Efficient and Healthy Schools – Enabling Investments in Energy Efficiency, Health, and Resilience

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ABSTRACT

Launched in 2021, the U.S. Department of Energy's Efficient and Healthy Schools Program has been working to support under-resourced K-12 schools in their efforts to improve energy efficiency, occupant health, and building resilience. The Program targets schools in disadvantaged communities, rural locales, and schools with a high percentage of students qualified for free and reduced-price meals. This Program aims to provide schools with technical assistance, resources, and tools to empower them to utilize federal funding made available by the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA), as well as other state and local funding opportunities. The COVID-19 pandemic exposed the pervasiveness of outdated school HVAC systems, which fail to provide adequate outdoor air and effective filtration to mitigate infection risk. In addition to this, many schools across the U.S. are also faced with the challenge of maintaining acceptable indoor air quality while impacted by wildfire smoke. Extreme heat presents yet another challenge, often necessitating substantial investments to add efficient cooling in schools that currently lack such infrastructure. While there are existing technologies to address these challenges, schools often have limited capacities to implement improvements. We will share examples of how the Efficient and Healthy Schools Program assists K-12 schools with strategies designed to support the unique challenges of under-resourced schools and time-constrained facilities staff. The strategies presented can enable capacity building and development through key resources developed to reduce implementation barriers, as well as expert consultation, partnerships, and field demonstrations.

Introduction

The Efficient and Healthy Schools Program was launched in 2021 with funding support from the U.S. Department of Energy (DOE) Building Technologies Office. At the time of launch, schools across the U.S. were faced with challenges posed by the COVID-19 pandemic. Substantial investments from the federal government were provided to K-12 schools to help enable safe in-person learning. Lawrence Berkeley National Laboratory (LBNL) was selected to lead implementation of the Efficient and Healthy Schools Program, providing technical assistance to schools in their efforts to improve energy efficiency, health, and resilience. The Program is specifically tasked with addressing challenges faced by under-resourced schools, many of them serving students in disadvantaged communities. The Program has been actively coordinating with other federal agencies – U.S. Department of Education (ED) and U.S. Environmental Protection Agency (EPA), to reach Title I schools[1], schools in rural locales, and tribal schools.

[1] Title I refer to federal funds that are allocated to districts to provide support for students from low-income families through educational strategies to help meet academic standards. Title I funded schools are either targeted assistance

While the COVID-19 pandemic exposed the widespread underinvestment in school facilities resulting in poorly maintained heating, ventilation, and air conditioning (HVAC) systems and deferred maintenance, the lack of capacities is particularly acute in under-resourced schools. The 2021 State of Our Schools report (Filardo et al. 2021) pointed out the inequity in investments comparing school districts at different poverty statuses (Table 1). The report analyzed ten years (2009-2018) of school construction capital outlay and two years (2016-2018) of annual operation & maintenance (O&M) using fiscal spending and investment data from the U.S. Census of Government annual survey of school districts, as well as a compilation of other national school datasets. Table 1 shows that high poverty school districts, and in particular those in rural areas, had the lowest spending on new construction and the lowest annual O&M. This implies that students living in these communities are more likely to be attending schools where facilities are in poor conditions. Overcrowding is another factor associated with poor school facilities. A NCES Survey (2000) found that schools that were overcrowded (enrollments exceeding capacity by 5% or more) were about twice as likely as schools that were within capacity or under enrolled to report having at least one type of onsite building in less than adequate condition. High poverty schools are among the school characteristics associated with overcrowding. The stark disparity has been documented for decades (GAO 1995), where vast differences between the best and the worst conditions were observed during school visits, sometimes in the same school district. The GAO report also estimated that about one-third of all K-12 schools in the U.S. reported needing extensive repair or replacement of one or more buildings. The report noted that about half of the schools reported at least one unsatisfactory environmental condition, such as poor ventilation, heating or lighting problems, or poor physical security. Despite that almost three decades have passed since the publication of the GAO report in 1995, the inequality of having access to school facilities that are in good condition continues to be a reality.

Table 1. Comparison of capital investments on new constructions and annual O&M from U.S. K-12 schools by poverty status

	New Construction (per school)	Annual O&M (per school)
Low poverty school districts	$5.2 million	$600k
High poverty school districts	$3.8 million	$430k
High poverty and rural districts	$2.3 million	$340k

High-poverty and low-poverty are defined in the 2021 State of Our Schools report as >65% and <33%of students qualified for free and reduced-priced meals, respectively. *Source*: Filardo et al. 2021.

