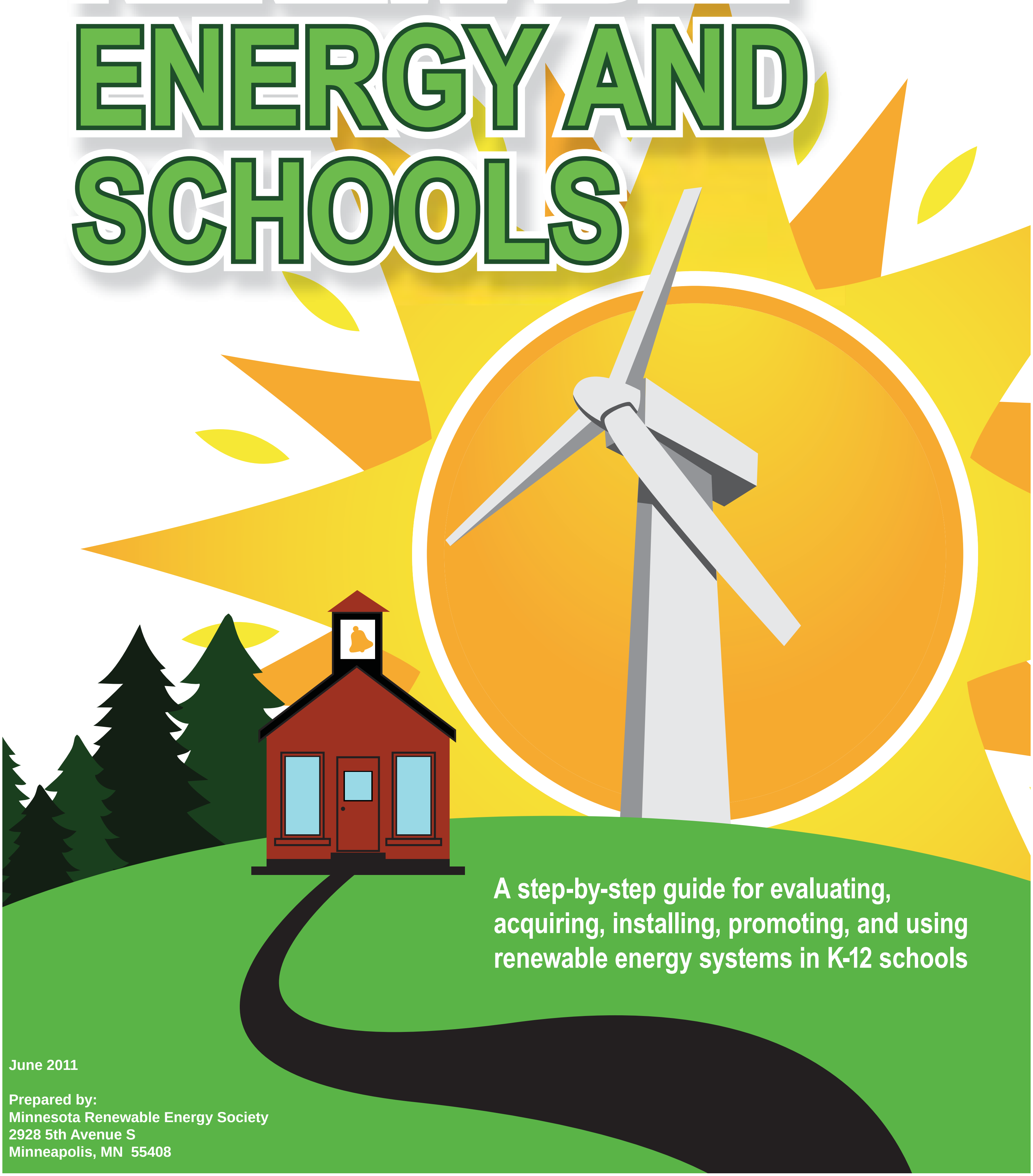
# RENEWABLE ENERGY AND SCHOOLS



A step-by-step guide for evaluating, acquiring, installing, promoting, and using renewable energy systems in K-12 schools

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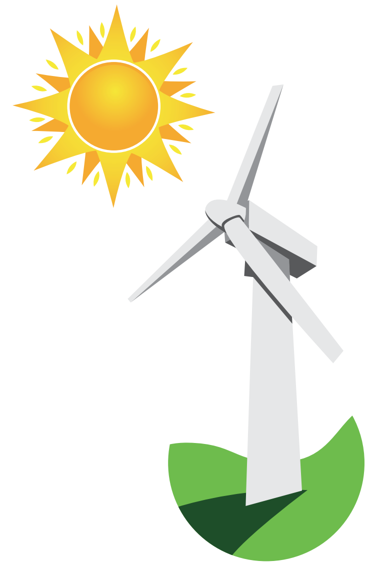
# Acknowledgements



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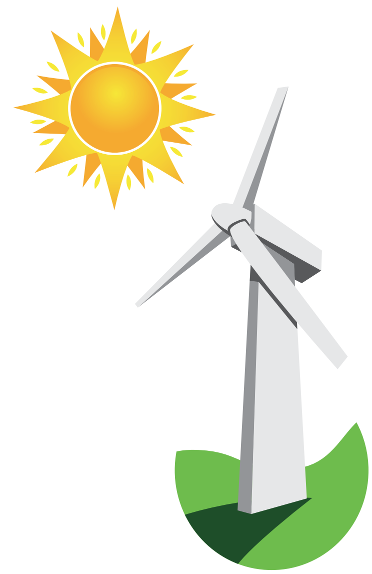
# Introduction

**Overview:**

- Minnesota school renewable energy systems trends
- The need for a step-by-step guide to renewable energy
- Understanding the guide



## I.1 Summary

Over the last 20 years, dozens of schools have installed renewable energy systems. Most of these installations have been in the last few years. Each school's story has been unique, with process and type of renewable energy systems ranging from large wind turbines generating most of the school's energy to small solar systems that are designed to be portable educational tools only. While each school's story is unique, most of these school projects share some common elements, including successes, barriers and dilemmas.

**Intent of this Guide**. This guide describes a process that will help schools learn from the experiences of other schools, identify clear goals and provide tools to achieve those goals. The guide provides a step-by-step approach to help navigate the sometimes obscure process of creating a successful renewable energy project that meets the school's educational, sustainability, fiscal and environmental goals.

### Key Questions Addressed in This Chapter

- Why a step-by-step guide?
- What have other schools done?
- How do I use the guide?

This guide lays out a general process, but also provides examples of details and technical information, as well as educational, financial, and technical resources available to schools. Readers need to be aware, however, that the renewable energy landscape is evolving rapidly and the resources noted in this guide will also change. The guide's emphasis, therefore, is on helping identify types of resources rather than specific programs, curricula or grants. This guide specifically focuses on wind and solar systems. Please see the explanation for this in the Renewable Energy Primer on page 24.

**Helping communities meet community goals.** This guide is not a sales pitch for renewable energy systems. Similarly, the guide does not develop the case for local action on climate change, energy planning or renewable energy school curriculum. Local priorities have been or will be set by local stakeholders. This guide is designed to help communities meet their local priorities, such as reducing the carbon footprint, moving toward energy independence, diversifying energy risk, utilizing local energy resources or educating the next generation on the principles of renewable energy. That these pathways are discussed is not advocacy of these goals, but intended to recognize that different communities have chosen to pursue renewable energy projects for different reasons.

**Audience for this Guide.** The primary audience for the guide is non-technical people (teachers, administrators, students) who see renewable energy as helping to meet their community's goals and who see the synergy of integrating renewable energy into school facilities, curriculum and community relations. The information and recommendations within are directed at parents, teachers and administrators who have made the decision to use renewable energy, but need to avoid pitfalls in resource assessment, financing, installation and curriculum development.

A renewable energy project cannot, however, move forward without addressing a host of issues (educational, financial, bureaucratic, engineering). The guide is written to help a non-technical team engage and work with technical assistance providers, but is not intended to displace the role or knowledge of technical experts. The guide is also not an educational tool for technical service providers who are entering the renewable energy field or a substitute for an experienced construction manager.

**Recognizing breadth of community needs.** Different types of schools and school districts will have dramatically different financial resources, staff capabilities and access to renewable energy. This guide provides information that will be helpful to communities with larger school systems (those more likely to have staff and financial resources) and small schools with more limited resources. Some of the information will be relevant only to some schools and not every contingency is addressed.

Consequently, each school needs to adapt the general process described here to the school's local conditions, resources, financial realities and technical capabilities. Some schools will have internal technical capability to scope, bid and oversee installation of renewable energy systems. Other schools will have virtually no such internal capability. Financial and educational considerations are similarly varied across Minnesota schools. Some steps in this guide will be less relevant and some more critical, depending on local conditions.

## I.2 Inventory of Minnesota Renewable Energy Installations

The first task in developing the Step-by-Step Guide was to assess the existing best practices (or lack thereof) in schools that have renewable energy systems. Points of interest:

- Type of renewable energy systems
- Methods of funding and financing
- Engagement of stakeholders within the school
- Engagement of the community
- Incorporation of the system into classroom curriculum

The inventory included direct outreach and interviews with school officials, teachers, administrators and renewable energy installers, in addition to reviews of case studies and inventories completed by others. The MN Schools Cutting Carbon program, now known as MN Schools Conserving Energy and Water (MnSCEW), had completed a number of school case studies that were an invaluable resource for this guide. Information was also gleaned from newspaper articles, school web pages and networking within the Minnesota Renewable Energy Society's (MRES)membership, including many renewable energy installers.

**Inventory of Schools**. Our inventory identified 32 schools (excluding colleges, but including environmental centers that provide education for K-12). There are some additional schools that were awarded State grants who are in the process of acquiring a renewable energy system but they are not included in this inventory. The schools we identified are scattered across Minnesota and include rural and urban schools, large and small schools, in large and small districts. The oldest installation is 17 years old, the newest was commissioned in December of 2010. Most of the schools, twenty-four, installed a solar energy system, five installed only a wind energy system and three installed both.

**Trends and Findings**. After setting up the information template, we contacted many of the schools again to fill in blanks. The data is still incomplete, but some clear trends have emerged:

- **Small systems**. Nearly all the schools installed small systems that serve as demonstrations, educational tools or symbols of sustainability. The energy contribution of the renewable energy projects is small, relative to the school's energy use. A few large wind energy projects are the exceptions.
- **Preference for solar.** Most of the installations are solar, rather than wind. Likely reasons include – fewer nuisances or perceived safety issues for solar, easier to scale down for small projects, solar resources are more readily available than wind.
- **Community focus**. Most of the installations included students or teachers reaching out to the community to participate in the project (financially or otherwise). Local financial resources were the focus of fund raising efforts.
- **Little financial participation by school district**. Very few school districts contributed financially to the project. Almost all the funds came from outside fundraising.
- **Little use of financing**. Very few projects included financing (loans of some type). The few places where financing was used were primarily where a new school was being built that included renewable energy systems (the financing was for the entire construction, not the renewable energy system).
- **Inconsistent incorporation into curriculum**. A number of schools stated that they used the system in curriculum, but in most cases the use was ad hoc rather than institutionalized curriculum. A number of schools claimed to be using the system for educational purposes, when the primary effort was a kiosk with energy production data or posting of the production on the web. Several schools stated that they planned to develop curriculum, but had not done so yet, or viewed curriculum creation as a separate project to fundraise for.
- **High level of student/community engagement in installation processes.** Very few schools used a systematic process for assessing resources, hiring an installer or overseeing installation. Installations were frequently viewed as a student or community project, using students and volunteers to get the renewable system installed. Resource or building assessments prior to committing to the project were unusual. Exceptions to this appeared to be when a single source (utility, foundation) funded the project.

**How case studies shaped the Guide.** The case studies served two purposes in creating the Step-By-Step Guide: 1) identifying the data and characteristics to allow for cross comparison on goals, procedures and practices; and 2) assemble anecdotal information on barriers and mistakes, inspirations, disappointments and recommendations for other schools.

The case studies identified several issues that the Step-by-Step Guide should address, including:

- The need for clearly identifying project goals
- The need to engage critical stakeholders early in the project
- Distinguishing between projects that are primarily educational or demonstrational and those that are serving sustainability or financial goals
- Identifying a process to complete bigger renewable energy installations
- Addressing the opportunities and pitfalls of funding options
- Addressing the difficulties associated with integrating a renewable energy system into curricula
- Ensuring reasonable and appropriate installation costs

## I.3 Why a Step-By-Step Guide?

As the cost of renewable energy systems continues to decline, and the popularity and interest in renewable energy continues to increase, more and more schools are considering installing systems. The State of Minnesota has seen many more requests for financial, technical and educational assistance for renewable energy systems at schools. However, as the State fields requests for assistance or information, many of the questions and much of the direction provided to schools covered the same topics. Moreover, as the interest in renewable energy grows, the need for baseline information for schools is becoming more apparent.

**Purpose and intent**. This Step-By-Step Guide was created to provide a foundation of information and a general process for investigating, installing and using renewable energy systems at K-12 schools in Minnesota. By following the guide, schools can better define the outcomes that they hope to achieve, the resources that they can use and the individuals and organizations who should be engaged. Following these steps will lead to a higher rate of success and fewer surprises that might minimize the project's benefits.

In some cases, the steps may lead a school to decide against installing a renewable energy system and instead:

- invest in energy efficiency opportunities at the school
- use an environmental learning center for renewable energy education
- design a new or remodeled building to be 'solar ready' in anticipation of a future project.

These are also good outcomes, as the goal of this guide is not to sell renewable energy, but to help schools meet their own goals.

**What the Guide is not.** The guide is not intended to answer all the questions that schools will have. The guide serves as a process that should help schools identify the questions they need to ask, rather than provide answers. Each school and project will need to adapt the process to local circumstances.

The guide is also not intended to serve as a technical manual for installations. While some technical content is included in order to help project teams make better planning decisions, each school will need to engage technical assistance at various points in the planning and installation process.

## I.4 Using This Guide

The Step-By-Step Guide is broken into five chapters, each with between four and six steps. The five chapters each cover an issue area that all schools considering a renewable energy system should address. The five chapters are:

1. Understanding Opportunities and Limitations
2. Evaluating the Site and Resource
3. Curriculum Integration
4. Funding and Financing Alternatives
5. Bidding and Managing the Installation

**Chapters**. The chapters are ordered sequentially in step-by-step fashion, and the content within each chapter assumes that the project team has completed the steps from the previous chapters. Two chapters, "Curriculum Integration" and "Funding and Financing," are less dependent on other chapters, but still built upon completion of Chapter 1 steps, in which the project team is formed, goals are developed and stakeholders identified. Each chapter uses the same organization:

1. A summary that outlines key questions and issues
2. A listing of the chapter's steps in sequential order
3. A detailed description of the steps, including how the steps are applied under different circumstances and any sub-steps that need to be followed
4. Case studies from Minnesota schools that illustrate the issue covered in that chapter
5. Resources for more information
6. A reference "glossary" page explaining terms used in the chapter. Words in the glossary will be indicated throughout the text in italics

**Steps**. Each chapter has between 4 and 6 steps, that are also assumed to be considered sequentially. Some steps can be skipped in certain circumstances, which is usually noted.

The detailed description of the steps includes technical information and recommendations for certain circumstances that schools may encounter. Some steps also have sub-steps that need to be considered sequentially.

## I.5 Glossary and Organization

**Action Step:** Each chapter is organized into a series of steps, that should be considered sequentially.

**Case study:** Minnesota has around three dozen schools with renewable energy systems. The guide draws from these schools' experiences, both good and bad, to illustrate different ways that schools have addressed the issues in the chapters, steps or sub-steps.

**Chapter:** The guide is organized into five chapters that should be considered sequentially.

**Consider Technical Assistance:** The guide uses a graphic notation in the sidebar section to identify the steps or sub-steps where the project team might need to get technical assistance.

**Technical Assistance Icon.** Throughout the chapter you will see this logo to indicate a part of the process where the project team may need to engage technical assistance.

**Educational Opportunity:** The guide uses a graphic notation in the sidebar portion of the page to indicate points that educators and students might be able to participate in the project or conduct a parallel process to a technical investigation.

**Educational Opportunities Icon.** This icon will appear throughout the chapter to indicate an opportunity to incorporate learning activities related to the renewable energy project.

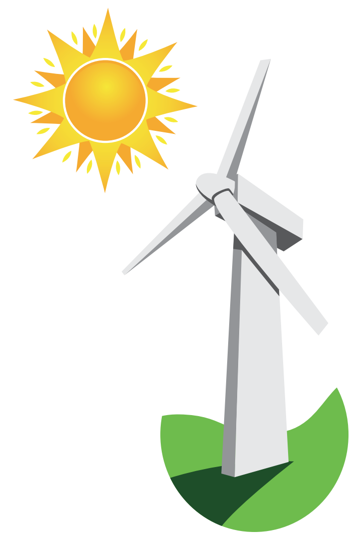
**Potential pitfall:** Some chapters identify potential pitfalls that project teams should note and avoid during the renewable energy planning process.

**Sub-step:** Some of the steps also have sub-steps that need to be considered sequentially.

# Chapter 1. Understanding Opportunities and Limitations

**Overview:**

- Addressing the question of why you want a renewable energy system
- The issue of "cost effectiveness"



## 1.1 Summary

Renewable energy systems are a powerful symbol of sustainability. Solar energy and wind energy are the most widely recognized sources of renewable energy in our country. Solar and wind energy systems can provide electricity and heat to our communities without some of the health, environmental and financial risks associated with traditional energy fuels. Solar and wind resources are part of our local economy, these resources are delivered every day free of charge to our communities. Solar and wind energy are distinct and interesting technologies from traditional energy sources.

Solar and wind energy systems can benefit a school, a community and the entire State by helping to achieve a wide range of goals that include educational goals, energy supply goals and environmental goals. This step-by-step guide provides a path to helping educators, students, parents and administrators understand how renewable energy can help meet their specific goals.

**Key Questions Addressed in This Chapter**

- **Why renewable energy?**
- **Who needs to participate?**
- **Who is a decision-maker?**

**Why renewable energy?** Renewable energy offers many opportunities to help schools meet these goals. But not all these goals are coincident. Schools must understand the limitations of solar and wind energy systems and the obstacles to using them at a school. Choices must be made and priorities need to be set. Different people will have different motivations for using renewable energy in their school. Advocates for the renewable energy project must, early in the project, identify the project goals in order to avoid conflicts and ease decision-making.

**Who will lead?** Moreover, the job of making a school renewable energy project happen is not assigned to a particular person at most schools. Renewable energy project managers are teachers, students, parents and community leaders. Successful projects have a core team of individuals who are willing to participate and to take the time to organize resources and people.  A solar or wind energy project is a learning experience for most people, which should be a positive point for a school.  Engaging and organizing supporters is one of the first steps in a successful solar or wind project.

**Who is a decision-maker?**  Like all organizations, decision-making authority in schools rarely resides with a single person.  In order to successfully install and use a renewable energy system, project leaders will have to identify critical decision-makers early on. Decision-makers are not likely, at least at first, to be advocates for the project.  Charting the path through different decision-makers, and creating advocates among decision-makers, can be a delicate process.

Photo by Pete Gravett

Energy Explosion Interns in front of the Hartley Nature Center installation.

## 1.2 Outline of Action Steps

People have an interest in renewable energy systems for different reasons. It is important to identify the people that will be important to the project and determine how their skills will best support the project. This will ensure a solid resource to rely on throughout the process.

The following action steps summarize how organization of a common set of goals relating to the renewable energy project will lay the foundation for a successful effort.

### Summary of Organizing and Understanding Action Steps

*Step 1 – Identify Project Team*

To successfully install a renewable energy system and use the system to its maximum benefit, a number of tasks and decisions will need to be completed. By creating a team of advocates, the project has many hands to complete many tasks and will address multiple perspectives.

*Step 2- Identify Project Goals*

Even the earliest decisions will vary, depending on the project team's and the school's goals. Installing a renewable energy system is not an end itself, but a means to a goal. Having clarity about the project goals will allow good decisions to be made on all the following steps.

*Step 3- Evaluate Opportunities and Limitations*

Before proceeding with the project, the project team needs to understand the opportunities and limitations of renewable energy resources and renewable energy technologies. Knowing the basics will avoid wasted time in pursuing applications that don't make sense for the school's situation and the project goals. Please see the Primer at the end of this chapter for Renewable Energy basics.

*Step 4- Identify Stakeholders and Decision-Makers*

The project will need approval from a number of people. Some decision-makers will likely not be advocates for the project. Identify decision-makers and critical stakeholders so that the project team can begin to work with them as soon as possible.

## 1.3 Details of Action Steps

A successful renewable energy project must engage stakeholders within your school's and your community's organizational hierarchy. A successful project is one in which human resources are engaged to create a solid plan.

### Step 1: Identify Project Team

Installing a renewable energy system on a school requires substantial effort by a number of people. Establishing a project team of committed advocates will allow effort to be spread around, will invest more people in the project and bring multiple skills to the table. Students can play critical roles in ensuring the project gets approvals, funding and media attention.

When identifying your project team, look for people who are willing to work. Teachers, students and parents are obvious candidates but people can be recruited from outside of the school too. Some schools have recruited renewable energy advocates from local environmental groups or local utility employees. Reaching out and engaging your local community can have many positive results.

The most important quality in project team candidates are people who are motivated to help the school have a renewable energy system installed. Another important quality is to choose people who work well in groups. There will be many different groups that will need to interact and you will need a team of people that recognizes the importance of cooperation.

*Potential Pitfall: Including a Renewable Energy Vendor or Installer on your Project Team*

Many school project teams have a limited knowledge of renewable energy technology or how renewable energy is installed. Recruiting a renewable energy vendor or installer to be part of the project team provides expertise. However, project organizers should be careful about including someone with an economic or business interest on the project team. The project team's top priority is to help meet the school's goals. A local vendor's interests may or may not be served by doing the best thing for the school or the district.

Local renewable energy advocates and technical experts are an asset, but the project team should ideally not be bound to a particular installation company or even a particular energy technology before even starting the project. Offers of discounted prices or free labor can be accepted without including the vendor on the project team.

## Step 2: Identify Project Goals

A successful project will have clearly identified goals. After establishing a project team, the team needs to consider the question "What do we expect to accomplish from installing a renewable energy system?" You might think that everyone interested in renewable energy has the same goals in mind, but such is generally not the case. Renewable energy can help meet a wide variety of goals. Different goals will, however, lead to different priorities in regard to system size, funding priorities, in what stakeholders and decision makers are to be engaged and even whether renewable energy is the best path to achieving your school's goals.

*"A vision without a plan is just a dream. A plan without a vision is just drudgery. But a vision with a plan can change the world."*
*– Old Proverb*

**Set goals.** A renewable energy system can help achieve a variety of goals. However, different project goals will lead to different choices about what type of system is best, how the system is configured within the school grounds, the type of renewable energy system to be installed, how limited dollars are prioritized and other decisions that must be made.

For instance, a focus on providing educational opportunities for students and community means that the development and management of the renewable energy system should maximize engaging students and community members. A small system that is physically accessible can more easily meet this need than a large solar system mounted on the roof or a wind turbine on a 120 foot tower. In contrast, the goal of reducing carbon emissions leads to a project where the renewable energy system should maximize useful energy production, even if the result is that students have less access to the system or fewer opportunities to participate in the planning, installation and operation.

*Setting and Clarifying Goals*

1. What do we want to accomplish through a renewable energy system?
2. To meet our goals, what else needs to happen besides installing a renewable energy system?
3. Can our goals be met in other ways without investing in a renewable energy system? How?

Many times, a renewable energy project in a school setting begins with an idea or a vision of an influential individual (board member or teacher) or group (enthusiastic students). If that is the case, the project team may be making an assumption about what type of resource and technology the project will use ("We want a wind turbine!").

In other cases, particularly high utility rates in one area (electricity, for example) or uncertain gas prices may drive the technology or resource choices: solar or wind for electricity, solar thermal for gas. A rural or small town school that must use propane for domestic hot water and space heating might be particularly motivated to examine solar thermal.

