Zero Energy Schools Toolkit

May 2020

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Cover Photo Credit: ©Arrowstreet Inc.
Project Name: Douglas & Gates School Building Project
Project Owner: Acton-Boxborough Regional School District
The Douglas & Gates School is a zero energy designed school utilizing the NE-CHPS Criteria.

About NEEP

Founded in 1996, NEEP is a nonprofit that assists the Northeast and Mid-Atlantic region in reducing building sector energy consumption three percent per year and carbon emissions 40 percent by 2030 (relative to 2001). Our mission is to accelerate regional collaboration to promote advanced energy efficiency and related solutions in homes, buildings, industries, and communities. We do this by fostering collaboration and innovation, developing tools, and disseminating knowledge to drive market transformation. We envision the region's homes, buildings, and communities transformed into efficient, affordable, low-carbon, resilient places to live, work, and play. To learn more about NEEP, visit our website at http://www.neep.org.

Disclaimer: NEEP verified the data used for this toolkit to the best of our ability. This paper reflects the opinion and judgments of the NEEP staff and does not necessarily reflect those of NEEP Board members, NEEP Sponsors, or project participants and funders.

Toolkit Purpose

A school building is a centerpiece of a community where learning, work, and other important gatherings occur. The purpose of this toolkit is to help communities create learning environments that are healthy, productive, and energy efficient. Understanding that designing and constructing a new school building is a major undertaking for a community, this toolkit provides best practices, resources, and other guidance that inform efforts at the local level. Material contained within this toolkit was created for a variety of key stakeholders, such as school building committees, facility directors, business managers, superintendents, interested citizens, and others. The intention of this guidance is to equip these important stakeholders with reliable information that can be used at certain intervention points throughout the development process of a healthy, zero energy school building.

Note: The Zero Energy Schools Toolkit is an output of The Massachusetts Achieving Zero Energy (MAZE) Schools initiative which is a collaborative effort facilitated by NEEP to rapidly advance the development of zero energy schools in the state. Learn more about MAZE here.

Definition of a Zero Energy School

The terminology used to describe a "zero energy" building varies widely, but for the purposes of this toolkit, a zero energy school is defined as an ultra-low-energy, combustion-free building that sources 100 percent of its annual energy from additional renewable energy sources. An ultra-low energy building utilizes various techniques to maximize lower energy use before the application of renewables.

A note on terminology: The concept of zero energy schools may be defined using site or source energy. Since this toolkit is intended for use by school districts and associated stakeholders, the site energy use intensity (EUI) metric is used. For a more in-depth look at the definition and calculations, refer to U.S. Department of Energy's (U.S. DOE), A Common Definition for Zero Energy Buildings. U.S. DOE defines a zero energy building as an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy. In layman's terms, a zero energy building is one that is so energy efficient, that a renewable energy system on-site can meet the annual energy required for building operation.

Key Point of Emphasis: Energy efficiency must be a higher priority – relative to renewable energy – to achieve a zero energy school. Improving the efficiency of a building not only lowers the overall annual energy consumption of a building, which makes zero energy possible, but it also reduces the size of energy systems (e.g. HVAC, solar PV, etc.) needed to maintain a comfortable learning environment. For instance, Passive House focuses on building elements like a tight building envelope, site orientation, energy recovery ventilation (ERV) systems, etc. By designing, building, and operating an efficient building, owners will be able to save on utility bills and costly equipment that goes into these buildings

Benefits and Impacts

Students spend, on average, approximately 15,600 hours in school buildings by the time they graduate high school[1]. The physical building can have a major impact, both positive and negative, on occupants. A zero-energy school is built to a higher standard to produce positive health benefits, enhanced learning and productivity for occupants, and increased energy savings for the school. Impacts of a zero-energy school can be far-reaching across the entire community. The information below details how building systems impact occupants:

From the educational perspective: The physical condition of the school building has a profound impact on student learning, teacher performance, and more.

- **Indoor air quality** supports cognitive function including concentration, decision-making ability, and memory. Advanced HVAC systems and monitoring of key metrics enable schools to precisely control ventilation and CO_2 rates.
- **Thermal comfort** plays a role in the focus levels of students and teachers in a classroom setting. Controllability and precision of heating and cooling systems allow occupants to maximize their comfort levels, which contributes to improved performance.
- **Visual comfort** impacts sleep cycles and overall alertness of students and staff. Quality artificial lighting, daylighting, and access to views are important design features for high-performance schools.
- **Quality acoustics** help to reduce distracting, unwanted sound, and ensures classroom discussions are not easily impeded. Learning spaces should be designed and operated to have low levels of background noise and short reverberation times. Acoustics are especially important in environments with young students and English-as-a-second language students.
- **School-as-a-teaching-tool** models integrate the physical school building into the curriculum. Students can learn about energy efficiency, renewable energy, building systems, sustainable design practices, and more by utilizing this hands-on model for teaching. Occupants should also be taught how their behaviors impact building energy consumption, which helps support zero energy goals.
- **Healthier learning environments** also provide benefits to staff members. Schools with better indoor environments lead to higher levels of staff satisfaction, which can result in better staff retention. Schools may be able to save money on hiring needs and substitute teachers.

From the health perspective: Many different facets of a school building contribute to the quality of air that students and other occupants breathe, and can ultimately impact the overall health of those occupants.

- **Green cleaning practices** protect both the health of students and staff and the environment by reducing the number of pollutants introduced into the indoor air. Maintaining a sanitary facility can be accomplished through the use and careful storage of safer cleaning products that reduce the toxicity of chemicals introduced to the school environment.

