Solar Transformation
One Village at a Time

Jeff Lahl

In the dry savannah villages of northern Nigeria, just south of the Sahara Desert, most people still scratch out a subsistence living, growing their crops in these harsh conditions. Although wood is a rapidly disappearing resource, it is still the primary fuel used for cooking. For lighting, most villagers still rely on kerosene lamps, which produce toxic fumes and pose a fire risk. Many villages obtain their water by a rope and bucket from open wells, which are often contaminated. Health resources are minimal, and village primary schools are often no more than dilapidated buildings lacking chairs, desks, and books.

And yet Nigeria is not without resources. As a member of OPEC (Organization of the Petroleum Exporting Countries), Nigeria exports nearly US$15 billion worth of oil each year and is the sixth largest supplier of oil to the United States. Ironically, very little oil revenue filters down to help the rural population. Of the funds that do make their way to northern Nigeria, most are used for larger-scale development projects, such as roads. Seldom do the funds or projects benefit the poorest people, the rural villagers.

Electrical energy has tremendous power to catalyze development in all sectors of community life, ranging from health and education to economic development. Although electricity is sporadically available in larger towns and cities, it is almost never found in small villages. Since oil revenues and the national grid offer little hope in the foreseeable future, another source of energy is needed to help these villages. And clean, free solar energy just happens to be the perfect technology to increase the quality of life here.

Ambitious Projects

In 2001, Robert Freling, executive director of the nonprofit Solar Electric Light Fund (SELF), and Nigerian Governor Saminu Turaki of Jigawa State initiated a proposal to use solar electricity (photovoltaics; PV) to provide energy for essential services in three villages. The projects were funded by the U.S. Department of Energy, through an interagency agreement with the U.S. Agency for International Development, and the Jigawa State government.

After extensive surveys and consultation with community members, an ambitious goal developed—to demonstrate the comprehensive use of solar electricity for a range of applications, including education, health care, water pumping, agriculture, and economic development.

To implement the projects, SELF partnered with the Jigawa Alternative Energy Fund (JAEF), a nongovernmental organization that promotes renewable energy use in northern Nigeria. As SELF's project manager, I visited the three villages with my JAEF associates, meeting with community members to assess each village's development needs. After getting their input, we drafted proposals to discuss with them. Once the proposals were approved, we sought bids from manufacturers to obtain the required equipment.

All from the Sun

Our first completed system was a streetlight. We had announced to the village of Wawan-Rafi that the first light would be installed by that evening, and a crowd of 40 to 50 people had gathered to watch the light click on. When it finally flickered on, people cheered and looked up at the light with delight and wonder, and children danced around

As a beautiful sunset blossoms, technicians race to complete the wiring on the first solar-electric streetlight —and the first source of electricity—in this village. Besides providing a measure of safety for the community, these solar-powered lights now illuminate evening gathering spaces for village members.

Village PV Applications

Application	No. of Systems
Three-light home system	40
Streetlights	34
Five-light home system	20
Clinics	3
Microenterprise centers	3
Mosques	3
Schools	3
Village water pumps	3
Mobile irrigation pumps	2

Village health clinics. A 160-watt PV array, charging a 400 amp-hour battery, provides energy for three, 11-watt CF lightbulbs, a small vaccine refrigerator, and a DC table fan.

Community water pumping. A 1-horsepower submersible pump, powered by 24, 80-watt Kyocera PV modules, provides between 3,000 and 5,000 gallons (11,356–18,927 l) per day of clean, fresh water from an uncontaminated aquifer.

Mobile solar irrigation pumps. In one village that has a year-round source of surface water, solar-powered pumps help the poorest farmers grow crops during the dry season, providing a critical inflow of food and cash into the village. Four durable Uni-Solar 64-watt PV modules (in a folding array) are connected through a linear current booster to a Conergy Solar Force piston pump. The systems

A stand-alone solar-electric system provides energy for this remote clinic's vaccine refrigerator, a small table fan, and compact fluorescent lighting.

the light pole. Electricity had come to this village for the first time.

We completed the other systems over the next few months. Below are brief descriptions of the types of projects we accomplished.

Streetlights. In a hot climate where people enjoy the cool of the evening, streetlights provide safe and pleasant gathering places for socializing and commerce. Each stand-alone system consists of a 50-watt PV module, a 100 amp-hour battery, a charge/light controller, and a 13-watt CF floodlight.

Village schools. A 320-watt PV array and 400 amp-hour battery provides energy to illuminate two primary school classrooms with nine, 11-watt compact fluorescent (CF) lightbulbs in each classroom. The school principal now has the village's first computer and the AC electricity to run it.

are mounted on traditional two-wheel carts that can be pulled from field to field by two cattle.

Microenterprise centers. A 1,600-watt PV array and a 1,440 amp-hour battery provide both DC and AC electricity for six small businesses at each center.

Peanut oil expeller. Making and selling peanut oil is one of the few sources of income for village women. An experimental solar-powered expeller saves time and labor, which helps the women earn more income. The 1-horsepower expeller is integrated into one the microenterprise centers and runs off of a Xantrex DR2424 inverter.