*Project Goals: Audubon Center of the Northwoods (ACNW)*

The Audubon Center of the Northwoods, one of Minnesota's six residential environmental learning centers that are accredited schools, installed several renewable energy systems and made energy efficiency investments to meet its goal of reducing the ACNW's carbon footprint by 80% over ten years.

Examples of different goals include:

- **Demonstrating sustainability.** Set a target percentage of energy to be acquired from renewable sources. Renewable energy production standards can take many forms, from a net zero energy building (usually requiring a new building) to a small percentage like 5% of total electricity use.
- **Energy independence**. Producing a local source of energy gives Minnesota more energy independence.
- **Educate students and the community**. Provide a hands-on educational experience for students and community members on renewable energy potential, and technology.
- **Stabilizing energy costs**. Traditional fuel costs are volatile. Providing a predictable fuel cost will make budgeting for the future easier.
- **Reducing air pollution**. Reducing the pollutants from fossil fuel burning technologies that cause asthma and other breathing related illnesses.
- **Meet climate protection goals**. Reducing carbon emissions to help Minnesota reach its goal of reducing carbon 25% by 2025 and 80% by 2050.
- **Lower school's energy costs**. Renewable energy systems displace energy purchased from utilities, lowering costs.

Consider whether investing in a renewable energy system is the most straightforward path to achieving your goals. If reducing costs is the primary project goal, energy efficiency investments will almost surely be a better path to achieving the goal than renewable energy investments. Renewable energy systems will reduce the

### *Potential Pitfall – Getting Caught in the "Payback" Dilemma*

Getting caught in the "payback" question distracts from other goals. Renewable energy systems will reduce the school's energy costs. However, a "cost reduction" project goal inevitably begs the question "what is the payback?" Payback is a concept that appears to be straightforward, but is rarely so. If the renewable energy system is funded entirely with non-school dollars (grants, donations, etc), the "payback" to the school is immediate. From a societal perspective (irrespective of where the dollars come from), the payback on the school's renewable energy system might, in contrast, be extremely long. New energy generation almost always costs more than existing generation, whether the new generation is wind turbines or coal-fired power plants and thus will only "payback" its investment over a very long time. Moreover, payback depends on assumptions about future cost of energy, discount rates and future environmental regulation.

school's energy costs, but cost reduction should be treated as an ancillary benefit that adds value to the project rather than a primary goal of the project. Project managers should recognize that investing in energy efficiency is almost always the most cost effective and shortest path to reducing energy bills. Combining energy efficiency and renewable energy is a meaningful and highly recommended strategy.

**Set criteria.** After deciding on your project mission or goals, identify how you will measure success. Pick criteria that can be clearly tracked. For example, a project goal might be to improve the school's sustainability by acquiring 20% of the school's total energy supply from renewable energy sources (a renewable energy production standard). This goal has self-evident criteria; identifying the schools energy use, measuring renewable energy production and comparing the two.

An educational goal, such as providing a hands-on method of educating students about energy technology, is a more ambiguous goal to measure. Criteria can include the number of courses offered to students on renewable energy, the number of classes that include labs using the renewable energy system or other measurement of educational actions.

When the goals and criteria are established, the next step will be to consider which type of renewable energy system will best fulfill your goals. Selecting a renewable resource and a renewable energy technology will require a systematic evaluation. In the next step your project team will connect your goals to particular resources or technologies and prepare the way for a site assessment (Chapter 2).

### Step 3: Evaluate Opportunities and Limitations

Opportunities and limitations for your project initially center around two aspects of renewable energy systems:

1. The availability of the solar or wind resource
2. The characteristics of the different renewable energy technologies

This section does not include a comprehensive assessment of resource and technology considerations, but does identify some of the primary examples of how schools need to think about solar and wind resources and technologies.

*Know your Energy Liabilities*

- Refer to your energy audit (or have an audit completed).
- Identify the biggest energy-related liabilities to your school (cost, greenhouse gas emissions, price volatility).
- Identify which systems in the school create those liabilities.
- Identify both energy efficiency investments and renewable energy resources that will offset these liabilities.

*Assessing Resource Potential: Minneapolis Public Schools (MPS)*

As described in the case study at the end of this chapter, MPS installed solar systems on four schools in 2010. An assessment was conducted at each school. However, after the four schools had proceeded with their projects, the District decided to conduct a more universal assessment of its buildings (with the assistance of one of the local community colleges that trains solar assessors). The solar assessments allowed the District to identify the ten best locations for future solar projects, some of which were better locations than the four schools were the systems were installed.

**Understanding the resource.** Solar and wind energy are everywhere. However, to be usable, the resource must be present in sufficient quantities for the renewable energy technology to work. Understanding the nature of the resource is critical to making good decisions about investing in the resource. Solar energy systems require unimpeded, unshaded access to the sun for several hours on either side of noon at all points in the year. Wind energy systems need a constant source of wind, rather than a gusty or intermittent wind, unobstructed by buildings or trees.

Minnesota has a very good solar resource. Usable solar resources are common throughout Minnesota, limited only by site-specific obstructions (trees and buildings). Minnesota also has an excellent wind resource. However, usable wind resources are not nearly as common as solar resources. The best wind resources are located in high prairie areas outside of urban areas. Very little opportunity for wind energy can be found in metropolitan areas.

**Understanding the technologies.** Renewable energy technologies in Minnesota include solar electric (*photovoltaic or PV*) *solar water heating, solar air heat* and wind electricity. Each of these technologies has potential and also limitations. Important issues are efficiency at converting energy, cost scalability, type of energy produced and compatibility with school facilities.

For instance, wind turbines usually require a 100-foot tall tower, at a minimum, in order to meaningfully capture the resource. The cost of the tower usually means that the total project cost cannot be scaled down as easily as a solar system can. As you will see in Chapter 2, just evaluating whether you have a wind resource can take time and money.

Wind energy technology is, however, efficient at converting the resource to usable energy. While wind energy projects tend to come with a higher price tag than solar projects, wind projects also produce much more energy relative to the cost. If your school has a meaningful wind resource, wind will present a better financial picture than solar.

Solar energy projects are much more financially scalable than wind projects. For some project goals, the size of the system or amount of energy production is not important. A small solar system is, for instance, just as valuable as a large system if your goal is to have a working example from which to incorporate educational curriculum for your students. A small system can, furthermore, be incrementally expanded over the years to create more energy and provide a learning opportunity for future students.

Solar energy systems come in three types; *solar photovoltaic*, solar hot water and *solar air heat*. *Solar photovoltaic* produces electricity, solar hot water and air produce heat. Project team members will need to be aware of several important differences between these technologies in the assessment process (Chapter 2). Please see the Renewable Energy Primer at the end of this chapter to learn more about renewable energy technologies.

**Combining Energy Efficiency and Renewable Energy.** A renewable energy system is an enticing goal. Some people, however, point out that the financially correct choice is to invest in energy efficiency, as the financial return is almost always preferable to investments in new energy supply. Financial goals would indeed dictate that energy efficiency should get the first and the lion's share of facility investments.

However, combining energy efficiency and renewable energy investment adds value to both investments. For instance, a school that sets, as a goal, a renewable energy standard (a goal of generating a specific percentage of the school's total energy use through renewable sources) can achieve the goal much more easily with investment in energy efficiency. The standard can be achieved through action on both the demand side and supply side of the equation; by reducing energy usage the production becomes a higher percentage of the total.

Your school should carefully assess energy efficiency opportunities as part of the renewable energy project.

## Step 4: Identify Decision-Makers and Stakeholders

After having established your initial plan, you will need to identify other important stakeholders and decision-makers. People other than those on the project team will need to weigh in on decisions. This could include the principal, superintendents, building facilities manager, teachers, students, parents, the school board, permitting offices and community leaders. The project team will need to ask several specific questions. Please see the sidebar for a list of these.

*Questions for Project Team to Consider*

- What approvals are needed from non project team members?
- What are the goals or motivations that will drive their decisions?
- What will their roles be?
- How can they help you?

**Consider creating an Advisory Group.** Creating an advisory group, separate from the project team, will help guide the school through the process of choosing a renewable energy system, as described in more detail in the next chapter (Evaluating the Resource and Site). Ideally, this group should consist of five or six people who are knowledgeable with the processes this project will have, including permissions, finances, logistics and curriculum. Creating an advisory group will help bring on board all of the parties that will eventually be involved and allow issues to be brought forth in the beginning of the process. This group will meet less often than the project team but should be engaged most when important decisions need to be made. You will see in the following case study the importance of identifying and engaging your stakeholders.

### *Example of School District Oversight Regulations*

- District Site Manager/Principal shall notify, in writing, the Director of Planning & Facilities immediately when any work or project on the facility or grounds has been identified. Upon review, the Director of Planning & Facilities will approve or deny the proposed work or project. This includes projects or work funded by grants, outside organizations and volunteers.
- Site Managers/Principals shall not enter into formal or informal agreements for use of District buildings or grounds by third parties except as permitted by District policy.
- If the work or project is approved, the Director of Planning and Facilities will assign the the appropriate Facilities representative to work with the site administration to assist in the development of work or project scope and to ensure that materials used and work performed meet District specifications and standards.

*Source: Minneapolis Public Schools, Superintendent's Regulation on Stewardship of District Buildings and Grounds*

## 1.4 Anecdotes/Case Studies

### Case Study: Lowell Elementary School

### Renewable Project Type: Solar Electric System

#### Description

In 2010, a 1.61 kW *solar photovoltaic* array was installed at Duluth Public Schools' Lowell Elementary School. There are seven REC 230 watt modules which are connected to Enphase *micro-inverters*.

#### Project Goals

The primary goal for the project was to have a teaching tool for students to learn about renewable solar energy. The project is also part of a larger mission of the Duluth Public Schools' program Sustainable Duluth Public Schools (SDPS). The goal of the SDPS program is to work to make Duluth Public Schools the greenest school district in the country. The district plans to have several of its school buildings meet Leadership in Energy and Environmental Design (LEED) standards and to incorporate energy efficiency practices in several others.

Photo by David Taylor, ISD 709

Installation in Progress at Lowell Elememtary

#### Background

SDPS began in January of 2008 when a group of school staff and students began organizational planning. One of the earliest ideas was to put a solar array on one of the district's schools. The project was the result of a partnership with Duluth Public Schools and the Earth Day Network. The Earth Day Network is a nonprofit organization located in Washington D.C. which was founded to broaden and diversify the environmental movement worldwide and promote a healthy sustainable environment. Earth Day Network has a Green Schools Campaign which works to create healthy, energy efficient and sustainable learning environments across the country.

#### Process - Engaging Critical Stakeholders

The SDPS team met regularly for over a year working on the solar panel project. They had to deal with many issues related to the project such as getting the project through the purchasing department at the school, meeting requirements of the building managers, and ascertaining permitting and inspection requirements. The SDPS team leader, the Activities Director at East High School, noted that one of the primary lessons learned was that many people need to be kept in the loop during the whole process. A number of people are affected by the new system in terms of decisions to be made and changes in responsibilities. All these people need to be kept informed and provided opportunity to provide feedback during the process.

### Funding and Financing

The primary funding source was a $15,000 grant from the Earth Day Network and the University of Phoenix.

### Educational Benefits of System

All schools in the district can download real time information on the energy being produced and carbon offset by the system. The monitoring and reporting systems shows that after a few months, the system had produced 744 kWh of electricity, or enough power for 25 homes for one day.

### Energy Efficiency

The SDPS plans also include implementing a number of energy efficient and sustainable practices. Some of their future goals include:

- Purchasing Energy Star electronics and appliances rather than the cheapest available
- Converting the district's vehicle fleet to carbon neutral options
- Containment systems for rainwater capture in plants on school grounds
- Energy efficient windows

### Looking Forward

SDPS is now composed of many students, faculty, administration and community members and meets regularly throughout the school year and is completing a comprehensive strategic sustainability plan which will enable the district to operate more efficiently. The group would like to do a much larger renewable energy project in the future, but feels that some standard guidelines would be very helpful in achieving such a goal because this project encountered many roadblocks.

## Case Study: Minneapolis Public Schools:

### South High School, Seward Elementary, Pillsbury Elementary, and Floyd B. Olson Middle School

## Renewable Project Type:  Solar Electric System

### Description

In the Fall of 2010, four 5 kW solar arrays were installed on four schools in Minneapolis.  The installations were part of a grant awarded to Minneapolis Public Schools by the National Energy Education Development (NEED) project, which was in turn funded for this project by the WalMart Foundation.

### Project Goals

Several organizations, including Minneapolis Public Schools (MPS), the NEED project and the WalMart Foundation all had project goals, and not all the goals were the same.  The NEED project is primarily to provide solar energy education to students through a combination of demonstration systems and training of educators.  MPS shared this goal, but also has a Board-adopted sustainability resolution (2009) that empowers staff to take actions and make investments that improve the sustainability of the  District.  MPS hired a Green Coordinator in 2008 who works in a variety of management areas to meet sustainability goals.  "The decision by the School Board to commit to environmental sustainability changed the whole conversation," said one staff person, "before that we had never brought it all together and taken an organized approach."

Photo by Bianca Rhodes, Mpls Public Schools

Representatives from Minneapolis Public Schools, Hennepin County, Walmart, the National Energy Education Development Project (NEED) and the installers celebrate the installation of solar panels at Pillsbury Elementary School.

## Background

The Minneapolis School District was contacted by the Foundation for Environmental Education (FEE) in 2010 to find out if the district would be interested in participating in a project to install solar panels on 20 schools in five cities across the US, Minneapolis being one of the chosen cities. The criteria for MPS to participate in the program were 1) qualified local installers and 2) that the schools did not already have solar panels.

The project is a partnership between the Walmart Foundation, which started a Walmart Solar Schools program through FEE and the NEED. NEED provides a large portfolio of teaching materials online for K-12 educators from curriculum guides to energy plays designed to introduce students to energy concepts.

## Installation Process

Even with the top-down support for this project, the process of meeting grant requirements, engaging the many stakeholders in four separate projects and getting Board approvals was time-consuming and slow. From the initial contact about the grant opportunity, staff worked for almost five months for the support of various building facility staff and educators at the four schools and at the district level. Due to the uncertainty associated with installing what was, to staff, a new technology on school buildings, the project met with initial resistance from facilities staff. "It took lots of conference calls with facilities staff to get everyone on board just to pursue the grant," said one of the project managers. "Departments are very sensitive to their time. Their plates are overflowing with their core responsibilities." But the commitment of the Chief of Business and Operations to the Board-endorsed sustainability goals helped carry the efforts, and facilities staff ultimately bought into the project.

## Funding and Financing

The project was funded entirely by the Walmart Foundation and the NEED project. Minneapolis Public Schools spent no money on the project, but did spend a considerable amount of staff time in the building assessment and project coordination of multiple teachers, schools and building managers. Even though the project ostensibly used 100% funding from outside the District, MPS staff were cautious of what they termed "the cost of grants." Granting entities require data to be gathered, reports to be filed, staff time in planning, coordination and sometimes commitments to promote the granting entity and the project.

## Educational Benefits of System

The most important part of the program is the renewable energy education that accompanies the installations. Joe Alfano, a science teacher at MPS, is leading the curriculum component. NEED provided the curriculum materials and the teacher training for the program. Science teachers at each of the four schools will use these materials in the 2010-2011 school year. Alfano hopes to tailor the NEED program to meet new MN science curriculum standards through feedback from participating teachers and evaluation of the curriculum materials.

## 1.5 Renewable Energy Systems Primer

There are multiple renewable energy sources readily available in Minnesota. Minnesota has a better solar resource than Germany, the world's leading producer of solar energy. Solar thermal systems capture the sun's energy as heat, usually in the form of *hot air* or *hot water*. Solar electric systems convert solar energy directly into usable electricity. Windpower is an abundant Minnesota resource, particularly in the southern and western parts of the state (although most locations have some potential), and can be exploited both with utility scale turbines (which may have a capacity up to 2 MW), and with smaller turbines that can be a small 1 kW in capacity or less. While Minnesota has some *hydropower* resources, they are rarely located near a school and exploiting them is technically and environmentally challenging. *Biomass* resources are abundent in Minnesota, and are utilized through a number of technologies, including co-firing with traditional fuels, gasification, and bio-gas digesters. These technologies require a higher level of engineering and are more specific to the school's heating system. Thus, this guide does not discuss hydropower or biomass.

A **solar electric system** captures the sun's energy with photovoltaic panels. As captured, this energy is in the form of direct electrical current (DC). Since most of our electrical appliances use alternating electrical current (AC), typical solar electric systems include an inverter to convert DC power to AC power. One can use batteries to store solar-produced electricity, but they are expensive, they waste some of the power and require maintenance. Since schools have access to utility power, we will focus on *grid-tied* systems that can feed excess power onto the utility grid when they produce more power than the facility needs, or draw power from the grid when the solar electric system cannot meet the demand.

The *grid-tied* approach makes solar electric systems very scalable. If financial resources are limited, or if the school wants a demonstration system, a small system can be connected even to a large building. But if resources and space allow, larger systems can be built. Systems can even be large enough to produce sufficient power that the facility becomes a net exporter of energy (although this can create additional concerns and design issues).

Solar electric systems are commonly placed on building roofs because that space is not usually used for other purposes and because there are usually fewer problems with shading. But solar electric systems can also be ground mounted on frames or poles. In some

### *Where is Geothermal?*

*Geothermal* resources are sources of heat from the enormous pressures inside the earth, such as the geysers and thermal features in Yellowstone National Park.

The State of Minnesota's geothermal potential is quite limited without drilling very deep into the earth's crust. Ground source heat pumps (sometimes confusingly referred to as geothermal) use the earth as a thermal mass for heating or cooling, and have tremendous viability in Minnesota.

*GSHPs* use electricity to draw up heat energy from groundwater or soil to heat or cool a building. They can provide several times more heating or cooling energy (from the earth) than the electrical energy consumed. As a result, a GSHP powered by renewably generated electricity (from sun or wind, for example) can be a very efficient and effective technology.

On the downside, the pipes that collect the heat must be buried in trenches or wells and digging the wells and trenches can be expensive and disruptive to the site.

cases, photovoltaic panels can be integrated into the architectural features of a building like the roof, walls or awnings.

**Solar thermal systems** are very efficient at converting solar energy into low temperature thermal energy. They use glass panels or tubes that capture the sun's heat in much the same way your car windows capture the sun's energy even on winter days. That heat can be carried away from the panels by water, antifreeze or by air.

Unfortunately, it is harder to use that energy effectively. We rarely have systems that distribute heat energy outside of a building, so a *grid-tied* arrangement like those for solar electric systems is not normally possible. Solar thermal energy production is a "use it or lose it" situation. While panels that produce hot water can store some of the heat in water tanks, there are practical limits on the size of storage. *Solar air heat* faces the same issues, there are not really any cost efficient ways to store the heat from the panels.

But since solar systems are often (for economic and physical space reasons) sized to meet only a portion of the building load, we can often make good use of the solar thermal energy. See sidebar for examples that work in Minnesota.

In some cases, *solar thermal water heating* systems can provide space heating, but design must be done carefully. Solar thermal systems produce low temperature heat, but many heating systems are designed to use higher water temperatures. You can't use the solar thermal energy if the output temperatures are lower than the temperatures in the heating system.

For solar thermal panels that heat water, there are practical considerations in the MN climate. The fluid in the panels and outdoor pipes must be protected from freezing when the sun does not shine or the water will freeze and break equipment.

One way to prevent freezing is to use a non-toxic antifreeze called propylene glycol. This works well but the heat then must be transferred to the water through a heat exchanger (which reduces the system efficiency somewhat). And the antifreeze must be protected from overheating—one can't just shut the pumps off in the summer.

The other approach is called a drain back system. When the sun does not shine or the storage temperature is already high enough, the pumps shut off and the fluid is allowed to "drain back" into a

*Smart Uses for Solar Thermal*

- Solar thermal panels, particularly flat plate, are particularly well suited for heating water. A properly sized solar thermal system with a storage tank can supply 50 to 75% of a buildings water heating needs very cost-effectively. This is a great option if your school has a large hot water load, such as locker room showers or an on-site kitchen.
- Solar thermal panels are very effective for heating swimming pools. In this scenario, the pools serves as the storage, and no tank is needed.
- Air heating panels are directly connected by ducting to a space that needs to be heated. When the building needs heat (think cold January days) the panels collect heat from the sun and a fan circulates the heated air, reducing the usage of natural gas or propane.
- See www.districtenergy.com

storage reservoir inside the heated space. The piping must be carefully designed to make sure the pipes drain well but this approach is very effective in larger systems.

**Wind energy systems,** particularly large utility scale wind farms, have become a common sight in Minnesota. Most wind turbines generate electricity, although the old farm water pumping windmills were effective tools before rural electrification. Although some schools have created wind energy systems with utility-scale (1 MW or larger capacity) turbines, there are options ranging from 1 kW to 999 kW of capacity.

For electricity generation, wind turbines are probably the most cost effective renewable energy system in Minnesota. They can interconnect with the utility grid in the same way that a solar electric system does.

Photo by Doug Shoemaker, MRES

The most common wind turbines are the familiar horizontal axis machines—so-called because the shaft of the rotating blades is horizontal. There are also some vertical axis machines (see photo at left), but these should be considered with caution as many such machines have not been proven to function as designed. There are more examples of horizontal axis machines that have proven themselves through actual electricity production.

Towers are the other primary features of wind energy systems. Near the ground, the friction between the moving air and the ground steals speed and energy from the wind and the produced turbulence can damage a turbine over time. Thus, the higher the tower, the better, although higher towers cost more and create maintenance and repair challenges. Wind energy systems need to be sited away from obstacles to the wind. The need for a safety zone around a tower, and space for erecting the tower, mean that wind energy systems usually need a large open area. Wind energy systems are not practical in urban/suburban landscapes. That is true even in small towns—a turbine would have to be located away from the residential and possibly commercial areas.

Wind energy systems are very visible—unlike solar panels, which can sometimes be hidden on a large flat roof. Everyone will know that you have a wind turbine. That can be an asset if your community is supportive of renewable energy but that visibility can be a liability if there are people who object to turbines on perceived aesthetic or noise issues.

## 1.6 Glossary of Terms

**Biomass:** Renewable organic materials, including wood, agricultural crops or wastes, and non-agricultural grasses such as prairie grass. Municipal wastes are sometimes considered biomass. Biomass can be burned directly or processed into biofuels such as ethanol and methane.

**Geothermal:** Geothermal energy is heat from within the Earth. We can recover this heat as steam or hot water and use it to heat buildings or generate electricity.

**Grid-tied system:** A renewable energy system producing electricity that is connected to the utility electrical grid. A grid-tied system allows the utility to seamlessly supplement the renewable energy system production when the renewable energy system does not meet the load. Conversely, it allows excess renewable electricity production to be used by other customers on the grid.

**Ground Source Heat Pumps(GSHPs):** Electrically powered systems that use groundwater or simply soil to cool a condenser instead of an outside coil and fan. They move heat energy from one place to the other to cool or heat depending on need.

**Hydropower:** Electricity produced by a turbine in a flow of water, usually from a mountain stream or a river.

**Micro-Inverters:** Small inverters sized for just one solar panel. Photovoltaic systems with micro-inverters have an inverter for each photovoltaic panel. Compared to photovoltaic systems with a central inverter(s) serving the whole system, micro-inverters allow the system to function better when one or more panels are shaded. Some micro-inverters also allow remote monitoring of individual panel performance.

**Solar Air Heat:** Solar air heat is a type of energy collector in which the energy from the sun is captured by an absorbing medium and used to heat air.

**Solar Photovoltaic:** Panels convert sunlight directly into electricity to power homes and businesses.

**Solar Water Heating:** Panels harness heat from the sun to provide hot water for homes and businesses. Most solar water heating systems for buildings have two main parts: a solar collector and a storage tank. There are two types of collectors; a flat-plate collector and an evacuated tube collector. These can also provide space heating.

