Sun Prairie Area
School District

Sun Prairie Area School District Energy Plan

December 31, 2023

Acknowledgment: "This material is based upon work supported by the by the Public Service Commission of Wisconsin, Office of Energy Innovation and the Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under the State Energy Program Award Number DE-EE0000163."

EXECUTIVE SUMMARY

Energy costs are often one of the largest operating costs for a school district. Implementing energy cost reduction strategies to lower operating costs and carbon emissions has long been a priority for Sun Prairie Area School District.

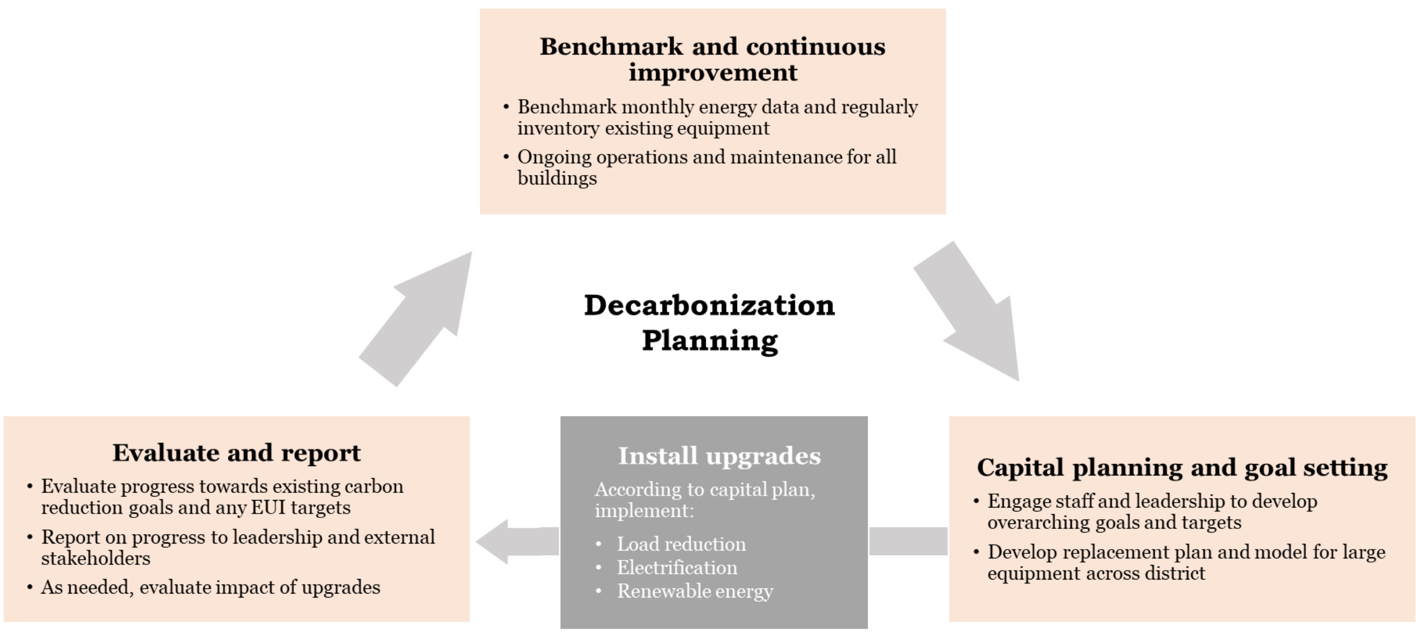
As a next step in its sustainability progress, Sun Prairie Area School District (SPASD), Monona Grove School District (MGSD), Oregon School District (OSD), and Middleton-Cross Plains Area School District (MCPASD) partnered to collaborate on a joint energy planning project. The project was funded by the Office of Energy Innovation and the goal of the collaborative project was to develop an actionable decarbonization framework while learning best practices from and alongside one another.

Over the last year, the school districts partnered with local nonprofit, Slipstream, to develop decarbonization plans for current school district operations. The joint energy planning project process included baseline data collection and benchmarking, analysis of energy efficiency, electrification, and renewable energy opportunities for the districts, development of recommendations for ongoing data tracking and reporting, and identification of funding sources for implementation.

As each of the school districts has already made significant strides in reducing energy use and started a transition to renewable energy, the planning process focused on full decarbonization, or elimination of carbon dioxide emissions, for buildings and fleet.

Figure 1 provides an overview of the decarbonization framework that guided the development of this plan for SPASD. The framework includes a series of steps: benchmark energy data and continuous improvement, capital planning and goal setting, install projects, and evaluate and report. These steps work together as a phased implementation approach to decarbonization.

Figure 1. Overview of decarbonization pathway



Understanding current energy use, energy costs, and CO_2 emissions, as well as existing systems, and replacement ages is an important first step in decarbonizing school operations. Table 1 details the CO_2 emissions, energy costs, and total energy use for each of SPASD's buildings. The costs are based on average energy use charges and do not represent exact 2021 costs.

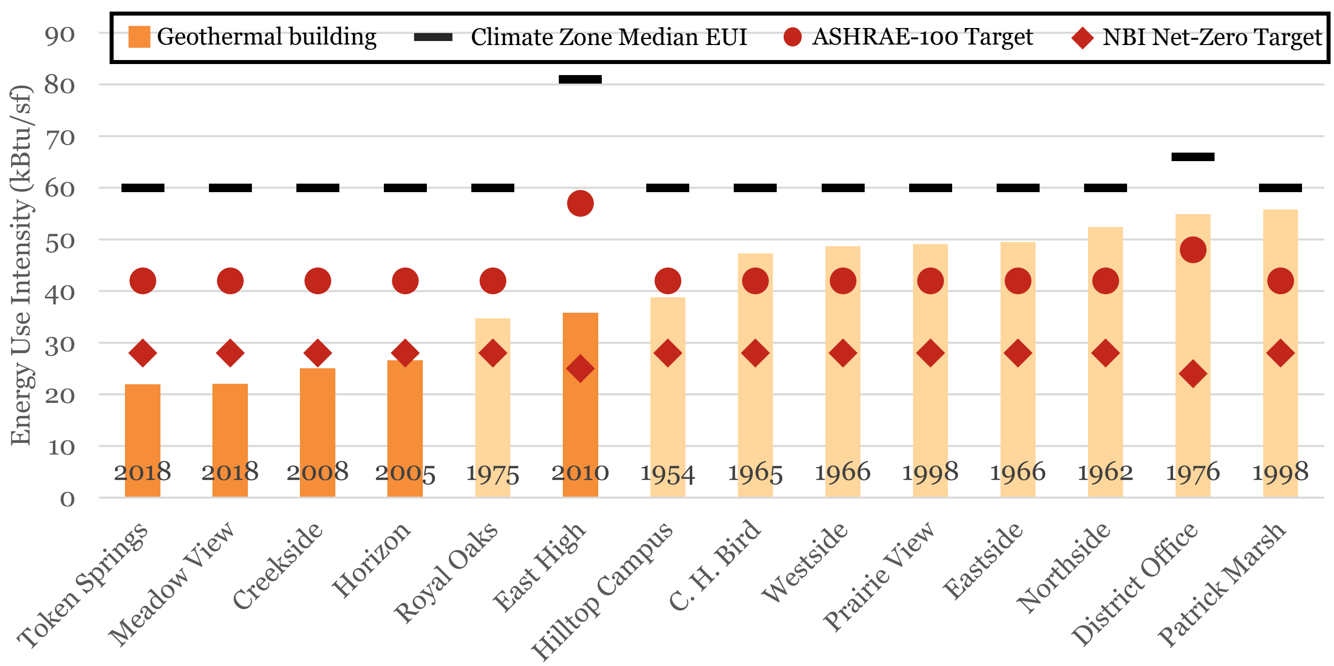
Table 1. Annual CO_2 emissions, energy costs, and energy use across SPASD buildings (2021 data)

Building	CO_2 Emissions (MT)	Energy Costs	Total Grid Energy (kBtu)
East High School	2,034	$380,800	14,550,910
Hilltop Campus	859	$151,120	9,970,190
Patrick Marsh Middle School	688	$123,650	6,992,100
Prairie View Middle School	623	$112,330	6,154,740
Token Springs Elementary School	414	$78,170	2,666,700
Meadow View Elementary School	401	$75,980	2,541,160
Creekside Elementary School	345	$65,190	2,197,800
Westside Elementary School	316	$56,590	3,288,300
C. H. Bird Elementary School	312	$55,070	3,541,390
Horizon Elementary School	309	$57,350	2,382,960
Northside Elementary School	308	$54,540	3,463,560
Eastside Elementary School	300	$53,650	3,107,970
Royal Oaks Elementary School	295	$53,500	2,777,010
District Office	281	$51,290	2,555,120
Total	**7,809**	**$1,369,230**	**70,519,050**

Site energy use intensity (EUI) is a metric that shows the building's total energy use divided by square feet of the building and provides a standard approach to examine energy performance of a building. Figure 2 illustrates the site EUI of all SPASD buildings compared to industry EUI targets schools in this climate zone. All SPASD buildings currently perform better than median regional EUIs, so the graph also includes a high-performance target from ASHRAE-100[1] and a net-zero target developed by New Buildings Institute (NBI).[2]

The net-zero targets represent best-in-class buildings and establishes targets for all schools to strive for through energy efficiency and electrification. The intention is that buildings meeting the net-zero target could cover the remaining energy use with onsite renewable energy.

Figure 2. Weather-normalized site EUI compared to ASHRAE-100 target and NBI net-zero target

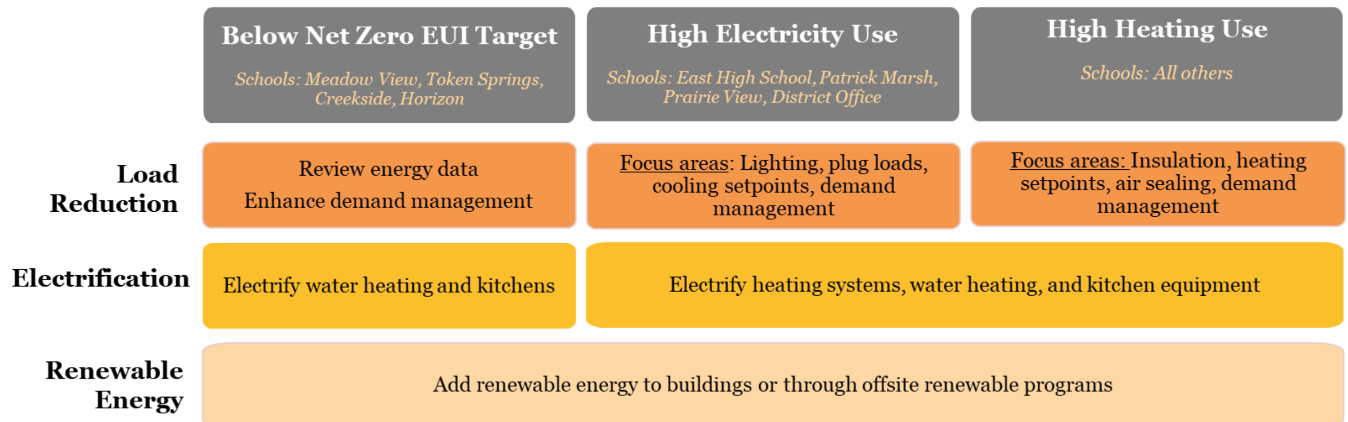


[1] The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) created Standard 100-2018 -Energy Efficiency in Existing Buildings that offers median EUI values as well as energy targets by building type. The energy targets represent the bottom (or best-performing) 25th percentile of energy use by building type. https://www.ashrae.org/news/esociety/updated-standard-100-published.

[2] New Buildings Institute, 2019, Zero Energy Commercial Building Targets, https://newbuildings.org/wp-content/uploads/2019/09/ZeroEnergyCommercialBuildingTargets.pdf

Informed by the baseline data and an inventory of current energy use intensity and equipment type and age, the team developed a decarbonization roadmap for the school districts' portfolio of buildings. Figure 3 summarizes the main three categories considered in decarbonizing buildings. Load reduction, or reducing overall energy use, is primarily achieved throuhg efficiency and demand management and leads to direct cost savings. Electrification, or transitioning to from delivered fuels (e.g. natural gas or fuel oil) to high-efficiency options, is a key step in the process of decarbonizing. As evidence indicates that the electric grid will continue to add clean sources, electrification of key equipment ensures that energy use will be increasingly sourced from clean sources, whereas continuing to use delivered fuels (e.g. natural gas) will lead to the same amount of emissions per unit of energy used. Adding renewable energy can further offset emissions and lower energy costs.

Figure 3. Recommended measures for load reduction, electrification, and renewable energy



It is recommended that SPASD plan for equipment replacements and renewable energy installations as part of its ongoing capital improvement process. As equipment upgrades are made, SPASD should regularly assess their impact and report on the progress towards its goals. The evaluation of upgrades should consider progress against any goals previously set districtwide. When evaluating progress, it is important to calculate the actual impact by accounting for weather trends and comparing a full year of data prior to the upgrade to a full year after the upgrade. This process should also incorporate regular reporting (through presentations, reports, or dashboards) to external stakeholders to continually engage and inform the community and demonstrate the districts ongoing commitment the goals.

The timing for implementing a comprehensive decarbonization framework is opportune with an unprecedented amount of state and federal funding available to school districts for clean energy projects. The federal funding is available through 2032, emphasizing the importance of starting upgrades now to leverage the available funding. Funding opportunities include:

- **Leverage fuel and maintenance cost savings to fund capital expenses.** Energy efficiency upgrades and solar installations will save SPASD money on annual operating costs. SPASD could quantify avoided costs and use those avoided costs to implement other recommended actions.
- **Utilize existing utility incentives.** Sun Prairie Utilities offers incentives both through WPPI and Focus on Energy for renewable energy installations and energy efficiency upgrades and installations.
- **Apply for federal tax credits.** The Inflation Reduction Act (IRA), a federal law passed in August 2022, represents an unprecedented amount of funding for energy and climate actions. Through this funding, it also includes a provision, direct or elective pay, that makes non-taxable entities eligible for the tax credits that can offset 30% of upfront costs.
- **Apply for other state, foundation, and federal grant and financing opportunities.** There are other grant programs and financing opportunities from the state, foundations, and federal grant programs that will fund these initiatives.

CONTENTS

GLOSSARY OF TERMS

Battery energy storage system (BESS): Equipment that is able to store energy and then release it when needed for use. Often lithium-ion batteries.

Decarbonization: Eliminating carbon dioxide emissions from operations of buildings, processes, and fleet. Switching from fossil-fuels to carbon-free sources.

Direct pay: A provision in the Inflation Reduction Act that makes non-taxable entities eligible for tax credits for clean energy items (including renewable energy and alternative vehicles).

eGauge monitors: Monitoring device that track energy use at a detailed time interval (down to 1 minute) that can be installed directly on electrical panels

Energy walkthrough: Assesses how a building currently uses energy and identifies opportunities to reduce the building's energy consumption.

Electric school buses (ESBs): School buses that are powered by a battery and electricity.

Electric vehicle (EV): vehicles; cars, trucks, and buses powered by a battery and electricity.

Electrification: Transitioning from fossil-fuel delivered fuels (such as natural gas or fuel oil) to electricity to lower carbon dioxide emissions, save money, and improve health. Transitioning to electricity is a benefit as the electric grid will continue to add clean sources while delivered fuels will maintain the same emissions rate.

Energy use intensity (EUI): Total energy use of a building divided by the total square feet of the building. Normalizes energy use across buildings of different sizes.

Focus on Energy: Wisconsin's statewide program to increase energy efficiency and renewable energy use among residents, businesses, and local governments.

Heat pump: Single heat pump replaces both furnace and an air conditioner; fueled only by electricity and very efficient.

Internal combustion engine (ICE): Conventional gasoline or diesel vehicles.

Inflation Reduction Act (IRA): Federal law passed in 2022 that directs significant funding to clean energy and climate solutions. A portion of funding is directed at local governments through rebates or grant programs.

Microgrid: A group of interconnected loads and energy resources that can connect and disconnect from the grid. Can operate as part of larger group or on its own.

Net metering: Billing mechanism that credits solar energy owners for electricity added to grid.

Non-taxable entity: An entity that is not required to pay income taxes. Includes nonprofits, local and state governments.

National Fenestration Rating Council (NFRC): Provides energy performance ratings for windows and doors.

PV: Photovoltaic solar energy; converts energy from the sun to electricity.

Renewable energy: Energy that is generated from a naturally replenishing resource that does not release carbon, such as solar energy, wind energy, or geothermal.

Retrocommissioning: A systematic process of investigating and analyzing existing building's systems for operational and maintenance improvements.

Solar heat gain coefficient (SHGC): A standard that estimates solar radiation that passes through a window compared to the amount of solar radiation that hits the window. The lower the number, the more efficient.

Total cost of ownership (TCO): Total cost of owning equipment, including upfront cost, any energy or maintenance costs, and resale forecast.

U-value: Performance rating for how well a window holds in heat or cool air. A lower number means less heat loss or higher efficiency.

Weather-normalized site EUI: The energy use a building would have consumed during 30-year average weather conditions. It can be helpful to use this weather normalized value to understand changes in energy when accounting for changes in weather. Energy use is divided by square feet.

