



U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy



# Energy Efficiency in K-12 Schools & State Applications

June 27<sup>th</sup>, 2013

## DOE's State and Local Technical Assistance Program

# DOE's Technical Assistance Program



# Priority Areas: Technologies and Programs

- **Peer exchange & trainings**
  - *Past and upcoming webinars* for K-12 schools on Solution Center
  - *Upcoming webinars* focused on state EE initiatives in specific sectors – next session on Higher Education, Thursday, July 25<sup>th</sup>
- **Resources**
  - Building Technologies Office site, including *Advanced Energy Retrofit Guides*: [www.eere.energy.gov/buildings/commercial/aerg.html](http://www.eere.energy.gov/buildings/commercial/aerg.html)
  - *Financing Energy Upgrades for K-12 Schools* on Solution Center now, *Guide for Performance-Based Contracting for K-12 Schools* later this summer
  - Energy Education & Workforce Development site, *K-12 Lesson Plans & Activities*: <http://www.eere.energy.gov/education/lessonplans/default.aspx>
  - Improved Solution Center *resource portals for Technologies and Programs* live later this year, including K-12 schools
- Apply for **one-on-one assistance** and **peer matching**

# How to Tap into These and Other TAP Offerings

- Visit the ***Solution Center***  
[www.eere.energy.gov/wip/solutioncenter/](http://www.eere.energy.gov/wip/solutioncenter/)
- Submit an ***application*** for assistance  
[www.eere.energy.gov/wip/solutioncenter/technical\\_assistance.html](http://www.eere.energy.gov/wip/solutioncenter/technical_assistance.html)
- Sign up for ***TAP Alerts***, the TAP mailing list, for updates on our latest and greatest  
[TechnicalAssistanceProgram@ee.doe.gov](mailto:TechnicalAssistanceProgram@ee.doe.gov)

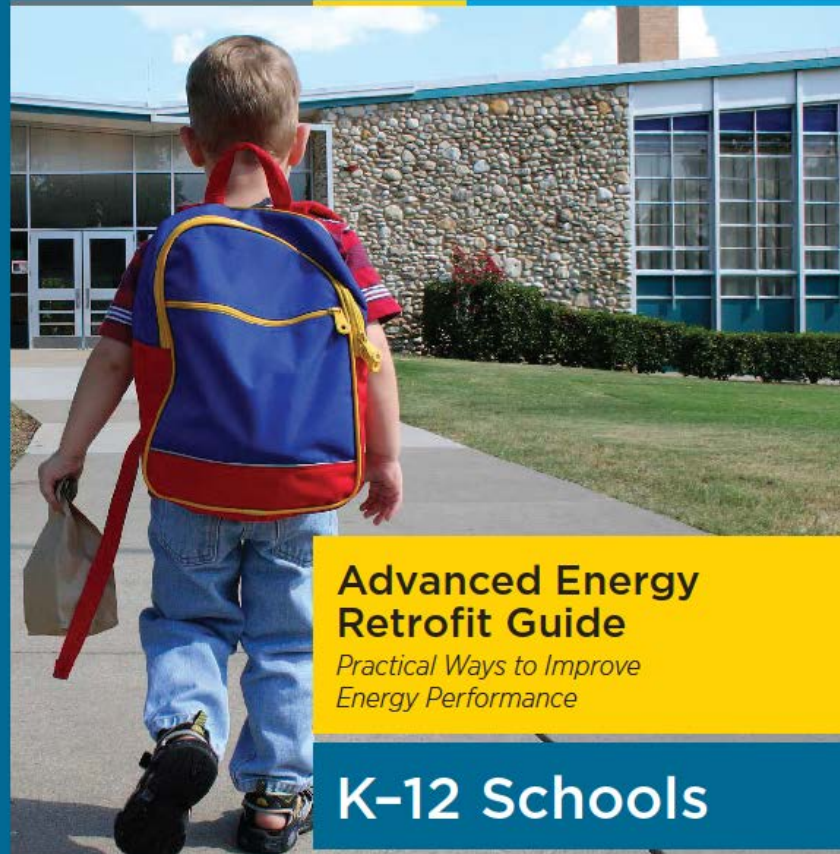
# Retrofit Best Practices for K-12 Schools

Bob Hendron – National Renewable Energy Laboratory

June 27, 2013

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BUILDING TECHNOLOGIES OFFICE



## Advanced Energy Retrofit Guide

*Practical Ways to Improve  
Energy Performance*

## K-12 Schools

Prepared by:

