It Takes a Village

Rural Electrification in East Africa

By Terry Mohn

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ACCESS TO ELECTRIC ENERGY IS AN "INDISPENSable element of sustainable human development," according to the International Energy Agency. Without access to modern, commercial energy, poor countries can be trapped in a vicious circle of poverty, social instability, and underdevelopment. About 1.6 billion people—more than 20% of the world's population—have no access to electricity. Moreover, about 2.4 billion people use traditional biomass for cooking and heating. Developing regions account for 99% of those who live without electricity, and four out of five live in rural areas of South Asia and sub-Saharan Africa.

Many such communities are unfamiliar with regular electrical usage. Since they are located far away from industrial or urban sites, basic infrastructure such as roads, water, sanitation, and communications is primitive at best (see Figure 1). It is necessary to educate these rural communities about the economic impact electricity will have on their way of life. General MicroGrids Inc. (GMI) develops projects around the globe that improve energy access. GMI develops scalable and sustainable models that provide affordable, reliable, cost-effective, and environmentally friendly electricity for individual communities. The projects employ innovative technologies that bring a multitude of benefits to local societies, including improved sanitation and health, improved

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educational opportunities, local economic development and jobs creation, and enhanced behavioral changes associated with electricity payment and reliable energy requirements. This article describes some of the elements needed to achieve such results.

figure 1. (a) Typical Kenyan village and (b) typical town. (Courtesy of General MicroGrids, used with permission.)

Have a Local Business and Process Plan

In East Africa, if a grid exists, it's unreliable. Most people live without running water, lighting, or cooling. There is no economic engine without reliable energy. Many factories and mines have shut down due to an unstable energy supply. As many countries depend mostly on hydropower generation, Africa's drought has severely consumed their general funds because they have transitioned to their backup power source: diesel thermal power. The region is in desperate need of affordable, clean, and dependable energy. But more than that, it needs economic growth. The fastest way to meet all of these crucial needs is by means of localized, distributed resources that can spur local industry.

To help achieve economic growth, a simple plan must be developed with input from both the local communities and the central government. The plan can be kept simple by recommending local, on-site energy production and including the ability to balance power production with demand. Some loads must be prioritized. Power capacity can be designed to scale both horizontally and vertically. Horizontal growth is normal grid expansion. Vertical growth is increased supply to match economic demand.

GMI is providing this service to various parts of Africa. The GMI microgrids will attach to one another or to the central grid as any of them expands close enough to be of support (see Figure 2). GMI works closely with its sister company, CleanSource Energy Partners LLC (CSEP), to maximize natural renewable resources. It is imperative that the community, as well as the central government, help in the planning

