THIRTY FIVE YEARS OF RESEARCH AND USE WITH MY FAVORITE HYBRID SOLAR CUM ELECTRIC OVEN IN COSTA RICA.

Shyam S. Nandwani

Retired Professor, Researcher, Promotor and User of Solar Energy, Heredia, Costa Rica.

Abstract

Author designed, constructed, and used solar food warmer first time in the house 1979. Looking into success, various models of cookers/ovens like conventional solar oven, hybrid solar electric oven, and also including dryer, were designed and used for next 35 years. Got a patent on Solar Oven for Costa Rica in 1984 and also published a practical book on Solar oven in Spanish, in 1992 and 2004. Also with the collaboration of Solar Cookers International, based at Sacramento, USA, organised a world conference on Solar Cooking in Costa Rica in July 1994.

These ovens were/are used for cooking, warming meal and other uses, when the climate permits, about 7-8 months for cooking and about 11 months per year for low temperature applications, like warming meals, pasteurizing water and drying domestic products. In this presentation only Hybrid Solar Electric Oven will be mentioned.

*Keywords: **S**olar oven, Solar electric hybrid Oven, Solar pasteurizer, Solar oven cum dryer, Smart switch, Energy saving.*

Introduction

Due to electric rationing imposed by National electric company, author constructed and studied solar food warmer for family use in April 1979. Looking into success, various models of cookers/ovens (Nandwani, 2012) like conventional solar oven (Nandwani, 1988), hybrid solar AC (Nandwani, 1989) electric oven, Solar Electric Microwave oven (Currin et.al.,1994). two compartments oven for research (Nandwani et.al, 1997), Multipurpose Solar Electric oven including dryer (Nandwani, 2007) etc. were designed, studied and published during 44 years of research. Got a patent on Solar Oven for Costa Rica (Nandwani, 1984) and also published a practical book on Solar oven in Spanish, in 1992 and 2004 (Nandwani, 2003).

These ovens were/are used for cooking, warming meal and other uses, when the climate permits, about 7-8 months for cooking and about 11 months per year for warming meals, pasteurising water and drying domestic agricultural products. etc.

Photo 1 shows some of the ovens designed and used by author and family at home.

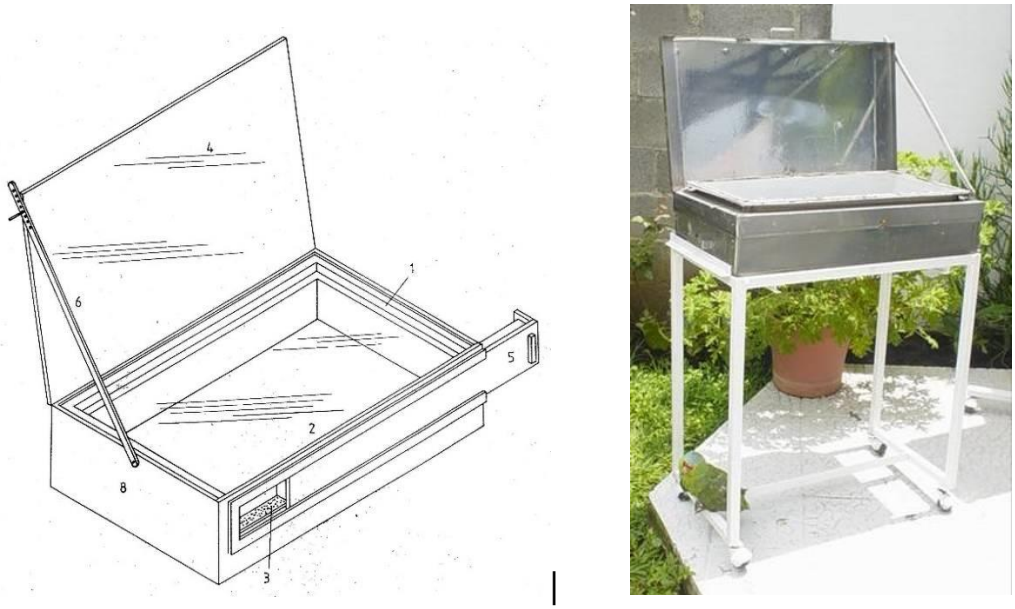
Selection and/or peer review under responsibility of Scientific Committee
10.18086/swc.2023.12.02 Available at http://proceedings.ises.org

Photo 1. Some of the solar ovens designed and used by author at home since 1980.

