Progress toward an ISO Standard for Solar Cooker Performance

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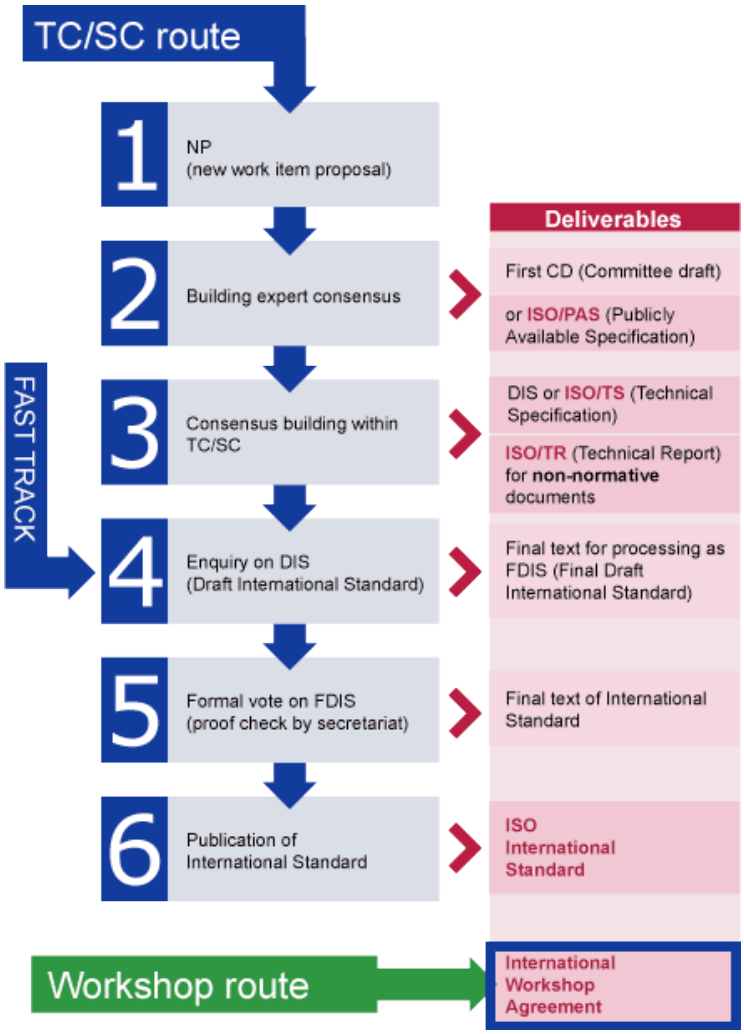
ISO, the International Organization for Standards, manages the development of international standards for all types of products, services and methods used by industry all over the world.

Starting in 2012, a new standard development process was launched for "Clean Cookstoves and Clean Cooking Solutions". It will provide a set of measurement protocols for consistent tests of **cooking power, efficiency, emissions, durability, safety and user acceptance** of all types of household-scale devices used for cooking food or heating water. This includes solar cookers.

Over 30 countries are involved in the development of this standard, including Bangladesh, Bolivia, Burundi, Cambodia, China, D.R. Congo, Ethiopia, Egypt, Germany, Gambia, Ghana, Guatemala, India, Kenya, Malawi, Nepal, Nigeria, Peru, Rwanda, South Africa, Tanzania, Uganda, and the USA. The photo shows the delegates who met in Ghana in October 2015.

Among the many delegates are a few solar cooker experts who have volunteered to help in the standard development; this includes Dr. Paul Funk, Catlin Powers of One Earth Designs, Inc., and Paul Arveson of Solar Household Energy, Inc. Pat McArdle is an observer.

The ISO standard development process has several stages, as shown below. For this standard, the work has been divided into four working groups (WGs): 1-Conceptual framework; 2-Lab testing; 3-Field testing; 4-User impacts.



Work since 2012 has included two plenary conferences (the first in Nairobi, Kenya in 2014 attended by Paul Funk, and the second in Accra, Ghana in 2015 attended by Paul Arveson). Between these conferences, frequent, sometimes weekly online meetings of delegates have been held to propose and comment on the language of the draft documents.

Currently the Lab Testing and Field Testing WGs are entering the Committee Draft phase of the process.

There are no emissions from solar cookers, so they are exempted from the emissions protocols. They are also exempted from the safety protocol for combustion cookstoves. There is a general durability protocol that applies to all types of cookstoves.

We have been successful in getting a solar cooker power protocol included in these Committee Drafts: ASABE (American Society of Agricultural and Biological Engineers) S580.1 [1]. Tests performed using this protocol were reported at the Clean Cooking Forum 2015 in Ghana. But much more work remains to be done.

Requirements for the Solar Cooker Power Standard:
1. Must conform to ISO definitions and is not excluded or "marginalized" as an exception.
2. Accommodates all types and sizes of solar cookers.
3. Yields repeatable and reproducible power measurements (in Watts).
4. Testing is relatively easy to learn and use.
5. Testing can be supported by low-cost instrumentation.