## 1.7 Resources

**www.eia.doe.gov**
Website for kids with the basics of Renewable Energy

**www.cleanenergyresourceteams.org/technology**
Technology facts with useful Minnesota based Case Studies

**www.learningcenter.net/library/building.shtml**
How to build a successful team

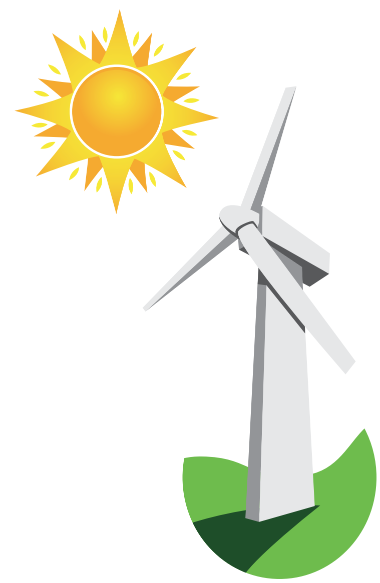
**www.usgbc.org/LEED**
More information on LEED Certification

**www.learningcenter.net/library/building.shtml**
How to build a successful team

# Chapter 2. Evaluating the Site and Resource

**Overview:**

- Conducting a renewable energy resource assessment
- Choosing an assessor
- Other types of relevant assessments



## 2.1 Summary

One of the great aspects about renewable energy is that renewable energy is everywhere. Except when it isn't. The sun shines and the wind blows, but that doesn't mean every school has a resource that can be captured. Renewable energy systems offer the attractive possibility of "free fuel," but sometimes the free fuel is just a trickle, and sometimes the fuel is very hard to reach. Your project team will need to plan for an assessment as to what and how much of a renewable energy resource the school has.

A good assessment will reduce overall system costs and produce a better result by helping your school's project leadership and the system designer make good choices early in the project and to help ensure the system will perform as expected. The assessment issues that the project team must address include:

**Key Questions Addressed in This Chapter**

- What are your renewable resources?
- Is your site suitable?
- Have you considered issues with surrounding properties?

**The "size" of your renewable energy resource.** To produce a meaningful amount of energy, the solar or wind resource needs to be steadily available. Occasional shading or intermittent wind can substantially lower the resource potential on your site. For example, a sunny location at noon might be shaded an hour later or a sunny location in September might be shaded in June, significantly lowering the resource potential. Wind must be steady rather than gusty or else energy production drops dramatically.

**Adjacent buildings and land uses.** Since the energy is "delivered" by the environment, features adjacent to your facility, perhaps not even part of your school property, can affect the amount of resource on your site. In the case of wind energy systems, large structures (e.g. trees or grain elevators) can disrupt the flow of wind energy across your site. Also, sensitive ecological systems near the school can be disturbed by the turbine's foundations or the tower height.

**Storage.** Because of the intermittent energy source, some renewable energy systems require storage. Solar thermal systems used for domestic water heating must have a place to store the hot water. In contrast, grid-tied solar and wind electric systems do not need storage, as the electric grid serves as a storage proxy.

**Integration with existing energy and building systems.**
Renewable energy systems need to be integrated with supplemental energy systems because of the intermittent nature of the renewable resource. Not all existing energy equipment is designed to supplement or be supplemented by on-site generation of electricity or heat. Similarly, the school roof was not intentionally designed to hold a solar array. Some roofs are fine, others require significant modification.

As a result of these factors, renewable energy project design begins with a careful evaluation of the available renewable energy resources, features that will affect how those resources can be collected and utilized, and how existing energy and building systems will interact with the renewable energy system.

**Independent assessment, or assess-and-install?**

A site assessment is often done by designers/contractors who will go on to design and build the system, but there is an advantage in having a third party assessor, where available, do the initial evaluation. Independent assessment is especially helpful when you have a choice between which renewable energy source to exploit as many renewable energy contractors specialize in only one type of system and do not have the expertise to suggest alternatives to what they have to offer.

In some instances, there are third-party site assessors who have received specialized training and certification in site assessment for each of the renewable technologies discussed in this guide. When available, these certified site assessors are a good choice and worth their professional fee to ensure you get objective information.

If an independent site assessor is not available, a common industry practice is for a renewable energy contractor to offer the assessment as a separate service. Often, the fee will be waived if the contractor is chosen to continue the work. If not, the customer pays a fee and the assessment report becomes the property of the customer and can be used by another contractor.

**Project Team Responsibilities.** Whoever does the site assessment, your project team will have some responsibilities in the process. Besides providing access to the site, you will need to provide background information, like building design, engineering information and utility consumption data to the site assessor. Keep in mind that the information may have to come from multiple sources (utility data from the business office and engineering data from building engineering/maintenance staff). Timely access to the data is important because your assessment report and the decisions you need to make will be on hold until the data is available.

Often, school staff can make some preliminary evaluations that can guide your choices of what energy source to pursue (or not). The direction of true south must be determined to see if tall trees obstruct the sun during much of year—such conditions might preclude a solar energy system.

**What is in a site assessment?**

A proper site assessment will look at the available resources and how the equipment necessary to collect that resource will "fit" with your facility. A site assessment will look for features that will support the project or for features that might suggest that a particular system is unsuitable. In the case of roof-top solar installations, professional structural engineers and/or roofers may need to be consulted.

**Educational opportunities.**

The site assessment can be a significant learning opportunity in a school setting. Classes can do preliminary analysis and even data collection if funds are available for equipment. Sometimes, site assessors are willing to demonstrate their work or involve students in the data collection. And even if the site assessment rules out an energy project, sharing the assessment result is a learning opportunity—part of understanding renewable energy is knowing what won't work in a given situation.

Photo by Todd Fink, Century College

The photo above shows a student using a Pathfinder to determine the amount of shading on this roof, a proposed solar installation site.

## 2.2 Outline of Action Steps

Depending on the type and scope of the project, some of these steps might be unnecessary, or need more specific efforts, but in general they represent a "common sense" approach to getting a good result. The following site assessment steps are likely to be applied in an iterative fashion. For example, a project might initially start out as a wind turbine project, but an initial site assessment might suggest solar is better, requiring you to start over.

### *Summary of Resource Assessment Action Steps*

*Step 1 – Preliminary Resource Self-Evaluation*

Which renewable energy resources and technologies work for you? What are your goals and what are your available resources, including the features of your particular site and how you use energy? Are there issues or circumstances in your community that will affect the final decision?

*Step 2 –Assemble Information Prior to Assessment*

For most renewable energy projects, some basic data will always be necessary. Examples include building and ground site plan, utility bills and some information about the pattern of building use.

*Step 3 – Develop a Scope for the Site Assessment*

A site assessment will be necessary, but the assessment might be a simple single visit or a more lengthy process and involve multiple technical experts. Form a small assessment oversight group, ideally a subgroup of your project team, but including a building engineer or maintenance person.

*Step 4 – Perform the Site Assessment*

This step can be simple or complex, depending on the size of the project, the resource choice and the technology choice. Be ready to support the assessor with necessary information and access. Consult with professionals as necessary (structural engineers, roofers, electricians).

*Step 5 – Receive the Report and Evaluate the Result*

Check the results of the assessment and compare it to what you know. Is there something missing or does the report suggest additional questions? Follow-up with the assessor.

## 2.3 Details of Action Steps

Good early decisions are key to a successful project. Your project team needs to ensure that assessment process is thorough, deliberate and consistent with your project goals. Of the proposed steps, the first may be the most difficult for the project team. Once a particular path (type of resource and technology) is chosen, engineering and cost constraints often make the decisions for you. But when you are deciding your path, lack of information can make the way forward unclear and the process daunting. As a result, some of these steps may need to be repeated to ensure a useful result.

Ask your renewable energy staff – Minnesota Division of Energy Resources

- Do we have potential for a wind resource at our school?
- Are there other wind installations in our area?
- Do you have a list of wind energy installers in our area?

### Step 1 – Preliminary Resource Self-Evaluation

Select resources and technologies based on your project goals. If your project team followed the steps in the first chapter, you may already be largely finished with this step. If not, a qualitative examination of your goals in comparison with the site and the available resources is now a must.

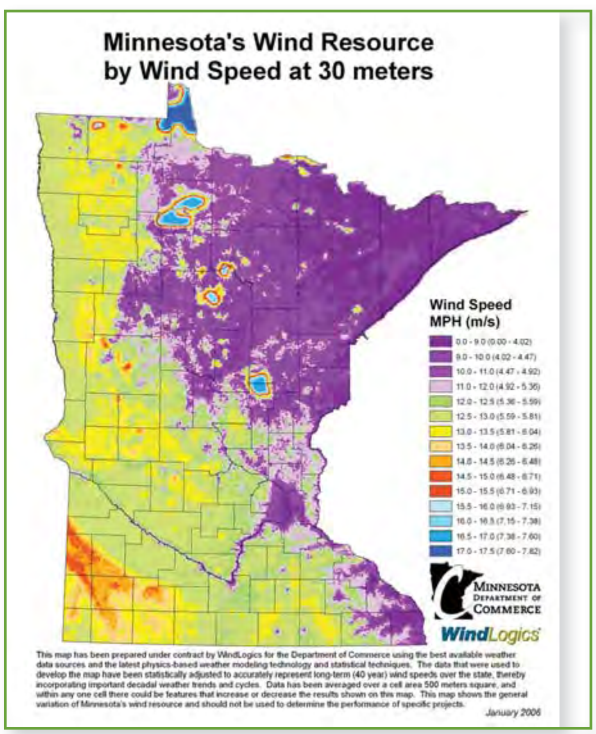
The project team needs to compare its project goals and the underlying motivations to the realities that face the school setting. A school location in a river valley surrounded by bluffs will not be a good location for a wind turbine no matter how excited the community might be by the prospect. While the wind does sometimes blow, the energy resource is merely a trickle over the year. For solar and wind projects, there are some basic "rules" that allow you to make some preliminary observations about project viability.

**Consider Solar Site Potential.** Do you have a south-facing shade-free location? In the case of solar projects you need a southern exposure in a spot that, preferably, is shade free for at least 80% of the day. Ideally, that 80% "window" will be centered over the middle of the day, although some variation is possible. Remember that the sun will be very low in the horizon during winter months— a modest sized tree may shade the site at that time of year even if it is not a problem at other times of the year.

Consider the differences between solar electric and solar thermal resources. Photovoltaic panels are particularly sensitive to shading. A small fraction of shading over a panel can disproportionately reduce the energy output of that panel. Likewise, shading on one panel can reduce the output of an array of panels wired in series. Note that snow covering the lower edge of the panels can have the same effect, which can be long lasting in a severely snowy winter. Solar thermal panels (both the air and water heating kind) are less sensitive to shading—the effect will be in proportion to the fraction of the panel that is shaded. As a result, modest wintertime shading by a deciduous tree without its leaves can be tolerated.

**Consider Wind Site Potential.** Do you have a location with steady strong wind? Check to see if the wind resource provided by your climate is adequate (which can be roughly assessed by looking at the Minnesota wind resource map). Next, consider the primary siting concerns for a wind turbine to maximize the sustained wind speeds and to minimize turbulent air flow. The general rule is to plan for as high a tower as you can (wind speed drops drastically as you approach the ground) and to place it sufficiently far from turbulence causing obstacles like trees and houses. An approximate rule of thumb is to have the bottom of the rotor be at least 30 feet above any obstacles within 500 feet. If the nearest obstacles are trees, be sure to account for future growth of the trees.

You will also need to allow access to the site for installation and future maintenance, which may require lowering the tower to a horizontal position. Additional considerations include the possible effects of noise (on-site and on adjacent properties), visual impacts and aesthetics, safety issues such as a preventing unauthorized climbing, zoning restrictions and distance to where the power is delivered to the grid.




The wind resource map for Minnesota (left) shows average sustained wind speeds approximately 100 feet above the ground and is one tool used to determine the viability of a site for a wind energy system. Additional maps for higher towers are available.

**Consider the scale of the project.** Assessment issues are substantially different for large systems than for small systems. The larger the system, the more likely the assessment process will entail multiple facets, such as structural engineering, load estimation or *soil borings*. Moreover, project scale also affects a number of economic parameters; large systems allow better economies of scale, but can also create interconnection and contracting (with the electric utility) difficulties. Minnesota law requires *net metering* for solar and wind electric systems up to 40 kW, which means the utility will reimburse you, at the rate you pay, for power fed back into the grid. But for systems larger than 40 kW, the utility will pay only the wholesale rate, which may be as little as $0.02-0.03/kWh.

For this reason, the assessment process will need to consider the building energy "load" or the size of the system relative to the typical energy use. Designing the system to match the load can be a prudent choice, even if the result is not as visually impressive. Matching load is important for solar thermal applications, where there is no way to sell the excess energy production to the utility.

System size may also trigger reviews or additional permits from local government in regard to zoning or development regulations. Renewable energy systems are subject to zoning regulation and this should be considered carefully in assessing the system scale.

A useful result from this step would be a statement of goals (as well as a discussion of those goals with stakeholders) and a listing of relevant challenges as well as areas where there are questions.

### Step 2 – Assemble Information Prior to Assessment

By bringing together useful data, you can save time for yourself and the assessor. The sidebar to the right includes some suggestions for information to have available to initially help the site assessor, and later system designers and installers. But a key point in this step is to focus on easily available information. If an item in the list will require several days to compile, find out if the assessor needs it. Since an assessment is about establishing feasibility, the result may change the picture and change what information is necessary.

Building and grounds site plans, utility bills, utility company contact information, contact information for zoning officials and some information about the pattern of building use (for example: when

#### What is a "large" system?

Large is a relative term--relative to the size of your facility, to the size of your load, to the perceptions of your neighbors.

Wind turbines have an accepted definition of "large" and "small". Large systems usually exceed 100 kW of rated capacity. Although a 10 kW turbine on a 100' tower may seem large to students and community members, the industry will call this "small" wind.

Solar systems do not have such clearly defined categories. Practically, the area of the collector array relative to the roof is one measure. Another is the capacity of the system relative to the building load.

#### Self-Evaluation Information List

- Statement of goals and interest
- Facility address and site plan or map
- Type of roof deck
- Contact person in school maintenance department
- Political jurisdiction (city and county)
- Roof top layout including vents and HVAC equipment
- Location of electrical lines and service
- Specifications for HVAC, water heating (pool) and electrical equipment
- Contact information for utility companies

occupied, length of academic year, summer uses).

Note that once this information is gathered, it can also be used for other project planning purposes, like building renovations.

### Step 3 – Develop a Scope for the Site Assessment

Developing a scope for a site assessment may be a very simple step, or it may be a complex step, depending on the size and type of renewable energy project. A small solar project may only need a *shading analysis* to identify an adequate site and the assessment can effectively become part of the bidding and hiring process. A large building-mounted solar project or a wind turbine will need sufficient assessment of resource, structure or soils, interconnection and building loads to be able to write a construction specification for a bidding process.

**Form a small assessment oversight group.** In the previous section, the project team identified important decision-makers and may have formed an advisory group. The assessment oversight group should include the advisory group members who are critical to building and grounds decisions. The key to the assessment or oversight group is to have people who can answer an assessor's questions promptly with the most accurate information. Most often, a senior representative from your building engineering or maintenance staff can provide the most valuable assistance since they know the facilities. Having a building facility representative on board, the more they will understand and be able to advocate for the project and problems can be addressed early on.

**Choosing an assessor.** Given the developing renewable energy industry, the site assessment services available vary by region and by the type of renewable energy resource being explored. The ideal situation is to have an independent site assessor with the training in your selected technology to recommend the best course of action without biasing your decision to a particular technology or installer.

**Independent assessor certification.** The Midwest Renewable Energy Association (MREA) trains site assessors for both wind and solar. You can find a list of their certified assessors on their website. The Minnesota Renewable Energy Society's Make Mine Solar program in the Twin Cities has qualified solar site assessment services available, particularly for solar thermal.

#### Duties of Assessment Oversight Group

- Assemble the information gathered in Step 2
- Determine the scope of the site assessment
- Determine the type(s) of assessors to hire
- Work with the assessor(s)
- Communicate the process to the larger school community
- Report progress and obstacles to the project team

#### Resources for Finding Independent Site Assessors

The Midwest Renewable Energy Association has the only regional certification for site assessors. Although there are other training programs, including Century College's Solar Program which offers a sixteen credit Solar Site Assessor certificate. Please see this chapter's Resources page to find a qualified, independent site assessor.

But sometimes an independent certified assessor is not available. A school can still have a useful assessment done by a qualified solar or wind energy installer as long as expectations are clear at the outset. Be clear that doing the assessment does not guarantee the assessor a contract to install a system and negotiate a fee for "assessment only" work.

**Devising the assessment scope.** A contract or work agreement should be prepared and executed before the work is done. That agreement should make clear the:

- Scope of the work—what kind of investigations and measurements will be done
- Format and content of the assessment report—what kind of written summary of the work will be prepared

**Measuring the renewable energy resource.** All assessments will have one component: a measurement of the renewable energy resource potential. Some technology-specific elements of a site assessment scope of work are:

- The cost—how much will you need to pay and when.
- For solar projects, a *shading analysis* should use a tool like the *Solar Pathfinder* or equivalent. For an uncomplicated site like a large, flat roof, this may seem to be unnecessary, but even relatively small obstructions like chimneys can pose significant problems for photovoltaic panels. Moreover, many solar rebate programs require such documentation.

- For wind projects, the ideal assessment includes advanced wind resource monitoring with an *anemometer* and a *data logger* over a long period of time. The key to assessing the resource is calculating an average wind speed over the year. However, the current consensus of wind energy professionals is that in areas of uncomplicated terrain (like the flatter prairie regions of southern and western MN) advance wind monitoring is time-consuming and unnecessary expense for small wind projects (less than 100 kW turbine capacity) as long as accepted siting guidelines are followed. But for larger projects, or where there are terrain complications (hilly terrain or river bluffs or tall trees or buildings), wind

### Wrapping the assessment into the installation bid

If your project team chooses to have a installer do both the site assessment and the installation, make sure:

- that having the assessment done does not commit you to the project;
- you are prepared to pay for the assessment even if you do not proceed with the project;
- the assessment price is clearly delineated;
- that you "own" the assessment report and can use it with another installer if you choose not to proceed with the installer doing the assessment.

monitoring may be necessary. Such site assessments require installing a monitoring tower and collecting up to a year's worth of data. Note that this step can be an educational endeavor in a school setting—a valuable project even if a turbine is never erected.

- The schedule—when will the report be done and what are the dependencies on that schedule (weather, waiting for information from local government).
- Who "owns" the report? In the ideal situation, the report is the client's once paid for and the school can take that information to any vendor you choose to continue project planning.

**Other types of assessment.** Larger projects and building-mounted projects may require more assessment than a resource assessment, including structural, architectural and electrical issues.

Roof Mounting Issues

Assessment of the roof structure and mounting methods are important considerations for building-mounted installations. As noted in Step 2, if the school's building management has access to the type of roof they should supply it prior to Step 3.

Once the roof type is known, mounting methods for the system will need to be considered. Solar electric and thermal systems, with their uplift component, need to be affixed to the building via bolts, threaded rod, etc. The following are three common mounting methods for roof top solar systems:

- Curbs - Common mounting method where system is anchored to blocks or beams attached to roof; roof penetrations required.
- Pedestals - Threaded rods/bolts secure the system to the roof through base plates, allowing for more effective sealing.
- Ballasted Racks - Use added weight to anchor panels to roof. The lack of roof penetrations lessens chances of leaks. Drawbacks to be considered include production impediment from snow build-up and the excess dead weight.

Other roof related issues to consider are the age and condition of the roof. Installing a system on an aged roof can be problematic. Typically if the roof is near the end of its life, replacement is recommended before moving forward with the project. This could also be incorporated into the scope of the solar installation project.

### Suitability of Different Types of Roof and Roof Sealings for Solar

- Concrete pre cast – Generally good for solar installs. Need to know the core pattern. The weight of the concrete reduces the uplift concern.
- Concrete on steel deck – Typically the best for a solar install. Pedestals can be anchored to the concrete. The weight of the concrete reduces the uplift concern.
- Steel deck on bar joist – The most difficult of the roof types as there are limited attachment points on the roof. Many factors come into play; E-W or N-S orientation, span, etc.
- Rubber or other flexible membrane – This roof system is often the easiest to install. Pedestals can be flashed with a standard pipe/plumbing vent jack. These flashings will need to be specific to the particular material for the roofing membrane.
- Pitch and Tar built up – These types of roofs can be very cumbersome for a solar installation. The costs of the penetrations and the flashings could be preclusive to the budget. If the building has this type of roof, cost for penetrations should be carefully reviewed before starting a project—this is a case where a ballasted rack mounting system might be the best choice if roof load capacity can support the weight.

Architectural Issues

There are many differing opinions about the aesthetics of solar panels. Typically a happy medium can be found in a balance between public display of the solar equipment and sensitivity to the architectural character of a building. Visibility of the system may be critical to your project goals and needs to be addressed from the architectural perspective.

An important component of many school renewable energy projects is having a public kiosk or display with real-time energy production data and renewable energy information. The project team needs to ensure that the installer designs and locates the kiosk or display to integrate within occupant traffic flows and allow for ease in visual interaction with the system. The location should be chosen based on where people are, not by the easiest location to connect to the system.

If your building has a historic designation or lies within a historic district (several types of historic designation exist), the project team or managing consultant will need to address additional regulatory considerations. The Minnesota State Historic Preservation Office offers guidance on historic designations (www.mnhs.org/shpo/). A historic building does not preclude a renewable energy project, but a historic designation will change the process and make the project more complicated.

Solar Structural Issues

Roof-mounted solar installations often require additional structural assessments. Equipment weight (referred to as dead load), "wind loading"(upward and downward forces caused by wind) and "snow loading" all need to be assessed to determine if the building is structurally sound enough to accommodate the system. Assessing these requires hiring a professional structural engineer.

Engaging a structural engineer early in the process reduces the risk of a stalled project due to unforeseen engineering issues. For smaller, uncomplicated projects, professional structural engineering services can wait for the design and permitting stages if all parties (school engineering/maintenance staff and the site assessor) believe the roof quality is good.

Large and building-mounted projects will most likely require a structural review in order to secure the needed permits. Engaging

Information needed to assess your building for Solar Thermal

- Accurate assessment of building hot water usage
- Knowledge of incoming water temperature
- Availability of space for storage tank in or adjacent to the central water heating location
- Age and efficiency of current water heating equipment. It is not recommended to incorporate solar into a dilapidated heating system
- Temperature of current water heating storage and distribution. Anti-scald or thermostatic mixing valve present?
- Location of the recirculation system tie-in
- Is there a back-flow preventer on the incoming water service or to the water heaters?

a structural engineer during the assessment phase is rarely a bad idea -- if the roof cannot handle the project, a different approach may be necessary such as a ground-mount solar project. Building structural issues can be a "game changing" factor for a project and getting the information earlier can save time and money.

Ideally, the structural engineer will have prior experience with solar projects. A qualified site assessor will be able to refer you to a qualified structural firm. Engineering firms hired by the school district in the past are also a great resource for referrals.

Solar Thermal Engineering Issues

Hot water production is usually "generated" on-site so solar thermal systems must be designed to more closely match building loads. Solar thermal systems have storage tanks to store the solar heat production until the system calls for it. Unlike solar electric systems, a solar thermal system must store any excess on site—or waste it.

Space, weight (water is heavy!) and temperature constraints, limit the amount of heat a tank can store. Once storage is full, heat collection must stop or excess heat must be dissipated. Stopping heat collection is most easily done with a drain back system, but as noted in the general system descriptions, drain back systems impose special design considerations. See sidebar for additional information needed to assess a building for solar thermal.

Wind Structural Issues

For wind projects, there is a similar balance between project scope and whether an engineer is necessary. Small projects can wait for the design phase, while larger projects may require engineering consultants in the assessment phase. In the case of wind, the pertinent issues are soil suitability for the foundation and noise or other potential nuisances. For larger projects, relevant professionals are available and a site assessor with expertise appropriate for the scale of the project will know who can be contacted for these services.

