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Photo 1 A herdsman at a RDC member farm milking a cow in the evening

CASE STUDY:

IMPLEMENTATION OF A SOLAR POWERED COLD CHAIN IN A RWANDAN DAIRY COOPERATIVE:

THE PILOT PROJECT AT RWIMBOGO DAIRY COOPERATIVE, GATSIBO DISTRICT, EASTERN PROVINCE OF RWANDA

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Executive Summary

In the months of May through July 2022, Rwimbogo Dairy Cooperative (RDC), Clean Energy Technologies (CET) and SunDanzer Refrigeration (SDZ), funded by the IFAD grant Green Technologies to Facilitate Development of Value Chains for Perishable Crops and Animal Products (GreenTech), partnered to conceive and implement Rwanda's first cooperative-wide solar powered cold chain. This included:

1. Installing a solar powered (with battery back-up) 500-liter bulk milk cooler and solar hot water at a Milk Collection Point (MCP); enabling milk collection from a previously unserved area and increasing overall collection volume and revenue.
2. Installing a solar powered (with battery back-up) 500-liter bulk milk cooler and solar hot water at a Milk Selling Point (MSP); enabling the volume sale of milk in a trading center at retail prices (as opposed to the government mandated minimum price).
3. Rehabilitating a defunct solar + storage at the Milk Collection Center (MCC); reducing operating expenses and safeguarding large volumes of milk from power outages.
4. Selling and installing 40 solar powered 50-liter chest refrigerators to farmers for storing evening milk and domestic purposes

This landmark project revealed itself to be only the first phase of work rather than an end in itself. Instead of a one-off project that solved a single set of related problems in the short term, what was needed was a comprehensive, systemic approach that identified and addresses all the changes necessary to take RDC to the next level for the long term.

The project laid the groundwork for RDC to greatly lower it operating expenses, increase productivity and revenues by establishing new sales outlets, but a major challenge remained that threatened all the progress made: being able to increase milk production during the Dry Seasons. Hence, a second phase project incorporating a solar powered water pumping infrastructure, solar chopping of livestock feed and Zero Grazing has been conceived to address this more critical issue.

This case study contains:

- Background information and an introduction to the key implementors: SDZ, CET, RDC
- Project evolution: how the project was initiated and how it unfolded organically bottom-up
- Details about each implemented project stage, including technical specifications, costs, impact and Lessons Learned
- Overview of the proposed next phase to increase milk production in the dry seasons, including phases, costs and impact
- Conclusion pointing to the need for a new paradigm of aid/funding based on supporting on-the-ground partners dynamically over the long term (not stop-gap projects in the short term)

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1. BACKGROUND

1.1. The Dairy Subsector of Rwanda

The activity of cattle farming is deeply rooted in the Rwandan culture, this is reflected in local taboos, sung poetries, ritual dances, friendship ties and gratitude gestures. For centuries, Rwandans have raised cows for their milk, skin, and meat. Cattle farming is still linked to economic status and well-being of households in Rwanda:

"The dairy subsector is the largest segment of the livestock sector in Rwanda, which accounts for 10.5 % of agricultural gross domestic product and is the fastest growing subsector within agriculture. This makes it a very important source of income for Rwandans, especially those in the rural areas that largely depend on agricultural activities for their source of income, therefore, investments in this sector to improve quality and increase productivity, have a paramount contribution in fighting poverty, not only in the rural areas but also for Rwanda at large as a country towards reaching a middle-income status." [1]

It is with this context that SDZ directed GreenTech funds to a pilot project with RDC to undertake three milk cooling sub-projects to increase the productivity and lower the operating expenses of the cooperative.

1.2. SunDanzer Refrigeration Inc. and IFAD GreenTech Grant

SunDanzer (sundanzer.com) is a US-based company that manufactures solar powered refrigerators. In 2018, it was awarded the multi-year, $2.2M USD IFAD grant entitled Green Technologies to Facilitate Development of Value Chains for Perishable Crops and Animal Products (GreenTech). The GreenTech program largely focuses on solar powered cooling solutions for dairy farmers and artisanal fishers in East and Central Africa. Two major GreenTech projects consisted of piloting small-scale, solar powered, PAYG enabled refrigerators (50-160 liters in volume) in the dairy sector, as well as smaller sized bulk milk coolers.

1.3. Clean Energy Technologies Ltd.

Clean Energy Technologies (cetsolarpower.com) is an engineering consultancy and sustainable energy solutions provider established in 2010 based in Kigali. They offer turnkey renewable energy solutions providing assessment, design, procurement, financing, implementation and maintenance services. CET was selected as SDZ in-country partner for GreenTech projects.

1.4. Rwimbogo Dairy Cooperative

Rwimbogo Dairy Cooperative is located in Rwimbogo Sector, Gatsibo District in the Eastern Province. The cooperative come into existence in 2005 as an initiative from the government of Rwanda, mobilizing Rwandans to work together in cooperatives to their advantage. The Cooperative was later registered on 2/2/2012 with the Rwanda Cooperative Agency (RCA), the organizing body provided by the government of Rwanda for the governance of cooperatives. Upon registration with the RCA, RDC had a general

assembly of 80 members. It currently has a general assembly of 211 members (174 males and 32 females), with leadership of 5 board members.