INTRODUCTION

Energy use in schools is often at the top of operating cost for school districts and is a large contributor of emissions. Significant cost savings from low-carbon and highly efficient schools can allow school districts to reallocate funding for use elsewhere. Recognizing the benefits from lowered operating costs, Sun Prairie Area School District has long been committed to sustainability and energy conservation. In 2006, the school district hired an energy and sustainability manager to focus on commissioning, scheduling, equipment replacements, and control sequences upgrades. Since that time, the district has retrofitted all of its buildings with LED lighting, replaced multiple chillers and boilers with high-efficiency equipment, and it now uses geothermal systems in all new buildings. The district has also installed solar arrays at several schools.

As a next step in its sustainability progress, Sun Prairie Area School District partnered with three other Dane County school districts in 2022 to collaborate on a joint energy planning project. The goal of the collaborative project was to develop an actionable decarbonization framework while learning best practices from and alongside one another. Together, Sun Prairie Area School District (SPASD), Monona Grove School District (MGSD), Oregon School District (OSD), and Middleton-Cross Plains Area School District (MCPASD) were awarded an energy planning grant from the Office of Energy Innovation in August 2022.

Over the last year, the school districts partnered with local nonprofit, Slipstream, to develop decarbonization plans for current school district operations. The decarbonization plan guides future actions and positions the school districts to apply for and access additional implementation funding from state and federal funding sources. Recognizing the value of collaboration, the school districts met regularly throughout the project period to share lessons learned and discuss items to be included in the plan.

The joint energy planning project process included:

Data collection and benchmarking. The team collected and compiled energy use data and information on current building systems to understand baseline conditions for each school district. The analysis included benchmarking current energy use and CO_2 emissions across buildings.

Building decarbonization planning. An analysis of current building systems and research to identify pathways to reduce carbon emissions across the school districts' building portfolio. This includes energy efficiency, demand management, and electrification. The team also conducted an energy walkthrough assessment at one school building to develop a more detailed example of the process and potential timeline for decarbonization.

Renewable energy analysis. The team analyzed potential renewable energy installation opportunities for a select number of schools and researched potential opportunities for off-site renewable energy for the district.

Fleet case study research. SPASD does not own its school buses, so the focus was to provide examples of how other school districts have worked with contractors to adopt low-carbon fleet alternatives.

Ongoing data tracking and reporting exploration. SPASD currently tracks monthly energy use for all buildings and hourly energy use at a select number of schools. The team evaluated opportunities for ways to better track the impact year over year and how to report on progress to school leadership and external stakeholders.

Fact sheet development. The school districts collaborated on creating fact sheets that describe some of the best practices they use in their schools. The goal is to share the fact sheets with other school districts across Wisconsin to share lessons learned.

Identification of funding sources for implementation. The process also includes identification of funding opportunities for the school districts to implement recommended actions in the plan. These included rebates and federal grant and financing opportunities.

This document serves as the decarbonization roadmap for SPASD's buildings. The document provides high-level direction and recommended actions across the entire building portfolio. Additional engineering, design, and final pricing of all recommendations will be required prior to implementation.

Figure 4 provides an overview of the decarbonization framework that guided the development of this plan for SPASD. The framework includes a series of steps: benchmark energy data and continuous improvement, capital planning and goal setting, install projects, and evaluate and report. Each of these steps is elaborated below.

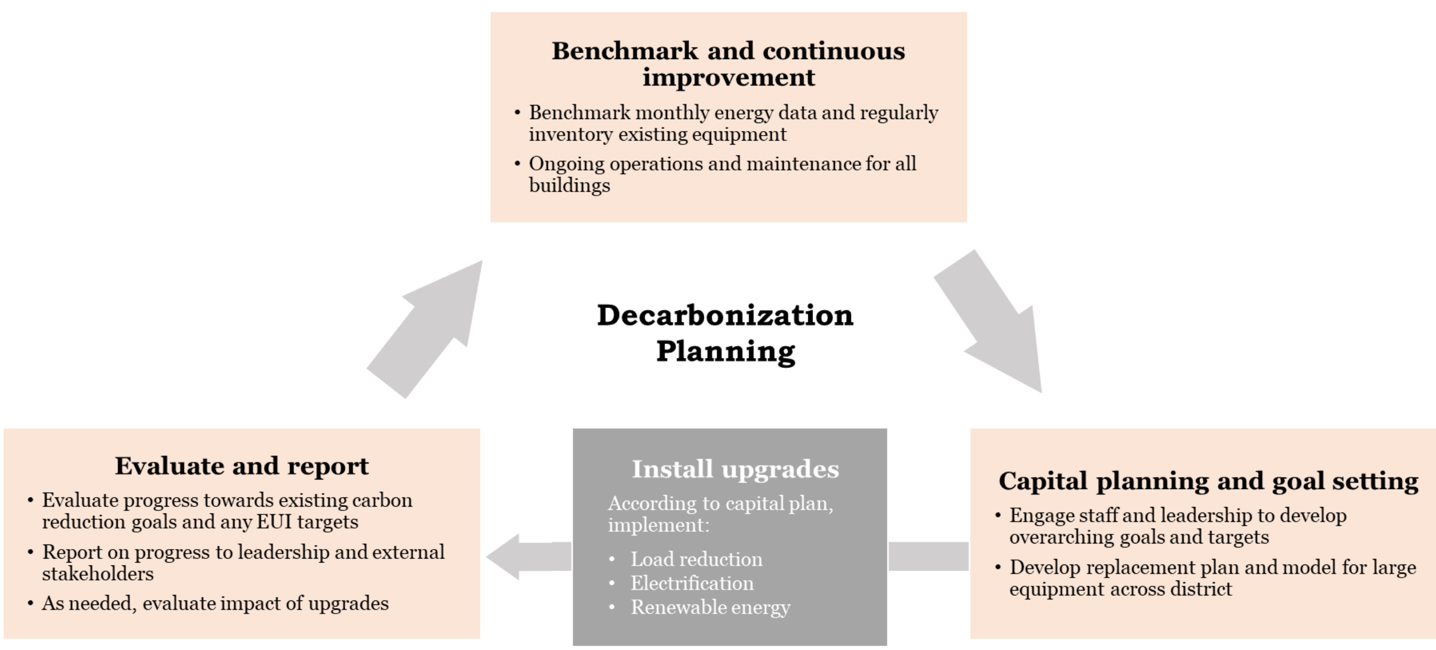
Benchmarking and continuous improvement encourages ongoing tracking of monthly utility bills, inventorying of current equipment type, condition, and age, and ongoing operations and maintenance for all buildings. Benchmarking provides information on relative energy performance by comparing energy use over time to other buildings. Inventorying of systems informs the potential need for upgrades. Diligent operations and maintenance make larger upgrades and energy reductions more successful over time. SPASD already engages in ongoing benchmarking with ENERGYSTAR Portfolio Manager. This report provides additional industry standard targets to aid in benchmarking, includes recommendations for inventorying of systems, and offers suggestions for ongoing operations and maintenance improvements.

Capital planning focuses on developing comprehensive goals and targets for overall SPASD emissions and for individual buildings. With those goals in mind, the plan creates a capital improvement plan to map out when equipment replacements will occur. Both steps should engage multiple internal stakeholders and consider how to engage the community at large. Moreover, capital planning should incorporate the age and condition of equipment, overarching goals, and timelines of available funding, such as federal tax rebates and grants.

As guided by the capital improvement plan, the school district should install upgrades as needed. The plan provides guiding information about how to prioritize projects and what to consider for energy efficiency, demand management, electrification, and renewable energy.

The last step is to evaluate annual progress and develop a process to report to stakeholders across the district. The roadmap includes an overview of tools and methods other school districts have used to both measure and validate savings, as well as develop a robust way to continuously report progress.

Figure 4. Overview of decarbonization pathway



BENCHMARK AND INVENTORY

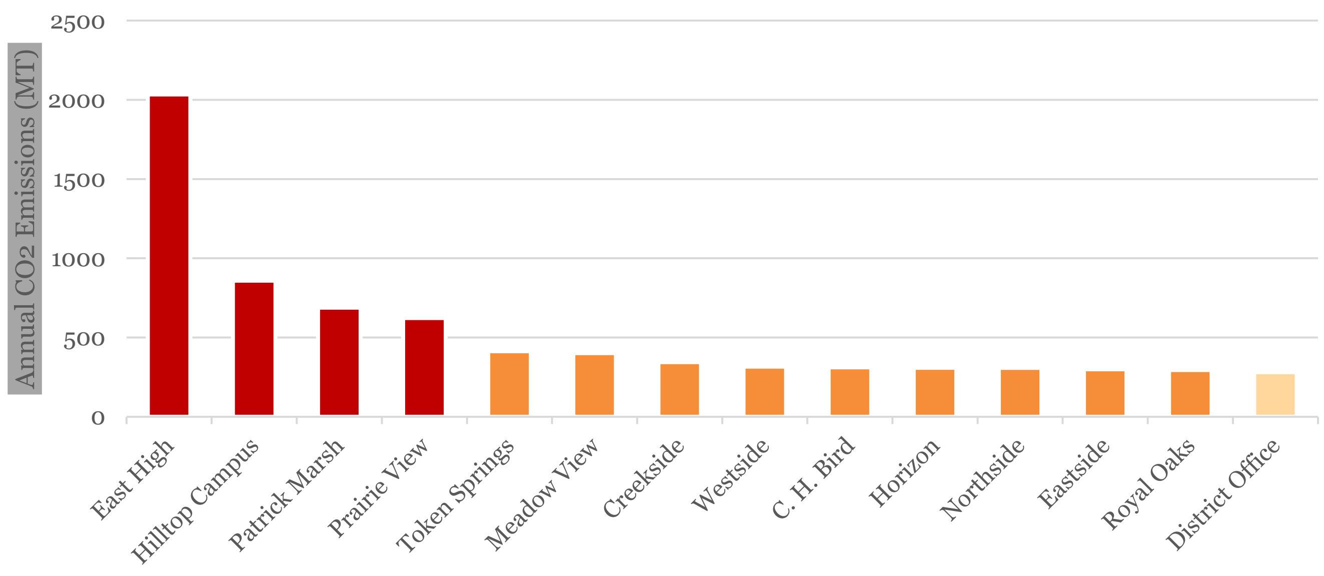
Understanding current energy use, energy costs, and CO_2 emissions as well as existing systems and replacement ages is an important first step in decarbonizing school operations. Table 2 details the CO_2 emissions, energy costs, and total energy use for each of SPASD's buildings. The costs are based on average energy use charges and do not represent exact 2021 costs. West High School is not included as it is too new to have meaningful data.

Table 2.Annual CO2 emissions, energy costs, and total energy across SPASD buildings (2021 data)

Building	CO_2 Emissions (MT)	Energy Costs	Total Grid Energy (kBtu)
East High School	2,034	$380,800	14,550,910
Hilltop Campus	859	$151,120	9,970,190
Patrick Marsh Middle School	688	$123,650	6,992,100
Prairie View Middle School	623	$112,330	6,154,740
Token Springs Elementary School	414	$78,170	2,666,700
Meadow View Elementary School	401	$75,980	2,541,160
Creekside Elementary School	345	$65,190	2,197,800
Westside Elementary School	316	$56,590	3,288,300
C. H. Bird Elementary School	312	$55,070	3,541,390
Horizon Elementary School	309	$57,350	2,382,960
Northside Elementary School	308	$54,540	3,463,560
Eastside Elementary School	300	$53,650	3,107,970
Royal Oaks Elementary School	295	$53,500	2,777,010
District Office	281	$51,290	2,555,120
Total	**7,809**	**$1,369,230**	**70,519,050**

Figure 5 illustrates the overall carbon impact of each building visually. This illustrates the relative impact of each on the districtwide emissions profile.

Figure 5. Relative CO_2 impact of each school in SPASD portfolio

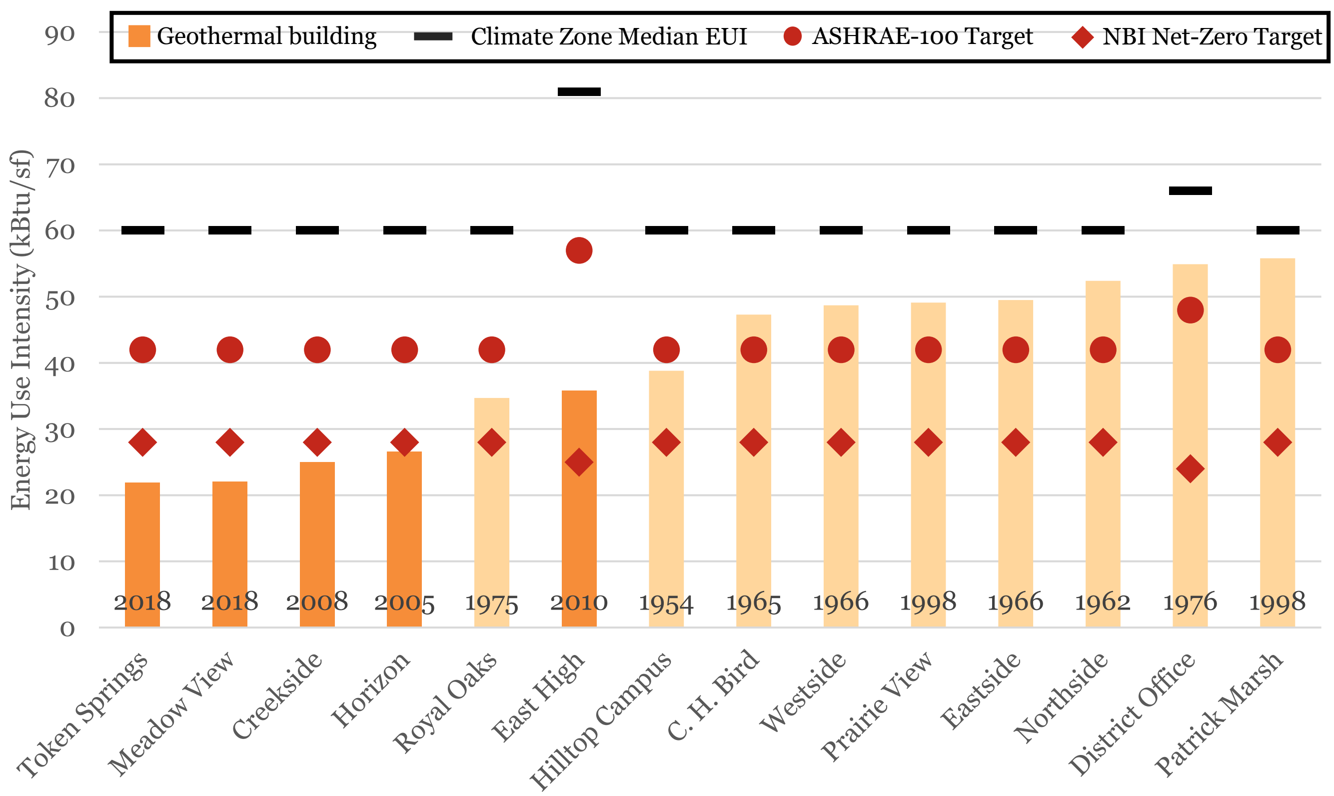


Site energy use intensity (EUI) is a metric that shows the building's total energy use divided by square feet of the building and provides a standard approach to examine energy performance of a building. Figure 6 illustrates the site EUI of all SPASD buildings compared to industry EUI targets for primary and secondary schools in this climate zone. All SPASD buildings currently perform better than median EUIs in the region, so the graph also includes a high-performance target from ASHRAE-100[3] and a net-zero target developed by New Buildings Institute (NBI).[4]

The net-zero targets represent best-in-class buildings and were developed to serve as a guide for new construction or as a goal for retrofits. The intention is that buildings meeting the net-zero target could cover the remaining energy use with onsite renewable energy. These targets are different for each building type, which is why East High School and District Office have different targets than the rest of the buildings.

The data illustrates those newer buildings with geothermal (Token Springs, Meadow View, Creekside, and Horizon elementary schools) all have EUIs already below the net-zero target, and several other buildings are below the ASHRAE-100 target. This helps identify potential buildings to prioritize for energy efficiency upgrades and establishes targets for all schools to strive for through energy efficiency and electrification.