Electrical Issues

Any project generating electricity will require evaluation of the capacity and condition of the building's electric system. The building's electric system must have adequate capacity to safely carry the additional electrical energy delivered by the renewable energy installation. If the building documentation is up-to-date and readily available, it may be sufficient to provide that information to the assessor. In other cases, a electrical engineer may need to be called upon early in the project to determine feasibility.

## Step 4 – Perform the Assessment

The assessment team will hire an assessment professional based upon the project goals, renewable energy priorities and assessment scope.

With the engagement of a qualified site assessor, and the advance work of the previous step, your team can step back and let the assessor do the work. Generally, a solar site assessor can do the work in a day, unless there needs to be follow-up work related to roof structural issues or electrical infrastructure issues that require professional consultation.

Similarly, a small wind site assessment can be done in a day, but for a larger utility scale project, full site assessment may take several months, or even a year if a full twelve months of wind monitoring data is necessary.

The assessor may come back to you with questions and if your team can answer those questions accurately and quickly the results will be better. One member of the team should serve as a communications liaison—the assessor can contact that person, and if they can't answer the question, they can find someone who can. A building engineering/maintenance person might be a good choice as they can provide access to the facility when necessary.

In the event a fully-qualified assessor is not available, or when a potential installation contractor is providing the service, the school team leading the assessment may need to be more involved in the process, asking questions about how the assessment is being done.

## Step 5 – Receive the Report and Evaluate the Result

Check the results and compare it to what you know. Is there something missing or does the report suggest additional questions? Follow-up with the assessor as necessary.

The assessment and project teams should expect a written report that meets the needs of the project team and any rebate requirements. The project team should examine the report at a

### Assessing for Wind, Installing for Solar: Transfiguration School

Transfiguration School in Oakdale set an aggressive goal to reduce its carbon footprint. To help accomplish that, they engaged an engineering firm to conduct a wind energy analysis and design a wind energy system. The analysis, however, demonstrated that the wind resource at their site was poor. The school then engaged a solar installation company to conduct a shading analysis for a solar system and ultimately installed a 40-kW rooftop system.

### Site assessment as educational exercise

- Do a preliminary site assessment when developing project goals. The work may have to be verified by a site assessor or installer, but can answer initial questions.
- If the site assessor agrees, students can "follow along" with the assessor. The students can't participate directly in all steps (like climbing on roofs).

- Students can do an assessment in parallel with the paid site assessor, then compare the results.
- Present the assessment report to students and ask them to recommend next steps or decisions.

meeting with the assessor, who can present the report and answer questions.

At this point, the way forward may be clear—the assessment report makes it clear that your goals, the wind or solar resource and your site can support a project. Your project team can now proceed with detailed project planning.

In some cases, the assessment will demonstrate a minimal wind or solar resource at your school, or that substantial structural, electrical or energy load barriers cast the project into doubt. While disappointing, heeding a clear unfavorable result will prevent money and time being wasted on an unworkable project. Your school can take alternative approaches to energy sustainability and incorporating renewable energy into your school's educational goals. You can consider a smaller project, moving from a building to a ground-mount solar system or investing in an off-site renewable energy system. In every case, your school has substantial opportunities to invest in energy efficiency that not only meet many sustainability goals but come with attractive financial returns.

## 2.4 Case Studies

### Case Study: East Ridge High School

### Renewable Project type:  Wind Energy

#### Description

South Washington County School District planned to install a 1 to 2 megawatt wind turbine in 2008 or 2009 as part of construction of the new East Ridge High School. No system has been installed, although the school continues to evaluate options.

#### Project Goals

The primary goal of the district was to generate a substantial portion of the school's energy through an on-site renewable energy source, serving as both a demonstration of sustainability and a long-term cost saving measure.  Secondary goals included opportunities to use the system as an educational tool in the classroom.

#### Background

In 2003, the Energy Manager at the South Washington County School District, began looking into options for simple but effective programs to reduce energy use in the district and educate students on the subject.  School administration was also becoming more interested in renewable energy.  When the district began planning for construction of the new East Ridge High School in Woodbury, energy and facilities staff saw an opportunity to do something bigger.  Staff set about evaluating the possibility of installing a renewable energy system that would provide a significant amount of energy for the school.  They briefly considered a solar array, but the size of a system able to produce the kind of energy the school hoped for would have been prohibitively expensive, and thus looked to wind energy.  Staff worked with several engineering firms to develop plans for a 1 to 2 megawatt wind turbine on school grounds that would stand about 190 feet tall and produce enough power to provide for 30-50% of the school's energy needs.

#### Assessment Issues

While the original concept had been to incorporate the wind energy system into the construction of the school, a number of assessment issues slowed the wind project.  Utility-scale wind turbines are usually sited based on up to a year's worth of wind speed measurement at the likely tower height.  Such measurements did not fit into the schools construction time frame. The location of the turbine foundation and tower was thus selected based on the topography of the site and the proposed location of the school building and other facilities rather than a wind energy measurement.

Upon approaching the City of Woodbury with the wind energy concept, the District discovered that the City did not have zoning guidelines that would accommodate renewable energy systems.

In 2008 the City Council decided the city needed to create an alternative energy ordinance.

The school district moved forward with planning for the project. However, as awareness about the plans spread, opposition began surfacing from residents and landowners near the site. Landowners expressed concerns about negative impacts on property values, falling ice and a safe fall zone if the turbine were to be toppled in a storm. City planners began developing the alternative energy ordinance with input from the citizens. All of this was happening while construction was underway on East Ridge High School.

The project reached a point where the school had to decide whether to move forward with installation of infrastructure for the planned turbine or wait for the city's decision. Postponing that part of the overall project would have increased costs so the school chose to go forward with the installation and filed requests for city permits.

Unfortunately because there were few examples of urban wind turbines to look to, and due to the neighboring landowners' opposition, the city decided not to issue permits for a turbine at that location. There were other locations on the school property where the city indicated a turbine would be more acceptable, however by this point conduit had already been installed connecting the school to the original location. Plans for the wind turbine stalled.

### Looking Forward

At this time the school is looking into installing a significantly smaller 40 kW turbine on the original site. The tower would be much shorter and therefore would comply with the new city ordinance. District officials say that the school is pursuing possible funding opportunities for the system, but that moving forward will likely be delayed until the impacts of the current economic downturn have abated. District staff are also looking into possibly doing a small solar array somewhere in the school district which would be tied into educational opportunities.

## Case Study: Hartley Nature Center

## Renewable Project type: Solar Electric System, Geothermal

### Description

The Nature Center has five different renewable energy systems as follows:

- Grid-Connected Solar System – Two solar arrays with panels rated at 165 watts each, one stationary mounted on the roof and one tracker-pole system (RWE-Schott Solar Inc.). The roof-mounted system will produce up to 11.8 kW electrical power and the tracker-pole system which maintains maximum generation by angling correctly toward the sun will produce up to 1.3 kW electrical power. The solar system is on the grid meaning that when excessive energy is produced beyond the building's needs, it flows back into the electrical grid and the center is credited for it on their bill. The power produced is direct current (DC), and therefore it is converted to alternating current (AC) before it is used. The six "Sunny Boy" inverters convert the power to AC and track power production. On a sunny day the solar panels can produce up to 13.1 kW of electricity.

- Solar Wall – The wall is located on the south side of the building and is made of material that absorbs heat from the sun (Solar Wall Inc.). A fan on the inside creates negative air pressure and draws the solar heated boundary layer through the perforations in the system. The fresh air coming in can be heated by as much as 54 degrees F which can dramatically lower heating energy costs. The heated air then travels to the buildings air intake and into the building's standard heating, ventilation, and air conditioning system.

- Ground Source Heating Pump – A closed horizontal loop geothermal system consisting of one mile of coiled plastic tubing buried eight to ten feet below ground in front of the building. The system carries fluid in a closed system to and from the indoor heat exchange unit. The fluid is one of two types of antifreeze, propylene glycol or methyl alcohol. These heat transferring solutions are mixed with water to form a solution for specific climate and ground conditions. An Econar Energy Systems Geosource 2000 heat pump compresses the fluid to extract the heat and then a heat exchanger transfers it to a fluid flowing through more plastic coils set into the concrete floors.

### Project Goals

It was always the intent of the building development to include renewable energy projects and to incorporate curriculum related to renewable energy into their programming. The goal was to install and model alternative energy systems by harvesting electricity from the sun, utilizing energy saving lighting and fixtures, and practicing energy conservation techniques.

### Background

Hartley Nature Center is an independent, non-profit organization governed by a board of directors. They are dedicated to environmental education for all people, focusing on school-aged youth from the surrounding region. The park is about 650 acres and a 7,500 square foot "green" building provides shelter, exhibits, classrooms, and office space.

After years of planning and fund raising, the "green" building was completed in 2003 to accommodate the growth in environmental education and stewardship. They worked hard to integrate environmentally sustainable design features including the renewable energy systems, energy conservation features, and use of recycled and non-toxic materials for construction. The center serves more than more than 20,000 visitors a year, including more than 12,000 children through field trips, special events and public programs.

### Assessment Issues

The project team originally intended to install an on site wind turbine installed at Hartley Nature Center. The center's utility, Minnesota Power, worked with the project team to conduct a wind energy assessment. The utility analyzed the wind source at the Hartley site and found that because Hartley was "in a bit of a bowl" the wind resource was poor. The project team also considered placing a wind turbine at nearby off site locations that had better wind resources, but the logistics of bringing power to the center from a distant turbine proved to be overwhelming. An alternative was to evaluate the site for solar energy potential. Hartley staff arranged for a solar site assessment, and after receiving a positive site assessment for a solar electric installation they pursued that path and began the design process.

## Process

The systems were installed at the same time of building construction and details on problems, volunteers, or other installation issues were not known as the current director came after the building was complete.

## Funding and Financing

The primary source of funding for the grid-connected solar system was provided in the amount of $250,000 by Minnesota Power.

## Energy Efficiency

The stationary roof mounted system on the roof does not produce near the power that the tracker pole system offers. The power bills are most beneficial in the summer months with average monthly bills around $50 to $60 which provides about 90% efficiency. In the winter, however, bills can reach as high as $800 a month. They tried to shovel the snow off the mounted system, but learned that mounted systems are just not very productive and in the future all of the systems should be of the tracker pole type or have a least a minimum of 46 degrees angle. The tracker pole system actually exceeded their expectations.

## Educational Benefits and Student Engagement

Energy related curriculum was integrated later after executive director, Pete Gravett came on board. It was very exciting times to have a building that not only accommodated classes, but had the renewable energy systems at hand to create dynamic curriculum for children. Initially, they tried lessons for 4, 5, 6th grade levels, but left it with some frustration as the curriculum just could not be aligned with state standards for this age group. Most of the state standards related to this area of learning is in the middle school age group.

Hartley has had great success getting bussing money and donor-related scholarship money to bring students to the center and there is a lot of enthusiasm out there from the schools. However, it is becoming more and more difficult to organize field trips from the middle schools. Schools keep cutting programs and the amount of work teachers are doing a day makes it very difficult to write grants, schedule field trips, and interrupt the short 48 minute class periods to attend a half or full day outing. So Hartley wrote more

grants and received a CERTS grant to go mobile with an energy trailer. The idea was to bring an energy trailer to the schools and offer time for classes to visit and try hands-on, music-making, energy powered systems. It was quite successful and the students really liked the program. Unfortunately, the trailer was a burden to drag behind someone's personal vehicle, it was difficult to do in the winter, and most important the students did not really remember the message as they were so busy making music. Following up with lessons in the classroom was not part of the program.
There is tracking software for the system available online and this can be a very important component, but it needs to be integrated into curriculum. Right now it is there to view, but with little direction or materials to go with it, the learning is questionable.

There is a need for sustainable programs in education. A one-time shot at topics as extensive as these areas is piece meal and does not do justice to the potential for teaching students about the future of energy and renewable sources. There was a year where Hartley had a grant to work with North Shore Community School that included six follow-up programs at the school. The program "rocked" said Pete Gravett. They were able to work closely with the teachers to extend the learning and incorporate it into their activities in between visits. "Re-assessing how we provide programming by going to the schools on a regular basis and working closely with teachers to integrate concepts in their day-to-day curriculum is key."

Photo by Hartley Nature Center

Students at a local school are visited by Hartley Nature Center's mobile Alternative Energy Trailer and engaged in learning about solar technology.

## 2.5 Glossary of Terms


Photo by Windustry

**Anemometer:** A device for measuring wind speed, usually consisting of three cups on spinning arms. An example is pictured at the right.

**Data logger:** An electronic device for collecting data (from an anenometer or the output levels of a photovoltaic system) and storing it digitally for transfer to a computer for display and analysis.

**Inverter:** A device that converts direct electric current (DC) to alternating electric current (AC). In a grid-tied renewable energy system, the inverter also conditions the power for compatibility with the grid and disconnects the renewable energy system from the grid in the event of a power failure.

**Net metering:** A protocol of electric utility billing and metering that accounts for on-site renewable electricity production. The electric meter accounts for the incoming electricity from the utility, and any outflow of electricity when the renewable energy system does not meet the load. The customer is billed for the net energy consumption. In some cases, net metering allows for a credit to be paid to the customer for the net generation of excess electricity during the billing period or other time period.

**Shading Analysis:** Measurements that determine when (time of day and time of year) a particular location will be shaded by adjacent trees, structures and other obstacles. One tool for doing this analysis is a *Solar Pathfinder.*

**Soil Borings:** Samples of soil taken with a specialized drill by a geotechnical engineering firm. The samples, often called "cores", are used to determine soil properties at different depths. The soil properties are used to determine what kind of foundation (shape, size and materials) is needed for a large, heavy structure like a wind turbine.


Photo Courtesy of Solar Pathfinder

**Solar Pathfinder:** A device for determining (with one measurement) on what days of the year and at what times of the day a particular location will be shaded from the sun. It is used to determine what locations are suitable for solar electric and thermal systems, and how the panels should be mounted and oriented. The photo to the right depicts the lens that is used to determine shading measurements.

## 2.6 Resources:

**www.eia.doe.gov**
Website for kids with the basics of Renewable Energy

**www.cleanenergyresourceteams.org/technology**
Technology facts with useful Minnesota based Case Studies

**www.usgbc.org/LEED**
More information on LEED Certification

**www.PolarHusky.org**
Go North! Adventure Learning Website

SOURCING INDEPENDENT SITE ASSESSORS

**www.makeminesolar.org**
Low cost, independent assessments for solar thermal and solar air heat

**www.mreacsa.org**
List of independent certified wind and solar site assessors

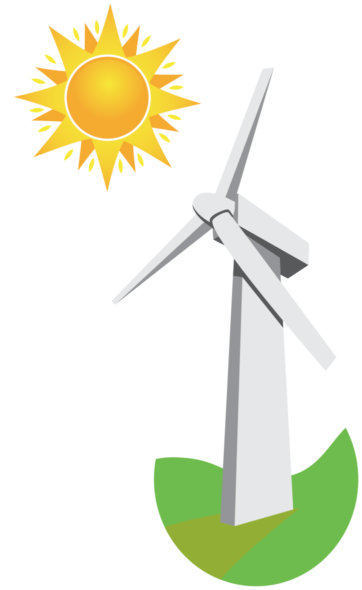
**www.rediresources.org**
Clean Energy Project builder Directory for Minnesota

**www.nabcep.org**
Certified renewable energy professionals

# Chapter 3. Curriculum Integration

**Overview:**

- Opportunities for using renewable energy in the classroom
- Curricula and educational resources on renewable energy
- Addressing Minnesota's Academic Standards



## 3.1 Summary

Renewable energy systems have a number of unique benefits that make them attractive investments for schools. Prominent among these benefits is the opportunity to use the system as a laboratory or demonstration in the classroom. Allowing students the opportunity to observe how renewable energy works, have an active part in collecting data first-hand, and using the system to meet educational goals can go a long way toward shaping their knowledge as we move towards a more energy independent future. Early exposure to solar and wind technologies may inspire young students to explore these topics in greater depth for future study. By providing a foundational education in renewable energy to all of our young students we can support them as future scientists, engineers, entrepreneurs, and members of a clean energy society. While many schools also hope for a financial benefit to housing a renewable energy system, this section will focus on the educational benefit and scope.

**Key Questions Addressed in This Chapter**

- What are some opportunities for incorporating renewable energy education at school?
- How can renewable energy education be tied into the MN Academic Standards?
- Where do I start? Easy ways to start incorporating renewable energy education?

Of the schools in Minnesota with renewable energy systems, very few schools have a formal *curriculum* that takes advantage of the system. Only a few more schools have been able to find even routine ad hoc methods of incorporating the system into the classroom once the system is installed. The value of the renewable energy system as a laboratory requires active engagement of students. A yearly re-introduction to the renewable energy systems, for both educators and students, is a necessary step to capture the educational value.

The case studies in this guide provide multiple examples of Minnesota students raising money for the installation, promoting the project in the community, assisting with installation and organizing celebrations. But the dilemma continues to be that once the system is in place little routine integration continues in the classroom.

Lessons learned from the case studies include:

- Almost every school originally had a plan to incorporate the system into curriculum or classroom, but success in this endeavor has been wanting.
- Projects underway or that were recently completed are more likely to have a curriculum element.
- Projects that were completed more than five years ago are more likely to be orphaned (from the standpoint of classroom integration), particularly when the original champion for the project is no longer there.

A working system that makes power for your school is a marvelous addition and the hands-on educational value can be incredible. The key is to make this an active learning opportunity. This will require intentional plans that include teacher training, curriculum goals and a purposeful timeline. As with any curriculum effort, someone needs to be designated as responsible for making sure the plans come to fruition, and the educational benefit of having an on-site renewable energy system reaches all staff and students as a reality.

### *Why is Curriculum Integration Important?*

A renewable energy advocate visited a Minnesota school with a strong environmental focus, multiple renewable energy systems and an elaborate and expensive monitoring station in the school's front lobby. The advocate asked passing students about the system and the monitoring, however not a single student was able to provide any information about the renewable energy at their site, or about the information that was available on the monitors. Having the system and system production data available is important, but without active learning to engage, the educational benefits are largely lost.


Photo by Bianca Rhodes, Mpls Public Schools

Students demonstrate solar curriculum activities for Mpls Associate Superintendent Mark Bonine.

## 3.2 Outline of Action Steps

Most educators recognize the educational value of having a renewable energy system on the school site. Gaining the most benefit from having a system requires a plan for overcoming logistics and application challenges, to maximize your efforts and attain your goals. The following action steps will not be able to address every eventuality nor will they apply to all situations, but they will help you focus on efforts that increase the educational value of your installation and reach a wide range of students.

### Summary of Curriculum Integration Action Steps

*Step 1 – Identify Curriculum and Classroom Goals*

What is the vision of how the renewable energy system will fit into classroom activities? Should renewable energy be a stand-alone project or class? Is the goal to have teachers use the system as a module in many subjects?

*Step 2 –Build Upon the Minnesota Academic Standards*

Numerous opportunities exist for incorporating curricula and classroom activities into the current Minnesota Academic Standards.

*Step 3 – Adapt Existing Curriculum Resources*

Consider using existing curricula, classroom plans and related resources. A number of sources provide free or low cost curriculum, classroom plans and exercises for using renewable energy to teach a wide range of skills to students. Focusing on integrating these materials is likely to be far more productive than developing curricula from scratch. Some strategies for teaching about renewable energy may be more about planning for guest lecturers, than setting up a full-blown curriculum.

*Step 4 – Include Teacher Training in Long Term Plans*

Many teachers are uncomfortable being held responsible for teaching a subject that is also quite new to them. Sustaining the renewable energy curriculum over time requires that teachers understand the topic.

*Step 5 – Consider Community Educational Opportunities*

Schools are extensions of a larger community. Renewable energy systems can provide a means to engage the community through community education programs.

## 3.3 Details of Action Steps

The steps described below cover a range of options to consider as you plan to link your renewable energy installation with the educational experience of the students, staff and community at your school site. This chapter asks you to consider your educational goals, while looking at a variety of ways to teach about solar and wind. There is no one right way to educate about renewable energy, but the one thing that proves true around the world is that renewable energy will be a part of our future. Preparing our students and communities to meet the challenge of our future energy needs is something we can plan for today.

### Step 1 – Identify Curriculum and Classroom Goals

The benefits of a quality, stand-alone renewable energy curriculum are undeniable. Clearly identified objectives, planned lessons, experiments and performance assessments have a lasting impact and are straight forward for teachers to use. However, teachers today are bombarded with expectations and responsibilities. In Minnesota and around the United States, teachers are typically provided with many quality curriculum guides, manuals and student workbooks along with expectations to use them. Teachers also have testing standards to meet, district requirements for teaching content and timelines, and other detailed tasks and objectives to be met. Teachers do not lack for material to teach, but they do lack time to prep new material and time to cover even the required curriculum content in the confines of the school day.

For this reason, teachers are sometimes reluctant to integrate any kind of new curriculum, especially if it is not on the 'required' list. Even with the best efforts, many well-designed renewable energy curriculum are not used to their fullest, frustrating both those providing it and the school administration.

Each school will have a different vision of how a renewable energy system fits into classroom activities. Some schools have very strict rules about what, when and how curriculum is taught. Other schools are very flexible about what curriculum is used as long as basic educational standards are covered and learning objectives are accomplished. Most schools fall somewhere in between these two examples.

This resource guide provides general information that can be adapted to an individual school's needs. This guide will help identify those educational opportunities and facilitate the goal-setting process.

Examples of educational goals include:

- Developing a stand-alone curriculum or class
- Creating short lessons on renewable energy that can be integrated into other lesson plans
- Building the capacity of teaching staff
- Using renewable energy education to meet the Minnesota Academic Standards *STEM* teaching goals
- Using renewable energy education as an aid to meet other educational goals

In setting goals, schools need to consider personalities, funding, and the "culture" at the school. Is a new renewable energy curriculum likely to create apprehension or resistance? One way to incorporate renewable energy learning without large financial and time commitments is to bring in guest instructors to provide supplemental curriculum. This type of learning opportunity removes the need for extra preparation by classroom teachers, and provides a great starting point to grow from. The school can plan ahead, setting aside funds in the initial budget for guest instructors to visit within the first two years of installation and into the future.

Similar benefits can be gained from an excursion to one of Minnesota's Environmental Learning Centers (ELCs)that have installed renewable energy systems and established renewable energy curriculum.

After identifying your school's curriculum and classroom goals, the project team should create an intentional plan for building on

### *Potential Pitfalls - Reliance on a Single Project Champion*

You might have one teacher at your school that spear-headed the renewable energy installation. If that teacher leaves, does the educational benefit to the school leave with them? Have a plan that eventually engages all teachers and students, so that the benefits are long-lasting and not dependent on one person.

the *Minnesota Academic Standards.* Many existing curricula will have been designed (or adapted) to meet the learning objectives of these standards. Schools may choose to create a stand-alone class or to integrate short lessons on solar and wind into curriculum throughout the year, both options utilizing the Minnesota Academic Standards.

*Math and Measurement Activities*

- Compare your school's energy use to its energy generation
- Analyze energy output and make predictions based on weather forecast
- Calculate $CO_2$ emissions saved
- Measure the effect of temperature, shading, sun angle or snow cover on solar energy output of a PV panel
- Learn about voltage, amperage, watts and kilowatt-hours
- Understand distributed energy and energy transmission

## Step 2 – Build Upon the Minnesota Academic Standards

The Minnesota Department of Education publishes information about the current Minnesota Academic Standards on their web site (http://education.state.mn.us). These state standards identify the skills and knowledge that students are taught at each grade level. This strong academic foundation helps our Minnesota students to have the literacy skills that they will need in order to graduate high school, be successful in college and for future careers.

