Agribusiness & Food Systems, Finance & Investment, and Clean Energy Practices

Scaling the impact of solar systems in agricultural value chains: Lessons from East Africa's smallholder dairy industry

Several recent trends in the distributed solar energy industry are improving the business case for Productive Use of Solar Energy in agricultural industries that depend on efficient and cost-effective cold chains. These include significant cost reductions in solar and battery technologies and growing interest from financial institutions in green projects

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It is estimated that 365 million people in Eastern and Southern Africa—most of whom live in rural areas—lack access to electricity. These regions account for more than half of the world's unelectrified population of 675 million[1]. However, closing the energy access gap requires multi-year budget commitments and the capacity to deliver grid extension and densification projects—both of which pose significant challenges for governments. In the meantime, East Africa has immense solar energy potential due to high, consistent, year-round solar irradiation (e.g., 5–7 kWh/m²/day in Kenya) resulting from its equatorial location. Kenya, Uganda, Tanzania, and Rwanda are expanding solar photovoltaic (PV) capacity, particularly in areas with limited electricity access.

Maximizing the impact of solar energy potential requires scaling up distributed solar energy systems, particularly in rural areas beyond the reach of national grids. Distributed solar systems, including solar mini-grids, are therefore a fast and effective strategy for accelerating clean electricity access for productive uses. Access to clean, affordable and reliable energy catalyzes investment in agricultural value chains and market access. It specifically bolsters investment in major, energy-dependent industries, including dairy, fresh produce, meat and poultry, and fish. The performance of these industries largely depends on the extent to which efficient cold chains are in place to keep products fresh and maintain quality. For their part, cold chains play a major role in reducing post-harvest losses, enhancing the profitability of agricultural value chains, and improving farmer incomes. Investment in cold chains builds smallholder farmers' trust in agricultural markets—which in turn increases investment in productivity-enhancing technologies. It also incentivizes broader participation by women and youth in value chains they would not otherwise invest in.

ORI's work supporting clients in East Africa to pilot, evaluate the economic viability and scale up high-impact business models for productive use of solar energy (PUSE) systems in dairy, meat, poultry, fish, and fresh produce industries has given us insights for how to expand the impact of agricultural industries that are cold chain-dependent. In this article, we outline key learnings for scaling PUSE projects based on our work in the dairy sector in underserved rural areas of East Africa. The article draws on analysis and interviews with dairy industry stakeholders, engineering, procurement and construction (EPC) and technology/energy services companies, market facilitation organizations/non-profits, financial institutions, and government/regulators. We aim to contribute to general understanding and inform industry stakeholders about how future projects and investments in distributed solar energy in smallholder agricultural development can be more efficiently and effectively designed and implemented.

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[1] https://www.worldbank.org/en/region/afr/brief/afe-energy

Context of East Africa’s dairy industry

East Africa’s dairy value chain typically starts with rural farmers, mostly organized in producer groups or dairy cooperatives. Farmer archetypes include smallholder households with fewer than 10 cows, medium-sized dairy farmers with herds typically ranging from 10 to 50 cows, and large producers with up to 200 cows. Depending on the level of investment and sophistication, farmers use extensive/traditional field grazing or intensive production systems/zero-grazing systems, or a mix of both. However, commercial medium-sized and largescale dairy farmers are more likely to make significant investments in production, ranging from high-yielding genetics to high-quality feeds and supplements, livestock housing, herd health, and production management–including cold-chain management. Smallholder rural farmers optimize their dairy engagement through collective action—beginning from the collection of milk on farms and its delivery to milk collection centers (MCCs), which are mostly run by the dairy cooperative in which they are members. At the MCC, milk is tested for quality and weighed to record the quantity delivered and its purity. Collected milk is stored in chilling tanks, which are energized to lower temperatures to the correct level over several hours. The chilled milk is then purchased by dairy processors and transported in insulated, truck-mounted tanks. Reliable chilling is, therefore, a critical step, as milk spoils without adequate chilling within 3 to 6 hours of harvest. Dairy processors will only purchase high-quality milk at the correct temperature, while lower-quality milk is sold in the informal market at a lower price.

