

# Introduction and Overview to the Advanced Energy Design Guide for K-12 School Buildings

ASHRAE Summer Meeting – Seminar 60

June 25, 2008

Paul A. Torcellini, Ph.D., P.E.

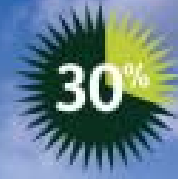
National Renewable Energy Laboratory

[www.nrel.gov](http://www.nrel.gov)

[www.highperformancebuildings.gov](http://www.highperformancebuildings.gov)

# Material to be Covered

- Development of the Guide
- What's in the Guides?
  - Foreword
  - Design Process
  - Recommendations
  - Case Studies
  - How to Tips
- Introduction of following presentations



## Advanced Energy Design Guide for K-12 School Buildings

Achieving 30% Energy Savings  
Toward a Net Zero Energy Building



Developed by:  
American Society of Heating, Refrigerating, and Air Conditioning Engineers  
The American Institute of Architects  
Sustaining Engineering Society of North America  
U.S. Green Building Council  
U.S. Department of Energy



# Development of the Guide

- Collaboration of Partner Organizations
- Management via a Steering Committee
- Volunteer team effort
- Focus group for conceptual review
- 65% and 90% reviews

# Project Committee Members

Paul Torcellini – <i>Chair</i>	
Merle McBride- <i>Vice Chair</i>	John Murphy- <i>SBIC Representative</i>
Don Colliver- <i>Steering Committee Liaison</i>	Mike Nicklas- <i>AIA Representative</i>
Jim Benya- <i>IESNA Representative</i>	Kathleen O’Brien- <i>AIA Representative</i>
Bill Brenner- <i>NCEF / NIBS Representative</i>	Larry Schoff- <i>USGBC Representative</i>
Leslie Davis- <i>IESNA Representative</i>	Jyoti Sharma- <i>USGBC Representative</i>
Charles Eley- <i>CHPS Representative</i>	Bruce Hunn- <i>ASHRAE Staff Liaison</i>
Milton S. Goldman, M.D. - <i>ASHRAE TC 9.7 Representative</i>	Lilas Pratt - <i>ASHRAE Staff Liaison</i>
Carol Marriott - <i>ASHRAE SSPC 90.1 Representative</i>	Shanti Pless- <i>Analysis Support</i>

# Guide Goal

- Present *some ways, but not all or the only way* to build energy efficient schools that use significantly less energy than those built to the minimum code requirements
- At least 30% energy savings when compared to ANSI/ASHRAE/IESNA Std. 90.1-1999
- 30% progress toward a net zero energy building

# Development Objectives

- Content
  - Specific recommendations (prescriptive measures) and design strategies (how to tips)
- Target Market:
  - Decision makers
  - Designers and engineers
- Format
  - Short, easy to use
  - How-to guidance
  - Examples and case studies
- Publication Type
  - Special Publication
  - Subject to Review
  - Not a code or Standard
- Useable for LEED



# Scope

- All new elementary, middle, and high schools
- Typical Space types
  - Classrooms
  - Administrative
  - Corridors
  - Restrooms
  - Gyms
  - Assembly
  - Kitchen
  - Media Centers
- Space types not covered
  - Pools
  - Wet Labs
  - Wood working or Auto shop
  - Field Lighting

# Development of Recommendations

- Recommendations for envelope, lighting, HVAC, and Service Hot Water that achieve at least 30% whole building energy savings
  - Additional Savings Strategies included, but not needed for 30%
  - Use practical off-the-shelf technologies and strategies available from multiple manufactures
- Energy is independent variable & cost-effectiveness (e.g. payback) is dependent variable
- Recommendations modeled to verify 30% savings

# What's in the Guide?

- Foreword – A Message to School Administrators and School Boards (unique to K12)
- Section 1 – Introduction – Essentials of Achieving the Savings
- Section 2 - Integrated design process to achieve energy savings (*how to integrate energy into the design of the building*)
- Section 3 -Recommendations by climate zone (*the specifics*)
- Section 4- Case Studies to show example building designs
- Section 5 - How-to guidance for implementing recommendations (*helpful hints and cautions*)

