



Solar Household Energy, Inc.

Solar Cooking for Human Development and Environmental Relief

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Findings from Solar Cooker Heating Data Comparisons Summer, 2016

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Findings from Solar Cooker Heating Data Comparisons Summer, 2016

The following tables summarize findings based on comparisons of heating curves (temperature vs. time) for pairs of solar cookers that were measured at the same time (that is, under the same solar radiation condition). This report is intended to accompany the earlier report TR-11, "Compilation of Solar Cooker Heating Experiments, 2016" and to provide discussions and findings from these experiments.

All dates are in months/days format. Temperatures are in degrees C. Volumes are in liters.

Date	7/29/2016
Sky	p.c.; no weather data obtained
Test Item 1	Haines refl. With GraniteWare pot, 1 l. tap water
Test Item 2	Haines reflector with Haines "Dutch Oven" pot, 1 l. tap water
Findings	GraniteWare pot 4 deg. Hotter at 150 min.

Date	8/2/2016 (Aug. 2, 2016)
Sky	p.c.
Test Item 1	Haines pot #2 with 1 l. tap water (505 g. pot)
Test Item 2	Haines pot #1 with 1 l. tap water (368 g. pot)
Findings	Repeatability check – within 5 deg. C, #1 hotter

Date	8/8/2016
Sky	Clear; then cloudy after 180 minutes; no irradiance data
Test Item 1	Haines #1 with 2.45 l. tap water (368 g. pot)
Test Item 2	Haines #2 with 2.45 l. tap water (505 g. pot)
Findings	Repeatability check – within 6 deg. C, #1 hotter

Date	8/10/2016
Sky	P.C.; no weather data obtained
Test Item 1	Haines #1 with 2.45 l. distilled water (368 g. pot)
Test Item 2	Haines #3 with 2.45 l. distilled water (368 g. pot)
Findings	Repeatability check – within 0 to 5 deg. C

Date	8/11/2016
Sky	Clear, hazy until 1400
Test Item 1	Haines #1 with 2.45 l. distilled water (368 g. pot)
Test Item 2	Haines #2 with 2.45 l. distilled water (368 g. pot)
Findings	Repeatable within 5 deg. C

Date	8/13/2016
Sky	Clear, PC later
Test Item 1	3 liter HotPot #1 with 2.32 l. d. water
Test Item 2	3 liter HotPot #2 with 2.32 l. d. water
Findings	Repeatable within 5-6 deg. C. Lower seal did not help.

Date	8/15/2016
Sky	Clear, light haze
Test Item 1	3 liter HotPot #1 with 2.32 l. d. water
Test Item 2	3 liter HotPot #2 with 2.32 l. d. water
Findings	Repeatable within 5 deg. C

Date	8/20/2016
Sky	Clear until 200 min.; low wind speed.
Test Item 1	3 liter HotPot #1 with 2.32 l. d. water
Test Item 2	3 liter HotPot #2 with 2.32 l. d. water
Findings	Repeatable within 2 deg. C during heating phase

Date	8/22/2016
Sky	P.C.
Test Item 1	Haines pot #2 with glass lid, 2.45 l. d. water
Test Item 2	Haines pot #1 with silicone sheet as lid, 2.45 l. d. water
Findings	Repeatable within 2 deg. Despite low irradiance

Date	8/23/2016
Sky	Clear until 200 min.

Test Item 1	Haines pot #2, glass lid, 2.45 l. d. water
Test Item 2	Haines pot #1 with silicone flat lid, 2.45 l. d. water
Test Item 3	ASSC with GraniteWare pot, 2.37 l. d. water
Findings	Haines repeatable within 7 deg., exceeded 100 deg. C (strange), ASSC reached only 70 deg. (had no cover)

Date	8/24/2016
Sky	Clear until 360 min.
Test Item 1	ASSC with clear plastic cover (PETE) taped to seal, 2.37 l. d. water
Test Item 2	Copenhagen with refl. Set at 3 inches, GraniteWare pot with silicone flat lid, wires thru lid gap, 1 l. d. water
Findings	ASSC reached 75 deg. C; Copenhagen reached 33 deg. C (self-shaded reflector)