MCCs are a key node in the dairy VC, linking rural farmers to markets. However, typical MCCs experience suboptimal business performance, which erodes the productivity of the dairy value chain and farmers' confidence in their ability to get milk reliably to market.

Key challenges faced by MCCs include: (a) Low capacity utilization of milk cooling equipment due to the inability to source sufficient volumes of milk, especially in the dry season, when productivity is reduced due to scarce water and pasture; (b) High operating costs; (c) Infrastructure related bottlenecks such as access to clean water, affordable and reliable energy[2], and (d) High post-harvest losses. In particular, the lack of access to affordable and reliable energy is a key factor undermining MCCs' performance. The majority depend on diesel-powered generators to power milk chillers or run backup generators during frequent power outages—a common challenge across East Africa's rural areas, even where grid access exists. Gensets are expensive to run—especially in the context of high and volatile diesel prices. In addition, gensets owned by dairy cooperatives are often old, inefficient, and require frequent maintenance. They also contribute to greenhouse gas (GHG) emissions, including Carbon Dioxide (CO_2).

High energy costs are a key driver of MCC operating costs, typically accounting for up to 40 percent. Expensive, unreliable power is also a key factor in high post-harvest losses, often due to poor quality products resulting from inadequate chilling. Post-harvest milk losses in the dairy value chain are the highest at the milk collection stage. The primary reason for milk losses is product rejection by processors due to poor quality. However, other factors also play a role, particularly limited market access, especially during the wet season when milk supply increases, and transportation challenges intensify.

Access to energy is, therefore, a key accelerator for the dairy value chain. Smallholder development organizations can leverage several recent trends that have improved the business case for PUSE, including significant cost reductions in solar and battery technologies and growing interest from financial institutions in green projects.

Even so, it is essential to overcome a number of constraints to the adoption of solar energy solutions, including:

— High upfront costs of investment in renewable energy technologies and the need for affordable financing solutions that would provide immediate cost savings to dairy cooperatives.
— Lack of appropriate financing mechanisms from commercial banks/financial institutions and the need to facilitate financial product innovation.

[2] For example, Uganda's rural electrification rate is ~31.8 percent, and most dairy cooperatives are off-grid or located in areas without reliable grid power.

- Lack of confidence in the quality and performance of solar and battery systems, and the need to reduce the technology and operating risk perceived by farmer cooperatives and financiers.
- Limited technical knowledge to compare and assess technical and financing options and to oversee construction, operation and maintenance of solar systems.
- Inadequate legal, institutional and enabling environment to incentivize and regulate smaller-scale, captive, commercial and industrial/productive use projects.
- Lack of coordination and exchange across the agricultural, energy and financial services sectors, and the need to inform and bring together stakeholders with a role in scaling up the productive use of solar energy.

Six lessons for expanding the impact of solar systems in dairy

First, it is essential to develop viable models to scale up access to finance for distributed solar energy assets. Investment in distributed solar energy projects for agribusinesses can be financially viable. However, this requires rigorous modeling to deliver financing efficiently. Examples include long tenor (~10-year) lease-to-own business models. Proactively engaging the C-level leadership of financial institutions—particularly commercial banks and their credit/investment committees—can bring urgency in banks to move in the right direction toward developing and improving financing options for PUSE. It can also increase the affordability of target finance products by dairy cooperatives and potentially apply to other capital constrained agribusinesses. Stimulating financial innovation is essential to expanding access to affordable finance and to facilitating the scale up of similar projects. Engagements with financial institutions that provide financing to agribusinesses and solar energy companies can drive financial innovation to improve access to finance for PUSE projects. Pilot projects can provide a model for how solar energy assets could be financed and improve understanding among financial institutions, dairy cooperatives, and market systems development organizations of the structure, terms, and requirements for similar projects to be financed in the future.