In this presentation I will be mentioning only Hybrid Solar Electric Oven, and some practical devices added, during last ten years to make the hybrid oven more friendly.

Solar Oven

Although Hot box oven is well known however we can mention in brief (Nandwani, 1988). As shown in Figure 2A and Photo 2B, it is a box having metal sheet, painted black on the top to receive the maximum -solar radiation, glass wool as heat insulation on four sides and below the metal plate,



A B

1.Two transparent window glasses, 2. metallic plate, 3. heat insulating material, 4. reflecting sheet, 5. door to keep and take out cooking pots, 6. rod with some holes to adjust reflector angle, 8. outer box.

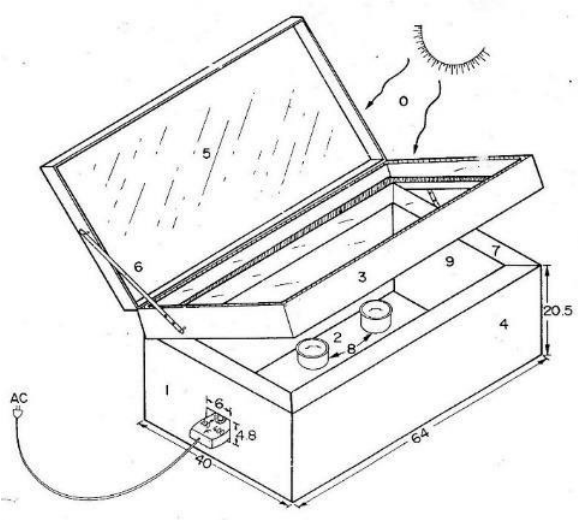
Fig. 2. Conventional Hot box, drawing (A) and Oven (B) at author house.

On the top of the box there are two transparent window glasses to allow the entrance of low wavelength solar radiation coming from sun and impedes the exit of high wavelength emitted from the hot metal plate. On the top of the box there is also one reflector (although could be more) to increase the solar radiation and thus increase oven temperature. In this way the box becomes very hot. On sunny day the oven temperature could reach up to 150 ℃ (without any meal) to cook meal and pasteurize water etc.

Hybrid solar electric oven.

The advantages of Solar ovens are well known, like free, clean and abundant solar energy, no smoke, reduction of deforestation, cooking even in absence of cook etc. (Nandwani, 1996). However, has the limitation like absence of solar energy, not only at night, but also during cloudy/rainy period. More than that, the fluctuating/ unpredictable climate even during sunny day, especially in Central American countries including in Costa Rica, mainly due to sea on both eastern and western coasts. Figure 10 will show the solar radiation drop on one particular sunny day at beginning. This is sufficient reason to frustrate most of the women when meal is not cooked, including my wife. Thus (fortunately) I was forced to find some solution. In 1986, I made, studied and published Electric cum Solar Oven (Nandwani, 1989).

As shown in Figure and Photo 3, The Hybrid Solar Oven is in fact similar to conventional Solar oven but with two changes, the normal metallic plate is replaced by electric grill plate (1000-1200Watts) and thermostat for fixing plate temperature. In this way, one put the meal in the box to be cooked and fix the plate temperature say about 100 ℃. Depending on the climate/ solar intensity, in case oven temperature is maintained, no electrical energy will be used, however in case the solar intensity falls, electricity will be used and again in case clouds disappear, no more electrical energy etc. In this way switching from Solar to Electrical energy and vice versa is automatic. More results can be seen in the original paper presented firstly at 1987 ISES Conference held at Hamburg/ Germany and published in the journal (Nandwani, 1989). The user is sure to get the meal cooked. but with the minimum use of electric energy. In other words, it can be used for cooking, baking and pasteurizing water even in cloudy climate. Thus, this is my favourite model.



0 Solar Radiation AC Alternating Current 1. Thermostat 2. Electric Black Plate 3. Two Transparent Glass Covers 4. Outer Wooden Box. 5. Reflector 6. Arrangement to adjust the angle of reflector 7. Glass Wool 8. Cooking Pots 9. Inner Wooden Box. All dimensions are in cm.