National Renewable  
Energy Laboratory

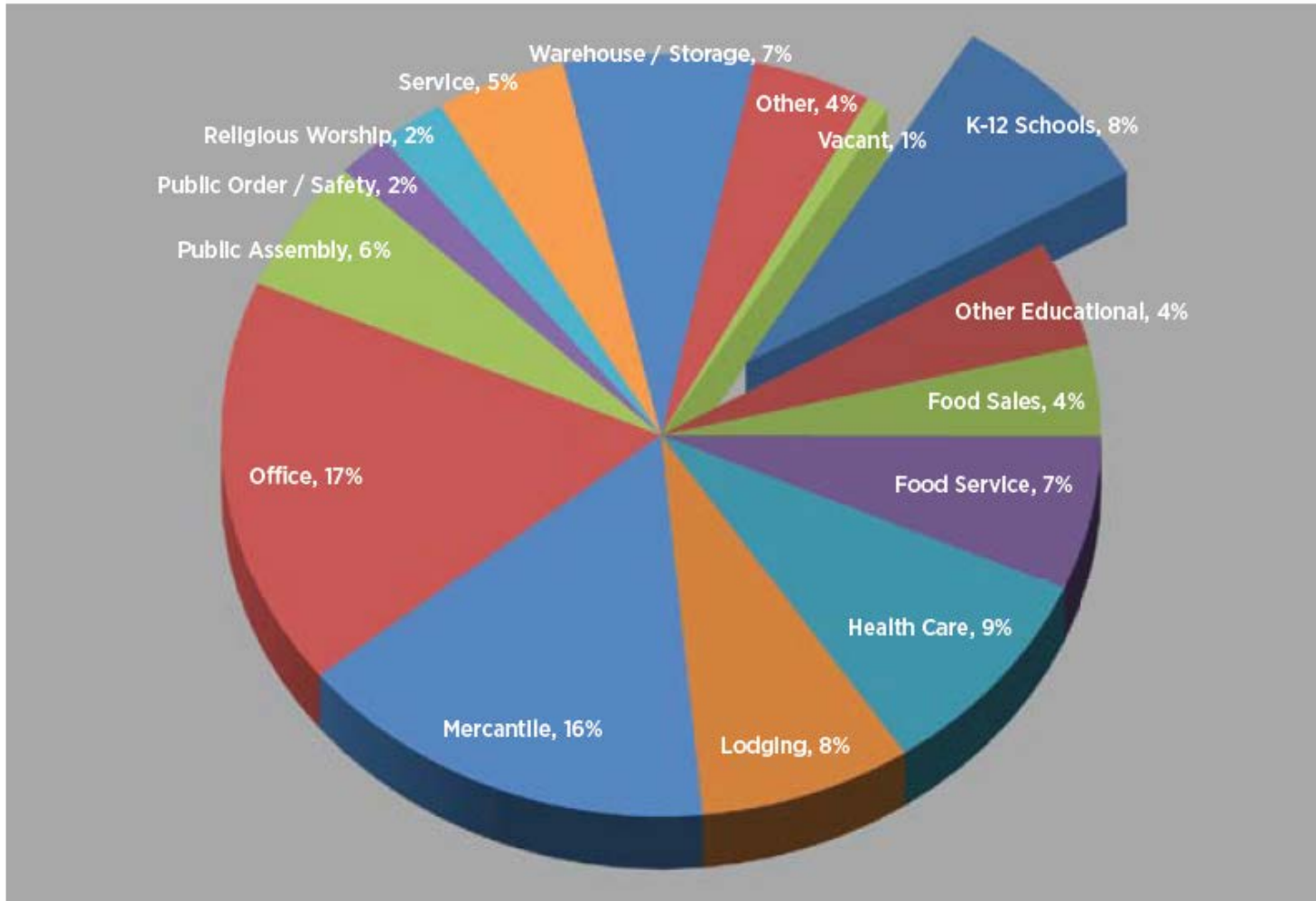
In collaboration with:

E Source  
Rocky Mountain Institute  
National Association of Energy  
Service Companies

