Off-Grid Solar PV: Opportunities & Barriers

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PV was developed in the most industrialized and technologically advanced nation; however, most of the potential customers of off-grid PV are not in the developed nations. This technology has an enormous and eager potential customer base in the developing world where nearly 1.5 billion people, representing 22% of the earth's population, do not have access to electricity.

Off-grid PV in the developed nations:
PV was developed in the most industrialized and technologically advanced nations, so it should not be surprising that the first applications of off-grid PV were primarily in these nations, including the United States. With its hyper-individualistic culture, part of the allure of PV for customers in the United States has always been the ability to generate electricity for personal use without being tied to the large and unaccountable structures of utility companies and the electric grid. However, though such psychological motivations may be strong, practical considerations are often more important.

In the US state of California, off-grid PV was pioneered by an unlikely industry: indoor marijuana farmers. These black market agriculturalists had two distinct needs: one, to generate power for lights to grow their illicit crops, and two, to do so without attracting attention from law enforcement. Indoor marijuana cultivation prospered in remote areas of Northern California, away from prying neighbours and often in areas not served by the power grid. Even for those who did have access to electricity, it was also important not to show a spike in an electricity bill that would tip off the power company that something was amiss, who might then pass such information on to police and federal agencies.

Potential customers – populations not served by the grid
However, most of the potential customers of off-grid PV are not in the developed nations, and these technologies have an enormous and eager potential customer base in the developing world. 1.5 billion persons globally, representing 22% of the earth's population, do not have access to electricity. These persons reside mostly in rural areas in South Asia and Sub-Saharan Africa, but can also be found in South America, Central Asia, and Central America, as well as in urban areas in less-developed nations. Many of these areas have good to excellent solar potential, much better than many locations in the developed world.

As a potential market, these individuals are not going away. Global access to electricity over the last few decades has remained remarkably static. World Bank officials have stated that the number of persons who do not have access to electricity may actually increase in the next few decades unless more effective policies are put in place to speed off-grid electrification and the expansion of existing utility grids into unserved areas.

Potential uses of off-grid solar in developing areas:
The benefits of electrification to rural communities and thus the potential uses of off-grid photovoltaics (PV) are many. Lighting is often the first need that is met, followed by radios and televisions, and later appliances such as washing machines and refrigerators. Access to electricity assists with income-generating activities, including agriculture. Rural electrification in India in the previous decade has largely focused on irrigation, which has moved the nation from a net food importer to a net food exporter. Other income-generation uses include in fisheries, processing of agricultural goods, and small-scale industry such as welding shops.

Electricity is also important for the function of schools and hospitals, and many demonstration and private philanthropy projects are designed to meet these needs. The significance of power for lighting should not be underestimated; studies of rural electrification indicate that supplying lights, which allow students to study into the evening hours, creates a greater potential income gain for families than uses that generate income directly. In Bangladesh, incomes increased up to 30% following electrification, mostly due to higher educational attainment.

Off-grid PV technologies
Between 500,000 and 1 million persons in the developing world are currently using off-grid PV technologies. These many people use a wide range of products, where a solar system connects to various DC appliances. Companies offer products from home lighting systems and water purifiers to street lights and lighting/fan systems using modules that supply from 3.3 - 250 watts of electricity. Batteries are an essential component of all such systems.

Construction of micro-grids is another way to meet the needs of rural communities, which often consist of a number of homes and businesses clustered closely together. Such micro-grids can potentially be powered by any technology, and for small villages in areas with rich sunlight, PV and more often PV/diesel generator hybrid systems are often practical solutions. In such instances, the PV installations are typically much larger than those used in solar home systems, and when combined with diesel generators, do not require batteries.

Economics of off-grid PV
For off-grid locations in developing nations, extension of the grid or the use of

diesel generators are the two competing solutions for electrification. In many places, installing off-grid PV can be more cost-effective than either of these options; though such calculations vary according to the location, the quality of the PV resource, the cost of diesel fuel, the type of system, and other factors. In Ethiopia, researchers discovered that off-grid SHS systems were considerably more profitable than installing on-grid PV in more developed nations; though the smaller size of the systems means that more individual systems must be sold to realize similar revenue.

However while costs over time are often lower, the up-front costs of installing PV systems is higher than diesel generators, whose primary cost is fuel. This means that education on cost savings and financing options for buyers in the developing world are important considerations.

Not only can PV be cheaper over time than diesel generation or grid extension, but it is often a financial improvement for rural families in the developing world than substitute energy costs, such as kerosene and dry cell batteries. Such expenses are typically USD$5-10 per month for enough kerosene and batteries to run a few lamps and a radio, a considerable portion of a many family budgets. Furthermore, purchasing kerosene and batteries can often mean lengthy shopping trips and long waits to replenish supplies, and even then, there can be issues with availability.

There are other advantages to off-grid PV for families in rural developing nations which can be harder to put a dollar value on. PV systems do not create air pollution like diesel generators, nor do they carry the fire risk of kerosene lamps.

Barriers to adoption of off-grid PV

There are multiple barriers that must be overcome for the development of a healthy off-grid PV business. The first is in the minds of PV manufacturers and integrators, most of whom are in the more affluent nations of the developed world, and who are used to marketing their products to wealthier customers in the developed world. Likewise, potential customers in the developing world are often not familiar with photovoltaic's and their advantages. For off-grid PV as a business to be successful in the developing world, manufacturers, integrators, and distributors must understand the unique challenges and opportunities of this market.

Lack of financing options can be a significant barrier, and researchers with the International Energy Agency suggest that financing carry over the lifetime of the system. However, other researchers indicate that such concerns are often overestimated, and in Bangladesh, one of the success stories for small-scale PV adoption, most customers buy their systems with cash even where financing is available.

Availability of DC appliances must also be considered. Most of the PV systems designed for off-grid applications in developing nations do not include inverters, which drive up system costs. While many solar home systems come with DC appliances, such appliances are not always readily available on the market. For off-grid PV to be successful, there is also a need for customer support, particularly in system maintenance and repair. The low levels of education in many areas of the developing world must be considered; in some cases PV systems may be abandoned after malfunctioning because the owner cannot read the manual.

Even in places where PV systems are visible, consumers in the developing world must be educated about the benefits of these systems. In some areas, there is a tendency to think of electricity from PV as "second-class" or not "real" electricity compared to that which is delivered from the central grid, and such attitudes must be overcome. In other areas where the government has supplied large numbers of PV systems to rural areas, there is a tendency to view the systems as a gift from the government. However, even in areas where the perception of PV as a state gift is widespread, there is still a tendency to use these systems for income-generating activities, to keep PV as backup power after grid-connection, and to invest in larger systems, indicating social acceptance of this technology.

Conclusion: Off grid Solar PV: A market holder of developing world

Off-grid PV remains a small if significant market in certain areas of the developed world; however the greatest market for off-grid PV is in rural areas of India and developing world. With the right combination of policies, business models and technologies these areas can develop into thriving markets for PV and related technologies. The economic advantages of solar for rural populations in developing nations can potentially create a cycle that drives demand for larger systems. In India and China, rural electrification has led to greater use of appliances such as televisions, washing machines and refrigerators, which are currently out of the reach of many in developing nations, just as they were in China in previous decades.

However, before this can happen, barriers need to be overcome by both governments and businesses seeking to expand into these potential markets. Consumer education will be as or more important in the developing world as it is in the developed world, with additional barriers of language and literacy. Likewise there is a need to educate government officials in these nations as to the advantages of PV, and to introduce policies that bring PV not as an aid product, but as a thriving industry, with strong local involvement ad sense of ownership.