EarthSpark INTERNATIONAL

Viable Productive Uses of Electricity Programs Remain Elusive:
A Practitioner's Field-Based Recommendations for Overcoming Challenges

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Productive uses of electricity (PUE) are core to unlocking the economic development potential of community microgrids around the world. While energy access funders are now interested in this concept, the reality remains that truly transformative 'plug and play' productive uses of electricity remain elusive.

PUE, especially on AC micro-grids, face high uncertainty regarding the viability of individual appliances. While guidance abounds on the most suitable *applications* of productive uses, such as milling or cold storage, and sound guidance on the implementation of PUE programs is available, such as the PRODUSE manual, practitioners promoting PUE require further support. We recommend the following:

- Expand the list of efficient, quality-assured AC appliances, emphasizing value-adding appliances
- Fund practitioners to field-test promising PUE appliances
- Analyze PUE case studies to extract best practices and lessons learned

Expand the Range of Quality-Assured AC Appliances

In the absence of a catalog of efficient, quality-assured appliances, practitioners and operators are, in effect, conducting the R&D themselves on the viability of a given appliance in a field setting. Even when users have extensively researched an appliance before its purchase, they remain vulnerable to many unknowns. Will productivity in practice meet the manufacturer's claims? Will the appliance withstand the climatic and operational rigors? Will a motor's start-up current fall within a micro-grid's load limits or will it repeatedly trip fuses? These are just a few of the many pitfalls that can befall even the most prepared practitioner or operator. These risks can be significant for a small operation to bear, often leading to unwelcomed delays and costs.

Qualified third-parties should validate a range of appliances for the most common PUE applications with a focus on value-adding technologies**.** Testing should adhere to relevant international standards and best practices. Once qualified, appliances should be listed in a widely-accessible online catalog that is regularly maintained and updated. Several initiatives have already made great strides in this respect, but room remains to enhance their benefits.

A few initiatives have made notable impacts. LEIA, the Low Energy Inclusive Appliances research and innovation program under the Efficiency for Access Coalition, is one such initiative. LEIA aims to advance the "availability, affordability, efficiency, and performance" of a range of appliances. Currently, the product categories are limited to refrigerators, televisions, fans, solar water pumps, and five enabling technologies, such as brushless DC motors. A second initiative, the Off-Grid Appliance Data Platform hosted by Global LEAP and supported by CLASP, assures quality on the same four product categories. In Colorado, the Shell Foundation is supporting FactorE to launch a quality-assurance program for a range of appliances.

Quality-assure a broader range of PUE appliances, with an emphasis on in-demand, value-adding AC technologies.

Third party validation of price, efficiency and performance reduce risks and bolster the business case of a given appliance. From a practitioner's perspective, these cataloging initiatives could provide even greater value if they were to expand the range of appliance categories with preference given to value-adding AC machinery and appliances. While televisions and fans may enhance quality of life, it would be helpful for catalogs to also focus on electric-powered equipment that can more directly unlock economic opportunities. PUE loads on AC microgrids have the dual benefit of unlocking economic opportunity for end users and also boosting loads - and revenues - for grid operators, thus enhancing the business case for robust microgrids. LEIA's scope could expand to include value-adding appliances in high demand, such as hand power tools, mills, and high-efficiency cooking appliances.

Fund Field Testing

The true viability of a PUE appliance is not complete until it has been thoroughly field-tested. Until that full viability is confirmed, practitioners and operators will continue to bear an enormous amount of risk, which deters wider implementation. Quality-assurance programs check for quality and performance, but that is only part of the picture; a more complete picture would consider the many challenges that only emerge in a field setting. For example:

- Are replacement parts available and affordable?
- Do local technicians possess the skills to do repairs?
- Does the operator know how to run and maintain the appliance?
- Does the typical operator/owner have the business skills to manage higher productivity afforded through electricity?
- Can the local grid handle the large load induced by the start-up current of a motor?
- In the case of food processing, the characteristics of the food processed in the field could be different than those for of the foods used in quality assurance tests. Do these differences compromise an appliance's operation?
- Is the equipment rugged enough to withstand field conditions such as extreme heat, dust, saline air, or frequent transportation?
- Do the outputs of the equipment meet local standards and tastes?

These are just a handful of the potential complications that a field-based operation may face that cannot always be predicted from a laboratory setting. Additionally, other challenges not previously conceived invariably appear. Consider EarthSpark International's experience in Haiti (see Box below).

One recommendation is to fund practitioners to field-test promising, in-demand, value-adding appliances. The tests should be performed under a uniform framework of procedures such that results are credible and replicable under similar conditions. Additionally, the field tests should be conducted in the geographies most likely for future electrification and PUE growth. Qualifying field-tested appliances should be cataloged and disseminated, perhaps as an additional category in existing catalogs of quality-assured appliances.

The field-tests should assess a number of factors, including but not limited to performance, durability, reparability, cultural appropriateness, and ability of owners/operators to manage higher productivity.

Commendable progress in this respect is already underway. The Global Leap Awards is supporting field testing in Uganda and will reward "Appropriate Design and User Experience". This type of testing should be scaled up and broadened to other geographies.

