ENERGY OPPORTUNITIES FOR AGRICULTURAL SYSTEMS AND FOOD SECURITY PROJECT

SOLAR PV OPTIONS FOR SMALL-SCALE DAIRY AGGREGATORS

Technical Brief #2

Introduction

Solar energy from the sun can be captured to Field work during the Energy Opportunities for Agricultural Systems and Food Security Project (E4AS), found that power interruptions and local power costs affect the profitability of fresh camel and cattle milk sales. While project observations centered around primary chilling at small-scale cooperative dairies in Kenya, the key issues and lessons learned are applicable to broader small-scale cold chain aggregation applications.

E4AS' report *Clean Energy for Productive Use in Post Harvest Value Chains: An Integrated Literature Review with Field Work for the Kenya and Senegal Dairy Sectors*[1] highlighted a number of different solar photovoltaics (PV) products as promising opportunities to improve uptake of clean energy in sub Saharan Africa. PVs offer an alternative power supply that can improve reliability of electric supply and lower overall electric costs. This brief expands on this finding by highlighting a series of technical factors specific to uptake by small-scale dairy aggregators of PV technologies.

This brief is the second of four practical guides developed by the **Energy Opportunities for Agricultural Systems and Food Security Project** (E4AS). Funded by USAID's Africa Bureau with field work in Senegal and Kenya, E4AS is implemented by Green Powered Technology in partnership with ACDI/VOCA. The objective of E4AS is to expand and focus information related to how clean energy (CE) and energy efficiency (EE) can strengthen post-harvest value chains and reduce loss in sub-Saharan Africa, while also contributing to low emission development strategies (LEDS) and incorporating gender-aware strategies. Visit www.agrilinks.org/post/clean-energy-productive-use-post-harvest-value-chains-integrated-literature-review-field-work to access additional briefs and an integrated literature review with field work findings.

Solar thermal explained

Cooperative dairies collect and chill milk in rural areas and transport it to urban centers where they sell the "fresh" product. To avoid the milk warming and spoiling on this journey, cooperatives chill it as much as possible before transport. Upon receipt, warm milk is poured into 20L jerry cans and placed inside chest freezers to chill and partially freeze overnight. The milk is then transport in a highly chilled - if not frozen - state, allowing it to be as fresh a possible when arriving at market. This process presents two primary problems: the energy costs required to adequately chill large quantities of warm liquid; and insufficient cooling due to common short and long duration power interruptions.

[1] To access the report as well as other E4AS briefs, visit: www.agrilinks.org/post/clean-energy-productive-use-post-harvest-value-chains-integrated-literature-review-field-work

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Energy Costs

Cooperatives typically power freezers for chilling with energy purchased from a local power utility, or from energy produced by diesel generators. In Kenya, the power purchased from the utility by dairy cooperatives typically ranges from 35,000 KSh (US$ 350) to 40,000 KSh (US$ 400) depending on the season. Other than the cost for the raw milk, this power bill is the single largest expense faced by cooperatives.

Power Interruptions

Daily power interruptions can be a common occurrence in developing economies. While not only inconvenient, these outages can be costly for cooperatives and other business that rely on cold chain integrity. In the case of dairy, milk that is insufficiently chilled overnight, may not remain fresh during transport to an urban market. In the case of longer outages, milk may even spoil prior to transport. If fresh milk spoils during the journey, it is still sold, however at a discounted price that may not cover the costs of transportation and the initial purchase of raw milk.

Alternative Supply Thorough Photovoltaics

The installation of photovoltaic (PV) systems to generate power and battery storage can allow cooperatives to improve the surety and consistency of energy supply and lower overall energy costs. A solar powered system with battery storage can provide either a complete off-grid power supply or a system to provide back-up power during utility interruptions.

Complete off-grid solar power supply

A 100% solar power supply would include sufficient photovoltaic panels to generate power throughout the daylight hours to provide the immediate power requirements and to charge batteries to provide power throughout the nighttime hours. An appropriate investment would allow a cooperative to provide all its own power and minimize any interruptions resulting in spoiled milk or insufficiently chilled milk.

> In the case of a Kenyan cooperative with 11 chest freezers and an average utility bill of 39,400 KSh for 2.74Kwh/hr, the estimated cost to provide a 100% solar power supply with 16 hours of battery storage is 4.7 million KSh (US$47,000).

Given chilling loads may vary regardless of installed capacity, past utility bills offer the best estimation of average energy consumption.

The avoided annual power costs can be calculated based on past utility bills. In this example they are estimated at US$4,600 annually. The reduction of costs due to milk spoilage must also be considered. This is difficult to estimate without exact records. Interviews with cooperative members showed it reasonable to assume that utility power interruptions and outages result in at least one loss of fresh milk (still sold as spoiled milk) per month. This costs the cooperative approximately US$4,200/year[2].

Therefore, **the total annual savings with a 100% solar powered system with 16 hours of battery storage would be approximately US$8,800/year for an investment of approximately US$47,000. This would result in a simple payback of just over five years**[3].

[2] *150 KSh/litre (fresh) – 80 KSh/litre (spoiled) x 500 litres x 12 months = 420,000 KSh/year ; this assumption may be conservative, and if in fact it occurs more frequently, then the payback period would be reduced.*

[3] *Simple payback does not account for slight degradation of panels and batteries over time and any maintenance costs.*

Partial Backup Power Storage

The largest cost component of a complete solar power supply as described above are the batteries necessary for power storage. Reducing the total amount hours of required storage, while continuing to supplement with power purchased from a utility, will reduce the overall installation cost. For example, a reduction in the storage capacity outlined above from 16 hours to 8 hours would reduce installation costs by US$15,000 to US$32,000[4]. Such an approach would still require the purchase of power from a utility. Using the same costs from our example above, if 8 hours per day were required to still be purchased, **the annual cost would be US$1,530, resulting in a total energy bill savings of US$3,070 per year. The same reduction of milk spoilage costs is also applicable under this scenario (US$4,200/year). Total annual savings of a partial backup system would result in a simple payback in 2.8 years**.

[4] *Reduction in number of batteries from 24 to 12, reduction in number of pv panels required as they are not required to charge the batteries, and various other savings.*