[1] https://schools.forhealth.org/Harvard.Schools_For_Health.Foundations_for_Student_Success.pdf

- **Low emitting materials** limit exposure to VOCs and other airborne particles that negatively contribute to indoor air quality. Building materials including floorings, paints, woods, etc. and furniture should be carefully selected as low emitting materials.
- **Heating, cooling, and ventilation systems** play a substantial role in the introduction, movement, and cleaning of air in a school building. Properly selecting, locating, and cleaning these systems is of the utmost importance to maintain a healthy indoor environment.

From the financial perspective: School districts often face budget constraints making school construction projects a challenging process, but high-performance schools may be achieved at little to no incremental cost.

- **Lifecycle costs** of zero energy schools should be examined rather than just taking into consideration the upfront design and construction costs. By reducing energy and water consumption and improving operations and maintenance procedures, these buildings that ***may*** cost more upfront typically generate long-term savings over the lifespan of the building.
- **External financial resources** from state authorities and utility programs should be maximized, whether working on new construction, major renovation, or simple capital improvement project. While programs vary by location, utilities are often able to provide incentives for projects that target more efficient equipment and can sometimes provide direct technical assistance on projects as well. Earliest possible engagement with utility program administrators is critical.

From the environmental perspective: Through an integrated, whole-building approach, a high-performance school produces many sustainability benefits that typical buildings do not offer.

- **Carbon emissions** are a key contributor to worsening conditions related to climate change. Achieving a zero energy school will greatly reduce carbon emissions due to decreased reliance on fossil fuels. Schools may further reduce their carbon emissions by looking at the embodied carbon of building materials used in the school.
- **Resource conservation** through improved energy efficiency, onsite renewable energy generation, and reduced water consumption can lessen the negative impact on the environment. Throughout the design and ongoing operations of a school building, resources should be managed in a way that supports desirable educational outcomes and mitigates carbon emissions and other environmental impacts.
- **Materials and waste management** provide another opportunity to further reduce the environmental impacts of school buildings. Sustainably sourced construction materials and recycling for everyday school by-products integrate sustainability into the school ensuring environmental burdens are diminished.

Additional Resources:

- https://schools.forhealth.org/
- https://www.centerforgreenschools.org/
- EPA Indoor Air Quality in High Performance Schools

Overview of the Process

The process of building a new school or renovating an existing building is a lengthy and nuanced one that is unique at each individual project level. Factors that impact the process include funding sources, project size and scope, stakeholder input, design and construction services, and more.

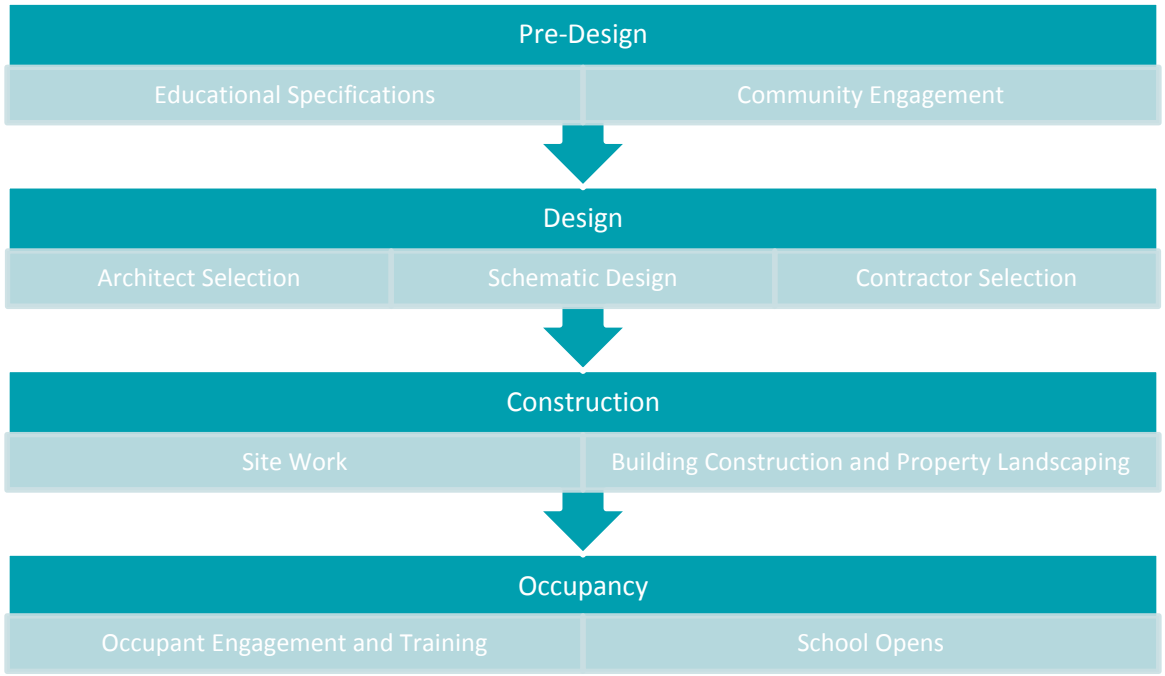
The first part of the process is to establish the need for a new building or renovation project. Typically, a school building committee is established to explore community needs and options in regard to the potential project. Someone on the school building committee should be commited to ensuring the project has energy goals. This individual(s) should incorporate energy as a priority into all discussions about the project going forward. See appendix A for links to examples of school building commmtteee members and their typical priorites.

Key Point of Emphasis: The formation of a school building committee is an important step for a community. The committee may be formed and meet regularly for years prior to the formal start of the design or construction of the school. The committee should represent the municipality, local committtees, and the community at large. The typical role of the committee includes, but is not limited to, engaging public and open forums, conducting surveys, and engaging educational leaders with the overall goal of finding the most educationally-appropriate and fiscally-responsible solution to the community's needs.