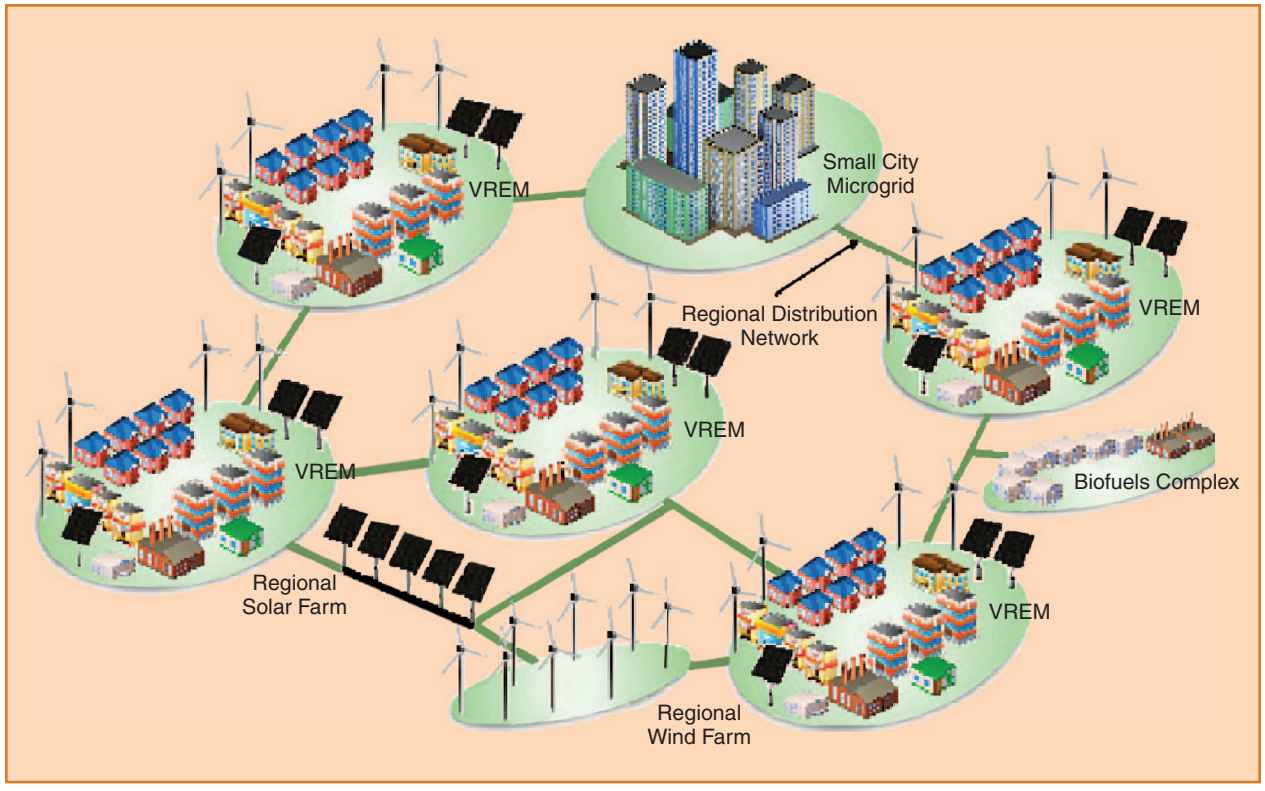

figure 2. Microgrid "cells." (Courtesy of General MicroGrids, used with permission.)

figure 3. The "decision tree." (Courtesy of General MicroGrids, used with permission.)

figure 4. Kampala International University. (Courtesy of General MicroGrids, used with permission.)

process so that the final result is the most cost-effective, reliable, and geographically dispersed system possible. Up-front planning is critical. Once the initial planning is complete, the community meetings begin.

Meet the Town Council Under the "Decision Tree"

Most African countries do not deliver sufficient generation capacity to meet their current demand, let alone for rural electrification. Yet test cases are needed to prove to the national government that smaller grids are just as sustainable as a larger grid extension project. To test the idea that locally built and managed microgrids are sustainable, it is necessary to meet with town councils around the country.

One such meeting took place in August 2012. After a three-hour journey to travel 60 mi, a GMI/CSEP meeting with the West Pokot, Kenya, town council was held. It's Africa. It's hot, dry, and beautiful. Waiting under a majestic tree in the middle of town were the town council members. They sat on eight-inch-tall, curved wooden seats with only one leg (see Figure 3). The meeting protocol was simple: the man wishing to speak had to request the "speaker's stick" from whoever held it. This was a pole about five feet long. After an hour of speaking and answering questions, the council came to a resolution. CSEP was allowed to build a power plant and install a water pump. GMI was allowed to improve electrical infrastructure and light up the community.

Find a Central Government Sponsor

After doing the initial planning, meeting with town councils, and finishing a sound development plan, it's time to meet with the central government agency chiefs. The first question is, how does one reach the right decision makers? All the government offices have telephones, but unfortunately most of them do not work or are so unreliable that they are tucked away inside desk drawers. Calls to the number listed on the agency's Web site typically go unanswered. It is very common for everyone to use a mobile phone, versus the landline. During meetings, calls received on cell phones are usually answered immediately.

A better approach to access decision makers, therefore, is to work through the local contact of some relative of an official. After a few "get acquainted" meetings, a sponsor can often be found who will make introductions at the highest level with all the agencies. This is common practice, even here in the United States—so why not? But as with any relationship, the "goods" must be delivered so as to protect the sponsor.

Hire a Local Workforce

GMI will build microgrids across each country. But finding a qualified workforce that will be on the ground for the next decade can be problematic. In addition, microgrid operators will be needed for the next 50 years. As is typical in most African universities, however, graduates are placed into government jobs (see Figure 4). Most agency ministers are attorneys. It is important to establish a public-private partnership with the universities to outline future hiring requirements. Meet with engineering deans and university vice chancellors to help develop a curriculum that focuses on science, technology, engineering, and math (STEM). These educators also need to impress on elementary school teachers the importance of STEM, so that more high school graduates will focus on engineering colleges. Meet with both two-year and four-year schools. Offer internships, student exchanges with U.S. schools, and long-term partnerships between education and industry. In this way, a workforce will be trained and available when the projects begin operating.

Understand the Problem

Families seeking improved wages, health, and education move to large urban areas because that is where the affordable energy infrastructure exists and enables those key socioeconomic advantages to be realized. Such migration has a two-fold impact:

- ✔ The additional pressure on urban infrastructure stretches national resources.
- ✔ The rural, distributed communities that are "left behind" become less viable over time, causing an urban-rural divide and resulting in the eventual disappearance of a rich base of local knowledge, wisdom, and culture; the agricultural production base is also undermined.

