Energy Efficiency and Renewable Energy Resources for Rural K-12 School Energy Managers and Educators

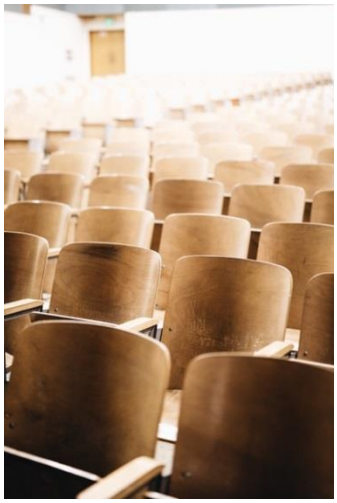
Overview

Rural school districts accommodate nearly 14 million students in facilities located in remote areas where it is often difficult to deliver information and services to maximize school building energy performance. Many web-based resources created by technical experts and K-12 stakeholders exist to help energy managers and educators reduce their schools' energy use and better adapt to changing energy infrastructure. Through the Better Buildings Initiative, the U.S. Department of Energy (DOE) partners with leading businesses, manufacturers, cities, states, universities, and school districts, who pledge to improve the energy efficiency of their buildings and infrastructure through voluntary commitments like the Better Buildings Challenge 10-year, 20% reduction goal. As of 2018, more than 350 Better Buildings Challenge partners have saved $3.1 billion since the start of the program. Leveraging these outstanding results and strategies, this document links to resources for K-12 school districts and provides some best practices for implementing energy efficiency in rural schools. This resource is intended to help states, local school administrators, school boards, and facilities personnel make prudent decisions around the use of operating funds, capital budgets, and other financing mechanisms for energy efficiency improvements as a part of their master facilities management plan.

Rural Schools: Opportunities

Rural schools represent about one-third (32,000) of the public schools in the Unites States. Despite the remote locations and under-resourced facilities, rural schools are characteristically known to be collaborative and intentional problem solvers. Energy management planning is a collaborative opportunity to assess and prioritize energy saving measures, identify funding sources, and prepare staff to operate building systems efficiently. Member-based organizations, like the Energy Association of Iowa Schools[1] that serves rural school districts, are a good resource for technical expertise in energy management that can be instrumental in getting utilities to provide energy usage data and efficiency incentives.

Rural Schools: Challenges



Due to their geographic locations and typically smaller sizes, rural schools face several energy efficiency and renewable energy challenges related to implementation, financing, and operations. For example:

- Many rural schools fall into a "service black hole," with equipment too large to be serviced by local technicians that work with residential-scale equipment, but too small a budget to afford a commercial-scale technical service.
- Smaller populations in rural areas oftentimes result in regionalized school systems, often placing facilities far from urban centers and specialized systems maintenance personnel.
- Many state-level and utility financial incentives are not developed with the rural school or facility manager in mind. In some situations, for example, retrofit financial assistance is only available to LEED[2]-accredited personnel, and many rural school facilities are managed by local personnel who are not LEED accredited.

[1] Energy Association of Iowa Schools (EAIS)

[2] The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) is a sustainable building and professional accreditation program.

Solutions

Rural school stakeholders can adapt existing Better Buildings and DOE technical resources to meet their specific needs. This information includes energy-efficient practices and principles building owners can apply with local perspectives on energy dependence and fuel sources in mind, complex technical information distilled for a mid-skilled workforce, and program options to accommodate a range of organizational buy-in. This document pulls together key technologies, strategies, and financial mechanisms from existing Better Buildings solutions and other sources that can help rural school district stakeholders become more energy-efficient.

Broadly, many of these solutions rely on reducing building energy use through the integration of energy efficiency measures (EEMs). EEMs are strategies that reduce energy use in a building. Energy efficiency is prioritized to minimize the level of energy demand for the building and maximize energy cost savings. The cost of integrating renewable energy technologies into a high efficiency building may become more affordable due to reduced energy demand. Renewable energy, such as electricity generated from solar photovoltaic panels, is another viable option for increasing sustainability in rural school buildings. Renewable energy investments require financing or upfront funding, as well as contractual agreements with the utility for grid interconnection or the power generation company for the electricity provided.