The major reason that motivated the members to form the cooperative, as narrated by a member in a Focus Group Discussion (FGD), was that farmers had an abundance of milk, but little market in the neighborhoods. They badly needed a market for their milk because it was being wasted and their financial needs were not being met. Therefore, in response to the RCA initiative by the government of Rwanda, they sought support in reaching markets for their milk.

2. Project Evolution

SDZ and in partnership with CET first approached RDC in May of 2020 with the intention of supplying farmers with solar powered fridges for the purpose of preserving evening milk collections for sale in the morning. This effort went nowhere. There was not a strong perceived need and there was the usual issue of trust. In October of 2021 CET approached RDC again, this time proposing offering solar powered 500-liter bulk milk coolers. This time there was interest and traction. There was a recent change in leadership and James Karangwa had just been hired as the new cooperative manager. There was inherent motivation to improve the situation of the Cooperative and farmers, both suffering financially. The new leadership saw an opportunity to lower expenses and increase sales. The Cooperative and CET, through numerous discussions and general assemblies, developed a clear strategy and three supportive cold chain projects, executed in three sequential stages.

1. **MCP and MSP Bulk Milk Cooling.** It was decided the two 500-liter bulk coolers would be used for a Milk Collection Point (MCP) and a Milk Selling Point (MSP) in Rwagitima and Kabarore trading centers respectively, to enable increased milk collection from farmers and then be able to sell the milk at the higher retail price.

2. **MCC Bulk Milk Cooling.** The second need was to rehabilitate a non-functioning 20 KW solar+storage system that was at the Milk Collection Center as a way of eliminating electricity costs but also solving the problem of major milk losses when grid power goes down.

3. **Farm Level Cooling.** The third and lowest priority was providing solar powered fridges to support farmers with preserving evening milk collection for sale in the morning and for domestic use. Here, SDZ provided the fridges to famers at an affordable, subsidized price or $400 USD.

The bulk milk coolers and small-scale fridges were within the scope of the GreenTech grant. However, the refurbishment of the MCC's solar system was not. Here, IFAD demonstrated support and flexibility by giving the go-ahead to fold this project into GreenTech. Funds were reallocated from a project in Zimbabwe, where a government team was failing to make progress on a cold-room project.

The projects were started, completed, and commissioned successfully. However, the Cooperative came to realize that during the dry season, when milk production fell to such a low level that they would not be able to maximize the benefits from the added cooling capacity and reliability as well as be able to make their installment payments to CET toward their 10% contribution toward the project costs.

In a follow-up visit, RDC communicated the critical Dry Season challenge to CET. Presently, SDZ, CET and RDC are working collectively and have defined a viable next phase solution that includes creating a

watering infrastructure using solar powered water pumping, solar powered feed choppers and project partners like Heifer International to transition the Cooperative to Zero Grazing. This critical follow-up to the project will require quick funding to enable implementation before the next Dry Season that begins at the start of June 2023.

3. Stage 1: MCP and MSP Bulk Milk Cooling

3.1. "Courting" of RDC

The RDC projects had their beginning in late 2021. However, the process that began over a year earlier with finding a list of all dairy cooperatives in the different regions of Rwanda. This was followed by Needs Assessment visits to individual cooperatives focusing on use cases for small scale 165-liter milk coolers. Visits were made to cooperatives in the Eastern Province, particularly in Kayonza, Gatsibo and Nyagatare districts. The visits then extended to the other districts in the Northern Province, Western Province, and Southern Province. Basing on the findings from the assessment, a decision was reached to give focus to the Eastern Province, where milk production was recorded to be relatively high.

In early 2021, the small volume bulk milk cooling component was shifted by SDZ from Tanzania to Rwanda to take advantage of CET's growing knowledge of the dairy sector and special expertise in implementing solar + storage projects. CET narrowed the selection for the bulk milk cooling pilot project to 3 cooperatives in Gatsibo district: Kibondo Dairy Cooperative, Kiramuruzi Dairy cooperative and Rwimbogo Dairy Cooperative. Each of cooperative's leadership was contacted and the project proposed to them. Of the 3 cooperatives, only RDC's newly hired Cooperative Manager had the vision and motivation to take advantage of the opportunity and take the risk of working with an unknown entity. It is important to note that it took great patience and perseverance on CETs part to win the confidence of the Board and members in a series of General Assembly meetings. As mentioned, the original project planned for the RDC farmers was to provide a farm-based cooling facilities using small fridges. However, it was the 500-liter bulk milk coolers that caught the new Cooperative Manager's attention.