The Abo Group  
Big Ladder Software  
The RMH Group  
Cumming

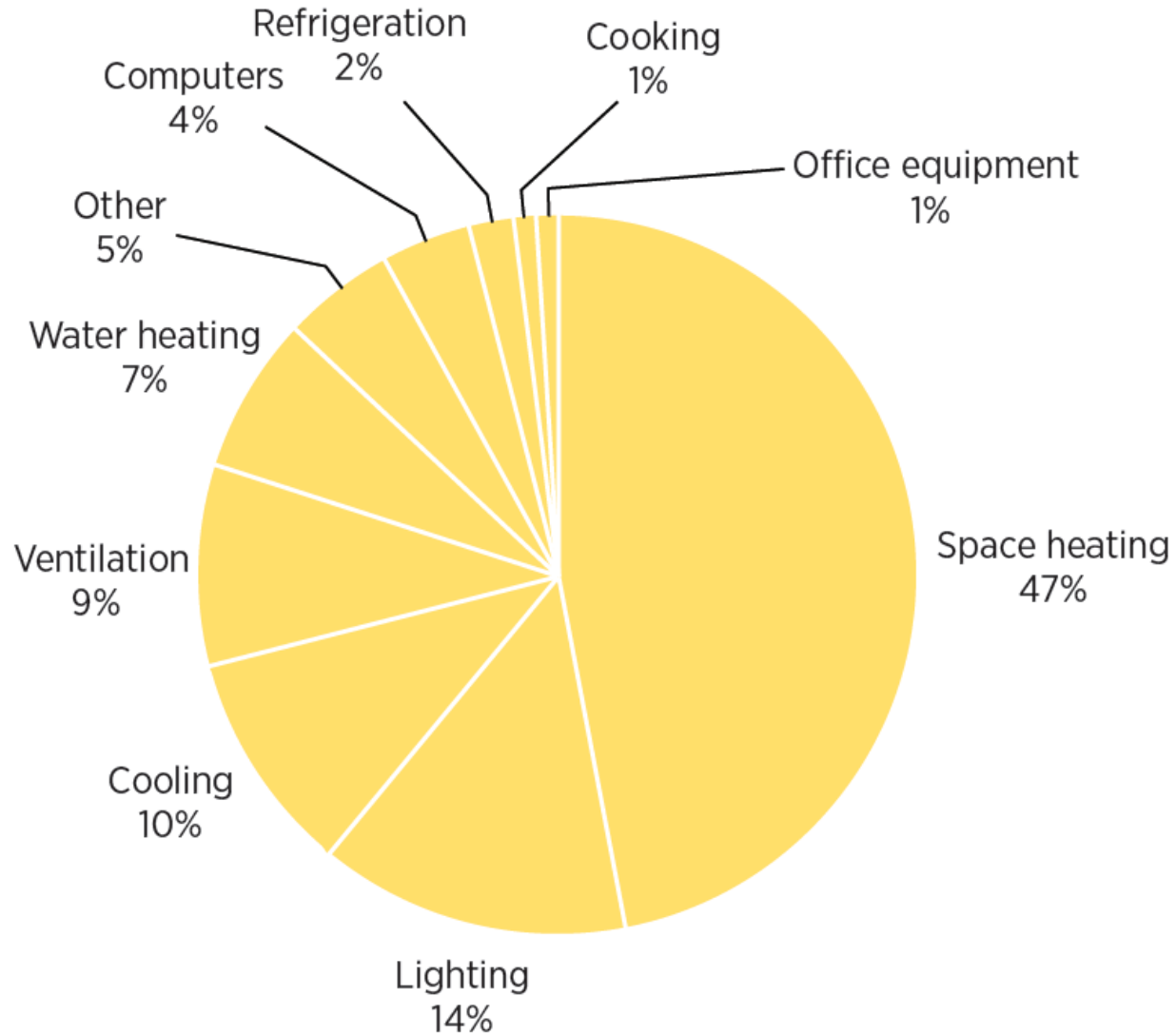


# Energy Use by Building Sector



DOE 2003

# K-12 School Energy Use Breakdown



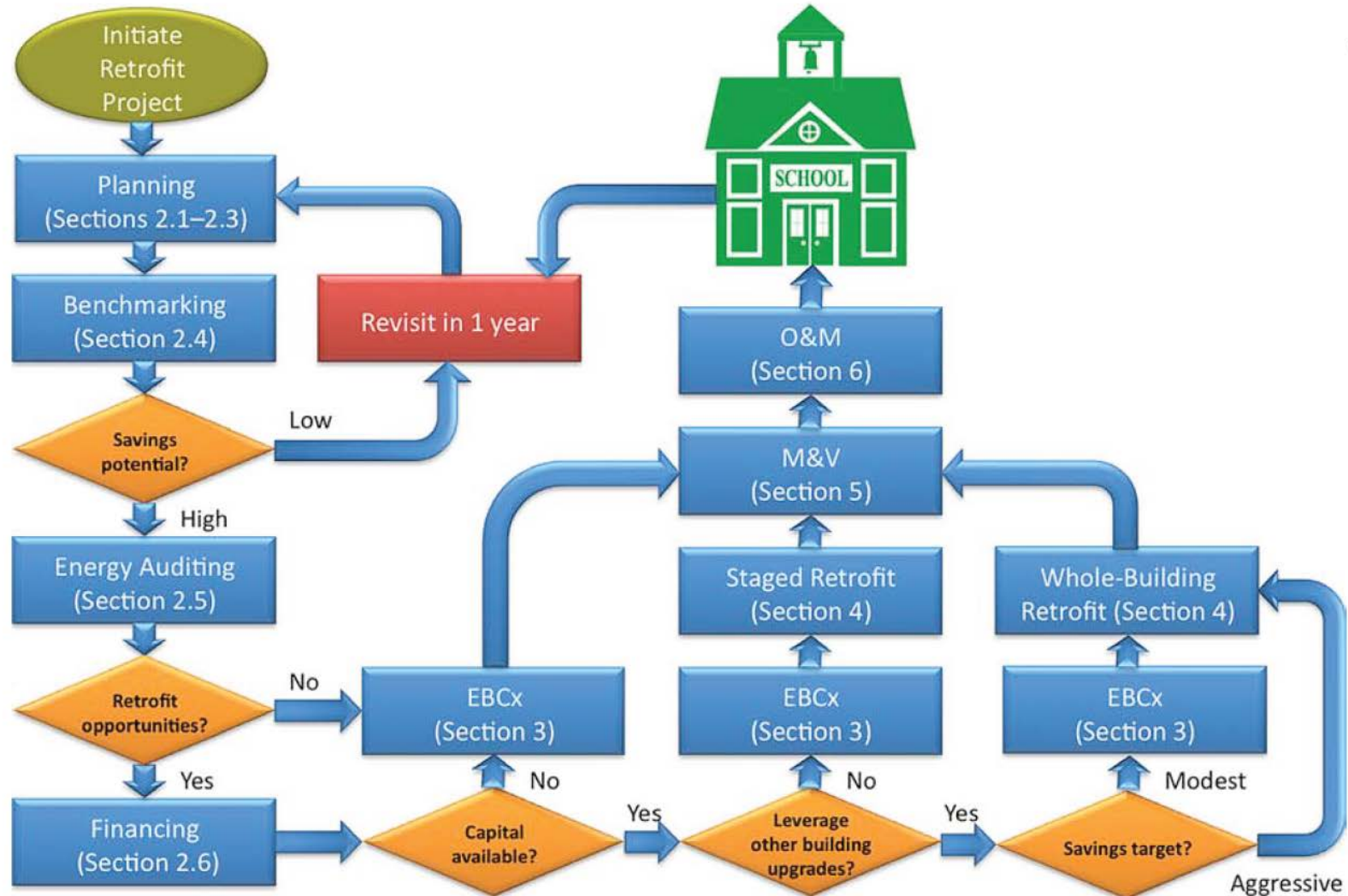
Credit: E Source, used by permission



# Potential Benefits of Energy Retrofits in Schools

- Lower utility costs
- Reduced maintenance costs
- Improved student performance
- Reduced absenteeism
- Enhanced community image