Once the need for a project has been established, the community must figure out how to deliver their poject. There are three main delivery models that most projects follow: design-build (DB), design-bid-build (DBB) and construction manager at risk (CM). If the project is going through the MSBA process, it must use the DBB or CM delivery model. For more details about the different delivery models, see AIA's Comparison of Project Delivery Models and NREL's Guide to Zero Energy and Zero Energy Ready K-12 Schools.

Key Point of Emphasis: Critical project goals, such as achieving a zero energy building, need to be raised early on. The zero energy goal should be discussed with the building committee prior to the pre-design phase. It should then be discussed throughout the designer selection phase to ensure the project will achieve this goal.

The chart below provides a simplified overview of a typical CM process.



Project Team

Selecting the appropriate project team is an essential part of the school design and building process. For municipalities to achieve zero energy for their school project, selecting the right team members can ensure that the project stays on budget while achieving its energy goals. Zero energy schools are financially feasible if the goal of zero energy is incorporated into the project from its inception and everyone on the project team is aligned towards that goal. However, if the project team isn't chosen thoughtfully, a zero energy school project can quickly go over budget and become a headache for the municipality.

Generally, the project team for a zero energy school is made up of:

- School Building Committee
- Facility Manager
- Key stakeholders (community members, parents, students, faculty, etc.)
- Owner's Project Manager
- Design Team (not limited to):
    - Architect
    - Landscape architect
    - Civil/acoustical/mechanical engineers
    - Project administrator (for LEED Certified projects)
    - Sustainability consultant
    - Energy Modeler

- General contractor/construction manager
- Subcontractors
- Commissioning Authority
- Building occupants

For many cities and towns, the first consultant selected for the project team is the **Owner's Project Manager (OPM).** As defined by Massachusetts General Law c. 149, Section 44A ½, an OPM is an

> *"individual, corporation, partnership, sole proprietorship, joint-stock company, joint venture, or other entity engaged in the practice of providing project management services for the construction and supervision of construction of buildings. The owner's project manager shall be a person who is registered by the commonwealth as an architect or professional engineer and who has at least 5 years experience in the construction and supervision of construction of buildings or a person, if not registered as an architect or professional engineer, who has at least 7 years experience in the construction and supervision of construction of buildings."*[2]

The OPM's job is to represent the municipality or school building committee throughout the design and construction process. This includes advising the owner on the hiring of an architect and general contractor/construction manager, ensuring the project stays on schedule and budget, and coordinating communication between the municipality and financiers for the project. For Massachusetts School Building Authority (MSBA)-funded projects, an OPM is required and must be approved by the MSBA selection board. The MSBA provides guidelines[3] to assist municipalities in the selection process by outlining the specific role of the OPM in MSBA-funded projects. It also provides instructions and a template for submitting an OPM request for services (RFS)[4].

Since the OPM guides the entire process on behalf of the municipality, the municipality must select an OPM that has experience working on projects that, at the very least, target zero energy as a goal. They must also be able to advise the appropriate design and construction team with zero energy school experience as well. There is an increasing number of design and construction firms in MA that are prioritizing the importance of building zero energy buildings. The municipality should begin identifying these firms so they can work more holistically with their OPM to select the right team for their project.

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[2] https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXXI/Chapter149/Section44A%201~2

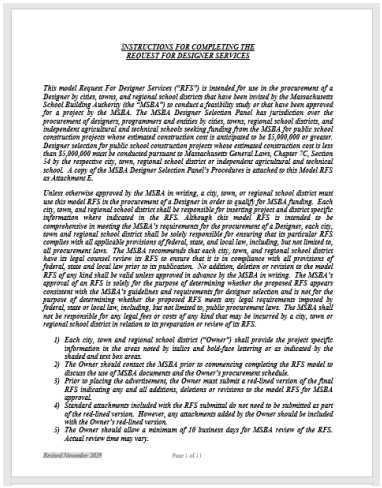
[3] https://www.massschoolbuildings.org/sites/default/files/edit-contentfiles/OPM/OPM%20Process%20Guidelines-%20FINAL.pdf

[4] https://www.massschoolbuildings.org/sites/default/files/edit-contentfiles/OPM/OPM%20RFS-%20FINAL.doc

Owner's Project Manager Selection Checklist (See Appendix for more OPM resources)	
☐	Does the OPM candidate have significant experience in the following: • Managing and working on zero energy school projects? • Working on projects with measurable performance targets (e.g., EUI)? • Ask for examples and data on real-world performance of previous projects. • Ask about communication style, if goals appear to be in conflict.
☐	Has the candidate worked on other MSBA-funded projects, whether zero-energy or high-performance schools?
☐	What design and construction firms has the candidate worked with on previous projects?
☐	Is the candidate knowledgeable about energy-efficient technology and making sure systems are properly chosen and sized within the project's budget?

Establishing Goals, RFP Language

The request for proposal (RFP) or request for services (RFS) provides municipalities with the ability to set ambitious energy goals for the design of their project. The RFP indicates to design firms submitting bids exactly what the municipality is looking for. Therefore, the RFP must be comprehensive to guide design submissions so that they achieve zero energy while also fulfilling the other goals of the proposed school. MSBA provides instructions and an RFP template for municipalities receiving MSBA funding for their project called the *Designer RFS Template*[5]***(Figure 1)***. Like the OPM, municipalities going through the MSBA process are required to use this template to receive funding from MSBA. However, the template streamlines the RFP by providing municipalities with all the necessary guidelines and information to be included while leaving the fillable section for each municipality to customize with specific information.