The solution is not to move families to the urban life offered by affordable energy but to move affordable energy to the rural, distributed communities so as to enable the jobs, health, education, and quality of life that will maintain—or expand—the local culture.

figure 5. The Kitale market in Kenya. (Courtesy of General MicroGrids, used with permission.)

Traditionally, developed and developing nations alike have focused their energy development on urban areas, where expensive infrastructure costs could be spread across large populations and numerous businesses to keep energy service affordable. At the same time, the energy industry has expanded services to rural areas outward from the urban centers, using an infrastructure model that makes sense in dense urban areas where there are hundreds of energy users per kilometer. But as the infrastructure is moved outward, only a few energy users per kilometer in the rural area are available to support the expensive infrastructure. Utilities understand this and only expand their infrastructure to the extent that there are enough energy users to pay for it. The end result for developing nations is that rural areas are being underserved.

Where the traditional, centrally developed and managed, expensive infrastructure is affordable to many energy users per kilometer (i.e., in urban areas), access to affordable energy thus provides economic development, health, and educational opportunities (see Figure 5). This leaves rural, distributed communities, especially those located in developing nations, with limited affordable energy solutions.

It is logical for the energy needs of a rural, distributed community to be served by a distributed solution, one that breaks from the traditional model of radial urban infrastructure. Complicating this point, however, is the fact that for 80 years, the traditional, centrally developed model has been institutionalized with utilities, regulators, and policy makers in developed and developing nations alike. For this reason, few solutions have been conceived that support rural, distributed communities.

Microgrids offer a locally managed, distributed solution for these numerous community clusters. With microgrids, such communities can generate and manage affordable energy that supports local economic and social development, improved health, and expanded educational opportunities so as to improve the quality of life in the community.

Extrapolating from the Existing Energy Market

Solving the energy poverty problem is not as difficult as it may seem. In developed countries, residential and business consumers are already generating their own power on their premises. Government subsidies have caused a surge in on-site electrical generation. Some of these systems are very sophisticated and are even capable of self-sustainability. They have the potential to "island" from the grid. When functioning in the islanded mode, these power systems can supply their own generation, storage controls, and load management (such as building automation).

Energy product suppliers have identified this new trend and market opportunity. The market for building automation, metering, and efficiency systems is well established. Growth is now occurring in the areas of virtual power plants, demand management, power system redundancy, and campus switchgear. This new market trend is directly applicable to rural electrification, particularly with respect to the needs of developing nations. Companies are reengineering their existing utility-grade products for these two new commercial markets. Both markets overlap in one aspect: they lead to independent power systems in the form of microgrids.

For traditional utility and grid markets, microgrids will develop when customers such as universities, rural farming communities, military bases, and island countries choose to improve local electric reliability and efficiency along with their carbon footprints. In addition to building new on-site generation, these locations will assemble smart grid–enabled power distribution with automation and grid arbitrage. In some cases, the local utility will offer microgrid services; in other cases, equity markets will provide funding to support customer self-generation.

In the case of village power for developing countries, new business opportunities will result as inhabitants will be trained to operate and maintain these systems, as well as collect payment for energy consumed. Furthermore, microgrids will be necessary to support the prioritization of certain loads, such

as hospitals and communication systems. As noted above, electrification will enable education, economic development, and health care improvements in these markets.

Lighting Is Simple but Necessary

In Africa, everyone meets in village or town centers. After work, when the sun sets, people continue with their social activities and commerce. Businesses frequently operate past midnight. They utilize small lanterns or dc-powered light-emitting diodes (LEDs) using 12-V batteries. Very few people own cars. The primary mode of transportation is by foot. People walk everywhere. Driving a car at night is very risky because of the immense number of people walking on the roadside.

Unfortunately, there is no public lighting along the road leading into the village. Even in the village, it is unsafe and uncomfortable for everyone. GMI is targeting city centers and schools, which are central to their local communities, in off-grid or semigrid areas (see Figure 6). With off-grid lighting, GMI can enable community sports in the evening.

One example of applying new technology to developing countries is solar LED lighting. When the sun shines during the day, the solar panel converts solar energy to electrical energy and stores it in the battery. At night the battery is discharged, releasing electrical energy to power the LED and thus lighting the road.

Microgrids are ideal control systems for off-grid lighting, reducing system costs through aggregated storage for the streetlights and using pole-mounted solar PV for both battery charging and distributed generation (see Figure 7).

The Dilemma Connected with Building Large Power Plants

Politicians in different countries have different ideas about how to use energy produced within their territories. CSEP has licenses to produce large-scale power in both Kenya and Uganda. Both countries have tenders open for more than 5,000 MW of new production. In Kenya, the government wishes the energy to be used by the citizens. In Uganda, the government wants to export everything to neighboring countries. Less than 20% of the population of each country has access to electricity. In Uganda, only 5% of the rural areas have energy. Yet there remains tremendous opportunity for large power producers in each country.