Date	8/25/2016
Sky	Hazy, thick at 230 min.
Test Item 1	Haines pot #2 with smooth Copenhagen reflectors, 2.45 l. d. water
Test Item 2	Haines pot #1 & refl., 2.45 l. d. water
Findings	Smooth reflectors were 12 deg. C hotter before clouds came over

Date	8/26/2016
Sky	Clear, p.c. after 120 min.
Test Item 1	Haines pot #1 with smooth reflectors, 2.45 l. d. water
Test Item 2	Haines pot #2 with #1 Haines reflector, 2.45 l. d. water
Findings	Smooth reflectors were 15 deg. C hotter before clouds came over

Date	8/27/2016
Sky	Very clear
Test Item 1	Haines pot #1 with smooth reflectors, 1 l. d. water
Test Item 2	Haines pot #2 with #1 Haines reflector, 1 l. d. water
Findings	With smaller load, smooth reflectors show faster heating and reach boiling at least 40 min. earlier

Date	8/28/2016
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Sky	Clear
Test Item 1	Haines pot #1 with smooth reflectors, 2.45 l. d. water
Test Item 2	Haines pot #3 (new) with 3 kg copper blocks
Findings	Attempted to use copper blocks to replace water load. Heat capacity of copper is much lower than water; much more metal would be required. Conductivity of touching blocks was not sufficient to maintain equal temperatures.

Date	8/29/2016
Sky	Hazy
Test Item 1	Haines pot #1 with refl. #1, 2.45 l. d. water
Test Item 2	Haines pot #2 with smooth reflectors, 2.45 l. d. water
Findings	Smooth reflector is about 10 deg. C hotter at 180 min.

Date	8/30/2016
Sky	Clear until 120 min.
Test Item 1	Haines pot #1 with refl. #1, 2.45 l. d. water
Test Item 2	Haines pot #2 with smooth reflectors, 2.45 l. d. water
Findings	Smooth reflector is about 17 deg. hotter at 180 min.

Date	8/31/2016
Sky	p.c.
Test Item 1	Cookit with GraniteWare pot & roaster bag, 3 l. d. water
Test Item 2	Solavore/Sport with Haines pot #1, 3 l. d. water
Findings	Sport with Haines pot boils at about 200 min. while Cookit only reached 70 deg. C

Date	9/2/2016
Sky	Clear, hazy
Test Item 1	Haines pot & refl. #1, 1 l. d. water
Test Item 2	Haines pot & refl. #2, 3 kg. copper blocks
Findings	Despite better match of heat capacity than experiment on 8/28, the copper blocks heated much faster than the water and heating curves looked very different because thermocouples were exposed to circulating hot air.

Date	9/5/2016
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Sky	Very clear until 240 min.
Test Item 1	Haines pot #1 with smooth reflector, 2.45 l. d. water
Test Item 2	Haines pot #2 with #3 reflector, 2.45 l. d. water
Findings	Differences of up to 7 deg. during early heating phase in clear sky, with #3 reflector higher. (This is not consistent with 8/30.)

Date	9/6/2016
Sky	Clear; breezy
Test Item 1	Haines pot #1, 2.45 l. d. water
Test Item 2	Haines pot #2 with smooth refl., 2.45 l. d. water
Findings	Smooth refl. Reached full boil in 2 hours, 17 deg. hotter than regular refl.

Date	9/7/2016
Sky	Clear until 80 min.
Test Item 1	ASSC with GraniteWare pot, no bag, 2.37 l. d. water
Test Item 2	Same
Findings	Performance is poor without cooking bag or other transparent cover. Note a spread of about 4 deg. C between 4 thermocouples inside the pot during the heating phase. Without insulation, there is more variation in temperatures inside the pot.

Date	9/8/2016
Sky	Clear for 2 hours, then p.c.
Test Item 1	HotPot #1, sealed lid, 2.32 l. d. water
Test Item 2	HotPot #5, unsealed, 2.32 l. d. water
Findings	Lid #1 developed reflective condensation which reduced its power slightly at higher temperatures, despite the seal. The other lid was clear.

