**THE SOLAR COOKING AMBASSADOR PROGRAM IN OAXACA, MEXICO: 5-YEAR EVALUATION  
  
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**Abstract**:   
The five-year evaluation of the solar cooker “ambassador program” in Oaxaca, Mexico, aims to assess project success in terms of adoption, impact and customer satisfaction; to build the global evidence base for long-term use of inexpensive panel-type solar cookers; and to draw lessons learned to inform similar projects worldwide and further project goals including program financial sustainability.   
Solar Household Energy promoted solar cooking in rural communities of Oaxaca, Mexico, where women cook predominantly with fuelwood. SHE Field Project Manager Lorena Harp trained local women “ambassadors” to sell subsidized solar cookers to fellow community members and provide customer training and support. Since 2018, over 750 solar cookers have been sold or donated in Oaxaca, often in partnership with local organizations, with ambassadors educating thousands of people.   
Our December 2022 surveys showed good adoption with the average user solar cooking 2.8 days per week, liking their solar cooker, cooking a wide variety of foods, reporting good SC condition with an average age of 4 years, good impressions on fuel savings, solar cooking high-carbon foods, health benefits, and satisfaction with training and support.   
This program showed success in ensuring long-term adoption, impact and satisfaction. This five-year evaluation helped identify subgroups more likely to have higher usage, and showed that solar cookers are valued and durable. Lessons learned can be applied to improve methods in order to grow the program sustainably to its full potential.   
  
**Keywords:** adoption, impact, long-term evaluation, Haines solar cookers, HotPot, Mexico, usage frequency, fuel savings, health, subsidized sales, value, versatility

**I. INTRODUCTION**  
  
Solar Household Energy, Inc. is a non-profit based in Washington, DC, whose mission is to promote solar cooking for human development and environmental relief in sun-rich, fuel-poor areas of the world. SHE first became engaged in promoting solar cooking in Mexico in 1998 when the HotPot (HP), a panel design solar cooker, was developed by SHE in collaboration with the Mexican Fund for the Conservation of Nature (MFCN) and the Florida Solar Energy Center. Since then, over 20,000 HotPots have been distributed in Mexico by the MFCN.   
SHE has also been collaborating with Lorena Harp, a solar cooking expert based in Oaxaca de Juarez, to promote solar cooking in small rural Oaxacan communities, starting with the HotPot solar cooker in 2004, and adding two models by Haines Solar Cookers LLC in 2017. All three models are panel reflector solar cookers that come with specialized pots.   
SHE contracted Lorena in 2017 to manage the ambassador program in rural Oaxacan communities, including carrying out baseline and market research, and running an ambassador-led enterprise to sell subsidized solar cookers and evaluate adoption and impact. Community baseline survey results from 22 women in seven low-income rural communities in 2017 showed that the average household burned 180 kg of wood and 49 kg of agricultural residue per month, spending 12 hours to collect it, and spent $5 on gas and $5 on charcoal from an average monthly income of $118 per month. Lorena then recruited, trained, and managed “solar cooking ambassadors,” low-income women who promote and sell Haines solar cookers on commission, and then teach and provide customer service to their fellow community members. Since sales kicked off in 2018, over ten ambassadors have been trained and hired, over 750 solar cookers have been donated or sold, and thousands have been educated in solar cooking through workshops and other events. This was sometimes carried out in partnership with local organizations, who also sometimes donated solar cookers.  
  
**II. METHODS**  
  
In December 2022, 43 randomly selected program participants were interviewed, mostly over the phone, with the purposes of evaluating the adoption and impact of solar cookers for each model; project assessment; and documenting the challenges and benefits of solar cooking from user feedback. Adoption indicators were solar cooker usage frequency, acceptance appraisal, cooking versatility, and equipment condition and durability. Impact indicators were fuel savings and health improvements. Survey questions included satisfaction with training and support, and suggestions for improvement.   
  
**III. RESULTS  
  
A. Demographics**   
  
1) Location  
The 43 survey participants lived in 18 communities in eight districts and three regions of the Mexican state of Oaxaca. 36 of them live in 17 communities in 7 districts in the “Valles Centrales” and “Sierra Norte” regions within two hours’ drive of the city of Oaxaca de Juarez where Lorena lives. In each of these 17 communities live one to three users, except for two of the poorest communities in the Zaachila district where 15 users live. Seven users live in the more distant Asuncion Ixtaltepec community/municipality in the Juchitan district in the Istmo (isthmus) region where Lorena provided solar cookers to victims of the 2017 earthquake.

|  |  |  |
| --- | --- | --- |
| **Fuel type** | **Number of users** | **% users** |
| Only gas | 7 | 16 |
| Mostly gas | 11 | 26 |
| Gas & wood/charcoal | 16 | 37 |
| Mostly wood/charcoal | 8 | 19 |
| Only wood/charcoal | 1 | 2 |
| **Total users** | **43** | **100** |

2) Fuel types  
Cooking fuel types were recorded as either gas or fuelwood/charcoal. Other than solar cooking, most users cooked with a mix of fuels, with 18 (42%) using only or mostly gas, and the rest (58%) using fuelwood or charcoal at least half the time (see left-hand table).