Solutions for rural K-12 school districts to consider include:

- **Understanding the building's current energy use by conducting a building energy audit, which can be as simple as reviewing energy bills.** The energy audit provides helpful insights into energy use and can be used to pinpoint areas for EEMs to be implemented that will result in the most significant energy and cost savings.
- **Considering how energy efficiency can make onsite renewable energy investments more cost effective.** Building owners can first consider EEMs, which typically offer properly sized equipment, reduced energy waste, and an appealing return on investment through energy saved. Furthermore, energy efficiency can reduce the renewable energy generation requirements for a project, thus reducing the initial cost for renewable energy installations and upgrades.
- **Considering occupants (teachers, students, and staff) when evaluating energy efficiency strategies.** Building owners can evaluate whether occupants will operate EEMs as intended. Occupant training can encourage energy-efficient behavior, such as turning off lights when they are not needed or closing windows and doors when the weather is unfavorable. EEMs that are complicated or significantly disrupt business-as-usual behavior often don't work and yield little energy savings.
- **Verifying that all decisions make sense financially.** Most EEMs have a favorable return on investment and will yield cost savings over the long term. Building owners can consider the return on investment and any financial incentives that reduce up-front costs to a school district when deciding to implement EEMs. Financial considerations for projects include reduced operations and maintenance costs. More in-depth financial analysis includes simple payback, internal rate of return, or net present value.
- **Conducting research before committing to offsite renewable power purchase agreements (PPAs).** PPAs are contracts that commit a school district to the purchase of power from a supplier over a set period of time. Before entering a PPA, school district officials can conduct a comprehensive financial and risk analysis to ensure that the risk of the PPA cost exceeding traditional power cost is low, assess factor transmission costs and feasibility, and verify or authenticate the offeror as a part of due diligence.

The following examples, resources, and technologies are used to expand upon these high-level solutions for reducing energy use in school buildings.

Resources

Benchmarking

Benchmarking is essential for understanding energy use patterns in all buildings, including rural K-12 schools. It is a proactive approach to energy management that emphasizes continuous improvement and helps organizations manage their energy use rather than react to it. Benchmarking can also help to assess the effectiveness of current building operations by verifying energy, cost, or emission savings. These results are then communicated in terms that are easy for building managers to understand. By tracking energy use, benchmarking compliments resource planning in setting goals, targets, and timelines. For example, the State of Iowa benchmarked 395 K-12 schools and identified energy use trends and equipment improvement priorities that are expected to save nearly $2.8 million in annual energy costs. To maintain this data, ENERGY STAR Portfolio Manager is a commonly used energy tracking resource; it makes benchmarking accessible to all types of building managers by performing weather normalization, adjusting energy calculations to account for changes in operation over time, and allowing for easy sharing of data.

- **Advancing Energy Efficiency through the Iowa Benchmarking Project**
- **ENERGY STAR Portfolio Manager**
- **Designing a Benchmarking Plan**

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Advanced Energy Design Guides

As an overarching resource, the Advanced Energy Design Guides contain detailed guidance for energy-efficient building design. The Advanced Energy Design Guides make the business case for energy efficiency and provide technical implementation details that are refined and validated through building energy modeling. They are a useful starting point for rural school districts seeking to achieve significant energy and cost savings through energy efficiency. These guides achieve 30% and 50% reductions in building energy use compared with ASHRAE 90.1-1999 and ASHRAE 90.1-2004, respectively. There is also a guide for K-12 school retrofits, and the recently published zero energy building guide for K-12 schools provides technical implementation details on how a K-12 school building can produce as much energy as it consumes from the grid on an annual basis.

- **Advanced Energy Design Guide for K-12 School Buildings: Achieving 30% Energy Savings**
- **Advanced Energy Design Guide for K-12 School Buildings: Achieving 50% Energy Savings**
  Advanced Energy Retrofit Guide for K-12 Schools
- **Advanced Energy Design Guide for K-12 School Buildings: Achieving Zero Energy**

Energy Audits

An energy audit is an assessment of a building's energy use. Energy audits are a best practice and first step in identifying potential energy efficiency strategies for any given school because they identify distinct energy and cost savings opportunities specific to the individual school. Audits range from simple to detailed; the simplest energy audit involves reviewing utility bills for energy use trends. Rural school districts can leverage these types of low- to no-cost energy efficiency strategies to take stock of current building energy use before investing in more costly upgrades that may not address existing facility issues.

Energy audits help the building owner identify issues such as failing or poorly-commissioned equipment and uncoordinated operations (e.g., lights left on in unoccupied spaces). Depending on the rigor of an audit, it can cost anywhere from $0.02 to $0.50 per square foot. Alternatively, many utilities or energy service providers offer free audits or incentives, such as rebates, to offset the cost of audits. Extensive information on energy audits can be found in the *Advanced Energy Retrofit Guide for K-12 School*s and *A*

Guide to Energy Audits (Section 2.5, pp. 27–31).