Figure 6. Weather-normalized site EUI compared to ASHRAE-100 target and NBI net-zero target

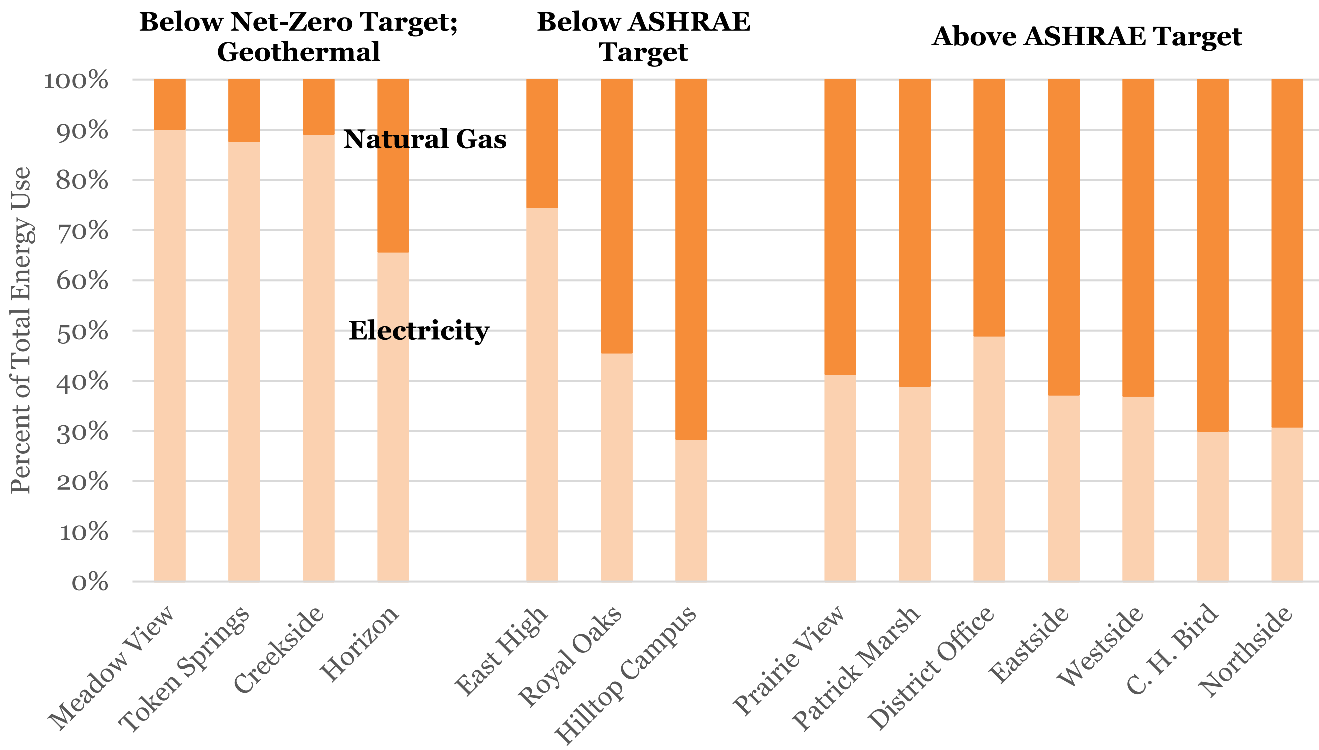


Another way to review energy use data and performance is to quantify the portion of electricity or natural gas consumption. This data can help identify which efficiency items might be most relevant. Figure 7 illustrates the percent natural gas and electricity across buildings. It also separates the buildings into three groups: below net-zero and ASHRAE-100, above net-zero and below ASHRAE-100 and above ASHRAE-100 target.

[3] The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) created Standard 100-2018 -Energy Efficiency in Existing Buildings that offers median EUI values as well as energy targets by building type. The energy targets represent the bottom (or best-performing) 25th percentile of energy use by building type. https://www.ashrae.org/news/esociety/updated-standard-100-published.
[4] New Buildings Institute, 2019, Zero Energy Commercial Building Targets, https://newbuildings.org/wp-content/uploads/2019/09/ZeroEnergyCommercialBuildingTargets.pdf

In conventional heating system buildings, most electricity use will be for cooling, plug loads, and lighting, while most natural gas use will be for space heating and water heating. Buildings with geothermal will use electricity for both heating and cooling, and as a result have little to no annual natural gas consumption.

Figure 7. SPASD buildings' portion of natural gas and electricity consumption



In addition to benchmarking energy use data, inventorying existing building systems is an important step to understanding potential opportunities. A regular inventory of systems should identify several important characteristics, such as age of system, current fuel, efficiency of systems, and a replacement timeline and installation schedule. Table 3 details the inventory done during this project.

Table 3. SPASD buildings' heating system, cooling system, and lighting inventory

School	Heating system	Cooling system	Lighting
Token Springs	Geothermal	Heat pump	Most LEDs
Meadow View	Geothermal	Heat pump	Most LEDs
Creekside	Geothermal	Heat pump	Most LEDs
Horizon	Geothermal	Heat pump	Most LEDs
Royal Oaks	Boiler hot water	DX A/C or RTU	Most LEDs
East High	Heat pump	Heat pump	Less than 50% LEDs
Hilltop Campus	Boiler hot water	Chiller	Most LEDs
C. H. Bird	Boiler hot water	Chiller	Most LEDs
Westside	Boiler hot water	Chiller	Most LEDs
Prairie View	Boiler hot water	Chiller	Most LEDs
Eastside	Boiler hot water	Chiller	Most LEDs
Northside	Boiler hot water	Chiller	Most LEDs
District Office	Natural gas furnaces and unit heaters	DX A/C or RTU	Most LEDs
Patrick Marsh	Boiler hot water	Chiller	Most LEDs

BUILDING PATHWAYS

Energy use in buildings is a sizable factor in annual operating costs and is the primary contributor to school district emissions. Significant decarbonization for the school district requires the implementation of load reduction (lowering overall energy use) and electrification (transitioning from delivered fossil fuels to high-efficiency electric options) measures as well as a transition to renewable energy sources. The implementation of these measures can lead to cost savings, CO_2 savings, and improved comfort in the district's buildings.

Figure 8 summarizes the main three categories to consider in decarbonizing buildings: load reduction through energy efficiency and demand management, electrification of heating systems, water heating, and kitchen equipment, and adding renewable energy to buildings. The figure highlights key considerations for three different sets of schools – 1) schools with an EUI below NBI net-zero EUI target, 2) schools with high electricity use, and 3) schools with high heating or natural gas use.

The schools with a low EUI all already have a geothermal heating system and operate very efficiently; the team recommends continuing to review energy data to ensure the maintenance of efficient operations, and electrifying water heating and kitchen equipment at their end-of-life. For schools with high electricity use, the priority efficiency items are lighting, plug loads, and cooling setpoints. For schools with high heating use, the focus areas include adding insulation, changing heating setpoints and air sealing. The team recommends replacement of heating systems, water heating, and kitchen equipment with high efficiency electric options at end-of-life for those schools with both high electricity use and high heating use. For all schools, full decarbonization requires the addition of renewable energy to buildings or through offsite programs.

Figure 8. Recommended measures for load reduction, electrification, and renewable energy

	Below Net Zero EUI Target *Schools: Meadow View, Token Springs, Creekside, Horizon*	**High Electricity Use** *Schools: East High School, Patrick Marsh, Prairie View, District Office*	**High Heating Use** *Schools: All others*
Load Reduction	Review energy data Enhance demand management	Focus areas: Lighting, plug loads, cooling setpoints, demand management	Focus areas: Insulation, heating setpoints, air sealing, demand management
Electrification	Electrify water heating and kitchens	Electrify heating systems, water heating, and kitchen equipment	
Renewable Energy	Add renewable energy to buildings or through offsite renewable programs		

Load Reduction

Ongoing Operations and Maintenance

The operation of a building and the behavior of building occupants has a significant impact on building energy use. Operational guidelines can save energy without significant investment and have the potential to positively impact occupant comfort and productivity.

The team recommends that SPASD update and continually refine the existing Energy Management Conservation policy that defines clear guidelines for the operation of buildings. The guidelines should be flexible enough to reflect that each building has unique characteristics and should convey a balance of energy use and comfort. Considerations should include ongoing maintenance practices, expectations for equipment and lighting shutdown at the end of the day, thermostat setpoints, guidance for when to use windows, and a communication method for building occupants to provide feedback on their comfort or the guidelines.

Energy Efficiency

Energy efficiency is an important step in reducing energy use, reducing costs, and improving comfort in buildings. The project team used utility bill analysis and a US Department of Energy tool, BETTER,[5] to evaluate energy efficiency and identify priority measures for buildings in the SPASD portfolio. BETTER analyzes monthly billing data to determine how much energy use is weather-dependent versus baseload energy use. The total energy use, weather-dependent energy use, and baseload energy use (energy use that is constant across the year and climate) is then compared to peers to help identify priority measures for the building.

To identify measures for each SPASD building, an aggressive EUI target was selected, which is defined as one half of a standard deviation better than the median performance of the benchmarking peer group. As noted previously, SPASD buildings already perform better than the median, so this target represents a more ambitious target for the district.

Table 4 includes the recommended energy efficiency measures identified by BETTER for SPASD schools. The schools below the NBI net-zero target, Meadow View, Token Springs, Creekside, and Horizon, are not included in the table as there were no recommended energy efficiency measures identified. Heating and water heating measures are not included in the table but are discussed in the electrification section.

Schools with high electricity use (East High, Prairie View, Patrick Marsh) are highlighted for plug load, lighting, or cooling setpoint measures while most of the other schools have priority measures related to heating load, such as insulation, windows, and heating setpoints. Each measure is described in more detail below.

Table 4. Recommended energy efficiency measures for each school (as identified by BETTER tool analysis)

	Reduce Equipment Schedules	Retrofit plug loads/ lighting	Increase Cooling Setpoints	Add Insulation/ Air Sealing	Upgrade Windows	Decrease Heating Setpoints	Ensure Adequate Ventilation Rate
East High	X	X				X	
Royal Oaks				X	X		
Hilltop Campus	X			X	X	X	X
Prairie View Middle	X		X		X		
Patrick Marsh Middle	X	X	X				
District Office	X	X		X	X		X
Eastside Elementary	X		X	X	X	X	X
Westside Elementary	X		X	X	X	X	X
C. H. Bird Elementary	X			X	X	X	X
Northside Elementary	X			X	X		X

Reduce equipment schedules: This measure recommends looking for opportunities to turn off equipment during low occupancy or reduced building use. The measure is recommended for any building with a load higher than the target on either the heating or cooling side. This could include checking building automation systems (BAS) on a regular basis, reviewing schedules and adjusting the schedules to occupancy. It could also include implementing operating policies to ensure systems are shut down by occupants at the end of day.

[5] BETTER online tool is available here and is free for use: https://better.lbl.gov/

Plug loads & lighting: There are a few buildings in SPASD portfolio with higher-than-expected plug loads and lighting loads. As most buildings have been transitioned to LEDs, the focus for lighting should be completing that transition and considering controls where possible. For plug loads, the school district can consider updating computers, printers, fridges, and other appliances to ENERGY STAR certified options and installation of advanced power strips to eliminate "vampire loads" consumed by electronic devices when they are turned off but still plugged in. SPASD can also consider the implementation of an operational policy to set standard guidelines for turning off lights and appliances during unoccupied hours.

Increase cooling setpoints: An analysis of billing data shows that buildings recommended for this measure start cooling at a lower temperature than most buildings. Building energy use can be significantly reduced through the review and adjustment of cooling setpoints. This may include a chilled water temperature reset/increase or simply adjusting timing of cooling. Focus on Energy offers retrocommissioning or tune-up rebates that could cover this cost.

Insulation and air sealing: Sealing doors and windows and adding additional roof and wall insulation can lower heating and cooling load needs. This measure was highlighted for buildings with higher heating loads compared to high-efficiency schools. Air sealing can be done with caulk, spray foam, or weather-stripping materials. Basic air sealing can be done at a relatively low cost by facilities managers or a local contractor; however, insulation can be a significant investment and should be considered during the capital planning process and installed during comprehensive building or roof upgrades. The first step for both should be a discovery process to understand current installation and air sealing levels and determine the best approach to adding more.

Window replacement: Windows can impact comfort in the building, as well as cooling and heating loads. Windows should be upgraded at end-of-life or during major retrofits. When replacing windows, specify products certified by ENERGY STAR or by the National Fenestration Rating Council (NFRC) and look for products with a U-Value of less than 0.30 and a Solar Heat Gain Coefficient (SHGC) of less than 0.25.

Decrease heating setpoints: This measure is recommended for any school that has a higher heating setpoint than similar buildings. By lowering the heating setpoint, significant heating energy can be saved while still providing adequate comfort in the schools.

Ensure adequate ventilation rate: Ventilation into buildings maintains safe and comfortable environments for building occupants. However, providing more ventilation than is necessary could increase the buildings' energy use. This measure is paired with all air sealing and insulation recommendations to ensure that adequate ventilation is provided as the building envelope becomes tighter.

Demand Management

Demand charges, or charge for peak demand in a month, can make up a significant portion of energy costs. Smoothing energy use across the day and month to avoid spikes in demand can lead to energy cost savings for the district. There are several actions the school districts can take to manage demand, explained below:

- **Granular or real-time monitoring:** SPASD already monitors data on a real-time scale but is implementing solutions, such as eGauges and EnergyCAP Smart Analytics, to enhance current monitoring and make the data public-facing. Expansion of these tools at all schools can help the district to both examine demand spikes retroactively and monitor energy use in real-time.
- **Implementation of controls and sequences:** Demand management can best be implemented through control systems for heating, cooling, and lighting. This could include shifting equipment schedules and implementing pre-cooling or pre-heating to avoid high energy use for cooling or heating during peak times of the day. Controls also enable real-time adjustments if a school is getting close to peak demand, such as slightly lowering heating and cooling setpoints or dimming lights where possible. A complete analysis of current BAS sequences is needed to develop specific

recommendations for the control changes. Focus on Energy provides funding for retrocommissioning and building tune-ups.

- **Battery energy storage systems:** Battery energy storage systems can provide load management capabilities by storing energy when demand is low and then discharging energy when a school is close to peak demand. The system can also provide resiliency benefits and replace generators. The primary concern with Battery Energy Storage Systems (BESS) is cost. As costs continue to decline, BESS is becoming a viable option especially for new construction or at generator replacement. From 2010 to 2018, battery prices fell by 85%, and costs are predicted to continue to decline at a rate of 18% each time cumulative volume installations doubles.[6] The U.S. National Renewable Energy Lab (NREL) estimates that a BESS costs $388 per kWh of energy and $775 per kW of capacity, compared to a diesel generator at $500 per kW of capacity.[7] For a BESS, the per kW and per kWh costs are additive– a one kW, one kWh battery would cost approximately $388 plus $775, or $1,063. As costs continue to decline, BESS with controls could be considered for both demand management and resiliency. New construction or time of generator replacement are especially opportune times to consider the addition of BESS.

Electrification

As explained earlier in this document, equipment electrification must be paired with efficiency to fully decarbonize buildings. Space heating, water heating, and commercial kitchens often use natural gas delivered directly to the school. The disadvantage of delivered natural gas is its constant emissions across time, while the carbon emissions intensity of electricity, or the amount of carbon released per unit of electricity generated, will continue to decrease in the future as the grid steadily transitions to cleaner sources.

Because equipment lasts for several decades, it is important to start electrification as soon as equipment fails to avoid locking in additional gas emissions for years to come. With high-efficiency electric options in the market, electrification becomes more feasible and allows for lower overall emissions over the lifetime of equipment and the potential to eventually emit zero carbon.

Heating Systems

Close to 40% of energy use in schools is from space heating and another 10% is from cooling. In Wisconsin, most schools are heated by the direct burning of natural gas. As the electric grid becomes increasingly renewable, the path to decarbonize these systems is electrification. For the most beneficial results, gas heating systems should be replaced with high-efficiency heat pumps, which output three to four units of heat for every unit of electricity used. This is compared to near one unit of heat for every unit of natural gas used by conventional gas heating systems.

Heating and cooling systems across SPASD buildings primarily fall into one of four categories:

- Schools with variable-air-volume (VAV) systems with 4-pipe hydronic systems/boiler and chiller (ex: Patrick Marsh)
- Schools with packaged VAV rooftop units (RTUs) and boiler hot water reheat (ex: Royal Oaks Elementary)
- Schools and offices with single zone systems such as single zone packaged RTUs, steam/hot water radiators with individual A/C units, or central furnaces with A/C (ex: District Office)
- Schools that are already served by geothermal or other heat pumps (ex: Token Springs Elementary)

[6] Goldie-Scot, Behind the Scenes Take on Lithium-Ion Battery Prices." https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/
[7] S. Mishra et al., "The ReOpt Web Tool User Manual," 2021. https://reopt.nrel.gov/tool/reopt-user-manual.pdf

Six schools in SPASD already have geothermal systems, however the remaining systems use natural gas heating systems. Several high-efficiency electric options exist to guide this replacement.

Table 5 provides an overview of the available heat pump systems that provide heating and cooling and key considerations for each. The comparisons in the table are relative to the other heat pump systems presented in the table and not to existing natural gas systems in the building. For example, an upfront cost of medium suggests that variable refrigerant flow falls in the middle of the range for other heat pump systems' upfront costs. Similarly, change to the building represents how disruptive an upgrade to each system would be, with dual-fuel RTUs and air-source heat pumps generally being the easiest to install. Lastly, energy efficiency indicates the relative efficiency across heat pump systems. It should be noted that all systems are high-efficiency systems, but a central heat pump system is the most efficient of the electrification technologies presented in the table.

It's valuable to note that geothermal systems are eligible for renewable energy tax credits (which are available for non-tax paying entities) until 2032 through the Inflation Reduction Act. A more complete description of the systems presented in the table are available in Appendix 1: HVAC Electrification.

