

# Chapter 14

## Other Considerations



### 14.1 Introduction

We have focused so far on the technical and some economic aspects of off-grid electrification. However, there are a host of other considerations that a practitioner should be mindful of. In this chapter, we discuss several of these considerations, drawing largely upon firsthand experiences of the author and other organizations. When appropriate, advice and generally accepted best practices are given.

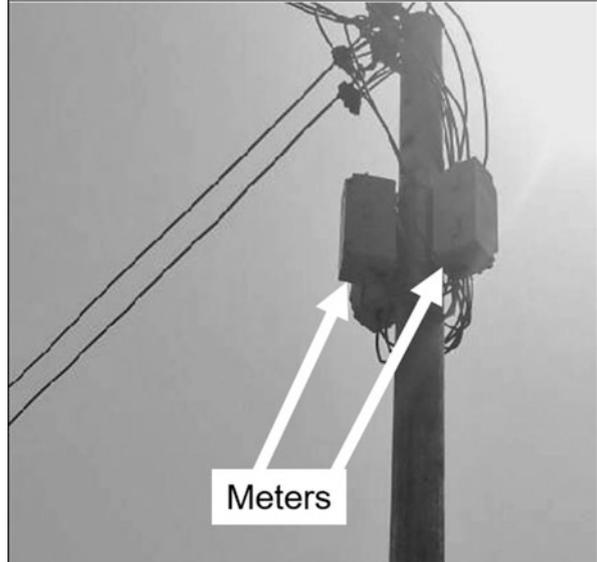
### 14.2 Electricity Theft

Theft of electricity is a problem that utilities face worldwide. It is also a concern for mini-grids. Electricity theft, also referred to as “nontechnical losses,” is generally low, at 1 to 2% of generation. However in many countries struggling with electricity access, the nontechnical losses can exceed 15% per year.

Precautions should be taken to guard against electricity theft. One way of stealing electricity is by tampering with or bypassing the meter. There are a few ways of making it more difficult to tamper with a meter. One way is to locate the meter in a place where it is difficult or impossible for the customer to access the meters. For example, it can be placed at the top of the distribution pole as seen in Fig. 14.1 or at the sending end of the customer’s line, rather than the end. Tamper-resistant meters can also be installed.

Low-voltage distribution lines can be susceptible to unauthorized connections by tapping or splicing them. Aside from the danger, this is problematic because it increases the load on lines, transformers, and inverters, perhaps exceeding their rated values. This can cause premature failure and increased voltage drop and losses along the line.

**Fig. 14.1** Placing customer meters on distribution pole tops, like these in Nigeria, can reduce meter tampering (courtesy GVE Projects)



Employees of the mini-grid can be bribed to inaccurately bill the customer or record payment when a payment was never received. Customers might refuse to pay all or a portion of the bill or chronically make late payments. Mini-grid operators should have checks and procedures in place to detect improprieties by its employees and to disconnect customers in arrears. Pay-as-you-go billing with remote disconnection functionality is a popular method to discourage late payment.

### 14.3 Use of Donated Equipment

Nonprofit organizations abroad often find that manufacturers of electrical equipment are willing to donate their products. These “in-kind” donations can offset several thousand dollars of project costs. However, an organization should carefully assess whether or not to accept these donations.

The most important disadvantage of using donated equipment is that it is often up to the recipient organization to manage the shipping logistics and importation. This task should not be taken lightly, as arranging for shipment by sea or air is expensive and can add weeks of uncertainty to the project schedule. Additionally, import taxes and duties—perhaps 25% of the declared value—might need to be paid. In many countries, solar equipment can be imported without duty; however, the organization bears the administrative burden of completing and submitting the necessary forms. The equipment must clear customs—a process that in some countries can take weeks or months. In some cases, unscrupulous customs officers have expected a bribe to expedite the process. Holding fees at the port of entry might need to be paid while the components wait to clear customs. Batteries will self-discharge during this period, perhaps leading to permanent damage.

Additionally, many manufacturers will not provide warranties for donated equipment or will only provide equipment that did not make their quality standards (this is somewhat common with PV modules). When the donated equipment fails, the organization is on their own to find a replacement. For these reasons some organizations will refuse to use donated equipment, seeing it as well-intentioned but more trouble than its worth.

## 14.4 Capacity-Building

The goal of many organizations, particularly nonprofits and social enterprises, is to positively impact a community in a more broad way than just providing access to electricity. One way is to build capacity—the skills, experience, and infrastructure—of the community. Mini-grids in particular offer an avenue for this.

