2006-2007 Solar for Schools
LCRA Final Report
January 2008

Executive Summary

In October 2006, LCRA contracted with the State Energy Conservation Office (SECO) to deliver LCRA's second phase of the Solar for Schools program. Under this contract, LCRA and 12 of its sponsoring wholesale electric customers supplied fourteen 1 kW photovoltaic (PV) systems, web-based monitoring, TEKS-aligned renewable energy curriculum and training to school districts across Central Texas, as well as community outreach support. The program raised awareness about renewable energy in rural Central Texas, small public utilities, and within LCRA. It assisted school teachers by bringing real-life applications of solar energy technology into the classrooms in a way that is aligned to state educational standards.

Over the contract's timeline (Oct. 2006 – Dec. 2007), LCRA worked hard to deliver the program in the most efficient and effective way possible. At times, innovation and amendments were needed to fulfill contract obligations. Program costs were high and enrollment was more difficult than expected, but LCRA successfully met its contract deliverables. The program even received national acclaim by receiving the 2007 Interstate Renewable Energy Council's (IREC) Innovation Award. In short, the 2006-2007 Solar for Schools program achieved its mission of bringing educational value and renewable energy awareness to rural communities throughout Central Texas.

PV System Design and Installation

LCRA contracted with Meridian Energy Systems to design, purchase, and install 14 photovoltaic (PV) systems. After a competitive bid process, LCRA selected Meridian Energy on the following criteria (in order of weight):

- Quality and approach of system design in order to meet technical specifications requirements;
- Ability to meet project schedule;
- Safety procedures and record;
- Pricing; and
- References.

For sake of simplicity, the systems' design was standardized for all fourteen sites. Meridian's description of their system design is detailed below.

Each system consisted of six Sharp 170-watt modules mounted on one DP&W top-of-pole mounted rack. The array output feeds DC power to a SMA Sunny Boy 1800U DC to AC inverter. The summary of the system's major components follows:

- Total array size (DC STC rating) = 1020 W
- Array Tilt = 35°
- Module Type = Sharp 170

- Quantity = 6
- Modules per Series String = 6
- Inverter Manufacturer = SMA SB1800U
- Inverter Rating, kVA = 1800

The Sharp modules were series connected into a single string with sufficient voltage to run a grid interconnected inverter, even under high ambient temperature conditions. Features of the Sharp 170-watt modules include:

- High power per module;
- Poly-crystalline silicon cells with 13 percent module conversion efficiency;
- Nominal 24Vdc output requiring fewer modules in series;
- Tempered glass and anodized aluminum frame for extended outdoor use;
- A 25-year manufacturer's warranty; and
- UL 1703 listed.

The SMA 1800 kVA grid-tie inverter was chosen for it low DC input voltage requirements, as well as its 120Vac output. Using an inverter with 120Vac output was deemed essential to the successful implementation of this project. The operating voltage allows the inverter to be attached to any available service, whether 120/240V split phase or 120/208V three-phase. The DC input range of the SMA SB1800U is 156-400Vdc, which will work optimally with the array all year long. Features of the SMA SB1800U include:

- Peak inverter effiiency of 93.6 percent;
- NEMA 4X stainless steel enclosure;
- Low start-up voltage and wide operating voltage range;
- 120Vac output that works with any standard service;
- A five-year manufacturer's warranty; and
- UL 1741 listed for grid-interconnection.

The arrays were mounted on a top-of-pole mounting rack manufactured by DP&W. The rack is designed specifically for six Sharp 170 modules. The racks were mounted atop a six-inch schedule 40 pole. PV modules were supplied with factory-fabricated frames for longer life and greater module strength. Top-of-pole mounting was chosen for the following advantages:

- Higher energy capture – Simply by facing the sun more directly, an optimally tilted array captures more energy.
- Cooler operating temperature – A pole-mounted array allows natural convection to cool the array, allowing modules to

operate more efficiently and increasing the equipment lfe.

