existing security cameras and an overall safer" feeling for patients and staff.

#### **Highlighted Information**

## **Building Envelope Recommendations**

#### Climate Zone 3 Recommendation Table for Table for Large Hospitals

	Item	Component	Recommendation	How-to Tips	1
	Form/space planning	Proper zoning	Group similar space types within the building footprint.	DL46	
	Roofs	Insulation entirely above deck	R-25.0 c.i.	EN2, 15–17	
<ul> <li>Vertical Fenestration</li> <li>Window to wall Ratio: 40%</li> <li>Thermal Transmittance: Nonmetal 6</li> <li>SHGC: Nonmetal framing 0.41, Metal</li> <li>Light-to-solar gain ratio: ≥ 1.5</li> <li>Exterior sun control: South orientation</li> </ul>			0.56, Metal 0.65 al framing 0.6 ation Projection Facto	or = 0.5	
		Window-to-wall ratio	40% of net wall (floor-ceiling)	DL7, EN20	
	Vertical feature	Thermal transmittance	Metal framing windows = 0.55 Metal framing windows = 0.65	EN18-20, 22-25	
	(full assembly—NFRC rating) Solar heat gain coefficient (SHGC)		Nonmetal framing windows = 0.41 Metal framing windows = 0.6	EN19-20, 23-25	
		Light-to-solar gain ratio (LSG)	All orientations ≥ 1.5	EN24	
		Exterior sun control	South orientation only - PF = 0.5	EN21, DL13-14	

## Lighting Recommendations

	All spaces	Comply with LEED for healthcare credits IEQ 8.1 (daylighting) and IEQ 8.2 (views)	DL3-6
	Diagnostic and treatment block	Shape the building footprint and form such that the area within 15 ft of the perimeter exceeds 40% of the floorplate.	DL6
Form-driven daylighting option	Inpatient units	Ensure that 75% of the occupied space not including patient rooms lies within 20 ft of the perimeter.	DL6
	Staff areas (exam rooms, nurse stations, offices, corridors); public spaces (waiting, reception); and other regularly occupied spaces as applicable	Design the building form to maximize access to natural light, through sidelighting and toplighting.	DL8-14, 20-23
1 10 11 10 10 10 10 10 10 10 10 10 10 10	Staff areas (exam rooms, nurse stations,	Add daylight controls to any space within 15	200300

- Form-driven daylighting option (design the building to maximize access to natural light, sidelighting, toplighting
- Non form-driven daylighting option (any space within 15 feet of perimeter window)
- Interior finishes
- Interior lighting
- Exterior lighting

Exit	sig	nag

Exterior lighting

All other exterior lighting

Façade and landscape lighting Parking lots and drives

0.1–0.2 W Light Emitting Capacitor (LEC) exit signs exclusively	EL22
LPD = 0.15 W/ft <sup>2</sup>	EL23
LPD = 0.1 W/ft <sup>2</sup>	EL23
LPD = Comply with Standard 90.1* Auto reduce to 25% (12 am-6 am)	EL23

## **Daylighting Example**





### **Electric Lighting: LDR**



Figure 5-24 (EL17) Labor, Deliver, and Recovery (LDR) Lighting Plan

## **Plug Load Recommendations**

Equipment/Appliance Type	Purchase Recommendation	Operating Recommendation
Desktop computer	ENERGY STAR only	Implement sleep mode software
Laptop computer or tablet —use where practical to minimize energy consumption	ENERGY STAR only	Implement sleep mode software
Computer monitors	ENERGY STAR flat screen monitors only	Implement sleep mode software
Printer	Consider multifunction devise, ENERGY STAR only	Implement sleep mode software
Copy machine	Consider multifunction devise, ENERGY STAR only	Implement sleep mode software
Fax machine	Consider multifunction devise, ENERGY STAR only	Implement sleep mode software
Water Cooler	ENERGY STAR only	N/A
Refrigerator	ENERGY STAR only	N/A
Vending machines	ENERGY STAR only	De-lamp display lighting
TV, VCR, DVD, DVR	ENERGY STAR with flat screens and sleep modes	Many of these items are only used during peak times and should be upplugged with occupancy sensors

