Getting the Most out of School Power...Naturally – How to Encourage Solar Education in New York State and Beyond

by Judy Jarnefeld

Sixth grade teacher Candy Dolan peers out the classroom window at Bethlehem Middle School as the early morning mist burns off. "Today the kids will be learning how photocells work," she explains. With just a few weeks to go before the ribbon-cutting ceremony she's planning for the school's new solar equipment, she wonders aloud how it will all get done in time. "If all goes well, we'll have the kids at the event talking about what they learned while wearing the *School Power...Naturally* T-shirts they made."

Figure 1. Students at Bethlehem get some fresh air while learning to relate time to the movement of the sun.

The *"School Power....Naturally"* she refers to is an innovative $2.1 million program from the New York State Energy Research and Development Authority (NYSERDA) designed to educate New Yorkers about energy, and, in particular, the role solar electric power – photovoltaics, or PV – can play in providing clean, reliable energy for our homes, schools and workplaces. Each of fifty schools, which were competitively selected in 2002, was awarded a 2-kilowatt (kW) grid-tied PV system, including features to collect and display data that link the hardware to lessons in the classroom.

Students in fifty New York schools are learning hands-on how PV works, but the program doesn't end there. **All schools across the state and elsewhere** can fully participate in the educational components of *School Power...Naturally* by using the curricular materials and data that are available on www.SchoolPowerNaturally.org free to all. In fact, the program has already enabled solar-powered schools in India and Germany to reach out to New York classrooms for pen pals and more.

Education is the heart of this program. A broad range of multidisciplinary materials -- created by professional curriculum writers -- meets Math, Science, and Technology learning standards for New York State students in grades five through 12. Lessons describe creative, interactive, and age-appropriate ways for students to learn more about the Sun and solar energy.

Figure 3. One lesson uses these photos from 1919 and 1981 (reproduced with permission: © The Field Museum, Chicago) to illustrate how acid rain can damage a statue. The lesson ties in data on "avoided pollution" from the PV systems.

Teachers can use them to build on students' knowledge and skills not only in science and technology, but also challenge them with lessons in disciplines such as language arts ("A Solar Brochure"), civics ("Prospects for a Sustainable Energy Future") or social studies ("Permit Trading"). There is even a Biology lesson called "Temperature and the Tomato" that talks about different varieties of tomato and how one might grow better in your area than another. It relates solar insolation data generated by the project to geographical hardiness zones. Each lesson describes which specific NYS learning standards it addresses, and many lessons directly integrate the data available from the fifty PV systems.

With sixty lessons to choose from, schools have lots of opportunities to foster creativity. By using interdisciplinary teams that cross grade and school boundaries, McGraw Central School District intends to provide instruction that flows seamlessly from 6th grade elementary school science right into 7th grade middle school technology education.

Figure 4 Some solar kit lessons only need one mini-panel per classroom, others need up to eight. At Colonie Central High School, these panels can be used for projects kids love.

Some teachers are using small PV demonstration kits (developed by NESEA) and the 15 kit-oriented lessons to provide hands-on instruction in their classrooms. The kit directions found on the website are simple enough for teachers to order components and assemble setups themselves. According to John Pinto, McGraw elementary school teacher, "These kits are high quality and I intend to get additional solar panels so we can share with the middle school more easily."

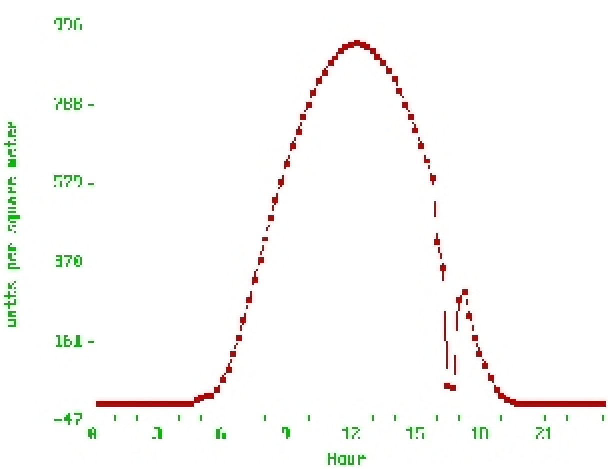

Figure 5. Solar irradiation data on a nice sunny day plots a bell curve over 24 hours, clearly showing dawn and sunset.

