Lessons learnt from three years of solar ice production in Kenya

Summary

Food supplies remain uncertain in many regions of Africa. Rural areas with poor infrastructure, long distances, and difficult conditions for maintaining the often necessary cold chain are particularly affected. Hygienic handling and cooled transport of fresh products to markets is challenging for fishermen and fish traders, especially under tropical conditions in Africa. Another problem is that the energy supply is often insufficient or unreliable. For this reason, off-grid solar-powered systems are usually the better alternative to grid-connected systems. During the course of the SolCoolDry project, two solar ice production and drying systems were installed in Kenya, one at the south coast and the other at Lake Victoria. Both ice machines are powered by off-grid PV systems, but with different supply and operation concepts.

More than three years of operation reveals the main advantages of the use by the local community and the social enterprise WeTu respectively but also shows the challenges between individual interests and real use. Beside technical issues, also the overall management stays the essential aspect for successful projects and long-time operation.

In this contribution, we will highlight the lessons learnt from more than three years of solar operation of ice machines on the technical and on the social and management side as well.

Keywords: off grid, PV, solar flake ice production, Africa

Field of applications for the findings: sustainable and solar post-harvest handling technologies for increased shelf live and fight against food spoilage.

Addressed audience: Initiatives and farmers in the global south, Federal Ministry for Economic Cooperation and Development; Federal Ministry of Agriculture, Food and Regional Identity

1. Abstract

In the SolCoolDry project, two solar ice production systems were installed in Kenya in addition to solar drying systems. In February 2023, after about six month of trial operation, the first solar ice production and drying plant was officially inaugurated and handed over to the Beach Management Unit (BMU) Mwazaro, at the south coast of Kenya. At this time, this flake ice machine has been the only machine in the wider area producing high-quality ice flakes and independent from fluctuations on the public electricity grid. The second system has been realized and inaugurated in August 2024 at Muhuru Bay at the Lake Victoria. Both ice machines are powered by Off-Grid PV systems, but with different system configurations.

The original plan for the project was to set up solar-powered cold storage rooms for temporary storage at each location. However, a baseline survey conducted at the start of the project clearly showed that there was instead a need for ice for the cooled transport of fish and other goods. This step was crucial to the success of the project. The decision to use flake ice was also made after initial research, as flake ice is best suited for the refrigerated transport of fish to market. The ice flakes are distributed optimally between the fish, ensuring the necessary cooling.

Since the daily and seasonal fish volume varies greatly between the two locations, this also results in different ice requirements. On the coast, the catch depends on the migration of fish shoals, which are subject to seasonal fluctuations and are also influenced by the weather. For these reasons, demand for flake ice has not yet reached the expected level and thus the technically achievable level. Sales of ice to restaurants, hotels, and fishmongers have never reached production capacity. The situation is quite different at Lake Victoria, where catches are more stable and fluctuate less overall throughout the year. Immediately after the ice machine was put into operation, this led to demand consistently exceeding production capacity, with only pre-ordered quantities available for collection.

At both locations, the roof area of shipping containers was additionally enlarged and used for the installation of PV systems. The system at the south coast has a PV system with an output of 15 kilowatts peak. It feeds into a three-phase, battery-supported island grid, which powers the ice machine and the cold storage room. The ice machine produces a maximum of 550 kilograms of ice during the day. Surplus solar power is fed into batteries with a total storage capacity of 19.2 kilowatt hours and is used to operate the ice storage room and to start the ice machine in the morning hours of the following day. The electrical system is regulated with priority given to supplying the ice machine. During the design and construction of the system, the solar operation of the flake ice machine proved to be the biggest challenge. Since the starting current is sometimes up to 15 times the operating current, the battery capacity had to be increased. In addition, when the sky is cloudy, the three strings of the PV system may not feed evenly into the three-phase island grid. In this case, the ice machine must first be started manually via the battery before the PV can be switched on. This workaround makes it possible to start the machine even under difficult irradiation conditions.

In order to circumvent the problem of high starting current in the second plant on Lake Victoria and at the same time ensure stable operation, this ice machine was equipped with a frequency converter, which on the one hand enables the machine to start up slowly and on the other hand allows direct coupling on the DC side of the PV system. This has the significant advantage that the machine starts up even when there is little sunlight in the morning, but also that the frequency (and thus the power of the ice machine) is adjusted during the day in line with the PV output. This enables frequency-controlled and therefore continuous operation. Another advantage of this configuration is that it eliminates the need for expensive battery storage, which also has a limited lifespan and increases invest and operation costs. This configuration has also proven itself in operation over the last year and a half. Of course, slightly higher ice production could be achieved with a constant energy supply from a local island grid. However, reliability and, in particular, the savings achieved by not having batteries and inverters are much more important. With a production capacity of 700 kg/d ice is produced that can be used to cool 2,100 kg of fish.

While the plant on the south coast is operated by the local BMU, the Kenyan social enterprise WeTu is responsible for the plant on Lake Victoria, where they also treat drinking water and charge and provide LED lamps for nightfishing fishermen. A comparison of the two locations clearly shows that both technical expertise and management experience are crucial for plant operation. Minor technical problems that have occurred during the operation of the plant on the coast have been resolved by BMU technical staff with remote support from Germany. However, it was almost impossible for the BMU to build up reserves for major repairs. A budget must be allocated for maintenance work. This became apparent recently when a technical problem occurred with the ice machine and a refrigeration engineer had to overhaul the machine. Despite some difficulties, local craftsmen are also available in Kenya to maintain ice machines. However, they are not available everywhere and usually have to travel long distances from the major cities of Nairobi or Mombasa to the respective location.

Thanks to the long-term operation of the plants, continuous monitoring from the outside, and regular support even though the project has been completed for years, the goal of sustainable operation has been achieved so far. Looking back, it has become clear that analyzing actual needs of the local people at the start of the project (co-creation) and adjusting the goals accordingly are essential prerequisites for the success of projects in the Global South.

The project was carried out in close collaboration with the following Kenyan organizations: KIRDI, KMFRI,

University of Mombasa TUM, WeTu and the German project partner Innotech Ingenieursgesellschaft mbH. The project was also supported by the commitment of the company Solar Cooling Technologies. .

This project was funded by the Federal Ministry of Agriculture, Food and Regional Identity (BMELH) based on a decision of the Parliament of the Federal Republic of Germany via the Federal Office for Agriculture and Food (BLE).