3) Solar cooker acquisition  
These 43 participants had acquired 61 solar cookers, with 12 participants acquiring 2 SC, and three participants acquiring three solar cookers. Five HotPots were acquired between 2007 and 2011, 33 SC in 2018 (19 HSC1, 13 HP, 1 HSC2), and 23 SC in the next four years due to a slowing of activities during the COVID-19 pandemic. As HotPot and HSC1 acquisitions decreased after 2018, HSC2 acquisitions increased, with four out of eight HSC2 sold in 2022.   
Acquisitions included 36 sales and 25 donations. Slightly more Haines solar cookers were sold (23 of 42) than donated (18), whereas most HotPots were donated (18 of 20).

**B. Adoption indicators**  
1) Solar cooker retention   
At the time of survey, 40 participants (93% of them) still had in their possession 53 SC. Owners of three 2018 HSC1 solar cookers (5% of SC) no longer had one in their possession, two due to quality issues and one due to participant dissatisfaction. Four HSC1 were gifted to relatives by participants already owning one or two SC, and 1 HP burned down in a house fire. Also excluded from usage measurements below are two participants who had never used their solar cooker: one who had lent hers out before ever using it, and one who feared for her dogs, resulting in 38 solar cooker users and 51 SC.  
  
2) Value impressions  
When asked whether they liked the solar cooker, all participants answered either “yes” or “very much.” None regretted buying the solar cooker. When asked whether they would want to buy another solar cooker, 79% said yes, three said maybe, and six said no – one because she already had two solar cookers. When asked about whether their family likes the solar cooker, 84% said “yes,” five said it was all the same to their family, one said “yes and no,” due to (baseless) fears of higher exposure to radiation and its long-term health effects. Comments regarding family impressions, and additional final comments regarding personal adoption are tabulated below.

|  |  |
| --- | --- |
| **Family reaction** | **Number of comments** |
| Like/surprised by SC capabilities | 14 |
| Good taste of SC foods | 11 |
| Family members use SC independently | 10 |
| They make/sell new dishes (cakes, jams) thanks to SC | 5 |
| Family members/friends have bought or want to buy SC | 4 |
| Fuel and financial savings | 3 |
| Other positive (good for picnics, ease of use, health) | 7 |
| Other negative (fear of radiation) | 1 |
| **Total comments** | **52** |

|  |  |
| --- | --- |
| **Comments on personal adoption** | **Number of comments** |
| Great tool/thank you | 4 |
| Take to work/vacation | 3 |
| Life issues (hospitalization, etc…) prevented me | 2 |
| Prefer HSC to HP | 2 |
| Other | 8 |
| **Total** | **19** |

In the “other” category, comments included that it is a connection to light and creativity, that the participant uses it for everything, even drying rags, that it is simply a matter of willpower, that people find the solar cookers too slow, that it saves cooking labor time, that it’s important to start cooking early, that the participant has to use it on her rooftop, that high winds reduce usage, that people stopped using their solar cookers during the pandemic, that the participant can only use it on weekends but enjoys doing so very much, and that the participant is seeking support from the government for solar hot water heaters to continue taking advantage of the sun and save money.

3) Solar cooker versatility  
Uses were asked which foods they cooked most often. The solar cookers were found to have high versatility, with participants listing 55 different dishes spanning a wide variety of foods: meats, eggs, breads, cakes and other desserts, beans and other legumes, grains, starches, seeds, vegetables, and more. The 2018 baseline survey showed that most users did not have a way to bake cakes or breads prior to receiving their solar cookers, as they had no ovens. Thus, the solar cooker is very much appreciated for its ability to prepare baked foods. Solar cookers were also used for toasting seeds and dehydrating foods, and also heating water for baths. When asked why they chose these foods to solar cook, most spoke of fuel savings and good taste. Some said it was easier to use since they could leave it at home unsupervised, saving time and labor, some said it allowed them to bake breads, dehydrate, toast without burning, bain-marie ingredients, etc.  
  
4) Solar cooking frequency  
*a) Overall average frequency*For these 38 users, the average solar cooking frequency per user in the sunny season was 2.8 days per week (previous studies showed that usage in the cloudy season decreased by less than half). However, true overall usage may be higher, as many users commented that they used it several times per day, used multiple solar cookers per day, (both situations were reported as solar cooking one day per week), that they shared their solar cooker with family members, or that they had used their solar cooker(s) more often previously, due to life events (moving, hospitalization), seasonal weather changes, or deteriorating solar cooker condition.