# Foreword

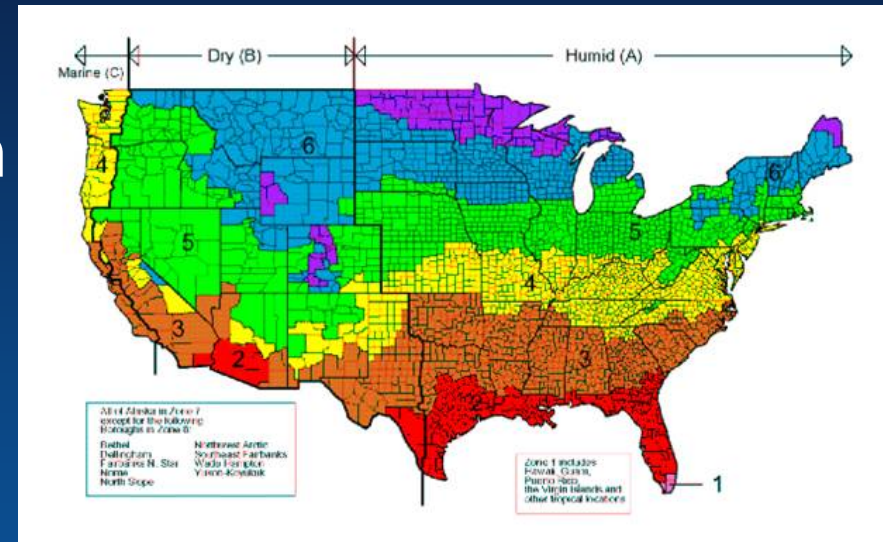
- A message to School Administrators and School Boards
  - Improved Learning Environment
  - Reduced Operating Costs
  - Lower Constructions Costs and Fast Paybacks
  - More Support for Construction Funding
  - Enhanced Environmental Curriculum
  - Energy Security
  - Water as a Resource
  - Reduced Greenhouse Gas Emissions
  - Achieving the 30% Energy Savings Goal
  - A Goal within Reach

# Using an Integrated Design Approach to Achieve Energy Savings

- A narrative discussion of the design and construction process that points out the opportunities for energy savings in each phase of design
- Includes reference tables that leads the user through the process of identifying, selecting energy savings measures, and defining the responsible party to meet major energy design goals

# Recommendation Tables by Climate

- Unique set of recommendations given by climate zone
- Combined energy savings based on “systems approach”
  - All recommendations are used
- Recommendations based hourly computer simulations



# Recommendation Categories

- Envelope
  - Roofs
  - Walls
  - Slabs
- Fenestration
  - Doors
  - Windows
- Lighting and Daylighting Systems
  - Daylit and Non-daylit Options
  - LPDs
  - System Efficacy
  - Controls
- HVAC
  - Unitary Roof Tops
  - Heat Pumps
  - Unit Ventilators
  - Fan Coil
  - Package VAV
  - VAV
  - Ducts and Dampers
- Service Hot Water

