Feasibility of Solar Cooking and Its Impact on Conserving Forests*

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Abstract

The technical and the cultural feasibility of solar cooking are considered. The amount of firewood saved by widespread application of solar cooking is determined, and the relevance for forest conservation is assessed.

Feasibility of Solar Cooking

Cooking practices are deeply rooted in tradition; they are diverse, complex, and important; any changes must be attractive in many aspects, before they are accepted.

Scientific Feasibility

Availability of solar energy depends on the geographical location and the time of day. In plain sunshine at noon it is close to 1 kW/m^2. A chart of insolation on a horizontal square metre is available at [1]. The energy received by a square foot of solar collector can cook all the food a person can eat; a square metre of collector in Toronto can boil 12 l/d of water in January, and 50 l/d in July.

Solar radiation has low entropy, and with concentration it can create a high temperature of several thousand degrees Celsius. Even without concentration, using the greenhouse effect alone more than 200 Celsius can be achieved in solar ovens – this is essentially the stagnation temperature of flat plate solar collectors; such temperatures are sufficient for all kinds of cooking.

Thermal storage of solar energy does allow cooking after sundown, or in bad weather. However, solar cookers with storage require a sophisticated technology.

Technical and Economic Aspects

Solar box oven without concentration is the simplest design for solar cooking. Two or three adjustments of direction during a day are sufficient to hold cooking temperatures from morning to late afternoon. A black box with a double glazed window, and 4 cm foam insulation in walls and floor has yielded 160 Celsius in Toronto; it was successfully used to cook soup and stew, bake bread, and roast beef.

A visitor to from India expressed two conditions for the acceptability of solar cooking in India's countryside: it should cost no more than $ 20, and offer the possibility of cooking at any time. A solar box oven with an auxiliary combustion chamber was developed at the Ryerson Energy Centre in Toronto following this recommendation. The prototype

worked well technically; the combustion was efficient and fuel consumption for cooking a meal was substantially less than in traditional ovens as the oven is well insulated. Unfortunately, the combination oven did not meet economic criteria; material cost alone was more than 500$ [2].

Concentrating devices using parabolic reflectors have been explored as well.
A survey of technical designs of solar cooker is given by Hafner et al. [3].

Energy storage is technically possible; however, the design requires much more attention than it has presently received before it will be economically feasible. In the 1980s AEG, a German company offered a solar cooker with storage for some $ 6000, which is economically not meaningful.

Cultural Considerations

The cultural barriers to accepting solar cooking are an additional problem. The Ryerson solar oven was demonstrated to the ambassador of Niger, and his reaction was: "How do you stir your pot?" The slow and gentle heat of the solar oven does not require stirring, but cooking in a certain way is a ritual, that people are not willing to change.

However, when a new technology is right, it will be accepted even if it is alien to the culture. An example for that is the transistor radio and tape recorder. In the culture of rural Niger, untouched by the industrial revolution, modern electronic technology is very popular; people will make economic sacrifices in order to be able to get batteries for their transistor radio. Therefore, when further engineering designs of solar cookers have matured to a degree that they are desirable, people will adopt a new cooking culture.

Average Power Used for Cooking

The minimum energy required to cook all meals for a person is calculated by assuming the quantity of hot meals including hot drinks is some 3 kg/d. Assuming further that the specific heat of food is roughly that of water, and that it needs to be heated from room temperature of 20 C to 100 C, and that the efficiency of the cooking method is 30% the minimum cooking energy for one day is approximately 3.4 MJ, or a daily average power of 40 W.

The measured firewood used per capita for cooking in developing countries is on average approximately 1.5 kg/d. An example of measured values in Nepal is given by Rijal, HB and H. Yoshida [4]. With $1.5*10^7$ J/kg heat of combustion average biomass energy used per capita for cooking is: 22.5 MJ/d, which is equivalent to average biomass power consumption of 260 W/person.

The power used for cooking is, therefore, approximately 11 % of the global average total power consumption, which is 2300 W/person. However, the picture is different for the regions. In rich countries, which use total power of some 10 000 W/person, and efficient methods, the cooking energy is approximately 1% of the total. By contrast, in the poor

countries, which cook with firewood, cooking energy is the bulk of total energy consumption. In Niger, for example, where most of the cooking in rural and urban areas is done by firewood, the total power should exceed 260 W/person. However, the data given by both, the IAEA, and the US EIA result in a total of 43 W/person [5]. Assuming that the tables of IAEA and US EIA only list fossil fuels Niger's total power consumption should be some 300 W/person. In this case, firewood represents 87% of total energy use in Niger. This is similar for most developing countries, particularly the rural areas. .

Biomass Savings

The forest area required to grow firewood energy at a rate of 260 W/person is determined by the overall energy productivity of a forest; the power produced in a hybrid poplar plantation is 0.44 W/m^2 according to [6]. Therefore, forest area required to produce firewood for cooking is at least 591 m^2/person; the required area is bigger in arid areas, where the ground cover is a fraction of that in a hybrid poplar plantation in Alabama.

Impact on Forests

Hafner et al loc cit [3] state: "In Sahel and Sudan-region in Africa the consumption of firewood exceeds the growth-rate of the forests. The regions loose about 5 % of their forests every year". According to Earth Trends 2000 [7], the annual loss of forests in Niger is 34% in 10 years 1990- 2000, and the forest area is 1100 m^2/person; as the ground cover of the bulk of forest in Niger is between10% and 25%, the actual productive green area is less than 275 m^2/person. Therefore, introducing the solar cooking technology in Niger will make an essential contribution to the conservation of this country's forests.

Conclusion

Solar cooking is scientifically and technically feasible; a collector of approximately 1m^2 suffices to supply the cooking energy for a family. There are economical and cultural obstacles to the implementation of solar cooking; these have to be addressed before the technology has a chance to become popular. In a global perspective, cooking requires less than 10% of the total world energy consumption. However, solar cooking energy is approximately 80% of the total energy consumption in developing countries, where cooking is done with firewood or charcoal; in these regions of the world solar cooking can make a relevant contribution to the conservation of forests.

References

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