# Typical School Retrofit Process



Credit: Bob Hendron/NREL

## Three categories of efficiency improvement

- Existing building commissioning (EBCx)
  - Low-cost/no-cost measures (no capital investment)
  - Quick payback
- Staged retrofit
  - Multiphase series of improvements
  - Aligned with a school's capital improvement program
- Whole-building retrofit
  - Higher savings possible
  - Timed with school remodeling, expansion, or other major building change
  - May be less disruptive in summer months

- School remodeling
- Major addition (new classrooms, auditorium, gymnasium)
- Roof, window, or siding replacement
- End of life HVAC, lighting, or other major equipment replacement
- Major upgrades to meet structural codes
- Large incentives targeted to schools
- Fixing an “energy hog”

Benchmark Type	Description
Best in class	The performance level of the top performer sets the bar when comparing buildings. Several net zero energy schools have been built around the country.
Performance goal	A specific performance level can be established as a target against which progress can be measured. For example, energy use intensity targets for K-12 Schools Advanced Energy Design Guide
Baseline	An initial performance baseline of the school, which is established before any commissioning or other EEMs are taken, can be used to track improvements over time
Above average	Percent energy savings relative to an average school. ENERGY STAR Portfolio Manager can be used to determine the average energy use of similar schools.
National ratings	National performance ratings, such as those established by ENERGY STAR, can be used as performance targets for specific buildings such as schools

# Types of Energy Audits

<b>Audit Type</b>	<b>Accounts for Interactions?</b>	<b>Application Notes</b>
Preliminary analysis	No	Indicates overall potential for improvement
Walk-through analysis	No	Identifies no-cost and low-cost EEMs
Single system/ targeted audit	No	Considers single systems in detail
Investment-grade audit	Yes	Accounts for interactions between building systems



- Capital Budget
  - Often very constrained for schools
- Revolving Investment
  - Energy savings for one school can help fund projects elsewhere in the district
- Bond Issue
- Energy Savings Performance Contract
  - Allows other building improvements to be bundled with energy efficiency measures
- Lease Purchase

*For further information see DOE's K-12 Schools Financing Guide (<http://emp.lbl.gov/sites/all/files/lbni-6133e.pdf>)*

- Focus on multi-year cash flow analysis
  - Energy and demand cost savings
  - First cost, replacement cost, and salvage value
  - Operations and maintenance savings
  - Financial incentives (tax credits, subsidies, etc.)
- Use net present value instead of simple payback
  - NPV considers long-term benefits beyond payback period
  - For retrofits, NPV captures impact of changes to equipment useful life
- Deep retrofits may allow use of incremental costs instead of full first costs

Provide power strips in easy-to-access locations to facilitate equipment shutdown

Repair broken and visibly damaged windows

Repair any damaged or missing pipe and tank insulation

TAB of chilled water pumps and valves, refrigerant lines, air handlers, and flow modulation devices

Verify or establish a comprehensive maintenance protocol for HVAC equipment

Verify correct operation of OA economizer

Apply thermostat setback/setup when building is unoccupied

Decrease ventilation flow rates to meet ASHRAE 62-1999 requirements

# Priority Retrofit Measures for K-12 Schools

Replace incandescent lamps in exit signs with LEDs

Replace T12 fluorescent lamps and magnetic ballasts with high- efficiency T8 lamps and instant-start electronic ballasts

Replace incandescent lamps with CFLs

Install wireless motion sensors for lighting in rooms that are used intermittently

Replace HID lights with T5 HO fluorescents in gymnasiums

Install more efficient exterior lighting for façades and parking lot

Replace kitchen appliances with ENERGY STAR models

Install low-flow showerheads in locker rooms

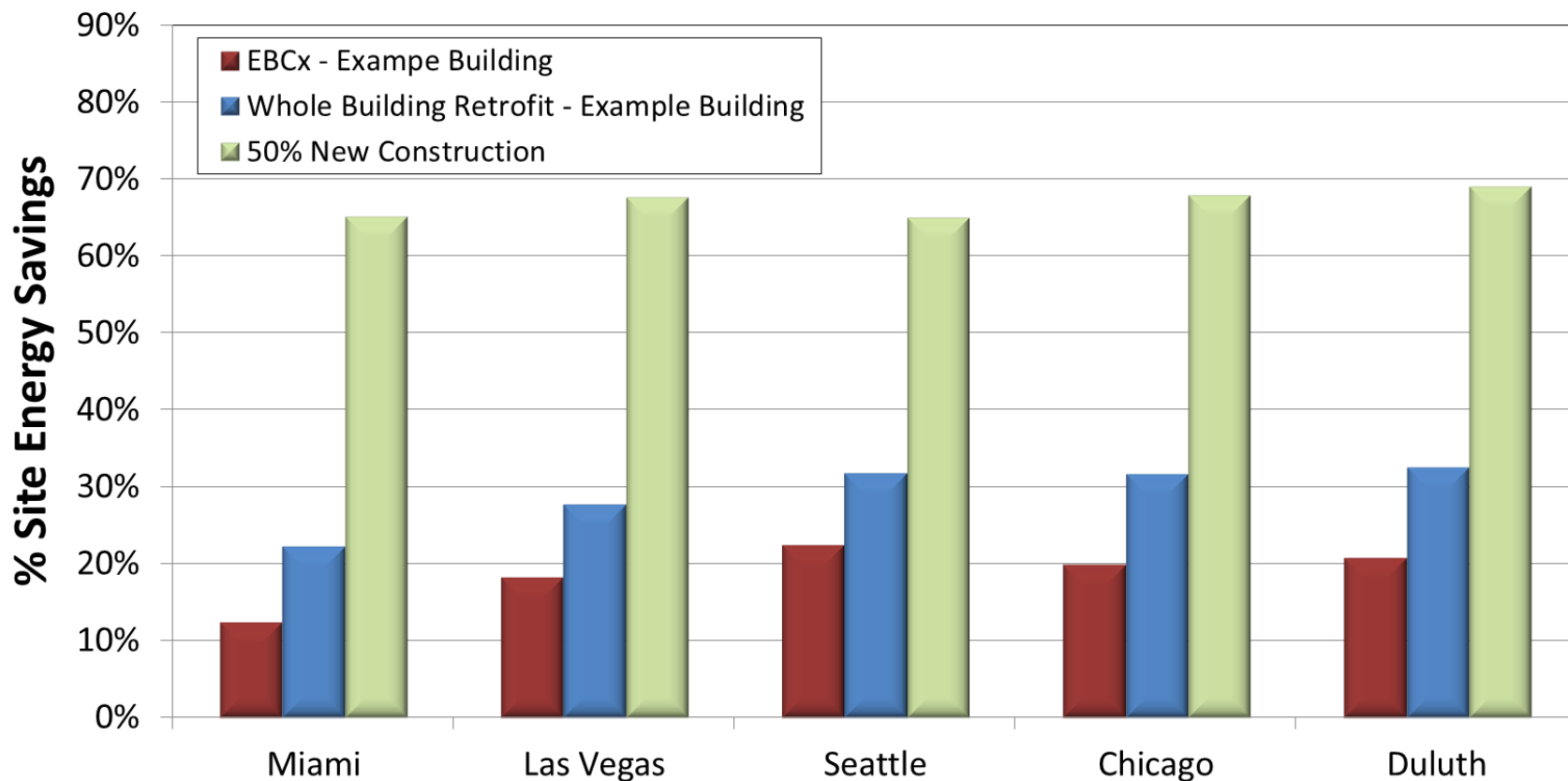
Add evaporative precooling of condenser supply air