The Standards define what all students are expected to know and be able to do, not how teachers should teach. Districts and schools adopt curricula that help educators teach these skills. A renewable energy installation at your school can easily be used to enhance instruction on many of these Standards.

A few examples of integrating renewable energy activities with Minnesota's Academic Standards are provided below. These examples address mathematics, science and energy standards. A broader set of examples are provided in the Appendix at the end of this chapter.

**Renewable Energy and Mathematics.** All students can and should be mathematically proficient, and even students who might otherwise struggle with more challenging mathematical concepts will do better with a real-world application to apply learning and understanding.

Real world forums that offer opportunity for scientific exploration and analysis are a perfect opportunity to embed math and science into something meaningful and fun.

The following table illustrates an example of incorporating an Academic Standards for Mathematics into renewable energy learning.

| *Mathematics Benchmark* | *Activity* |
|---|---|
| Calculating area | Example: The school's renewable energy system takes up space on the grounds or the roof of your school. Calculate the area this system occupies. Consider the utility bill and kilowatt-hour use at your site. How much space would an RE system that produces 100% of the kWhs used at your school need? |

**Renewable Energy and Science Topics.** School districts have a lengthy and detailed list of tasks and objectives for specific science topics, providing a list of benchmark activities that align with these make it possible for the teacher to accomplish required teaching goals and at the same time integrate those engaging and important renewable energy activities. The science benchmarks include STRAND benchmarks 1 through 4.

Many of the standards are repeated across multiple grades, and the activity suggestions can be expanded to meet the needs of students of all abilities. The activities are meant to be very broad, providing a starting point for easily integrating discussions into a variety of activities. The key is to start somewhere; make it a goal to integrate this crucial aspect of learning into the classroom each day. The table on the following page details a couple of examples of incorporating renewable energy into learning objectives for the Academic Standards for Science.

| *Science Benchmark* | *Activity* |
|---|---|
| Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations. | Example: Students visit the school solar array and note the weather conditions. Discuss the basics of how the photovoltaic effect works when sunlight hits the cells, and describe how heat tends to reduce amperage output, while cold increases voltage output. Generate questions related to the current conditions and test your hypothesis with actual readings from the solar inverter. |
| Trace the changes of energy forms, including thermal, electrical, chemical, mechanical or others as energy is used in devices. | Example: Use the school's solar thermal system to teach about energy changing forms as it goes from sunlight to the collector, to the fluid in the collector, to the heat exchanger, to the water, to the end user. |

*Energy-Related Lab Equipment*

The United States Department of Energy (DOE) provides opportunities for schools to acquire used energy-related laboratory equipment for use in energy research and educational activities. The DOE also offers resources for K-12 lesson plans on energy and technical assistance with science fairs.

*Source: Energy-related lab equipment program (www.energy.gov/index.htm)*

**Energy Fuels and Our Future.** Our society has grown increasingly dependent on energy as our society becomes more technologically advanced. Global political relationships often hinge on energy resources. Cultural norms are shaped by energy choices. Students must understand that each of our energy choices, including energy production and energy consumption, have consequences. Students need to understand where energy comes from, what happens when different energy resources are used, and what environmental consequences result from production and consumption choices. This broad topic can engage students in conversation (and perhaps debate) across subject areas including many science and social studies topics.

**Monitoring Systems.** Many of the above suggestions for integrating renewable energy into the classroom are dependent on have a monitoring or data tracking systems installed along with the renewable energy system. Planning for some type of monitoring system is often a critical part of the project. Monitoring systems are easily added to the output information on your solar or wind energy system. Some data collection is more advanced and more costly than others. Even a very basic lobby display will show the current output of your system in volts, amps, watts and some kind of historical display of your system's production over time. Knowledge is powerful; bringing accessible information about energy production to an easily accessed public space will go a long way toward engaging students and adults in conversation about renewable energy. The person who maintains computer and internet functions at your school should be involved in the conversation with the solar or wind installer to help decide what system and software will work best at your site. Even a simple flat screen monitor mounted in the lobby, with no interactivity, can provide excellent information. Some renewable energy installations can be equipped with more detailed input like temperature, solar *insolation* data and wind speed at the installation site. Since all of these variables can affect the output of your system, science and math classes may find this additional information helpful. Most systems are designed to be able to put a link to energy production information on your school's web site.

The key to having an active learning community involved in your renewable energy installation is to have a plan and a core person or group responsible for the educational mission. Perhaps your administrator will be responsible for continuing this learning. Or a student group, classroom, or a local community member who is passionate about renewable energy could be trained to take responsibility for continued outreach and school involvement in your renewable energy education goals. It is an easy ball to carry and pass on, but somebody needs to take on the role and help students get the educational benefit of having an on-site renewable energy system.

### Step 3 – Adapt Existing Curriculum Resources

Enthusiastic educators, renewable energy installers and school administrators often focus on developing in-depth and comprehensive curriculum to support renewable energy topics being explored at their site. Many curriculum resources have already been developed for grades K-12 and are publicly available, both free and for a nominal fee. Some of these lesson plans focus on a particular renewable energy topic, others focus on energy conservation and how it relates to renewable energy, and still others have a specific subject area focus, such as a science topic.

Teachers and administrators are already asked to meet a host of goals, requirements and certifications; few have time or energy to add another element to an already crowded curriculum. Fortunately, a number of organizations and schools have already created curricula for teaching about renewable energy or using the topic of renewable energy as a vehicle for meeting educational goals. Existing curricula, classroom plans and other educational resources are used nationwide and some organizations have Minnesota-specific materials for use by Minnesota schools.

Some sample curriculum lesson plans developed for renewable energy are described in the appendix at the end of this chapter. As with any curriculum topic, when adapting model curricula for introducing energy and renewable energy ideas to their students, teachers need to consider best practices and their own school's educational goals and mission.

Minnesota's Environmental Learning Centers (ELCs) are another place for educators to look for educational resources and individuals trained in presenting about renewable energy. Six Residential ELCs have recently been awarded an Environment & Natural Resources Trust Fund grant through the Minnesota Legacy Amendment to reduce their carbon footprints while disseminating energy education that focuses on renewable energy, energy efficiency and conservation options. Much of the grant will fund upgrades or installation of new renewable energy systems

*Examples of Existing Curriculum*

- U.S. Energy Information Administration
- Will Steger Foundation
- Department of Energy
- Center for Energy and Environment
- Facing the Future
- National Energy Education Development Project
- Wisconsin K-12 Energy Education Program (KEEP)
- Science Museum of Minnesota
- CREED Project

(See Resources section for more information)

as well as developing curriculum to support educational goals. Other ELCs have also integrated renewable energy systems into their programming for students and the public. Investigate these excellent resources as a means of jump-starting your school's education efforts.

**Students Engaging Students.** Another suggestion for involving the school in learning about your new renewable energy system is to include short but regular updates embedded in regular school communication. Maybe there is a group or club that does some kind of 'green' effort like recycling or conservation that could be in charge of coming up with a question of the week or a 15 minute activity of the month to be promoted in a school newspaper? Maybe you have a school video broadcast and instead of a weather forecaster, you could have a solar reporter, telling how much energy your solar is producing at the current time, what it generated yesterday and other interesting facts. Students become more actively engaged in learning when educational opportunities are hands-on, like the MRES Solar Boat Regatta. MRES' Solar Boat Regatta provides an opportunity for middle and high school students to build a boat that runs on solar power and test their designs by competing with other students.

Photo by Doug Shoemaker, MRES

City Academy, one of the winning teams in the 2011 Solar Boat Regatta, display their solar handiwork.

### Step 4 – Include Teacher Training in Long Term Plans

Any new technology will be new to both students and adults alike. Incorporating the topic of renewable energy into existing classroom practices, and understanding how to use the school's renewable energy system as a teaching tool, can be a daunting task for many teachers. In order for teachers to be able to teach creatively and successfully impart knowledge they must have opportunities for becoming grounded in the topic they are being asked to teach. Planning and budgeting for teacher training may be a critical component of incorporating renewable energy into the classroom. Teacher training can be scheduled for school workshop days, funding could be allocated to provide for substitute teachers for during-school planning or to allow for continuing education outside of the regular school day.

An alternative to teacher training is using outside renewable energy educators and experts to lead workshops, assemblies or field trips. As noted previously Minnesota's ELCs have invested in renewable energy education, as have some renewable energy advocacy organizations. These efforts also provide students and teachers with the chance to learn from experts. Schools can plan to bring off-site classroom learning opportunities back to the school in the future.

Staff development time and funds should be allocated to allow teachers to increase their knowledge and skills. A well-trained teacher using quality curriculum that meets local academic goals and standards is an educational asset for students.

### Step 5 – Consider Community Educational Opportunities

Children and young students are not the only people wanting to learn about renewable energies. Families, adults, long-time community members – many people have an interest in the energy that will power our future. In addition to classroom curriculum,

*Potential Pitfalls - Remember that Curriculum doesn't teach itself*

Be careful of putting the cart before the horse. If you plan to have in-depth instruction for the students via a curriculum or stand-alone class, be sure you have budgeted for or otherwise provided ample opportunity for the teacher to be trained in that curriculum. The NEED and Wal-Mart foundations recently awarded complete renewable energy systems to over 20 school systems across the nation (including Minneapolis). The package included not only systems and curricula, but funded training for teachers so the curricula can be used. Moreover, remember that training might need to be offered routinely in order to sustain the educational value of the system over time.

your school might be able to offer educational services to the community at large. Educators for these efforts do not have to be teachers, but could include advocates, professionals, trades people and even students, such as the Eden Valley Watkins students have done (see Chapter 4 Case Study). The installer who worked with your school to put in the system could also be asked to present to the community, perhaps linked with an annual maintenance check.

A small group of students who learn details about the system is a great springboard for a community outreach effort to engage the general public. Just like a large telescope or observatory can get the community involved in looking to the stars, a local renewable energy system, especially one with monitoring easily accessible, should be considered a local resource for educational outreach.

Engaging the community in renewable energy education will help emphasize the value of your school's system. Community education efforts will also create a sense of ownership - give your school and project team credit for their accomplishments.

Many communities have knowledgeable renewable energy advocates who can present introductory classes in the evening or after school. Renewable energy organizations have people willing to come to your community to introduce students and adults to renewable energy. Your school's renewable energy system could also be on the Minnesota Solar Tour which is held every October. This is an excellent opportunity to give your community a chance to see your system up close and learn more about it.


Photo by Doug Shoemaker, MRES

Experiential learning activities like this solar water pump give students opportunities to see how sunlight hits photovoltaic cells and produces electricity, and how shading the cells affects the pump.

*MN Residential Environmental Learning Centers:*

Minnesota's Residential Environmental Learning Centers (RELCs) are a great resource for incorporating curriculum and educational experiences relating to renewable energy, without having to spend large amounts of time and money in curriculum development and training.

The RELCs are accredited through the North Central Association of Colleges and Schools as "Supplementary Schools." This accreditation ensures that learning occurring at the RELC's adheres to MN educational standards and is worthy of counting as student contact hours. In addition to programs offered at the RELC locations, some of the RELCs have outreach classes, bringing the learning right to your school location.

The six RELCs are listed below along with a sample of some of the renewable energy classes offered. More classes are currently being developed.

- Audubon Center of the North Woods, Sandstone*
- Deep Portage Conservation Reserve, Hackensack
- Eagle Bluff Environmental Learning Center, Lanesboro*
- Laurentian Environmental Center, Virginia †
- Long Lake Conservation Center, Palisade *
- Wolf Ridge Environmental Learning Center, Finland †

* Outreach programs available
† Curriculum downloads available

## 3.4 Anecdotes/Case Studies

### Case Study: Rochester School District: Mayo, Century, John Marshall, Lourdes High School

### Renewable Project type: Solar Electric System

#### Description

In 2009 a 5.88 kW solar array was installed on the roof of Rochester's Mayo High School. In 2010 a 6.1 kW array was installed on Century High School and a 5.88 kW array was installed on John Marshall High School.

#### Project Goals

The initial project goal was to install solar panels on Mayo High School to demonstrate how renewable energy systems can reduce energy use and to educate students about renewable energy. This goal was expanded to all of the Rochester high schools. The student founders of this initiative created a non-profit group called the MN Student Energy Project (MNSEP). Their goal has expanded to ultimately partner with schools all over the State of Minnesota to install as many solar panels as possible and to incorporate renewable energy education into these schools.

#### Background

The project started when one of the student founders approached the Mayo High School Principal and said he wanted to try to get solar panels installed on the school. The Principal gave the go ahead and a group of students quickly began fundraising efforts for the purchase and installation of a solar photovoltaic (PV) system. As the fundraising efforts met with success, the student group began to entertain the idea of putting solar panels not only on Mayo High School, but on all of Rochester's high schools, including the not yet constructed Lourdes High School.

#### Funding and Financing

The funds came from a number of sources, including: businesses and community organizations; a Clean Energy Resource Team (CERTs) grant, funding from the four participating schools, the American Public Power Association ($75,000) and other fundraising events. The student group was able to raise $140,000 in six months for the initial Mayo project. The group continues to use similar methods to raise funds for additional school projects. The MNSEP web site now has a page where visitors can donate online.

## Student Engagement

The project was started by students and continues to be run primarily by students. MNSEP has a board of directors with four students and three community members. Primary leadership is provided by the students. The three students who initially started the program have since graduated and gone on to college and a new group of student have stepped in to lead the program.

In recognition of its outstanding work, MNSEP was awarded the 2010 Simms Award for Outstanding Youth in Philanthropy by the National Association of Fundraising Professionals.

*MNSEP Organizational Goals*

"A simple combination of two words, education and carbon, EduCarbon is a combination in which our mission is fully represented. Its education component represents the importance of educating high school students about the vast rewards of utilizing sources of renewable energy. . . It is the education half of our mission that so greatly increases the value of the solar panels that we help schools install. While cutting the carbon footprint of the school and saving the school money in terms of utilities costs, they shine every day on the school's roof, representative of a school containing a future generation of people informed and proactive in regard to a cleaner state, country, and world."

*Source: www.MNSEP.org*

## Educational Benefits of System

School staff, administration, students and the Department of Energy are now working together to develop curriculum to implement into the classrooms. The plan is to have wide ranging curriculum dealing with science and renewable energy, climate change, economics and policy behind energy reform and to incorporate these elements into multiple subjects (math, political science, business, economics, English and others). Production data from the four solar installations will be available on the web for use within the curriculum and student science projects.

The Rochester School District has invested a lot of effort into planning, funding and installing these four renewable energy systems. However, they still have much work to do to reach their final goal of developing and incorporating the curriculum described above. Planning for and funding curriculum integration in the early part of the project will increase the likelihood of achieving curriculum goals.

## Looking Forward

MNSEP is currently exploring opportunities for partnerships with other school districts and hopes to have 25 partnerships in place by 2012. MNSEP is also working with Minnesota's state government and local Congress members to try to get legislation passed to support its mission.

Photo by Able Energy Co.

Solar electric system on Century High School in Rochester.

## Case Study: North Shore Community School

## Renewable Project type:  Solar Electric System

### Description

The renewable energy system, a 16 panel, 2.67 kW solar PV array, was installed on the wall of the school gymnasium near the entrance to the North Shore Community School (NSCS).

### Project Goals

The primary goal was to use the installation and associated curriculum to address a new sixth grade science curriculum standard.  Once the curriculum was created at NSCS the intent was to share the curriculum with other area schools through a partnership with the Northeast Clean Energy Resource Teams (CERTs).

### Background

An important part of the project was developing and using a sixth grade science curriculum and a curriculum for an elective sixth grade class on energy.  The curriculum was also posted on the NSCS website to be shared with other area schools.  As part of the program students also participated in other learning opportunities such as an energy tour of the school, a school energy audit and educational programs at the Hartley Nature Center in Duluth.  The environmental education staff person applied for additional grants in 2007 for the purpose of expanding the program to include wind energy generation and additional curriculum materials.

### Curriculum

Creating and using a curriculum does not, however, institutionalize it.  In 2008 the environmental educator who had championed and led the project left NSCS for another career opportunity.   Without a champion, the project lost momentum and after additional staff changes the curriculum was discontinued.  Eventually the environmental educator position was filled with a new part time environmental educator who looked to pick up the energy curriculum.  Unfortunately, the new coordinator has been unable to locate the energy curriculum materials.  The original program worked while the original champion administered it, but training a replacement in the event of staff turnover takes additional resources and planning.

The school's Director, Susan Rose, noted that transforming curriculum is difficult to do one school or one classroom at a time. "Each educator has their own passion," noted Ms. Rose. "One educator will have a passion for solar, another will have a passion for water conservation. Carrying innovation forward through staff changes is extremely difficult. "

## Funding and Financing

The NSCS curriculum coordinator applied to, and was awarded, a $9,900 grant from the Environmental Protection Agency (EPA). Additional grants and financial support, totaling about $24,000, were provided by the Minnesota Department of Commerce, Minnesota Power, Great River Energy and Conservation Technologies. Northeast CERTs provided additional assistance throughout the project including assistance with curriculum development.

## Looking Forward

The NSCS environmental educator is currently working on a variety of environmental initiatives for the classroom, including restarting the solar education program and restarting use of a school greenhouse. The knowledge, materials and capacity lost through staff turnover are significant barriers. The environmental educator would like to restart the solar education program as well, but time is limited and the barriers to reconstructing a curriculum are again high.


Photo by CERTs

## 3.5 Glossary of Terms:

**Curriculum:** This term refers to the means a teacher uses to impart learning to students. It is often a series of lessons on a particular topic. Curriculum is designed to teach particular skills or information to students of a certain age.

**Insolation:** The amount of sunlight hitting a horizontal surface. A measure of solar radiation energy received on a given surface area in a given time. It is commonly expressed as average irradiance in watts per square meter.

**Integration:** This term refers to putting the skills students are learning into a variety of contexts. Curriculum integration helps students learn and remember, because they have opportunities to put their skills to use in a practical application.

**Minnesota Academic Standards:** State standards that identify the skills and knowledge that students are taught at each grade level.

**STEM:** An acronym for Science Technology Engineering and Mathematics.

## 3.6 Resources

<u>Renewable Energy Curriculum Resources</u>

**www.solarenergy.org/solar-schools**

Information about how solar works, geared towards students and teachers. Extensive list of resources including downloadable curriculum for wide range of grade levels, as well as teacher trainings, lists of resources and answers organized for younger and older kids. At this writing they also have a free high school level online course "Introduction to Renewable Energy."

**www.need.org**

National Energy Education Development Project - downloadable curriculum on a large variety of topics; NEED Curriculum Correlations to the National Science Education Standards for all grade levels, for all states. Science fair project ideas for students.

**www.kilowattours.org**

A documentary film about energy efficiency, including curriculum.

**www.willstegerfoundation.org**

Will Steger Foundation - Climate Change curriculum, downloadable lesson plans and expedition supplements. Summer Learning Institutes for teachers, and Adventure Learning for students to follow the expeditions.

**www.energy.gov/index.htm**

Department of Energy - Search for "students" and you will find contests & competitions, energy glossaries, scholarships & internships. Search for "teachers" and your list will include student science programs, teacher training courses, support for schools, and resources.

**www.mncee.org**

Center for Energy and Environment - Home of the Minnesota Energy Challenge! Join the challenge, find actions, create a team.

**www.facingthefuture.org**

Facing the Future - Curriculum materials (free and for purchase) in all subject areas; includes simulation, differentiated instruction, and alignment with state standards. Searchable by grade and topic area.

**www.eia.doe.gov/kids/energy.cfm?page=6**

U.S. Energy Information Administration - Lesson plans, teacher's guides, field trip reports, career corner

**www.uwsp.edu/cnr/wcee/keep/ProfessionalDevelopment/index.htm**

Wisconsin K-12 Energy Education Program

**www.smm.org**

Science Museum of Minnesota

Renewable Energy Resources
**www.cleanenergyresourceteams.org**
Clean Energy Resource Teams

**www.seek.state.mn.us**
SEEK - Partnership of environmental educators in Minnesota, sharing resources and events, press releases, employment opportunities

**www.mnsolartour.org**
A free, public self-guided tour of renewable energy systems across the state

Carbon Emissions Calculators
**www.cleanerandgreener.org/resources.html**
**www.infinitepower.org/calculators.htm**
**www.carbonfootprint.com**

Minnesota Environmental Learning Centers (ELCs)
**www.audubon-center.org**
Audubon - Sandstone, MN. Programming in natural history and science, team-building, adventure programming and outdoor/environmental education.

**www.deep-portage.org**
Deep Portage - Hackensack, MN. Hands-on natural resource education experiences. School visits, summer camp, adult & family programs.

**www.eagle-bluff.org**
Eagle Bluff - Lanesboro, MN. Eagle Bluff is dedicated to fostering environmental awareness and promoting respect and personal responsibility. Experiential classes in an outdoor setting.

**www.moundsviewschools.org/laurentian**
Laurentian - Britt, MN. Public residential educational facility that combines science, environmental education, leadership training, and outdoor skills recreation programs. Elementary, Middle, and Secondary School programs, free downloadable wind energy curriculum.

**www.llcc.org**
Long Lake - Palisade, MN. Overnight field trips, day trips, classes, activities and a mobile classroom program.

**www.wolf-ridge.org**
Wolf Ridge - Finland, MN. Overnight and day trip options are available. Curricula in biological, environmental, and earth sciences, cultural history, personal growth & team-buildling, outdoor recreations skills, aligned with Minnesota Graduation Standards.

**www.creedproject.org/index.html**
CREED Project

## 3.7 Appendix: Additional Curriculum Examples

**Reading and Writing Benchmarks: Informational Text and Foundational Skills**

Your school media specialist or the librarian at your public library can help locate appropriate books for your students on renewable energy topics. Students can read non-fiction texts at a variety of levels that teach about scientists and the manufacturing processes for solar and wind materials, science topics such as how solar works or why the wind blows, or short stories about other students engaged in solar and wind projects. There are examples from around the world of people, young and old, working to bring electricity to their part of the world by making use of natural resources like solar and wind. "The Boy Who Harnessed the Wind," by William Kamkwamba, is an inspiring example.

Many students are likely doing some kind of journal writing or brainstorming in class. Consider including an invitation in the morning announcements from the teacher or principal to write about a renewable energy related topic:

- "How would the world be different if all of our energy came from solar power instead of from burning coal and other fossil fuels?"
- "Solar power needs to be in the sun to work well. Describe a sunny spot near where you live, and tell why it might be a good spot for a solar energy system."
- Write a letter to a class, telling them something about their renewable energy system and asking them a question that would inspire them to answer. Have the students write a letter back to you in response and get a solar dialogue going via letter writing, since this is an important curriculum element as well.

Additional writing activities include:

- Journal entries detailing the installation process from the student's perspective, including sketches of what they see, explanations that they've been given, questions that they still have and thoughts about the end product.
- Article for the local newspaper, or Letter to the editor
- Report on how a renewable energy technology works.
- Read, discuss and summarize current news reports on renewable energy topics.
- Research the history of solar/wind/geothermal energy production.

Your youngest students might write a simple journal entry using descriptive language to tell about observing the solar or wind installation on a particular day, illustrating the journal entry. Writing for older students might include media technologies as they design, tape, digitally edit, and broadcast a public service message for a local cable channel, summarizing the benefits of renewable energy and/or conservation efforts at their school.

In these lessons, students will be exposed to writing a variety of text types, for a variety of purposes. In doing so they will follow the writing process in the production and distribution of the writing. Their writing will be based somewhat on their own personal information-gathering, and can be supplemented by research to build on their present knowledge, whether by reading informational books, or by interviewing people such as the solar installation team, a wind manufacturer, their principal, or even the school board about how the project came to be. Students could even engage in a multimedia presentation to report on the project, summarizing points, sharing an opinion or hypothesis, sequencing ideas and details, and adapting a presentation to a variety of contexts. Invariably, students will also be exposed to new vocabulary with real world connections.