#### Table 5-8 Recommendations for Efficient Plug Load Equipment

### Plug and Process Load Recommendations

- **Computers:** laptops = minimum 2/3 of total computers, Power savings during unoccupied hours
- Energy Star<sup>®</sup>: computers, equipment appliances
- Vending machines: delamp and specify best in class efficiency
- Occupancy sensors: office plugs
- **Timer switches:** coffee makers, small appliances during unoccupied hours
- **Kitchen equipment**: Cooking equipment, refrigeration equipment, exhaust hoods
- **Elevators**: traction for all, regenerative traction for high-use

dd			refrigerant, evaporative condenser	
		Exhaust hoods	Side panels, larger overhangs, rear seal at appliances, proximity hoods, VAV demand- based exhaust	PL8, 10, 13
	Process loads	Elevators	Use traction elevators for all elevators, and use regenerative traction elevators for all high-use elevators.	PL16

## **Food Service and Refrigeration**

Table 5-9	commercial Food Service Appliance ASTM Standard Test Methods			
ASTM #	Appliance Type			
F1275-03	Griddles			
F1361-05	Open deep-fat fryers			
F1484-05	Steam cookers			
F1496-99(2005)	Convection ovens			
F1521-03	Standard test methods for performance of range tops			
F1605-95(2001)	Double-sided griddles			
F1639-05	Combination ovens			
F1695-03	Underfired broilers			
F1696-96(2003)	Energy performance of single-rack hot-water sanitizing, door-type comm dishwashing machines	ercial		
F1704-05	Capture and containment performance of commercial kitchen exhaust ver systems	ntilation		
F1784-97(2				
F1785-97(2	Table 5-10 Refrigeration	on Technology Savings I	Estimates and Application	ons
F1786-97(2	-			
F1787-98(2	Technology	Estimated Savings	Applicable To New	Applicable To
F1817-9	rechnology	Potential (NRC 2011)	Construction?	Retrofit?
F1920-98(2			Construction.	Retront
F1964-99(2	Floating head pressure controls	3% to 10%	Yes	Yes
F1905-99(2	Liquid proceuro omplifior	Lip to 20%	Voc	Voc
F 1991-99(2	Liquid pressure ampliner	001020%	162	Tes
F2093-0	Subcooled liquid refrigerant			
F2140-0 F2141-0	Oversized condenser	5% to 9%	Yes	No
F2142-0	Mechanical subcooler	Up to 25%	Yes	Yes
F2143-0		00102070	100	100
F2144-0	Evaporative condensers	3% to 9%	Yes	Yes
F2237-03	Upright overnired brollers			
F2238-03	Rapid cook ovens			
F2239-03	Conveyor broilers			
F2324-03	Prerinse spray valves			
F2379-04	Powered open warewashing sinks			
F2380-04	Conveyor toasters			
F2472-05	Staff-served hot-deli cases			
F2473-05	Water bath rethermalizers			
F2474-05	Heat gain to space performance of commercial kitchen ventilation/appliance	systems		
F2519-05	Grease particle capture efficiency of commercial kitchen filters and extra	actors		
F2644-07	Commercial patio heaters	•		

Table 5-9 Commercial Food Service Appliance ASTM Standard Test Methods

Commercial patio heaters

### Service Water Heating Recommendations

HWS		Gas water heater (condensing)	95% Efficiency	WH3, HV8 PL11, WH3 WH3
	Service under heating	Point-of-use water heater	0.81 EF or 81% Et	
	Service water realing	Electric-heat-pump water heater	eat-pump water heater 2.33 EF WH3	
		Pipe insulation ( $d \le 1.5$ in./ $d \ge 1.5$ in.)	1.0 in/1.5 in.	WH3, HV8 PL11, WH3 WH3 WH7

#### Service water heating

- Gas water heater: condensing, 95% efficiency
- Point-of-use water heater: 0.81 EF or 81% Et
- Electric-heat-pump water heater: 2.33 EF
- **Pipe insulation**: 1.0 in. for d < 1.5 in., 1.5 in. for  $d \ge 1.5$  in.

