

Rural Milk Preservation with the ISAAC Solar Icemaker

Carl Erickson
Solar Ice Company
627 Ridgely Avenue
Annapolis, Maryland 21401

Abstract

Rural communities of developing nations need refrigeration to preserve perishable foods like fish or milk, for cold drinks, and for other needs. Because of the increasing cost and scarcity of traditional energy sources, and because a large percentage of the rural population does not have electrical service, they cannot depend upon electricity for refrigeration. It is preferable to utilize alternative energy sources if possible. This article describes the “ISAAC” a solar powered ice maker and its application to milk preservation in two rural small-scale farmer villages in the coast of Kenya. Three solar icemakers were installed in each of two separate rural communities and two profitable dairy co-operatives were established. Over one hundred farmers have increased their income by selling more milk. The project was funded by the World Bank’s Development Marketplace program. The project partners are Solar Ice Company and Heifer Project International. The project generates rural income, rural jobs, alleviates poverty, and contributes to food and energy security. The project has enormous potential for replication.

The ISAAC Solar Icemaker

The ISAAC solar powered ice maker is designed to operate entirely without electricity. It is based upon the intermittent ammonia/water absorption refrigeration technology, which is driven by heat rather than electricity. It is easy to operate and it is very durable. The system was developed by Energy Concepts Company (www.energy-concepts.com) of Annapolis, Maryland and is produced and promoted by Solar Ice Company, (www.solaricemaker.com), a spin-off company. The system is called “ISAAC”, which stands for “intermittent solar ammonia absorption cycle”.

The operation of the ISAAC is diagrammed and explained in figure 9 and 10. The system operates in a day mode when ammonia refrigerant is generated by capturing solar energy, and the night mode when the refrigerant is cycled back to the generator and ice is made. The ISAAC is operated by repositioning five manual valves each morning and evening.

The ISAACs used in this project have an 8 ft by 16 ft solar collector. The system produces 50 kg of ice per sunny day. Milk is chilled by making an ice bath and immersing milk in milk cans into the ice bath. Fifty kilograms of ice is sufficient to chill 100 liter of milk for a day. Although this is a small amount of refrigeration by US standards, it is a useful and valuable for rural communities.

Project Development

Solar Ice Company (SIC) promoted the ISAAC solar icemaker to rural development organizations and met Heifer Project International. Heifer is a major NGO that concentrates on dairy development and has programs in over fifty nations. The Kenyan office of Heifer was interested in using the ISAAC in their programs in the coast of Kenya.

The coast of Kenya is a rapidly growing urban area and so has a strong market for milk. The area inland from the coast is a rural farming area with limited electrical distribution. Most of the farming is small-scale subsistence farming. There is a lot of unemployment and wages are low in the rural areas. Their main crop is maize which they grow for their own consumption and sell the excess for income. Other crops they have are cashews, charcoal, a variety of vegetables, bananas, mangoes, goats, chickens, etc. Much of the produce is sent to market by individual farmers on the public buses that serve the area.

Heifer has been working in that region for several years to alleviate poverty by teaching and promoting dairying and take advantage of the strong milk market in the coastal urban areas. Heifer has been successful in increasing milk production. The farmers like dairying as it produces milk for their own families and it generates daily income. Many of the farmers have increased milk production beyond what they can consume within their own families or sell to their neighbors. Typically the farmers have less than five liters per day of extra milk. Selling this milk would bring important additional income to them. The farmers want to sell to the urban area but marketing milk to a distant market is difficult and it spoils within a few hours.

The demonstration project was to install three ISAAC solar icemakers in each of two communities, collect milk, chill it, and sell it to the urban areas for a profit. Heifer project would make the arrangements with the villages and Solar Ice Company would provide the equipment, training and technical support. The project was funded by the World Bank's Development Marketplace (www.developmentmarketplace.org), under the name "Rural Milk Collection", for the year 2006, in the country Kenya. As a Development Marketplace winner, the project is recognized as an innovative development project and is replicable to other areas. Small-scale dairying is an important part of the farming sector in many tropical countries. The solar icemaker is also needed for artisan fishing, for cold drinks, for vaccine preservation, and cold drinks. This project enables many small-sale, environmentally sustainable rural businesses.