Climate Zone 6 Recommendations for K-12 Schools

Item	Component	Recommendation	
Packaged DX Rooftops (or DX Split Systems)	Air conditioner (>240 kBtu/h)	Comply with Standard 90.1*	
	Heat pump (<85 kBtu/h)	13.0 SEER/7.7 HPSF	
	Heat pump (>85 and <135 kBtu/h)	Comply with Standard 90.1*	
	Heat pump (>135 kBtu/h)	Comply with Standard 90.1*	HV
	Gas furnace (<225 kBtu/h)	80% AFUE or E <sub>1</sub>	
	Gas furnace (>225 kBtu/h)	80% E <sub>1</sub>	
	Economizer	>54 kBtu/h	HV
	Ventilation	Energy recovery or demand control	HV
Fans		Constant volume: 1 hp/1000 cfm Variable volume: 1.3 hp/1000 cfm	HV
WSHP System	Water-source heat pump (<85 kBtu/h)	Cooling: 12 EER at 85°F; Heating: 4.5 COP at 68°F	HV
	Water-source heat pump (>85 kBtu/h)	Cooling: 12 EER at 85°F; Heating: 4.2 COP at 68°F	
	GSHP (<85 kBtu/h)	Cooling: 14.1 EER at 77°F and 17 EER at 59°F Heating: 3.5 COP at 32°F and 4.0 COP at 50°F	HV
	GSHP (>85 kBtu/h)	Cooling: 13 EER at 77°F and 18 EER at 59°F Heating: 3.1 COP at 32°F and 3.5 COP at 50°F	
	Gas boiler	85% E <sub>1</sub>	HV
	Economizer	Comply with Standard 90.1*	HV
	Ventilation	DOAS with either energy recovery or demand control	HV
WSHP duct pressure drop	Total ESP < 0.2 in. H <sub>2</sub> O	HV	
Unit Ventilator and Chiller System	Air-cooled chiller efficiency	9.6 EER 11.5 IPLV	HV
	Water-cooled chiller efficiency	Comply with Standard 90.1*	HV
	Gas boiler	85% E <sub>1</sub>	HV
	Economizer	>54 kBtu/h	HV
	Ventilation	Energy recovery or demand control	HV
	Pressure drop	Total ESP < 0.2 in. H <sub>2</sub> O	HV
Fan Coil and Chiller System	Air-cooled chiller efficiency	9.6 EER 11.5 IPLV	HV
	Water-cooled chiller efficiency	Comply with Standard 90.1*	HV
	Gas boiler	85% E <sub>1</sub>	HV
	Economizer	Comply with Standard 90.1*	HV
	Ventilation	DOAS with either energy recovery or demand control	HV
Pressure drop		Total ESP < 0.2 in. H <sub>2</sub> O	HV
Packaged Rooftop VAV System	Rooftop air conditioner (>240 kBtu/h)	Comply with Standard 90.1*	HV
	Gas furnace (>225 kBtu/h)	80% E <sub>1</sub>	
	Gas boiler	85% E <sub>1</sub>	HV
	Economizer	>54 kBtu/h	HV
	Ventilation	Energy recovery or demand control	HV
	Fans		4.0 hp/1000 cfm

# Climate Zone Tables

- Prescriptive recommendations help to achieve energy savings without calculations or analysis
- Energy-saving recommendations for each climate zone contained in table
  - 2½ pgs
- Tables color-coded to maps
- Note references to “how-to” section
- “No Rec” – means the more stringent of either 90.1 or local code requirements (no additional recommendations)

**Climate Zone 6 Recommendations for K-12 Schools**

	Item	Component	Recommendation	How-To Tip	
Envelope	Roofs	Insulation entirely above deck	R-25 c.i.	EN1, EN2	
		Attic and other	R-38	EN3, EN15, EN16, EN18	
		Metal building	R-13.0 + R-19.0	EN3, EN15, EN18	
		SRI	Comply with Standard 90.1*	EN1	
	Walls	Mass (>HC > 7 BtuWf)	R-13.3 c.i.	EN5, EN15, EN18	
		Steel framed	R-13 + R-7.5 c.i.	EN6, EN15, EN18	
		Wood framed and other	R-13 + R-7.5 c.i.	EN7, EN15, EN18	
		Metal building	R-19 + R-5.6 c.i.	EN8, EN15, EN18	
	Floors	Below-grade walls	R-7.5 c.i.	EN8, EN15, EN18	
		Mass	R-13.3 c.i.	EN9, EN15, EN18	
Slabs	Steel framed	R-30	EN10, EN15, EN18		
	Wood framed and other	R-30	EN10, EN15, EN18		
Doors	Unheated	R-10 for 24 in.	EN11, EN17, EN18		
	Heated	R-15 for 24 in.	EN12, EN17, EN18		
Vertical Fenestration	Swinging	Nonswinging	U-0.700	EN6, EN18	
		Swinging	U-0.50	EN13, EN18	
	Total fenestration to gross wall area ratio	Nonswinging	35% max	EN20	
		Swinging	35% max	EN20	
		Thermal transmittance—all types and orientations	U-0.42	EN19, EN24, EN28	
		SHGC—all types and orientations	SHGC-0.40	EN19, EN24, EN28	
Lighting	Interior Finishes	Exterior sun control (S, E, W only)	Projection factor > 0.5	EN21, EN23, EN26	
		Interior room surface average reflectance	70%+ on ceilings and walls above 7 ft 50%+ on walls below 7 ft	DL14, EL1	
	Classroom daylighting (daylighting fenestration to floor area ratio)	Toplighted—	South-facing roof monitors: 8%–11% North-facing roof monitors: 12%–15%	DL1–19, DL28–35	
		Skidlighted—	South-facing: 8%–11% North-facing: 15%–20%	DL1–19, DL20–27	
		Combined toplighted and skidlighted—	South-facing skidlighted: 6%–8% Toplighted: 2%–3% North-facing skidlighted: 9%–13% Toplighted: 3%–5%	DL1–19, DL20–35	
		Gym toplighting (daylighting fenestration to floor area ratio)	South-facing roof monitors: 5%–8% North-facing roof monitors: 7%–10%	DL1–19, DL36, DL37	
	Interior Lighting—Daylighted Option	LPD	Light source system efficacy (linear fluorescent)	1.2 Wf/ maximum	EL9–16
			Light source system efficacy (all other sources)	50 mean lmW minimum	EL2, EL 3, EL5
		Occupancy controls	Manual on, auto off all zones	Manual on, auto off all zones	EL6, EL8, DL16
			Dimming controls daylight harvesting	Dim fixtures in classrooms and gym and other fixtures within 15 ft of skidlighting edge and within 10 ft of toplighting edge	DL16
Interior Lighting—Nondaylighted Option		LPD	Light source system efficacy (linear fluorescent)	1.1 Wf/	EL9–16
			Light source system efficacy (all other sources)	50 mean lmW minimum	EL2, EL3, EL5
	Occupancy controls	Manual on, auto off all zones	Manual on, auto off all zones	EL6, EL8, DL16	
		Dimming controls daylight harvesting	Dim fixtures within 15 ft of skidlighting edge and within 10 ft of toplighting edge	DL16	
HVAC	Packaged DX Rooftops (or DX Split Systems)	Air conditioner (<65 kBtu/h) Air conditioner (>65 and <135 kBtu/h) Air conditioner (>135 and <240 kBtu/h) Air conditioner (>240 kBtu/h) Heat pump (<65 kBtu/h)	Comply with Standard 90.1* Comply with Standard 90.1* Comply with Standard 90.1* Comply with Standard 90.1* 13.0 SEER/7.7 HPSF	HV1, HV7, HV8, HV10	