*b) Owning single vs. multiple solar cookers*   
For users with a single solar cooker, the average usage was 2.2 days per week: 2.0 days/week for 13 HSC1 users, 2.5 days/week for 4 HSC2 users, and 2.4 days/week for 9 HP users. For those with multiple solar cookers, it was 4.1 days per week. This may be due to experienced users acquiring additional solar cookers, or additional solar cookers encouraging users to cook more often.

|  |  |  |  |
| --- | --- | --- | --- |
| Sold vs. donated | Sold SC | Both SC | Donated SC |
| Average usage dy/wk | 3.6 | 3.0 | 2.4 |
| Number SC | 8 | 9 | 21 |

*c) Sold vs donated solar cookers*As seen in the right-hand table, average usage is higher for users who purchased their solar cookers. This suggests participants who purchased their solar cookers are more likely to use them, perhaps because their conditions were more conducive to higher usage, and because buyers were more motivated to recoup their investment.

No correlation was found between fuel type and solar cooking frequency.   
  
5) Solar cooker condition  
Users were asked to describe the condition of their solar cooker(s). A rating system from the UN Clean Cooking Alliance report “A recipe for adoption and impact indices” was applied. 37 out of 55 SC still owned (67%) were in good condition. Results are displayed below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Condition** | **SC model  Rating** | **HSC1** | **HSC2** | **HP** | **Total SC** | **% owned SC** |
| **Destroyed or in disuse** (rusted pot, burnt in fire) | **1** | 2 | 0 | 2 | **4** | **7** |
| **With modifications that alter its functionality** (eg: slower cooking, heavy damage to parts, functions) | **2** | 3 | 0 | 1 | **4** | **7** |
| **With modifications that do not alter its functionality** (regular wear and tear – dull reflectors, cloudy polycarbonates, small parts lost) | **3** | 7 | 2 | 1 | **10** | **18** |
| **Good conditions with low maintenance** (light wear and tear, small parts (paper clips) replaced) | **4** | 5 | 0 | 1 | **6** | **11** |
| **Good conditions with good maintenance** (always stored after use, new condition) | **5** | 11 | 5 | 15 | **31** | **56** |
| **Lent/Gifted** | **N/A** | 5 | 1 | 0 | **6** | **N/A** |
|  | **Total SC** | **33** | **8** | **20** | **61** | **100** |
|  | **Avg rating** | **3.71** | **4.43** | **4.30** |  |  |

It is difficult to draw conclusions about durability of any particular solar cooker model, as there are several factors that may affect solar cooker condition. Condition generally degrades with age and usage, but this is mitigated by good maintenance, and for the HSC1, higher-quality versions improved upon previous versions’ weaknesses thanks to iterative design development by Haines LLC. Indeed, there was a weak correlation (0.26) between solar cooker condition and the year it was received for the HSC1, but comments suggest this has more to do with improvements in the HSC1 over the years such as replacing string with Velcro, brass fasteners with snap buttons, or scratchable non-stick pots with stainless steel pots. Two out of three solar cookers rated 1 for destroyed had non-stick pots whose coating had rusted and were from the first batch of Haines solar cookers distributed in 2018. Many of the 2018 pots were later replaced.  
   
**B. Impact indicators**  
1) Fuel savings  
In terms of fuel savings, 36 out of 38 users (95%) who used their solar cookers were “impressed” or “very impressed” with fuel savings, of both gas and fuelwood/charcoal. No correlation was found between fuel savings and solar cooking frequency. Participant 11, who said she uses mostly firewood but some gas, said her gas tank now lasts almost twice as long: “Mi tambo de gas me duraba antes 2 ó 3 meses, ahora me dura 4 meses.”

2) Carbon impact of food choices  
As mentioned earlier, users cooked a wide variety of dishes in their solar cooker. Categorizing these into food groups, we have, in decreasing number of mentions, meats (56 times), desserts (41), legumes (40), starches/grains (39), and vegetables (27). Meats and legumes are mentioned 96 times out of 203 foods mentioned, or around half. As a rule of thumb, meats and beans take more energy to cook than starches, vegetables and desserts, as the former are traditionally simmered in large pots on wood fires for hours. This implies more carbon emissions are avoided and suggests that the carbon impact of solar cooking is higher than that expected from frequency of use alone.

3) Health impacts  
In terms of health impact, 27 out of 38 users (71%) noticed one or more changes in their health or that of their family since they started using the solar cooker. There was a strong correlation (Pearson CC = 0.62) between health impacts and solar cooking frequency. Most comments related to using less oil and fat when cooking with the solar cooker, as recommended by participants’ doctors to lower cholesterol levels.