Heifer Project International selected the rural towns of Makambani in the Kwale District and Matano Manne in the Kilifi District of the Coastal Region of Kenya for the demonstration sites. The agreement with the villages that SIC would install three solar icemakers in each of the villages, train the operators, and provide technical support for the icemakers. Heifer would provide management support. The villages would:

- 1) Form a farmer's co-operative and register with the Government of Kenya:
- 2) Rent offices and provide space for installation of the solar icemakers
- 3) Operate a rural dairy

The villages were enthusiastic for this project because they had a lot of milk that they were having difficulty selling. The people of the community came together, formed a co-operative and elected officers. In Makambani, the dairy is called the Kidzo Farmers Co-operative and in Matano Manne the dairy is called the Sovimwamri Farmers Co-operative. There is no relationship between these two dairies, except that they are both in the Rural Milk Collection project. Both names are a combination of the names of the areas they will serve. Membership in the co-operatives grew rapidly, currently to 423 for Sovimwamri and 202 for Kidzo. The co-operatives registered with the Government of Kenya. The GoK had recently implemented new laws for farmer's co-operatives and established offices throughout the country to assist with the formation and management of co-operatives. The Ministry of Co-operatives provided training and management assistance to the new cooperatives. Each co-operative formed a committee to select two people to be trained and be the operators their solar icemakers. The co-operatives rented a building for dairy operations, and a space for installation of the solar icemakers.

When the icemakers were installed, the co-operatives would collect, chill, and market milk. From the income they would pay the farmers, the icemaker and dairy operators, and the other expenses of the co-operative.

Installation, Training

The icemakers were shipped to Kenya and installed by SIC with the assistance of the technicians from the co-operatives and other men from the village. Installation is a very straight forward process of preparing the foundation, putting components in position, piping components together, installing the collector, and charging with refrigerant. Installation is an important part of training the operators. After the equipment was installed, the operators were trained how to operate the icemakers. They learned how to operate the equipment quickly by demonstrating operation a few times and then having them operate the machine themselves. For additional information, the physical processes occurring were described. After a few days, the assessment of the operators is that the equipment is "easy to operate". Considering everything, the installation and training went smoothly and the icemakers are performing well. The solar icemakers were making up to 50 kg of ice per sunny day.

For the actual chilling of milk, milk in 50 liter milk cans is immersed into an ice bath. The icebath is in a plastic water barrel, which are readily available. Fifty kg of ice is able to chill 100 liters of milk. With three icemakers each, each dairy can chill up to 300 liters of milk per sunny day.

Dairy Start-Up

After the solar icemakers were installed and operating, the co-operatives proceeded with the other preparations for milk collection and sale. The co-ops needed to be licensed and trained to handle milk. They learned how to make mala and yogurt. They learned how to package milk and they acquired all the necessary equipment and supplies. Heifer provided training on record keeping for a dairy.

The co-operatives also needed to develop their marketing plan. New dairies have three problems, getting milk, handling milk, and selling milk. For getting milk, Heifer had done a survey to show that milk is available in the area, when operations started, farmers would bring their milk. To assist with milk handling, the solar icemakers would provide the refrigeration capacity. When the co-operatives started looking for specific answers for marketing milk, it became a challenge.

One option for marketing is to sell milk to the major dairy processors. The major processors pay about 20 Ksh per liter. The two new co-operatives were planning to pay that amount to the farmers, so the co-operative itself would not be able to make money. The retail price for milk is 40 Ksh/liter and more for the value added products of mala or yogurt. If the co-operatives choose to retail milk, they would get the higher price, but then they would have the additional tasks and expenses of transportation, distribution, and selling. Also, there is competition in the urban milk market from the major dairies and from numerous “close-in” farms that sell milk directly. Both of the newly created dairies decided on direct sales to get the retail price. There is strong demand for milk and the urban buyers are ready to help farmers groups as much as they can, so hopefully the co-operatives would be able to market successfully.

The dairies started operating in mid August 2008. Operations started slow, but picked up steadily. The experience was similar for the two dairies, even though they operate completely independently. On the first day of operations, Kidzo dairy collected 15 liters from five farmers, a modest beginning. The milk was tested and put in the milk can and immersed into ice. The next morning the milk was still fresh. For test the milk was kept for a second day. Some additional ice was needed to compensate for heat leak, but into the second day the milk was still fresh, remarkable feat for a rural community.

Milk sales also started slow. For Kidzo, at the beginning, they had one restaurant in the urban area that bought milk. The restaurant was requesting more milk from day to day but with the cost of transportation, the profits were low. Each day, more farmers would bring milk. As milk intake increased, the co-operatives needed to find more customers. Fortunately, there was good market right in the vicinity of the co-operatives, so they started selling back to the local community. The dairies sold from their office and they ran bicycle routes through the surrounding community. The co-operatives also started making mala and yogurt, which is popular and is sold at a higher price. When there was a holiday period, the urban customer stopped taking milk. After that the co-operatives had sufficient local market for the amount of milk being delivered, so they continued to concentrate on local sales only.

