The Lightoven - a new portable solar cooker

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Motivation: Of the many existing solar cookers only a few designs exist which are portable and lightweight enough for backpacking, bike riding, canoeing, etc. Most of these designs do not use a parabolic reflector. This might be due to difficulties in retaining the exact shape while at the same time maintaining low weight. Therefore, they either suffer from considerable light losses due to inaccurate focusing (true for all panel cookers) or compensate these inaccuracies by bulky cooking pots, which however exhibit high thermal losses (e.g. the HotPot). All of these portable cookers consequently require quite long heat-up times until boiling, although some of them reach quite high stagnation temperatures (e.g. the Copenhagen). The Lightoven was designed for heating up a significant amount of water until boiling in less time than other portable cookers with similar weight and packing dimensions. Such a design requires a concentrating reflector and an adapted cooking pot design with low thermal losses.

Design: The design has been inspired by the CooKit, however using instead of few reflecting panels many segments which follow a parabolic curve on a reflecting bottom plate. The vertical focal line should ideally hit the cooking pot entirely. However when the angle of incident rays is not perpendicular to the reflector, the focal line tends to elongate. Reflector and cooking vessel are therefore designed in a way that all rays are reflected onto the cooking vessel - provided the sun elevation is at its geometrical optimum. The present design of the cooker is best suitable for medium elevation, i.e. the latitude of Central Europe. The parabolic reflector can be tilted from vertical orientation by about 15° backwards to account for higher sun elevation angles.

The cooking vessel of the present model has a size of 1.5 liters and is designed as a slim jar which however allows cleaning by hand down to the bottom. The pure aluminum vessel has a custom made rim suitable for fitting the top tightly to a heat retention tube made from polycarbonate. There is an air gap of a few millimeters between the cooking vessel and the tube which limits thermal losses.

The reflector base material is 4 mm thick polypropylene core flute which is covered by a self-adhesive aluminized Mylar foil. To allow rolling for transport, the material surface is cut in regular intervals along the flutes on the non-reflective side. The reflector is connected to the bottom plate by Velcro flaps which follow a parable. The dimensions of the reflector in operation are 114 x 45 x 45 cm (width, height, and depth) resulting in a maximum aperture of 0.57 m2 in total including the bottom plate. For transport both parts of the reflector can be rolled around the cooking vessel resulting in a 45 cm long package with a diameter of 17 cm. The total weight of this package is 1.6 kg including a watertight transport bag.

The cooking vessel is fixed to the bottom with a lug which prevents it from tipping, especially when the cooker is tilted back by attaching the foldable wedge below the bottom plate. With sufficient practice, the cooker needs about two minutes to assemble and about one minute to disassemble.

Another feature is the combined indicator for solar elevation and focusing. The present operation point is indicated in the color-coding of a traffic light (green: ok, yellow: at the limit of good adjustment, red: should be adjusted for better performance).

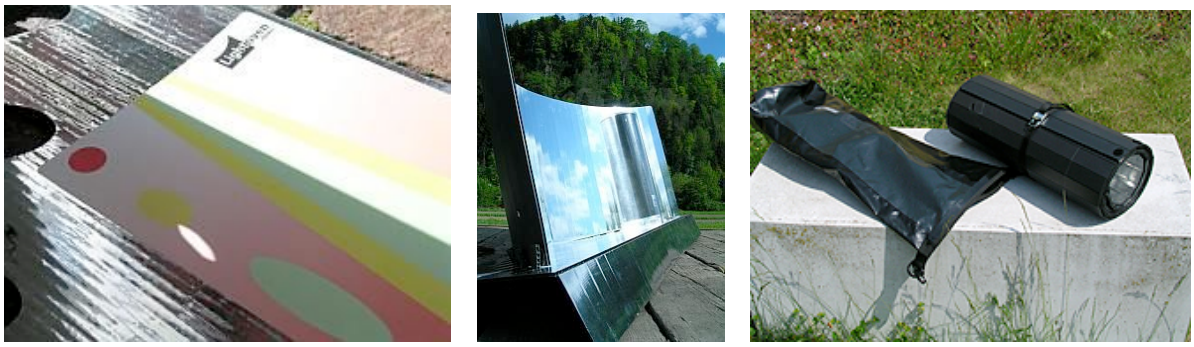

Figure 1 Left: The sun indicator of the Lightoven. A pinhole is used to indicate sun elevation and necessary tilting. The focusing of the cooker is checked by the shadow of the reflector border which has to fall into the green marked acceptance angle. Middle: Side view of the cooker in tilted position. Right: Cooker rolled for transport around the cooking vessel with watertight bag next to it. Photos by Michael Bonke