#### **Heating system**

- No central steam for hot-water distribution system
- Point-of-use steam for humidification and sterilization

### Measurement and Verification Recommendations

¥		Electrical submeters	Design and circuit for separate submeters for lighting, HVAC, general 120V, service water heating, renewables, and whole building	QA12-14	
<b>Q</b> 8	80	Measurement and ventication	Benchmarks	Benchmark monthly energy use.	QA15
			Training	Facility operator on continuous benchmarking	QA12-15

- Electrical submeters: lighting, HVAC, general 120V, service water heating, renewables, whole building
- Benchmarks: monthly energy use
- **Training:** facility operator on continuous benchmarking

### **Case Studies**

#### SWEDISH ISSAQUAH HOSPITAL A CASE STUDY

Located in the Issaquah Highlands near Seattle, Washington, Swedish Issaquah is a 350,000 ft<sup>2</sup>, four-story acute-care hospital with 175 beds, and is the first greenfield hospital to be built in King County in 25 years. When fully complete, it will be part of a 550,000 ft<sup>2</sup> campus that includes the acute-care hospital (composed of emergency, surgery, imaging, labor and delivery, pediatrics, intensive-care unit, cancer, and medical/surgical facilities), a 200,000 ft<sup>2</sup> emedical office building (MOB), and a stand-alone central utility plant (CUP) connected by a utility tunnel.

#### INTEGRATED DESIGN

Design began in May of 2009 with an EUI target of 150 kBtu/ft<sup>2</sup>-yr or lower. Similar hospitals in the Pacific Northwest have an EUI of about 260–265 kBtu/ft<sup>2</sup>-yr. Using an integrated project delivery approach, all the stakeholders were brought together early in the process. This spirit of cooperation and involvement extended through completion of construction and included the pipe fitters and sheet metal installers. Once it was understood that efficiency was a key element of the design, even the number of pipe bends and duct offsets became important.

The design team met weekly to discuss how best to expedite design. The integrated design approach carried through into the roles and responsibilities shared by the mechanical design engineer and contractor. All major equipment, pipe racks, ductwork, skids, and assemblies



Annual Energy End-Use Breakdown (EUI) Modeled EUI = 135 kBtu/ft<sup>2</sup> yr





Energy Savings Analysis				
Strategy	Total Cost	Annual Energy Savings	Simple Payback	
Light Occupancy Sensors		\$22,941	1	
VAV	\$973,047	\$342,183	3 years	
Heat Recovery System	\$1,103,971	\$115,081	10 years	
Low Static Pressure AHUs	\$398,312	\$31,742	13 years	
Low Static Pressure Ducts	\$314,983	\$19,538	16 years	
VSD Chiller	\$208,998	\$11,144	19 years	

Examples of High Performance Buildings – Demonstrates Flexibility in Achieving Advanced Energy Savings

## **Technology Examples**



## HV1 – First Tip

#### HV1 – Thermal Zoning

"Coordinate the location of nonclinical spaces so that they can be served by HVAC systems that can be setback or shut down when their locations are unoccupied (with temperature setback control and optimized start up). Typical examples are administration and finance offices, dining, outpatient services, and occupational/physical therapy areas."

# Major Energy Uses in a Large Hospital



Figure 3-1 Comparison of Baseline to Prescriptive 50% AEDG Solution Showing Breakdown of Energy Savings Components

### **Aggressively Address Reheat**



Figure 3-18 Reheat Energy (in Red) Compared to other Energy Uses in Healthcare Facilities

- Supply dry air to OR
- Recover heat from chilled water system

# 50% Advanced Energy Design Guide for Large Hospitals

### HVAC systems included in tables:

#### Surgery areas

• Chilled-water air-handling system

#### Non-surgery areas

- Water-source heat pumps with a dedicated outdoor-air system (DOAS)
- Four-pipe fan coils with DOAS
- Chilled-water VAV air-handling system with separate OA treatment

## 50% AEDG for Large Hospitals Surgery Areas

- Chiller plant
  - Chiller: 6.50 COP (0.54 kW/ton) full load
  - $15^{\circ}$  F chilled water  $\Delta T$
  - 14° F condenser water  $\Delta T$
  - Variable-speed cooling tower fans
  - Control to minimize chiller + tower energy
- Central, chilled-water AHU
  - Consider series desiccant wheel for low dew-point applications

## Use AEDG recommendations to Balance Installed and Operating Costs

- Reduced flow rates results in
  - Smaller pumps, pipes, and cooling towers
  - Lower operating costs
- Variable primary flow results in
  - Fewer pumps
  - Lower operating costs
- Heat recovery chillers result in
  - Reduced energy purchased for reheat
  - Reduced tower energy, make-up water and water treatment costs