The co-operatives had built up local sales as much as possible. Eventually they started restricting the number of farmers delivering milk. But still there are many more member farmers in the area that want to deliver their milk to the co-operatives too. The co-operatives started working on urban sales again. In February 2009, Kidzo started selling 60 liters per day to the city and Sovimwamri is working on arrangements to sell 100 liters

per day to the city. Hopefully they can keep expanding upon these urban to serve the needs of the many more farmers in the area.

Dairy operation data for the first five months is indicated in tables 1 and 2. On average each farmer is delivering 2 liters per day and earning 60 US cents per day, an important income increase for them. By December 2008, 114 farmers were delivering to Kidzo and 68 were delivering to Sovimwmri. Both of the co-operatives started from the very beginning and with little experience in dairy operations or dairy marketing. Their progress is commendable. The farmers are making money, and the co-operatives are making money, especially Kidzo.

Ice is used to prevent spoilage of milk. It takes several hours to sell all the milk. It needs to be chilled so it will not go bad before it spoils. The co-operatives like the solar icemakers, because they do not have electricity and even if they did the monthly power billings is a problem. Although there are rainy periods, the area is predominantly sunny so that solar equipment is beneficial.

So far evening milk collection has been minimal. Most of the farmers have local breed cows that produce only a few liters per day. The farmers are in the habit of milking only once per day, partly as a means of limiting production because of the difficulty selling milk. As the dairy co-operatives are able to collect more milk, the farmers will modify their dairying habits to produce more milk and make more money. This would include evening milking, increasing feed, and breeding with exotic breeds. As evening milk collection increases the need for refrigeration increases to keep milk through the night.

Rainy and overcast days are a problem for the dairy because the refrigeration depends upon solar energy. The co-operatives started by restricting milk collection when there is no ice, which is the day after a rainy day. Another strategy is to store extra ice from sunny periods in an insulated box for rainy days. It is also possible to buy ice from where it is available. Another option is to have a back-up ice making system. As the project progresses, the strategy for providing refrigeration during rainy periods will evolve. On average, the location is sunny, so that over a full year, solar icemaking is an advantage.

The icemakers performance was good in the beginning, making nearly 50 kg of ice on sunny days. The co-operatives had sufficient ice for their modest beginning. The capacity of the icemaker is based upon a sunny day. Heavy haze or cloudiness during the day decreases performance. In December, the co-operatives reported a decrease in ice making capacity, not due to cloudiness. This is most likely due to the reflective surface degrading, inhibiting performance of the solar collectors. It is planned to apply a new more durable reflective surface to reestablish icemaker performance, on the next visit. Assuming the collector performance can be re-established; the co-operatives are pleased with solar icemakers and would like to have more.

As of February 2009, the co-operatives are only five months old. The new co-operatives are still evolving in their operations and organization. Although production is modest their accomplishments so far are commendable. In particular, they have formed a dairy

co-operative and with basically no experience in the dairy field, are competing in the urban milk market. They are doing this while introducing a new solar powered ice making system and learning how to cope with its particular operating characteristics. There are two reasons for the success of this project: it addresses the basic need of the community – milk marketing for income generation; and the hard work of the co-operative staff. The project brings the community together to collectively work on their own problems.

	8/14 to 9/30	Oct 08	Nov 08	Dec 08	Jan 09
Ice production Kg		2,488	2,120	2,472	1,536
Farmers Served		61	80	114	116
Farmgate Ksh/liter	25	25	25	25	25
Milk Collected liters	2,860	3,059	4,900	8,261	8,834
Daily Average Liter/day	68	102	163	275	285
Milk sold liters		3,059	5,093	5,941	8,834
Gross Sales Ksh	80,655	158,580	260,730	290,895	434,720
Payment to Farmers Ksh	68,925	76,487	122,500	206,537	220,865
Co-op Net Income Ksh	11,730	82,093	138,230	84,358	213,855
Gross Sales in \$	\$1,241	\$2,440	\$4,011	\$4,475	\$6,688
Payment to Farmers in \$	\$1,060	\$1,177	\$1,885	\$3,177	\$3,398
Co-op Net Income in \$	\$180	\$1,263	\$2,127	\$1,298	\$3,290