Fig. 3 and photo 3. Hybrid Electric cum Solar Oven at authors house and in working mode at exhibition in Costa Rica

.

Hybrid multipurpose solar electric oven

In the hybrid Solar Electric oven mentioned already and made in 1986 at my university the outer box was made of wood, due to budget limitation. Later on I made the similar one for the house but with stainless steel, for better durability, as well with some changes like including Solar dryer as shown in Photo 4. Dryer is very useful for drying some domestic products, and require less temperature, like coriander and other herbs etc. (Nandwani, 2007).

Photo 4. Multipurpose and Hybrid Solar electric Oven designed and used at authors home since 1988.

Energy measuring and controlling device.

During last 35 years of use, I have found this as useful oven. Then I decided to add some additional devices to make this favourite Hybrid oven more practical for safety and measurements, like oven thermometer, Watt meter to measure electricity consumed, switching ON and OFF oven remotely, and measurement of oven temperature and solar intensity remotely with smart switch and cell phone etc. Some recent experimental data will also be informed.

a. Oven Thermometer.

In conventional solar oven its good to have oven thermometer (photo 5) to know the air temperature while cooking meal but in the case of Hybrid solar oven its very much necessary also for the safety reasons. May be due some problem with thermostat the oven temperature can increase too much and it can burn your hand while taking meal.

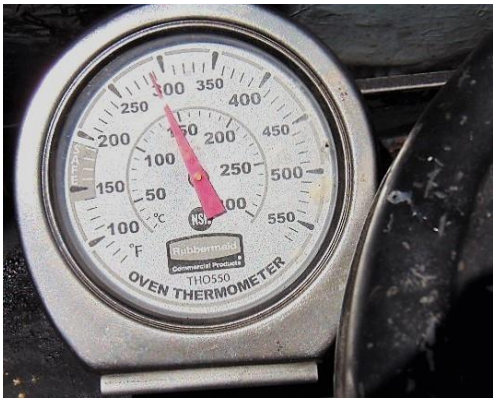


Photo 5. Oven thermometer to measure temperature.

b. Energy Measuring Device.

Although the meal can be cooked in any climate, with minimum use of electrical energy, however the researcher and user may want to know the electrical energy used/saved. The simplest way could be observing the time LED light ON Time, in the thermostat. Adding this light time (hr.) and multiplying with average wattage of electrical plate (1.2 kW), one can calculate the total electrical energy used (kWh) for cooking. Now I use Kill a Watt meter (Photo 6a) connected in series to Hybrid solar device (Photo 6b) to know the electricity used and also for public demonstration etc. In case any researcher/cook wants to know total energy consumed, he/she can use portable solar meter.

Photo 6. One of the commercial Energy Meter, KILL A WATT (a) Oven and connection to oven (b) for measuring electric energy used.

c.Smart Switch

Solar Oven, in addition to save conventional fuel also has another BIG advantage, it can cook unattended, it means, user can keep the meal and go for shopping and even to office, The SUN will be doing his job to cook the food. The food will not burn as solar oven is slow cooking device. and does not attain very high temperature (about 100 ℃, with meal inside). But with Hybrid Oven, it cannot be done always, especially when you are not at home. May be the user has to disconnect electricity after 2-3 hours depending on climate and quantity of meal etc. Although some programable timers are available for switching off the devices after particular time, commonly used for Electric water heater, TV or other appliances etc. However around 8-9 months ago I found Smart Switch (Photo 7) which combined with Smart Cell phone can switch the Hybrid Solar/Electric oven whenever you want, even you are in the office, market in or out of country, (Nandwani, 2022).