A report by University of California Berkeley's Center for Cities+Schools (Vincent 2018) identified key challenges faced by small districts in California, many of them located in rural areas. Through data analysis to understand the capital investment and facility-related characteristics of these school districts, as well as interviews with school staff, the report points out several key challenges that are particularly acute for rural districts: severe capital budget constraints, lack of technical expertise, and inadequate staffing for facilities. Another key

schools or schoolwide program schools. Title I schoolwide program schools have 40% or more of their students from low-income families. We use Title I schools in this document to refer to those receiving funding for schoolwide program.

limiting factor is the limited access to funding, either through local bonds or in their capacity to apply for facility funding. These findings spotlight the importance of providing direct technical assistance to schools and training school staff on facilities, in addition to addressing the fiscal challenges that many schools face.

The National Center for Education Statistics (NCES) is part of ED and is responsible for collecting and reporting statistics on the condition of education activities. The 2021 NCES data (Figure 1, left panel) show that there are more students attending high poverty[2] schools (36%) in cities than those in other locale types: suburban (15%), town (18%), and rural (13%). Figure 1 (right panel) shows clear differences in the race and ethnicity of students attending high poverty schools versus others. The percentage of students who attended high poverty schools was highest for Hispanic students (38%), followed by Black students (37%) and American Indian/Alaska Native students (30%). In comparison, only 7% of White students attend high-poverty schools. These data show that students living in cities and students of color are attending high-poverty schools disproportionately. The NCES report on the Condition of America's Public Schools Facilitates (Alexander et al. 2014) shows that high poverty schools had significantly more of their permanent buildings rated fair or poor (32%) compared to the national average (24%). This disparity held true across many building systems and features, including building envelope, lighting, and HVAC.

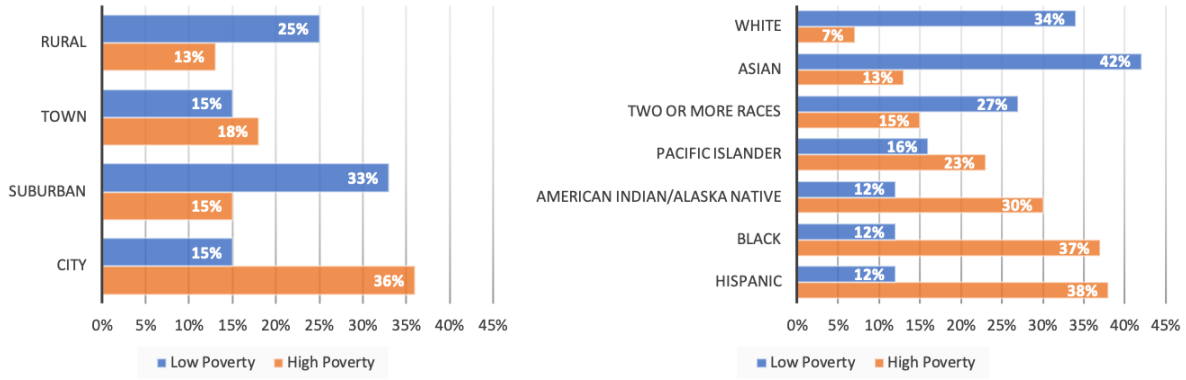

Figure 1. Percent of public school students for each school locale (left) and race/ethnicity (right), presented by school poverty level using Fall 2021 data. *Source*: https://nces.ed.gov/programs/coe/indicator/clb

Program Highlights

The Efficient and Healthy Schools Program set a goal of 500 school districts joining by 2025, of which 20% are in rural locales. In addition, the Program is set to engage with 25,000 schools, with at least 40% being Title I schools. The Program is on track to meet the targets set for rural and Title I schools, and will continue to expand outreach efforts to increase the number of participants. While it is not formally part of the Program goals, the focus on Title I schools and schools in rural areas are prioritized through the other key offerings, including technical assistance, recognition opportunities, creating resources, collaboration with partners, and demonstration projects. The Program extends beyond the rural locale definition used by ED to

[2] NCES defined "high poverty" and "low poverty" as schools with more than 75% and less than 25% of students eligible for free or reduced-price meals, respectively. https://nces.ed.gov/programs/coe/indicator/clb

also include tribal schools, some of which are operated under the Bureau of Indian Education (BIE). In the U.S., there are 183 BIE-funded schools[3], of which 55 are BIE-operated while 128 are tribally controlled.

A key element of our outreach strategy is working with partners who have existing relationships with schools. For example, ED's Rural Education Achievement Program (REAP)[4] is designed to help rural districts that may lack the personnel and resources to compete effectively for federal competitive grants. The Efficient and Healthy Schools Program successfully connected with a small number of the state coordinators of REAP, who assisted in letting rural schools know about technical assistance, free webinars, and other available resources. To reach tribal schools, BIE invited the Efficient and Healthy Schools Program to present topics related to indoor air quality and energy benchmarking. BIE also assisted the Program in identifying tribal schools interested in assessing their energy use and indoor environmental quality (IEQ) – thermal comfort, air quality, lighting, and noise, and made the initial outreach to the schools for their consideration in engaging with the Program. Overall, we found that it is very helpful to leverage existing connections that partners have with schools as an outreach strategy.

