OVERCOMING HURDLES TO SOLAR COOKING DIFFUSION BY DESIGNING FOR DIVERSITY OF LIVING STANDARDS

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Abstract: Solar cooking technology has been around for the better part of a century. However, there are several challenges to its introduction as a viable complement or alternative to fuel-based cooking. When reviewing the outcomes of several projects we see that durability and price has been an issue. Other issues include the failure to provide adequate training, design for cultural compatibility and setting of appropriate expectations. Solar cooking also has an image of being a "product for the poor" or (especially in developed countries) a product for eccentric environmentalists and preppers. Multiple hurdles must be overcome if the technology is to be consistently implemented long-term.

Building on the living standards model developed by Hans Rosling, we challenge the traditional approach. We propose that a solar cooker or introduction project that intends to be successful over the long term must account for the needs at all levels of living standards.

This approach to solar cooker design and introduction accounts for the dynamic nature of societies and the living situations of the people within them. We build on the diffusion of innovation theory proposed by Everett Roger, stating that people tend to follow opinion leaders. How and when opinion leaders take on an innovation can determine how quickly it spreads in a community.

Our hypothesis is that this approach can result in a more positive image of solar cooking, ensure a broader acceptance of the technology, establish the tangible and intangible infrastructures needed to ensure permanent implementation of the technology and increase the success rate of humanitarian initiatives involving solar cookers.

Although we see several advantages with this approach, we still have to be aware of the usual challenges that appear when introducing new technology. Some of these challenges are cultural, while others are more practical. Nevertheless, we will offer suggestions for dealing with them.

Keywords: Solar Cooking, Diffusion

1 INTRODUCTION

Solar cooking technology har been around for the better part of a century. It meets several of the Sustainable Development Goals (SDG) from United Nations. In combination with other fuel-efficient cooking methods it has a clear-cut role in reducing our environmental footprint.

These advantages have prompted individuals, NGOs and businesses to dedicate considerable time and resources to the promotion and distribution of solar cooking technology. According to Solar Cookers International (SCI), several hundred NGOs have promoted solar cooking in different ways over the past decades. Furthermore, more than 3.3 million units have been distributed around the world[1].

Despite these initiatives, it is difficult to find exemplary cases of successful long-term adoption of solar cooking technology in communities around the world. Neither are they actively encouraged by politicians [1]. This is especially noticeable in rural parts of the global south where most of pro-solar cooking NGOs have executed their initiatives. Why is this the case?

In this paper, we will therefore try to identify which of these scenarios is the most likely explanation for the striking paucity of exemplary cases. We will then propose a process for designing and running solar cooking distribution projects that may address the shortcomings of previous initiatives. In so doing, we wish to invite other members of the solar cooking community to build on our work.

2 OBSTACLES TO SOLAR COOKING DIFFUSION

To better understand the nature of the obstacles facing the adoption of solar cooking technology, we conducted a brief literature review. We looked for documentation regarding the long-term adoption of the technology and possible indicators that could help assess the likelihood of success or failure.

We have define long-term adoption to mean:

- Regular use of the technology in a household situation as opposed to research centers or by outliers and enthusiasts
- Use in normal/everyday situations as opposed to extreme situations (disasters, refugee camps, etc.)
- The technology is in continued use after the closure/exit of the original initiative
- The technology is diffused organically into the society after the closure/exit of the original initiative

This definition implies that we will go beyond indicators such as the frequency of solar cookers distributed. After all, such an indicator tells us nothing about the sustainability of the initiative - or whether the solar cookers are still in use. After all, if the solar cookers are no longer in use, the distribution would have essentially been a waste of resources.

We chose Solar Cookers International's (SCI) wiki as the starting point for our research, since they are the largest organisation for solar cooking worldwide.

Ultimately, the data we found indicated that the obstacles to solar cooking adoption are more complex than a single, simple explanation can address. Rather there exists a combination of issues that together create obstacles to long-term adoption.

These issues can be boiled down to:

- Paucity of quality data that is both relevant and current
- Short-termism and lack of financial sustainability in the initiative's design
- Ineffective communication strategies
- Failure to consider and integrate local needs, culture and perspectives into the initiative's strategy
- Underuse of available leverage (influencers, gatekeepers, local ideology/religion, etc.) in initiatives

2.1 Observation 1- Paucity of quality data that is both relevant and current

One of the first things one notices about solar cooking is the difficulty of finding papers, research and documentation at the academic level. At the time of writing this paper, a search in the Directory of Open Access Journals[2] for the exact term "solar cooking" yielded only 5 papers. The same search in the Biefeld Academic Search Engine[3] yielded 224

[1] https://www.solarcookers.org/about/blog/33-million-solar-cookers-and-counting

[2] https://doaj.org

[3] https://www.base-search.net

hits. A search using Google scholar[4] yielded more results at 3740 hits reaching back to 1959 (though it should be noted that a number of these are likely duplicate hits). For a technology that has existed since at least the 1950s, these are strikingly low numbers!