After more interactions with the leadership at RDC, it was agreed that one bulk milk cooler could anchor a MCP in the unserved area of Gitoki, increasing the volume of milk collected and thereby potential revenue. In addition, the total volume and quality of the milk could be further improved by testing away from MCC and cooling the milk right away, reducing rejection rates. The other bulk milk cooler could be strategically located in a nearby trading center to as an MSP. Here the milk could be sold at higher price than to the major dairy Inyange or to locals in the rural area where the MCC is located.

The increased income from the bulk milk coolers would support the cooperative to meet its operating costs as well as pay off their 10% investment/contribution for the coolers. A feasibility assessment was conducted for the possible locations suggested by the cooperative members. Rwagitima trading center was selected as the new MCP and Kabarore trading center was chosen as the MSP.

3.2. Agreement for the Bulk Milk Coolers

After selecting the points for installing the bulk milk coolers collectively with RDC members, an assessment for the solar and storage requirements of installing the coolers was done by CET based on the technical

specification of the coolers. A bill of materials and importation, transport and installation costs for the project were determined and presented for approval by SDZ. On approval of funding for the subproject, discussions between SDZ, CET and RDC leadership were initiated, resulting a signed a Letter of Intent on 10/12/2021 that outlined the key terms agreed by all parties.

Three of the critical agreement terms were: 1) for the cooperative to contribute 10% of the total cost for installing the coolers to show their commitment to the ownership and sustainability of the project, 2) the remaining cost of 90% was a grant donation to RDC for the subproject and 3) RDC agreed to rent, renovate and staff the MCP and MSP locations and take responsibility for the systems and their security immediately after its commissioning.

At the time of the signing of the agreement, the Cooperative was not in position to raise their 10% share of the total cost. It was agreed CET would support the Cooperative by financing the 10% upfront payment. RDC agreed to pay back the loan monthly in 24 installments after a grace period of 3 months in a separate agreement exclusively with CET. After the 10% down payment prerequisite, CET and SDZ signed an installation agreement.

Photo 2 Focus Group Discussion conducted with RDC members to establish their real needs

CET and SDZ then engaged pan-African solar distributor African Energy (AE) to provide all the equipment needed for the subproject, including purchasing and shipping the bulk milk coolers from Italy. CET worked with AE directly with SDZ paying the invoices. In addition to paying for the equipment, SDZ paid for the materials that could be bought on the local market needed for installation and labor to CET directly to implement the project.

In summary, the agreements and arrangements took considerable time and effort and required a great deal of creativity and flexibility. The perseverance and dedication of CET and the RDC management were instrumental in getting the project to the implementation stage.

3.3. Technical Specifications and Costs

At both the MCP and MSP locations, single smaller volume bulk milk coolers were installed. These quality milk coolers had a capacity of 500 liters and were manufactured by FIC Spa in Italy and ran-on AC electricity. The brand and model were selected based on power efficiency. Each cooler requires power of less than 2 kW to operate. Extra capacity was designed into the photovoltaic system to allow future growth, should RDC need to install a second cooler with increases in production and sales. The solar power system at each site has 6 kW of solar panels installed with an TBB inverter/charger and 5 Lithium Weco batteries of 5 kWh each (totaling 25 kWh of energy storage). The power storage system was included to support night cooling of milk when this should become necessary. The national electrical grid acts as the back-up to the system.

The total installed cost of the two bulk milk coolers was approximately 88,000 USD. This cost included installation of the entire milk cooler systems, including solar water heater systems to provide hot water for sanitation.

Photo 3 Nkotanyi Innocent, RDC staff, at the RDC MSP in the Kabarore trading center filling containers of customers with milk

As mentioned, RDC has assumed the operational costs. As of October, 2022, the milk coolers both at the MCP and MSP have been in operation for about 2 months and no major technical challenges have come up. This was affirmed by the two staff of the cooperative, employed to run the MCP and MSP at Rwagitima trading center and Kabarore trading center respectively. Vincent Nshuti, who runs the MCP at Rwagitima trading center, narrated his experience with the bulk cooler:

"I have not had any challenges with the cooler since it started operating. I am not worried about the powering of the cooler because the cooling system is efficient and effective in such a way that even when there is no sunshine, it has a storage system for power that will be used and, if all comes to the worst case, it can use grid power, which I do not think will ever happen based on my experience so far."

In a follow up visit by CET to monitor the functionality of the milk cooler project and its useability by the RDC staff, Innocent Nkotanyi who runs the MSP at Kabarore trading center, put out an important concern:

"I would like to gain more knowledge on how to read the liters of milk with the specifications that are provided inside this cooler, how to read off the degree of coldness and make adjustments that will be favorable in maintaining the quality of milk and other functions that the cooler delivers that I may not be aware of. This will help me maintain the cooler in good condition."

It is worth noting that, even though the agreement to install the coolers was signed on the 10/12/2021, progress of installation work was delayed due to the COVID-19 restrictions that were in place, both globally and within Rwanda. Despite such challenges, CET managed to complete installation work of the two bulk milk coolers by July 2022. Operations started immediately afterward.