Table 5. Available heating system electrification technologies: description and major considerations

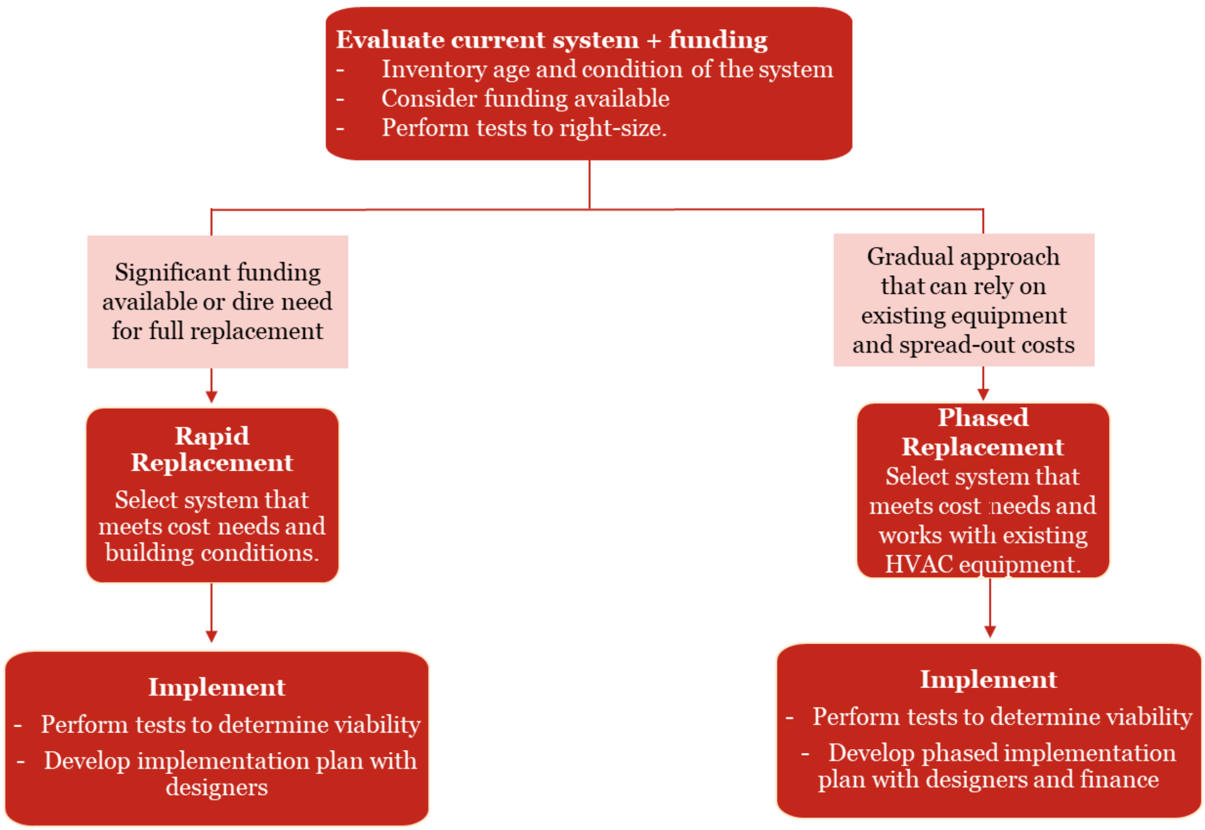
System	Variable Refrigerant Flow (VRF)	Air Source Heat Pumps	Distributed Water Source Heat Pumps	Central Heat Pump Plant	Heat Pump / Dual Fuel RTUs
Description	Air-source Variable Refrigerant Flow heat pump system with DOAS	Distributed single-zone mini-splits with DOAS	Single-zone Water-air heat pumps with condenser loop and DOAS	Central heat pump plant with condenser loop; either VAV or FCU+DOAS	Heat pump rooftop units with optional gas backup heat. Can be single-zone or part of a VAV system.
Upfront Cost	Medium	Low	Medium/High	Medium/High	Low
Funding Available	-	-	Geothermal eligible for up to 40% tax credits through direct pay	Geothermal eligible for up to 40% tax credits through direct pay	-
Change to Building	Medium	Low	High	Medium	Low
Energy Efficiency	Low to Medium	Medium	Medium to High	High	Low to Medium
Environmental Risk*	High	Medium	Low	Lowest	Medium

* Environmental risk refers to the risk of leaking HCFC- and HFC-based refrigerants. These substances are used in almost all HVAC systems and have a Global Warming Potential (GWP) up to several thousand times that of carbon dioxide.

Existing heating systems that are fueled by natural gas can be challenging to decarbonize and will take significant time and investment to convert to electric heat pumps. Figure 9 illustrates recommended steps as school districts start to consider decarbonization: (1) evaluate current HVAC system, (2) determine the replacement approach, (3) decide on the best replacement system, and (4) implement plan.

The evaluation of the current system and funding available directly informs the replacement approach. The two possibilities for replacement are rapid replacement and phased replacement. Rapid replacement removes all existing system equipment and completely replaces it with a new heating system. This approach requires significant upfront funding but provides flexibility in selecting any electrification technology. The phased approach is likely more common and retains equipment from the existing system while slowly replacing and building out the fully electric option. The phased approach spreads out cost but requires considerations of which electric options would work with existing HVAC equipment. Depending on the baseline HVAC system, there are specific electrification technologies and steps a district could take. Appendix 1: HVAC Electrification includes more detailed information on how to evaluate the current system and how to determine the replacement approach and system based on existing HVAC technology.

Figure 9. HVAC system replacement recommended set of steps



Water Heating

In most schools, water heating accounts for a relatively small portion of total energy use, approximately 10% on average.[8] However, many older schools in the district have inefficient water heaters and full electrification requires transitioning from natural gas to electricity, which makes water heating an important consideration. The primary technology solution for central water heating electrification is heat pump water heaters. Small instantaneous electric resistance water heaters are options for specific schools or zones in schools with relatively low water loads.[9] For buildings with a central water heating plant, central or commercial heat pump water heaters with large hot water storage tanks are an emerging option. Air to water heat pumps can also provide domestic hot water as well as heating.[10]

A heat pump water heater is a high-efficiency option that uses electricity to move heat from one place to another instead of generating heat directly. Table 6 includes some considerations for heat pump water heaters, including current availability, efficiency, carbon savings, and cost. The systems are readily

[8] US Department of Energy & NREL, Advanced Energy Retrofit Guide: K-12 Schools. https://www.nrel.gov/docs/fy14osti/60913.pdf
[9] US Department of Energy Better Buildings, Low Carbon Technologies for Primary Schools. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Primary_School_BB_Carbon_Strategies.pdf; US Department of Energy, Low Carbon Technologies for Secondary Schools. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Secondary_School_BB_Carbon_Strategies.pdf
[10] NBI, 2023, The Building Electrification Technology Roadmap (BETR) for Schools, https://newbuildings.org/wp-content/uploads/2023/12/BETR-Roadmap-for-Schools_2023-12.pdf

commercially available but do have a higher cost compared to conventional systems. The improved efficiency leads to significant emission savings. However, the operating cost savings depend heavily on local rates for natural gas and electricity.

When deciding on a water heater, it is recommended that any selected equipment is ENERGY STAR certified[11] or on Northwest Energy Efficiency Alliance's (NEEA) Qualified Products list for heat pump waters heaters.[12]

Table 6. Heat pump water heater main considerations[13]

Availability	Efficiency	Carbon Savings	Cost
•Commercially available in sizes between 40 and 120 gallons •Most require a 220-volt electrical line •New emerging technology for 120V HPWHs for 50-80 gallon systems	•Two to three times more efficient than conventional storage water heaters •Works well in cold-climates	•50% or larger reduction in CO_2 emissions compared to conventional water heaters	•Incremental cost over conventional systems depends on size of water heater •Operating cost savings significant compared to electric resistance; mixed results compared to natural gas

Kitchens

Cooking equipment within school buildings accounts for a small percent of total energy use in school buildings, on average about 1 to 2% of total energy use.[14] Nonetheless, decisions when replacing kitchen equipment should consider CO_2 emissions and ongoing operating costs. Efficient and electric equipment should be installed to lower overall energy use and gradually eliminate natural gas combustion.

The benefits of electric equipment include higher efficiency compared to gas stoves or kitchen equipment, improved indoor air quality from elimination of gas combustion, and in many cases improved cooking performance.

ENERGYSTAR appliance lists should be consulted when replacing equipment, and SPASD should consider replacing any existing cooktops with induction cooktops. The upfront cost for ENERGYSTAR or induction equipment is often higher than conventional systems but operating cost for the equipment is often lower.[15]

Renewable Energy

A transition to 100% renewable electricity is vital to fully decarbonize SPASD buildings. This transition can be completed via installation of renewable energy onsite, the utility decarbonizing the grid, and offsite renewable energy opportunities. As of 2023, SPASD has solar energy installed at five schools: East High, West High, Royals Oaks, Token Springs, and Meadow View. The analysis of renewable energy for SPASD included identification of additional schools for onsite installations and identification of existing programs through the utility that could provide offsite renewable energy opportunities.

---

[11] A list of ENERGYSTAR water heater products is available here: https://www.energystar.gov/productfinder/product/certified-water-heaters/results
[12] NEEA's qualified HPWH list is here: https://neea.org/resources/residential-hpwh-qualified-products-list
[13] Details from the following sources: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Decarbonizing%20HVAC%20and%20Water%20Heating%20in%20Commercial%20Buildings%2011.21.pdf; https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Secondary_School_BB_Carbon_Strategies.pdf
[14] NBI, Key Measures about Carbon Neutral Schools, 2022, https://newbuildings.org/wp-content/uploads/2022/06/NBI_Key-Messages-About-Carbon-Neutral-Schools_June2022.pdf
[15]ENERGYSTAR, Guide for Cafes, Restaurants, and Commercial Kitchens https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/ES%20Restaurant%20Guide%202017-2018%20v16.pdf

Onsite Renewable Energy Opportunities

The onsite renewable energy analysis evaluated five additional buildings for solar installations. The team excluded other buildings from this analysis due to concerns about space available on the roof or ground, condition of the roof, or other architectural considerations. The analysis incorporated available space at each school, monthly historical data for the building, and the actual utility rates. More detail on methodology is available in Appendix 2: Solar Results.

For each of the schools analyzed, the team developed a range of options for a solar installation. The options typically included one that maximized the space available and one that minimized the upfront cost.

Table 7 includes a range for each metric to represent the high-end and low-end for the options analyzed. The full set of alternatives is available in Appendix 2: Solar Results. The table includes the solar array size, percent renewable electricity for each site, the simple payback period, annual CO_2, and cost savings. The solar array size is determined by examining roof or ground space, monthly energy use of the building, and cost-effectiveness. The payback period is calculated by dividing yearly utility bill savings by the net upfront cost. The energy cost savings represent annual energy cost savings – after the payback year all of these will be direct savings for the city. The CO_2 savings represent annual emissions avoided.

Table 7. SPASD onsite solar array performance metrics by building

School	Size (kW DC)	Percent Renewable Electricity	Payback (Years)	Annual CO_2 Savings (MT)	Annual Energy Cost Savings
Prairie View	50 – 100	8-17%	12 -14	43 - 86	$5,955 - $11,235
Patrick Marsh	50 – 150	7- 21%	13-15	42 - 124	$5,465- $15,555
Hilltop	50 – 267	7-38%	12 - 14	43 - 230	$5,600 - $26,825
Northside	50 – 90	18-33%	14 -16	42 – 75	$4,970 - $8,520
Creekside	50-200	10-40%	13 - 15	42– 168	$5,460 - $18,420

Table 8 includes costs for each array. The estimated upfront cost is based on size and location on roof or ground. The Focus on Energy incentives represent local incentives available and are based on the size (generating capacity) of the array. Cities are also eligible for the Inflation Reduction Act's clean energy tax credits through elective pay, a provision that allows non-taxable entities to receive the credits (see Funding Opportunities). The credit is 30% of the upfront cost and is paid after the array is installed. Net cost represents total cost after the incentives and tax credit is applied.

Table 8. SPASD onsite solar array cost details by building

School	Upfront Cost	Focus on Energy Incentives	IRA Tax Credit	Net Cost
Prairie View	$125,000 - $210,000	$6,750 - $13,000	$37,500 - $63,000	$80,750 - $134,00
Patrick Marsh	$125,000 - $315,000	$6,750 - $18,000	$37,500 - $94,500	$80,750 - $202,500
Hilltop	$125,000 - $560,720	$6,750 - $29,700	$37,500 - $168,215	$80,750 - $362,800
Northside	$125,000 - $188,685	$6,750 - $11,730	$37,500 - $56,610	$80,750 - $120,350
Creekside	$125,000 - $420,000	$6,750 - $23,000	$37,500 - $126,000	$80,750 - $271,000

Offsite Renewable Energy

Onsite solar installations on school district facilities will only be able to cover a fraction of total district electricity use. Space is limited at each facility, and some facilities have little to no capacity due to roof issues or ground space being used for other purposes.

WPPI, Sun Prairies Utilities' parent company, has goals to reach a 45% reduction in greenhouse gas emissions by 2025 compared to 2005 levels.[16] The transition to renewable energy by the utility will have a large impact on overall emissions for the school district. Additional ways to partner with the utility to increase percent renewable for the school district are below:

- **Offsite renewable energy:** Offsite renewable energy is solar arrays or wind turbines that are installed on a plot of land (owned by the district or a third-party) not currently occupied by a school facility. The district purchases renewable electricity directly from the offsite array and can claim that electricity as offsetting grid energy use. Multiple utilities in Wisconsin offer offsite renewable options under which school districts could lease currently unused space or purchase a section of an upcoming solar installation. SPASD could work with its municipal utility to identify opportunities for offsite renewable arrays.
- **Choose Renewable program**: For two dollars a month, school districts can purchase a 300-kWh block of renewable energy.[17]

Purchasing Policy

One way to institutionalize decisions around new equipment and decisions at end of equipment life is to develop purchasing guidelines. By implementing a policy to ensure that sustainable decisions are being made at replacement, SPASD can steadily work towards its goals, while making upgrades during the normal capital improvement process. This will minimize costs by limiting the need for early replacement, and ensure the equipment selected leads to lower operational costs.

Sustainable purchasing policies have been recognized in many areas as a best practice for meeting energy and carbon goals. The guidelines can be written to incorporate flexibility and to incorporate cost and performance considerations. For example, the policies could stipulate considerations of high-efficiency electric or ENERGY STAR appliances for any equipment replacement. It could require that total cost of ownership and CO_2 emissions comparisons between each are calculated to determine the final purchasing decision. Total cost of ownership would consider upfront cost differential, ongoing operating costs differential, and any changes in maintenance costs.

[16] WPPI goals are available here: https://wppienergy.org/wp-content/uploads/resources/2021-WPPI-Energy-Annual-Report.pdf
[17] Details on the program are available here: https://wppienergy.org/program-type/renewable-energy/

EVALUATION AND REPORTING

Evaluating and reporting on progress towards carbon reduction goals and EUI targets is a key step in a decarbonization framework and plan.

An evaluation approach should consist of assessing progress towards existing targets and goals, as well as analyzing impact of a major change or upgrade to a school.

Reporting is also a critical tool in facilitating communication, engagement, and buy-in with stakeholders. Both efforts provide a way for school districts to celebrate successes along their decarbonization journeys.

Evaluation and data tracking

Tracking facility energy consumption and emissions data is essential for enabling facility and energy manager to compare a building's current performance with baseline data for that facility. Tracking energy data is also needed to assess a facility's performance against relevant regional benchmark building performance levels. Additionally, energy and emissions tracking enables districts to assess their progress toward their efficiency and decarbonization goals.

Ongoing energy data tracking can quantify cost and CO_2 savings from past actions. The data can also guide priorities for future actions.

To analyze impacts of energy saving strategies over time, energy consumption data must be weather-normalized to eliminate the influence of different temperature patterns on consumption. At least a year's worth of energy use data prior to, and after a change is required to assess the impact from an upgrade.

Two strategies that enable facility managers to more quickly identify energy waste, maintenance concerns, and cost-effective upgrade opportunities are 1) monitor energy consumption in near real-time; and 2) collect sub-metered energy use. Sub-metering isolates energy use by load type and/or within different zones in a school. This more granular energy data can lead to prioritization for energy saving measures and analysis. Energy monitoring devices, such as eGauges, can be installed on submeters to provide energy data at frequent time intervals and by section of the school.[18]

Reporting

Providing regular updates on energy use and emissions through presentations, reports, or dashboards provides a way to inform all stakeholders on a district's progress toward its energy and/or decarbonization goals. Utilizing public data visualizations can help with clear communication to stakeholders, and these data can promote energy competitions amongst schools or can challenge schools to meet a specific energy consumption reduction goal.

SPASD energy staff already creates an annual report for the Board in April. Moving forward, this annual report can benchmark EUI and total energy use against targets for buildings and overall goals.