Instrumentation and educational software hooked up to the PV arrays at the fifty schools work in concert to generate computerized, up-to-the-minute performance data. Information is displayed in each school's computer system so students can monitor the performance of their own system in real time. The most ***exciting*** feature of the program, however, is that data for each school is posted on a public website according to 15-minute averages. This means ***any school*** in New York (or anywhere in the world) can log on and use the data from any or all of the fifty schools, either by itself, or in conjunction with the curricular materials. Jim Donnelly of James A. Green High School in Dolgeville and 2003-2004 National Principal of the Year says, "Teachers and students in my whole district look forward to comparing the data from our system with the data from other schools, both those nearby and farther away. Even when they are not involved in a formal lesson, the kids will enjoy watching how the numbers show weather patterns passing overhead or sweeping across the state."

Figure 6. Darrow's Samson Environmental Center, where their PV system is located along with an ecological wastewater treatment system, provides unique hands-on learning opportunities to Darrow students and over 400 visitors each year.

Teachers exposed to both the curricular materials and features of the data collection system are charged up about bringing new lessons to their students. Craig Westcott, co-director of Darrow School's Samson Environmental Center and Solar Coordinator says, "As the ethic of sustainability grows stronger in our community, the culture of the School becomes increasingly committed and dedicated to this cause. The PV and data acquisition system, the curricular materials available through *School Power…Naturally*, and the Center are robust modern technological enhancements for our school that, since its inception, has been dedicated to extending the Shaker legacy of care for the land through hard work. We envision many creative ways in the future to increase our utilization of solar and other alternative energy sources and to continue to integrate sustainability into the educational fabric of our school."

***School Power...Naturally* can breathe life into communities.** The fifty schools chosen to receive PV systems are in cities, towns, and villages scattered throughout the state, so there is a good chance there is one near most New York residents. Each one will incorporate solar energy and the equipment they receive into educational planning and community outreach. These catalytic schools, already proven to be willing to get involved in solar energy education, are becoming hotbeds of community interaction. For example, Joe Timm, a teacher at Our Lady of Lourdes High School in Poughkeepsie, reaches out to fellow members in his local community group 'Sustainable Hudson Valley,' encouraging their natural interest in solar energy.

Figure 7. At the 2003 North Country Sustainable Energy Fair, interested members of the public compared weather parameters and performance data side-by-side from Canton and Beaver River, two schools in neighboring counties.

A Solar Coordinator, typically a teacher or building manager, volunteers as an on-the-ground worker to encourage interdisciplinary learning and hosts open houses, ribbon-cuttings, installation tours, or workshops where members of the public learn how they, too, can "go solar." Last spring, Solar Coordinators at Shaker Senior High School in Latham and Dryden Junior-Senior High School hosted half-day workshops that together attracted more than 150 people. The take-away message at such events is that solar education is not just for kids! Photovoltaic solar energy can help power your home, farm, or business.

Sister Joan Gallagher, Solar Coordinator for St. Francis of Assisi in Brooklyn, says, "The state of our Earth is at a critical juncture. There is a great need for us to 'unlearn' some of the ways we live on our precious planet and to educate ourselves in more sustainable practices. *School Power...Naturally* is all about learning and has the potential to go beyond state learning standards. It can prepare students (and adults) to regain an intimacy with the natural world. The ability to invite families, neighbors, business owners and civic groups into a school to learn about the power from our sun can have a tremendous impact on an entire neighborhood. To witness how solar energy can be used in such a mutually enhancing way holds the possibility of brightening any neighborhood! By reaching out beyond one's school will help bring about the day when talk of solar energy goes from being an alternative energy source to being one of our essential energy sources." She goes on to urge, “Any school could designate their own Solar Coordinator to organize events and energize teacher teams.” Many schools plan to contact their local rotary clubs, museums, community colleges, or weather departments at TV and radio stations, seeking their involvement.

Figure 8. Computer-based activities are one way to link schools and other organizations together.