Starting in 2024, our Program is expanding how we reach tribal schools in order to actively learn, amplify voices, and provide tailored support for Native communities. Our initial focus is building strong connections with a small number of tribal schools where we can establish a foundation of trust for subsequent collaborations. The Program is developing materials specifically for tribal schools to convey key messages that are culturally sensitive and meaningful. The goal of this initial phase is to create a space for tribal communities' voices to be heard and to understand tribal perspectives on education, the environment, and the role of energy efficiency and better indoor air quality for a healthy learning environment.

Our Program conducted targeted outreach to identify additional organizations active within certain states with many rural and/or high poverty school districts. For example, the Program had connected with one of Wisconsin's Cooperative Educational Service Agency (CESA-10)[5] that provides facilities support to rural districts. CESA-10 plays an important role because many rural districts do not have dedicated staff with sufficient capacity to handle the many facility needs in their schools. We also connected with state and regional programs to learn from their experiences of working with rural schools in their areas. For example, Efficiency Vermont's School Indoor Air Quality Program implemented air quality monitoring in 50 schools, and shared with us their approach and challenges faced. Tennessee Valley Authority's School Uplift (Hoover et al. 2022) implemented a program to provide training and capital improvement funding to underserved schools. Their multiprong approach to engage with schools through low-cost operational and behavioral measures, funding partnership opportunities, and competitions to drive participation from school districts and among students and teachers, were important lessons learned that influenced our Program.

[3] Listing of 183 Bureau of Indian Education funded schools: https://www.bie.edu/schools/directory

[4] U.S. Department of Education Rural Education Achievement Program: https://oese.ed.gov/offices/office-of-formula-grants/rural-insular-native-achievement-programs/rural-education-achievement-program/

[5] https://www.cesa10.k12.wi.us/

Efficient and Healthy Schools Program Participants

Our Program exceeded the goals of at least 20% of participants in rural locales and at least 40% Title I schools. Currently, the Program has 188 participants (Figure 2), representing nearly 8,000 schools. About 26% of participants are in rural locales, and 70% of the represented schools are Title I schools. The high percentage of Title I schools is due to the participation of many large urban school districts, such as the New York City Department of Education, Los Angeles Unified School District, and Clark County School District, each with many Title I schools.

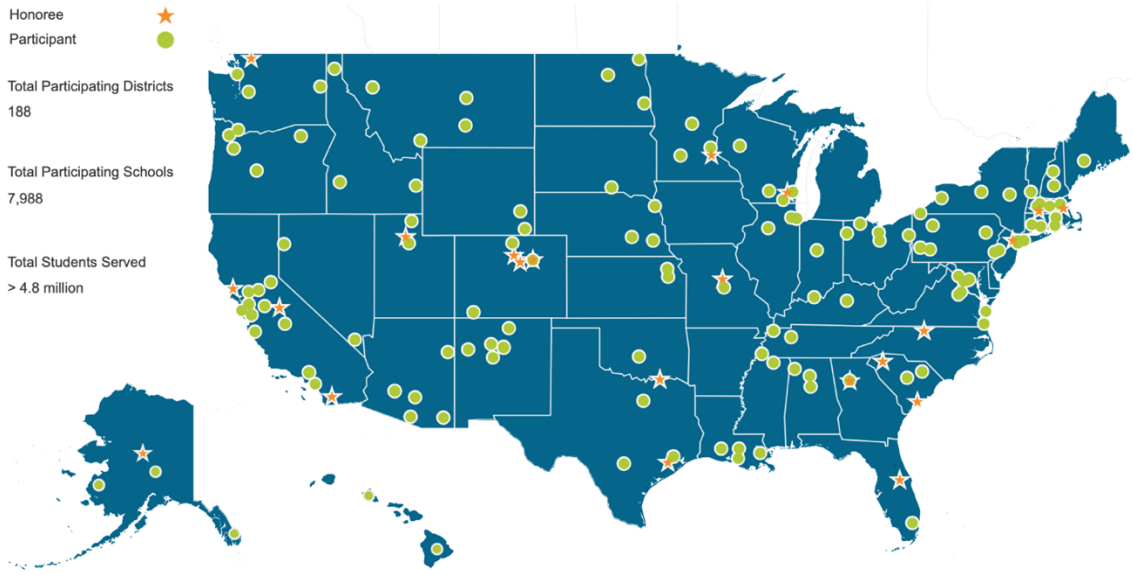

Figure 2. Map showing school/district participants and recognition honorees (2021-2023).
Source: https://efficienthealthyschools.lbl.gov/