Install VSDs on chilled-water and hot water pumps

Replace oversized, inefficient fans and motors with rightsized NEMA premium efficiency models

Upgrade to DCV to reduce OA flow during partial occupancy

# K-12 Schools AERG Example Building Energy Savings Summary



# Georgina Blach Intermediate School Case Study

- Location: Los Altos, California
- Year built: 2002
- Gross square footage: 61,500
- Building expansion and retrofit
- Key measures
  - Daylighting strategies (clerestories at classrooms, daylighting dimming controls)
  - Efficient lighting design (reduced footcandles, direct/indirect lighting fixtures, occupancy sensors)
  - Efficient ventilation solutions (low energy fans, natural ventilation, door contacts connected to local HVAC system that turn fans off when doors are opened)
- 41% site energy savings per ft<sup>2</sup>



# Carol & Park B. Smith Middle School Case Study

- Location: Bernards Township, NJ
- Gross square footage: 280,474
- Building addition and retrofit
- Key measures
  - Two 2-MMBtu condensing hot water boilers.
  - Lighting controls and high-performance lighting.
  - Premium efficiency motors, variable frequency drives, and variable air volume units in each classroom.
- \$955,000 initial investment (\$755,000 with incentives)
- 39% site energy savings per ft<sup>2</sup>
- 4.4 year payback (3.5 years with incentives)

www1.eere.energy.gov/buildings/commercial/aerg.html

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## Building Technologies Office

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**Take Action to Save Energy**

**Activities**

- 179d Tax Calculator
- Advanced Energy Design Guides
- Advanced Energy Retrofit Guides
- Energy Asset Score
- Buildings Performance Database
- Data Centers
- Energy Modeling Software
- Global Superior Energy Performance Partnership
- Research Projects
- State & Local Energy Efficiency Action Network

### Advanced Energy Retrofit Guides

The Advanced Energy Retrofit Guides (AERGs) were created to help decision makers plan, design, and implement energy improvement projects in their facilities. With energy managers in mind, they present practical guidance for kick-starting the process and maintaining momentum throughout the project life cycle. These guides are primarily reference documents, allowing energy managers to consult the particular sections that address the most pertinent topics. Useful resources are also cited throughout the guides for further information. Each AERG is tailored specifically to the needs of a specific building type, with an emphasis on the most effective retro-commissioning and retrofit measures identified by experts familiar with those unique opportunities and challenges. The guides present a broad range of proven practices that can help energy managers take specific actions at any stage of the retrofit process, resulting in energy savings for many years to come.



Prepared by: National Renewable Energy Laboratory | In collaboration with: U.S. Green Building Council, Energy Research Institute, National Association of Energy Service Companies | The Building Research Software Solutions Center

The Advanced Energy Retrofit Guides (AERGs) help building owners and managers as well as design and construction professionals plan, design, and implement energy efficiency upgrades in commercial buildings.

### Popular Commercial Links

**Success Stories**



**Walmart Partnership Brings LEDs to Parking Lots**

**Tools**

- EnergyPlus Whole Building Energy Simulation
- OpenStudio Energy Simulation Application Suite
- High Performance Buildings Database
- Building Energy Software Tools Directory

# Contact Information

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# **High Performance Schools The Kentucky Experience**

National Renewable Energy Laboratory  
Webinar  
June 27, 2013

Greg Guess, Director  
Division of Efficiency and Conservation  
Kentucky Department for Energy Development and Independence





# Characteristics

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Photo courtesy Sherman-Carter-Barnhart Architects

- Healthy and Productive Environment
- Cost Effective to Operate and Maintain
- Sustainability
- Reduced energy consumption saves districts money
- School Facility as 3-D Classroom



# Healthy & Productive Environment

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- High levels of acoustic, thermal, and visual comfort
- Large amounts of natural daylight
- Superior indoor air quality
- A safe and secure environment



Photo courtesy Richardsville Elementary School, Warren County Public Schools

# Cost Effective to Operate & Maintain

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- Energy analysis tools optimize energy performance
- A life-cycle cost approach reduces the total costs of ownership
- A commissioning process ensures the facility will operate in a manner consistent with design intent



# Sustainability

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- Integrates Energy conservation and renewable energy strategies
- High-performance mechanical and lighting systems
- Environmentally responsive site planning
- Environmentally preferable materials and products
- Water-efficient design.



