SunStore Cooker – A battery type solar cooker charged by an automated sun tracking system

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Abstract: *Heliac has developed the SunStore Cooker (SSC), a portable solar cooker designed to be charged by sunlight using light-concentrating films. The cooker delivers heat for 2-3 hours of cooking at maximum temperature of 250-300ºC. The units can store the heat for up to 2 days.*

The targeted cost for the end-users is USD0.6/day allowing for profits throughout the full supply chain. By delivering inexpensive, high-temperature heat when and where the user needs it, the SSC addresses the main challenges facing other solar cookers.

Keywords: Battery, Solar, Thermal, Food Processing

1. Introduction

Heliac has developed a method for inexpensive production of lenses that focus sunlight in the same way as magnifying glasses.

Based on these lenses, Heliac has previously developed a solar cooker, so-called Heliac Solar Cooker. The cooker was tested in India, Kenya, Uganda and Zambia in 2018. It has been proven to work well in different environments.

Figure 1: The previous Heliac Solar Cooker

In general, test users are satisfied with the power of the cooker and the variety of meals it allows for cooking.

However, the tests have also shown that there are some challenges making it difficult for the cooker to become a part of daily cooking activities.

The most common feedback from the test users were that;

- the size of the cooker was too big to store
- too big to transport
- timing of cooking is challenging as the cooker does not work without sunshine
- cooking stops as soon as the sun disappears
- the need for tracking the sun every ten minutes also turned out to be an obstacle when adopting a cooker because the users wanted to manage other activities while cooking.

Based on these feedbacks, Heliac has developed a new type of solar cooker, SunStore Cooker (SSC) which works like a heat battery.

2. The concept of SSC

Some of the challenges mentioned in the user tests can be solved by improving the existing solar cooker. However, most of the challenges are not only technical issues but also deeply related to cooking cultures and behaviours. For example, modifying the timing of cooking to utilize solar cooker requires great efforts in behavioural change communication and a long-term follow up. Therefore, Heliac has decided to develop a solar cooking solution that resembles normal or common cookstoves and that works when users want to cook.

3. Technical development of SunStore Cooker

The outer shell of SSC is made of aluminium sheet of 10 mm thickness. The inside of SSC contains a mixture of harmless molten salt and several metal bars. This salt mixture melts at around 400^{o}C and release the heat gradually over hours. The metal bars inside transfers the heat to the top surface where a cooking pot is placed for cooking. One unit of the present version of the SSC weighs 23kg.

Figure 2: SunStore Cooker tested in the laboratory without insulation

The temperature of the cooking surface when fully charged is 300^{o}C. SSC keeps the heat high enough to cook regular meals such as rice and soup for 2 - 3 hours. It takes about 15 minutes to boil a litre of water in laboratory tests without insulation.

While the temperature drops after cooking meals, SSC can keep the heat relatively high for 5 to 6 hours. Excess heat after cooking can be used to keep food warm, or to provide heat in the kitchen or a room as well. When SSC is not used for cooking and kept in a proper insulation, it can keep heat for up to 2 days.

Figure 3: SunStore Cooker design

Figure 4: SunStore Cooker with an insulation

4. Charging unit

SSC is designed to be charged by a charging unit which Heliac has developed for utility scale solar thermal fields.

Figure 5 shows the solar collector designed for utility-scale solar thermal production. Each lens concentrates sunlight over 2 meter's focal distance and produces 1200 W. The size of the lens is 145cm x 145 cm. The temperature at the focus point reaches more than 1000^{o}C.

Figure 5: Sun tracking system for the utility scale solar thermal field

In the utility-scale version of the solution, the concentrated light hits small heat exchangers through which a liquid flow. By this, the liquid is heated enabling a transfer of the collected heat through a larger heat exchanger.

When used for the SSC, the small heat exchangers are replaced with the chargeable heat storage units enabling each collector to charge eight SSCs at once.

The collector is controlled by an automated sun tracking system with safe operation mode for very windy conditions (15m/h). Charging starts once SSCs are placed under the focal point of the lens, and the charging takes 2 to 4 hours. Power to operate the unit is 72 W and can potentially be provided by solar cells.