Recognition

Schools that have made significantly progress in improving energy performance and the learning environment are recognized annually for their outstanding achievements. Receiving national recognition not only spotlight efforts that schools had already invested in, it also motivates schools to continue their commitment in improving in their facilities. Through our outreach efforts, the Program encouraged school districts with a high percentage of Title I schools to apply for recognition. Year 1 of recognition included three school districts (out of nine applicants) with 50% or more Title I schools. In Year 2, more than half of the applicants (11 out of 18) that applied for recognition were from school districts that had 50% or more Title I schools. Both years of recognition included only one rural school district. This is perhaps a reflection that many rural districts are small and may lack dedicated facilities staff who have the capacity to apply for recognition. Vincent (2018) reported from interviews with 40 rural and small school districts across California that almost half (N=19) do not have dedicated staff who serve as facilities managers. To address the issue of some school districts lacking the capacity to apply for recognition, the Efficient and Healthy Schools Program assists interested applicants by hosting working sessions and acting as a sounding board to identify best practices that other schools can learn from. Over the years, the recognition process has been streamlined to make

applying more straightforward. The Program regularly reach out to supporters, such as architects, engineers, and energy service companies, to voluntarily assist schools that they are working with to apply.

Technical Assistance

The Program actively seeks out schools in rural and tribal areas from among our participants to support with technical assistance. Once a school or district joined the Program, a point of contact is assigned to identify potential areas for technical assistance related to assessments, retrofits, operational improvements, and strategic planning. Even though the extent of technical assistance being offered by the Program is not as direct as retrofit implementation, the support provided is intended to guide and empower schools and districts to make progress towards improving energy efficiency and creating a healthy school environment. In the Program's first two years, 45 schools and districts, of which 13 are located in rural and tribal areas, received technical assistance on various topics. Table 2 shows the topic areas where schools and districts sought assistance, with indoor air quality, energy benchmarking, and recognition idea synthesis leading the chart. Schools and districts often welcomed curated lists of resources[6] on a range of topics, such as funding and decarbonization planning, through direct one-on-one consultation. Our Program is able to provide technical assistance on a range of topics by leveraging the expertise of DOE national labs and resources provided by other federal agencies.

Table 2. Technical assistance topic areas provided by the Efficient and Healthy Schools Program during its initial two years: 2021-2023

Topics	Technical Assistance Count
Indoor air quality	13
Energy benchmarking	10
Recognition idea synthesis	10
Funding	7
Decarbonization planning and goal setting	6
Solar	3
Construction and design	1
Commissioning	1

Source: Efficient and Healthy School Program statistics.

The Efficient and Healthy Schools Program often relied on existing resources when providing technical assistance rather than developing one-off solutions that would not be easily replicable by others. For example, the Program used ENERGY STAR Portfolio Manager, which is freely available to all K-12 schools for energy benchmarking. Even though there is already an abundance of instructions and resources available online on Portfolio Manager, our direct assistance sets schools on the right path, providing them with the data they need to take the next steps to improve their facilities. In some cases, our assistance provided to ease the burden from inputting utility data, such as by reaching out to utilities directly to get the needed information, clears the data access hurdle that had prevented schools from energy benchmarking. Schools and

[6] Efficient and Healthy Schools Program – Resources for Schools: https://efficienthealthyschools.lbl.gov/resources

districts that are already tracking their energy use were introduced to other tools that are connected to Portfolio Manager. For example, the Building Efficiency Targeting Tool for Energy Retrofits[7] (BETTER) is a software tool that can recommend energy efficiency measures using a change-point model and compare heating, cooling, and baseload energy use with benchmarking data. BETTER can estimate energy, cost, and greenhouse gas reduction potential of low-to-no cost operational improvements. This tool was used to assist one school district in comparing their energy use before, during, and after the pandemic to assess changes in their energy use associated with HVAC adjustments implemented for COVID-19.

In the initial two years of the Program, many schools and districts sought guidance on approaches to improve ventilation, filtration, and air cleaning technologies in response to the COVID-19 pandemic, as indicated in Table 2 where indoor air quality is the leading topic area. The Program offered expert consultation on new guidance from agencies such as EPA and the Centers for Disease Control and Prevention (CDC). We assisted school staff in understanding proven and emerging technologies to achieve clean air in their buildings. In addition, the Efficient and Healthy Schools Program partnered with the Pacific Northwest National Laboratory (PNNL) Healthy Buildings Initiative to conduct IAQ audits and other assessments in several tribal schools through BIE. From the IAQ monitoring data and other building information gathered by PNNL, the tribal schools were provided with a list of retrofit measures that have the potential to not only save energy but also improve the indoor conditions in their school buildings. More recently, the Program has been loaning out IAQ monitors to other school participants interested in getting hands-on experience using them. Schools received IAQ monitors on loan and were provided instructions on deploying them. Because we provide the schools with technical assistance in collecting and interpreting interpret the data, this lowers the barrier to schools interested in getting hands-on experience with monitoring.