Photo 4 Solar panels and solar hot water installed at the RDC MCP in Rwagitima trading center

3.4. Goals of Milk Collection Point and Milk Selling Point

The Rwagitima MCP is located 12 KM away from the Rwimbogo MCC and the MSP is at 5KM away from the Kabarore MSP as a strategy to expand the territory for both milk collection and milk sales. This achieved the goals of opening a new territory where unserved farmers far away from the main would contribute a new source of milk as well as expanding the market for RDC milk to a major local trading center where it could be sold at a higher retail price. Both facilities not only increase the income of RDC, but also create employment.

July 28, 2022 was the first day of milk collection from Gitoki Sector at Rwagitima MCP. 3 farmers delivered 37 liters of milk at the MCP and by September 5th 2022, the number of farmers delivering milk at the MCP had increased to 12, delivering 81 liters of milk as per the records at the MCP. By December the MCP was

collecting and cooling 350 liters a day. These figures were reached without any outreach to farmers to deliver their milk to the MCP. However, the next step will be for RDC to reach out to farmers in the neighboring areas that there is now an MCP where they can monetize both morning and evening milk.

In addition to the milk collected at the Rwagitima MCP, RDC also delivers additional milk from the MCC. Starting with 444 liters on the 28/7/2022, by 5/9/2022 the liters delivered had increased to 637 liters. This confirmed that RDC's premise that there exists a local market eager to consume their milk.

Photo 5 Nkontanyi Innocent, 25 years of age. on the right of the motorcycle receiving milk at the Kabarore trading center MSP from the RDC MCC, behind him are customers waiting to take milk home with them.

At the MSP in Kabarore trading center, on an average day, the RDC delivers about 400 liters of milk per day from the MCC. Each liter sells at 350 RWF, currently lower than its competitors in this trading center, but significantly higher than the 200 RWF minimum price paid by Inyange at the time (recently the government raised a price to 300 RWF). This was one of the strategies that the cooperative put in place to attract customers as well as customer care, higher quality milk and efficiency and effectiveness. The major competitive advantage that the MSP has over its competitors is that it spends zero Rwandan francs on powering the milk cooler, which enables it to sell milk profitably at the lower price of 350 RWF per liter, while competitors sell it at 400 RWF.

The bulk milk coolers have not only benefited the RDC members, but also community members as shared by one of customers at the MSP in Kabarore trading center, Marie Rose Uwineza, a female of about 30 years old:

"This milk selling point is near, we do not have to walk a long distance to collect milk to use at home. The milk also goes for a lower price than the other shop. The milk at this selling point is of very good quality and nutritious. It is not diluted with water, does not smell bad and does not go bad, giving us value for the money. For most households in this town, our first choice is to buy milk here. We only go for other options in the trading center only when the milk runs out here. We are very satisfied and happy."

Youth like Vincent Nshuti, 30 years old, and Innocent Nkontanyi, 25 years old, have gained employment and learned business skills. When interviewed they affirmed:

"I am employed by the Cooperative to work here at Rwagitima. This is a great deal for me. I am paid at the end of the month but most important of all, I have been able to learn a lot of practical business skills. For example, I have learned the importance of taking business records every day. I now understand this information is helpful in informing business decisions. I am confident that when the time comes, I shall do my own business successfully. I also can visibly see that the Cooperative is gaining financially." ***Vincent Nshuti***

"Personally, I have gained employment with this selling point in Kaborore, but also the Cooperative has been able to access another market for its milk other than the dairy location, where it sells a liter for 325 RWF. The Cooperative is also able to buy milk from other farmers at the diary location not necessarily in the Cooperative and sell it for a higher price of 350 RWF per liter here at the MSP, which would have not been a possibility before. Where the dairry is located, a liter goes for 325 RWF. So this is increasing the Cooperative's income". ***Innocent Nkotanyi***

3.5. Lessons Learned

- Milk was purchased based value. Customers at both the MSP and MCP preferred to buy milk not only because the price was a little lower than other milk vendors, but because the quality of milk was higher than other milk vendors in the area.
- The MCP and MSP are sources of employment for Youth where they can learn business skills that will help them in the future if they open their own businesses (which further increase employment for youth).
- While the Cooperative was badly in need of additional bulk milk coolers, affordability was a major challenge. Even at a payment of only 10% of the total cost. Hence, financing institutions have to have easy-to-access, low-cost loans with reasonable payment plans to support farmers.
- IN FGDs, cooperative members expressed need for small bulk milk coolers in the village areas for the collection of evening milk, especially for farmers with large volumes of evening milk that cannot be stored in fridges.
- There is a need to train the staff operating the bulk coolers in depth about equipment functionality and maintenance to ensure proper usage. Adequate training was overlooked.
- A dairy cooperative has the knowledge and acumen to develop their own strategic plan that will improve their operations and take them to the next level.
- Preliminary positive results showed that a cooperative investing in solar powered "productive use" can potentially repay their share of the costs through increased sales and cost savings.