Performance: At our location at 52°N latitude, the direct insolation, which is a function of the sun elevation and visibility, can reach about 500 W/m2 in winter and up to 900 W/m2 during summer (at 10° and 65° elevation, respectively). Tests throughout the year have shown that the Lightoven can easily reach boiling temperatures in this elevation range, with the best performance between 30° and 50°. The Lightoven therefore turns out to be an all-season solar cooker for this latitude.

The maximum cooking power of the Lightoven is about 200 Watts. The average heat loss during the process of heating water from 20°C to 100°C is about 40 Watts. This means that the effective cooking power is 20% less than the maximum cooking power. These numbers can be derived from the heating curve (an example is given in Figure 2). The total efficiency taking into account reflection, focusing, transmission, absorption and thermal losses is about 50%. Performance data can be converted into a combined daily and seasonal usage diagram. This is shown for our location in Figure 3 (clear sky and high visibility assumed).

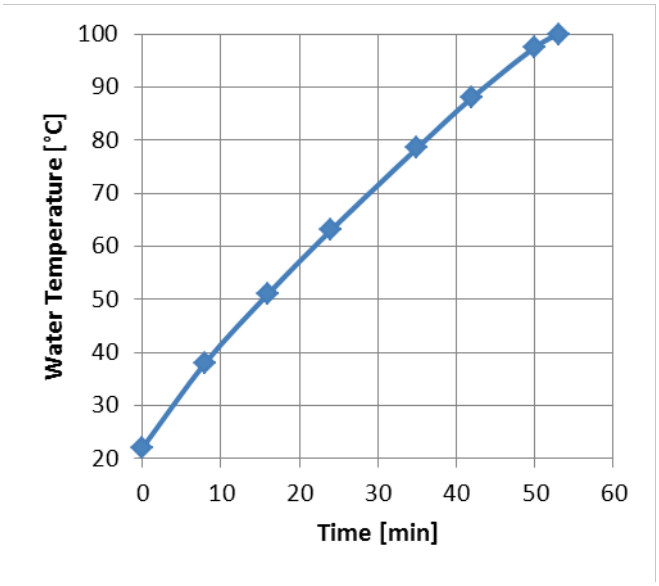

Figure 2 Heating curve from ambient temperature to boiling for an amount of 1.5 liters water exposed on 30th July 2012 at 9 AM.

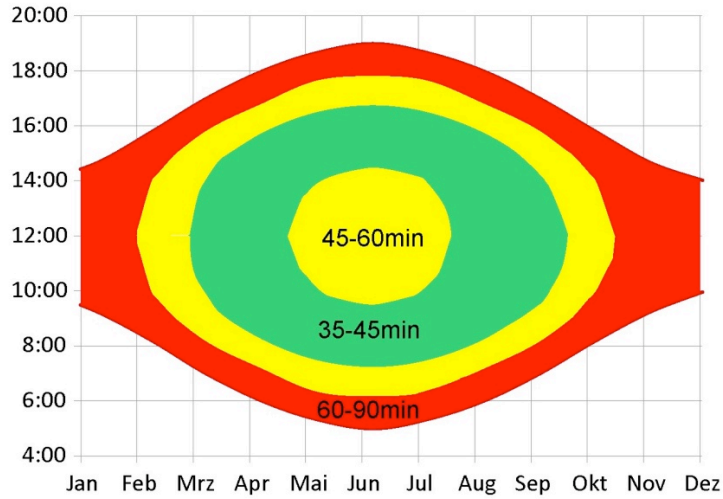

Figure 3 Usage diagram of the Lightoven: Colors indicate approximate heating up times per liter of water from ambient temperature to boiling. Conditions are clear sky and high visibility at 52°N latitude. Noon time corresponds to maximum solar elevation and is not corrected for summer/winter time. The cooker is presently manufactured as a small series in Germany. It is primarily intended for camping and other outdoor activities in industrialized countries to promote solar cooking. Purchasing information is available on the website www.lightoven.de.