Photo courtesy Tate-Hill-Jacobs Architecture



# Reduced Energy Consumption Saves Money

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- Milton Elementary School, Trimble County Kentucky
- One of 7 Kentucky Schools to earn EPA ENERGY STAR score of 100
- The lowest cost per square foot school in Kentucky, the year it was built.
- Facility size – 47,300 square feet
- Cost per square foot - \$149.46
- Energy management plan implemented for two years (FY 2011 – 2012) achieved cumulative avoided costs \$102,122.

# School Facility as 3-D Classroom

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## Three Dimensional Teaching Tool

- Opportunities for students to access, monitor, and learn about building performance
- Energy-based curriculum
- Introduce students to careers in environmental sciences
- Create lifelong environmental stewards

# Integrated Design Process

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Creating a school with these characteristics is not difficult, but does require an integrated, whole-building approach to the design process.

Engage all stakeholders in:

- Design
- Construction
- Operation





# Building Blocks

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Acoustic Comfort  
Commissioning  
Day lighting  
Durability  
Energy Analysis Tools  
Energy-Efficient Building Shell  
Environmentally Preferable  
Materials and Products  
Environmentally Responsive Site  
Planning

High-Performance HVAC &  
Electric Lighting  
Life Cycle Cost Analysis  
Renewable Energy  
Safety and Security  
Superior Indoor Air Quality  
Thermal Comfort  
Visual Comfort  
Water Efficiency

# LEED

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- LEED, Leadership in Energy and Environmental Design.
- Developed by U.S. Green Building Council to provide building owners and operators a concise framework for identify and implementing practical and measurable green building design, construction, operations and maintenance solutions.

## **New Construction and Major Renovations**

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Innovation and Design Process

# Partnering With ENERGY STAR®

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- U.S. Environmental Protection Agency national energy performance rating system.
- Facilities among the top 25 percent of all comparable buildings.
- Measure a year's worth of energy-use data.
- ENERGY STAR buildings must receive at least 75 out of 100 points in EPA's rating system.



# ENERGY STAR Resources

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## Designed to Earn the ENERGY STAR®

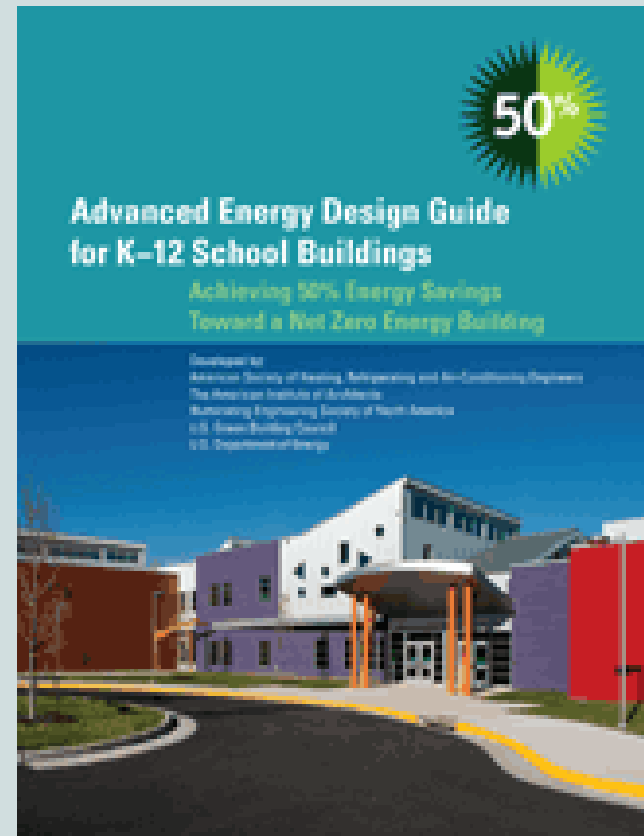


- Helps architects and owners save money, energy, prevent carbon emissions and answer EPA's call to fight global warming.
- Target Finder, no-cost online tool enables architects and building owners to set energy targets and receive an EPA energy performance score for projects during the design process.
- Design projects that meet the commercial building space type criteria and receive an EPA energy performance score of 75 or higher from the online Target Finder tool are eligible for Designed to Earn the ENERGY STAR certification.

# High Performance Design Guide

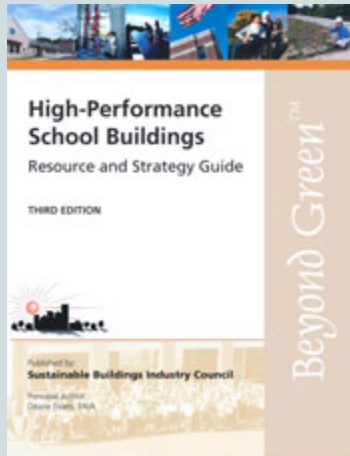
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- Developed for several building types.
  - Current series provide recommendations for achieving 50 percent energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-2004.
  - Allows designers to easily achieve advanced levels of energy savings without detailed energy modeling or analyses.
- 
- ASHRAE
  - AIA
  - IESNA
  - USGBC
  - USDOE



# Resources

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- Sustainable Buildings Industry Council – High Performance School Buildings Resource and Strategy Guide



- Collaborative for High Performance Schools

# The Net Zero Concept – the Next Step

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## Questions:

- Could we create a building that **consumes a minimal amount of energy?**
- Could we then offset that by allowing it to **produce clean energy?**

# Net Zero

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**Net Zero** is defined by the Kentucky Department of Education as a facility that, although connected to the power grid, would produce as much energy as it would use annually.