Many schools and school districts have successfully employed various models for stakeholder engagement. Highlighted below are a few examples from school districts acrossthe country:

Seattle Public Schools: Seattle Public Schools provides a public dashboard with energy use, cost, and greenhouse gas emissions data over time for the district overall and for each school.[19]

Fairfax County Public Schools (VA): The district provides monthly energy use and cost data by school and across the school district for the last several years. The dashboard is available to the public and powered by EnergyCAP software.[20]

[18] Details on eGauges are available here: https://www.egauge.net/

[19]Seattle dashboard: https://app.powerbi.com/view?r=eyJrIjoiNGFlYWQ3OGQtNTAxNi00MWNmLThlZWMtOTM1ZGVjOTJhMzJiIiwidCI6ImQ0MzFkMTU4LTYwNzQtNDgzMi04NzgzLTUxZWE2ZjZkZDIyNyIsImMiOjZ9

[20] Fairfax County Public Schools dashboard: https://get2green.fcps.edu/overview_db.html

Discovery Elementary (Arlington, VA): This school created an age-appropriate dashboard onsite to show power consumption, power production and net power, and uses it as a teaching tool for students and the community. This is also important for continuous learning with student turnover.[21]

Orange Unified School District (Orange, CA): Provides solar information for each solar array on school buildings. Includes generation data and comparison points on the equivalent amount of trees or cars off the road the avoided energy emissions accounts for. [22]

Santa Monica School District (CA): Worked with a contractor to understand energy savings and develop an energy dashboard that shows energy costs and energy use by school. The dashboard helps identify worst-performing schools and emissions.[23]

Energy Management Tools – Reporting and Evaluation

A number of advanced tools exist that allow for tracking, evaluation, and reporting of energy use across time. The tools integrate with existing eGauge or energy bill benchmarking programs, and can provide measurement and verification, cost tracking, real-time monitoring, alerts for peak demand, and public dashboard support. Sun Prairie Area School District has already contracted with EnergyCAP Smart Analytics to support evaluation and reporting efforts. It is recommended to use the tool on an ongoing basis. The tools provide some of the following functionality:

- **Performance metrics:** Includes tracking of energy use intensity, total energy use, total costs, and greenhouse gas emissions. Can help track progress towards goals. Often integrate directly with ENERGY STAR Portfolio Manager.

- **Dashboards (internal and external):** The energy management software platforms have dashboards for use by internal staff that allow for better analysis of energy use trends through built-in and custom visualizations. The software also often has the capability to build external dashboards that can be linked on school district websites.

- **Weather normalization and evaluation**: Many of the tools allow for setting a baseline period and then calculating savings according to standard measurement and verification methods. This includes weather-normalizing data and comparing baseline to current data to identify impact.

- **Real-time data tracking and demand alerts**: The tools track real-time data and send alerts when energy use is getting close to hitting peak demand. The tools detect outliers and send alerts via email and through the app.

[21] Discovery Elementary’s dashboard information: https://www.nwf.org/EcoSchoolsPortal/Home/Dashboard?schoolId=4448
[22] Orange Unified School District dashboard: https://www.orangeusd.org/departments/facilities-planning/energy-management
[23] Santa Monica School District dashboard: https://www.smmusd.org/EnergyDashboard

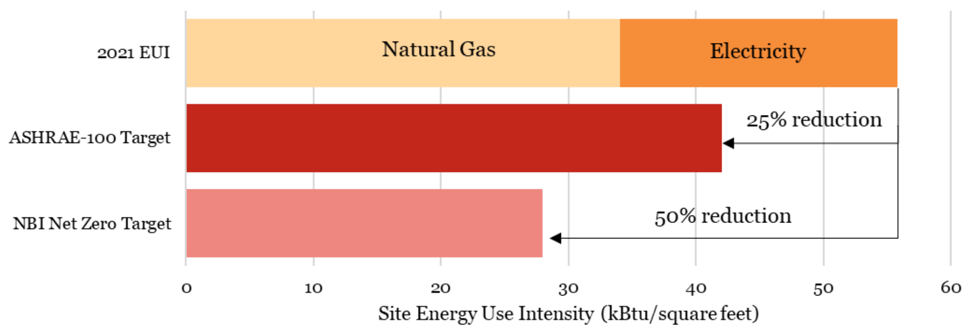
AN EXAMPLE ROADMAP: PATRICK MARSH

Benchmark and inventory

The team performed a walkthrough of Patrick Marsh Middle School to inform a sample roadmap for the school. Patrick Marsh currently has the highest EUI of all SPASD buildings but still performs better than the national median EUI of similar schools. Figure 10 illustrates current EUI compared to two high-performance EUI targets.

Evaluation of monthly energy bills identifies that a higher percent of energy use comes from electricity and a higher percent of gas baseload energy use compared to other schools in the district.

Figure 10. Patrick Marsh 2021 EUI compared to ASHRAE-100 target and NBI net-zero target



The building currently has all LEDs with occupancy sensors installed and a boiler and chiller heating system. Two of the boilers are 80% efficiency and two boilers are new condensing boilers installed that were upgraded in 2020. The chiller is approximately eight years old after being replaced in 2015.

Capital planning and implement upgrades

Large-scale upgrades and reductions in energy use and carbon emissions will require a phased approach determined by capital planning. SPASD should consider the recommended updates for Patrick Marsh early, and integrate a phased replacement for the heating system, a solar installation, and efficiency items into a multi-year capital plan. Figure 11 includes the general recommended timeline for items specific to Patrick Marsh, and the following section provides additional detail on those items.

Figure 11. Recommended timeline for Patrick Marsh efficiency, electrification, and renewable energy

	First 1- 3 years	3-5 years	5+ years
Load Reduction	Reduce DHW setpoint Reduce plug loads Review HVAC controls and efficiency	Continued review of EUI targets and data	
Electrification	Inventory existing heating and water heating systems Discuss phased replacement timeline as part of capital planning process Begin testing to right-size equipment	Consider installation of a supplemental water to water heat pump Test bore drills and prepare for geothermal bore field Designers review electric service capacity	Start and expand borefield Phase in water-to-water heat pumps Decommission gas systems Replace water heating system
Renewable Energy	Present solar options in capital planning discussions to determine timing. Prioritize before 2032 to leverage federal tax credits of up to 30% Install 150 kW of solar panels on roof. Phase installations as needed to limit upfront cost constraints		

Efficiency

Patrick Marsh Middle School was identified with a higher-than-normal load – primarily due to baseload natural gas use and high electricity use within the school. Through our walkthrough and monthly billing data analysis, the team identified several opportunities. These energy efficiency upgrades could be eligible for retrocommissioning, building tune-ups, or appliance replacement rebates through Focus on Energy.

Reduce DHW setpoint to 120 degrees from current setpoint of 135 degrees. Domestic hot water is typically set to 120 degrees for safe operation and reducing from current setpoint could generate significant savings. This higher setpoint likely partially explains higher natural gas baseload.

Reduce plug loads. Evaluation of monthly utility bills suggests a higher electricity load at the building. As the school already has LED lighting and lighting controls, the main culprit is likely appliances and other plugged-in equipment. The district could complete an inventory of equipment to try to understand which might be contributing to higher load, and then institute regular shut down processes, use equipment with smart powerstrips or replace with ENERGY STAR equipment.

Review HVAC controls and efficiency. The heating load at the building is higher than target buildings. With relatively new chillers and boilers, addressing efficiency of systems is likely the first order of improvement. Improvements may include ensuring the condensing boilers are set with a return temperature less than 100 degrees, staging multiple boilers to fire at low modulation, and closing the partially open bypass valve to lower return temperature.

Electrification

The first step to electrifying gas systems in a building is to evaluate the existing systems. Prairie Marsh has a 4-pipe variable-air-volume (VAV) system with boilers and an air-cooled chiller. As noted above, the district already made a recent investment to improve efficiency with a new air-cooled chiller and new condensing boilers. There are also newer gas domestic hot water heaters. Since the existing systems will last another 10 to 15 years, a phased replacement to an eventual central heat pump plant with geothermal may be the best approach to electrifying the heating systems. This would allow the district to take advantage of the Inflation Reduction Act and other current funding opportunities while spreading costs over a longer period. In this hypothetical scenario, the school district sets a target to fully electrify Prairie Marsh's heating systems in 15 years.

The phased approach allows several options for the space systems. With hydronic piping throughout the building, a top option is to convert the existing hot water and chilled water plant to a central heat pump plant. This system has medium impact on the building while allowing the building to keep a VAV system, as noted in Table 5.

1-3 years:

- Evaluate existing systems, collect data on equipment models and sizes, and review control sequences.
- Investigate heating loads and heating hot water temperatures. Logging key points within the BMS to review time dependence and peak heating demands will support design considerations for a heat pump conversion. Consider testing the viability of reducing hot water supply temperature in the building. Gradually reduce setpoints and check for when set points are no longer being met or occupants complain. This process will help inform the feasibility of heat pumps as current heat pump technology has difficulty heating water above 140°F. Running these tests will help the school identify if they can avoid replacing equipment, reduce the size of the new heat pumps, and save

energy in the meantime, all reducing costs. It will also help identify any coils that absolutely need to be replaced or control configurations to alter.

- Begin discussions about phased replacement timeline as part of capital planning discussion. Begin to discuss options with design team.

3-5 years:

- Test bore drills and make other preparations for the geothermal bore field.
- Work with design team to plan for a new supplemental water-to-water heat pump that can work alongside the existing the plant and be the foundation of a geothermal heat pump at the end of the project.
- The designers can also take a close look at the capacity of the electric service and switchgear to ensure there is adequate service for new heat pumps.

5+ years:

- Start drilling and construction of the geothermal bore field and piping it to the supplemental water-to-water heat pump and beginning to replace sections of heating coils identified in the hot water tests.
- Slowly expand the bore field while decommissioning the non-condensing boilers, adding additional water-to-water heat pumps until there is a fully electrified main heating system. Thermal storage can be considered to reduce thermal peaks and manage electrical demand charges.
- The school also looks at electrifying the domestic hot water system in the building. Replacing units as they fail with Energy Star heat pump hot water heaters. The geothermal hot water system could also supplement the domestic hot water heaters once the system is complete.

Renewable energy

Patrick Marsh has a good amount roof space available with a favorable southwest orientation that could fit up to 150 kW of solar panels. A 150-kW system could cover up to 21% of current electricity use, and lead to over $11,000 in energy cost savings annually. The array would be eligible for Focus on Energy rebates and elective pay tax credits up to 30% of the upfront cost.

Reporting and evaluation

In annual reports and evaluation for Patrick Marsh, those in charge of reporting should consider the following:

- Compare EUI over time for Patrick Marsh and in comparison, to the ASHRAE-100 and net-zero target.
- Break out natural gas versus electricity use to understand how any changes have impacted previous energy use split.
- Compare baseload energy use versus weather-dependent use for natural gas and electricity. The BETTER tool can provide an indication of how Patrick Marsh compares to similar buildings and indicate which measures to prioritize in the future. The tool uses ENERGY STAR Portfolio Manager directly.
- Report to stakeholders as part of a larger districtwide building energy progress update. Integrate Patrick Marsh's performance into larger energy goals and targets.

SCHOOL BUS FLEET

School bus transportation, contracted through Kobussen, contributes to overall CO_2 emissions for SPASD operations. The current buses are diesel buses, which have significant CO2 and air quality emissions. To fully decarbonize school operations, a transition to low-carbon buses will be needed. The most-adopted low-carbon alternative is electric buses. There are currently electric models for various sizes of buses.

Important features of electric school buses include:

- Buses can drive 120 – 150 miles between charges, which could enable them to serve morning and afternoon routes without requiring mid-day charging.[24]
- Fleet managers may reduce fuel costs by over 70% per mile and reduce GHG emissions from buses by over 50%.[25]
- Electric school buses have fewer moving parts than diesel buses and may require less maintenance. For this reason, the cost of labor and supplies to maintain electric school buses is at least one-third less than equivalent costs to maintain diesel buses.[26]
- Electric buses reduce exposure of children to NO_x and other harmful emissions as they enter, exit, and ride the district's buses.

To reduce the district's indirect emissions produced by buses and improve air quality for students, SPASD can engage its transportation contractor to develop a plan to transition the buses the contractor uses to serve SPASD from diesel models to electric school buses. While the fuel and maintenance costs for electric school buses is currently lower, the purchase cost of an electric school bus is significantly higher than the purchase cost of an equivalent diesel bus. In addition to the purchase price, installing adequate EV charging equipment would add to the contractor's initial cost to incorporate electric school buses into its fleet.

Incorporating electric school buses requires consideration of several factors that may not be applicable to its diesel buses, including selecting vehicle charging equipment, anticipating effects of reduced vehicle range in cold weather, and staff training. Electric school bus manufacturers may provide data, guidance and support, which the district or its contractor may leverage for planning and implementation purposes. For example, one manufacturer, Blue Bird estimates cold weather vehicle range loss of 20%-25%. To minimize winter range loss, Blue Bird recommends starting to charge the electric school bus while it is still warm, immediately after it returns from its last route and, if possible, to install EV charging infrastructure in locations that offer some protection from the wind.[27]

Other school districts that have implemented electric school buses into their fleet can also provide relevant information and lessons learned. As one case study, the team discussed electric buses with the Cedar Rapids (IA) Community School District (CRCSD). CRCSD owns its bus fleet and added two electric buses to its bus fleet in August 2023. The district selected Blue Bird Vision Electric Buses with a battery size of 155 kW and a 120- mile range. In addition to the buses, the district installed two 60 kW fast chargers. Relevant considerations and lessons learned from CRCSD's initial experience are summarized below:

---

[24] Statement based on vehicle specifications provided by bus manufacturers.
[25] Based on an average cost of electricity in Wisconsin and historical data on the cost of diesel fuel,
[26] Levinson, M. Burgoyne-Allen, P. Huntington, A. and Hutchinson, N. *Recommended total cost of ownership parameters for electric school buses: Summary of methods and data.* WRI Technical Note. 2023
[27] Blue Bird Electric School Buses, July 2020.
https://assets.ctfassets.net/ucu418cgcnau/362sQcGinJzFxVqFh0DBCr/cb2ee507e5c8f646ee133bfdabbccbfb/02_Blue_Bird_Electric_Bus_Presentation_Truck_and_Bus_NOTES_V2.pdf

- **Cost and funding.** The total cost for each electric bus was approximately $500,000 and the installation cost of the two charging stations was $200,000. The district leveraged funding from Alliant Energy, its electric utility, as well as from Iowa's VW Settlement Funds to offset purchase and installation costs. CRCSD's net cost after applying grant funding was $87,000 per bus. The district currently pays $135,0000 per diesel bus that it purchases.
- **Vehicle charging plan and route selection.** CRCSD installed two Nuvee 60 KW fast charging stations in an unsheltered outdoor location at its primary garage to power the buses. It charges the buses overnight, as well as during the time between completing morning routes and starting afternoon routes. To reduce concerns about running out of charge mid-route, the buses currently serve some of the district's shorter routes.
- **Winter driving range reduction.** The fleet manager anticipates significant range reduction due to cold weather and snow. The district installed supplemental diesel-fueled space heaters on the buses to mitigate some of the range loss. Despite range loss, the district expects that it will continue to use the electric school buses to serve regular routes in the winter.
- **Staff training.** CRCSD maintenance staff are not certified to work on high voltage systems, so it has outsourced vehicle maintenance, as well as maintenance for charging stations. For the pilot, the district trained five drivers to run the electric school buses. These staff are the only drivers who operate the buses. The district limited operations to a sub-group of drivers so that these drivers can more easily provide feedback on bus operation and become comfortable with the electric buses.
- **Stakeholder feedback.** The district's fleet manager reports that its drivers love operating the electric buses. They have found that electric buses are much quieter than diesel buses and that the quieter interior environment supports improved behavior and reduced noise levels by riders. Drivers also enjoy finding ways to adjust driving habits as they attempt to minimize the amount of charge that the bus uses for each route.

A gradual transition to electric school buses is an important strategy as part of the district's decarbonization journey. Piloting EV buses in the next several years can also allow the district and its contractor to benefit from available funding through the U.S. Environmental Protection Agency (EPA)'s Clean School Bus Program and available vehicle tax credits. More information about the EPA's grant program and about the Clean Vehicle Tax Credit is available in the Funding Opportunities section below.

FUNDING OPPORTUNITIES

The cost of the upgrades identified in this plan are substantial and may be a barrier to implementation. This section is intended to provide an overview of potential funding opportunities for the upgrades identified in the report.

Leverage fuel and maintenance cost savings generated through solar energy and building energy efficiency to fund capital expenses.

As identified in the report, energy efficiency upgrades and solar installations will save SPASD money on annual operating costs. SPASD could quantify avoided energy and maintenance costs from solar and efficient buildings and use those avoided costs to implement other recommended actions during the subsequent budgeting cycle.

Utilize existing Focus on Energy incentives.

Sun Prairie Utilities offers incentives through Focus on Energy for renewable energy installations and energy efficiency upgrades and installations. It is recommended that SPASD provide a copy of this report to its Energy Advisor and ask for assistance in identifying the best way to access rebates. The amount available is determined by each energy efficiency measure and often specific characteristics of the equipment, such as the size of the solar system or efficiency of the new equipment.

Apply for federal tax credits.

The Inflation Reduction Act (IRA), a federal law passed in August 2022, represents an unprecedented amount of funding for energy and climate actions. The IRA channels a substantial amount of its funding through tax credits and rebates for renewable energy. Through this funding, it also includes a provision, direct or elective pay, that makes non-taxable entities eligible for the tax credits. The tax credits are available through 2032 and can be paired with other grants, forgivable loans, or tax-exempt bonds if the total funds do not exceed the total cost of the project. The tax credits have no cap on total amount a district can claim in a year.

Most notable for the school district is the availability of renewable energy tax credits for up to 30% of upfront cost. For any system under 1 megawatt (MW), 30% is the base amount, and if the installation meets domestic content requirements,[28] an additional 10% is available. For systems above 1 MW, additional restriction must be followed.[29] Geothermal, solar, and battery installations are all eligible items under the Investment Tax Credit for renewable energy. The credit is reduced by 15% for any project that is funded through tax-exempt bonds.