“My school doesn’t have solar equipment, but I’m not letting that stop me.” This can-do attitude is exhibited by Sassa Letton of The Susquehanna School in Binghamton, “Solar Buddy” to Spencer Van Etten Middle/Senior High School. These two schools are forging ahead with plans to work together. By partnering with nearby solar-powered schools, Solar Buddies without their own PV equipment are spreading solar education throughout entire regions -- forming solar clubs, exchanging information, and conceiving new ideas for outreach and learning. Solar Buddies statewide are planning visits to solar-powered schools for tours or activities such as the Junior Solar Sprint, which is a model solar car curricular event and annual competition for middle schoolers.

The systems are sophisticated. Students are exposed to the workings of a 2-kW PV system, sized for its suitability as an educational tool; such a system can meet about 25-30% of the energy needs of a typical home. The system itself includes solar panels, an inverter that converts the DC power from the solar array to the AC power the school uses, and a sophisticated but teacher- and student-friendly data collection and monitoring system. Besides the real-time software for the classroom, and the internet-based database and plotting software, there are sensors that measure electricity in kWh, DC current and voltage coming from the solar array, current and voltage in the converted AC power going into the school’s electrical system, ambient (outdoor) air temperature, temperature of the solar

Figure 9. The sensors collect data for uploading to the web.

panels, wind speed (anemometer), and solar radiation (pyranometer). The data is automatically analyzed to display daily and cumulative electricity generation. An "avoided emissions" feature shows students how much of certain air pollutants *would* have been emitted had the electricity from the systems been generated by the typical energy mix of power plants in New York.

It's easy to get involved. You can help us spread the word and improve our program. Consider becoming the Solar Coordinator at your school. Give us feedback on how specific curricular activities work in your classroom so we can improve lessons as needed. There are lesson review forms on the website, and we'll be updating the lessons according to that feedback. Or, give us new ideas such as more ways to use the data we are generating. For example, can you think of ways to compare data from five different schools? Or a creative activity that shows how the output changes as clouds or rainstorms pass? Let us know!

School Power...Naturally is a work in progress. Almost all of the fifty schools are outfitted and wending their way through various approval stages before the equipment can be turned on. As of Fall 2005, the website is displaying data from more than half of the schools, but the rest will be added throughout the winter. As the program grows, more schools are inquiring about how they too, might receive PV systems. Although the special deal the pioneers got is now over (each system cost about $24,000; each school contributed $1,500 of that), if you are interested in generating solar energy at your school, other programs can help. For instance, in New York, NYSERDA incentives reduce the cost of a PV system by about 50%.

Figure 10. *School Power...Naturally* used installers eligible to receive the NYSERDA incentives. Related efforts at NYSERDA help grow all PV markets through training and certification programs for installers.

No matter what kind of school building you have, there are installations to accommodate different roof types. For example, Tabernacle Christian Academy's system in Poughkeepsie was installed flush to a sloped roof, Carthage Central High School's was put on a flat roof using weighted ballast trays, and Armstrong Middle School's in Ontario Center was mounted on a wall like an awning. Wayne Technical and Career Center BOCES in Newark had their system pole-mounted on the ground. Whether or not your school has its own PV system, there is a lot that can be learned from *School Power...Naturally.*

Figure 11. Warwick Valley High School's awning mount.

Why not create your own solar school program?

NYSERDA has not traditionally been involved with education of schoolchildren. Because education was new to us, we surveyed schools to find out their needs and wants. Though results indicated schools were quite interested in solar education, they couldn't afford the full cost of 2-kW PV systems – the most common response was that they were willing and able to pay about $2000, an amount attainable through fundraisers like bake sales. We originally estimated that the PV systems would cost about $20,000, though the true cost averaged closer to $24,000. The results were then used to develop *School Power...Naturally*.

Do's and Don'ts: NYSERDA's program is becoming more and more successful but we learned a lot along the way. If you are developing a solar school program for your own region, our experiences may help you avoid mistakes. A few general points and then more detailed comments follow.

- Most importantly, provide a comprehensive, interactive and fun program that includes not just PV systems on schools, but also meaningful data monitoring, use of data in curricular materials, teacher training, and community outreach. This approach could help your program have staying power long after the funding is gone.