The ASABE S580.1 protocol meets requirements 1 and 2. Experimental studies have been conducted intensively over the past year to establish repeatability of the protocol [2]. Repeatability is essential if the results are to be useful in making comparisons between different designs.

Power Measurements of Solar Cookers

The protocol requires the following physical measurements to be collected as a function of time:

1. Solar irradiance
2. Wind speed
3. Ambient temperature
4. Internal temperature in the cooking vessel

1. Solar Irradiance Measurement Requirement

For many solar energy applications (such as photovoltaic panel installations), the prescribed measurement is Global Horizontal Irradiance (GHI), which is equivalent to the power on a 1 square meter horizontal surface.

The ASABE S580.1 protocol calls for measurements of Tilted Normal Irradiance (TNI), by tilting the sensor to point toward the sun. The resulting data is a "hybrid": the instrument is pointed directly in the sun direction, but it uses a sensor with a wide-angle cosine response. This requirement in the standard is a brilliant idea. It is more appropriate than GHI, because it is aimed toward the incident radiation, as a solar cooker would do. But it has a wide acceptance angle, as is typical for box and panel-type solar cookers. Therefore this protocol is more likely to represent the actual radiation that is collected in solar cookers of all types. (TNI values above and below certain levels are excluded from the power measurements.)

2. Wind speed measurement requirement
An anemometer is used to measure wind speed, and in this case the anemometer must be located near the solar cookers being tested. Power measurements above a specified wind are excluded from the measurements.

3. Ambient temperature measurement requirement
Power calculations in the standard are based on the difference between internal vessel temperature and the ambient temperature in the vicinity of the solar cookers being tested.

4. Internal cooking vessel measurement requirement
A load of 7 liters of water per square meter of reflector area (normal to the sun direction) is specified. The internal temperature of the load is measured at 10-minute intervals. (It is recommended that measurements will be made on at least two copies of the test item at the same time. This will provide a check on the repeatability of the measurements under the same solar conditions).

Other Instrumentation requirements

Data loggers:
To collect the data from the various sensors, programmable digital data loggers are required. The data loggers must have sufficient voltage range to accommodate the sensor signals, and digital resolution better than the accuracy of the sensors.

Measurement platform:

Panel and box-type solar cookers should be mounted on a platform that will allow the user to adjust the tilt angle of the base. This is necessary to allow the system to maintain similar sun angles depending on the latitude of the test location. Also, each cooker reflector must be allowed to rotate at specified intervals to track the sun. For typical box or panel cookers, the cooker is turned once per hour; however, the manufacturer may specify a different interval and angle.

These requirements lead to a platform that has three parts: a) the base on which the whole platform is supported; b) the tilt platform with a tilt angle indicator; c) the rotating platform, on which the test item is placed; this platform has a horizontal angle indicator.

The Prototype Measurement System

Notice that there are two solar cookers under test. Two or more items may be measured at one time in order to check repeatability and increase productivity. This system can actually measure up to four cookers at one time. (The test platforms were not constructed at the time of this photo.)

The white "Stevenson box" has a pyranometer and the anemometer attached to the top, and contains the electronics package. A small solar PV panel is also deployed to provide power to the anemometer and powered pyranometer.

Measurement Accuracy and Precision Requirements

Analysis of the power calculation in the ASABE S580.1 standard shows that the accuracy of the final power measurement is directly dependent on the accuracies of the solar irradiance and temperature sensors. Hence the instruments making these measurements must have deviations in accuracy and precision that are smaller than those expected due to random variations in the solar cooker tests.

Over 30 experiments were conducted with the prototype system on clear days in 2016 to determine repeatability and to conduct comparison studies of various solar cooker designs. This experience will enable several improvements in the next generation of the system, which is being developed in a partnership between Solar Cookers International and Solar Household Energy, Inc.

Conclusions

Delegates from many countries are participating in the development of an international standard for cookstoves, including solar cookers.

The standard power protocol prescribes testing requirements which are currently being implemented to conform to the anticipated ISO standard. In 2016, a prototype system was assembled to collect heating curves and power measurements on many designs of solar cookers. Increased experience with this system will allow us to determine its repeatability and reproducibility.

The solar cooking community has an exciting window of opportunity in the development of this ISO standard. Having such a standard will achieve many desirable goals:

- It will raise the quality and performance of solar cookers by establishing a level playing field for everyone to define performance in the same way.
- It will raise the credibility of solar cooking as a viable option to complement other types of cookstoves in locations where the climate is suitable.
- It will encourage the manufacturing and distribution of solar cookstoves and thus unleash the many benefits of this technology to the world.

References

1. American Society of Agricultural and Biological Engineers, “Testing and Reporting Solar Cooker Performance”, ASABE S580.1. (Nov. 2013)

2. Arveson, P. “Towards an International Standard for Measuring Solar Cooker Performance”, *J. of the Washington Academy of Sciences*, v. 102, no. 3. (Fall 2016)