Second, there is a continued need to deploy impact capital to facilitate scale up of PUSE in agribusiness value chains. Commercial financing options for PUSE remain limited—until the financing ecosystem is better developed. In particular, it will likely remain challenging for dairy cooperatives (or other cold chain dependent agribusinesses) that lack a solid credit history, maintain poor financial record-keeping, and cannot demonstrate sufficient cash flow to service a lease/repay a loan to access finance. The financing gap could be addressed by establishing blended financing instruments, potentially involving a range of impact investors with aligned missions and a focus on renewable energy in emerging markets.

Third, market facilitation, capacity strengthening and technical oversight are key to successful project delivery. Having project managers with an engineering background has been critical to the success of pilot projects and sustained technical oversight of project development and execution. In addition to engineering skills, financial modelling and structuring are needed to assess the economic feasibility of projects and financing options. There is also a continued need to work closely with dairy cooperatives and financial institutions across multiple fronts during scale-up phases, including early involvement of financiers in project development. This includes ensuring dairy cooperatives understand financing requirements for the projects and, where necessary, working with those that do not yet meet the criteria to access asset finance, including to strengthen governance structures and financial recordkeeping. Financial institutions should be brought into project development at an early stage so their concerns and structuring inputs can be addressed and incorporated.

Fourth, technical assessments and engineering design should be comprehensive. The engineering design should help frame the business model early on. The cost of replacing existing equipment should be factored into the business model. For grid-tied solar systems, this needs to include an assessment of existing back-up generators, including their size (to be at least twice the maximum demand of the milk cooling center), the frequency control systems, and automatic voltage regulator capabilities. If generators have unstable power output and cannot be integrated with the solar PV system, then the cost of batteries (or a replacement generator) should be included in financial models. The energy efficiency of milk chilling units should be assessed as part of the technical assessment, and the economic viability/cost-benefit of replacing highly inefficient units versus over-sizing the solar PV system should be considered at an early stage. In addition, the existing power infrastructure should be assessed and incorporated into the technical design. System design and sizing should anticipate and accommodate increases in power demand for cooperatives, allowing for land/space to expand the solar PV array and racking systems to accommodate battery additions at a later stage.

Fifth, the maintenance and replacement of batteries, inverters and other parts requires budgeting over the full lease term. It is important to ensure that the solar PV systems are maintained and continue to operate reliably and cost effectively for the full lease term (10 to 20 years, depending on the project) and, preferably, longer. The lease payments should cover the replacement costs of batteries and inverters, any required equipment, and operations and maintenance (O&M) costs. This structure reduces technical and operational risks for the cooperatives and has helped de-risk their investments. For pilot projects, impact capital providers and the blended finance ecosystem can play a vital role in bearing the risks and costs of equipment failure. It is in their interest to ensure the quality and durability of the equipment and that O&M costs have been fully factored into project costing. In addition, an opportunity exists to capitalize on the lower cost of systems, brought about by the reduction in Lithium-ion battery prices in recent months, and moving forward.

Sixth, it is important to assess project feasibility based on cost savings and impact on MCC operations. In scale-up phases, it is vital to assess project feasibility and potential impact on a case-by-case basis, and to prioritize the most viable projects with the greatest impact. This should also be based on location-specific circumstances. In general, projects are more viable where dairy cooperatives have established governance structures and meet the financing criteria of investors—as well as where they show a high level of interest and 'readiness' to make investment decisions. They are also more economically viable and have a greater impact in off-grid locations and where they displace diesel generators. As market conditions continuously change and the technologies available continue to evolve and improve—particularly in the case of components such as batteries—the economic viability of these projects may change over time.

In summary, we recommend designing facilities that meet essential requirements without unnecessary complexity, closely managing equipment spend, and improving MCC operations and planning long-term.

This article was written by ORI experts and captures the views from Agribusiness and Food Systems, and Clean Energy Practices.