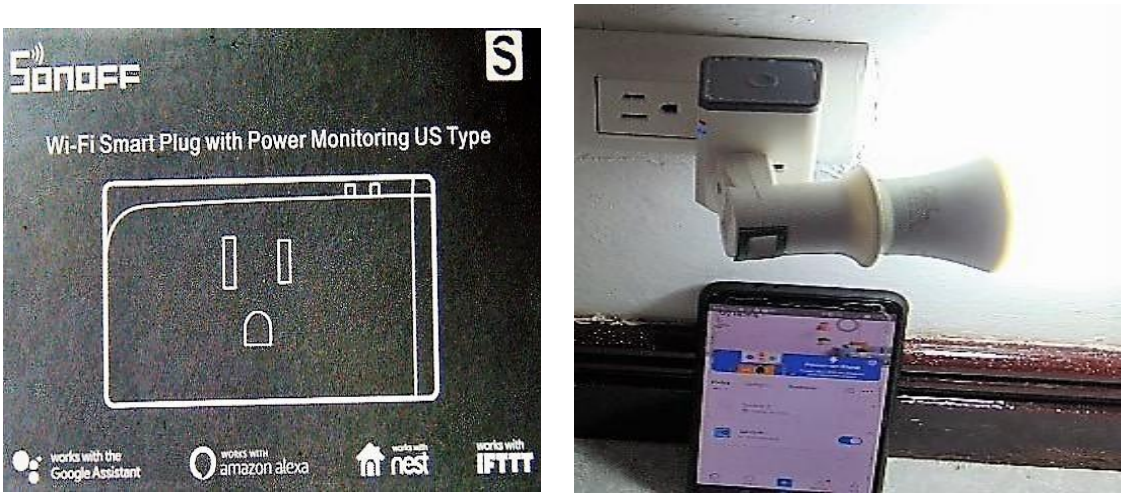


Photo 7. Smart Switch (left) and Smart Cell phone (right), to control Hybrid Solar Oven, via Wi-Fi.

d. Data reading remotely.

So far everything is OK. Being a retired person, I continue doing some research at home with solar thermal and photovoltaic devices. At home I do not have data logger to record data. While doing measurements manually, some time I have to leave home say for 1 to 2 hours and do not want to miss data, like solar intensity and oven temperature. Fortunately, recently I could find a smart DC camera (Photo 8). Through this camara and corresponding application in smart cell phone, one can see the data through Cell phone, even you are on the road or at some coffee shop etc. One can either note the data or take screen shot to note down later.

Photo 8. Smart Wi-Fi camara with Cell Phone to measure some variables remotely.

Some experimental results

Although in the earlier papers (Nandwani, 1989 and Nandwani, 2007) on this subject. many experimental results are informed; however I will add only one more experimental data measured recently, where by chance climate change occurred.

On October 4, 2023, two solar ovens, one conventional and another hybrid Oven were used to cook same quantity of meal. At 8 am both ovens were kept in patio without any meal. Solar radiation and oven temperatures were measured each 15 to 30 minutes. At 11 am, the oven temperature was about 105-110 °C, in each oven (Fig. 10). Now we put vegetables (260 g of potatoes) in both ovens (Photos 9).

(a) (b)

Photo 9. Solar (a) and Hybrid Oven (b), with the same quantity of meals kept at 11 am.

Unfortunately for cooking (but fortunately for study) the solar radiation started reducing, due to clouds.

I connected the hybrid oven with electricity and Energy meter (kill a Watt). From the Figure 10, one can see very clearly the drop of oven temperature in conventional solar oven and the housewife has the sufficient reason to get frustrated. At 12:30 pm, meals in both ovens were checked and the meal in solar oven was not cooked whereas the meal in hybrid oven was cooked, consuming only 0.16 kWh of electrical energy.

To the best of my knowledge, at least hybrid electric Solar ovens are sold commercially at least in India and USA, but without additional accessories mentioned here..