**D. User support assessment and suggestions**

1) Satisfaction with trainingUsers were asked if they were satisfied with the training and support they received. All 43 participants said yes, and 24 also provided comments. Ten users commented that they know how to use it well, although some reported having learning difficulties at the beginning. Three users commented that they are still learning to use it on their own. Four users commented they would appreciate more support.  
  
2) Suggestions for additional support  
Users were asked for suggestions on future support to improve solar cooker usage. All users provided comments. The most common suggestion was more workshops, mostly for general sharing of recipes and experiences (mentioned 23 times), but also specific topics (12 times) like making ointments and desserts. In terms of equipment or materials for the solar cooker, the most common suggestion was pastry molds (11 times), a recipe booklet (9 times), a new or bigger solar cooker (9 times), replacement parts (8 times), a cover from the dust (4 times), and six mentions of other items.  
  
3) Comments on solar cooking promotion  
Users were asked if they had any final comments or questions. Lorena Harp also wrote down relevant information she knew about the users. Most of the information from these comments is incorporated into the pertinent sections above. Additional topics included comments on encouraging the promotion of solar cookers in schools (3 times), hope that it spreads to other communities (3 times), ambassadors’ difficulties in selling (3 times), and interest in being ambassadors (2 times).

**IV. Discussion**  
1) Summary   
In small rural communities in Oaxaca, women cook predominantly with fuelwood, as was seen in the 2017 baseline survey, and in this 2022 survey showing 58% of users use wood or charcoal for half or more of their fuel needs (excluding solar cooking). Between 2007 and 2022, the 43 survey participants had acquired 61 SC. At the time of the survey, 88% of users solar cooked regularly, and 95% of solar cookers were still in use, or lent or gifted to friends. All users liked their solar cooker, with no purchase regrets; 79% wanted to buy another; 84% reported their family liked the solar cooker. Solar cookers were found to have high versatility, not only in cooking and baking 55 dishes from all food groups, but in toasting and dehydrating foods, drying items, and heating bath water. The average user reported solar cooking 2.8 days per week. However, actual solar cooker usage, in times per week, for all its users, borrowers included, is probably higher. Higher solar cooking frequencies were found for those owning multiple solar cookers (4.1 days/week), and those who purchased their solar cookers (3.6 days per week). A few comments provided explanations for lower usage, such as damaged solar cookers, working away from home, high-wind areas, or changes in life circumstances. 67% of solar cookers were in good condition, with an average age of 4 years. The condition of the HSC1 was mildly correlated with age, as iterative design development of the HSC1 led to more durable versions with each distribution. 95% of users were impressed or very impressed with fuel savings, and nearly half of reported solar cooked foods were meats and legumes that are traditionally cooked for long periods over wood fires, increasing carbon impact. 71% noticed one or more health changes since they started solar cooking. All users said they were satisfied with training and support. Suggestions for future support included more workshops for sharing knowledge, and accessories such as pastry molds, recipe booklets, etc. Final comments showed interest in promoting solar cookers in schools, other communities, and in becoming ambassadors.  
Solar cookers were highly valued for ease of use, good taste, baking capabilities, fuel savings, positive health impacts, and more. Solar cookers were found to have high versatility, but not all users are necessarily aware of their many different uses.

2) Recommendations  
In the future, we should direct marketing, sales or donations to high-usage groups, such as stay-at-home cooks, who already have one solar cooker they appreciate. We can also take the users’ recommendations to heart. We can organize more workshops, so that users can share recipes, tips and tricks, like how to toast seeds, stabilize solar cookers in the wind, or solar cook while you’re away at work. We can also make sure that replacement parts, and accessories like pastry molds, are made available. We are currently working on creating an improved user manual with local recipes. Finally, we can improve reporting methods for more accurate future evaluations.  
  
3) Challenges and ideas to explore  
There are some challenges to implementing some of these recommendations. Ambassadors need to be paid to organize and lead workshops. To reduce costs, we could explore the use of virtual self-paced video training courses, or help users form self-help groups, or focus our efforts on one community.  
Haines is developing two new models of solar cookers that we hope will solve some user issues. The new Haines 2 is more affordable, easier to assemble, and comes with heat-retention capabilities with added towels.   
We could also look into buy-back programs for the few who no longer use their solar cookers due to changing life circumstances, for resale or donation.  
These past 5 years of the solar cooking ambassador program has taught us many lessons, and we are still learning. We hope to continue improving our processes and products to one day build a financially sustainable social enterprise, capable of rapid growth so we can bring the benefits of solar cooking to all the people of Oaxaca and beyond.

**REFERENCES**  
  
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