INSTRUCTIONS FOR COMPLETING THE REQUEST FOR DESIGNER SERVICES

This model Request For Designer Services ("RFS") is intended for use in the procurement of a Designer by cities, towns, and regional school districts that have been invited by the Massachusetts School Building Authority (the "MSBA") to conduct a feasibility study or that have been approved for a project by the MSBA. The MSBA Designer Selection Panel has jurisdiction over the procurement of designers, programmers and entities by cities, towns, regional school districts, and independent agricultural and technical schools seeking funding from the MSBA for public school construction projects whose estimated construction cost is anticipated to be $5,000,000 or greater. Designer selection for public school construction projects whose estimated construction cost is less than $5,000,000 must be conducted pursuant to Massachusetts General Laws, Chapter 7C, Section 54 by the respective city, town, regional school district or independent agricultural and technical school. A copy of the MSBA Designer Selection Panel's Procedures is attached to this Model RFS as Attachment E.

Unless otherwise approved by the MSBA in writing, a city, town, or regional school district must use this model RFS in the procurement of a Designer in order to qualify for MSBA funding. Each city, town, and regional school district shall be responsible for inserting project and district specific information where indicated in the RFS. Although this model RFS is intended to be comprehensive in meeting the MSBA's requirements for the procurement of a Designer, each city, town and regional school district shall be solely responsible for ensuring that its particular RFS complies with all applicable provisions of federal, state, and local law, including, but not limited to, all procurement laws. The MSBA recommends that each city, town, and regional school district have its legal counsel review its RFS to ensure that it is in compliance with all provisions of federal, state and local law prior to its publication. No addition, deletion or revision to the model RFS of any kind shall be valid unless approved in advance by the MSBA in writing. The MSBA's approval of an RFS is solely for the purpose of determining whether the proposed RFS appears consistent with the MSBA's guidelines and requirements for designer selection and is not for the purpose of determining whether the proposed RFS meets any legal requirements imposed by federal, state or local law, including, but not limited to, public procurement laws. The MSBA shall not be responsible for any legal fees or costs of any kind that may be incurred by a city, town or regional school district in relation to its preparation or review of its RFS.

1) Each city, town and regional school district ("Owner") shall provide the project specific information in the areas noted by italics and bold-face lettering or as indicated by the shaded and text box areas.
2) The Owner should contact the MSBA prior to commencing completing the RFS model to discuss the use of MSBA documents and the Owner's procurement schedule.
3) Prior to placing the advertisement, the Owner must submit a red-lined version of the final RFS indicating any and all additions, deletions or revisions to the model RFS for MSBA approval.
4) Standard attachments included with the RFS submittal do not need to be submitted as part of the red-lined version. However, any attachments added by the Owner should be included with the Owner's red-lined version.
5) The Owner should allow a minimum of 10 business days for MSBA review of the RFS. Actual review time may vary.

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Figure 1: MSBA Designer RFS Template

In terms of building efficiency, MSBA-funded projects must meet either Northeast Collaborative for High-Performance Schools (NE-CHPS) criteria or US Green Building Council's LEED for Schools Rating System (LEED-S) including a minimum of 10 percent better than the current energy code. To receive an additional two percent

[5] https://www.massschoolbuildings.org/sites/default/files/edit-contentfiles/Building_With_Us/Project_Team/Designer/Designer%20RFS%20Template_November%202019.doc

reimbursement from MSBA, the project must achieve at least a 20 percent improvement of the current energy code. Both building standards ensure that efficiency is a central part of the building design and verified through each standard's respective scorecard. However, zero energy language isn't reflected in MSBA's RFS template which may make it difficult for municipalities to ensure that the right firms respond to the RFP with zero energy submissions.

See **Appendix A** for examples from Massachusetts projects.

Key Point of Emphasis: To achieve a zero energy school in the Northeast climate zone, an EUI target should be established in the range of 18-25 kBtu/ft2·yr. This target should be established early and, ideally, prior to selecting the design team. Discussions between the school district and architect should demonstrate the design team's commitment to this goal. For more information about establishing EUI goals, see NREL's Technical Feasibility Study for Zero Energy K-12 Schools.

In addition to MSBA's RFS template, there are other resources available to municipalities to help establish goals and craft RFP language for a zero energy school project. For instance, the New Buildings Institute (NBI) provides recommendations[6] for what project teams should consider when crafting zero energy RFP language. These recommendations are broken down into categories of focus within the RFP. The following is a table of NBI's categories and recommended considerations for zero energy building RFP language.

NBI RFP Guidance

Program Requirements	• **Building designs must reflect the community's climate action plan and environmental policies (if applicable).** • **Building designs must align with specific jurisdictional environmental goals (zero energy, zero carbon, efficiency targets, etc.).**
Bidder Experience	• Bidders (i.e. architects) must have experience with high-performance or zero energy buildings. Experience must extend to managing a design team to achieve advanced energy efficiency performance. • Bidder may be asked for current energy performance data of previous projects.
Qualifications	• Bidder must have prior experience in design and/or construction administration of high-performance and zero energy buildings.

[6] https://gettingtozeroforum.org/gtz_resources/request-for-proposal-guidance/

	• Bidder to provide examples of team experience with high-performance and ZE buildings. Include both design (predicted) and operating (measured) EUI.
Scope of Services	• Owner will separately contract the building systems commissioning agent. (note: MSBA projects require commissioning) • Bidder to include an envelope commissioning agent.(note: MSBA projects include envelope commissioning) • Bidder to contract with controls integrator. • Bidder to arrange and conduct a comprehensive ZE project charrette. • Bidder shall integrate sustainability principles into the design, development, and construction of the project. • Bidder to conduct four lifecycle cost analyses (LCCAs) throughout the project to minimize total cost of ownership of the facility, using a whole building, life-cycle approach. • Bidder to provide draft energy budgets to achieve zero energy. • Bidder to seek third-party Zero Energy certification. • See the owner's project requirements (OPR) for other design considerations.[7]
Performance Requirements	• Bidder to commit to a building design energy use intensity (EUI) of 18 to 25 kBtu/sf-year, or as necessary to operate at ZE based on estimated on-site solar availability. • The intent of this RFP is not to be prescriptive, but to challenge the design team to develop its own unique solutions.