Different countries also have different off-takers. For instance, in Kenya the government-owned distribution company is the normal off-taker. But power producers may also sell directly to industrial companies in Kenya. In Uganda, however, only the government-owned transmission company is the off-taker. Also of note is that each country offers incentives to encourage foreign investments. Conducting business

figure 6. Lighting neighborhoods. (Courtesy of Philips Lighting, used with permission.)

figure 7. Solar LED streetlight with battery. (Courtesy of Philips Lighting, used with permission.)

in East Africa is very different than any business experience in the United States in that the desire for new energy production is so high, and the gap between existing capacity and demand is so great, that government offices gladly open their doors if they are presented with a sound business plan.

Conclusions

Seeking opportunities for a better life, many African rural residents have migrated to the cities. Yet without adequate infrastructure to handle the population increase, this migration to urban areas has created more problems than it has solved.

If rural areas could obtain access to electricity, many of the future problems facing city planners would be avoided. Increased opportunities for rural development might even negate the incentive for large-scale migration into urban areas (see Figure 8). On a village-wide scale, greater agricultural production is possible with electrified pump sets, allowing for better land use, and food storage could give farmers more time to get their crops to market. Electricity for refrigeration would allow storage for much needed medications. At the same time, water purification would become possible. Improvements in home lighting would certainly reduce cooking emissions as well as improve literacy for students.

Microgrids offer consistent, reliable electricity to rural communities. While many distributed generation projects focus on only one type of technology, microgrids allow for the integration of various technologies. Villages can use biomass, biogas, solar, wind, geothermal, or any other energy source. Local energy production minimizes transmission and distribution losses, and sophisticated systems allow for load balancing and real-time control. With the option to link into the larger government-owned grid or operate as stand-alone systems, microgrids operate in the space between grid extension and decentralized solutions.

Microgrid development will help solve the energy poverty problem and allow for increased economic and social development, all with a much lower carbon footprint. While Africa is not expected to contribute more than 2–3% of the overall global carbon emissions total by 2050, that number could increase if economic development and urban migration are not planned carefully. Governments could look to microgrids as a means of repopulating encouraging residents of the outer urban slums to relocate and become producers of farming, industry, and new economies. Microgrid development could spur economic development across the continent, eradicate energy poverty, and offer a new model for sustainable energy development.

A rapid growth in microgrid implementations will also open up tremendous new business opportunities for the energy sector, both in the United States and globally. A more prosperous world that has access to adequate electric service will also open new energy markets. The world today is faced with multiple challenges. Global population has exceeded 7 billion for the first time. World economic growth remains sluggish. The threat of climate change continues to grow unchecked. And 1.6 billion people across the globe—one in five—have no access to electricity, while nearly 2.6 billion still use wood, charcoal, and dung for cooking and heating. Now is the time to act. The commercial energy market suppliers must apply their vast experience to this emerging marketplace. Who knows? After a few years' experience developing rural electrification projects, perhaps the knowledge gained can be translated into more efficient and sustainable systems in the industrialized world.

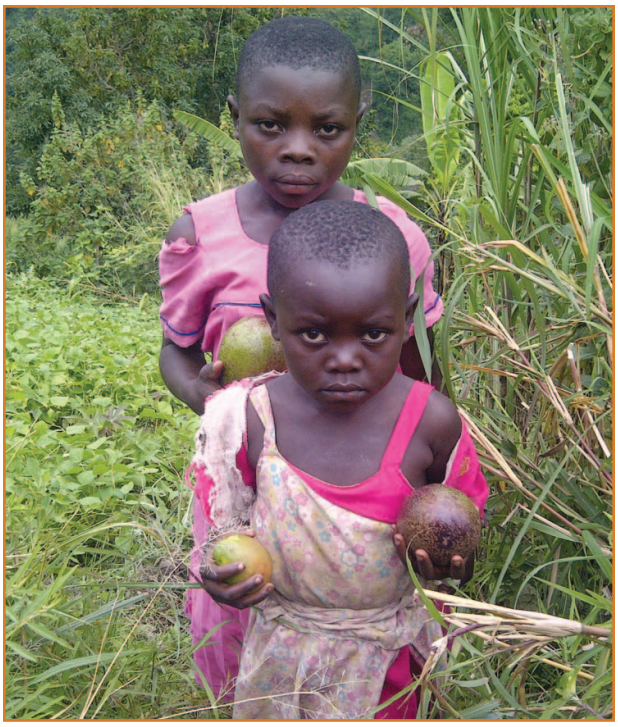

figure 8. Life in rural Uganda. (Courtesy of General MicroGrids, used with permission.)

For Further Reading

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Biography

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