The school district could also work with its fleet contractor to encourage use of the Commercial Clean Vehicle Tax Credit for up to 30% of vehicle cost or a cap of $40,000 for vehicles over 14,000 pounds. Similarly, SPASD could work with building contractors to claim the Energy Efficient Commercial Buildings Deduction (179D) for any building upgrades that reduce energy use by at least 25%. The credit is not available for elective pay and the school districts' contractors would have to claim the credit and reduce the total cost to the school district.

The IRS has released guidance on how entities can receive direct pay. The set of steps are listed in Figure 12.[30] The guidance for pre-filling registration was released in late December 2023.[31]

[28] Domestic content requirements applies to steel, iron or manufactured products. All steel and iron manufacturing must occur in the US. Manufactured products require that 40% of total costs of all materials are mined, produced, or manufactured in the United States.
[29] Prevailing wage requirements state that contractors Shall be paid wages at rates not less than the prevailing rates for construction, alteration, or repair of a similar character in the locality in which such facility is located as most recently determined by the Secretary of Labor. Registered apprenticeship requirements state that 15 percent of hours must be completed by a qualified apprentice (enrolled in registered apprenticeship program)
[30] More information is available here: https://www.irs.gov/pub/irs-pdf/p5817.pdf
[31] Registration information is included here: https://www.irs.gov/credits-deductions/register-for-elective-payment-or-transfer-of-credits

Figure 12. Inflation Reduction Act direct pay – steps for receiving credit

1. **Identify project and credit you want to pursue**
   Confirm project is eligible for one of the tax credits

2. **Determine when tax return will be due**
   Tax return due 4.5 months after end of taxable year – taxable year is year of installation

3. **Complete pre-filling registration with IRS**
   This step must be done early enough to ensure you have a registration number when you file tax return

4. **Complete project and place it into service**
   Project must be complete before you can receive credit

5. **File tax return by due date**
   Use a form for non-taxable entities and file a return

Apply for other state, foundation, and federal grant and financing opportunities.

There are other grant programs and financing opportunities from the state, foundations, and federal grant programs. A few programs are highlighted below:

- **Couillard Solar Foundation:** The program supports an in-kind solar module donation of 50 kW DC (valued at $20,000) to school districts. The foundation will support at least one installation per district.[32]
- **Renew America:** The Department of Energy's Renew America program funds energy efficiency and clean energy upgrades at schools. The grant is anticipated to open for a second round in spring 2024. The funding is flexible and covers HVAC, lighting, building envelope, and renewable energy technologies.[33]
- **Clean School Bus Program:** Through federal funding, the Environmental Protection Agency provides $5 billion over five years to transition school buses to low-carbon alternatives. The current round is open until January 31, 2024, and future rounds will open before 2026. School districts can apply and pass funding to a private contractor, or a private contractor could apply directly. The 2023 round allows for an application for up to 25 buses and will fund up to $200,000 of the cost depending on the bus size.[34]
- **State of Wisconsin Office of Energy Innovation:** The Energy Innovation Grant Program funds implementation of renewable energy and energy efficiency. The grant program usually opens annually in the fall with applications due in January.

[32] More information is available here: https://couillardsolarfoundation.org/solar-on-schools/
[33] More information is available here: https://www.energy.gov/scep/renew-americas-schools
[34] More information on the Clean School Bus Program is available here: https://www.epa.gov/cleanschoolbus

APPENDIX 1: HVAC ELECTRIFICATION

Electrification Replacement Process

Existing heating systems that are fueled by natural gas can be challenging to decarbonize and will take significant time and investment to convert to electric heat pumps. There are a series of recommended steps as school districts start to consider decarbonization: (1) evaluate current HVAC system, (2) determine the replacement approach, (3) decide on the best replacement system, and (4) implement plan. This section describes step two and three in more depth to help building operators

Evaluate the current HVAC system
Two possibilities should be considered when evaluating the existing HVAC system, reuse of system infrastructure or replacement of the entire system.

The first step, which is the same for every natural gas heating system, is to take inventory of all heating, cooling, and air handling unit equipment. This will help inform decisions about when and if equipment should be replaced, and which electrification systems are viable when reuse is desired over a need for replacement. It will also identify the starting point for sizing equipment and estimating building loads for the design and construction team.

One important item to inventory is the hot water temperature for buildings with boilers, the most common heating system for SPASD buildings. Heat pump alternatives for boilers are being developed, but one barrier of adoption is that heat pumps can only heat water to around 130°F to 140°F, and ideally would heat at 110°F to 130°F for best efficiency. Most buildings using boiler systems were designed to use hot water that is 160°F to 180°F. Some systems do incorporate hot water reset which lowers supply water temperatures under conditions with lower heating loads.

Exploration of building heating demands and system limitations is critical for heat pumps to replace boiler hot water systems. Ideally a heat pump system could be retrofit to provide heating for most of the year allowing it to operate at higher efficiencies and utilize more readily available equipment. A supplemental heat source like an electric boiler and thermal storage could provide a additional capacity when needed. This holds true for both air-source and water-source (geothermal) heat pump equipment.

There are multiple ways to evaluate if a building can reduce the heating hot water temperature. It could be done through analyzing existing data from AMI gas meters or BAS to see if how often the building would be at risk if hot water temperature is not at design. Through this, an evaluation of equipment should be done to understand the limitations to coils sizes and equipment capacity at lower hot water temperature. And finally, an easy way to see if the building system hot water temperature can be lowered is to slowly lower the hot water temperature over a week or a month and see when students or teachers complain (don't lower the hot water temperature below 140 F if boilers are non-condensing boilers as that could damage the boilers).

It is also important to ensure that the building's envelope and insulation are considered along with electrification. Electrifying a heating system in a building with high air leakage and poor insulation will result in large equipment and high electric bills. It would be a better investment to tighten up the building's envelope and subsequently downsize the heating system to save energy in the meantime. Electric heat pumps will use more electricity than comparable air conditioning systems, so the size of electric service and electric switchgears and panels should be carefully evaluated to determine if they can handle additional electric capacity.

Determine the replacement approach and strategy
The next two steps in the process require determining if the district wants to pursue a rapid replacement of the current heating system by completely removing the current system, or a phased replacement in which the district slowly transitions from the existing system to a fully electric system. If resources are available

or the need for replacing aging systems is dire, then rapid replacement may be the most practical. Any new electrified heating system could be used if the old systems are completely removed. In rapid replacement under certain scenarios, some existing infrastructure could be retained to reduce cost.

Advancements in technology is a factor to consider in electrification of heating systems. New systems that combine heat pumps and thermal energy storage are beginning to come to market, the ability for heat pumps deliver high supply water temperatures is starting to emerge with some limitations, and new low GWP refrigerants will be phased broadly into the market starting in 2025.

A more likely approach is the phased approach. The phased replacement would retain equipment from the existing system while slowly replacing and building out the fully electric option. This will spread costs and disruption over several years while taking advantage of existing equipment still in good condition. The new electrification systems may be limited by the existing building and should be chosen to take advantage of existing infrastructure and available funding.

The following sections go into more detail on three common types of existing systems and how different electrification heating systems could be implemented given the existing system.

4-pipe VAV (boiler + chiller)

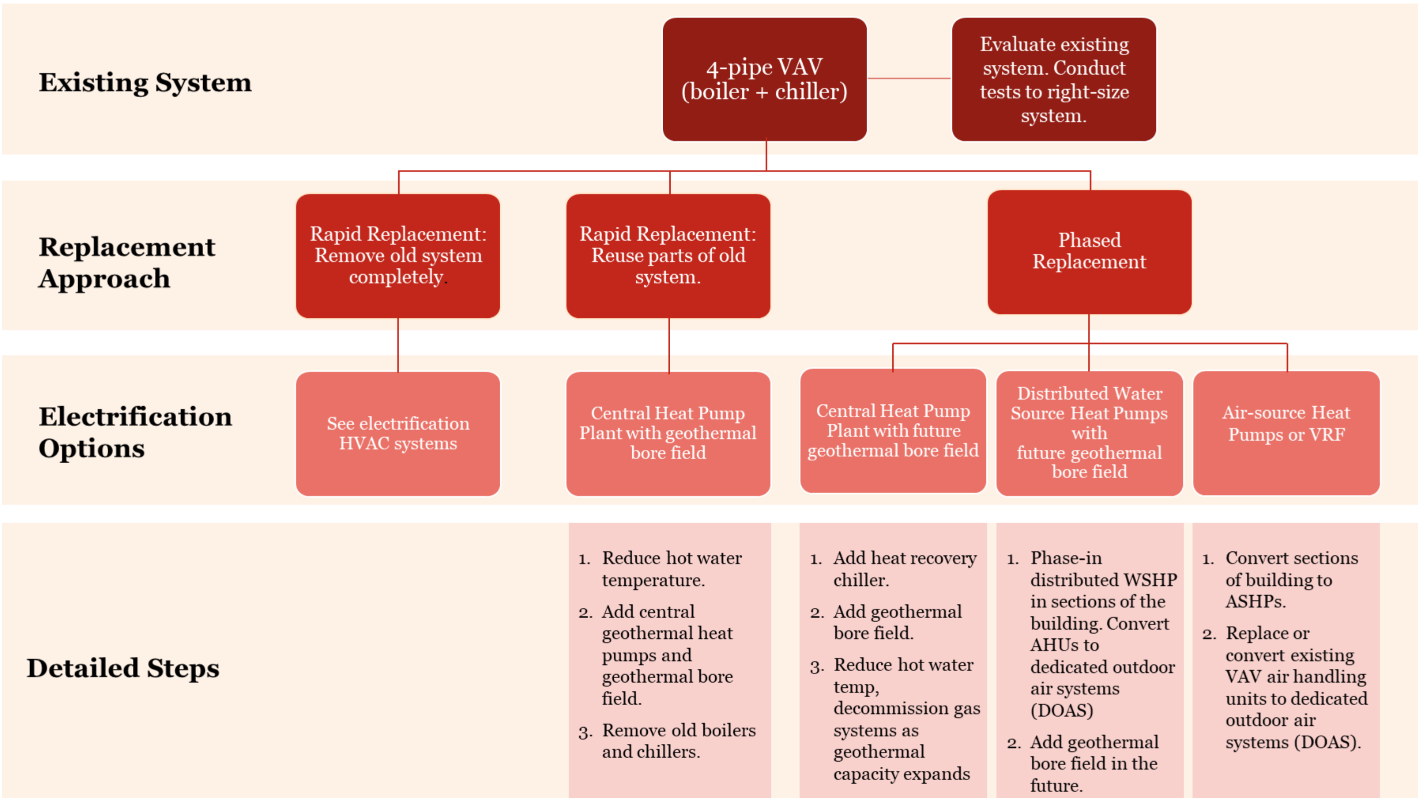
A common system in SPASD schools is 4-pipe VAV or boiler and chiller systems. Figure 13 includes an overview of options for transitioning from a 4-pipe VAV system to a fully electrified system. The challenge that decarbonizing with these systems presents is reducing the hot water temperature to a temperature that can be produced by heat pumps. However, the existence of a central chiller and boiler plant also presents an opportunity for conversion to a geothermal heat pumps system.

If rapid replacement of systems is feasible and desirable, the existing system can be demolished and replaced with any electrified heating system. There is also an opportunity to reuse components of large central plants, such as piping and pumps, by converting these systems to a water-to-water central heat pump plant served by a geothermal field. This system will produce low temperature hot water (120°F) and chilled water to allow reuse of the VAV air system. Some heating coils may need to be replaced with equipment designed for 120°F hot water.

If phased replacement is selected, then the first step should be seeing if it is feasible to install a geothermal bore field. If there is room for a geothermal bore field, consider converting the boiler and chiller plant to a central heat pump plant. This will retain the building piping system and limit changes to just the water plant. A key step for this is making sure that the hot water coils can run at a lower hot water temperature from the water-to-water heat pumps. One way to phase this option is to add a water-to-water heat pump as a heat recovery chiller, add the geothermal bore field, and add more water-to-water heat pumps as geothermal expansion allows. Another option is to convert the building to distributed water source heat pumps, taking advantage of existing boilers and heat rejection equipment, and then converting to geothermal when feasible.

One other replacement option, particularly for smaller schools without the land for a geothermal field, would be to slowly convert to air-source heat pumps or VRF. The boilers can remain for back-up heat, if necessary, until those can be electrified.

Figure 13. 4-pipe VAV boiler and chiller system electrification replacement options



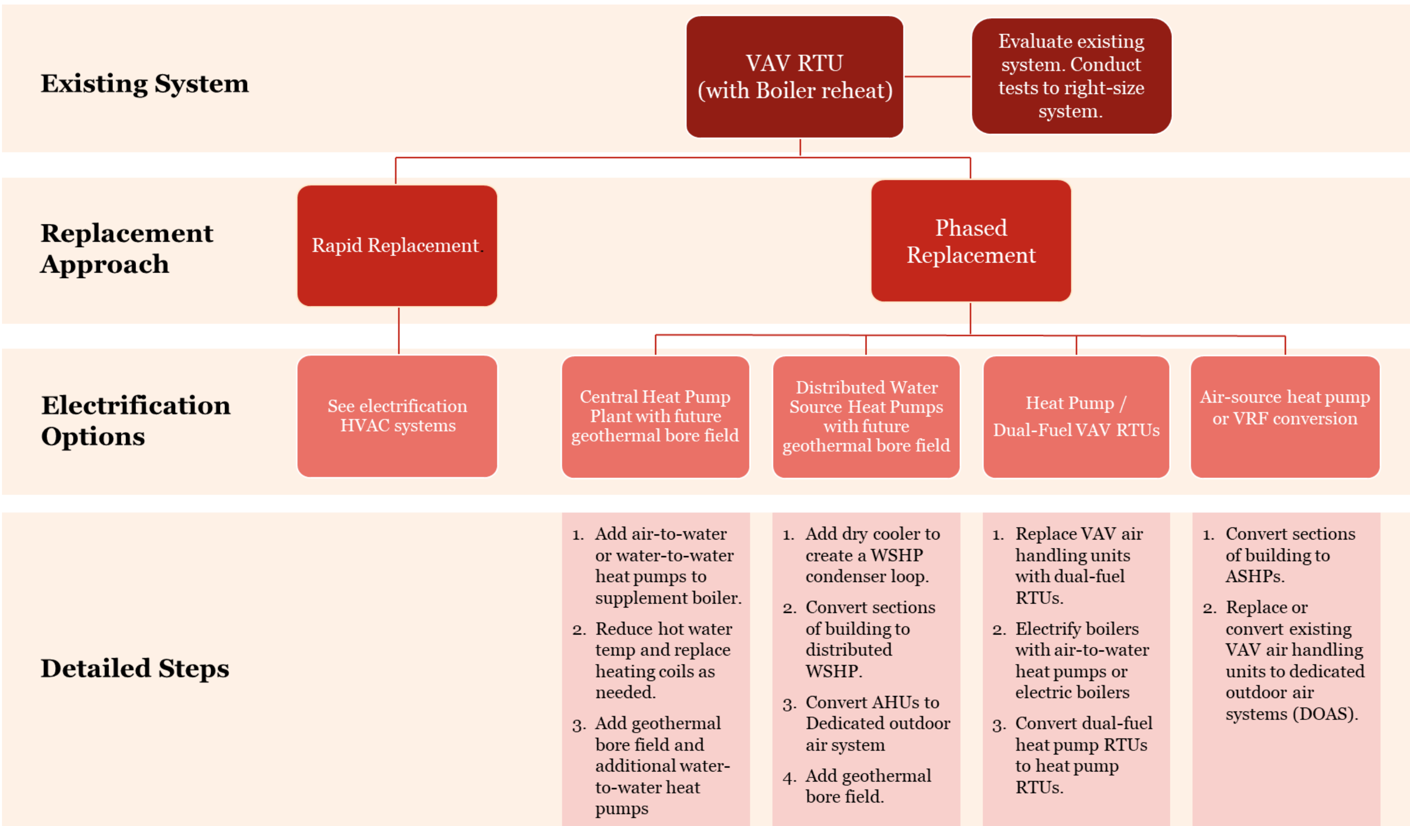
VAV RTU (with Boiler Reheat)

Another existing system for SPASD schools is variable air volume (VAV) with a boiler and roof top unit (RTU). Figure 14 includes an overview of options for transitioning from the existing system to a fully electrified system. The barrier to electrifying these systems is that heating is provided by both a gas boiler system and RTU preheat coils, requiring multiple points of electrification.

If rapid replacement of systems is feasible and desirable, the existing system can be demolished and replaced with any electrified heating system. One emerging technology to replace these units are dual-fuel RTUs, which uses both heat pump heating and gas heating depending on the outdoor air temperature. As heat pump RTU technology matures, fully electrified RTUs can replace the dual-fuel RTUs.

Converting to an electrified HVAC system in phases may be more involved if dual fuel RTUs are not used. If the boiler system is sufficiently large, it can be converted to a central heat pump plant by adding a dry cooler for rejection, and slowly converted to water-source heat pumps or geothermal system. Adding distributed heat pumps when adding a geothermal field or water-to-air rejection (later converted to geothermal) would also be an option. A final opportunity would be to replace or convert the RTUs to dedicated outdoor air systems (DOAS) and add air-source heat pumps or VRF heat pumps to heat and cool the building.