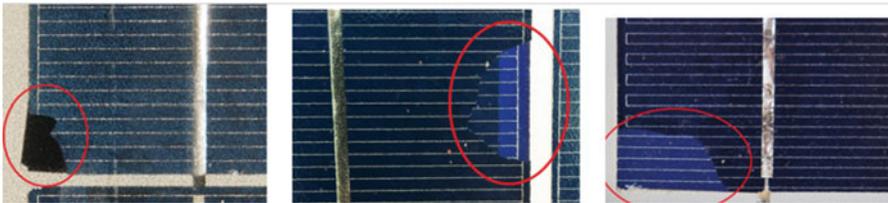
In many countries, use of in-country components is not possible. However, using in-country equipment distributors, logistics companies, and installers *is* possible. The advantage of this beyond building capacity is that the equipment supply chain and regular and warranty-related service can be managed in-country.

Many volunteer organizations from abroad rely on volunteer or student labor to implement the project. Although this offers a meaningful, if not transformative, experience for the participants, it must be done carefully, respectfully, and in a way that preserves the dignity of the community. Many tasks can be done by locally available labor—digging trenches for the distribution system, clearing land for poles, or making bricks. Reverse outsourcing of these tasks by volunteers should be avoided. There may be an opportunity to train and hire locals to manage the system once installed.

## 14.5 Substandard and Counterfeit Components

Many consumer products found in Sub-Saharan Africa are substandard or counterfeit. Unfortunately, this is also true for off-grid systems. Substandard components are those that do not meet applicable performance and quality standards set by manufacturers and local or international organizations. Counterfeit components are those that appear to be made by one manufacturer (typically a widely recognized, brand name manufacturer) but are made by another manufacturer. The counterfeit components are almost always of lower quality than the authentic components. Counterfeiting also occurs when a component is mislabeled and a lower-quality or lower-rated component is substituted. Used or damaged authentic products might be sold as new, sometimes after a superficial cosmetic treatment. Although hard numbers on the extent of problem are difficult to come by, one study estimated that approximately 50% of the solar home systems and solar lanterns worldwide or counterfeit [3]. Counterfeit and substandard components are appealing because

**Fig. 14.2** A “Ciemans” charge controller (courtesy of P. Dauenhauer)



**Fig. 14.3** Examples of PV modules with “dummy” material replacing active material (courtesy K. Sinclair, M. Sinclair, Zayed Energy and Ecology Centre )

they are often offered at a discounted price, sometimes accompanied by a reasonable story for the discount. Substandard components tend to reduce the reliability of the system due to premature failure or malfunction.

Practitioners in off-grid electrification frequently encounter substandard or counterfeit components. An example of a misleading label of a charge controller is shown in Fig. 14.2. Here, the controller brand name is “Ciemans” a simple play on the recognized brand name of “Siemens.” Figure 14.3 shows a PV module where instead of silicon, some of the cells are simply pictures printed on paper. Another example is when a fake nameplate indicates that a component, for example, an inverter, is rated a higher value than it actually is.

Practitioners can and should take precautions against using substandard or counterfeit components. Use of established, reputable, and official distributors is the best way to reduce the risk. Even still, diligence is recommended. All components should be at least visually inspected for signs of counterfeiting or substandard quality. Inspection of PV modules is the subject of IEC 62257-10 [1]. All components should have labels and nameplates specifying the manufacturer, ratings, and model and serial number. If inspection of each component is not possible, batch-checking should be done, in which one or more components from every batch or pallet are inspected.

Contracts with suppliers should clearly state the ratings, manufacturers, and models to be used and should be written to include warranties—typically 1 or 2 years. A portion of the payment should be withheld until the materials have been verified to be of acceptable quality. If the system is installed by a contractor, it should be tested to ensure proper installation and operation.

## 14.6 Standards

In engineering, a “standard” refers to a document that specifies the technical details and characteristics of a product, system, or process. Standards are used to ensure consistency, safety, compatibility, and quality. However, adherence to a particular standard is not mandatory. Manufacturers, installers, and design engineers may or may not decide to follow a standard.