- Use our RFP and school application as starting points to your program.

- Consider phasing in a pilot program before launching the full, ambitious effort. Confirm all design, engineering, regulations, and approvals. Then inform remaining schools of any subsequent changes.

- Feel free to direct teachers to use the curriculum and website we developed. The website lists all kinds of links to general solar information as well as specific links to solar school programs in other states.

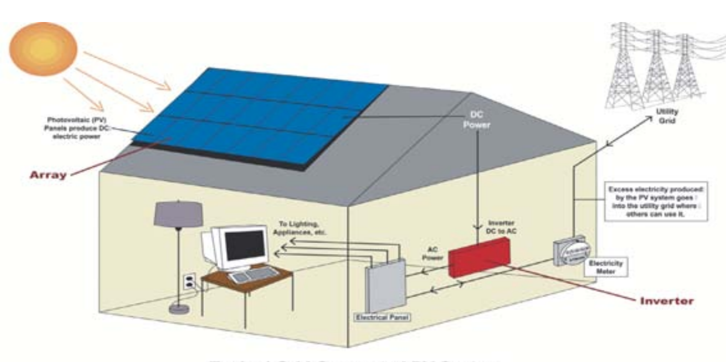

Figure 12 This educational diagram of a house was made into a poster that was distributed to schools.

Manage school expectations. It doesn't matter what you said -- what matters is what the schools thought you meant. The biggest mistake we made was leading schools to believe that all 50 schools would be installed with PV equipment in the first year, and all costs would be covered except a $1500 school contribution and travel or substitute teacher costs associated with the required teacher training. Neither of these was completely accurate; the first installation was not completed until a year later, and schools bore an astonishing variety of unanticipated costs, though some were self-imposed.

Figure 13. There's no array here. The roof of St Francis of Assisi posed a design challenge, so it will be among the last to receive equipment. The wait was worth it since we successfully avoided the need for an expensive steel cradle installed with cranes.

A clear and well-articulated application can help avoid this kind of confusion and disappointment. Try to list everything the school will need to do, not only at application time but also later, during the program. Describe specific documentation they are expected to provide, cooperation and signatures needed from various personnel (including administrators, facility managers, computer managers, and teachers), maintenance training, teacher training, and equipment such as a dedicated and preferably new computer.

Clear and fair selection criteria are also a must. It is possible technical issues will prevent some schools from participating. Don't promise them inclusion until an on-site technical evaluation is done. (Though even this procedure is not foolproof – some structural problems are well hidden, and not all schools can accommodate alternate locations.) Choose a number of back-up schools, but keep that confidential. In our case, we chose to provide additional financial help to keep some schools in the program, but we still replaced one school when they lost interest in participating.

Finally, create a sensible time line, and remind schools they can't all be first.

Don't rush the application process or installation schedule. Schools have their own culture and unique schedule. For example, every year, some schools take computers offline in August for software upgrades. Then, back-to-school is crunch time. Summer school staffing is different so it can be hard to contact the right person. Timing your requests for information can be tricky; give schools too much time to sign a form, and you risk sinking to the bottom of their to-do list, too little and you delay progress while you wait for them to catch up. Schools often need to get permission from their board for expenditures, so give some thought to not only the time of year the application is due, but also to the amount of time you give schools to respond. Finally, remember that schools may need time to get multiple layers of approval beyond the school board, including the State Education Department.