Resources

As participants sign up to join the Efficient and Healthy Schools Program, they are asked what resources they would find helpful in implementing energy retrofits that also improve IAQ in their schools. Top choices from current participants are energy savings and cost effectiveness data on technologies and approaches. To address this need, we developed two resources intended to assist under-resourced schools so that they can more easily take stock of their buildings and identify and compare different retrofit alternatives that go beyond single energy conservation measures (ECMs). The resources described below aim to provide easy-to-use tools and references that any schools can utilize to gather the necessary data and come up with a retrofit plan.

School Energy Assessment From

The School Energy Assessment (SEA) form is designed for schools to easily collect information to assess their facility conditions, capturing important details on HVAC, lighting, and building construction properties. The form provides helpful graphics and how-to descriptions to assist schools with identifying building equipment and construction properties important for

[7] The Building Efficiency Targeting Tool for Energy Retrofits (BETTER) – a software toolkit using 12 consecutive methods of energy use data to identify energy efficiency measures and estimate saving potentials: https://better.lbl.gov/

determining energy efficiency improvements. When the SEA form is used in combination with the U.S. Department of Energy's Quick Building Assessment Tool (QBAT) in the Building Energy Asset Score (Asset Score) platform[8] managed by PNNL, schools can quickly obtain a report that includes retrofit opportunity information, estimated energy savings, and health and safety benefits. QBAT also includes an ECM Cost Estimates tool that provides ranges on implementation costs for retrofits. Together, this suite of tools enables any school, even if they lack staff with facility expertise, to take the first step towards assessing facilities and applying for competitive grants that may otherwise be out of reach.

DOE's Renew America's Schools is a case in point where grant applicants can use the SEA form and QBAT to describe their schools and create needs and benefits assessments. Instead of limiting schools to third-party assessments that can be costly and time consuming to conduct, this suite of tools is freely available and easy to use, allowing more schools to apply for grant funding. DOE implements other strategies to encourage schools to apply to the Renew America's Schools grant, such as implementing a two-phase application process: a concept paper followed by a full application. The concept paper is a simple process with clear instructions and free, easy to use tools that schools can use to describe their statement of need: community need, facility needs assessment, and fiscal need capacity. As a result, DOE received many applications (N=1,053) from the concept paper phase, with total project costs of 70 times the $80 million planned.

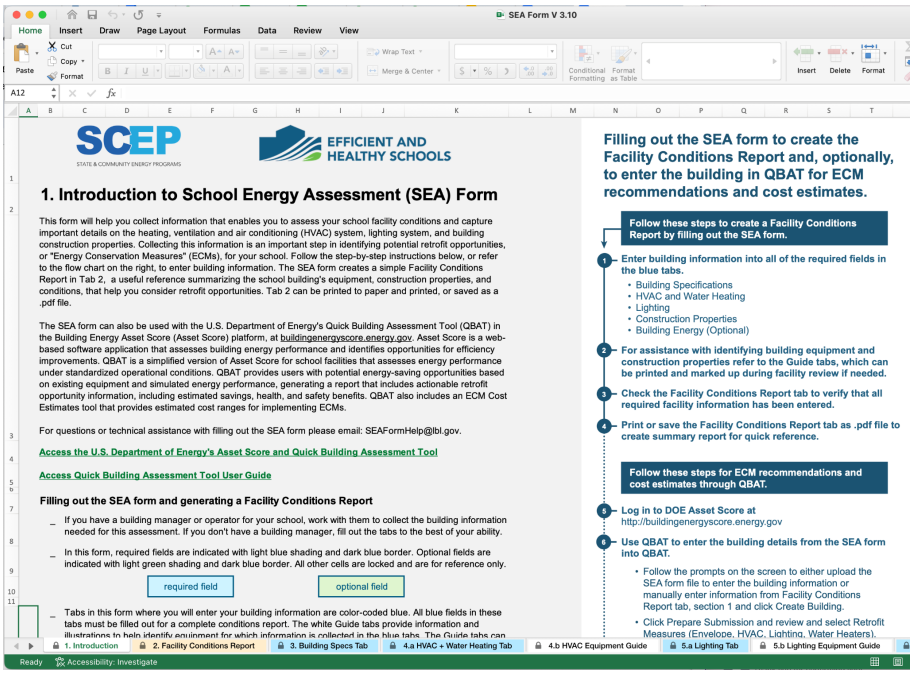

Figure 3. School Energy Assessment (SEA) form. *Source*: https://www.energy.gov/scep/school-needs-and-benefits-assessment-resources