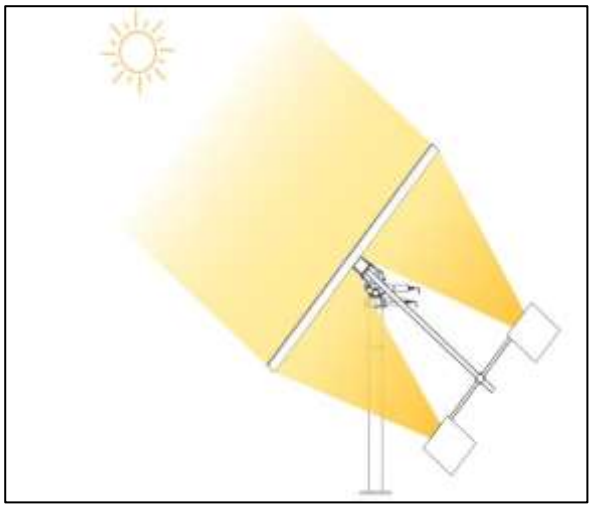

Figure 6: Image of charging unit charging SSC

5. Possible application

The SSC allows users to cook indoor, in the evening, and to use the excess heat to heat cooked meals and their homes. In this way the solution addresses the barriers that other types of solar cooking solutions face such as tracking of the sun, adjusting timing of cooking and heat retention.

SSC is relatively small and there is no major risk of injuries such as eye damage and burns when it is properly insulated. The charging unit needs to be operated collectively from security perspective and also as the unit is too large to install in individual houses. This means that SSC operation requires an ecosystem that connects fabricators to end users, and it consequently contributes to create job opportunities for the local community.

SSC is primarily targeting refugees and rural population that are affected by the shortage of firewood and increasing price of charcoal. However, the rapid increase of charcoal price is equally affecting urban population in many places. Therefore, SSC has a great potential for contributing to improve access to clean cooking energy in all kind of settings, and the application is not limited for humanitarian operation. In the next column, an example of business model is explained.

6. Operational model

Each charging unit can run 3 charging cycles per day allowing for charging a total of 24 SSC per day.

- The collector is operated by a local business having 32 SSC at their disposal.
- When eight SSC are charged, charging of eight new SSC will start while the business delivers the first eight to eight users.
- When delivering a charged SSC, the business will bring back a discharged SSC used the previous day by the user. The local business rents out the SSCs at $0.6/day – equal to the estimated price of charcoal. Assuming the charging unit together with 32 SSC units on average can operate for 300 days per year, then 9,600 SSC can be rented out per year at a price of $0.6 per unit which makes revenue of about $4,000.

Assuming the local business can finance the cost of the system by a loan of $7,000 running over three year at an interest of 13%, then the loan must be repaid with approximately $2,650 per year allowing for a profitable business.

Since the system's components are robust, it can easily be relocated, and all SSC are accounted for daily, risks for a micro-lender are limited, thus likely making a 13% return rate a decent business.