This means, on average, generates enough energy to meet its annual energy demands.

These facilities are typically extremely efficient, to the point that the addition of renewable energy sources to meet the energy needs become cost effective.



# Net-Zero Ready

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**Net-Zero Ready Schools** – defined as one that is designed with components and building strategies integrated into the design process to achieve state-of-the art energy efficiency – operation at or below 20 kBtus/sf/yr, with hardware and engineering in place to readily accept renewable energy installations at a later date.

Kentucky Department of Education reports 14 Net-Zero ready school projects completed or initiated.

# Integrated Design Team

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- Owner's needs to set the design criteria for design team.
- Design professionals: architects and engineers.
- School Administrators.
- School Facility Staff.

# Consider

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- Site
- Source
- Cost



# Construction

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- Building Commissioning is key
- Required for LEED certification



Photo courtesy Tate-Hill Jacobs Architects

# Operation

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Photo courtesy Sherman-Carter-Barnhart Architects

- Top-down leadership and support is critical for success.
- Need to involve all building occupants:  
operations and maintenance staff,  
fiscal personnel, parents and  
community.

# Kenton County School District

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- Recognized by the EPA as an ENERGY STAR Leader for increasing the energy efficiency of its entire portfolio of buildings by 20 percent.
- Saved more than \$1 million in operational costs since the district's first high-performance school opened in 2005.
- 11 ENERGY STAR school facilities, out of 18 buildings district-wide.
- Energy management is a critical component of the district's mission and vision to prepare students for the global workplace and market.
- The E=WISE2 (Education creates Wisdom in Saving Energy and the Environment) program, a student-led energy education program created in partnership with the NEED (National Energy Education Development) Project is the foundation of the district's behavioral-change initiative.
- Utilizing the district's Energy Center, a comprehensive Web application provided by NET (New Energy Technologies), this team focus on monitoring, improving the habits of building occupants and educating the faculty, staff and community about energy efficiency and environmental stewardship.



# Designed Net-Zero Ready

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## **Turkey Foot Middle School Kenton County School District**

Year School Built 2010

School Building Size 133,000 sf

PV installation completed April 2012

Consuming 25 kBtu/sf/yr before solar

443 kW solar PV

Construction Cost - \$200/sf with solar PV

Architects: PCA Architecture

Engineer: CMTA Consulting Engineers

Building Performance - 13 kBtu/sf  
(May 2012-April 2013)



# Turkey Foot Savings Comparison

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Photo courtesy Kenton County School District

## **New vs. Old** Turkey Foot Middle School Comparison

**2011-2012 Savings of \$56,395**

	<b>Old TF School</b>	<b>New TF School</b>	<b>% Difference</b>
Square Footage	66,523	133,000	199.9% increase
Annual Energy Cost	\$94,954	\$38,558	59.4% decrease
EUI (kBtu/sf)	79.2	13.6	82.8% decrease



# Net-Zero Energy

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Warren County, Kentucky Photo courtesy Sherman Carter Barnhart Architects

Richardsville Elementary School is the first net-zero energy public school in the United States.

Building is 72,285 sf and serves over 500 students

Uses 75% less energy than the average American school.

Produces as much clean energy as it consumes by converting solar power to electricity with a 349 kW solar panel array.

# Richardsville Elementary

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Cost - \$15.2 million (with solar)  
\$12.4 million (without solar)



349 kW solar  
panel array

Photos Courtesy Sherman-Carter-Barnhart Architects

# Richardsville Elementary

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- ✓ Registered as a LEED Gold School with the USGBC, making it as environmentally friendly as it is energy efficient.
- ✓ Constructed at a cost equal to a conventional school.
- ✓ Teaches students environmental stewardship by involving them in monitoring the building's performance.
  - Student energy teams analyze the school's plug-in devices and lighting.
  - Student monitored recycling program.
  - The weather station, part of the outdoor classroom, helps students monitor solar panel efficiency.

# Strategies

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- ✓ High Performance Building Envelope
- ✓ Active Day lighting
- ✓ Geothermal HVAC
- ✓ Monitoring Controls
- ✓ Dedicated Outside Air System with Energy Recovery and CO<sub>2</sub> Sensors
- ✓ Alternative Renewable Energy Source
- ✓ Green Kitchen Strategies
- ✓ Operations and Maintenance Plan
- ✓ Wireless Computer Technology

# Energy in Education Collaborative

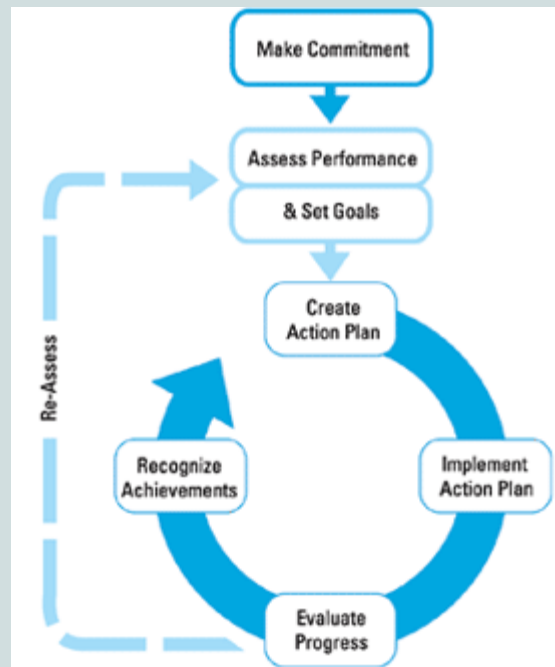
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- A multi-faceted partnership including the Kentucky Department for Energy Development and Independence; the School Energy Managers Project; Kentucky National Energy Education Development Project; and the Kentucky Green and Healthy Schools Program.
- Provides sustainable solutions to Kentucky's K-12 schools
- Reduces operational costs through energy efficiency initiatives and supporting student environmental learning.