**Renewable Energy and Mathematics**

The following chart shows a sampling of benchmarks in mathematics, taken from the Minnesota K-12 Academic Standards in Mathematics (2007) (http://education.state.mn.us). The Example Activities described in the following table show how easily a renewable energy topic can be integrated into these skills already being taught in the classroom.

| *Mathematics Benchmark* | *Activity* |
| --- | --- |
| Solve problems in various contexts involving conversion of weights, capacities, geometric measurements and times within measurement systems using appropriate units. | Example: Check the data sheet for the solar modules installed at your school. Many internationally sold products are described using the metric system for measurement and temperature coefficient. Use this real world scenario to give students practice with unit conversion. |
| Demonstrate fluency with multiplication and division facts. | Example: Solar installers use ballpark estimates on size of the space and size needed for the solar energy system. Measure one solar module and round to the nearest foot. Calculate how many modules would fit, laying flat, in a given space like the classroom, football field, the roof on the gym. |
| Tell time to the minute, using digital and analog clocks. Determine elapsed time to the minute. | Example: Data collection reports for your solar or wind system need to be compiled based on time of day. Use a digital or analog watch to collect power output and temperature data over a period of time. Average the data and aggregate over future time. |

**Renewable Energy and Science Topics**

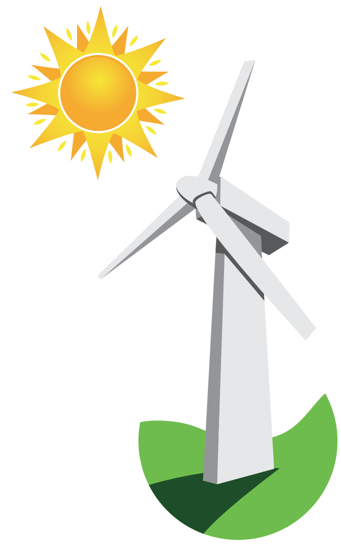
Here are some of the benchmarks from the Minnesota K-12 Academic Standards in Science (2009) (http://education.state.mn.us) that address the topic of energy resources and fossil fuels. The Example Activities included here show how a renewable energy topic could be integrated with these Science Benchmarks.

| *Science Benchmark* | *Activity* |
| --- | --- |
| Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed. | Example: Create a daily log from the inverter readings (either current reading at same time each day, or daily total reading at same time each day). Include weather conditions in the log, as well as student notes about the energy production. |
| Construct reasonable explanations based on evidence collected from observations or experiments. | Example: Record monthly energy output totals from your solar or wind inverter. Students will summarize these energy outputs providing explanation for the production as it compares to this system's norm. |
| Recognize that the practice of science and/or engineering involves many different kinds of work and engages men and women of all ages and backgrounds. | Example: Interview an administrator, renewable energy system installer, or building operations personnel about the process for installing the renewable energy system. Outline the various professionals required in each step of the process. |
| Use appropriate tools and techniques in gathering, analyzing and interpreting data. | Example: Students will use a scientific journal and a standard format for collecting daily data about their school's energy production. Engaging in classroom discussion about their notes and interpretations will allow students to gain additional skills. |

# Chapter 4. Financing and Funding Alternatives

**Overview:**

- Ideas for financing and funding renewable energy systems
- Creating a project budget
- Engaging financial stakeholders



## 4.1 Summary

This section reviews the history of funding and financing of school renewable energy projects in Minnesota and examines funding sources, financing techniques and programs that schools might be able to use in the future. Issues covered in this section include typical funding sources, possibility of using traditional financing tools, explanation of specialized renewable energy financing tools and community-based funding techniques.

Over 30 schools in and near Minnesota over the last 20 years have installed renewable energy systems (wind or solar energy) that provide power or heat for school operations. These schools used a variety of funding tools to complete their renewable energy installations. Including:

- ✓ Energy utility grants
- ✓ State grants
- ✓ Local fundraising events
- ✓ Donated labor
- ✓ Funding from general budgets
- ✓ Foundation grants
- ✓ Federal grants
- ✓ Business donations
- ✓ Student labor
- ✓ Third-party financing

**Key Questions Addressed in This Chapter**

- What are the elements that affect our project budget?
- How is funding linked with project and educational goals?
- What are potential funding options?

The most common means of funding school renewable energy projects in the past was through grants, donations and local fund-raising events. However, other methods and sources of funds can be used to fund school renewable energy projects if the circumstances warrant. Each school will need to conduct an assessment of funding options and have an understanding of why funding methods might or might not be appropriate. Choosing among funding options will depend upon the project goals, the resources that are available and the renewable energy system characteristics. This section of the Step-by-Step Guide provides a framework for assessing the different methods of funding projects and relating those methods to project goals and local circumstances.

**System Size.** Of all the characteristics that shape which funding options are most appropriate, the intended size of the renewable energy system is the characteristic that makes the most difference in regard to funding. Small-scale projects can be "bootstrap" funded using a variety of ad hoc sources that are likely to be available to most schools. Large-scale projects will almost certainly need to consider some form of financing in order to proceed, an option also available to most projects, but usually requiring engagement of and sign-off by many more stakeholders. Because of economies of scale, larger scale projects are more likely to show reasonable financial returns than small projects and are thus more likely to be able to use financing tools where energy production can pay for financing costs.

**Project Goals.** System size also bears a close relationship to project goals. The model historically used by most schools focuses on community-based demonstration projects. Demonstration projects will have only a very small impact on the schools energy costs or carbon footprint, but have great value in regard to community-engagement, promoting renewable energy locally and providing opportunities to incorporate energy technology into curriculum. If the project goals are primarily educational, small systems provide more opportunities for student and community engagement. Using a variety of community-based funding sources creates more local stakeholders, and provides more opportunities for actively engaging students. The fundraising process can itself become an educational opportunity.

In contrast, large-scale projects meet goals associated with long-term financial benefits, significant reductions in GHG emissions or moving the school toward a renewable energy standard or a net zero-energy standard. Larger-scale projects are likely to require more financing tools and more sophisticated financial analysis.

**Renewable Energy Technology.** The choice to use solar or wind energy technologies will also have an effect on funding options, although the distinction is more closely linked to project size. Wind systems are more difficult to scale down in size, and therefore more likely to be higher cost (and to see better financial returns). Solar energy is more scalable, and therefore easier to fund smaller projects.

## 4.2 Outline of Action Steps

As noted in Section 4.1, the appropriate funding and financing actions steps depend upon other decisions previously made in the renewable energy project. The project goals and the intended system size will greatly shape the school's funding and financing choices. The project team should properly sequence the funding and financing action steps, since these will affect every part of the project, including the size, scope and timeline.

### *Summary of Financing and Funding Action Steps*

*Step 1 – Identify Funding and Financing Resources*
Identifying resources includes an inventory of potential sources of cash funding, which may include utility rebates, grants, local foundations and community contributions. Financing mechanisms, such as loans, bonding and *Power Purchase Agreements (PPAs)* are additional funding resources to be identified.

*Step 2 - Create a Draft Project Budget*
A project budget should include the approximate installed costs of preferred renewable energy technology, monitoring or data gathering equipment, costs for incorporating the project into the classroom (curriculum) and cost contingencies for uncertainties such as structural review of the host building.

*Step 3 - Engage Financial Stakeholders*
All funding and financing options require engaging people outside the project team. Others that may need engaging include decision-makers at the school or school board, financing professionals at the school district, the energy utility, local businesses, banks, foundations or third-party financing entities.

*Step 4 – Complete Financing Process*
For projects that use financing, completing the financing process before moving on to other steps will limit uncertainty and ultimately help keep costs down and expectations in check. Financing can be a complicated and time-consuming process, whether the financing choice is loans, *power purchase agreements*, basic bonding or using a more esoteric renewable energy bonding tool.

*Step 5 – Engage the Community*
Schools are extensions of a larger community. Schools have political, social and financial ties to a much larger group of people than those who work at or attend the school. Recognizing barriers and opportunities is critical to funding the project.

*Step 6 – Integrate Funding into Bidding*
Funding and financing choices affect the way that the school selects and manages contractors for the project. Third-party financing or use of volunteer labor or contributed services and materials must be clearly identified in bidding the project out or contracting with a renewable energy installer.

## 4.3 Details of Action Steps

The steps in addressing funding and financing of the school's renewable energy project require that some non-funding decisions be made. For instance, assessing of funding and financing options should be undertaken after identifying the school's project goals (Chapter 1) and renewable energy resources (Chapter 2). Some of the considerations that will affect funding and financing choices include:

- Large-scale renewable energy projects of any type will have more attractive financial returns than small-scale projects, but also require access to much more capital, more involvement from the school district board and consideration of more complex financing tools.
- Solar energy projects are more scalable than wind energy projects, allowing the school to increase or decrease the capacity of the system depending on financial resources.
- Wind energy projects provide a better return on investment than solar projects, provided the site has adequate resource and funding or financing options are sufficient for the project.

### Step 1 – Identify Funding and Financing Resources

The first step in funding a renewable energy project is to assess the potential options for paying for the project. A wide range of options is available to all schools, but the size and complexity of the options is also very wide. To simplify the decision-making process, schools can think of options in two basic categories: sources of cash and sources of financing.

**Cash funding.** This funding category includes all forms of funding that do not have to be repaid. Cash funding includes:

- ✓ School budget allocation
- ✓ Energy utility grants and rebates
- ✓ State or Federal grants
- ✓ Foundation grants
- ✓ Fundraising
- ✓ Community/business contributions
- ✓ Volunteer labor
- ✓ Donated materials or services

✓ **School Budget** – The individual school or the school district can provide funds out of cash flow, provided the project is consistent with the intent of the budget allocation. Renewable energy projects that are primarily intended as educational tools or to provide a laboratory for a component of the curriculum are no different from other expenses that meet the educational mission of the school.

✓ **Grants**– Most schools have some form of grant dollars that they can use to leverage other funds for renewable energy projects. Energy utility grants are the most common form of grants. Most of the large investor-owned utilities, such as Xcel Energy and Minnesota Power, offered renewable energy grants in 2011, although grants in the future may be largely replaced with the rebate program (more information later in this section). Some municipal utilities have also provided grants, including Rochester, Owatonna and Austin. The most common utility grant programs are for small solar systems and are not specific to schools. Some utilities have helped fund school renewable energy systems, including wind energy, on a project-specific basis.

The State of Minnesota has offered grant programs for renewable energy installations, including some programs directed at schools. The sources of these funds are limited and most of the grant programs have expired. As of the publication of this document, some small amounts of funding are still available. Check with the Minnesota Division of Energy Resources (Department of Commerce) for more information.

✓ **Federal Tax Credits** - Some incentives such as *Federal tax credits* for renewable energy are rarely used for school projects, as schools are not directly eligible for tax credits (since most schools do not pay Federal taxes). *Third-party financing* does allow a for-profit third party to capture and indirectly pass on to the school the benefits of the tax credits and similar incentives, for which at least one example can be found in Minnesota (see case studies).

**Grants: Proctor High School**

Proctor High School installed a 20-kW wind turbine in 2006. The school obtained grants from Minnesota Power ($20,000), Proctor Public Utilities ($2,800), and Braitmayer Foundation of Marion, Massachusetts ($10,000). The school financed the remaining amount through a loan obtained from a local bank. Grant research and applications were provided by school district staff and University of Minnesota Duluth students.

***Potential Pitfalls***

Approaching school administrations to ask for renewable energy project funding can create problems in an era of school budget shortfalls. Direct school funding has typically only been used after demonstrating that the school funding is leveraging substantially greater dollars from outside the budget.

✓ **Utility Rebates** – Many electric utilities offer some form of rebates or grants for customer renewable energy systems. The Solar*Rewards program run by Xcel is the most significant of these, although many other utilities also administer rebate programs. Even if the utility does not have a rebate program, some utilities (including municipal utilities) have worked with community institutions such as schools to fund energy demonstration projects.

✓ **Foundations and Organizations** – Schools have received funding from local, state and national foundations and from community organizations for renewable energy projects. Local community foundations and organizations supported school renewable energy projects in Willmar, Rochester and Cuyuna Range. National foundations funded the National Energy Education Development (NEED) Project that provided renewable energy systems, associated curriculum and training for four Minneapolis schools.

✓ **Other Local Fundraising –** Business and individual donations can be a valuable source of funding. A number of existing school renewable energy projects successfully used local fundraising. These fundraising efforts included: direct solicitations to businesses; fundraising events hosted by students, parents and teachers; and using social media to solicit donations. In most cases these efforts usually do not raise substantial amounts of money. The process is, however, invaluable for publicizing the project within the community, creating ownership in the project and actively engaging students. The funds raised, while usually only a few thousand dollars, are sometimes critical for leveraging other funding sources, such as foundations, grants and school district support.

✓ **Donations and Volunteers –** Many school renewable energy projects found material or labor donations to install the project. Such donations rarely are a substantial portion of the total project, but help create community support and ownership for the project, leverage other funding sources and provide sponsorship opportunities.

✓ **Financing –** This funding category includes a wide range of funding options that are some sort of loan and repayment.

Financing options include:

- ✓ Third-Party Financing
- ✓ Federal energy bond allocations
- ✓ Financing through cost-savings
- ✓ Utility loans
- ✓ School bonding
- ✓ Bank Loans

Financing can be complicated and time-consuming, and generally only used for larger-scale projects, although some notable exceptions are found. Conversely, financing options can enable larger-scale, more cost-effective projects to proceed where smaller projects cannot be fiscally justified, particularly when the renewable energy project is part of a package of other energy improvements that will generate positive cash flow. Determining financing feasibility is a delicate balance that the project team must evaluate under your particular set of circumstances.

Minnesota has only a few examples of schools using financing tools for renewable energy projects. In most cases, financing was not considered or was quickly dismissed by the project managers as too difficult given the relatively small size of renewable energy projects. Getting approvals, qualifying for loans and justifying payment schedules require a similar amount of effort for a $10,000 project as for a $100,000 project.

✓ **Loans** – Community banks or local branches of larger banks can provide loans for renewable energy projects. As with all financing, the project team must identify a method of making loan payments. Bank loans may be best considered to fill the gap in funding to allow the project to move forward until other funds become available. Some more creative use of loan guarantees issued by economic or community development programs might leverage local bank loans if the project can be justified under economic development criteria. Minnesota currently has no examples of such techniques for school renewable energy projects.

✓ **Bonding** – School districts frequently bond for capital projects. For larger projects that can demonstrate a positive cash flow, bonding is an option to consider. However, bonding is considerably more complex and involves many more stakeholders than other financing options. Bonding has been used for Minnesota school renewable energy projects, but only when the project was part of a larger capital investment, such as building a new school.

### Third Party Power Purchase Agreements

Third party financing of large PV systems is typically used by non-taxed entities that cannot benefit from federal tax incentives if they directly own a system. In addition, under a solar Power Purchase Agreement (PPA), one party (the host) can obtain a solar PV system on-site without the high up-front costs and project complexities that make solar projects difficult to implement. Under the terms of a solar PPA, the second party owns, operates and maintains the PV system and sells 100% of the solar electricity produced to the host at a contracted price for a term of 20-25 years. Federal solar tax incentives available to businesses can offset 50% or more of the installed cost of a PV system. The developer qualifies for these incentives and passes a portion of the savings on to the host through the PPA. As a result, the third party ownership model can be a cost effective arrangement for many entities with no up-front capital investment required.

Source: Assessing the Feasibility of a Third Party Ownership Model for Minnesota Schools, Minnesota DER, 2010.

✓ **Tax Credit Bond Allocations –** The Federal government has created several tools that allow local governments to issue bonds for renewable energy or energy efficiency that provide local government extremely low interest (close to zero) rates and provide loan guarantees. Several varieties of these bonds exist, including *Clean Renewable Energy Bonds (CREBs)*, *Qualified Energy Conservation Bonds (QECBs)*, and *Qualified School Construction Bonds (QSCBs)*, which are generically referred to as Tax Credit Bonds. With tax credit bonds the borrower (school district) pays back only the principal of the bond. The bondholder (lender) receives federal tax credits in lieu of the traditional bond interest. The bondholder may take the tax credit quarterly to offset the bondholder's tax liability. The school district can apply for an allocation for eligible projects out of the Federal pool. While these bond allocations can make large scale projects much more financially attractive, the bonding process is complicated and best suited for larger districts or for an aggregation of projects. The project team can discuss examples from states with large scale renewable energy projects that used *CREBs* or *QECBs* with the school district's finance professionals. A number of summaries and case studies are available from the National Renewable Energy Laboratory (NREL).

✓ **Third-party financing** – *Third-party financing* is a form of lending that allows an outside entity to invest in the school's renewable energy system. Several companies offer some form of renewable energy *third-party financing*, and this mechanism is likely to become more viable in the future.

The National Renewable Energy Laboratory and the Minnesota Department of Commerce investigated the potential for public schools to use *third-party financing* (*power purchase agreements (PPAs)*, see study referenced in the sidebar). The conclusion was that significant barriers still exist for public schools to use third-party financing. The barriers can be overcome - the largest school renewable energy project in the state, at Pipestone High School, does use a PPA for its 750 kW wind turbine. A private school, Transfiguration School in Oakdale (see case study at the end of the chapter) also uses third-party financing through an 18-year lease of its 40 kW rooftop solar electric system. Any PPA or third-party ownership model will need substantial legal and contractual vetting, an expense that should not be taken lightly. As PPAs become more common, and barriers are removed, third-party financing should prove to be a sustainable means of acquiring renewable energy systems.

✓ **Financing through cost savings** – If the project team identifies cost savings as a primary project goal, the team should consider making the renewable energy project part of a larger energy efficiency effort as a means of indirectly "financing" the project. Bundling a small renewable energy project with energy efficiency investments can result in a total project that can be financially justified over time (irrespective of the educational or demonstrative benefits that the system and efficiency improvements provide).

*"The cheapest kWh that can be purchased is the kWh saved through energy efficiency investments."*

*– Anonymous*

Creating an energy efficiency initiative to justify renewable energy investment is a potential means of engaging students in the funding effort. Students can calculate how much energy bills will need to be reduced in order to complete a funding portfolio for a renewable energy project, identify energy efficiency initiatives and even manage energy conservation efforts.

## Step 2 - Create a Project Budget

The school has already set goal priorities and identified the school's renewable energy resource and a technology preference (wind, solar electric, solar thermal). These choices allow project leaders to create a draft budget. The budget is just an estimate that allows the school to move forward with following steps, but should be realistic enough to begin fund-raising and financing.

a) Identify approximate costs of preferred technology.

b) Identify additional equipment that is desired to incorporate the energy system into the classroom, such as production monitoring and electronic data gathering.

c) Identify potential costs of curriculum development or costs associated with adapting an existing curriculum. Consider any costs associated with teacher training as well.

d) Consider whether the technology will need ongoing maintenance and how that can be budgeted. Solar systems require less maintenance than wind systems, and solar electric systems generally require less maintenance than solar thermal systems. It may make sense for the school to set up an account to track and set aside the profits from renewable energy production that can be used to pay for maintenance

**Kennedy School, St. Joseph**

When faced with the issue of adding additional school space, the district decided to create a model "green" school which met current standards for efficiency and provided an environmental teaching tool for students. The school was designed and built to achieve LEED (Leadership in Energy and Environmental Design) Gold certification, the first school so certified in Minnesota. The Kennedy Community School was completed in 2008 and includes a 5.6 kW photovoltaic array on the south facing roof and a Skystream 3.7 kW wind turbine, all financed as part of the school construction. The school uses a geothermal loop field and water-to-water head pumps for heating and cooling of the school.

and potentially serve as a source for future sustainability projects. This especially makes sense if the school district incurred very little costs in implementing the project (i.e. primarily done through community support or grants).

e) Add cost contingencies for uncertainties. Examples of contingencies include: additional costs for an engineering structural review of the building (required for roof-mounted systems), third-party analysis of site conditions and design of wind-energy tower foundations.

**Multi-Source Funding Model**

| | |
|---|---|
| Local donations | $6,500 |
| Utility rebate (Xcel Energy) | $4,500 |
| First year utility savings from efficiency | $2,500 |
| Existing School Budget (Teacher training) | $1,500 |
| Bonding | $6,000 |
| School District contribution | $2,150 |
| Total funding | $23,150 |

*Concept Budget for 2-kW Roof-Mounted Solar Project*

| | |
|---|---|
| Resource Assessment (Solar) | $ 400 |
| Structural Review & Recommendations | $ 1,500 |
| Structural Enhancements | $ 2,500 |
| Electrical System Enhancements | $ 750 |
| Equipment & Installations costs (based on $6.50/watt install cost) | $13,000 |
| Monitoring Sytem & Educational Kiosk | $ 3,000 |
| Curriculum/training for teachers | $ 2,000 |
| | $ 23,150 |

(See multi-source funding model in sidebar to left)

### Step 3 – Engage Financial Stakeholders

Funding will require project leaders to engage other people in the project. In Step 1, project managers identified sources of funding. For each source, project managers should identify the person whose approval is needed to acquire or apply for funds. For some sources, such as financing options, the school will need to move through a well-defined process with the lender, where school district standards and rules must be met. For others, such as grants, the granting entity is obviously a decision maker, but school district officials may still need to be engaged in order to pursue the grant.

a) **School district -** In almost all cases project managers will need to engage financial decision-makers at the school district or Board. For some funding sources project managers will need simple approvals. For any financing source, the school administration will not only need to grant approval, but will also have to expend staff time and perhaps up-front dollars in securing the financing. Options such as using Federal bonding capacity for projects require substantial effort and should only be considered for large-scale projects.

b) **Utility** - Most schools will need to engage the energy utility in the project, including the funding. The most significant utility funding is through programs explicitly designed to encourage renewable energy (primarily large investor-owned utilities including Xcel Energy and Minnesota Power).

c) **Lender** - When loans are incorporated into the project, the lender obviously becomes a critical stakeholder. While renewable energy systems are more commonplace than five years ago, lenders still have little experience in how such projects work and what kind of financial risk is associated with the systems.

d) **Third-party financier** - This funding option is described in detail in Step 1. Third-party financing is usually put together in a package by a vendor or installer, rather than by a school. Such methods do, however, create a new set of stakeholders to engage and frequently require much deeper engagement of school administrators in order to assure everyone that the risk is manageable. Moreover, schools would be well-served to engage legal review of any such proposal by someone familiar with such contracts.

**Steps to Engaging your Energy Utility**

1. Identify your electric utility
2. Check to see if the utility offers grants or rebates for renewable energy systems. Places to look include the utility's website, the DSIRE website, the State's Division of Energy Resources
3. If a program exists, contact the utility representative to get the details of the program
4. If no program exists, consider engaging the utility as a community partner in the project. Utilities frequently fund ad hoc economic development or community development projects. Engaging the utility in this manner is likely to require a number of meetings with higher level decision-makers or program staff.

## Step 4 – Complete Financing Process

When projects are financing as a component of total funding, the financing should, in most instances, be finalized prior to bidding the project. Financing options have their own schedule and can create project delays, which can lead to construction delays and unforeseen costs. Moreover, having secured financing allows the school to get more competitive bids as financial uncertainty to the installer is reduced. Some financing options, however, will be wrapped into the bidding process, such as use of a *power purchase agreement* or a leasing arrangement.

## Step 5 – Engage the Community

Schools are extensions of a larger community. Schools have political, social and financial ties to a much larger group of people than those who work at or attend the school. Recognizing barriers and opportunities between the school and it's community is critical to identifying other funding options for the project.

Methods for engaging the community will vary by project. The following are descriptions of opportunities that all projects should consider.

**Fundraising as engagement.** Most of the existing school renewable energy projects used fundraising as a means of engaging the community. Step 1 described the kinds of funding or other donations that can help make the renewable energy project move forward. As noted in Step 1, the amount of money raised was usually only a small portion of the total project funding, but the benefit from engaging the community and bringing attention to the project was quite valuable.

**Engagement through publicity.** Use the local media to make the project part of the community. The school district may have


Photo by Pete Gravett

Energy Explosion interns at Hartley Nature Center demonstrate the uses for renewable energy, garnering visibility for the center's renewable energy efforts.