Package Modeling Report

[8] Asset Score – a tool for assessing the physical and structural energy efficiency and identify retrofit potentials of commercial buildings using whole-building simulations: https://buildingenergyscore.energy.gov/

Another common barrier under-resourced schools face is limited exposure to more complex, system-based approaches to energy retrofits. In other commercial building sectors, it has been demonstrated that system retrofit packages combining multiple equipment and controls upgrades for energy savings can benefit from the interactive effects of the different system elements (Regnier et al. 2018). The strong connections between various building systems, such as HVAC, lighting, domestic hot water, and building envelope, impact the overall energy use of a building.. For example, lighting retrofits can lower internal heat gain, thus lowering the cooling load and enabling a smaller capacity cooling system to be installed. The Efficient and Healthy Schools Program extended LBNL's ongoing research efforts on retrofit packages to develop, test and validate, and model the energy performance and cost savings in schools for climate zones across the U.S. The report (LBNL 2023) provides electric, gas, and CO_2 savings from nine different retrofit packages that combine energy conservation measures, including HVAC controls and equipment upgrades, lighting efficiency upgrades, and electrification technologies, such as heat pumps for space conditioning and domestic hot water. Schools can look at these modeled retrofit package results for the climate zone that they are located in to learn about associated energy cost savings, carbon reductions, and descriptions of potential health and safety benefits.

When modeling energy use in schools, some of the key inputs are related to the existing conditions of the school buildings. The initial set of modeling results used DOE reference models that are considered generally representative of a typical primary school and a secondary school in urban areas. Through a combination of literature review, data analysis, and expert interviews, a new set of models were also developed to reflect distinctive aspects of existing rural schools better (LBNL 2024). Rural schools tend to have lower building utilization, and thus, the classroom occupancy was modeled to be 20% lower than in urban schools. Experts knowledgeable of rural schools recommended selecting constant air volume (CAV) systems as the default for HVAC instead of variable air volume (VAV) systems, which are more common in urban schools. We adjusted the parameters used to describe the building envelope, including wall, roof, and window performance specifications, to reflect that rural schools are generally older than urban schools. These changes generally resulted in slightly higher energy cost savings and carbon reductions in cold-climate rural schools compared to urban schools. The difference between rural and urban schools is smaller in milder and cooling-dominated climates. These results are presented to schools in a modeled retrofit package performance report (LBNL 2024) with lookup tables to make it easy for schools to find the modeling results that best describe their buildings.

Partnerships

While the work described thus far was led by LBNL, the Efficient and Healthy Schools Program also engages with various organizations to amplify school support. Supporters, including industry and nonprofit organizations, researchers, contractors, and vendors, are key to further promoting, implementing, and scaling up facility upgrades nationwide. The diversity in expertise and geography of our supporters enables the Program to reach more schools. ASHRAE and the US Green Building Council (USGBC)'s Center for Green Schools are two leading organizations that the Efficient and Healthy Schools Program is actively working with to expand our reach. Examples of our collaborative efforts are described below, which range from providing training, creating resources, and directly engaging with schools and districts in planning and assessment activities.

ASHRAE Chapters

In 2022, ASHRAE formally launched a school pilot program where local chapters lead outreach with under-resourced schools in their areas. Members from the local chapters, many of whom are professional engineers and designers, share technical information on how to improve the energy and IAQ performance of school facilities. ASHRAE's Schools Leadership Team has worked with local chapters, conducting one-on-one meetings to discuss needs and assess challenges. The Leadership Team has conducted several educational webinars to lay the groundwork for the program, informing members about outreach strategies with schools and districts, and providing technical assistance training. The local chapter members represent local expertise and are committed to sharing ASHRAE's knowledge base and industry-leading resources with schools in need. ASHRAE has committed to continue supporting the pilot program, and potentially extending from professional local chapters to include student branches to increase participation. So far, fourteen local chapters have signed up and volunteered to share relevant resources on facility assessments and energy retrofit guides with their local school districts, including:

- Alaska
- Baltimore
- Central New York
- Central Oklahoma
- Detroit
- Florida Gold Coast
- Houston
- Memphis
- Miami
- Minnesota
- Rochester
- Southern California
- South Texas
- Utah

Engagement between ASHRAE chapters and schools in their local areas are slowly expanding. One notable example is the ASHRAE Memphis chapter had demonstrated significant contributions by engaging with their local school district. The Memphis chapter provided technical assistance to the Memphis-Shelby County Schools on assessing their building needs and identifying improvement opportunities. This district was recently awarded a DOE Renew America's Schools grant to demonstrate a set of energy conservation measures in one of their elementary/middle schools, including: lighting replacement, HVAC upgrades, boiler plant electrification, new exterior windows, and solar array. The proposed work in Memphis will include piloting energy-related learning activities to be replicated across other middle schools in the district. The work being planned by the Memphis-Shelby County Schools also includes additional community stakeholder engagement, including coalitions serving disadvantaged communities, municipal leaders, workforce, and labor groups representing diverse populations, older adults, faith groups, and local business.