\* Note: If the table contains “Comply with Standard 90.1” for a component, the user must meet the more stringent of either the applicable version of ASHRAE Standard 90.1 or the local code requirements.

# Case Studies

- Features real examples of advanced building energy designs
- Demonstrates flexibility offered in achieving advanced energy savings levels
- Text describes energy features used
- Tables are given for energy savings features implemented and measured energy usage in each case study



# “How-To” Implement Recommendations

- “How to’s” organized by building system
  - Good design practices
  - Cautions
  - References
- Each “how to” numerically referenced in recommendation tables
- Gives Good Design Practice – i.e. The “rules-of-thumb” and “should considers”
- A greatly expanded section on daylighting design concepts—more on this later

# **“How-To” Implement Recommendations Additional Savings**

- Electrical Distribution System
- Plug and Phantom Loads
- Ground Source Heat Pumps
- Thermal Storage
- Thermal Displacement Ventilation
- Photovoltaic Systems
- Energy Efficient Schools as a Teaching Tool
- Exterior Lighting

# Summary

- The K-12 AEDG provides simple, easy-to-use recommendations
- Clear prescriptive path to 30% savings
- Recommendations easily found in a single location
- How-to tips and Additional Savings
- Case Studies of Actual Applications
- Slightly different from previous AEDGs:
  - More complex buildings & not limited on size
  - Greater emphasis on daylighting
  - Greater variety of HVAC systems
  - Recommendations tables have more options
- LEED awards 4 EA Credit 1 points for using the Guide

# Availability

- Free download of pdf from ASHRAE web site (over 15,000 of K-12 Schools to date)
- Printed copies available from ASHRAE bookstore
  - [www.ashrae.org/aedg](http://www.ashrae.org/aedg)
  - [www.iesna.org](http://www.iesna.org)
  - [www.aia.org](http://www.aia.org)
  - [www.usgbc.org](http://www.usgbc.org)
  - [www.highperformancebuildings.gov](http://www.highperformancebuildings.gov)
- We want to hear about your success stories—
  - [www.ashrae.org/aedg](http://www.ashrae.org/aedg)

# Next Presentations

- Envelope and Fenestration Recommendations
- Lighting and Daylighting Recommendations
- HVAC Recommendations
- Modeling Results to Show 30% Energy Savings

[www.ashrae.org/aedg](http://www.ashrae.org/aedg)