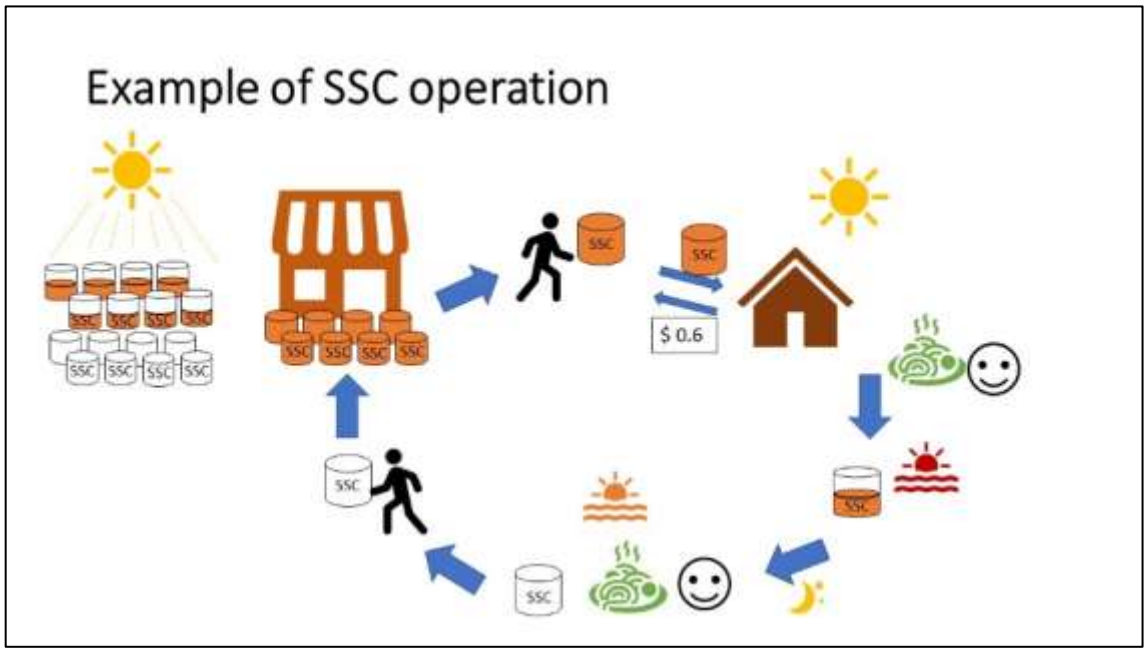

Figure 7: SSC operation

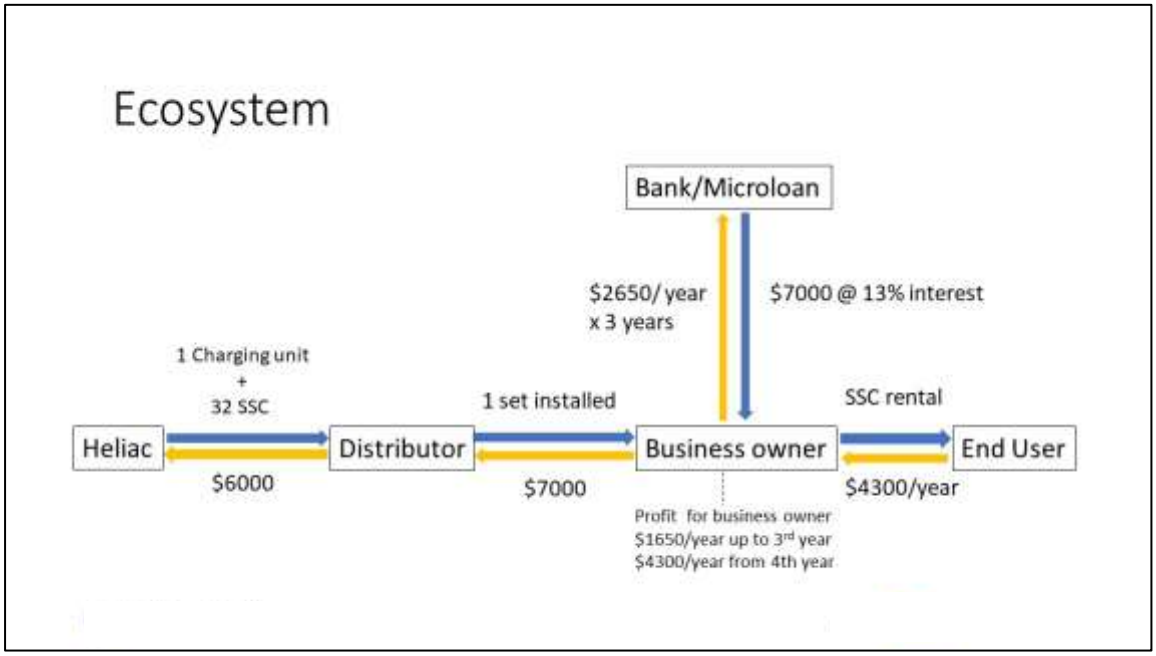

Figure 8: Example of ecosystem for SSC

7. Conclusion

The development of SSC is still in progress and much still needs to be done before entering a market as a commercially applicable product. Future improvements and verifications include;

- identifying the right material and an efficient heat transferring system inside SSC,
- identify the best insulation material to keep the heat efficiently over a long time.
- developing a business model possibly based on the suggested model described above with any needed adjustments to deliver SSC to the end users.