- **Advanced Energy Retrofit Guide for K-12 Schools**
- **A Guide to Energy Audits**

Energy Efficiency Measures (EEMs)

EEMs are strategies to reduce building energy use. Examples include switching to more energy-efficient heating, ventilating, and air-conditioning (HVAC) equipment; improving insulation; installing energy-efficient windows (e.g., insulated glazing units); adding occupancy- or daylight-sensing lighting controls; upgrading to energy-efficient lighting; or changing building operation protocols (e.g., coordinating the use of HVAC systems for maximum comfort only during occupied hours). K-12 school building energy use is largely attributable to HVAC and lighting. Because the building envelope has a major effect on heating and cooling loads, improvements to the building envelope also offer significant energy efficiency opportunities. Below are descriptions of common EEMs and links to helpful resources.

- **Lighting and Daylighting**: Advances in lighting technology, particularly solid-state lighting, allow facilities to reduce their lighting power densities by replacing existing light bulbs. Lighting is typically one of the top three energy end-uses in schools, so school districts frequently consider implementing lighting changes as part of a school's energy efficiency design or upgrades. A school can install daylight-responsive lighting controls and occupancy or vacancy sensors to further reduce lighting loads. Many spaces in a school are good candidates for these controls (e.g., classrooms, auditoriums, and cafeterias). Note that controls only work well when they are commissioned and operated properly. Daylighting also involves addressing glare from low-angle sun and optimizing the window orientation and sizing to maximize energy and cost savings opportunities. Although these strategies are most effective when applied early in the design process, existing schools can leverage the principles of "daylight harvesting" through daylight-responsive controls. For example, Henderson County Public Schools in North Carolina integrated daylighting and responsive controls in two of their newest facilities, Hillandale and Mills River Elementary Schools, which are expected to achieve an annual energy savings of $60,000 to $70,000.

  - **Solid-State Lighting Information: Fact Sheet**
  - **Design Guide for Low Energy Building Lighting Controls**
  - **Daylighting Schools: How-To Guide**
  - **Daylighting in School: Improving Student Performance and Health at a Price Schools Can Afford**
  - **Lighting Retrofit Strategies for California Schools**
  - **Energy Case Study: Henderson County Public Schools**

- **Heating, Ventilating, and Air-Conditioning (HVAC)**: The opportunities for energy savings through improvements to the HVAC systems of a school are discussed in the Advanced Energy Design Guides as well as the resources listed below. Note that rural school districts should consider only installing equipment that can be maintained with local experts or with access to a good servicing

network. Complex systems can be difficult to maintain in rural districts. Rural school districts tend to be more successful when staff can address minor maintenance and equipment operations and the school district has a responsive service plan. For example, River Trails Middle School in Mt. Prospect, Illinois faced inconsistent comfort levels and constant work maintenance orders. With outdated controls, building occupants and maintenance personnel did not have as much control over the HVAC systems as they would have liked. The district implemented an upgrade of the HVAC controls and retro-commissioned the building systems that is expected to result in a 15% annual energy savings and $11,000 annual cost savings.

- **High-Performance HVAC**
- **Introduction to Commercial Building HVAC Systems and Energy Code Requirements**
- **River Trails School District 26: River Trails Middle School**

- **Plug and Process Loads**: Plug and process loads include all plug-in and hard-wired loads in a building that are not associated with HVAC, lighting, water heating, or other major building equipment needed for basic building operation. Plug and process loads account for 10% of energy use in educational buildings. Ad-hoc equipment changes and additions in the classroom can make this percentage even higher in rural schools. Coffee pots and electric resistance space heaters can adversely affect the energy use of a school. For example, Carrollton-Farmers Branch Independent School District in Texas partnered with an energy services company to assess how energy was being used and where it was being wasted. An audit pilot program conducted at three schools discovered a potential energy savings of $23,000 annually through improvements to lighting, heating and cooling, food preparation, kitchen and cafeteria, and office appliances.
  - **Saving Energy through Advanced Power Strips**
  - **Flowchart for Selecting a Control Strategy for Plug and Process Loads**
  - **Selecting a Control Strategy for Miscellaneous Electrical Loads**
  - **Better Buildings Decision Guide for Plug and Process Load Controls**
  - **Carrollton-Farmers Branch Independent School District: Panoramic Power Helps School District Identify Nearly $23K in Energy Savings**