- Easy access – This mounting appraoch allows easy access to the solar modules for maintenance, repairs, or educational tours.
- High visibility – Pole-mounted arrays are generally superior to commercial roof-mounted arrays in terms of visibility for educational purposes.

The Sharp 170 modules were supplied with USE-2 conductors with Multi-Contact Quick Connect plug-and-play connectors. Meridian supplied additional USE-2 sufficient to wire the PV array feeder wires into a pole-mounted PV transition box. This transition box is NEMA 4-rated and located out of reach of unauthorized personnel. Inside the box, the USE-2 conductors transitioned to THWN-2 conductors in conduit. All C feeder wires were rated for 90 degrees Celsius. The transition box further facilitates the safe operation and troubleshooting of the array by providing easily accessible test points.

Wiring from the array to the inveters was in three-quarter-inch RMC or three-quarter-inch EMT as required by the application. RMC was used in all trenches, allowing for a shallower trench that would less likely damage existing underground elements. A 30 amp DC disconnect switch rated for 600V DC was provided at each inverter scaffold. Meridian provided all the PV interconnect wiring, DC feeder wiring, inverter scaffold wiring, and AC wiring to the point of interconnection. All DC and AC disconnects were also provided, as well as the interconnection breakers for all locations.These components were installed according to the stamped engineering drawings.

The electrical installation conformed to applicable local and 2005 National Electrical Codes. Upon Meridian's completion of work, LCRA electrical inspectors deemed all systems safe for operation.

PV system performance is influenced by a wide variety of factors including system installation practices, wire sizing, weather conditions, inverter loading, orientation towards the sun, available sunlight, etc. As such, the system's output cannot be predicted with absolute accuracy. The forecasting model used for system design purposes included these factors and showed the annual AC output of each system to be 1,382 kWh or a combined AC output to be 19,348 kWh per year.

The twelve participating schools included:

1. Bastrop Intermediate School (Bastrop County)
2. Brenham Intermediate School (Washington County)
3. Flatonia Junior High School (Fayette County)
4. Harper School (Gillepsie County)
5. Hempstead Middle School (Waller County)
6. Kendall Elementary School - Boerne ISD (Kendall County)
7. Lampasas Junior High School (Lampasas County)
8. Llano Junior High School (Llano County)
9. Luling Junior High School (Caldwell County)
10. Manor Middle School (Travis County)

11. San Saba Middle School (San Saba County)
12. Waelder Intermediate School (Gonzales County)

Two non-school locations included:

13. McKinney Roughs Natural Science Learning Center (Bastrop County)
14. San Marcos Electric Utility Office for SMCISD (Hays County)

Based on the success of the 2005-2006 program, we originally expected fifteen of our wholesale customers to sponsor school sites during the 2006-2007 program. However, only eleven initially enrolled in the program. One of those, Bluebonnet Electric Cooperative, sponsored two school sites (Bastrop and Manor), which brought program participation to twelve sites. To fulfill our contract obligations of fourteen, we enrolled two alternative sites, the City of San Marcos' Utility Office and LCRA's McKinney Roughs Natural Science Learning Center. Both of these hold great potential to reach thousands of community members with the program's renewable energy message. SECO agreed to this amendment under the contingency that each site develop a detailed action plan that incorporates the renewable energy education materials into area schools.

Web-Capable Data Acquisition Systems

Each system uses a SolTrex datalogger for real-time monitoring. The performance results are available to students and instructors via the internet at www.soltrex.com. Teachers received training on how to navigate the web site and how to use it as a hands-on learning tool for their students.