### Community Solar: Using a Village to Raise a Solar System

People have many reasons for organizing or participating in a community solar project. Just as their motives vary, so do the possible project models, each with a unique set of costs, benefits, responsibilities and rewards. This section reviews several project models:

- Utility-Sponsored Model, in which a utility owns or operates a project that is open to voluntary ratepayer participation.
- Special Purpose Entity (SPE) Model, in which individual investors join in a business enterprise to develop a community solar project.
- Non-Profit "Buy a Brick" Model, in which donors contribute to a community installation owned by a charitable non-profit corporation.

*Source: A Guide to Community Solar, National Renewable Energy Lab, 2011* communications professionals or staff who know how to engage the media, and the project team should contact both to use them as resources and to make sure that publicity efforts are done consistent with district policies. Make use of the school's publicity machine: e-mails, newsletters, student mailings, website, daily announcements, community education catalog, etc to put the word out. The project team should develop some short press releases and press alerts and compile a list of local media to notify. Claim credit for all milestones reached, for all successes large and small, particularly when project goals are achieved. If the project goal is to reduce the school's carbon footprint, claim credit for the first ten tons of $CO_2$ avoided. If the goal is meeting a portion of the school's electric use through renewable energy, give a progress report partway through the year.

## *Sample News Release Format :*

TITLE WITH SCHOOL NAME & BASICS

Date: The date that the Press Release is sent

Media Contact: (Name, title, organization, phone and email)

YOUR TOWN, MINNESOTA – A bird's eye view of what you did and why. Two to three sentences. It's best to connect it to things going on across the country, Minnesota, and/or your community so that the media outlet and their audiences can get context.

Now include a quotation from someone involved in the project talking about the project and its importance and/or impact

Here you should mention specific details that you want people to know about the project. How many students were involved? How much energy will the project produce? How will the system be included in the curriculum and other learning opportunities? How will it be used to educate the community about the benefits of renewable energy? You may decide to have this fill a couple paragraphs.

And feel free to include one more sentence here about the partners that made the project possible and what this will mean for the future to get people inspired! A quote from an influential partner or someone important in your community would also be good (owner of company, mayor, school principal, etc).

If there is a place to go for people to get more information, like your school's website, include that here at the end.

ABOUT: Write something basic about your school and the group working on the project here.

###

Press release sample courtesy of CERTs

Issuing a press release is a simple thing to do, and students can even be engaged to help write or distribute press releases. A simple press release will remind people that the system is still providing benefits to the community. Positive press will make residents and businesses who contributed financially to the project feel that their investment is paying off. Many environmental non-profit organizations, such as MRES or CERTs, will gladly add press releases (with pictures) to their monthly newsletter or social media sites.

**Engagement through education.** The renewable energy system is an opportunity to educate not only the students, but the larger community. Consider offering community education workshops on renewable energy that can coincide with the installation process, and continue on after the installation. The project team will need to identify resources for these efforts, as workshops and classes require presenters and teachers. But offering a solar or wind energy workshop once or twice a year, or during the fundraising or installation effort, will create advocates for the project and promote the educational value of the system. School and community events offer great opportunities for education and awareness around the project. Some of these include homecoming, sporting events, community education fairs, school orientation, crazy days, art fairs, farmer's markets, environmental fairs, lion's club events, etc.

*Potential pitfall: The value of volunteer labor*

Many schools believe they can lower up-front costs of renewable energy systems through the use of volunteers. Schools need to be aware, however, volunteers can actually increase project costs because:

- Volunteers require more management than paid workers.
- Volunteers are not necessarily qualified to do the work that is needed to be done.
- Volunteers (even professionals who are volunteering) may not show up if the volunteering turns out to be inconvenient. The project team needs to have a contingency plan if this occurs.
- Using volunteers may not save costs if the installer ramps up their bid to account for the higher level of uncertainty and greater management effort.

### Step 6 – Integrate Funding into Bidding

Funding and financing choices affect the way that the school selects and manages contractors for the project. Choices to use *third-party financing*, volunteer labor or contributed services and materials must be clearly identified in bidding the project out or contracting with a renewable energy installer.

Other school requirements or preferences may also need to be integrated, such as a preference for local contractors, "Buy American" considerations that are associated with some grant funds, and delineation of tasks that are to be completed by school facility staff. One of the more problematic issues for an installer is efficiently sequencing stages of the project. To the extent that school facility staff are serving as general contractors, the sequencing responsibility will be the school's rather than the installer's. Sequencing delays in the construction schedule will result in increased costs.

## 4.4 Anecdotes/Case Studies

## Case Study: Eden Valley Watkins High School

## Renewable Project Type: Solar Electric System

### Description

Eden Valley Watkins installed two solar systems, a 1.29 kW solar PV tracking system on the school grounds in the spring of 2010, and a 0.43 kW roof mounted system in December of 2010. The systems are linked to an information kiosk in the main entryway of the school that shows real time and historic production of both systems (along with other information about the school).

Photo by EVW Student Marketing Team

### Background

The Eden Valley Watkins school project started when teacher Becky Haag received a postcard from MN Schools Cutting Carbon describing their program to fund school energy projects. Mrs. Haag asked students if they would be interested in designing a project to demonstrate cutting the school's carbon emissions. Fifteen ninth graders enthusiastically said yes. The students came up with a list of five different possible energy projects. School administration narrowed that list down to three and the students voted on which one they wanted to do. They chose solar panels.

### Funding and Financing

The single primary funding source, for $10,000, was a Schools Cutting Carbon grant administered by the Clean Energy Resource Teams (CERTs). Much of the system cost, however, was covered through local donations of money, time and materials. Students took charge in community outreach to find community members to help with time, labor, parts and funding for the project. Student outreach into the community created free or reduced prices for a number of elements of procurement and installation of the project, including:

- A local company donated concrete for the foundation
- A local manufacturing company donated labor to weld and haul the pole
- Volunteer electricians helped connect the panels to the school system

### Student Engagement as a Funding Tool

The planning and installation process relied heavily on student leadership and participation. Students from the shop class built a kiosk for a computer in the main lobby to display energy collection and computer class students designed a presentation for the display. Students were also very involved in the construction of the project from digging wiring trenches to welding the cage to hold the solar panels. This provided them with invaluable hands-on experience. Students also planned a Green Fair to commemorate and celebrate the installation of the solar panels and invited local businesses that had helped with the project.

At the Green Fair there were tours, a Go-Green class and prizes. The group also took a survey to determine topics for student assisted community education classes to be provided. Based on the results, classes were offered on tax incentives and grants for renewable energy, audits, products for home use and basics on solar, wind and geothermal energy.

### Integrating Community Donations into the Installation

With the considerable amount of volunteer labor and donated supplies, installation of the solar panels went fairly smoothly. On May 14th workers set the pole, two weeks later the solar panels were added. Proper sequencing was somewhat of an issue. Some components were on back order and slowed the project. The selected type of solar panel was out of stock and wouldn't arrive on time, so a decision was made to use a different size of panel than the initial design called for. When it came time for the Green Fair celebration, the tracker mechanism had not arrived yet, so volunteers and student workers installed the panels on the pole and later removed them, installed the tracker and re-installed the panels. Building and electrical inspections needed to be conducted after the pole was installed and again after the panels were added.

Coordinating all the volunteer labor was a substantial effort. An experienced solar installer who had volunteered considerable time on the project served as the general contractor and gave the coordinators (students and teacher) the general overview of a solar project so they could locate parts, make appointments and have other businesses come and help.

## Case Study: Transfiguration School

## Renewable Project Type: Solar Electric System

### Description

In November 2010 Transfiguration Parish in Oakdale installed a 40-KW rooftop solar system on its school building. The project uses an innovative leasing arrangement to minimize up-front costs to the school. The system also uses an internet based tracking system to show solar production.

Photo by Eric Hanson

### Project Goals

The primary goal for the project was to help the parish better exemplify Catholic social justice principles, in particular the principle of caring for God's creation. The parish had already completed other initiatives, but considered energy efficiency and renewable energy to be a necessary expression of faith. "To make a demonstration of our faith is important... and to live the ethic is equally important."

### Background

In 2007 the parish formed Creation Care, a stewardship team, headed by the Deacon and supported by 10-15 active members. One of the earlier discussions was to implement a renewable energy project on the parish campus. A nearby community was in the process of developing a wind energy project, so the Committee started compiling information to assess a wind turbine project.

## Assessment

The parish had wind energy professionals come out and make analytic measurements, including satellite data on land forms and distance to obstructions such as trees, although no wind speed measurements were conducted. But after the bid was submitted, the committee determined that the wind resource did not justify the substantial investment. After consulting with the Clean Energy Resource Team (Metro CERTs) the group decided to investigate solar energy. The process took about six months. From that point the project took another 18 months until install was complete.

## Funding and Financing

Transfiguration parish engaged a solar installation company that specialized in an innovative type of third-party financing: leasing. The school entered into an 18-year lease for the rooftop solar system that was structured to be revenue-neutral to the school during the first five years and would yield significant savings during years 6 thru 18. In other words, the lease payments are designed to be equal to the reduction in utility bills for the first five years, and after that the lease payments are fixed, which will allow the school to save dollars as the price of electricity increases. Increases in the average cost of electricity vary between 3.6% (Minnesota average) and 5.6% (national average), so the projected saving over the lease term are between $20,000 and $34,000. On the front end, the leasing arrangement allows the solar installer to take advantage of tax credits that the non-profit school is unable to claim.

Structuring the lease arrangement did require careful legal review and negotiation with the solar leasing company. Transfiguration school received pro bono legal assistance for this, a benefit probably valued at thousands of dollars. Although there was overall support for the project, parish council members also had natural concerns about the unusual financing method and the process had to address concerns and answer questions. Ultimately, all parties were confident in the fairness of the deal and it was promptly signed.

## Installation

Once the equipment arrived, the engineering was completed and all permits were in place, then the installation could commence and was completed without any major set backs. One area of particular concern was to make sure that the roof warranty remained untouched – this required the involvement of the general contractor for the original building, a key step in making sure there would be no future issues over the life of the solar system.

### Student Engagement and Educational Opportunity

Engaging students during the investigation, assessment, and installation process was not very viable or practical. However, integration of solar learning and exposure to school project are natural fits for the school curriculum. Committee members and the solar vendor have met with teachers and staff, who are excited about using the system as a science tool. The on-line monitoring program provides real-time production from the system and a natural platform for learning opportunities. . The committee has discussed putting a webcam with a weather station by the panels to be able to see how weather affects production – this is one of many future opportunities to challenge the young minds in the school. Besides the value of clean energy for our school and church, we will also benefit from broader learning opportunities for many years to come!

## 4.5 Glossary of Terms

**Clean Renewable Energy Bonds (CREBs):** The CREB program is administered by the IRS and provides bond authorization for public entities on a competitive basis for renewable energy projects, with public entities receiving bonds at "zero" percent interest. The revenue or cost savings from the renewable energy systems are used to pay the bonds, while the bondholder receives tax credits instead of interest.

**Qualified Energy Conservation Bonds (QECBs):** Similar to CREBs, but are used for funding energy conservation projects.

**Qualified School Construction Bonds (QSCBs):** QSCBs were created by 2009 American Recovery and Reinvestment Act (ARRA) to fund school construction. Similar to CREBs and QECBs, they pay the bondholder a tax credit and provide the school interest free funding.

**Federal Investment Tax Credit:** The "Energy Improvement and Extension Act of 2008," signed into law on October 3, 2008, includes an eight year extension of the 30% residential and business Investment Tax Credit for solar systems. Third party ownership models introduce a tax paying entity, allowing the host to indirectly benefit from the federal investment tax credits, which significantly reduce the cost of a PV system.

**Federal Modified Accelerated Cost Recovery System (MACRS):** The IRS allows taxed entities to use a five year accelerated depreciation schedule for qualified assets of a solar installation, thus reducing income subject to taxation in the early years of a project.

**Power Purchase Agreement (PPA):** A contract between one party that is producing electricity to sell electricity to another party. PPAs could be between a school and a renewable energy generator who owns a renewable energy system located on school property, or a renewable energy generator (which could be a school) and an electric utility that is purchasing the generation from the school.

**Renewable Energy Credits (RECs):** Also known as Green Tags, Renewable Electricity Certificates or Tradable Renewable Certificates (TRCs). These are tradable, non-tangible energy commodities in the United States that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource. Solar RECs are specifically generated by solar systems. These certificates can be sold, traded or bartered and the owner of the REC can claim to have purchased renewable energy. Renewable energy system owners can use the proceeds from RECs to finance their system construction costs.

**Third-party financing:** Financing arranged and managed by someone other than the source of capital and the beneficiary of the renewable energy project. In the case of a school project, the third party would be someone other than the school and the entity(s) providing the capital, who has contracts with both, in order to make the project work.

## 4.6 Resources

**www.energy.mn.gov**
Division of Energy Resources for the State of MN

**www.cleanenergyresourceteams.org**
Clean Energy Resource Teams (CERTs)

**www.nextstep.state.mn.us**
Minnesota Sustainable Communities Network

**www.dsireusa.org**
U.S. Department of Energy's Database of State Incentives for Renewable Energy (DSIRE)

**www.rurdev.usda.gov/energy.html**
Rural Energy for America Program: Renewable Energy Development Assistant (REAP)

**www.eetd.lbl.gov/ea/emp/reports/63434.pdf**
Windustry and American Wind Energy Association (AWEA) financing document

**www.windustry.org**
Windustry - A non-profit that provides education and advocacy for wind energy.

**www.awea.org**
American Wind Energy Association - A national trade association that promotes wind energy.

**www.NREL.gov**
National Renewable Energy Lab - Government run renewable energy and energy efficiency research group.

<u>Resource Documents (perform a Google search using the document title)</u>

*Assessing the Feasibility of Third-Party Owned Solar Photovoltaic Installations in Minnesota Schools*. Report to the Legislature, MN Department of Commerce, Division of Energy Resources, December, 2010.

*Financing Energy Improvements: Insights on Best Practices to Engage Stakeholders and Marry Dollars with Demand.* MN Department of Commerce, Division of Energy Resources; January, 2011.

*Community Wind: Once Again Pushing the Envelope of Project Finance*. M. Bolinger, Lawrence Berkeley Laboratory, January, 2011 (eetd.lbl.gov/EA/EMP/re-pubs.html).

*A Guide to Community Solar: Utility, Private, and Non-profit Project Development*. National Renewable Energy Laboratory: November, 2010.

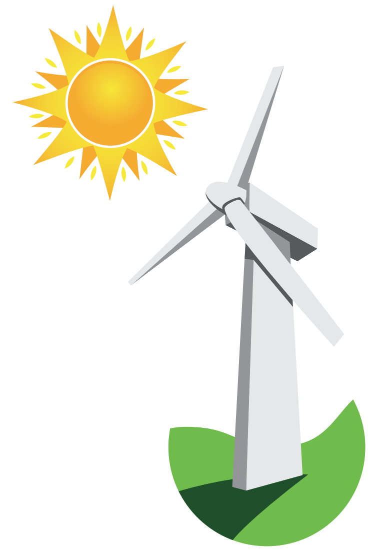
*Power Purchase Agreement Checklist for State and Local Governments*. Energy Analyst Factsheet series on financing renewable energy projects, National Renewable Energy Laboratory; Oct 2009.

*How Solar Financing Works: Financing Large-Scale Solar Projects*. One Globe Solar, April 1, 2010. www.oneglobesolar.com

# Chapter 5. Bidding and Managing the Installation

**Overview:**

- When and what is needed for technical specifications
- Bidding projects and hiring a renewable energy installer
- Construction issues



## 5.1 Summary

The assessment explorations of Chapter 2 should give you a good sense of feasible renewable energy options. Your overall project team should carefully consider the assessment results and consider the choices in light of your goals and prepare some recommendations for your school.

At this point, those recommendations will need to be presented to the appropriate decision-makers who include the school board, superintendent, building engineers and/or building committee. Your goal at this stage is to get the "go-ahead" to develop a system design and some firm cost estimates.

Procedures at this point are dependent on the expected size and cost of the project, and the specifics of your school's fiscal management practices. If you do not have *public bidding* rules (possible in many private schools) or the expected cost is under the threshold requiring public bidding, you may be able to work with a reputable installer (or installers if you want to see multiple proposals) who will prepare a full design and cost estimate without an up-front fee.

If your school needs or chooses to enter the public bidding process, you will need bidding documents prepared, including attendant component specifications and construction drawings. The bidding documents will allow for an apples-to-apples comparison of different systems and installers.

Who prepares this design will depend not only on the bidding structure, but the type of project. In new construction, the architect may coordinate this effort, calling on the appropriate

**Key Questions Addressed in This Chapter**

- Does the project need to go to bidding?
- Is the final design consistent with project goals and assessment findings?
- What is system commissioning and what occurs during this step?

engineering expertise as necessary.  A retrofit solar thermal or solar electric project will probably be designed by mechanical and electrical engineers respectively.  For larger wind projects, specialist wind developers may be the proper choice, although some mechanical or civil engineering firms may have relevant experience. The design should specifically reflect your project goals and any recommendations from the site assessment.  Since there may be many design possibilities that will help you meet your goals, you will need to make sure that there is enough flexibility in your specification to allow creative and innovative approaches to meeting your renewable energy needs.  An overly specific and narrowly written request for proposals (i.e. naming specific models of equipment) may exclude some good installers from bidding on the project. Requiring certified equipment however, is highly recommended.

If public bidding is not required, the balance of cost and performance issues can be weighed during the selection process. Selection will be primarily driven by lowest cost in a public bidding scenario, with performance concerns addressed during a qualifying examination of the lowest bid.

With a contract commitment in hand, the winning bidder will proceed with construction.  It is recommended that a school staff person or representative with sufficient construction experience will oversee the installation. Project issues in a school situation are similar to any other construction project.  System *commissioning* and testing is an important step.

Your school's renewable energy project is likely to be a focus of student and community attention. Plan to use the installation process as an educational opportunity, and to further the project goals.

Photo by EVW Student Marketing Team

Eden Valley Watkins students assist with hoisting panels up to the roof prior to installation.

## 5.2 Outline of Action Steps

Implementing a renewable energy project follows many of the same steps as any other building or renovation project. Some unique design and installation nuances do, however, require involvement of professionals familiar with the industry.

The following action steps assume completion of previous chapters' action steps. Whether you worked with an independent site assessor, an installer who performs assessments or used a design firm, you should have data that serves as the basis for these next steps.

### Summary of Bidding and Managing the Installation Action Steps

*Step 1 - Selecting Design Consultants (not applicable for small projects)*
A renewable energy project will likely require a public bidding process. A bidding process typically uses a design team of architects and engineers to develop construction documents and manage the project from bidding to installation. If the project is a part of new construction, the architect and their consultants will incorporate the renewable energy systems into the base set of plans and specifications.

*Step 2 - Developing the Scope of Work*
The project team will work with the school, administration and the chosen design consultants to establish the detailed project design and construction schedules. The project team should ensure project goals and assessment findings are incorporated into the final design or bidding specifications.

*Step 3 - Issuing the Bid*
With the construction documents complete, the project can be listed on one of the public bidding exchanges. If public bidding is not required, the project team should attempt to encourage several qualified firms to submit bids.

*Step 4 - Hiring the Contractor*
Once the bids are received, the low bidder will need to be qualified as meeting the intent of the bid documents. The qualification includes technical as well as administrative matters (i.e. insurance, affirmative action, etc).

*Step 5 - Construction Begins*
The contractor will mobilize to the job site. Construction will take place in accordance with measures identified in the construction documents. Incorporating volunteers and educational activities into this phase will increase visibility of the project.

*Step 6 - Commissioning the System*
Once the construction is substantially complete, the contractor will initiate the necessary tests to establish system operation and code/inspection compliance.

## 5.3 Details of Action Steps

### Step 1 - Selecting Design Consultants

Small projects can usually skip this step. The project team can create a simple scope consistent with project goals, site assessment results and funding requirements and offer it for bid or work directly with an installer. Anything other than a small renewable energy project will likely be above the threshold for public bidding procedures. Competitive bidding requires the creation of bidding documents.

Even if public bidding is not required, the project team should solicit more than one firm for a proposal and cost estimate. On a larger project, one may still have to contract for the design work separately from the construction work, as no firm will commit to a cost estimate for a large project without clear specifications. Design/build contracts, usually coupled with a guaranteed maximum price, are also good options.

Bidding is almost always the best way to ensure a qualified installer and a fair price. A public bidding process works best when there are multiple firms with the capacity and experience to do the job. Renewable energy technology may be new to many established firms in some areas of the state. When faced with an unfamiliar technology, firms may unintentionally overprice their work to hedge against perceived risk. Conversely, firms may offer low bids because they do not understand all the requirements. Clear communication with bidders is essential, and thus the need for bid specifications.

An architect or engineer can develop *construction documents* and manage the project from bidding to installation and *commissioning*. If the project is a part of new construction, the architect and their consultants will be incorporating the renewable energy systems into the base set of plans and specifications.

The project team, or overseer of the project, needs to carefully select the design consultant. Many otherwise competent design firms have little or no renewable energy experience. As of 2011, numerous projects are out for competitive bidding with poorly prepared bid documents.

The technology being employed may dictate the lead design consultant. A solar thermal project, for instance, should enlist the services of a mechanical engineer. Similarly, a solar electric project should employ the services of electrical engineers. When projects require multiple disciplines, the lead consultant may hire the structural engineer as a sub-consultant.

In some cases an architect may be the best lead consultant. An architect is well suited for large projects or ones that are unusually complicated or projects with sensitive aesthetic considerations. They would be responsible for assembling the team of structural, mechanical, electrical engineers or other professionals deemed appropriate.

If the project is new construction and involves renewable energy systems, the base building architect would be responsible for incorporating the renewable energy system into the overall project.

### Step 2 - Developing the Scope of Work

The project team will work with the school's facility managers, the design consultants and possibly other stakeholders to establish the detailed project design and schedules.

Renewable energy projects include architectural, structural, mechanical and electrical building related considerations. For small projects, these can frequently be wrapped into a single scope of work by the project team. For larger projects, or for projects requiring public bids, addressing these items as part of the design process will allow the bidding and construction to proceed with much greater ease.

The following summarizes some of the major design issues and decisions that should be addressed in the scope of work for solar electric, solar thermal and wind electric systems.

### Solar Electric Systems:

**Size of the system in** *kilowatts peak capacity (KWP)*. This, in conjunction with the available solar resource in your area, sets an upper limit on how much electricity will be generated.

*Educational Opportunities in System Design*

The design phase is another educational opportunity. The selection of the design professional can include consideration of how they

might present their work to the school or otherwise "mine" the educational value in their work. If possible and appropriate, this kind of work should be included in the contract and compensation for the design professional.

At a minimum, some kind of explanation about the system design should be shared with the school community as the bidding process proceeds. Likewise, there should be explanatory updates as the construction proceeds. A qualifying question for contractors would be how they can accommodate the educational goals of the project in the construction process.

**Type and number of photovoltaic panels.** The type of panels will determine how much of the system capacity will be realized and whether the system will be higher or lower in the range of typical costs. Single crystal silicon panels are the industry standard for low cost and high performance, but there are other options such as *polycrystalline amorphous silicon* and thin film that may be appropriate for your situation. The need to create an efficient roof layout may determine the physical size of panels and arrangement.

**Mounting (including racking systems/roof connections).** The mounting system orients the panels to capture as much solar energy as possible and minimize the effects of wind loading, snow load and aesthetics. For all solar mounting systems, particularly roof-mounted systems, the attachment system is a critical component. The attachments hold the panels against wind and snow loads, but must be installed in a way that protects the integrity of the roof.

**Inverters.** The *inverters*, which convert the Direct Current (DC) produced by the solar panels to the Alternating Current (AC) of the electric grid, are an expensive system component. The *inverters* are also more prone to failure than other components. Project managers should understand and verify manufacturer's warranties. *Inverters* come in a range of sizes and types, from a small *micro-inverter* on each panel, to one or more large central *inverters* for multiple panels. Performance monitoring equipment would tie into the *inverter*(s), and could be used for classroom instruction on electric production. Ideally, renewable energy projects should include educational components related to performance monitoring of the system.