	8/14 to 9/30	Oct 08	Nov 08	Dec 08	Jan 09
Ice production kg		2,600	1,536	1,944	1,640
Farmers Served		66	59	68	46
Farmgate Ksh/liter	20	20	20	20	20
Milk Collected liters	4,325	3,710	4,064	3,204	2,104
Daily Average Liter/day	103	124	135	107	68
Milk sold liters		3,175	3,539	2,349	1,947
Gross Sales by Co-op Ksh	87,921	99,490	114,138	77,845	66,832
Payment to Farmers Ksh	76,940	74,200	81,290	64,080	42,080
Co-op Net Income Ksh	10,981	25,290	32,848	13,765	24,752
Gross Sales in \$	\$1,353	\$1,531	\$1,756	\$1,198	\$1,028
Payment to Farmers in \$	\$1,184	\$1,142	\$1,251	\$986	\$647
Co-op Net Income in \$	\$169	\$389	\$505	\$212	\$381

Impact

Income Generation:

In the first five months of operation the project has generated 1,670,806 Ksh of sales. This is \$25,720 at the exchange rate of 65 Ksh per dollar. Of this 1,033,904 Ksh (\$15,906) has been distributed to 184 dairy farmers.

Community Empowerment:

Two dairy farmers co-operatives have been established, Kidzo in Kwale District and Sovimwamri in Kilifi District. The membership of Kidzo is 202 and Sovimwamri is 403. These organizations operate as a for-profit business and generate income.

Future activities

Additional solar icemakers are needed to serve the many more farmers in the area and to increase volume to make the urban sales profitable. It is important that proper financial agreement are made for these installations to make the project economically sustainable.

Acknowledgements

The author thanks:

Heifer Project International for ongoing support for this project.

The management and technicians of the Kidzo and the Sovimwamri Dairies in Coast Region of Kenya

Energy Concepts Company of Maryland and

Ben Knowlton of Maine for his work in the US and in Kenya.

Figures:



Figure 1. Excess milk. The lady has about three liters per day of excess milk. Before the Rural Milk Collection project, she was not able to sell this milk.



Figure 2. Local people helped install the solar icemakers.



Figure 3. Three units were installed in Kilifi District at Sovimwamri Dairy.



Figure 4. Three more units installed in Kwale District at Kidzo Farmer's Dairy Co-operative.



Figure 5. On a good solar day, the icemaker makes six blocks. Each block is 2 by 9.5 by 26 inches, weighing 8.3 kg each.



Figure 6. Milk is chilled in an ice-bath milk chiller. Each ISAAC produces enough ice to chill 100 liters per day.



Figure 7. Farmers average 3 liters per day. Mostly they bring milk by bicycle or by foot. The two dairies are serving a total 138 farmers.



Figure 8. Milk, yogurt, and mala are sold from the dairy or distributed to the local community via bicycle.

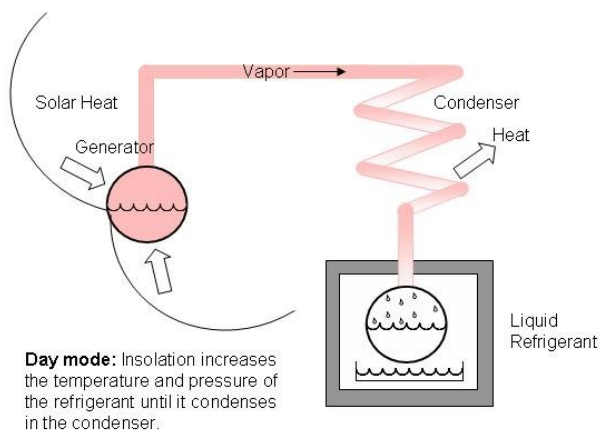
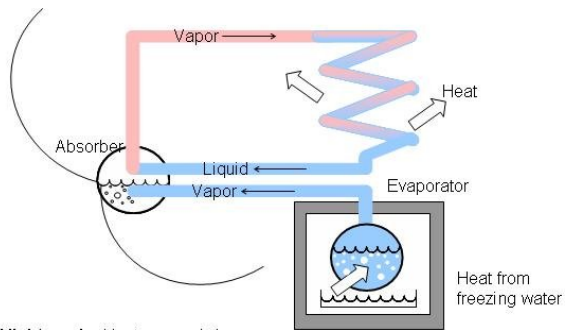


Figure 9. Day Mode Diagram



Night mode: Heat removal via thermosyphon decreases absorber pressure, allowing refrigerant to be reabsorbed. As the refrigerant evaporates, the water freezes.

Figure 10. Night Mode Diagram.



Figure 11. The system is operated by manual valves. Operation is routine and easy to do. The valves are operated in the morning and late afternoon. Water to be frozen is put into the evaporator in the afternoon; it is ready to be removed as ice early the next morning.

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