There are many standards that apply to certain aspects of off-grid electrical system components, including inverters, PV arrays, and lead–acid batteries. For example, IEC 61215 and IEC 61730 pertain to quality and safety of crystalline PV modules. However, standards relating to the off-grid systems as a whole are limited. At the time of writing, there are two major international standards relating to mini-grid systems:

- IEC TS 62257 Series—Recommendations for renewable energy and hybrid systems for rural electrification.
- IEEE 1546.4—Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

Additionally, IEEE 1526 and IEEE 1013 provide a method for sizing stand-alone PV systems as discussed in Chap. 12. Some practitioners feel that the presently available standards require updating—indeed several are being revised—or that additional standards are needed for developing country context. Both the IEEE and IEC are developing independent standards for low-voltage DC mini-grids.

Adherence to any standard is optional. However, new practitioners should be familiar with practices described in the standards as a starting point. Lighting Global also has standards for solar lanterns and solar home systems, considering characteristics such as lumen maintenance, durability, health and safety, and truth-in-advertising [2]. It is recommended that before purchasing a product, it is checked to see if it meets the appropriate standard.

## 14.7 Applications Requiring Heightened Reliability

Losing power for an everyday application such as lighting can be annoying; loss of power to more critical applications, however, can result in economic loss or even danger to the community. Health care is one such critical use of electricity.

Access to adequate medical services in remote, unelectrified communities is often limited. Among the challenges is storing vaccines at the proper temperature. Vaccines must be stored at low temperatures in order to prolong their shelf life and to prevent the vaccines from degrading. However, if vaccines are exposed to too low of a temperature, they risk freezing, which causes an irreversible loss of potency. Solar-powered refrigerators offer a solution to store and regulate the temperature of vaccines at off-grid health-care facilities. The vaccine refrigerator should be designed to be extremely robust and reliable and meet performance quality standards set by the World Health Organization WHO [4]. To improve reliability, the vaccine refrigerator electrical system should not supply other loads, including lights and other medical equipment. If the off-grid system is capable of serving an AC load, WHO-approved refrigerators can be used. Consumer refrigerators intended for home or business use generally do not meet the WHO standards and should not be used for vaccines.

## 14.8 Human-Powered Generation

Using human motion to power generators for electricity access has been proposed by various researchers and organizations. A few commercial products exist, particularly those with applications in emergency or disaster situations, such as a hand-cranked radio or shake-style flashlight. Human-powered generation has found limited success in providing higher-tier electricity access. To many, it is treated as a novelty rather than a practicable, scalable solution. Human-powered generation does offer several advantages: no resource assessment is needed; the systems can be cheaply manufactured using locally available components such as bicycles and automobile alternators; and it can create jobs locally in the manufacturing but also powering the devices.

The disadvantages tend to outweigh the advantages. Chief among them are that the end-to-end efficiency of human-powered generation is prohibitively low. Unlike most renewable resources, the input energy to a human-powered generator is not free—the person powering the device must ingest additional calories to compensate for the added production and be compensated for their time. Average humans are not capable of sustained high-power output, perhaps only tens of watts. To supply 1 kWh requires several hours of effort and about 10 kWh of input (food) energy, roughly four times an average daily intake. This is likely not practical. In addition, time spent generating electricity is time that cannot be used for other, probably more productive, activities.

## 14.9 Summary

No textbook can replace field experience in off-grid system implementation in developing countries. Practitioners usually have many stories about ways that off-grid projects did not go as anticipated. Some of these are amusing, and some resulted in delayed, over-budgeted, or aborted projects. Volunteering for organizations such as IEEE Smart Village and KiloWatts for Humanity is a good way to gain experience prior to pursuing a career in off-grid electrification. New practitioners and organizations should remember that off-grid communities are underserved and vulnerable in many ways and should not be used as testing grounds simply to gain experience or to implement hobby projects and products.

## References

1. IEC: Recommendations for renewable energy and hybrid systems for rural electrification – part 10: Silicon solar module visual inspection guide. IEC Std. TS 62257-10: ED1, International Electrotechnical Commission, Geneva, Switzerland (2017)
2. Lighting Global: Quality assurance program (2018). URL <https://www.lightingglobal.org/quality-assurance-program/>
3. Sturm, R., Njagi, A., Blyth, L., Bruck, N., Slaibi, A., Alstone, P., Jacobson, A., Murphy, D., Elahi, R., Hasselsten, J., Melnyk, M., Peters, K., Appleyard, E., Orlandi, I., Tyabji, N., Chase, J., Wilshire, M., Vickers, B.: Off-grid solar market trends (2016). URL <http://documents.worldbank.org/curated/en/197271494913864880/Off-grid-solar-market-trends-report-2016>
4. World Health Organization: A guideline for manufacturers of solar power systems. Tech. Rep. WHO\_PQS\_E003\_GUIDE 2 3.doc, WHO (2010)