4. Stage 2: MCC Solar + Storage System Rehabilitation

4.1. Background of the MCC's "Dead" System

A large 20 kW solar + battery storage system on the premises of the MCC was installed in 2019 through a project funded by IFAD and implemented by Heifer International, as part of the Post-harvest and Agri-business Support Project (PASP) initiated by the Rwanda government. The PASP goal was to alleviate poverty, increase rural income and contribute to the overall economic development of Rwanda. The system worked for some time but stopped functioning due to the absence of maintenance and lack of funds for repair. Therefore, it did not help with the challenges at RDC: major milk losses caused by sudden power cuts and the high cost of electricity that was needed to run the coolers.

While conducting a Needs Assessment utilizing small scale fridges for evening milk in 2020, SDZ and its in country partner CET, become aware of the non-operating solar + storage system at the MCC compound. The solar system had an array of 88 ground mounted panels. They were examined and established to produce about 20 KW of peak power, supplied to a hybrid inverter/charge controller that stored the generated power in batteries that was then used to power large bulk milk coolers. When it functioned the biggest challenge of the system was that it operated manually. When the sun was up, the system was turned on manually to run the coolers with solar power and, when was not available, the system was turned off to use grid power, which frequently went down causing major milk losses to the RDC.

SDZ and CET further examined the "dead" system and found out that the batteries and inverter/charger of the system were damaged beyond repair and that the inverter/charger was an unknown Chinese brand. This finding was shared with the RDC board and efforts were made to reach the providers of the manufacturer in China for replacement, but no trace as found.

In several interactions and meetings conducted CET with RDC members, the issue of reviving the non-functioning solar + storage system came up frequently as a priority to avert the major milk losses due to power failure and the high cost of grid electricity. These challenges then were presented to SDZ. With the full support of IFAD, an ensuing proposal to rehabilitate the system was approved and folded into the GreenTech program as an add-on project.

Photo 6 Solar panels of the “dead system” at the RDC premises that was resurrected

Only the solar panels could be salvaged from the old system could not produce enough power to keep an appropriately sized battery bank charged. So, the proposal included not only replacing the power electronics, but also expanding the size of the array to 40 KW and the battery bank so that the dairy could run the coolers off-grid both day and night as well as have extra capacity for adding another bulk milk cooler in the future. The prediction for future expansion of the cooperative business proved to be accurate. As the progress of the refurbishment of the solar system was on going, the cooperative acquired a new cooler, with a capacity of 2,500 liters in addition to the already existing coolers that had a total capacity of 5,500 liters. This validated the necessity for the additional 20 kW of solar panels that were installed on the rooftop of the structures at the compound of the MCC. The solar + storage system was designed to accommodate cooling capacity of about 10,000 liters, which makes the current system still able to support future expansion of 2,000 liters.

Photo 7 Additional solar panels that were installed by CET on the rooftop of the MCC

4.2. Agreement for the Rehabilitation of the Non-functioning System

Following the approval of the proposal to “resurrect” the “dead” system, an amended contract was signed on 1/4/2022, taking the same approach as for the bulk milk cooling project. One of the key conditions of the agreement was the cooperative had to commit to a down payment of 10% of the total cost for rehabilitating the system, as their way of demonstrating ownership. The amount was added to the 10% commitment that the cooperative had made initially made towards the bulk milk project. CET again loaned the 10% to the RDC. RDC is now repaying CET in installments for a period of 24 months.

4.3. Alert to the Next Challenge

During one of the monitoring visits to check on the progress of the project, in a Focus Group Discussion with cooperative members, a concern was raised that threatened the ability of the cooperative's ability to make the payment of the monthly installments and which was initially not anticipated at the signing of the agreement:

"We were mobilized and sensitized about the agreement content; we agreed to the content and our cooperative leaders signed it on our behalf to show our commitment. We are all aware of the agreement, the content in the agreement and our obligations to the agreement and agree to our obligations. We are ready to meet our obligations, however, we are challenged with by the quantity of milk decreasing greatly when it comes to the dry season. This could hinder us from properly meeting our repayment obligations. For us to overcome this obstacle, there is an urgent need to have sufficient water for cows during the dry season without the cows having to trek long distances to the lowlands as is the practice, which also further reduces their productivity. Unfortunately, we cannot find a way out to this obstacle".

This initial observation still needed affirmation. A discussion with the cooperative board confirmed the existence of the challenge. CET and the RDC Manager started to think critically on how the Cooperative could be supported in overcoming the challenge and developed a detailed phased plan and proposal (summarized later in this case study). The core of this proposal is a solar water pumping infrastructure and solar powered feed chopping stations to support a transition Zero Grazing.

4.4. Technical Specifications and Cost

The solar+storage was upgraded to 40 kW with an additional roof mounted array of Amerisolar 450 watt modules, a pair of 20 kW Azzurro hybrid inverters integrated with 16 Weco 5.3 kWh Lithium batteries. High voltage boxes were used to raise the voltage to the 800V that the inverter/chargers require.