Figure 14. VAV RTU (with boiler reheat) electrification replacement options



Single-zone RTUs, steam/hot water radiators, central furnaces with ACs

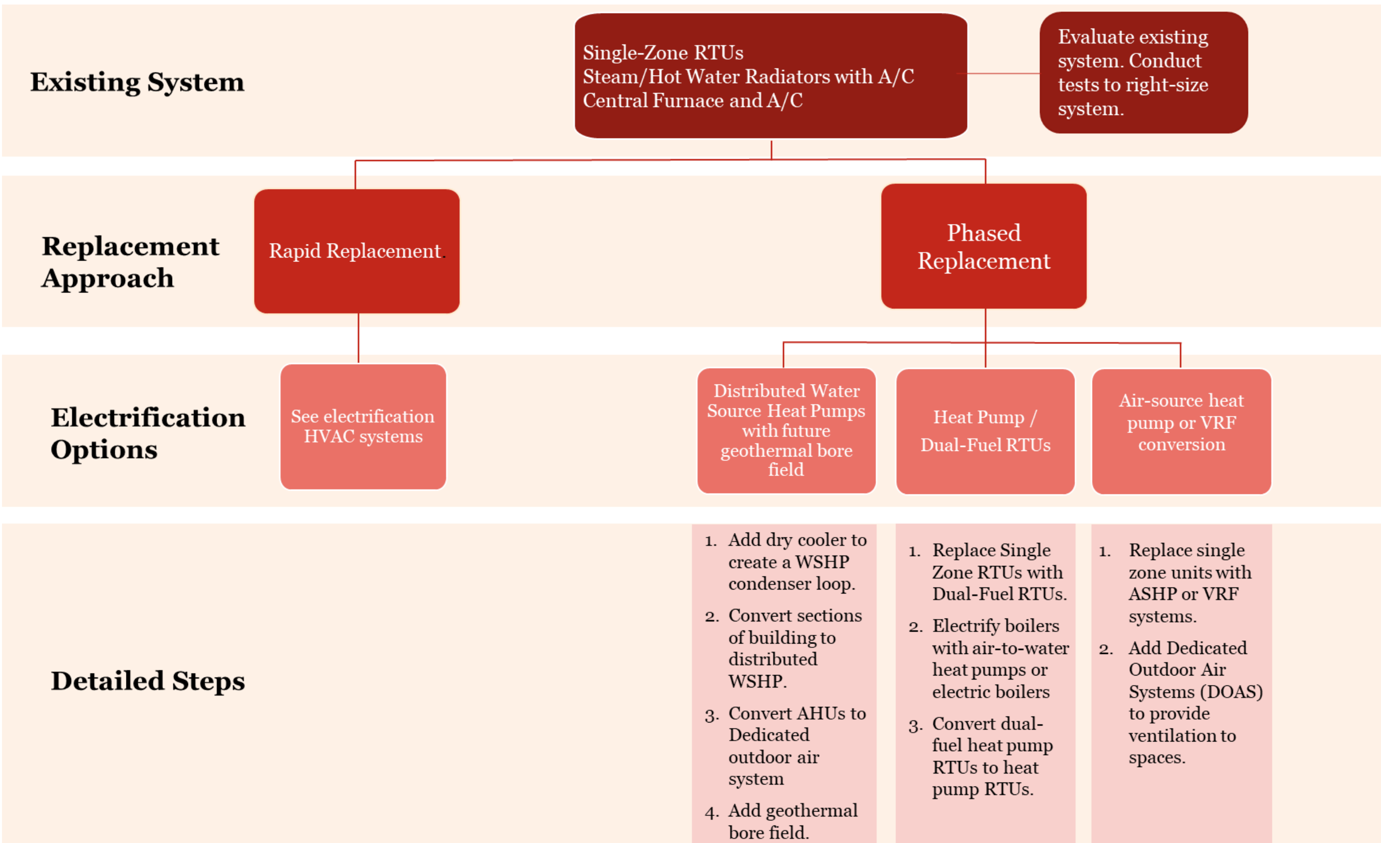
A less common existing heating system is single-zone units. These include single-zone RTUs, steam/hot water radiators, and central furnaces with ACs. Single-zone RTUs are still common for large open spaces like gymnasiums, cafeterias, and auditoriums. Steam/hot water radiators are common in older school buildings, which often were served by unit ventilators or similar units. A furnace and AC/unit system are common in offices, and currently used in Sun Prairie's District Office. Figure 15 includes an overview of options for transitioning from the existing system to a fully electrified system.

Like the previous systems, evaluating the system and determining if rapid replacement is an option is the first step. Given that these are generally smaller systems, rapid replacement may be easier.

Where radiators or unit ventilator style systems are the prominent heating system, consider converting to air-source heat pumps or VRF, or using distributed water source heat pumps. The latter two options have indoor unit options that are designed to retrofit into radiator or unit ventilator equipment. The water-source heat pump option can be converted to geothermal in the future. A central heat pump plant could also be feasible with careful study, though the smaller distributed systems are likely more cost effective.

For single zone equipment serving specialty areas or sections of building, first consider if they can be added to the primary system (e.g., determine if a geothermal system could cover a RTU covering the gym). Otherwise, single-zone RTUs should be converted to dual-fuel RTUs and later heat pump RTUs as the technology becomes more widely available. Furnaces could be converted to residential dual-fuel heat pumps and later heat pumps.

Figure 15. Single-zone RTUs, steam/hot water radiators, central furnaces with ACs electrification replacement options



Electrification Technologies

Variable Refrigerant Flow (VRF)

Variable Refrigerant Flow (VRF) systems consist of multiple fan coil units (known as "indoor units") in different rooms attached to a central compressor and outdoor heat exchanger (known as an "outdoor unit"). In buildings where different rooms need heating and cooling at the same time, some "heat recovery" VRF systems can recycle thermal energy used for cooling to heat other rooms. Most VRF systems use a dedicated outdoor air system (DOAS) to provide ventilation, which can use the same heat pump technology as the outdoor units. While VRF systems can come in water-source or geothermal configurations, most VRF installations are air-source.

Most VRF systems are very efficient because they use the most advanced heat pump technology. Some VRF manufacturers have "cold-climate" models which overcome the capacity limitations of other air-source heat pumps at low outdoor temperatures. Cold-climate VRF systems avoid the need for any backup heat. VRF systems are relatively easy to install in retrofit applications because the refrigerant lines connecting the system are small compared to pipes or ductwork, and existing ductwork can be reused to provide ventilation air from the DOAS. However, designers can encounter difficulties related to code requirements for refrigerant safety. Additionally, VRF systems are at an elevated risk for leaking refrigerant compared to other systems because they require a larger refrigerant charge and because running the refrigerant lines requires numerous field connections, which are more prone to leakage than factory-installed piping.

Opportunities

- VRF systems with optional heat recovery feature can reduce power requirements when there are simultaneous heating and cooling loads
- High operating efficiencies at non-peak loads

Risks

- Increased risk of refrigerant leakage compared to other systems
- System can experience extensive maintenance issues if improperly installed

Ideal systems to replace

- Any

Recommendations

- Make sure to specifically name a cold-climate VRF system in any owner's project requirements or specification documents. Require that the system be able to maintain 100% of its AHRI rated heating capacity at an outdoor temperature of -4 F.
- Require that contractors bidding on installing a VRF system provide documentation that their staff performing the work have received the proper training for installing the manufacturer's specific system, as well as prior experience with VRF installation.

Air Source Heat Pumps (ASHPs)

A new generation of air source heat pumps, often referred to as "mini-split heat pumps," are small air-source heat pumps which consist of a single indoor unit paired with a single outdoor unit. An ASHP heats and cools a single room, so buildings typically install multiple units. Each ASHP can provide its own ventilation air individually with a matched outdoor air intake, or multiple ASHPs can be paired with a DOAS.

Most ASHPs are very efficient because they use the most advanced heat pump technology; and most are made by the same manufacturers that produce VRF systems. Like VRFs, most manufacturers have "cold-climate" model options which enable them to provide sufficient heat even at low outdoor temperatures. ASHPs are simple and easy to install and maintain compared to other systems, although the large number of compressors can require substantial maintenance time. In larger buildings, an ASHP can be used to condition a single room or specialized space where it is difficult or impractical to extend the main HVAC system.

Opportunities

- Simple and easy to maintain
- Easy to deploy in small, specialized applications

Risks

- Large number of heat pump units can lead to substantial maintenance time

Ideal systems to replace

- Furnace and A/C units
- Single Zone RTUs

Recommendations

- Make sure to specifically name cold-climate heat pumps in any owner's project requirements or specification documents. Require that the system be able to maintain 100% of its AHRI rated heating capacity at an outdoor temperature of -4 F.

Distributed Water-Source Heat Pumps (WSHPs)

A distributed water-source heat pump system consists of multiple heat pumps distributed throughout a building and connected to a common condenser loop. The condenser loop can be attached to a geothermal borefield, or to boilers and a cooling tower to supply and remove heat from the building. The system provides ventilation through a DOAS, which is also a water-source heat pump connected to the condenser loop.

A key advantage of this system is that it can be used as a "bridge" between an existing system and a geothermal system: if a building's existing boilers are relatively new, they can supply heat to the water-source heat pumps and be removed when a geothermal borefield is installed later. The building could also retain the boilers as a backup heat source. This reduces the risk of the boilers becoming a stranded asset. Furthermore, since the system does not use air-source condensers, more room is left on a building's roof for installing solar panels. When the system is installed with a geothermal borefield, its efficiency is extremely high.

A drawback to this system is that its installation costs are likely high relative to VRF or air-source heat pump systems, both because of geothermal costs and new piping has to be run to all the water-source heat pumps. There is federal funding through a tax credit under the Inflation Reduction Act that can lower the cost of the systems. Also, reduced costs related to refrigerant safety compliance may make this less of an issue when compared to VRF systems.

Opportunities

- Can be a "bridge" system in a phased conversion of a building to fully electrified HVAC

Risks

- Potentially high installation costs compared to other systems

Ideal systems to replace

- 4-pipe VAV
- Single-Zone RTUs
- VAV RTUs
- Steam/Hot Water Radiators with A/C

Recommendations

- During conceptual design, determine whether to install a geothermal borefield immediately or wait until existing equipment has depreciated further. Take into account the age of existing boilers and chillers and the additional cost of installing a geothermal field.

Central Heat Pump Plant

A central heat pump plant consists of a bank of water-to-water heat pumps which supply chilled and hot water to air handling units and fan-coil units in the building. This system consolidates the functions of a boiler and chiller into a single heat pump-based plant. The plant can either connect to a geothermal field or use boilers and a cooling tower to add and remove heat from the building. The system can either provide ventilation through a DOAS or function as a VAV system with mixed air delivery.

A key advantage of this system is that it can be used as a "bridge" between an existing system and a geothermal system: if a building's existing boilers are relatively new, they can supply heat to the water-source heat pumps and be removed when a geothermal borefield is installed later. The building could also retain the boilers as a backup heat source. This reduces the risk of the boilers becoming a stranded asset. Since the system does not use air-source condensers, more room is left on a building's roof for installing solar panels. When the system is installed with a geothermal borefield, its efficiency is extremely high. The system is flexible to install, and can work both with existing fan coil systems and VAV systems. It can potentially reuse both existing ductwork and piping in the building if it replaces the hot and chilled water plants of a fan-coil or VAV system in place. However, the lower hot water temperatures provided by heat pumps may cause heating capacity issues with older VAV heating coils. This can be addressed by replacing heating coils and distribution piping, but at additional upfront cost.

Drawbacks to this system are that its installation costs are relatively high due to the costs of installing a geothermal borefield. Also, although the system can retain boilers as a backup heat source, chillers must be replaced, which can turn new chillers into stranded assets.

Opportunities

- Can potentially re-use existing VAV system ductwork and terminal units if desired
- Can be used in phased replacement of existing boilers
- Very high efficiency system

Risks

- Heat pumps provide lower hot water temperatures than boilers, raising potential heating capacity issues

Ideal systems to replace

- 4-pipe VAV
- Single-Zone RTUs
- VAV RTUs
- Steam/Hot Water Radiators with A/C

Recommendations

- During conceptual design, determine whether to install a geothermal borefield immediately or wait until existing equipment has depreciated further. Take into account the age of existing boilers and chillers and the additional cost of installing a geothermal field.
- If a building has lots of simultaneous heating and cooling, consider adding a heat recovery chiller to improve efficiency even further.

Dual Fuel/Heat Pump RTUs

Dual fuel rooftop units (RTUs) are very similar to the rooftop units that are widely used in small to medium-sized buildings. These systems consist of an air conditioner, furnace, supply fan, and ventilation air intake included in a single enclosure and sited outside the building, typically on the roof. Dual fuel RTUs upgrade the air conditioner to an air source heat pump, shifting the role of the furnace to a backup heat source in extremely cold weather. Some models omit the furnace entirely and rely solely on the heat pump. However, the overwhelming majority of available products are the dual fuel type.

Dual Fuel RTUs allow a building to electrify the majority of its heating service. Nevertheless, in very cold weather the system still uses some natural gas when the furnace turns on. The amount of natural gas displaced by electricity depends on factors such as the quality of the heat pump and the minimum temperature at which the heat pump can operate. Installing dual fuel RTUs does not require replacement or conversion of interior ductwork, and therefore the system can be suitable for projects with a limited budget or which require a limited renovation footprint. Because of their similarity to a long-established HVAC products, maintenance procedures are often familiar to operations staff.

Opportunities

- Able to electrify a large part of a building's heating requirements
- Low installation footprint
- Familiar maintenance procedures

Risks

- Some natural gas use remains due to operation of backup furnace

Ideal systems to replace

- Conventional RTUs (furnace or electric resistance heat)

Recommendations

- Evaluate other HVAC conversion options which allow for full electrification before considering dual fuel RTUs

APPENDIX 2: SOLAR RESULTS

Solar Methodology

The project team identified solar opportunities by reviewing energy use profiles and roof and ground space available by building. The team excluded certain schools due to roof constraints or architectural requirements. From there, SPASD staff and Slipstream worked together to determine priority buildings to include in our analysis.

For the other buildings, the team started by identifying the space available by reviewing the buildings with Google satellite mapping. The satellite images provide an idea of the amount of space available, the direction the array could face, and degree tilt. South-facing arrays offer the most cost-effective opportunities, followed by east or west facing arrays. The degree tilt represents how angled the panels. On average, matching the degrees of tilt for the panels to the degrees latitude of the solar array will produce the most electricity over the course of a year. If a building's roof is not tilted at this angle, panel mounting can apply a tilt. However, the amount of tilt must be balanced against shading effects created between rows of panels.

The roof space available was combined with monthly energy data (hourly for Prairie View) and utility rates and entered into the technoeconomic tool, ReOpt, to find the most cost-effective solution. ReOpt takes inputs of a building's energy loads, utility rate, and based on inputs and constraints from the user, optimizes the sizing of solar PV.

The analysis assumes that the net metering limit is 20 kW DC. This is the current limit set by the utility and any solar installations below this size receive the full utility retail rate for any overproduction of solar that is sent back to the grid. Any solar size above 20 kW DC receives the buyback rate (or wholesale rate) instead. The buyback rate is lower than the retail rate and changes yearly. Both rates are only applicable when the amount of solar produced at a certain time is higher than the building's consumption. The remainder of the time the solar array is saving money as no energy must be purchased from the grid.

Other assumptions include:

- The lifetime of the system is 25 years. This is a conservative value; estimates range from 25 to 50 years.
- The upfront cost of the system is $2,500/kW for roof systems below 75 kW and $2,100/kW for systems above 75 kW. Ground systems are assumed to be 30% more expensive than roof systems. These costs are based on market research and similar quotes in Wisconsin.
- Roof loading and electrical panel space needs to be verified by a trained design professional.
- Operations and maintenance costs are low per year. Inverters need to be replaced at year 15.

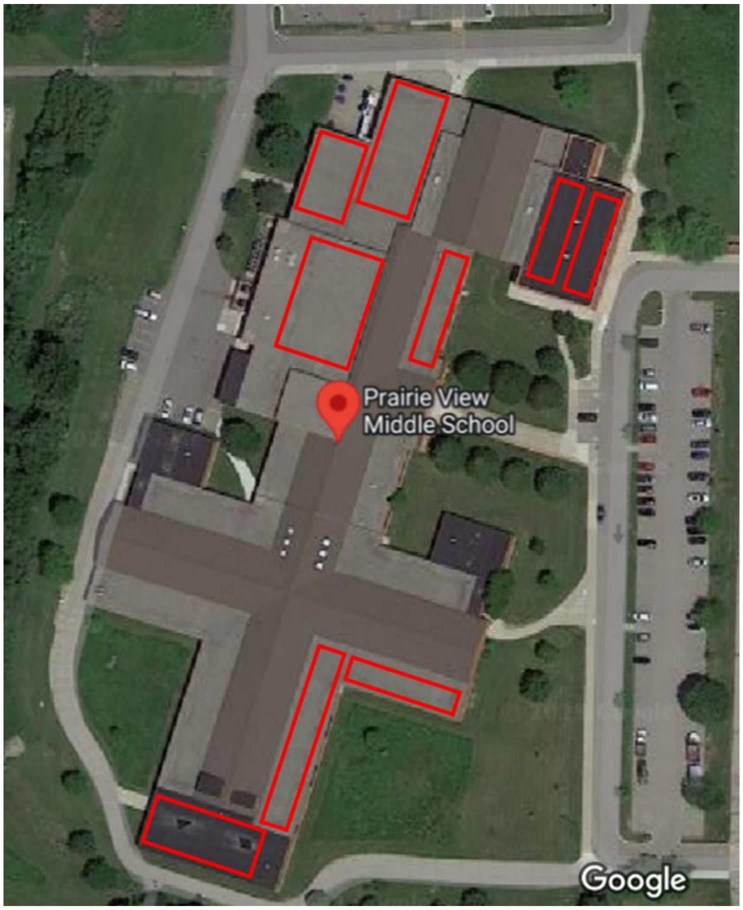
Table 9 below includes a definition for each output.