USGBC Center for Green Schools

Improving indoor air quality in schools has been a key focus for the USGBC Center for Green Schools in response to the COVID-19 pandemic. The Efficient and Healthy Schools Program collaborated with the Center for Green Schools to conduct a school staff survey (Bueno et Mesquita et al. 2022) to better understand the implementation of ventilation, filtration, air cleaning, and other strategies to mitigate airborne infection risks. The report identified several key differences between urban and rural schools. For example, rural schools are more likely to rely on state and local guidance rather than guidance from federal agencies or national organizations. Understanding these differences is important to develop effective communication approaches to motivate schools to improve their facilities.

In 2023, the Efficient and Healthy Schools Program collaborated with the Center for Green Schools and EPA and provided in-person IAQ training for about 50 school staff. These training events were invaluable in fostering relationships among school staff where they could discuss challenges, share solutions, and learn from each other. School staff also gained knowledge from experts presenting on a range of IAQ topics, such as creating an IAQ management plan, IAQ monitoring, and funding opportunities for IAQ improvements. These training opportunities were attended by school staff traveling from nearby areas, generally representing more urban and larger school districts with dedicated facilitates staff who are responsible for IAQ.

Looking forward, the activities between the Efficient and Healthy Schools Program and the Center for Green Schools will continue with the goal to leverage and expand the support for schools on IAQ, decarbonization, and related topics. In addition to co-hosting in-person events, creating training materials and resources for energy efficient, healthy, and sustainable schools are among the core elements of this partnership. Making sure that the materials are accessible and address the needs of under-resourced schools is a priority.

Field Demonstrations

There are a number of demonstration projects being carried out as part of the Efficient and Healthy Schools Program to showcase broadly replicable solutions for rural and tribal schools in their unique climate and locations. While documenting the technology and outcomes are important, even more critical is making sure that the approaches are broadly replicable so that many schools can reference these demonstration projects as best practices as they plan for retrofits. A significant contribution from the Program is to lean on measurement and verification (M&V) and document the value of

Alaska Schools Commissioning and HVAC Control Upgrades. Alaska schools are faced with high total site energy costs. This is due to the cold climate and resultant high heating use (Hirshberg and Green, 2021) across the state, the high unit costs of energy associated with the remoteness of settlements and their educational facilities, and the limited fuel options for generating heat and electricity in these locations**.**

Two schools - located in Emmonak Bay and Scammon Bay in the Lower Yukon - underwent scheduled HVAC retrofits and were selected to demonstrate the impact of commissioning and

control upgrades that reflect adherence to ASHRAE Standard 55[9]. Energy metering and IAQ monitoring were installed to document the benefits of the HVAC system replacement, as well as any additional improvements from commissioning and control upgrades. The commissioning activity and control upgrades utilized the newly installed remote direct digital control (DDC) system access at both sites. This enabled the team to review schedules, setpoints, and relied on user knowledge of the facility to identify energy savings opportunities. Data collection for the post-commissioning phase is currently in progress; measurement and verification (M&V) analysis will bring the project to conclusion in summer.

Hawai'i Schools HVAC Retuning and Controls. High per-unit energy costs in the islands mean that a significant portion of the state Department of Education's (HIDOE) budget is spent on energy for school facilities. Meeting classroom indoor air quality and thermal comfort requirements, particularly during the tropical summer, can be a challenge for facility HVAC systems, which are frequently under-maintained due to the competition for scarce department resources.

HIDOE was already engaged in a large-scale facility assessment program, whereby the value of data monitoring for indoor environmental quality (IEQ: thermal comfort, air quality, lighting, and noise) can be used to improve building operations. The focus of this demonstration project was also to collect data on energy use and demonstrate the energy and IEQ impacts of unit retuning and implementation of scheduling and occupancy controls for in-window air conditioning units and split systems, both commonly used in Hawai'i schools to provide mechanical cooling. Implementation of the retuning and retrofits at the field demonstration site on O'ahu has been completed, and M&V analysis of the retuning and retrofit impacts will be conducted when post-retrofit data collection is scheduled to conclude this summer.

Tribal Schools Building Retrofits in Southwestern Region. Prior ventilation assessments conducted by BIE at two schools - one in New Mexico and another in Arizona - identified the need to bring in more outside air for better indoor air quality. Each school faced additional challenges around meeting IEQ requirements for teachers and students due to local climate and weather conditions and the operation of their building systems.