The solar+storage system is designed to run in total off-grid mode or accept power from the grid to add to the power generated on-site (as back-up or if it becomes necessary for future expansion at the dairy). The entire cost for rehabilitating the solar system was about 80,000 USD, used to purchase equipment, materials and pay for the technical labor for installation.

4.5. Expected Benefits

- On average the dairy was paying about 600 USD per month for grid power, which will now be saved, hence achieving one of the intended goals of the project of reducing the high cost of grid power and using the savings to repay the loans made by CET.
- Since there will now be a provision for constant and reliable source of power for cooling milk, the large losses that occurred when grid power went on and off will not re-occur. An analysis conducted by the RDC management in early 2022 showed that 1,000s of liters and 100s of USD were lost every month due to power failures and rejected milk.
- It will be possible for the dairy to expand its capacity for cooling milk in future, using the same solar system from the current capacity of 8,000 liters to about 10,000 liters, which will increase productivity and milk revenue.

4.6. Lessons Learned

- As of October 2022, the solar + storage system has operated totally off grid, proving to be a successful intervention in reducing the power costs for running the dairy and eliminating losses. This confirmed that well designed systems using name brand components installed professionally by a local company that can provide on-going service are key to solving problems with solar. It is important not to succumb to the "low bidder" poor quality system. The end result is low life expectancy and premature failure.
- Challenges are ongoing and systemic. As soon as one problem is solved, it exposes another. Consequently, it is vital to provide on-going support over the long term. Otherwise, progress will be halted in its tracks by the next constraint.
- There is urgent need to identify and train local technicians in the Rwimbogo Sector that can support with simple repairs and maintenance of the solar + storage system, when the need arises. This is a preventative measure as well as a practical one since technicians would otherwise have to travel from Kigali, a trip of over three hours and provides a good opportunity to provide more skilled jobs to the Youth of Rwanda. This finding points to a general need for technicians in more rural areas.

5. Stage 3: Small Scale Fridges at the Farm Level

The second amendment for the rehabilitation of the solar+storage system included making available up to fifty 50-liter solar powered chest fridges to its members at a heavily discounted price of $500 USD (normally $800 USD). At this point, the relationship between CET and RDC was well established and the cooperative was open to the potential benefit of having farmers be able to cool evening milk.

A practical arrangement was made for CET in that RDC promoted the product and agreed to the collection of payments from individual cooperative members in the form of milk. First, a demonstration system was installed at the MCC for viewing and members were informed that they had two months to take advantage of the special pricing. Whoever was able to pay an initial down payment of 25 USD was eligible for a payment plan of 25 USD per month. Members signed a delivery note and entered into an agreement with the Cooperative. CET then installed the fridges. RDC is now deducting the fridge payment from their milk payment to the farmers, aggregating the payments and making a single payment to CET. CET was able also to deliver fridges and store them at MCC in bulk. This arrangement enabled the deep discount and made the fridges more affordable to farmers.

The fridge initiative was intended to support the cooperative members toward having a fridge for domestic purposes as well as preserving and monetizing evening milk. In total 40 fridges were sold to famers during the "sale price period". Each fridge is powered by a Zimpertec Litio solar home system containing a 25 Ah lithium battery and two 120-watt solar panels. In addition, the system includes 4 LED lights and adapter cable to charge phones. Thus, in addition to preserving evening milk, cooperative members bought the fridges for other domestic reasons like cooling other drinks like drinking water and juice, lighting their homes at night, and charging their phones.

In interviews conducted with some of the individuals that bought fridges, when asked why they bought their fridges and how it has worked out for them, below are two responses:

As narrated by Aloys Rwakamuzizi, a male of 73 years old:

"I bought a fridge to cool milk I collect in the evening so that it could be possible for my family to use it the next day, but also be able sell off the rest and make some more money in the morning. My family and I now enjoy cold water and milk to drink, which is so refreshing when the sun is hot and one has to run around the farm the whole day. The fridge has bulbs that have enabled us to have light during the night, this has also made it possible for my child to do their homework after school comfortably when it gets dark. I can charge my phone as well. Buying the fridge was a great idea".

Consolata Nyirarudodo a female of 70 years and a mother of 5 children, stated:

"When I came to know that the cooperative management had received fridges for members to buy, I had no doubt that I needed to have one to cool evening milk that I collected and light my house at the same time. Immediately I approached the cooperative management to register as a cooperative member first since I was not a member, so that I could purchase one before they all were bought. I am glad I bought a fridge. My family no longer must stay in the dark when it comes to nighttime; it feels very safe at night with lights on. As a family we can have a cold drink of water, juice or milk when it gets hot during the day. I can charge my phone which is so also helpful when I need to use it to make communications."