Date	9/9/2016
Sky	Thin clouds all day
Test Item 1	HotPot #5 (sealed), 2.32 liters distilled water
Test Item 2	HotPot #1, unsealed, 2.32 l. d. water
Findings	Lid #1 still a few degrees hotter despite the unsealed lid. Both lids were cleaned with steel wool prior to test.

Date	9/12/2016
Sky	Clear; HotPot 1 in shade after 100 minutes; others in shade after 180 minutes. No pyranometer data.
Test Item 1	HotPot lid #1, sealed, 2.32 liters distilled water
Test Item 2	HotPot lid #2, sealed, 2.32 liters distilled water
Test Item 3	HotPot lid #5, unsealed, 2.32 liters distilled water
Findings	All pots had almost equal power. Pots in sun reached full boil.

Date	9/13/2016
Sky	Clear.
Test Item 1	HotPot lid #1, sealed, 2.32 liters distilled water
Test Item 2	HotPot lid #2, sealed, 2.32 liters distilled water
Test Item 3	HotPot lid #5, unsealed, 2.32 liters distilled water
Findings	HotPot #2 (sealed) was best, but unsealed #5 was better than #1 (sealed). Somewhat puzzling behavior of the notorious HotPot.

Date	9/14/2016
Sky	Clear; some high cirrus early.
Test Item 1	Haines #1 with refl. #2, 2.45 liters distilled water
Test Item 2	Haines #2 with refl. #1, 2.45 l. d. water
Test Item 3	Haines #3 with smooth reflector, 2.45 l. d. water
Findings	#3 heated faster and reached a full boil in 135 min. followed by the others at about 180 minutes. Clean data set.

Date	9/23/2016
Sky	Clear
Test Item 1	Haines #1 painted Ultra-Black, refl. #1, 2.45 liters distilled water
Test Item 2	Haines #2 with refl. #3, 2.45 l. d. water
Findings	#2 heated faster. The reflector #3 appeared to be brighter than #1. This higher reflectivity made more difference than a blacker pot. However, the reflectivity has not been measured; this is just a visual observation.

Date	9/24/2016
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Sky	Clear initially, then overcast.
Test Item 1	Haines #1, refl. #3, 2.45 l. d. water
Test Item 2	Haines #2, refl. #1, 2.45 l. d. water
Findings	Sky was overcast; GHI never got above 200 W/m ² and pots only heated to about 30 deg. C. This illustrates the need for clear sky conditions.

Date	9/25/2016
Sky	Variable; test started late.
Test Item 1	Haines #2, refl. #1, 2.45 l. d. water
Test Item 2	Haines #1, (Ultra Black), refl. #3, 2.45 l. d. water
Findings	Heating nearly identical until 180 min., then test ended. Ultra Black paint did not improve performance of the Haines pot, possibly because it is fully wrapped in polycarbonate sheet which reflects much of the light.

Date	11/5/2016
Sky	Clear; started late
Test Item 1	ASSC 2.0, pot #1, roaster bag, 2.37 l. d. water
Test Item 2	ASSC 1.0, pot #2, roaster bag, 2.37 l. d. water
Test Item 3	ASSC 3.0, pot #3, roaster bag, 2.89 l. d. water
Findings	ASSC 3.0 performed best. It was larger and had different shape, but the water load was also proportionately larger. ASSC 2.0 had a more reflective surface than ASSC 1.0, and this was very helpful.

Date	11/7/2016
Sky	Clear; started early
Test Item 1	ASSC 3.0, pot #3, roaster bag, 2.89 l. d. water
Test Item 2	ASSC 1.0, pot #1, roaster bag, 2.37 l. d. water
Test Item 3	ASSC 2.0, pot #2, roaster bag, 2.37 l. d. water
Findings	Repeat of 11/5 but started earlier, and obtained more than 3 hours of clean data. Results confirm 11/5. Pots did not reach boiling after 3 hrs.

Date	
Sky	
Test Item 1	
Test Item 2	
Findings	