Home lighting systems. Both three-light and five-light home systems demonstrate the benefits of CF lighting, a vast improvement over kerosene lamps. Besides offering improved brightness, using CF bulbs also eliminates toxic fumes and the risk of fire. The three-light systems pair 50-watt PV modules with 100 amp-hour batteries; the five-light systems have 80-watt PV modules with 160 amp-hour batteries. The CF bulbs are rated at 9 watts each.

This mobile solar irrigation pump makes watering tomatoes and other crops a much easier task.

Mosque systems. Lighting makes nighttime activities possible, and an AC-powered public address system facilitates the call to prayer. An 80-watt PV module with a 100 amp-hour battery powers the system.

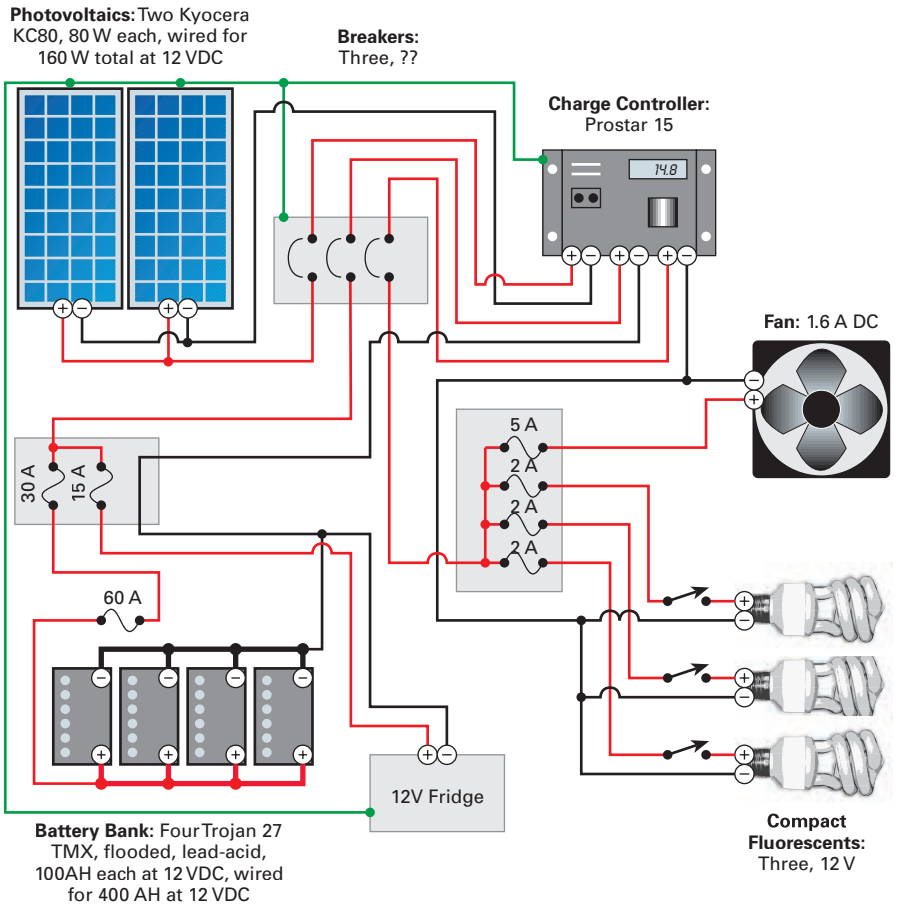
Future Sustainability

The true measure of project success is not if you can complete the installation, but rather if the installation is still working in five or ten years, or at the end of the project's expected life.

Access to electricity gave this barber, who occupies a space in one of the microenterprise centers, the opportunity to trade in his scissors for electric clippers, increasing his productivity—and his profits.

PV-powered lighting enables this classroom space to be used 'round the clock—for adult education classes and for a children's study space.

Lahl Baturiya Clinic System



We took great care to address the technical, financial, and organizational aspects of sustainability. JAEF, structured as an "energy service company," owns all the project PV systems, and charges each user a small monthly fee to cover operation and maintenance expenses. These fees, which cover spare parts, technician wages, and administrative costs, also provide funds for equipment that needs replacement. In four or five years, when batteries start to fail, there will be enough funds to replace them. In most cases, the monthly fees, which range between US$3 to $5, are no more than what families were spending on kerosene for their lamps.

Two levels of paid JAEF technicians keep the systems operating. Technicians living in the villages perform basic maintenance tasks, such as checking and watering batteries, cleaning modules and lamps, or performing rudimentary troubleshooting. Another group of technicians with more education, experience, and PV training visit the villages monthly, overseeing the local technicians and handling more complex repairs.

JAEF was furnished with enough spare CF bulbs, lamps, controllers, and fuses to last the villages for about one year. In that time, enough fees will have been collected to order another batch of supplies. Each village was given a solar water distiller so that distilled water is always available to top off the batteries. Depending on sunlight and ambient temperature, the simple, passive distiller made by SolAqua produces 0.75 to 1.5 gallons (2.8–5.7 l) of distilled water per day, which is more than enough to service all the batteries in each village.