Table 1: NBI Request for Proposal/Qualifications Guidance

Another resource available to municipalities is the *Guide to Zero Energy and Zero Energy Ready K–12 Schools*[8] (**Figure 2**) published in collaboration between National Renewable Energy Laboratory (NREL), Department of Energy (U.S. DOE), and McIntyre Communications Inc. The guide is broken down into seven steps, beginning with conducting a building needs assessment and ending with how municipalities can showcase and replicate their zero energy school once it has been built. Examples of existing zero energy schools are also showcased throughout to demonstrate the range of possibilities that are available for designing zero energy school buildings.

[7] https://gettingtozeroforum.org/gtz_resources/owners-project-requirements-guidance/

[8] https://www.nrel.gov/docs/fy19osti/72847.pdf

ASHRAE published an Advanced Energy Design Guide for K-12 School Buildings[9] as part of its Achieving Zero Energy series that also includes a guide for small-to-medium commercial buildings. The guides are free to download on its website (linked above).

In 2016, Needham Public Schools created an RFP for one of its proposed school programs. While it wasn't related to the development of a zero energy school, the RFP incorporated a *Comparative Evaluation Criteria* section that is replicable for a zero energy school RFP. This section evaluated each bid by rating them as highly advantageous, advantageous, or not advantageous for each aspect of the bidder's submission. For municipalities not going through MSBA's process, using a similar evaluation criteria format can be helpful when comparing bids based on how effectively they meet the municipality's goals for its zero energy school.

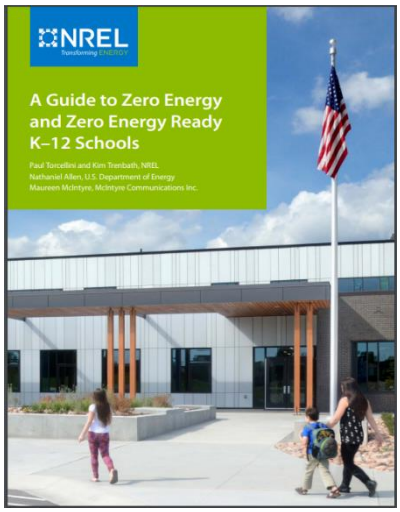


Figure 2: Guide to Zero Energy and Zero Energy Ready K-12 Schools

Project Goals and RFP Checklist (See Appendix for more RFP resources)	
☐	Establish a target EUI and include it in the RFP
☐	Identify programmatic requirements and energy performance goals
☐	Identify if a building standard must be achieved beyond the minimum (for MSBA-funded projects)
☐	Include any onsite renewable expectations for the project

Selecting the OPM, Design and Construction Teams

The questions below for the design and construction team candidates were adapted from A Guide to Zero Energy and Zero Energy Ready K-12 Schools. See page 39 of the guide for more questions and guidance the responses.

[9] https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download

Questions For The Design and Construction Teams
How will you achieve the energy goals established in the RFP?
Can the established energy goals be guaranteed?
How will you build a zero energy school within the scope of the budget?
How will you ensure that the new school will continually meet the energy goals over the lifespan of the building?
What other projects have you been involved with where a low-EUI target was established and achieved? Do you have experience with projects that have set energy performance targets (e.g., EUI targets)? Do you have data on real-world energy performance of past projects? How will you respond when project goals appear to be in conflict?

Questions to Ask The OPM
How can the community be assured that the process and contractors selected will represent the owner's interests and achieve the stated goals?
How will you ensure the project is completed within the budget?
How will you work across the entire project team to ensure long-term success for our community over the lifespan of the building?
What successful, low EUI, projects have you been a part of in the past? Do you have operational EUI data for past projects? What is your strategy for keeping costs down while still maintaining a focus on energy performance targets?
What approach will you take to ensure the owner can effectively operate and maintain the systems within the building once the project is complete?

Financing (Utilities, MSBA, etc.)

The main source of financing for a school building in Massachusetts is MSBA. However, municipalities can also seek outside funding through utility programs and other sources.

MSBA provides financing for municipal school projects (ranging from 31-80 percent reimbursement) in Massachusetts by guiding municipalities through its module program. MSBA provides a helpful Module

Overview[10] to assist municipalities understand the overall process. The town of Danvers, which is currently going through MSBA's program for its Ivan G. Smith Elementary School Project[11], provides a helpful infographic[12] of the process. Once a municipality reaches the funding module of the process, they must submit all necessary documentation for the project scope, budget, schedule, and MSBA financial participation to MSBA's board of directors for approval. Once approval is granted, the municipality and MSBA can enter into a Project Scope and Budget Agreement (PSBA). After this, the municipality must gain community authorization and financial support through local government before a formal Project Funding Agreement (PFA) can be signed and the municipality can begin applying for reimbursement from MSBA. The project can only be reimbursed for design and construction beyond the feasibility study phase. While it is a fairly intensive funding process, MSBA clearly outlines the process and provides necessary resources on the website's Module 5- Funding the Project[13] page.

Innovative Funding

The town of Newburyport completed a building in 2014 that combines the Francis T. Bresnahan Elementary School and senior center into one building. The town was able to connect with the local business community to help fund part of the project. Common areas throughout the school, such as the media center, were sponsored by local businesses. In return, placards with logos have been placed throughout the school to promote the business and, moreover, to show the business's deep-rooted interest in serving the Newburyport community. This model can be used as a funding source and community engagement opportunity.