# School Energy Managers Project

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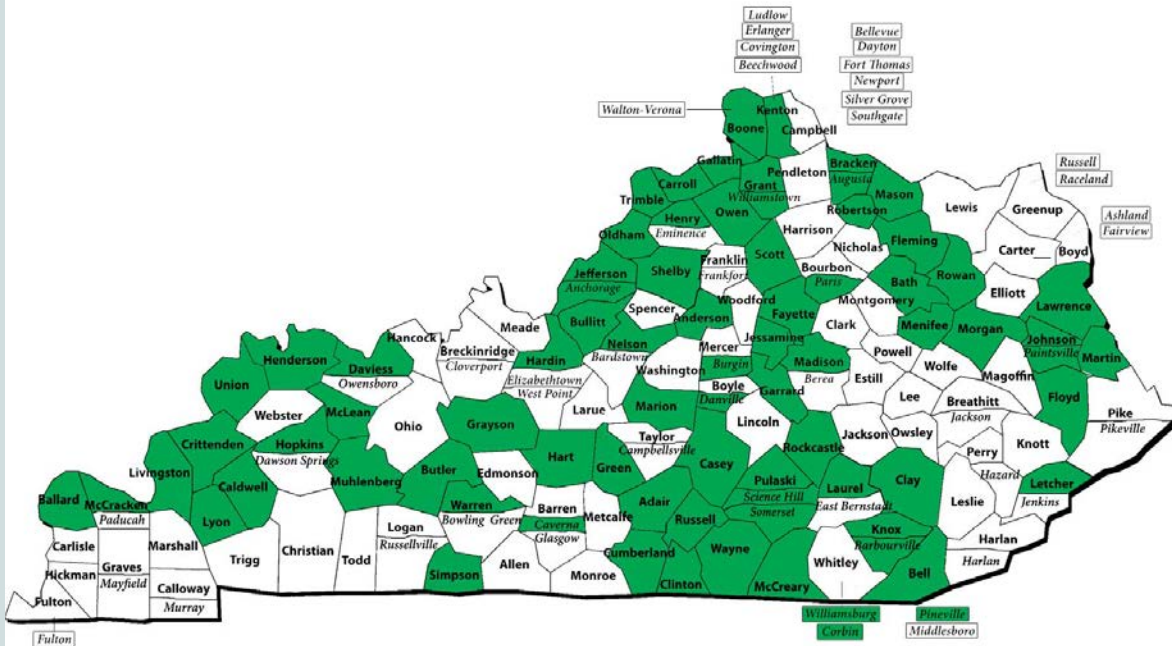
- School Energy Managers Project (SEMP)
- Foundation is ENERGY STAR's Guidelines for Energy Management
- [http://ww.energystar.gov/index.cfm?c=guidelines.guidelines\\_index](http://ww.energystar.gov/index.cfm?c=guidelines.guidelines_index)



# Kentucky School Energy Managers

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## School Energy Managers



31 School Energy Managers  
serving 68 districts

2 pending to be serving  
9 districts



# KY NEED

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- National Energy Education Development (NEED) Project
- 30+-year old national non-profit
- Provide curriculum materials, activities kits and workshop to train teachers
- Assist with the formation of school-based energy teams
- Provide for recognition of achievement at the state and national level



[www.need.org](http://www.need.org)

# Green and Healthy Schools

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## **Kentucky Green and Healthy Schools (KGHS)**

KGHS is a project-based and student-centered program that empowers students and staff to move their school toward becoming safer, healthier, and more environmentally sustainable

Inquiry-based program uses the entire school building and grounds as a learning laboratory for students  
Student teams evaluate school practices in 9 different areas, including energy, water and solid waste.

As students implement improvements in each area, they get recognition for achievements.

Not staff intensive, mostly computer-based.

[www.greenschools.ky.gov](http://www.greenschools.ky.gov)



# Kentucky Accomplishments

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- 70% increase in ENERGY STAR schools in less than 3 years.
- Places 5<sup>th</sup> nationally in percentage of schools ranked ENERGY STAR.
- 15% of Kentucky's ENERGY STAR schools have scores above 95.  
Among these schools, eight have scored a near-perfect 99, and ten schools are among the most efficient schools in the nation with a score of 100.
- Two districts out of four nationwide received the 2013 ENERGY STAR Partner of the Year Award for energy management
- 12 districts recognized as ENERGY STAR Leaders for portfolio-wide energy efficiency improvements of 10%, 20% or 30% or more on organization-wide baseline.
- First Net-Zero Energy K-12 School in USA, located in Richardsville, KY
- LEED Existing Building project currently underway in Wilmore, KY
- Six schools received US Green Ribbon Awards, 2012 and 2013 combined.

# Take-Aways

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- You can do this!
- Challenge design team – efficiency does not have to cost more.
- Do design charrette – know what you want.
- Don't be afraid to set ambitious goals.
- Do building commissioning.



[www.energy.ky.gov](http://www.energy.ky.gov)

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