Table 9. Solar output definitions

Output	Definition
System Size	Total solar photovoltaics size in kW dc
Payback (years)	Calculated as net upfront cost divided by first year cost savings
Percent Renewable Electricity	Total electricity produced divided by total energy consumption
Lifetime CO_2 Savings (MT)	Avoided grid electricity use multiplied by a grid hourly emissions factor
Lifetime Energy Savings	Total energy bill savings over the lifetime of the solar panels (25-years). Assumes flat utility rates over time.
Upfront Cost	Total initial upfront cost ($/kW multiplied by system size). Assumed flat utility rate across time.
Focus on Energy Incentives	Focus on Energy Business rebates[35]
IRA Tax Credit	30% direct pay through Inflation Reduction Act
Net Upfront Cost	Total initial upfront cost minus rebates and tax incentives

[35] Solar incentive information is available here: https://assets.focusonenergy.com/production/inline-files/2023/RR-Solar-PV-APL.pdf

Prairie View Middle School



Available roof space: ~33,000 square feet

Utility rates: $0.092/kWh on-peak, $0.0447 off-peak. $7.50 demand charge

Wholesale (buyback) energy rate: $0.04458/kWh on-peak and $0.03212 off-peak

Orientation: Southeast facing at 20-degree tilt

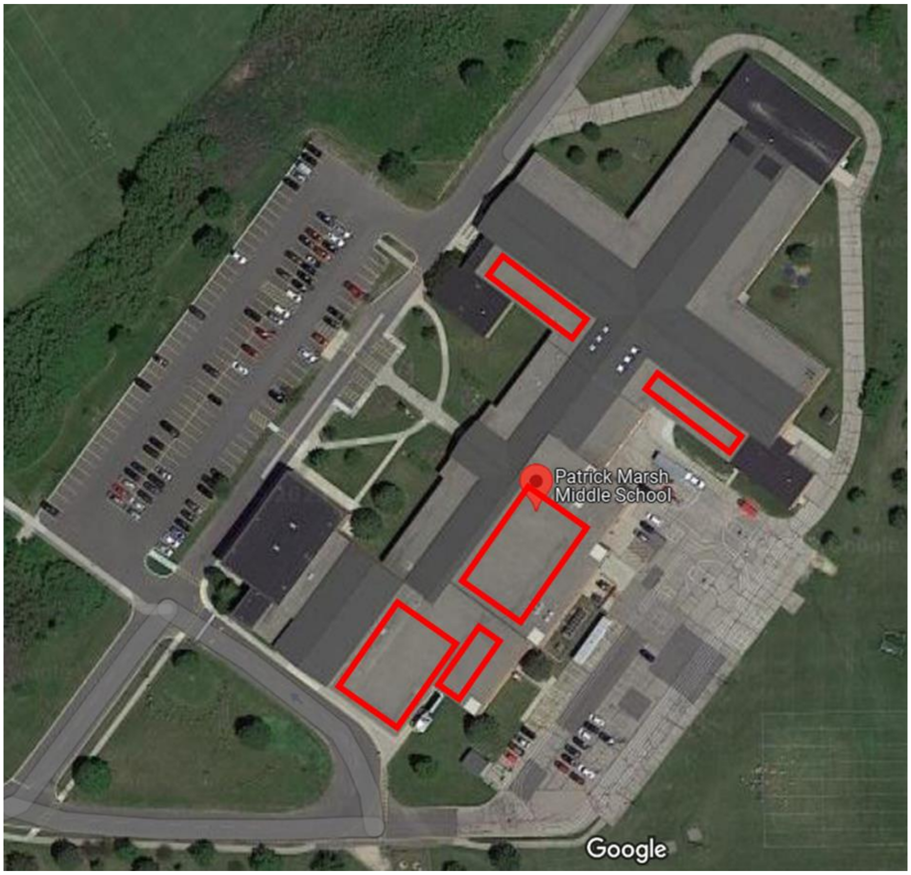
Annual energy use: ~ 699,000 kWh

Table 10 presents the options for solar arrays on the Prairie View Middle School roof. The three options presented only use about a third of the available roof but minimize the upfront cost for the school district. The higher payback period for the 75 kW and 50 kW array sizes represents the higher upfront cost per kW for the smaller arrays. Generally, larger arrays have a lower cost per kW.

Table 10. Prairie View Middle School solar array options

Metric	**100 kW**	**75 kW**	**50 kW**
System Size (kW DC)	100	75	50
Payback (years)	11.9	14.0	13.6
Percent Renewable Electricity	17%	13%	8%
Lifetime CO_2 Savings (metric tons)	2,160	1,620	1,080
Lifetime Energy Savings	$280,890	$217,230	$148,850
Total Upfront Cost	$210,000	$187,500	$125,000
Focus on Energy Incentives	-$13,000	-$9,880	-$6,750
IRA Tax Credit	-$63,000	-$56,250	-$37,500
Net Cost	$134,000	$121,375	$80,750

Patrick Marsh Middle School



Available roof space: ~15,000 square feet

Utility rates: $0.092/kWh on-peak, $0.0447 off-peak. $7.50 demand charge

Wholesale (buyback) energy rate: $0.04458/kWh on-peak and $0.03212 off-peak

Orientation: Southeast facing at 20-degree tilt

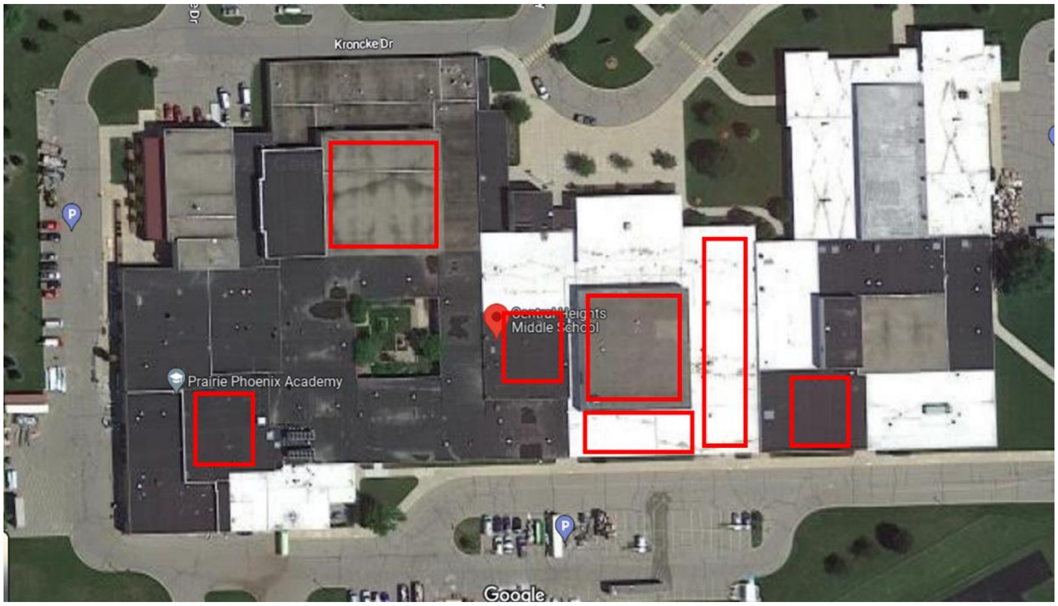
Annual energy use: ~ 800,000 kWh

Table 11 provides system information for Patrick Marsh Middle School. The first array maximizes given the roof space available and other two provide lower upfront cost options.

Table 11. Patrick Marsh Middle School solar array options

Metric	Maximize Size	100 kW	50 kW
System Size (kW DC)	150	100	50
Payback (years)	13.0	12.6	14.8
Percent Renewable Electricity	21%	14%	7%
Lifetime CO_2 Savings (MT)	3,109	2,072	1,036
Lifetime Energy Savings	$388,860	$265,815	$136,620
Total Upfront Cost	$315,000	$210,000	$125,000
Focus on Energy Incentives	-$18,000	-$13,000	-$6,750
IRA Tax Credit	-$94,500	-$63,000	-$37,500
Net Cost	$202,500	$134,000	$80,750

Hilltop Campus



Available roof space: ~27,000 square feet

Utility rates: $0.092/kWh on-peak, $0.0447 off-peak. $7.50 demand charge

Wholesale (buyback) energy rate: $0.04458/kWh on-peak and $0.03212 off-peak

Orientation: South facing at 20-degree tilt

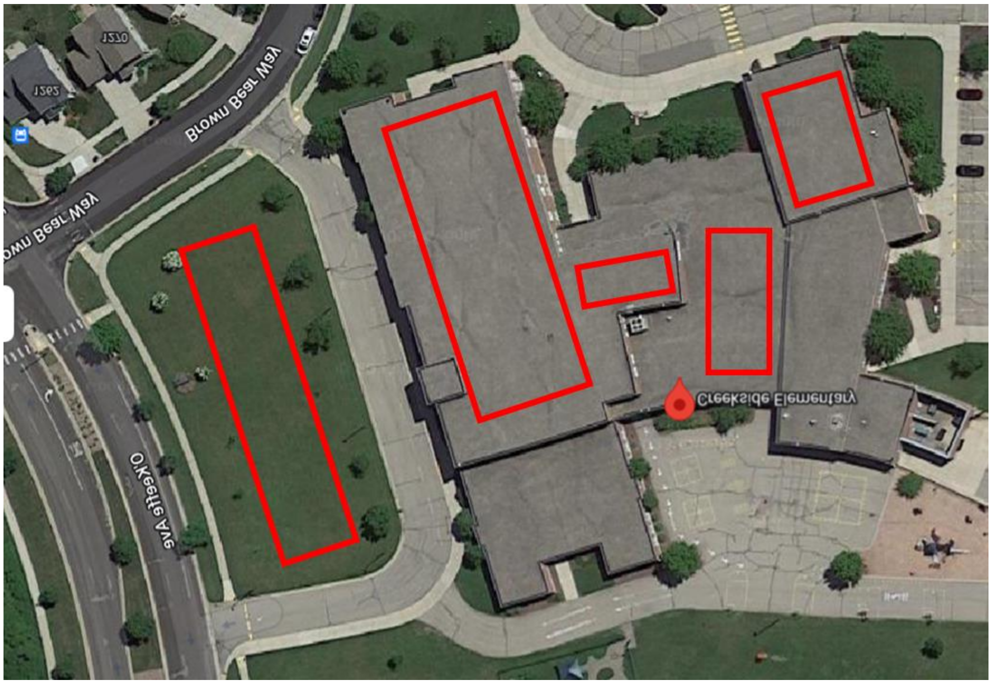
Annual energy use: ~ 830,000 kWh

Table 12 presents the Hilltop Campus solar array options. The maximum size uses all the roof space available while the 100 kW and 50 kW represent lower upfront cost options. The 50 kW has the highest payback due to the higher upfront cost per kW for smaller size arrays. The higher payback period for the maximum size (267 kW) compared to the 100 kW system is a result of the incentive amount per kW from Focus on Energy decreasing for systems above 100 kW.

Table 12. Hilltop Campus solar array options

Metric	**Maximum Size**	**100 kW**	**50 kW**
System Size (kW DC)	267	100	50
Payback (years)	13.5	12.4	14.4
Percent Renewable Electricity	38%	14%	7%
Lifetime CO_2 Savings (MT)	5,770	2,161	1,080
Lifetime Energy Savings	$670,630	$270,975	$139,960
Total Upfront Cost	$560,720	$210,000	$125,000
Focus on Energy Incentives	-$29,700	-$13,000	-$6,750
IRA Tax Credit	-$168,215	-$63,000	-$37,500
Net Cost	$362,805	$134,000	$80,750

Creekside Elementary School



Available roof space: ~20,000 square feet

Ground space: ~10,000 square feet

Utility rates: $0.092/kWh on-peak, $0.0447 off-peak. $7.50 demand charge

Wholesale (buyback) energy rate: $0.04458/kWh on-peak and $0.03212 off-peak

Orientation: South facing at 20-degree tilt

Annual energy use: ~ 575,000 kWh

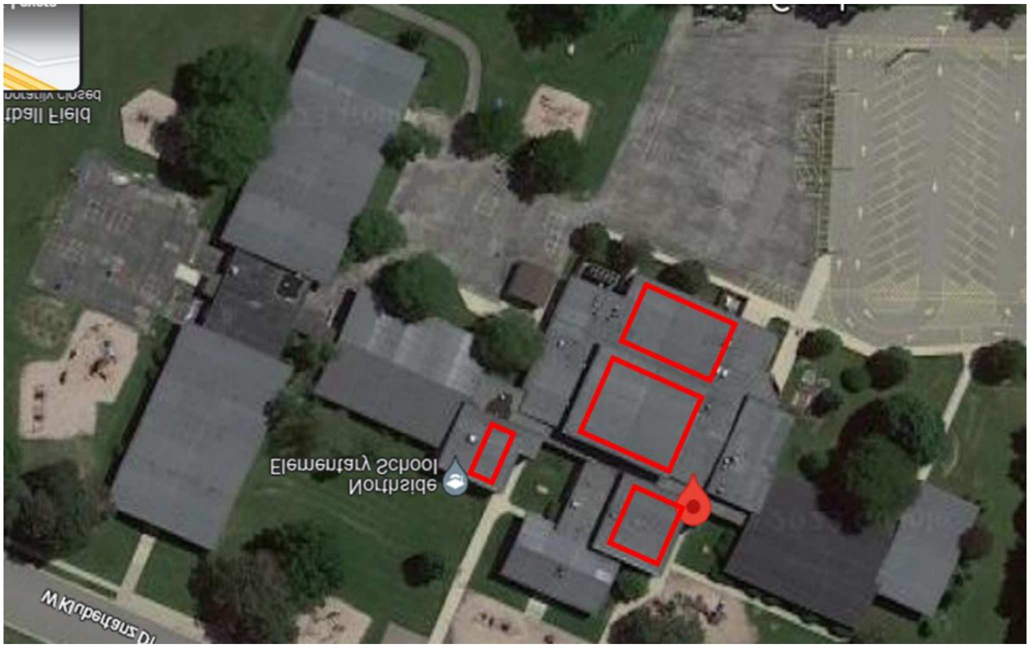
Table 13 provides system information for Creekside Elementary. The first option is for a ground array – it has a higher payback period as ground systems usually have higher upfront costs. The array maximizes the amount of space available on the roof and minimizes payback period.

The optimized roof system balances maximizing roof space with payback period, while the 100 kW and 50 kW systems minimize upfront cost. These scenarios were developed in discussion with SPASD staff. The higher payback period for the optimized size (200 kW) compared to the 100-kW system is a result of the incentive amount per kW from Focus on Energy decreasing for systems above 100 kW.

Table 13. Creekside Elementary School solar array options

Metric	Ground	Roof - Optimized	Roof – 100 kW	Roof – 50 kW
System Size (kW DC)	36	200	100	50
Payback (years)	16.2	14.7	13.2	14.8
Percent Renewable Electricity	11%	40%	20%	10%
Lifetime CO_2 Savings (MT)	740	4,194	2,097	1,048
Lifetime Energy Savings	$97,530	$460,435	$253,825	$136,465
Total Upfront Cost	$97,110	$420,000	$210,000	$125,000
Focus on Energy Incentives	-$4,945	-$23,000	-$13,000	-$6,750
IRA Tax Credit	-$29,135	-$126,000	-$63,000	-$37,500
Net Cost	$63,030	$271,000	$134,000	$80,750

Northside Elementary School



Available roof space: ~9,000 square feet

Utility rates: $0.092/kWh on-peak, $0.0447 off-peak. $7.50 demand charge

Wholesale (buyback) energy rate: $0.04458/kWh on-peak and $0.03212 off-peak

Orientation: Southeast facing at 20-degree tilt

Annual energy use: ~ 313,000 kWh

Table 14 provides system information for two options for the Northside Elementary solar arrays. The maximum size optimizes both the payback period and the roof space while the 50-kW option minimizes upfront costs. The school district can also consider phased installations if budget constraints prevent the larger size from being installed all at once.

Table 14. Northside Elementary School solar array options

Metric	Maximum Size	50 kW
System Size (kW DC)	90	50
Payback (years)	14	16
Percent Renewable Electricity	33%	18%
Lifetime CO_2 Savings (MT)	1,877	1,044
Lifetime Energy Savings	$213,070	$124,310
Total Upfront Cost	$188,685	$125,000
Focus on Energy Incentives	-$11,730	-$6,750
IRA Tax Credit	-$56,605	-$37,500
Net Cost	$120,350	$80,750