PV system design also plays a big role in sustainability. Because undercharging batteries (or overuse) contributes to premature battery failure, the system arrays were "oversized" compared to many systems installed in the developing world. Among other benefits, this allows a battery to recover to full charge after an extended discharge period, such as one caused by several days of cloudy weather.

In the larger systems, such as the microenterprise centers, multiple inverters and charge controllers were used. This is especially important in developing countries, where equipment is often subject to severe environmental conditions, such as extreme heat, dust, and insects, and where the frequency of failure can be much greater. Having multiple controllers and inverters provides an insurance policy of sorts—you can lose a component, do a little

System Costs

Item	Cost (US$) Clinic	School
Sun Frost vaccine refrigerator	$1,704	–
2 Kyocera PV modules, 80 W	517	$517
4 Trojan batteries, 12 V, 100 AH	228	228
Fusing, wire & misc. hardware	167	390
Studer AJ400 inverter, 24 V, 400 W	–	363
11 Sollatek CFL lamps, 24 V, 11 W	–	187
Xantrex C40 controller w/ meter	–	170
Top-of-pole PV mount	124	124
Morningstar PS-15 controller	68	68
3 Sollatek CFL lamps, 12 V, 11 W	48	–
Digital volt meter	29	–
Table fan, 12 in. DC	29	–
Steel pole, 4 in. diameter	20	20
Plywood battery box	15	15
Total	$2,949	$2,082

This PV array provides energy for a mobile solar irrigation pump. The cart, moved from field to field by two cattle, enables farmers to irrigate their crops during the dry season, providing food and income for their families.

The technicians for the project were a diverse group; some had technical backgrounds and university degrees, while others had barely handled tools before. Before the projects began, all attended a one-week training course at a nearby university, where they got a good handle on the basics of PV installation.

rewiring, and still have all or most of the system functioning until further repairs or replacements can be made. This insurance is particularly important to the microenterprise centers, where at least six families depend on the income from each center.

Progress & Growth

The PV systems have had a positive impact on the 8,000 residents of these villages. One village principal says that he is using his two lighted classrooms five nights per week. Adult education classes are being offered for the first time and are attended by 30 to 40 adults. The brightly lit classrooms are also open for children to work on their lessons.

The health worker in one village reports that with lights, he now opens the clinic three to four nights per week. He also says that procedures, such as giving injections and starting intravenous drips, are now much easier and safer to do under decent lighting.

The illuminated areas below streetlights have become major gathering places for people socializing or doing business. In one village, some enterprising young women now sell prepared food under one of the lights—perhaps the first "fast food" in Jigawa State. In another village, streetlights now guard the entrances to the village, making people feel more secure.

Before the installation of solar pumps, people in these villages either drew impure water with a rope and bucket from an open well, or stood in long lines at one of two hand pumps that served hundreds of families. Government supplied diesel-powered pumps lay unused and rusting in most villages, due to a lack of funding for fuel and maintenance. Now, the PV pumps, connected to a distribution system that feeds a half-dozen or more spigots placed around the villages, are not only supplying plenty of clean water, but are saving people time and effort in gathering it.

For the same monthly amount this family paid for kerosene to fuel their lamps, they now enjoy clean, reliable, and nonpolluting solar electricity that provides energy for several compact fluorescent lights in the house.

The microenterprise centers have enabled the electrification of existing businesses: Barbers have switched from hand clippers to electric clippers, tailors from pedal-driven sewing machines to electric ones, and radio repairers from a heated metal rod to an electric soldering gun. We expect electrification to increase productivity and raise the incomes of these businesses. A microfinance program affiliated with the centers also has enabled people to start new businesses. Once these loans are satisfied, new loans will be available to help additional businesses.

Several spin-off benefits from this project have resulted. Jobs have been created for solar technicians. Our

A source of reliable (and clean) electricity supports several small businesses in this microenterprise center.

women technicians have modeled new roles in a culture where women are traditionally sequestered behind the walls of the family home. JAEF has greatly increased its experience and capacity to do similar projects. Outside the project villages, other communities are requesting their own reliable power supplies, making it likely that JAEF will start a PV sales division.

This project was a model of peaceful and positive cooperation between the United States and a Muslim society. The goodwill we've generated and the friendships made while working in these villages have been deep and profound.

Moving Forward

Solar electricity is available as a powerful tool to help people who have been stuck in poverty with few opportunities and until now, with little optimism. Remote areas no longer need to wait years or decades for the national electric grid, nor do they need to rely on diesel generator-based microgrids. PV-based electrification can jump-start every aspect of development in impoverished villages. And rather than just addressing one area of development, such as health or education, solar electrification can enable improvements in all sectors.

This comprehensive project has provided a model for larger programs, and improved the prospects for people in some of Africa's poorest villages. Now, for these people, hope truly rises with the sun.

Access

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