New Mexico. Indoor temperatures throughout the school are heavily influenced by the low U-factor of the skylight glazing, which, during the hot summer, results in excessive heat gain in the main part of the building. In winter, the same skylights deliver uncomfortably cool conditions, especially in the morning. An undersized heat pump split system results in too-hot and too-cool conditions in classrooms in a separate wing of the building. The planned field demonstration will involve an upgrade to the skylights via the installation of high-performance secondary glazing and the replacement of the existing split system heat pump with a larger-capacity, high-efficiency unit. These retrofits are planned for the summer recess, with the energy and IEQ impacts evaluated once M&V data collection has concluded in the fall. The results will be compared with data collected previously at the school.

[9] ASHRAE Standard 55 (2023) Thermal Environmental Conditions for Human Occupancy. https://www.ashrae.org/technical-resources/bookstore/standard-55-thermal-environmental-conditions-for-human-occupancy

Arizona. The current HVAC system configuration and operating mode have led to restricted classroom ventilation air supply. This resulted in inadequate ventilation, indicated by high carbon dioxide (CO_2) levels accumulating in the school building. BIE is implementing a deep retrofit and replacement of the existing HVAC system. Our demonstration work will focus on measurement and verification of the new system once the retrofit is complete and compare energy and IEQ data with prior data collected at the school. It is expected that the project M&V phase will take place during the fall.

Lessons Learned from Demonstration Projects

Through our wide-ranging activities, all geared to support schools, the Efficient and Healthy Schools Program came across different challenges in our interactions with schools. Below are some of our lessons learned.

Local Connection. Hands-on work with schools often requires a lengthy effort to get the necessary buy-in from the school administration to move the project forward. School administration is often overloaded with many requests that require their attention. The unfamiliar nature of being part of a demonstration project with new partners can cause hesitation. This process may be shortened if there is already a trusted relationship in place. In each of the above projects, the Efficient and Healthy Schools Program works with entities and contractors who are already familiar with the areas where the school sites are located. Having this local connection makes collaboration with the schools much easier.

Flexibility. Across the board, school facilities staff are very time constrained, and there are often competing issues that can take priority at a given time. The project team needs to build in some flexibility in plans and schedules. School facilities staff can be pulled in many directions. During the course of a school year, there are periods when events like return to school and preparation for school breaks and urgent matters like safety and security concerns will cause delays to non-essential project work.

Data Access. Because of the remoteness of some rural and tribal school locations, getting the right information to the project team can be challenging. Sometimes the barrier is a result of the physical distance and limited transportation options. Accessing utility bills alone can also be time consuming to do, requiring asking multiple people in the organization for needed information. The project team needs patience as they are gathering building data and should only ask for the necessary data fields.

Remote Assistance. Since the COVID-19 pandemic, most school staff are comfortable with remote assistance and project coordination. This opens up opportunities for more school staff to interact with the Efficient and Healthy Schools Program. Some portion of the preparation work can be completed with remote assistance, if clear guidance is provided to school staff and regular check-in meetings are scheduled to maintain clear communication with school staff.

Communicate Outcomes. Schools are often interested in learning how various approaches to improve energy efficiency and indoor air quality actually perform when installed. Creating case

studies[10] and featuring the results observed from demonstration sites are immensely important to communicate this work to the public. Our Program routinely share success stories on our website and invite schools to discuss lessons learned through webinars. School staff finds trustworthy information that they can rely on to be very important when making the case for their decision makers and the greater school communities at large.

Conclusion

The Efficient and Healthy Schools Program has been working to support under-resourced K-12 schools in their efforts to improve energy efficiency, occupant health, and building resilience. We shared examples of how the Program assists K-12 schools with strategies designed to support the unique challenges of under-resourced schools and time-constrained facilities staff. This report describes our strategies to enable capacity building through key resources as well as expert consultation, partnerships, and field demonstrations to reduce implementation barriers. We observed great needs to improve school facilities among our participants. We designed our Program such that it is simple to join, and provide flexibility in letting participants decided what areas to focus on. The Program also create case studies and resources to encourage other schools to replicate and follow best practice. Schools interested in recognition can obtain assistance with their applications. Our experience with implementing the Efficient and Healthy Schools Program is that in order to engage with a broad range of schools nationwide, it is important to provide technical offerings spanning many topics that schools may be focusing on at a given time, such as indoor air quality during the COVID-19 pandemic and wildfires, and planning for clean energy adoption to access funding opportunities. Equally important is the wide-ranging approaches that the Program use to engage with schools as we have described here. It is our goal to continue working with our partners, and increasing participation among K-12 schools in all aspects of the Program in the years to come.

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