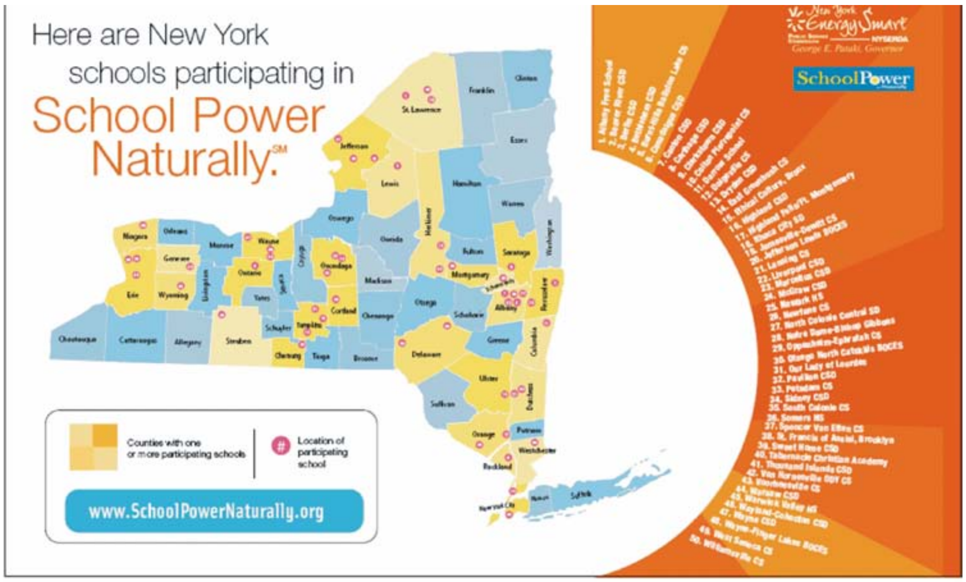

Figure 14. The fifty schools with PV equipment are scattered across the state.

Select schools equitably. New York State has more than 700 public school districts, and our program could fund only 50 schools, so a first-come first-served program did not seem appropriate. The application process we developed considered a variety of criteria including geographic distribution across the state, age of the students at the site, and demographics. Eligible schools were public or private, “System Benefits Charge” ratepayers, and contained grades five or higher. Only one public school per district could apply, (controlled by requiring the district superintendent’s signature). The most emphasis during selection, however, was given to variables that schools could directly influence; each application included an essay that described the school’s interest in the program, and their plan for action in the school, district, and greater community.

Explain school responsibilities up front. As part of *School Power...Naturally*, schools get to use and own their system once the installation is complete (Installations took 2-4 days). However, schools have responsibilities too. The most obvious is the $1500 school contribution. (Note: school contributions were reduced from $2000 to $1500 through dedicated funding from cosponsor AMERESCO.) Requiring each school to pay something for their system may help them value it. If some schools find a modest cash contribution to be a hardship, funds can be set aside to aid them.

In order to ensure that the panels will actually work as intended and become reliable demonstrations of PV technology, train on-site personnel in routine maintenance and simple troubleshooting. Consider requiring long-term maintenance contracts.

Involve all relevant school officials up front, and get their contact information on the application. We required signatures of not only district superintendents on our applications, but also the principal, facility manager, and "Solar Coordinator." Each school appointed a Solar Coordinator as the primary contact, who was often a teacher but sometimes a building manager or principal. At first we contacted only the Solar Coordinator for all engineering, technical, legal, financial and educational issues, but we later learned to rely on the Principal or Superintendent for issues requiring legal or other authority. In retrospect we should have also required signatures of both the computer manager as well as the specific facility manager in charge of the electrical room.

Figure 15. The inverter and related equipment are installed in a secure electrical room.

Commissioning of the software goes more smoothly if the computer manager is required to attend during software installation, but this will not prevent post-commissioning issues, many of which can be very site-specific. (Examples include network settings configurations, trouble during the switch to daylight savings time, resetting screen image sizes, poor back-up procedures, etc.) Provide a software manual and develop a Frequently Asked Questions list to help address possible firewall or networking issues. Address Mac vs PC issues. Be prepared to buy software for schools using outdated "legacy" programs and operating systems. Have installers mount a small sign on the server computer to prevent school staff from turning it off at night or worse, over summer vacations. Install an uninterruptible power supply. As for non-technical issues, snow on the roof shows up pretty clearly in the data – consider developing a procedure to identify this situation and ask schools to remove it. Also expect turnover in school personnel and realize that familiarizing new staff with the program can affect administration costs.

