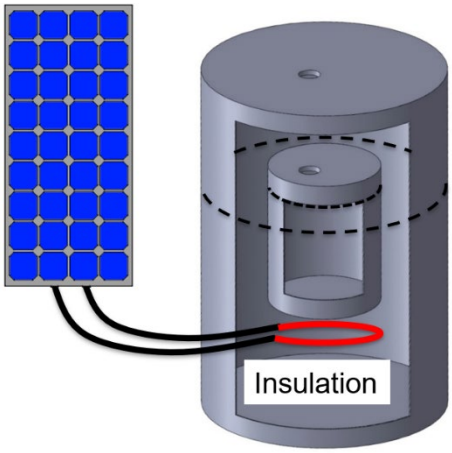
CAL POLY SAN LUIS OBISPO

# Thermal Storage with Phase Change Materials

## MECS Final Report, *Executive Summary* (for more, see full report)

***Pete Schwartz*** *California Polytechnic State University, San Luis Obispo, July 2022*

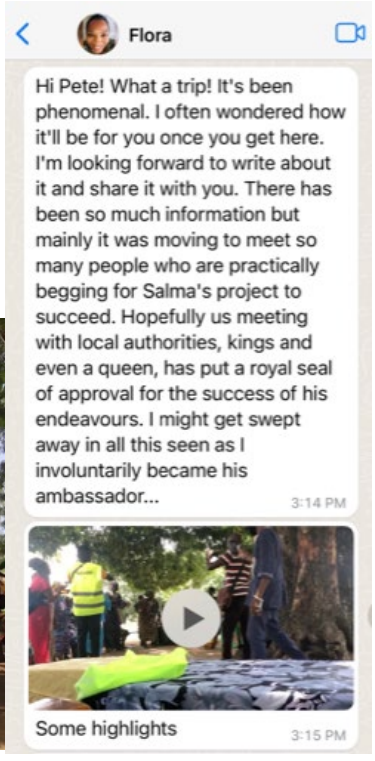
**Insulated Solar Electric Cooker** (ISEC) is a solar panel directly connected to a heater inside an insulated chamber. ISEC overcomes adoption barriers of traditional solar cooking because it allows cooking in the privacy of the home without reorienting with the shifting sun. ISEC can be inexpensive, depending on how much solar PV is added. 100 W brings 1 liter of water to a boil in one hour, so a full day of sun can cook a 5 kg meal 100 W solar panels are sold in Africa and India for $25 - $50. The low-power solar panel is inexpensive but *requires insulation for the food to get hot enough to cook*.




**Additional Variations** include:
- Ability to connect to grid electricity. The insulation reduces electricity costs.
- Energy storage to provide additional power and the ability to cook after dark.
- Electricity access for other appliances such as cell phone and lights.

**Local Production** of ISECs by small enterprises stimulates local economy while promoting education and technological innovation. Manufacturing proximity can better provide product support, accommodate local preferences, and take advantage of locally available resources.

**Half the MECS funding** was used at Cal Poly to innovate technological improvements while the other half subsidized local enterprises (called *collaborators*) mostly in Africa, to build manufacturing capacity. The ~$100,000 MECS grant was matched by more than $100,000 in university research support, and engagement of ~200 students over the 2 ½ year funding period. In the process, we created a living, global learning community of students, collaborators and enthusiasts with weekly online meetings, that continues growing with new opportunities, challenges, and additional members. As an example, while visiting a collaborating EcoVillage in Jamaica, PI Pete Schwartz and his daughter, Tekuru, met Flora, a Nigerian educator. Flora subsequently spent 10 days with collaborator Salma in Togo. Pete will spend the coming year on sabbatical,

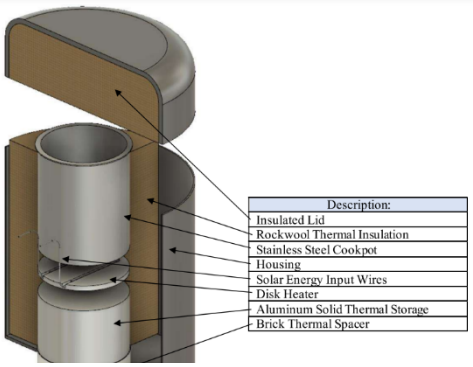


visiting collaborators. See Travel Log

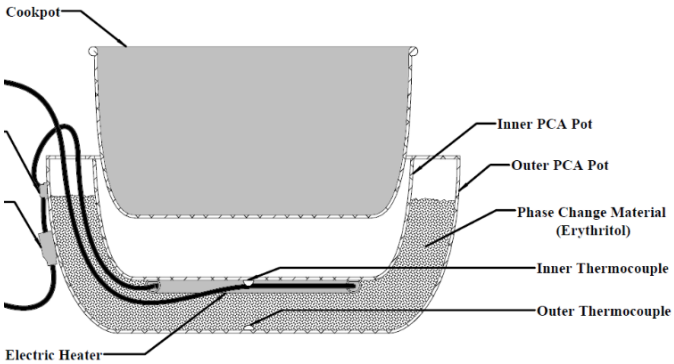
**Energy Storage**

While 100 W can cook a meal for a family during the day, people want more power and the ability to cook after the sun goes down. Our research focus has been to develop thermal storage capacity by two methods: heating a piece of metal, and by melting a phase change material (PCM). Each innovation is tested extensively, usually in Schwartz's kitchen (for example)

**Solid Thermal Storage (STS)** A large cylinder of aluminum can store the daily energy output of the solar panel. When placed in contact with a cookpot, the food heats up with more than the 100 W of the solar panel. The disk heater between the cookpot and STS can be raised so that only the cookpot is being heated.




**Phase Change Material (PCM)** is confined between two concentric pots, so that food is cooked in the inner pot, see for example, a video featuring Martin, who met us in Ghana and subsequently came to the USA, wrote his master's thesis on ISEC, and lived two summers with Pete. We have used three different PCMs: two sugar-alcohols (erythritol and xylitol) and a mixture of nitrate salts. The higher melting temperature of the nitrate salts (220°C – 300°C), means they perform better but have more demanding material requirements, while sugar alcohols degrade over time.




**Important Lessons**

- Supporting collaborators while providing freedom to innovate resulted in unexpected diversity of technology innovations, education outreach, development of business models, and community engagement.
- Sourcing materials is challenging, in particular solar panels and nonflammable insulation such as fiberglass. What began as a technology challenge, has shifted to business and social.
- ISEC inherently involves rural electrification. People are very interested to have access to other electricity applications such as charging batteries and pumping water.
- PCM thermal storage is powerful and convenient because heat is not conducted to the PCM until the cookpot is hotter than the PCM melting point.
- Hot wires and wire junctions often corrode over the course of a few months.
- Heat flow across the solid-solid interface limits power flow. Surface smoothness is crucial.

For comprehensive full report, please see: http://sharedcurriculum.peteschwartz.net/wp-content/uploads/sites/3/2022/08/MECS-Final-Report-Calpoly.pdf