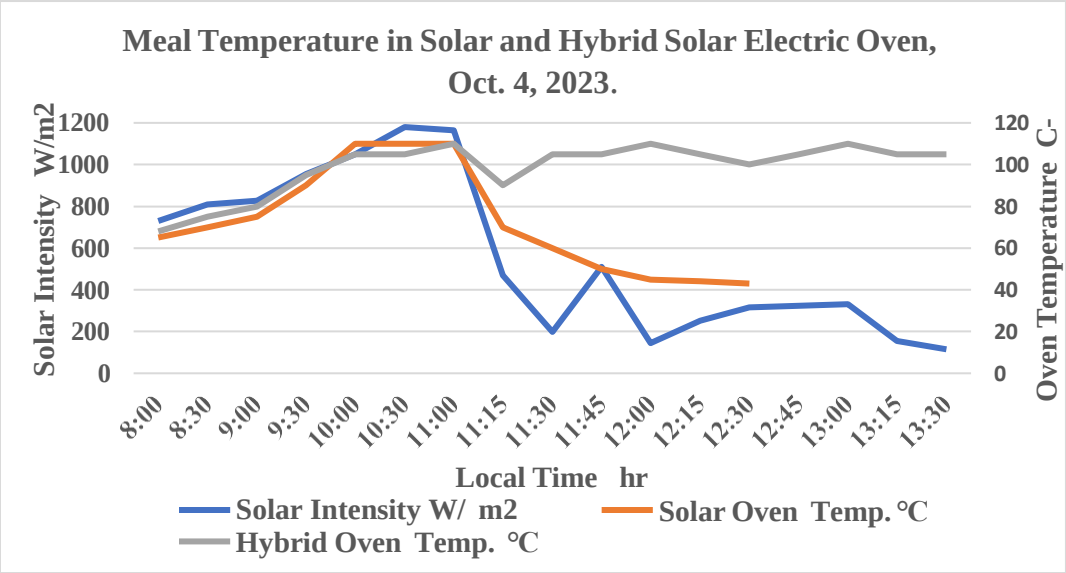


Fig. 10. Variation of Meal temperature with solar intensity, in Solar and Hybrid Oven.

Conclusions

With this hybrid gadget, which can be used mainly in electrified areas, with electricity generated from fossil fuel or from Renewable sources, one can heat, cook bake and roast meal, pasteurize water and dry spices etc., using mainly solar and electricity if required). Thus we can consider the device with accessories mentioned above as a practical device for user as well for researcher etc. In the case of rural area, the other fuel could be firewood or electricity from PV panels. This will help in reducing conventional fuel and cool the only planet we have (Nandwani, 1996).

Acknowledgement

Author is thankful to all ex collaborators, Eliecer Madrigal, Marvin Alpizar, Carlos Delgado and Guillermo Torres etc. for the help in construction and measurements.

References

Nandwani, S., 1984. El Horno Solar. Patent No. 2367. *National Register, Costa Rica*.

Nandwani, S., 1988. Experimental and theoretical analysis of simple solar oven in the climate of Costa Rica,
Solar and Wind Technology, Pergamon Press, 5 (2), pp.159-170.

Nandwani, S., 1989. Design, Construction and Experimental Study of Electric Cum Solar Oven-II, *Solar and Wind Technology*, Pergamon Press, 6 (2), pp.149-158.

Currin, Ced., Nandwani, S., Alpizar, Marvin., 1994. Preliminary study of Solar Powered Microwave Oven. *Second world Conference on Solar Cookers, Use and Technology*, Costa Rica, 12-15 July 1994. Published in Proceedings., April 1995, pp. 149-158.

Nandwani, S., 1996. Solar cookers – cheap technology with high ecological benefits. *Ecological Economics*, Vol. 17, pp. 73- 81, 1996.

Nandwani, S., Steinfart, J., Henning., H.M., Rommel, M., Wittwer, V., 1997.Experimental study of Multipurpose Hot box at Freiburg, Germany, *Renewable Energy, an International Journal*. Pergamon Press, Vol. 12, pp. 1-20.

Nandwani, S., 2003. Book: La Cocina /Horno Solar, *Editor, Fundacion Universidad Nacional Costa Rica*, pp. 1-126. ISBN, 9977-906-39-4.

Nandwani, S., 2007. Design, construction and study of a hybrid solar food processor in the climate of Costa Rica, *Renewable Energy- An International Journal* (Elsevier Ltd). 32 (3), pp. 427-441.

Nandwani, S., 2012. Solar Cookers and Dryers to conserve Human and Planet Health, Invited article. Published in
Encyclopedia of Sustainability Science and Technology, Robert A. Meyers (Ed.) Springer Verlag, pp. 9486-9509.

.

Nandwani, S., 2022. Hybrid Solar/electric Oven with Smart Switch and Smart Phone, *Acta Scientific Computer Sciences*, 4(8),
pp. 10-14.