Prepare schools for the possibility of unidentified costs. Though it seemed obvious to us, our application form did not specifically state that schools would need a dedicated computer. Some schools didn't have one to spare. In addition, there were a number of other unanticipated documents required for approval of installations. For example, we needed a letter from the roofer regarding the effect the PV system had on the warranty, a letter addressing whether asbestos would be disturbed during installation, a letter stamped by an architect or engineer indicating the roof could sustain the required weight (even though the application addressed the loading weight), another letter to the State Education Department approving the exact location and mounting style (in some cases stamped by professional engineers), and a letter for the utility indicating a 24/7 emergency contact. Some of these letters were costly for schools.

Figure 16. There are many inexpensive ways to teach students about solar energy. Tape measures can help show how the length of the sun's path changes over a year's time.

Be ready for unexpected cost hikes. Don’t fret over outside influences beyond your control, but do plan for them with both extra time and a contingency fund equal to at least 10% of the budget. In our program, suppliers went out of business, markets for solar energy picked up dramatically, which made panels hard to get at agreed-upon costs and schedules even with signed long-term purchase agreements, installers dropped out of the program at all stages, contracts expired and had to be renegotiated, and insurance costs for small businesses like installers skyrocketed. Though the majority of subcontractors were honest, one wangled advance “hardship” payments and then performed poorly.

Realize that schools are not residences. Special rules and situations unique to schools can cost more than predicted: approvals requested or required by local education boards or state education departments, urban considerations such as use of cranes, local building codes, historic building reviews, design issues such as allowing for a longer distance between the array and the utility room, prevailing wage rates, worker requirements for school access, less-accessible installation locations, and even 100-year-old wiring. These all add cost.

When it comes to interconnecting the school PV systems to the electrical grid, standard interconnection rules developed for homeowners in New York do not apply. Utilities charge interconnection fees that differ for each utility and even for different schools within same utility. Though we knew this, the systems we installed were 2 kW, a size commonly found on homes, so there was some hope for comparable treatment. Greater high-level utility support and involvement in early planning and design may have helped our case; public relations and marketing benefits from solar school programs can be substantial. As program familiarity has grown at the utilities, so have positive results. Processing times have shortened, forms and inspections are more routine, fees are more standardized, and in some cases a softer stance has been allowed on technical issues such as outside disconnect switches.

Schools should understand publicity expectations. Delineate both what publicity procedures you expect from the school, as well as what the school should expect from you. Provide press release templates that describe the overall program, and explain when and how to use them. A time line can be used to explain clearly how installation and interconnection differ, and that publicity is more effective after the latter. Develop procedures for invitation of officials and media to publicity events. Require schools to prepare photos to provide to the media along with the press release. Consider requiring schools to sign a publicity clause as part of the application process.

Figure 17. Colorful brochures and other materials help promote the program.

Gear outreach and marketing material to the audience. As the program progressed, we chose to focus most of our marketing on teachers, rather than students or their parents. Although student-based giveaways like bookcovers, rulers, and pencils can be a big hit, we may have made a more lasting impact with the curriculum CDs we distributed to hundreds of science teachers, student teachers, and home school instructors, as well as the educational kits we gave to a smaller group. Although the materials are all available on our website, teachers seem to strongly dislike downloading, perhaps because many are hampered by slow modems. Educational posters are also useful for schools to display in lobbies.

On-going communication is essential. Do plan on monthly telephone conferences among team members. Document do's and don'ts in your own program in monthly reports, because someday you may want to use what you learned to expand your program. Though at that moment it seems you will never forget the hot-button issue of the day, when a new problem arises and the old one is solved it is easy to forget what you have learned.

Also keep schools as informed as possible. We email a newsletter to Solar Coordinators, Principals, and Superintendents at the 50 schools. Because it was cumbersome for us to send an email to large numbers of people, and we did not expect the demand for it, we compromised by directing additional teachers, parents and interested public to the website to read past issues. A direct emailing of a newsletter to all interested parties, however, may be better because it could increase the chances that you get valuable feedback. In our program, getting teachers to pilot lessons and provide feedback has been slower than anticipated.

Allow room for an evolving program. A data set from fifty schools is a huge resource.