Fund practitioners to field-test promising, in-demand, value-adding appliances, while adhering to a strict testing protocol.

Field Realities of PUE Promotion: EarthSpark International's Experience in Haiti

Starting in 2013, thanks to a USAID Powering Agriculture grant and other donors, EarthSpark expanded a microgrid in the coastal town of Les Anglais, Haiti, to serve 450 connections with a 100KW solar+diesel+storage minigrid. A central objective of this project was the transformation of agricultural processing through productive uses of electricity. After careful analysis of existing and potential agricultural processing that could make a viable switch to electric power, the leading opportunities were identified as a corn mill and corn thresher. In spite of extensive front-end research, EarthSpark faced unforeseen challenges in the field operations of these two PUE technologies. This example serves to highlight the critical importance of field-testing PUE technologies before issuing an endorsement.

Corn Mill

Mr. Julio Francois ran one of the town's most prominent corn milling operations, using a 25-year-old 15 HP marine engine to turn a hammer mill. During the height of corn season, he would run the mill 8 hours a day, processing over a thousand pounds of corn a day.

Corn milling in Les Anglais

A detailed analysis of Mr. Francois's operations compared to a promising electric mill indicated the electric mill would double the milling rate while reducing operational costs, improving profits and recovering the investment within a reasonable timeframe.

In practice, however, a critical complication emerged that reduced the electric mill's profitability to that of the diesel engine: in Haiti, corn kernels have a higher humidity content than the kernels used at the manufacturer's testing site in the US. Less brittle kernels do not crack as readily. This one simple characteristic depressed the throughput rate by over 80%, from the manufacturer's claim of 900 lbs/hr to 150lbs/hr.

Corn Thresher

In Les Anglais, corn kernels have traditionally been stripped off of dried corn cobs by hand at a rate of 20 lbs/hr. An electric corn thresher identified by EarthSpark held promise of stripping kernels at a rate of 440 lbs/hr. Financial calculations indicated the switch would recover the operator's investment within a reasonable timeframe and yield an acceptable profit.

In practice, however, several realities complicated the operation's viability:

- The belt for the pulley supplied by the manufacturer was in fact a larger belt that had been cut to length and reconnected with a single staple which, not surprisingly, broke after a day's use. A suitable replacement belt could not be located anywhere in Haiti, requiring a specialized belt be sourced from the US.
- The throughput rate of the machine was 220 lbs/hr in practice, exactly half of the manufacturer's claim.
- The motor created an in-rush current upon start-up of six times its steady state current, which repeatedly tripped load limits in the meters.
- Potential clients were reluctant to transport their corn cobs to the thresher's location, in the center of town even though the cost to have cobs mechanically rather than manually threshed would have been less.

Manual corn threshing

Piloting the new mechanized thresher

Synthesize Case Studies

Practitioners seeking guidance on best practices for promoting PUE have limited resources at their disposal. Guidance consists primarily of the aforementioned PRODUSE manual, and a range of case studies. Two collections in particular host case study libraries: again on PRODUSE[1], which profiles 17 projects across three continents, and on Energypedia[2], which hosts the "PUE Portal – Examples of Productive Uses", which profiles 11 projects. While

[1] PRODUSE Projects, http://www.produse.org/index.php?lang=eng&page=7.

[2] Energypedia, Productive Use Portal, Examples of Productive Use, https://energypedia.info/wiki/Portal:Productive_Use.

it is helpful to have access to these studies, they are of limited value to the practitioner who seeks case studies of direct relevance. The studies, by contrast, vary too widely in geography, PUE technology, scale, methodology, or cultural context to be of consistent value, and sorting through them is inefficient.

In addition to a case study methodology for future PUE field trials, some overarching syntheses that extract common themes, success factors, best practices, and potential pitfalls would be helpful for practitioners. The analyses could be categorized by PUE applications. Helpfully, Energypedia has already conducted such an analysis on milling, lighting and cooling.

The following actions could make greater use of case studies to PUE practitioners:

- Expand the analyses to cover other common PUE applications
- Deepen the analyses with more case studies and ideally common methodologies and reporting templates
- Make the analyses widely available
- Keep the analyses current with periodic updating as new case studies and new PUE applications emerge

In summary, these three proposed actions would provide concrete, immediately actionable guidance and resources to practitioners and prospective owners of PUE appliances who are currently overburdened with the high risks and costs of field-truthing PUE appliances on their own and who are best-positioned to ultimately validate PUEs.

About EarthSpark International

EarthSpark International is non-profit incubator for clean energy enterprises that can solve energy poverty. To date EarthSpark has spun-off SparkMeter Inc., a venture-backed smart meter technology company, and Enèji Pwòp S.A., a Haitian clean energy retailer and microgrid operator. SparkMeter now has meters installed in over 120 microgrids across 22 countries, and Enèji Pwòp has sold over 18,000 clean energy products. EarthSpark has also built Haiti's first town-sized, solar-powered smart grid and has another 3 in development towards a scalable model for microgrids in Haiti and beyond.