Photo 8 Two 120 W solar panels installed on top of the roof of the house of Joyce Mushmirwa to power her

Photo 9 Joyce Mushimirwa standing next to her fridge, the green box above the solar fridge is the Zimpertec controller

It is evident from the responses of the individuals interviewed, that besides the goal of selling fridges to enable evening milk cooling, there were other clear benefits that the individual and the cooperative gained. For example, the cooperative being able to attract and register new cooperative members like Consolata Nyirarudodo and school children in the homes of buyers being able to study when it got dark as narrated by Aloys Rwakamuzizi. Such benefits underscore that the fridges are an impact item for dairy farmers to own.

5.1. Lessons Learned

- Selling Productive Use small scale fridges to the dairy sector is challenge that can be overcome. Customer acquisition, installation and logistics costs are high. Once the high hurdle of trust was cleared, it was proven that a partnership with a cooperative could introduce significant economies of scale and lower the cost-of-sale so that lowered he cost to farmers could be made affordable and provide significant efficiencies for the Last Mile Distributor.
- Most of the beneficiaries have been able to use the fridge systems for other domestic purposes like lighting the house, charging phones and cooling milk for domestic use besides cooling evening milk
- Selling fridges to cooperative members with the endorsement and support of the cooperative gave the members the confidence and trust to take the risk to become Early Adopters.
- Some of the farmers reported to collect large volumes of evening milk that cannot be cooled and stored in the fridges provided. RDC members suggested that having additional Milk Collection Points with bulk milk coolers at some points in the villages as a helpful solution.
- Most of the customers of the fridges indicated that they did not face any technical issues with their fridges and that they were working well for them. A few respondents from the FGD and interviews

indicated that the fridges seemed not to function well for them for the evening milk collection. This was noted by CET, who plan a visit to assess such issues and resolve them, including walking beneficiaries through the user manual of the fridge on correct usage (e.g., not trying to cool large volumes of milk, which is the most common problem).

6. Next Phase: Proposed solar powered project to increase milk production during the dry season

Once again, while implementing the previous projects as well as in interactions, meetings and Focus Group Discussions, the challenge of extremely low milk production during the dry season kept coming up as the paramount concern. The cooperative members suggested that the solution would be having a water supply system in place that would provide the animals with sufficient drinking water, especially during the dry season. This would also stop the long distances livestock had to trek into the lowlands to find water, which further lowers milk production. It was also suggested that having feed for the cows would be essential to keeping production high.

It is with this backdrop that CET proposed the next intervention of revitalizing abandoned water tanks and adding other infrastructure fed by solar water pumping systems and five boreholes. This added infrastructure will provide the dairy farms of cooperative members with a sustainable source of ground water through the dry season. This would not only help increase milk production, but also prevent soil erosion caused when livestock move to and from the lowlands to find water for drinking. Livestock disease transmission, which happens through interactions of animals from different farms, would also be minimized. The neighboring communities will have access to the same water source as a way of avoiding conflict between the farmers and community members. Besides improving dairy production, provision of water will become a means of improving hygiene and sanitation practices for the farmers and their communities.

Water infrastructure is only a partial solution. Equally important, solar powered chopping equipment will turn agricultural waste from nearby rice and maize farms into feed, so that cows could Zero Graze during the Dry Season and keep up their milk production. Training and support for the transition to Zero Grazing will be key and provided by Heifer International (heifer.org), an organization specialized in advancing livestock practices in developing countries. Additional support may be provided by Inyange Industries (https://www.inyangeindustries.com), the principal off-taker and major producer of dairy products.

Finally, RDC will require additional cooling capacity when production levels increase. Therefore, a final phase involves upgrading existing cooling facilities at the MCC and expanding the network of cooling facilities at the MCP level.

Before the next stage proposal was developed, to be sure that the observations made were accurate, interviews were conducted with the RDC Manager James Karangwa and the Accountant Vincent Musingazi, and more FGDs held.

Photo 10 One of the current water sources for livestock at one of the RDC farms which is not reliable during dry seasons

Photo 11 Geologist and hydrologist conducting technical surveys to establish the prospects of underground water on farms

Preliminary technical surveys to determine ground water availability were conducted in the farm areas of RDC members. The prospects were found to be good, confirming that the project is viable.

This project, as its predecessors, will be implemented in Rwimbogo Sector, covering 6 villages, including 5 villages of Rwikiniro Cell 1 village of Nyamatete Cell. 211 cooperative members and their household members will be direct beneficiaries of the project as well as their neighboring communities. The 6 villages consist of about 100 farms, each farm with an average of about 25 diary livestock, occupying a total land surface of about 3,756 hectares. The total population of the villages is about 10,372 people.

The goal of the project is to increase milk production in the Dry Season from about 1,000 - 1,500 liters to between 3,200 - 4,200 liters (as in the Rainy Season), which will proportionately increase their incomes and improve their livelihoods as well as contribute to gross national domestic production. In addition, the increased milk production will increase food security for the households of RDC members and local community.

Photo 12 Cows at one of the farms of a RDC member, most of which are local breeds with low milk production capacity

6.1. Funding and Proposed Agreement

The puzzle that remains is finding funding to implement the project. The entire project is estimated to cost $1.6 M USD. The project will be implemented in 3 phases and timeframe for implementing the first phase of the project is anticipated to run from October 2022 to May 2023, just before the next Dry Season.