For projects going through MSBA, give special consideration to the use of alternative funding mechanisms because, in some cases, MSBA may reduce its funding contributions. Consult with MSBA prior to making any final decisions.

Utility Program Offerings

In mid-2020, the Program Administrators of Mass Save will be launching a zero net energy program pathway for commercial/industrial and institutional customers such as municipalities (which includes schools). The goal of the pathway is to help customers achieve deep energy savings. The new program track will offer enhanced technical assistance and higher incentive dollars for projects that engage with the program early in design – for K-12 school projects, this means during early feasibility. Contact your utility partners or Cape Light Compact for more details.

[10] https://www.massschoolbuildings.org/building/modules_overview

[11] https://www.danversma.gov/ivan-g-smith-elementary-school-project/

[12] https://www.danversma.gov/msba-process/

[13] https://www.massschoolbuildings.org/building/funding

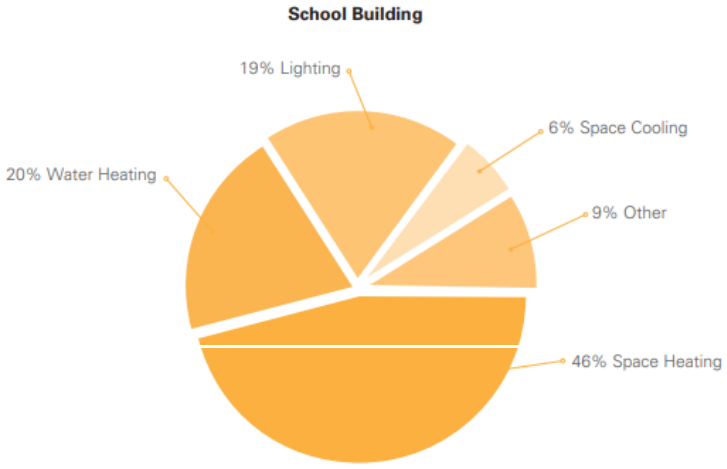
Financing Checklist (See Appendix for more financing resources)	
☐	Engage and research MSBA programs early on in the process for a zero energy school
☐	Consult local utility for any financing opportunities for renewable energy systems, appliances, etc.
☐	Explore innovative funding streams like grants, facility sponsorships, cooperative financing, etc.
☐	Determine life cycle cost impact and how they apply to upfront and long-term costs

New Construction, Renovations, Technologies

Focusing on the energy efficiency of the building is often just as, if not more important, than the supplemental technology used to help the school reach zero energy. For example, in new construction, designing the building so that it is oriented to maximize daylighting and other passive systems can mitigate indoor lighting needs in conjunction with an efficient window to wall ratio. Passive systems improve the school's resiliency in the face of extreme weather events. Building orientation is important when considering roof-mounted PV solar for electricity and water heating systems. It is also important when considering load reduction strategies – like passive solar and daylighting – which maximize natural sunlight for indoor lighting and solar heat gain in cold winter months. The building envelope is important for building efficiency in both new construction and renovations. School buildings can achieve a tight building envelope by focusing on air sealing, proper insulation, and high-performance windows with low thermal bridging. A tight envelope makes space heating more efficient because the building leaks far less heat. A tight building envelope makes a huge difference in Massachusetts' cold winter months because less energy is spent on maintaining indoor temperatures. High-efficiency mechanical ventilation is also important to pair with a tight building envelope and other systems to maintain healthy indoor air quality and efficiently bring in clean/conditioned air from outside the envelope. By focusing on building efficiency through non-mechanical and passive systems, schools can cut their energy load, making building technology like heating/cooling systems and renewable energy generation more cost-effective in terms of system scaling.

To achieve zero energy, it's important to understand the most energy-intensive systems in a school building. According to a Department of Energy chart on energy usage in school buildings (**Figure 3**), space heating, water heating, and lighting make up 85 percent of a school's energy usage, with almost half of the total load coming from space heating (46 percent). For new construction and renovation, addressing building technology plays a major role in achieving zero energy.

Lighting is often considered “low hanging fruit” because it is the most straight forward and replaceable of the building systems associated with a school’s energy usage. LED lighting uses between 25-80 percent less energy than traditional lighting like incandescent bulbs and fluorescent tubes. In new construction, LED lighting is generally an industry standard at this point due to enhancements in lighting standards. To maximize the efficiency of the lighting system, careful consideration should be given to lighting controls and daylighting techniques. However, existing schools that are trying to take steps towards zero energy can replace their lighting system as a low-cost first step.



Source http://www.eere.energy.gov/buildings/info/schools/index.html

Technologies to consider for water heating are heat pump water heaters, tankless demand-type water heaters, and solar waters heaters. For space heating and cooling, more efficient technologies, such as heat pumps and variable refrigerant flow (VRF) systems, are good fossil free alternatives. VRFs are a type of air source heat pump that can serve many commercial building types and larger residential buildings by moving heating or cooling through refrigerant lines rather than large air ducts. The community should work with the design team to assess the viability of and encourage the inclusion of these more efficient technologies. These systems are important to consider for zero energy schools because they can be powered by renewable electricity, geothermal wells, or solar thermal rather than traditional systems that are powered by oil fuel, natural gas, or propane.

For space heating, heat pumps are highly energy-efficient systems that use electricity to remove heat from cool spaces and pump that heat into another space to make it warmer. This makes warm spaces warmer and cool spaces cooler, similar to a refrigerator, which allows heat pumps to be used for both heating and cooling. There are three types of heat pumps: air-to-air, water source, and geothermal. According to the Department of Energy, heat pumps can reduce electricity usage up to 50 percent[14] compared to electric resistance heating for furnaces and baseboard heaters. NEEP offers resources[15] on energy-efficient technologies like heat pumps.