To date, the SolTrex web-based monitoring system shows a combined total output of 11,439 kWh since monitoring began; offsetting the emissions of 15,930 lbs of carbon dioxide, 69 lbs of sulphur dioxide, and 34 lbs of nitrogen oxides. This recorded amount is less than the projected output because several of the data loggers experienced problems sending information to the SolTrex site. Factors at play included:

1) No internet connection. After speaking to a network technician, Meridian deduced that a user identification and password for their proxy server may have been outdated. A new user identification and password resolved the issue.
2) An internal network component went down and some settings were changed. Reconfiguration solved this issue.
3) The wireless access point was unplugged, and thus not working. Simply plugging it back in fixed this problem.

Providing strong explanation and explicit instructions to school IT staff regarding the data loggers' connection helped minimize potential problems, but on-site troubleshooting was also needed at times.

Documentation of Installation for Site Tours

The installation process for a top-of-pole mounted PV system was documented via digital photographs and reviewed during teacher workshops. Teachers received a CD of the photographs and the step-by-step installation process and were encouraged to become spokespeople for the technology during site tours. A summary of the installation process follows:

1. Site selection
2. System engineering
3. Dig post hole / trench conduit run
4. Install post / run wires
5. Mount rack / install modules
6. Mount solar equipment / pull wires
7. Make final connections / test system
8. Final inspection

Pre and Post Installation Surveys

Each teacher completed a pre-installation survey before receiving any training. Survey results showed that most science teachers have a basic knowledge of renewable energy in general and a weaker understanding of PV technology and its applications. Non-science teachers lack even the general knowledge of renewable energy.

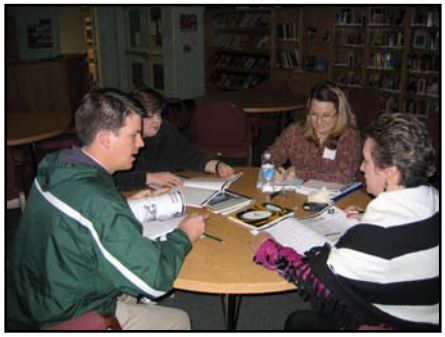
Post-installation surveys were distributed via email at a later time to the same group of teachers. These survey results indicated an overall increase in basic and technological knowledge of renewable energy systems and its applications. However, only ten surveys from five sites were returned. Sample pre-installation surveys are included as Attachment A and post-surveys as Attachment B.

Educational Materials, Teacher Training, and Action Plans for Non-School Locations

Each participating site (school and non-school systems) received four hours of teacher training, at which time the educational materials were distributed. Workshops were open

to all interested teachers within the participating school districts. Campus science teachers were in full attendance at each workshop. Other subjects represented were math, language arts, and curriculum directors/trainers. The materials are well-suited for language arts and social studies. The reading passages, vocabulary lists, discussion topics, and writing assignments are plentiful and very easy to incorpoarte into classroom activities. These subjects should be considered a natural fit with the program and promoted as such.

The workshops were very successful, in large part due to our increased understanding of the technology and renewable energy industry trends. Attending solar installation workshops and solar industry conferences over the past year improved our level of expertise, which better served the workshop participants. Our increased expertise also served as an excellent resource for community inquiries, which can be expected from this program. Teacher workshop summaries are included as Attachment C.



The two off-site locations (San Marcos and McKinney Roughs) developed detailed action plans to incorporate the energy education materials into area schools and education programs. San Marcos' plan is included as Attachment D and McKinney Roughs' plan is Attachment E.

Operation and Maintenance Training

Meridian Energy Services equipped each school with a binder that provides relevant contact information, copies of the stamped engineered drawings, PV system output projections, product specifications, troubleshooting instructions, equipment serial numbers, warranty information, and product manuals. Additionally, Meridian provided school maintenance staff with a suggested PV system manintenance plan and log.

