A New Approach for Providing Low-Cost, Efficient Solar Powered Electric Cooking in Refugee and Relief Settings

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Concept:

Efforts made in developing alternative stove and fuel technologies to reduce daily firewood needs of refugee families are well documented. However, many of these technologies, while increasing over all cooking efficiencies, have fallen short in the field. Recently, MIT Lincoln Laboratory (MIT LL) and Columbia University have demonstrated that coupling a solar photovoltaic (PV) micro-grid technology with highly efficient cooking methods/appliances for cooking daily meals can approach the price points that can allow one to substantially reduce fuelwood and solid biomass use with all the associated (and now well proven) detriments, especially in refugee settings. Cooking would be in the privacy of one's home with an electric wire coming to one's home/tent/structure. The primary compromise would be that the timing of when one is allotted the electricity would be prescheduled and would be during daylight hours. One kWh (equivalent to one kW for one hour) of such energy at large scale is now possible at 5 cents/kWh. At smaller settlements scales, with needed wiring costs as well as higher per kW installation costs, and factoring inefficiency in utilization, energy could be provided at 20 cents/kWh or about $6/month. These price points are now approaching the costs of fuel wood. For something as basic as cooking rice for a family of 5 to 6, the cost per meal would be as low as 5 cents. Early stage prototype efforts would focus on dense refugee camps where the fuel wood challenges are particularly acute; where families live in close-proximity (keeping micro-grid costs low), and where allotment of pre-specified scheduled times for cooking would provide at least a significant part of the meal would be possible.

Background:

Much of the food prepared in refugee settings is cooked with firewood; which is very inefficient and has strong health and environmental implications. Experiments done with rice (similar work is planned for other food items), show that if an efficient method of cooking could be provided, then cooking electrically can be very efficient. Further, if this electricity can be provided by solar PV without storage, then it can also be cost-effective. Bringing an electric wire into the home allows cooking to be carried out in the privacy of one's own abode. With advances in cost reductions of solar PV and the ability to provide sophisticated yet low-cost control systems to schedule cooking times, then it would be possible to eliminate battery storage.
Additional small amounts of power for cell-phone charging or LED lighting would be a trivial draw and hence those services become possible without any additional investments.

To verify these findings, the team from MIT LL and Columbia recently started to carry out rice cooking experiments, which compared different methods using electric rice cookers, pressure cookers, and induction burners. Processes involving electric rice cookers were, by far, the most energy efficient while maintaining a high and constant production rate. In addition, electric rice cookers are inexpensive, simple to operate, and do not require specialized cookware like pressure cookers or induction burners.

Extrapolating these results to cook a major meal including other foods, leads us to believe that it would be possible to displace major cooking needs with the provision of one kW of power for one hour (including other combinations of power and time). The team also ran computer simulations estimating daily power generation for small, fixed panel microgrids at a geographic location similar to Dadaab. The results taken over the course of a virtual year with variable sunlight levels showed that a small microgrid (about 10 kW range) could easily generate enough power for major cooking needs of about 40 families.

In work done by Columbia University by Sustainable Engineering Laboratory (qsel.columbia.edu) we have been able to show that it is possible to deploy micro-grids without storage that can generate electricity at today's low PV costs at less than $1500/kWp installed. These attractive economics lead us to claim that indeed the time to explore and exploit the low costs of installed PV for cooking has come.

Potential Impacts:

By creating a PV solar-based cooking infrastructure for areas of high cooking needs and few energy resources, such as in refugee and internally displaced people (IDP) camps, families can gain:

1. Greater cooking flexibility, such as the ability to cook indoors
2. Increased safety, by not having to search for solid fuels (e.g. wood)
3. Reduced indoor pollution, through a reduction in the impacts of combustion products

Additionally, the development of a scalable microgrid system could accommodate community growth and different environments (i.e. small vs. large camps), while also providing initial capabilities and physical components for powering future community needs.

Next steps:

While solar cooking infrastructure has the potential to overcome many problems with current cooking methods, the concept needs to fully examined with a real world deployment. The team is ready to carry this out.

A more thorough investigation needs to be completed to determine the viability of PV microgrids with cooking appliances to reduce firewood collection. Additional work should include:

- Exploration of different microgrid architectures to accommodate environmental and use-case requirements
    - Determine system trade-offs
    - Identify areas for innovation (e.g. new components and methods)

- Creation of a scaled, laboratory prototype of a microgrid-based cooking infrastructure
    - More detailed experimentation with cooking appliances and methods
    - Design specifications for robust hardware and appliances
    - Serve as a testbed for future analysis and testing

- Research-oriented visits to representative environments, such as refugee and IDP camps
    - Understand family cooking needs
    - Discover site and installation requirements and limitations
    - Determine on-site training and maintenance capabilities

- Piloting of microgrid-based cooking infrastructure within actual camps in coordination with governing organizations