## **Aggressively Address Reheat**



while minimizing reheat energy

Dual-Path Air Handler Treat outdoor air separately

# 50% AEDG for Large Hospitals WSHPs with DOAS

## • WSHPs

- Two-stage or variable-speed compressors
- Variable-speed fans
- $\geq$  4 tons, but encouraged for smaller units also
- Cooling: 17.6 EER (part load), 15.0 EER (full load)
- Heating: 5.7 COP (part load), 5.0 COP (full load)
- Dedicated OA system
  - Deliver air cold when possible
  - Exhaust-air energy recovery (60% effective)
  - Demand-controlled ventilation

## 50% AEDG for Large Hospitals Fan-Coils with DOAS

- Multiple-speed or variable-speed fans
- Chiller plant
  - Chiller: 6.50 COP (0.54 kW/ton)
  - $15^{\circ}$  F chilled water  $\Delta T$
  - 14° F condenser water  $\Delta T$
  - Variable-speed cooling tower fans
  - Control to minimize chiller + tower energy
- Dedicated OA system
  - Deliver air cold when possible
  - Exhaust-air energy recovery (60% effective)
  - Demand-controlled ventilation

## **How-To Tips**

HVAC			Water-cooled chiller	6.5 COP	HV8, 35	
	Water-circulation pumps	Water-circulation pumps	VFD and NEMA premium	HV35		
		Cooling towers VFD on tower fans	VFD on tower fans	HV37		
	ery		Boiler efficiency	90% Ec	HV8	
	S.	Fan-coil system with DOAS	Maximum fan power	0.4 W/cfm	HV21-22, 24	
	Suo	FCU fans Multiple speed	Multiple speed	HV5		
z	A (humid Exhaust-air energy recovery in DOAS C (marine	A (humid zones) = 60% total effectiveness B (dry zones) = 60% sensible effectiveness C (marine zones) = 60% total effectiveness	HV9, 15–16			
			DOAS ventilation control	DCV with VFD	HV10-11	

HV5	Fan-Coils w	The cooling equipment, heating equipment, and fans should meet or exceed	the efficiency
	In fan-coil sy levels listed in the recommendation tables in Chapter 4 or listed in this chapter		
	factory desig cooling equipment should also meet or exceed the part-load efficiency level, when		
	and possibly	formance requirements for ducted fan coils are (1) 0.30 W/cfm design supply a	air to a space
	Fan coils with VAV operation and (2) coil chilled-water $\Delta T$ s of at least 14°F.		
	corridor (or some other noncritical space), or in a closet adjacent to the space (see the WSHP		
figure in HV2 as an example). However, the equipment should be located to meet the acoustic			
goals of the space; this may require that the fan coils be located outside of the space while also			
attempting to minimize fan power, ducting, and wiring. Fan coils should be equipped with a			
	variable-spee	ed fan to automatically enable VAV operation and enhance motor efficiency.	
	All the fa	an coils are connected to a common water distribution system. Cooling is provided	

## 50% AEDG for Large Hospitals Chilled-Water VAV System

- Separate treatment of OA
  - Exhaust-air energy recovery (60% effective)
  - Demand-controlled ventilation
- Chiller plant
  - Water-cooled heat recovery chiller: 4.55 COP
  - Water-cooled cooling-only chiller: 6.50 COP
  - $15^{\circ}$  F chilled water  $\Delta T$
  - 14° F condenser water  $\Delta T$
  - Variable-speed cooling tower fans
  - Control to minimize chiller + tower energy

## **Demand Control Ventilation**

- Sensing technologies
  - CO2 sensors in densely occupied spaces
  - Occupancy sensors where population variation is minimal
  - Time-of-day for zones that are sparsely occupied or predicted occupancy patterns
- Std 170
  - "Reduce airflow rates during unoccupied hours in surgery rooms and other spaces with minimum air-change requirements"
  - Maintain pressurization requirements

## **High-Performance VAV System**

### **Optimized VAV system controls**

- Optimal start/stop
- Fan-pressure optimization
- Supply-air-temperature reset
- Ventilation optimization (including demand-controlled ventilation)



## **Additional Bonus Savings**

- Other HVAC Strategies
- Radiant Heating/Cooling with Displacement Ventilation, Fan Arrays, Evaporative Condensing,
- Combined Heat and Power, Water Restricted Locations
- Renewable Energy
- Photovoltaic, Wind Turbine, Solar Hot Water Systems, Power Purchase Agreements
- Electrical Distribution
- Transformer Efficiency, System Design, Metering

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