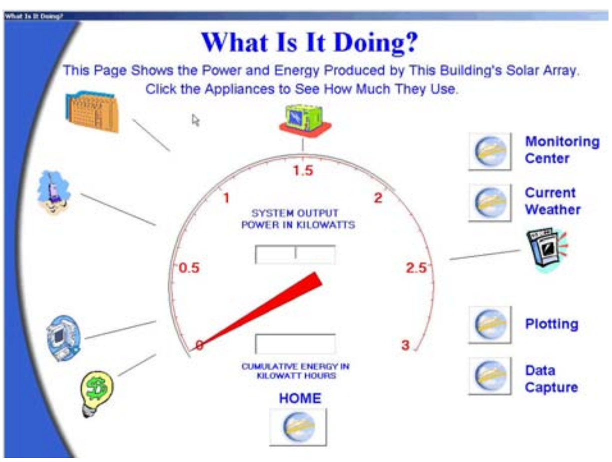

Figure 18. Meters on the graphical interface at each school move in real time as the inputs change. The "speedometer" and "odometer" illustrate 1) that meters can have more than one application and 2) how speed and distance have the same mathematical relationship as power and energy – a concept that can be taught quantitatively, (cut out the area under the curve and weigh it) algebraically, or with calculus.

But, since our curriculum was written before any of our PV systems were up and running, the writers did not have a chance to work with the graphical interface for the data monitoring system. In the future, improved lessons could be geared more directly to the data. Data could even be layered with geographical information through use of GIS software. Still, even without formal lessons, some concepts can be taught with the existing setup. For example, aggregated data from all 50 systems can be used to lead classroom discussions about the meaning of emerging concepts such as distributed power generation or "virtual power plants." Conservation of energy, an important concept, can be demonstrated by comparing ambient and module temperatures. Modules are hotter than ambient air during the day while running because they are converting some of the incoming energy to power and some to heat.

Thank you's count. A multifaceted program like *School Power...Naturally* requires extensive coordination. As a final word of advice to those hoping to start a solar school program, remember to publicly thank key players, both those on the team as well as in the schools and communities. Their dedication makes it all possible. Special thanks for *School Power...Naturally* go to: all of the Solar Coordinators and Solar Buddies, Solar Works, Inc. (overall management and installation), Heliotronics, Inc. (data instrumentation and educational software), The Research Foundation of the State University of New York (curriculum development and teacher training), The Northeast Sustainable Energy Association (classroom kit), AMERESCO, (supplemental funding), Creighton Manning Engineering (administration), the equipment installers, teacher trainers, and regional outreach coordinators. Many thanks of course also to lots of other teachers, administrators, facility managers, and school staff, as well as the New York State Department of Education, the electric utilities, and all of the people in the communities that helped this program happen.

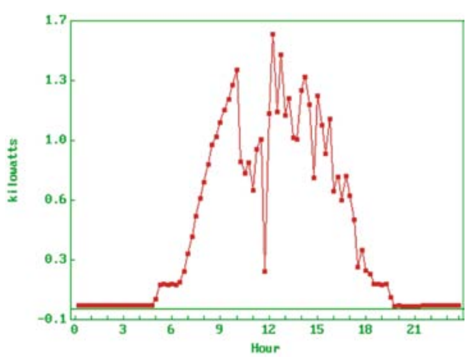

Figure 19. Power output fluctuates but is still significant as heavy clouds and perhaps a downpour take place at one school.

Parents learn from kids, and kids grow up to become consumers. Campaigns to help stop smoking, stop littering or encourage seatbelt use all led to behaviors that became social norms because kids taught their parents new paradigms. With *School Power...Naturally*, we hope kids will show their parents that solar energy is a viable choice for New York State. People who associate solar power with warm, sunny states like New Mexico or Florida may not be aware that a hot day is not required, and in fact PV works best on cool, sunny days. The combination of enough sunlight, relatively expensive electricity, and incentives from NYSERDA makes New York one of the best states to invest in PV.

Solar energy is becoming more mainstream. *School Power...Naturally* and teachers everywhere can help make this happen, in New York State and beyond. It's all part of NYSERDA's commitment to help New Yorkers learn how to use the power of the Sun at school and at home.

Portions of this article were adapted from a feature that appeared in the Fall 2004 issue of Northeast Sun. NYSERDA welcomes your thoughts and inquiries on School Power...Naturally and our solar incentives. Contact us at PowerNaturally@nyserda.org