While a more expensive option due to the site development needed for geothermal wells, ground-source (geothermal) heat pumps are a highly efficient option for both space and water heating. Since air source heat pump water heaters draw heat from the air to heat tank water, they are more efficient in more seasonably warm climates. Underground temperatures in geothermal wells are more stable, regardless of climate.

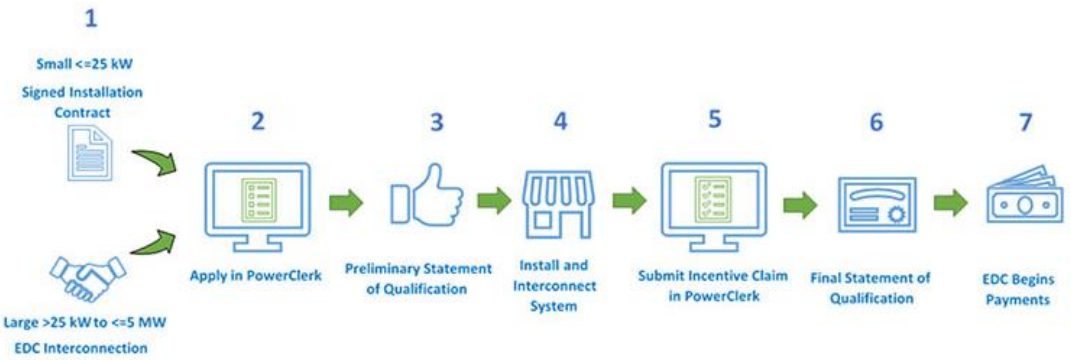
[14] https://www.energy.gov/energysaver/heat-and-cool/heat-pump-systems

[15] https://neep.org/ashp

Therefore, geothermal heat pump water heaters are a great option for zero energy schools in Massachusetts' cold winter climate zone.

Since zero energy schools prioritize electrification over the use of fossil fuels, renewable energy procurement is an important consideration in the school development process. When possible, on-site renewables like roof-mounted PV should be incorporated into the school design and budget. However, many schools have site constraints that prevent roof-mounted PV systems like limitations on building orientation and available roof area. Other procurement options include the purchase of renewable energy credits (REC) and power purchase agreements (PPA) for the development of off-site PV systems that meet additional requirements. Massachusetts Clean Energy Center (MassCEC) offers helpful resources[16] for PV procurement and the available incentives.

In 2018, the Solar Massachusetts Renewable Target (SMART) PV program was launched by the Department of Energy Resources (DOER) and sponsored by the electric utility companies Eversource, National Grid, and UnitilThe goal of the program is to support the development of over 1,600 MW of solar PV generation capacity in the state. SMART is a long-term declining block incentive program that supports the development of PV project of all shapes and sizes, up to five MW per project. For more information about the SMART Program, please visit its website at: http://masmartsolar.com/



How to particpate in the SMART Solar Porgram

New Construction, Renovation, and Technology Checklist (See Appendix for more resources)	
☐	Consider and apply load reduction strategies/passive systems (building envelope, orientation, etc.) whenever possible.
☐	Model building energy load and determine most cost-effective mechanical systems for heating/cooling, ventilation, etc.
☐	Determine life cycle costs of each space heating & water heating system properly sized for the school

[16] https://www.masscec.com/commercial-solar

☐	Size onsite renewable system and consider innovative solutions to meet school load (storage, solar canopy, etc.)
☐	Building commissioning to ensure systems are operating properly to maximize building efficiency
☐	If solar isn't feasible upfront, consider making the building, parking lots, and field canopies solar ready for future installation of PV arrays.

Operations & Maintenance

Zero energy schools are predicated on their design and construction, but it's also very much about proper building operations and maintenance. Building owners and operators are just as crucial as the designers and contractors in terms of level of responsibility for the success of a zero enrgy school. Architects can design and contractors can build a school that is capable of achiving zero energy status. However, building operators need to operate the school effectively to actually get there. In 2004, the Department of Energy published a report[17] on energy cost savings for school operations and maintenance (O&M). The report is quite dated but many of the things discussed are still relevant today. The report found that schools could see energy cost savings of anywhere from five percent to 20 percent, regardless of the school's age. While technology and building techniques have changed a lot since 2004, and there are more ways to help schools achieve zero energy, some of the recommendations highlighted in this report are still important for O&M of zero energy schools. Some of these recommendations included:

1. Update O&M best practices
2. Create a culture of energy efficiency through school policy, training, and education.
3. Properly train staff to effectively manage, maintain, and operate physical plants.

One of the biggest obstacles for O&M of zero energy schools is training and best practices for using newer systems efficiently. Retro-commissioning is an important tool that helps building owners ensure that systems are operating optimally. By collecting data on system efficiency and building energy use post-occupancy, training and O&M policies can be improved to increase the performance of the building.

One important part of O&M of zero energy schools is to educate the building owner and all building occupants on plug load (all the energy used by electrical appliances and products in the building) of the school. . As zero energy schools electrify, the plug load of the building increases due to all systems using electricity rather than fossil fuel for energy. It's important to educate building occupants like teachers and students on the importance of efficiently using appliances. Policies for switch-operated appliances should be established to ensure energy

[17] https://www.energy.gov/sites/prod/files/2015/04/f21/ED486496.pdf

isn't wasted when appliances are not in use. Training should be conducted as needed and policies should be clearly posted around the school.