- **Envelope**: As the primary means of managing the transfer of thermal energy into or out of a building, the envelope—the exterior shell enclosing the building—presents several opportunities for energy efficiency improvements. High performance windows and aftermarket window treatments or films can admit light while controlling solar loads, and low-e coatings can improve the insulating value of the glazing, keeping heat in the building in winter. Additional options include improving insulation and retrofitting overhangs for solar shading. These and other technical implementation details are discussed in the Advanced Energy Design Guides and other resources. For example, Poudre High School in Colorado, an 1,800 rural student facility, underwent a life cycle activity analysis and building envelope assessment. Based on this data, the district performed deep retrofits at Poudre High School that achieved a 26% reduction in annual energy consumption. The building envelope measures included removing single paned windows and

potential asbestos caulking surrounding frames and replacing them with double paned counterparts with aluminum frames and thermal breaks.

- **Building Envelope Design Guide**
- **Building Envelope Thermal Bridging Guide**
- **Poudre School District: Poudre High School Infrastructure Replacement**

- **Commissioning**: Commissioning is the process of ensuring that the mechanical systems of a building are installed and performing according to the criteria in the original design and engineering documentation. This process is performed on new buildings, but it may be revisited over time, particularly if building energy or thermal comfort performance is not meeting expectations (e.g., if identified as an areas of opportunity in an energy audit as described elsewhere in this document). For example, Parkway West High School has a student population of approximately 1,260 and is one of five high schools within the rural Parkway School District in Missouri. The school conducted a retro-commissioning study due to its low building energy performance and occupant discomfort that produced suggested performance and indoor quality upgrades. After building improvements, the project is expected to result in an annual energy savings of 15% and an annual cost savings of $55,000.
  - **Building Commissioning**
  - **Net Zero Building Commissioning**
  - **A Guide to Building Commissioning**
  - **Parkway Schools: Parkway West High School Retro-Commissioning Project and HVAC Maintenance Improvements**

- **Operations and Maintenance (O&M)**: A building may be designed to be energy-efficient, but even the most energy-efficient strategies and technologies will underperform if not operated and maintained in an energy-efficient manner. This is often the culprit when EEMs are deemed failures or labeled as “not working.” To increase the likelihood that a building will be operated in an energy-efficient manner, rural school districts can train facilities maintenance staff on how to interact with the energy-efficient aspects of the building. Similarly, building occupants, including teachers and students, can also be trained on how to use the building in an energy-efficient manner (e.g., turning off lights when no one is in a classroom or using daylighting when feasible).
  - **Realizing High-Performance Buildings: How To Maintain Energy-Efficient Design Intent During Building Operation**
  - **Operations and Maintenance Guide**
  - **Operations & Maintenance: A Guide to Achieving Operational Efficiency**

- **Measurement and Verification (M&V)**: This strategy involves the measurement of installed energy efficiency measures and building system performance in order to verify the systems are commissioned properly and delivering the performance expected. During measurement and verification, a building owner can identify areas where a building is underperforming from an energy perspective. Fixing identified issues can lead to more energy and cost savings, especially when addressing simpler issues in rural schools where it may not be feasible to conduct comprehensive equipment upgrades.
  - **International Performance Measurement & Verification Protocol**
  - **Standard Measurement and Verification Plan for Lighting Retrofit Projects for Buildings and Building Sites**
  - **Measuring Campus Performance: Submetering Fact Sheet**

Renewable Energy and Combined Heat and Power (CHP)

Renewable energy, such as photovoltaic panels, may be installed in a new construction project or during a retrofit to offset a school's base energy use and resulting environmental footprint. CHP systems can use renewable biomass or conventional fuels and can be an attractive option for some schools to reduce energy costs.[3] The use of renewable energy is a common strategy for achieving near zero energy or even zero energy status. A zero energy building produces energy on-site or purchases renewable energy equal to the total amount of energy it consumes on an annual basis. Financing for renewable energy is available, commonly through a PPA, an agreement to purchase power from a solar or wind power provider or a utility at a certain cost over a defined timeframe. For example, Anne Arundel County Public Schools in Maryland financed a 1.4 MW solar array through a PPA with a local solar company. The PPA allowed the school district to meet the energy needs of Maryland's fourth largest school district producing almost 2,000 MWh of electricity and return a savings of nearly $1.8 million over the life of the project through lower energy costs.