The proposed project agreement will include:

- A contribution of 10% from RDC towards the overall cost of the project in the form of a long-term loan
- Contribution by project beneficiaries in-kind towards the project by allowing water pipelines to go through their land without compensation and for casual labor commonly known as “umuganda” in the local language.
- Beneficiaries committing to pay for the water usage, as support for maintenance of the water system for sustainability purposes.
- Responsibility of the entire community in protecting the water system from vandalism

6.2. Phase 1 Core Water Infrastructure ($394,885 USD)

The first two of five wells will be drilled at surveyed points (the sites have already been identified by a professional hydrological study. The wells will then be installed with a solar powered pump. Water will be pumped uphill into existing and new Glass Reinforced Plastic (GRP) tanks through High Density Polyethylene (HDPE) pipes. From the water tanks, water will flow by gravity to the end users. This first phase will build the core infrastructure and serve approximately half of the beneficiaries.

6.3. Phase 2. Expanding Cooling Capacity of RDC and Lighting Protection ($404,149 USD)

The added milk production resulting from Phase 1 will necessitate an increase in the cooling capacity of the MCC

To achieve this, CET will upgrade the three dated bulk milk cooling tanks with new, more efficient condensing units and compressors, enabling RDC to cool 2,500-3,000 additional liters at the MCC. Part of the work at the MCC will be implementing a proper lighting protection system to protect the solar arrays and electronics. Three solar powered bulk milk coolers of 1,000 liters each (along with solar hot water) will be installed at Milk Collection Points operating currently without coolers; this will further expand the cool chain within the Cooperative. Additionally, there will be some incremental work on the infrastructure.

6.4. Phase 3. Core Infrastructure Expansion and Feed Chopping Center ($758,028)

Phase 3 will entail expanding the infrastructure to reach all beneficiaries and further increase milk production to fully utilize the expanded cooling capacity. Equally critical to increasing production will be the establishment of three bulk fodder and agricultural residue choppers by solar. These will be situated in different locations so they can be accessed by most farmers. Feed, derived from the waste of nearby maize and rice farms, will enable cows to Zero Graze, be better fed and produce more milk.

7. Major Lesson Learned from RDC Projects: A New Paradigm of Aid and Funding

SDZ and CET discovered that cooperatives like RDC have many hurdles to overcome… that what is needed is a systematic approach implemented dynamically, step-by-step over a number of years. This is contrary to the traditional and misguided approach of implementing short term, piecemeal projects. As a result, our credo became Partnership Not Projects. The typical approach focuses on meeting a single need, providing one piece of the whole puzzle, and does give attention to solving other related problems that will hinder or prevent beneficiary communities from reaching full development. We concluded that a series of organically derived solutions is a better way to do things. Moreover, we concluded that these efforts needed to be and could be driven bottom-up. Therefore, the route taken by SDZ and CET was towards collaboration, capacity building and empowering RDC members and their neighboring community members; to take responsibility for the projects rather than just receiving assistance.

For the previous organic, holistic and long-term approach that SDZ and CET evolved into with RDC to work there needs to be supportive and corresponding funding support. IFAD was able to provide appropriate support by being flexible with the spending of grant funds and understanding the dynamic and understanding nature of programs and projects. This was embodied by GreenTech project supervisor Dan Martin.

This newer paradigm of aid/funding is not new. Evidence of its emergence can be found in 2010 in the follow-on project to the Harvard-based AIDS Prevention Research Project, supported by the John

Templeton Foundation. The purpose of their funding was “to provide strategic support to applied research and pilot programs in health and well-being that embrace indigenous people and their beliefs and practices with solutions that come from within communities”. This model was preferred because solutions to community needs, grounded in the local culture, using the resources of the local culture and communities, concluded to be sustainable and far superior to relying on continuing outside assistance, that was said to only lead to dependence and a devaluing of even the best aspects of local culture.

To reap the advantages of a systemic/holistic approach towards development, it is important that this new paradigm of aid/funding is considered, since its flexibility supports communities towards ownership and sustainability of their projects. SDZ and CET have been successfully using this model of funding in previous project implementations with RDC, with funding from the Green Tech IFAD grant and the support of Dan Martin, and will use the same approach in implementing the water project and any other future projects that may come along in scaling up the pilot project with RDC to other communities.

In conclusion, with this paradigm of funding and a systemic, holistic approach of project implementation, funders and donors can change the way they do business. They can make several visits to projects, observing changes and impact on the beneficiary communities. They can relinquish a great deal of control and observe and beneficiary communities reach their full potential of development, without worrying about how to micromanage projects remotely. This subsequently enhances the relationship of the donors and beneficiary communities consequently, which will build trust in the long run between the donors, different project stakeholders and beneficiaries, for scaling up future holistic developmental projects as true partners.

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