Available Training Programs

Improving the operation and maintenance of a building to enhance energy performance requires a highly skilled and qualified workforce. When looking to hire within the commercial building workforce, it is important to ensure potential candidates have gone through an accredited program for their certifications. A workforce should have the proper necessary training to complete a job in a successful manner, with consistent and quality work. In order to ensure credentials from different certificate and training programs are comparable to national standards, one resource is the Better Buildings Workforce Guidelines (BBWG).

In order to develop the BBWG project, the Department of Energy (DOE) established a partnership with the National Institute of Building Sciences (NIBS) experts in the Commercial Workforce Credentialing Council (CWCC)**.** The National Institute of Building Sciences is a congressionally-authorized nonprofit organization and well-respected building industry convener. The Council has numerous resources available and leads the development of voluntary national guidelines to improve the quality and consistency of commercial building workforce credentials. The purpose of the BBWG project is to reduce the confusion and uncertainty around workforce credentialing, to lower costs, and to support better credentials, better workers, and better buildings. The BBWG set an industry-validated Job Task Analysis (JTA) for the different job titles, as well as certification schemes and learning objectives for available training programs.

The following stakeholder groups receive specific benefits from the BBWG:

Certification programs: Recognition by U.S. DOE as an accredited program that meet high-quality industry guidelines

Employers and building owners/managers: Objective way to identify high-quality certification programs that train skilled and qualified workers

Governments and utility programs: Objective criteria for specifying workforce certification requirements for contracts on government buildings or for contractors participating in incentive or ratepayer-funded programs.

Workers: Transparency in the training and certification market; clearer professional development pathways; increased skills and greater mobility.

Train and Certify Facilities Personnel Through a Comprehensive O&M Training Program

A good example of a comprehensive O&M training program is The Building Operator Certification (BOC™), a nationally-recognized training and certification program that focuses on practical skills improvement for facility operators. This program was developed by the Northwest Energy Efficiency Council, and courses are taught by an experienced group of instructors with practical experience in their subject matter at select locations nationwide. Locations where courses are taught can be found on the BOC website in the resources below.

BOC participants earn certification by attending training and completing project assignments in their facilities. Upon successful completion of the course, operators have learned techniques that will assist with operating facilities in a manner that promotes energy conservation, indoor air quality, and enhances the environmental health and safety of building occupants. In fact, independent evaluation research shows that BOC-certified operators apply concepts learned in training and undertake measures such as large energy conservation projects and IAQ improvements and are saving money and energy in their facilities. . Average annual per participant energy savings are estimated by this research to be 172,000 kWh per year, equivalent to $12,000 annually at national average electricity rates.

The BOC is not the only program that teaches energy efficiency building operation and management skills. Other organizations, such as the Building Owners and Managers Association (BOMA) and the Association of Physical Plant Administrators (APPA), offer programs targeted towards their respective audiences of real estate owners and educational facility managers. BOMA is an international organization that developed its curriculum in partnership with the U.S. Environmental Protection Agency's ENERGY STAR program, and APPA specializes in campus management.

ENERGY STAR also has its own online training program that is free and available to the public. It consists of live web conferences, animated presentations, and pre-recorded trainings accessible from the website located below. There are workshops geared towards specific sectors such as government and educational organizations, healthcare or entertainment.

Additionally, many state agencies and utility companies periodically offer training sessions that are relevant for building operators. These trainings, often called "BOC Light", are an introduction to the full BOC program. Please consult the resources listed below for upcoming training opportunities in any of the aforementioned programs. Training for custodians responsible for recycling and waste diversion programs can be provided by tours of local recycling or composting facilities.

For more information about proper operations and maintenance in school buildings, see NEEP's Regional Operations and Maintenance Guide.

Training for Building Occupants

In addition to O&M training for facility managers and building system operators, there is training available for building occupants like students and faculty on the importance of energy-efficient zero energy schools. Eversource offers a number of programs for schools and their students like the Eversource Challenge[18] program that provides resources to teach K-12 students about energy savings, energy-efficient technology, and sustainability in their community. Eversource also has a school fundraising program called "Change a Light, Change the World".[19] The fundraiser teaches students about energy-efficient technology and supplies them with light bulbs to sell in their community at no cost to the school. The school keeps 100 percent of the money raised

[18] https://www.eversourceinschool.com/challenge/

[19] https://www.eversourceinschool.com/fundraiser/#about

and there is no limit on how much a school can raise. For more information about these programs and others offered by Eversource, please visit the school programs page[20] on its website.

Operations & Maintenance Checklist (See Appendix for O&M more resources)	
☐	Create or update O&M guide with new technology operations information and energy efficiency principles
☐	Gain buy-in through training/lessons for administrators, teachers, and students
☐	Establish or update building inspection plan
☐	Establish or update school energy policy
☐	Retro-commissioning to ensure systems are operating effiently post-occupancy throughout the building life cycle

Examples of Zero Energy Schools

The table below will be updated periodically as new projects are completed.

School Name	Link to Exemplar
National ZE Schools Database	https://newbuildings.org/wp-content/uploads/2019/02/2019_SchoolsWatchlist.pdf
Douglas Gates Elementary School	https://www.arrowstreet.com/portfolio/douglas-gates-elementary-school/
King Open School	https://www.arrowstreet.com/portfolio/king-open-cambridge-upper-street-schools-community-complex/
Fales Elementary	https://neep.org/sites/default/files/resources/Fales%20ES%20Exemplar_v2.pdf
Table Updated on May 18, 2020	

[20] https://www.eversource.com/content/ema-c/about/community/supporting-the-community/school-programs

Appendix A

The Request for Services (RFS) below are intended to provide communities with examples of language that can be used in their own RFS documents when hiring the project team:

Acton Boxborough

- OPM RFS
- Designer Services RFS

Arlington

- Designer Services RFS

Westwood

- OPM RFS