- **Power Purchase Agreements**
- **Third-Party Financing and Power Purchase Agreements for Public Sector PV Projects**
- **Power Purchase Agreement Checklist for State and Local Governments**
- **Financing Solar Photovoltaic at Government Sites with Power Purchase Agreements and Public Debt**
- **Municipal Bond-Power Purchase Agreement Model Continues to Provide Low-Cost Solar Energy**
- **Financing Energy Upgrades for K-12 School Districts: Boulder Valley School District, Colorado**
- **Anne Arundel County Public Schools Completes First Major Solar Project**

Financing

In addition to the resources on PPAs listed in the renewable energy section, there are other mechanisms available to finance K-12 energy efficiency upgrades included in the resources below. For example, in the *Financing Energy Upgrades for K-12 School Districts* publication, a case study on the Douglas County School District in Nevada describes in detail the energy savings performance contract (ESPC) process, which enabled energy savings upgrades in a district with several aging buildings over 35 years old. Through an ESPC, Douglas County School District implemented $5.1 million in improvements. Within 18 months of initiating the project, the work was complete and saving the district money. Additionally, the Oxford Area Community School District in Michigan bundled an ESPC contract with limited-tax general obligation bonds to fund nearly $3 million of energy efficiency improvements in its district with eight schools, achieving a 15-year payback period and about $340,000 in annual savings. Finally, a number of states offer ESPC technical assistance and/or low-cost financing for energy efficiency upgrades. For example, the Texas LoanSTAR Program is a revolving loan fund program for Texas public schools and other public entities across the state. Rural schools can also sometimes access financing through their rural electrical cooperative. DOE provides loans to qualified rural residents to implement cost effective energy efficiency measures through the Rural Energy Savings Program (RESP), a program that helps rural families and small businesses achieve cost savings by providing loans to qualified consumers to implement durable cost-effective energy efficiency measures. School districts are encouraged to contact their state energy offices to discuss financing options for energy efficiency.

- **Innovative Financing Resource**
- **Financing Energy Upgrades for K-12 School Districts: Douglas County, Nevada and Oxford Area Community School District, Michigan**

[3] The U.S. Department of Energy manages CHP Technical Assistance Partnerships in ten regional offices across the country. For more information and how to contact regional experts, you can view a two-page summary here.

- **Energy Savings Performance Contracting: A Primer for K-12 Schools**
- **Energy Savings Performance Contracting Toolkit**
- **Rural Energy Savings Program (RESP)**

Federal, State, and Local Incentives

At the federal, state, and local levels, there are numerous incentives for implementing energy efficiency. Grant and loan programs, tax credits, exemptions, and other initiatives all exist to support schools in search of financial aid for energy efficiency projects. A detailed list of these opportunities is beyond the scope of this document, but there are online resources that include applicable programs for schools like the *Database of State Incentives for Renewables & Efficiency*, a comprehensive source of information on incentives and policies that support renewable energy and energy efficiency. For example, Tennessee's Energy Efficiency Schools Initiative (EESI) is a state-wide energy efficiency program offering financial and technical support with a 98% participation rate of all eligible school districts and 16%-25% energy savings across all programs.

- **Database of State Incentives for Renewables & Efficiency**
- **Tennessee Energy Efficient Schools Initiative**

Behavioral Change Programs

Behavior change strategies are low- to no-cost approaches to educate students and staff on the benefits of energy efficiency. Educators and student engagement through energy curriculum and energy data monitoring to initiate conservation activities can save a significant amount on energy bills. Energy-efficient operations can be a learned behavior and can be encouraged through competition. For example, Aurora Public Schools routinely engaged its students and facilities staff by holding informal competitions for efficient building operations; the school with the best energy performance (i.e., largest energy savings over a baseline) in a given period won a financial incentive to reinvest in school projects. Aurora Public Schools measured a 12% reduction in building energy use intensity from a 2013 baseline in 2017 and realized over $1 million in cumulative cost avoidance since the 2013-2014 school year. This is one example of a low-cost method for increasing energy efficiency awareness and realizing energy and cost savings.

- **Aurora Public Schools: Innovations for Incentivizing Energy Conservation**
- **Powering Down: A Toolkit for Behavior-Based Energy Conservation in K-12 Schools**

For More Information

Visit the Better Buildings Solution Center for more examples of schools making significant progress and achieving their energy efficiency goals. The State and Local Solution Center also provides resources to enable strategic investments in energy efficiency and renewable energy technologies through the use of innovative practices across the United States by a wide range of stakeholders, in partnership with state and local organizations and community-based nonprofits.

The resources listed in this document are not exhaustive. They are intended to be an introduction to information and technologies that can lead to high performance schools in rural communities.

If you have any questions or comments, contact us at stateandlocal@ee.doe.gov

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