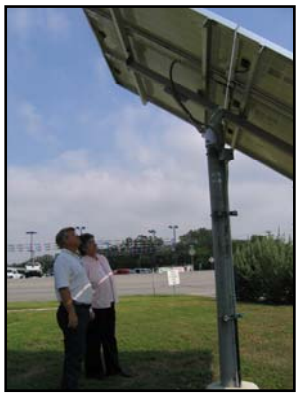
Community Outreach and System Tours

We worked closely with our participating wholesale customers to install sponsorship recognition signs for community awareness. Several of our participating wholesale customers hosted dedication ceremonies at the school sites once the systems were installed. Press releases that were timed to highlight program milestones were also helpful with community outreach. Sponsoring electric utilities and local newspapers included:

- Bandera Electric Cooperative - The Boerne Star (Kendall ES)
- Bluebonnet Electric Cooperative -The Bastrop Advertiser (Bastrop Intermediate)
- City of Brenham (Brenham Middle School)
- City of Flatonia – The Flatonia Argus (Flatonia Junior High)

- Central Texas Electric Cooperative – The Harper Newspaper (Harper School)
- City of Hempstead - Waller County News-Citizen and The Hotline Press (Hempstead Junior High)
- City of Lampasas (Lampasas Middle School)
- City of Llano - Llano News, Llano Buzz, and the Hill Country Highlander (Llano Junior High)
- City of Luling (Luling Junior High)
- City San Marcos – The San Marcos Record (SMCISD)
- City of San Saba -San Saba News (San Saba Middle School)
- City of Waelder (Waelder Middle School)

Teachers were also encouraged to become the school's spokespeople for the technology and its educational value. They received information on the system components and installation process, enabling them to further educate colleagues, parents, and community groups. Each workshop included a tour of the PV system, empowering teachers to replicate the tour during Open Houses, staff meetings, etc.



Installed Project Costs

Installed project costs are summarized below. Prices include all work outlined in LCRA's scope of work for Meridian Energy (superintendence, photovoltaic equipment costs, training, labor, permits, tools including heavy equipment cost, associative travel cost, supplies, machinery, materials, shop and field fabrication, documentation and any other tasks/materials/equipment necessary for the purchase and installation of (14) PV systems).

1. Bastrop Intermediate School = $18,190
2. Brenham Intermediate School = $19,430
3. Flatonia Junior High School = $19,470
4. Harper School = $19,460
5. Hempstead Middle School = $19,530
6. Kendall Elementary School = $19,390
7. Lampasas Junior High School = $19,380

8. Llano Junior High School = $19,360
9. Luling Junior High School = $18,230
10. Manor Middle School = $18,130
11. San Saba Middle School = $19,480
12. Waelder Intermediate School = $19,430
13. McKinney Roughs Natural Science Learning Center = $18,190
14. San Marcos Electric Utility Office (SMCISD) = $18,160

Program Benefits

For two years running, LCRA's delivery approach to the Solar for Schools program has earned an award. This year, the program was the recipient of the 2007 Interstate Renewable Energy Council's (IREC) Innovation Award, receiving national acclaim (Attachment F). Modeled after the successful first year of implementation (2005-2006), LCRA replicated many of the program's implementation steps. By enrolling our wholesale customers as sponsors for their community's installation, we received additional funds to cover the installations ($3,500 per PV system). This approach also benefited the local utilities by providing them the opportunity to demonstrate support for their schools.

The program increased awareness and interest in renewable energy sources, particularly solar, in fourteen rural communities throughout Central Texas. Since the program began, we have received numerous phone calls from community members interested in learning how they can install PV systems on their homes. And prior to the workshops, teachers were uneducated on how the technology works and how it can benefit their school's learning community. Teachers appreciated the explanation of the PV panels and their applications, as well as the educational materials that are directed toward the TEKS. The Solar for Schools program also provides teachers the opportunity to learn more about renewable resources in general, which they can then pass on to students, parents, and colleagues.

Benefits received by students and school faculty include real-life applications of a renewable energy technology that will last for many years. In the words of Manor ISD's Curriculum Director, "The use of the system and the associated lessons will be written into the curriculum at all grade levels. A sustained effort will be made to create awareness in every child and in the community that energy conservation is a scientific and civic concern that must be integrated into all aspects of society."