**Wiring.** The system designer and installer will make design choices on how the panels are wired together and wired to the *inverter*. The wiring design affects panel performance, the amount of energy lost through transmission and the size (and cost) of the wiring system.

**Grid connection.** The scope of work should define how the system connects to the grid. The connection point is usually required to be at the central electrical panel of the building and the National Electric Code requires special switching and over-current protection.

## Solar Thermal Systems:

**Size of the system.** The size and output of solar thermal systems should be matched to the building's hot water or space heating loads. A system that routinely produces more heat than needed is not only wasteful but can create maintenance headaches.

**Type and number of panels.** Two types of solar thermal panels are suitable for Minnesota's climate - flat plate collectors and evacuated tube collectors. Flat plate collectors produce the range of temperatures required for hot water heating. Evacuated tube collectors are more efficient in colder weather for space heating uses.

**Freeze protection.** There are two main methods of freeze protection and both have specific requirements. Systems using propylene glycol, a food grade antifreeze, may need a *double-walled heat exchanger* separating the antifreeze and the domestic water supply. Drain back systems drain the fluid away from the panels and into heated space to avoid freezing, but may also require some antifreeze and thus a *double-walled heat exchanger*. Drainback systems also have specific slope requirements for the piping. Generally, a drain back configuration is preferable for large systems, but building layout sometimes dictates which system type is more suitable.

**Mounting (including racking systems/roof connections).** The same concerns that apply to solar electric panels also apply to solar thermal panels, which usually weigh more. High tilt angles for winter time production usually produce higher wind loads.

**Plumbing and insulation.** All plumbing and pipe runs must be carefully designed to minimize pumping and heat loss. Pipe insulation (outdoor pipe runs) must be protected from the elements (especially sunlight) and able to withstand system temperatures. Provisions must be made for air elimination from the pipes and for system draining when repair or maintenance are required.

**Storage.** Most systems include storage to carry some of the heat over into the nighttime or the next day. Currently, there are tanks that will retain the heat over the course of a whole week. Water is usually the storage medium. Because of the weight, the placement of the storage tank is an important structural concern. After the panels, the storage tank can be the most expensive component. In some space heating configurations, and with swimming pools, a storage tank is not necessary.

*Educational Opportunities through Visibility*

Making the renewable energy system visible is a key design issue for educational settings.

Strategies include:

- System designs that make the equipment visible to the school community and the public. Visible systems spur comment, discussion and learning. Even if not visible, signage and bulletin boards can tell the story.

- Accessible systems encourage incorporation into classroom discussions. Where system placement and design allow for safe access, renewable energy systems can be available for "show and tell".
- Make performance data available. Consider using a kiosk for these displays. Budget for Performance monitoring and recording equipment--the data can be incorporated into class activities.
- Use the construction process to train new installers. If the school has institutional support and the proper insurance coverage, a renewable energy installation can be the host site for a training workshop.

### Wind Electric Systems:

**Turbine size and type.** The turbine needs to be matched to the wind regime, and should be a model that has a proven track record. Repairs involve not only the expense of fixing the turbine, but also the lost electrical production during downtime and the need to either climb the tower or lower the turbine to the ground. A significant failure point is the gear box that adjusts the blade rpm to match the turbine. Direct drive turbines, with no gearbox to repair, have been available in smaller sizes and are starting to be developed in larger sizes, but performance is not yet proven.

**Tower.** There are several types of towers as well as systems for raising them. After considering the wind resource and nearby obstacles that block the wind and cause turbulence, tower technical considerations include adequate space for guy wires if necessary, as well as soil and foundation interactions. Some "tilt-up" systems allow pulling up towers with ground vehicles, but most towers and turbines require a crane for installation. Turbine service requires either a trained technician with safety equipment to climb the tower or a return visit with the crane. If a crane is required for installation, there must be access to the site for the heavy equipment.

**Inverter/power electronics.** Some, but not all turbines generate DC current and will thus require an *inverter* similar to that of a solar electric system. Some turbines generate AC current, which will require either external or internal power conditioning circuitry to match the power and frequency to the grid.

**Wiring and interconnection.** As with solar electric systems, the point of connection to the grid is usually at the main electrical panel for the facility. Because turbines are located outside and are usually a significant distance away from the building, the length and size of the wiring run is an important design consideration. In some cases, connection with the grid can take place at an outside location, such as the main transformer.

## Code Issues:

Code compliance is an issue for most renewable energy projects. Your design professionals should have conversations with the relevant code officials early in the process so they can anticipate issues specific to the design. If significant "red flags" are raised

*Renewable Energy Installer Credentials*

Installers of solar and wind renewable energy systems have the opportunity to pursue certification through the North American Board of Certified Energy Practitioners (NABCEP). NABCEP offers certification for solar PV and thermal and small wind installation. NABCEP's mission is to develop and implement quality credentialing and certification programs for practitioners.

You should hire a NABCEP certified installer if one is available in your area, since contractors who choose to become certified demonstrate their competence in the field and their commitment to upholding high standards.

For more information or to locate a NABCEP certified installer visit www.nabcep.org during these early discussions, there should be an attempt to resolve them before significant work is done on the design.

Technology specific code issues include:

**Solar electric.** Panel mounting structural and aesthetic concerns; roof edge set backs for firefighter safety; wiring to electrical code, accessible system disconnects. Your utility may also have specific interconnection requirements.

**Solar thermal.** Panel mounting structural and aesthetic concerns; roof edge set backs for firefighter safety; plumbing and heating code issues; anti-scald valves on hot water delivery system.

**Wind electric.** Turbine siting and setback codes; noise and shadow flicker ordinances; wiring to electrical code; accessible system disconnects. Your utility may also have specific interconnection requirements.

## Step 3 - Issuing for Bidding

With the *construction documents* complete, the project can be listed on a public bidding exchange. If public bidding is not required, the project team will need to encourage qualified firms to submit bids.

The design consultant typically handles the bidding process, fielding questions and issuing addenda as needed for clarification. In retrofit projects, a mandatory pre-bid walk through by all bidders is highly encouraged. The consultants will need to closely monitor any deviations from the bid specifications suggested by bidders.

The contractor qualification requirements need to be well defined. The renewable energy industry is relatively immature and many contractors are attempting to break into the renewable energy field. Due to the immaturity of the industry some geographic areas will not have firms with renewable energy experience. As bringing in a distant firm may add significant costs to the project, your school may need to work with a firm that is developing its expertise. Your design consultants may need to be paid to guide the work. Any risk associated with learning should be borne by the contractor.

## Step 4 - Hiring the Contractor

While not all projects will go through a bidding process, both small and large projects will need to engage in a contractor screening process.

*Ensuring Quality Equipment*

In order to ensure the maximum performance, safety and longevity of your renewable energy system, consider using certified equipment. The following are third-party organizations that certify equipment in the renewable energy industry.

- Solar Rating & Certification Corporation - SRCC is a non-profit organization providing authoritative performance ratings, certifications and standards for solar thermal products.
- Small Wind Certification Council - SWCC certifies that small wind turbines meet or exceed the requirements of the American Wind Energy Association's Small Wind Turbine Performance and Safety Standard
- UL - UL is an independent safety science company dedicated to supporting the production and use of products which are physically and environmentally safe to prevent or reduce loss of life and property. This certification is most relevant to solar photovoltaic panels, electric system controls and monitoring device.

For small projects, the contractor screening will begin once consultants have been engaged and/or system financing is established. It is common on smaller projects that the contractor and the customer, in this case the school, work together to develop the scope of work.

For projects that go to bidding, the process begins once the bids are received. The apparent low bidder will need to be qualified as meeting the intent of the bid documents. The qualification includes technical as well as administrative matters (i.e. insurance, affirmative action, etc). The lowest responsible bidder will then be awarded a contract.

The project team or designated bid reviewer must insure that the lowest bidding contractor is qualified and has submitted a responsible bid. Often the school has staff that stringently manages the bid opening and makes certain the bid package contains the required documentation, bid surety and appropriate signatures. After the initial paperwork is accepted, the bidder should be interviewed to confirm that they have met the intent of the *construction documents* in their bid. The design professional in charge should conduct the interview confirming the proper equipment was selected, specific scope items unique to the project are included, any unique building interface measures are addressed, installation procedures are understood and the schedule can be met. If both parties agree that the bid is well understood and complete, the design team makes a recommendation to the school to award the contract.

Allow for adequate time in the schedule for the paper work process. At this point, formal application for code approval should begin to make sure that construction has been approved before ordered equipment is delivered. It is the responsibility of the installer to work with your electric utility on an interconnection application, if applicable, and secure all required permits.

Payment schedules should be clearly spelled out. In some renewable energy projects, capital costs for specific pieces of equipment make up a majority of the costs. As a result, major portions of the project cost may be incurred before construction begins necessitating advance payment schedules in some situations.

*Tips for selecting an installer*

1) Call references: Ask contractors for customer references and call them. Check the contractor's service, performance and adherence to timeline and budget. Be wary of installers who are hesitant to give references.
2) Confirm Licenses and Certifications: Make sure the contractor's licenses are current. Look for renewable energy industry certifications as well, see sidebar in this chapter for examples of these.
3) Expect a load evaluation: The contractor should spend time assessing your energy needs. A bigger system isn't always better. A contract should let you know about other less expensive ways to reduce your energy costs.
4) Get written, itemized estimates: When comparing contractors' proposals (bids), be sure to compare cost, estimated energy production and warranties. The lowest price may not be the best deal.
5) Get it in ink: Sign a written proposal with a contractor before works begins. Specifying project costs, model numbers, job schedule and warranty information may protect you from unforeseen future costs.

## Step 5 - Construction Begins

The contractor will mobilize to the job site. Construction will take

place in accordance with measures identified in the *construction documents*.
With a well-prepared set of construction documents, the construction process will more likely be smooth and seamless. Even with the best design and experienced contractors issues will arise. The design team should manage the field issues and distribute field clarifications and change orders as needed.

School officials will want to coordinate the interface of the renewable system with the building. Some operations will require shut down of the building systems (i.e. connecting a solar electric system may require a service disruption to the whole building) and need to be coordinated with school schedules.
Site access, security and safety all need to be addressed as part of the work plan.  Because renewable energy technology is still a novelty in some areas, there will likely be lots of attention to your project—a safe and secure workplace will help maintain a positive public image of the project.

In fact, the beginning of construction is a good time to keep building connections with your stakeholders by announcing the beginning of construction, or perhaps even holding a ground-breaking or launching ceremony.

There should be a clearly identified school representative to handle communication with the contractor.  It is advisable to create clear guidelines to manage change order requests.  See Potential Pitfall in this Chapter for more guidance.

Ideally, volunteers (ranging from students to parents to renewable energy advocates) could be included in the system construction process to reduce costs and enhance the educational benefit. But in most situations, workplace safety rules

### *Pitfall: Change orders*

Agree before construction starts how change orders will be handled and incorporate the procedure into the written contract. A change order is necessary whenever the contractor will deviate from the specification in a way that substantially affects the cost, function or appearance of the system.  Change orders protect the client (the school) from changes that increase the cost or alter function without approval, and protect the contractor from nonpayment for services.  Preferably,  the institution appoints a representative authorized to sign-off on change orders.

and legal liability issues will prevent hands-on construction work by volunteers. If this is the case, however, volunteers can still be involved. Preparing an educational display about the renewable energy project, or a public presentation about the project, can be a great way to include enthusiastic students and involved parents.

*Celebrate success!*

Successful system *commissioning* is the end of a long process for your school. You have successfully planned and executed a renewable energy project that will provide financial and educational benefits for your school and community. Don't forget to celebrate that success with a special event that calls attention to the milestone and recognizes all who participated. This can be a reception for school staff and students, a special assembly, or even an open house for the public.

## Step 6 - Commissioning the System

Once the construction is substantially complete, the contractor will initiate the necessary tests to establish system operation and code/ inspection compliance.

*Commissioning* can be quite simple or complex. The minimum requirement is the necessary code inspection by the local authority having jurisdiction. A further minimum test will be required for solar electric and wind electric systems. The utility will require a system tie-in (*anti-island*) test and inspection.

System commissioning and verification of operation are especially critical since there are usually backup systems in place (the electric grid for wind and solar electric systems, backup heating systems for solar thermal). If the renewable energy system fails to operate, it will not show obvious signs of failure; the backup systems will automatically cover the load. Monitoring systems that display the renewable energy production are a good tool for preventing this situation.

Beyond the minimum code and utility inspections are system tests that verify the functionality of the system. Wind systems are a bit more particular. The electrical and utility tie-in are very similar to a solar electric system. The commissioning checklist for the turbine and tower would be more unique to the specific manufacturer.

Finally, commissioning will include training of the staff in operation of the system and delivery of an owners' manual. Final payment to the contractor is typically linked to these last two items.

# 5.4 Anecdotes/Case Studies

## Case Study: Willmar Middle School

## Renewable Project type:  Solar Electric System

### Description

In 2007 a 2.38 kW solar PV array was installed on the roof of the foyer at the school's main entrance.

### Project Goals

The primary goals were to have a renewable energy project with an educational component that would be visible on the school roof to the community and students.  Willmar Municipal Utilities (WMU), who assisted with the project, also has a program to identify green energy opportunities in the area.  The Middle school worked with WMU to do the project.

### Background

The Willmar School District had a grant to hire a part time employee to evaluate energy use in the district and make recommendations for energy efficiency practices.  A middle school science teacher and the energy evaluation employee brainstormed possible projects.  They wanted to come up with a showcase project that would be a model for other schools.  Will Steger had also recently visited the community to present his research on global warming and the staff and students were inspired to set an example for addressing climate change at the school.

### Funding and Financing

The project was paid for primarily through fundraising activities led by the science teacher and middle school students, so there was no bidding done. The teacher rode his bike to school for a year and asked students and the public to sponsor him per mile ridden. They also asked Will Steger to sponsor the school, which he did. Other fundraising activities included solicitations on open mic at the local radio station, ads in the newspaper and solicitations of service groups and local businesses in the community.  The Willmar Foundation donated $5,000, as did the local business organization.  The community was also extremely generous and positive about the project.  Local businesses and residents gave in amounts from $10 up to hundreds of dollars.

The project was delayed because of some installation problems, including some issues that unexpectedly increased costs. The installer made some assumptions about the installation process that needed to be reexamined further into the project. The awning the panels were to be mounted on needed to be reviewed by a structural engineer, which added extra costs. Problems also arose in getting city permits for installing the solar system at the selected location on the roof which took some extra time and money to get resolved. Mounting the system also increased in cost, as the structural analysis required drilling all the way through the concrete deck and installing bars on the other side to secure the mounts, instead of the typical mounting of putting bolts in the concrete. At that time the project was already well under way and a lot of money had been raised. To complete the project the school district contributed from its general budget.

### Educational Benefits of System

One of the primary project goals was to create a curriculum to accompany the solar installation. The school is working to integrate the system into classroom curriculum. However, uncertainty about how the curriculum will fit the new state curriculum standards, and the sense that standards keep changing, have dampened enthusiasm.

Photo by Innovative Power Systems

## Case Study: Winona Area Public Schools

## Renewable Project type: Solar Electric System Geothermal heating/cooling

### Description

Winona Area Public Schools has a history of incorporating energy efficiency in construction and policy. Beginning in 2007, the school district made strides in reducing energy consumption through three innovative projects. The Winona Area Learning Center includes a geothermal system, light harvesting sensors and power conserving media labs. In 2008, a 5 panel, 1 kW solar array was installed on the roof of Winona Senior High School's Agriculture building. The district will complete a new bike shelter with a roof of solar panels in 2011.

### Project Goals

The geothermal and solar projects achieve many district-wide goals including efficiency in operation, innovative learning and financial responsibility. The geothermal and solar project help the district reduce its carbon footprint while also providing an educational tool to students. Additionally, energy efficiency reduces the cost to the taxpayer of running school buildings and puts those funds into educational programs.

### Background

Sustainable practices are a priority for the whole community of Winona. A collaboration called Sustain Winona includes public and private institutions, which work together to implement community-wide environmentally conscious practices. In summer 2009, the collaboration acquired certification as an ISO 14001 community, meaning the participating organizations meet international standards for energy efficiency and environmentally friendly operations.

### Process

During the development and design of the new Winona Area Learning Center, environmental and energy reducing technologies were considered. Three primary innovations include the geothermal HVAC system, lights that dim or brighten based on the amount of outdoor light in the room and computers that use a quarter of the energy of other computers. Construction of the new building took place in 2007 with students attending class for the first time in January 2008.

Later in 2008 came the installation of a solar array on the roof of the Winona Senior High School Agriculture Building. The project was initiated by teachers Dwayne Voegeli and Jed Olson. The students of the Environmental Studies class worked to raise funds for the solar panels. Student interest in the solar panel project led the district to apply for the Minnesota Schools Cutting Carbon grant through the Minnesota Pollution Control Agency.

The grant was awarded in 2010 to fund a bike shelter at Winona Senior High School. A student survey indicated more students would bike to school if bikes were protected from the weather and from theft. The grant funds purchased steel framing and lexon to provide a three-sided enclosure. A security camera will monitor the bike shelter to deter theft or vandalism. The Cutting Carbon team thought a roof of solar panels would create a unique educational tool and reduce some the of the school's energy consumption.

Winona Area Public Schools staff applied for a grant from the Minnesota Office of Energy Security (now called the Division of Energy Resources) to purchase the solar panels. The district received the award. Building and Grounds staff are currently in the process of installing the panels on the bike shelter. They will work with Xcel Energy to wire the panels into the school's system. While the panels will not create enough energy to feed back to the grid, it will harvest enough renewable energy to greatly reduce the schools carbon footprint.

### Funding and Financing

Funding for the renewable energy projects came from a number of sources. Construction of the Winona Area Learning Center, including the geothermal program, came from a community tax levy and energy rebates.

The Environmental Studies teachers and students received a number of grants for the Agriculture Building solar project including:

- Clean Energy Resource Teams grant
- University of Minnesota
- Winona County Economic Development Authority
- WSHS Student Activity Fund
- Minnesota State Rebate

The Winona Senior High Environmental Club contributed funds raised by students, and school staff contributed labor.

### Student Engagement

Students at Winona Area Learning Center and Winona Senior High School become increasingly active in the development of ideas and planning of projects. The Winona Area Learning Center students are passionate environmentalists who have studied practices to reduce their carbon footprint and completed a habitat restoration project at their school.

Environmental Club and Studies students participated in a number of field trips to increase their understanding of environmental issues. They organized Earth Day activities to spread knowledge to peers and teachers at Winona Senior High. Students led the survey to determine which environmental projects were most popular with the rest of the student body. They have worked to increase use of reusable water bottles in the school and supported School Nutrition's Farm-to-School program.

### Educational Benefits of System

An online computer tracking system will record the energy intake of both solar panel projects by the end of summer 2011. The Winona Area Learning Center displays information about the geothermal project to visitors and students. Educational displays are planned for the solar panel projects at Winona Senior High School. The Environmental Club will develop a curriculum to share with other students for fall 2011 about the solar panel projects.

### Energy Efficiency

Winona Area Public Schools is currently in the process of conducting a facility analysis for all school buildings. The preliminary report outlines a number of opportunities to increase efficiency and reduce overall use of energy. An engineering study will determine the impact of projects from the report. With this information, the school district will continue to incorporate energy reduction and move to renewable energy when appropriate. District staff and students will continue earth-friendly practices as simple as turning off lights, recycling and biking to school.

### Looking Forward

Students are constantly developing ideas to reduce their own carbon footprint and the school's. At Winona Senior High School, the Environmental Club is the conduit for student action along with the Environmental Studies class. Science teachers are looking to incorporate an Advanced Placement Environmental Studies course as an elective course for the many students serious about making a career in the area.

The next renewable energy project needing funding in Winona Area Public Schools is a solar thermal system. Both Winona Middle School and Winona Senior High School include pools requiring large amounts of energy to heat. A solar thermal system would reduce use of fossil fuels and reduce the expense to taxpayers.

Photo by Winona Public Schools

## 5.5 Glossary of Terms

**Commissioning:** The process whereby mechanical and electrical equipment, such as a renewable energy system, is brought into service at the end of construction. Commissioning procedures ensure that the equipment is operating as designed.

**Construction documents:** Construction documents are a set of plans that specify in detail how a renewable energy system will be constructed and what materials will be used. Construction documents are first used by contractors to develop accurate cost estimates and bids for system construction, and then they are used to guide the actual construction.

**Double-Walled Heat Exchanger:** A plumbing component that allows for the transfer of heat from one fluid to another without direct contact of the fluids. In solar thermal systems, heat exchangers are used to transfer heat from antifreeze and/or un-pressurized solar collector piping to the pressurized, potable water system. A double-walled heat exchanger has two layers of barrier material (usually metal) between the antifreeze and the potable water, with a drainable air space in between, that allow for the detection of a fluid leak if it occurs. Double-walled heat exchangers are a plumbing code requirement for solar hot water heaters in Minnesota if antifreeze is used in the system.

**Islanding:** A hypothetical situation that could occur with a grid-tied renewable energy system during a utility power outage. When islanding occurs, the renewable energy system has kept producing power during the outage and delivers the power back on the grid, thus creating an "island" of energized wiring that pose a threat to utility crews making repairs. In practice, grid-tied systems are connected to the utility grid through special inverters that have "anti-islanding" controls that disconnect and shut-down the renewable energy system in the event of a utility outage. This is why grid-tied solar electric systems do not continue to work during a power outage.

**Inverter:** An electronic device that converts direct electric current (DC) (such as that coming from batteries or photovoltaic panels) to alternating electric current (AC). In a grid-tied renewable energy system, the inverter also conditions the power for compatibility with the grid and disconnects the renewable energy system from the grid in the event of a power failure.


Photo by Able Energy Co.

**Micro-Inverters:** Convert direct current (DC) produced by the solar system to alternating current (AC). The electric power from several micro-inverters is combined and sent to the consuming devices. Micro-inverters contrast with the conventional "string inverter" devices, which support a large number of solar panels connected to single inverter. The principal advantage of micro-inverters is that shading of any one solar panel, or a panel failure, does not disproportionately reduce the output of an entire array.

**Public bidding:** Also called open bidding. A process usually used in construction projects involving public funds whereby the project specifications (usually in the form of construction documents) are made available to all qualified firms for competitive bidding. There are usually specific legal rules about how the information is provided, how the bids are to be submitted and the criteria for selecting the winning bid.

**Poly Amorphous Silicon:** A type of photovoltaic panel made with silicon in multiple smaller crystals (polycrystalline) or even many microscopic crystals (amorphous). Amorphous silicon can be created in a very thin film layer that allows the construction of flexible photovoltaic panels.

**Watts peak capacity:** Often labeled Wp, the watts peak capacity of a photovoltaic panel indicates how much electricity the panel will produce under standardized temperature and solar radiation conditions. In some cases, entire photovoltaic systems with many panels are given an overall peak capacity rating in kilowatts peak capacity (KWp). A kilowatt equals 1000 watts.

## 5.6 Resources

**www.willmar.k12.mn.us/middle_school/content/solar-panels**
Willmar Middle School

**www.solar-rating.org**
Solar Rating and Certification Corporation

**www.smallwindcertification.org**
Small Wind Certification Council

**www.ul.com**
UL Corporation

**www.jimdunlopsolar.com/vendorimages/jdsolar/PVInspectionChecklist.pdf**
A comprehensive check list for solar electric system commissioning and functional testing

**www.akvedukt.net/manualer/uppstart_manual.pdf**
A comprehensive check list for solar thermal system commissioning and functional testing

**www.nabcep.org**
North American Board of Energy Practitioners - Independent organization that certifies site assessors, installers and other renewable energy professionals

**www.ISO.org**
International Organization for Standardization - Organization that sets international standards for many things, including energy efficiency and environmental safety