The wiki maintained by SCI[5] presents 38 evaluation reports of solar cooking technology and its distribution. What stands out about this data is that a large amount is not current. Of the 38 evaluation reports, only 34% (13 reports) are from within the last 10 years. Some of the organisations mentioned are no longer active or no longer working with solar cooking technology.

The wiki has also gathered 16 "most significant solar cooking projects" [2]. Out of these 16, only 12.5% (2) specifically address the use of solar cookers in a household [3, 4]. The rest deal with solar cooking within the contexts of natural disasters, refugee camps and general distribution projects.

Several of the listed projects focus on their work distributing solar cooking technology, but lack systematic evaluation and follow-up studies that could be used to assess the project's efficacy. Lacking such an evaluation or follow-up does not seem to be unique to the projects listed on the SCI wiki. The same observation is echoed by Iessa a. o. [5], in a report that examines 32 solar cooking projects in sub-Saharan Africa. The author observes that "many articles show a prosolution bias and there is a lack of methodologically sound impact studies."

2.2 Observation 2 - Short-termism and lack of financial sustainability in the initiative's design

The vast majority of the projects listed on the SCI wiki are funded through donations, grants or a combination of the two. Several of these projects have used the lion's share of their funds to distribute solar cookers to the community for free, not requiring anything in return. This meant that there wasn't enough funding for replacement units or repairs. As a result they returned to the initiative when their unit broke or reached end-of-life, expecting to get another unit for free, only to be turned down. (Information received by author from email conversation.)

In addition to an inadequate budget, these projects failed to provide the recipients of the solar cooking technology with adequate training to repair or reproduce their units [5]. Much as in the previous scenario, this risks the abandonment of the donated technology. Such an outcome is both a waste of resources and undermines the credibility of solar cooking more generally.

In contrast to the previous examples, some of the most successful projects in the wiki have operated as social enterprises , even if one of them was partially dependant on donations [6]. One of these was a restaurant. Another successful program was an institutional kitchen in India serving 50 000 people per day. Unfortunately, the company is no longer in business. One organisation have moved away from solar cooking and now focus more on improved efficiency stoves [5].

In spite of their current development, these three enterprises have still demonstrated distinct success over time. This implicates that sustainability of the project demands a sustainable financial strategy, such as that of a social business.

2.3 Observation 3 - Ineffective communication strategies

MacClansy J. [7] describes many of the obstacles of solar cooking. At the end of his report, he makes an interesting comment:

"There is, however, one last problem I wish to consider, and that is the image of solar cooking. For many people, though seemingly very poor and with few apparent options, still wish to hang on to their sense of personal dignity, no matter how constrained that might appear to us, affluent Westerners.

In rural Lesotho, many who consider buying a solar oven ask themselves, 'What do white people do?'

'Do I use a solar oven?', they ask."

Pia Otte [8] also observes that solar cooking among the poor is perceived as not being "cool":

"As this leads to an image of solar cooking as a technology for 'the poor'. It is not attractive to the intended target group (who do not want to be seen as poor). In this context, people will be disinterested in solar cookers because of the stigma associated with them. In short, solar cookers may prove unpopular if they are not regarded as a modern and fashionable product" [9]. The statements is used when referring to Narayanaswamy's handbook "Making most of the sunshine" [10] "India is a country blessed with sunshine and for India's poorer people, the solar cooker would be a godsend".

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[4] https://scholar.google.com

[5] https://solarcooking.fandom.com/wiki/Project_evaluations

In the material on solar cooking that attempts to convey its benefits, the focus often lies on technical features of the solar cooker itself and the specific benefits they may confer. It is as if the current communication style is predicated on the information deficit model (the idea that simply conveying or explaining facts will enable the audience to understand them). Until recently, STEM (Science, Technology, Engineering and Mathematics) subjects at universities in western countries have approached public communication from the basis of the deficit model [11, 12]. This might explain why the technical style is so common in initiatives run by those with a scientific, engineering or mathematical background.

The information deficit model is now regarded as outdated and fallacious, but it is still very persistent [13, 14]. To step away from the deficit model we need to become more open to local cultures and perspectives - both at home and abroad.

Perhaps the most critical takeaway here is what marketing expert Mark Earls refers to when he writes that "What people say to each other is less important than what they do."[15] We as solar cooks must embody the exemplary case before we can expect others to do so. With our actions, we send a message that may be stronger than any words or performance tests. In essence, we have to become the role models and promote solar cooking both abroad and at home.

2.4 Observation 4 - Failure to consider and integrate local needs, culture and perspectives into the initiative's strategy

Iessa a. o. [5] observes that "local needs are often not sufficiently considered" and "existing cooking and fuelwood practices are seen as obstacles." This echoes MacClansy [7] and Otte [9]. Like them, Iessa a. o. observes that

Some needs, such as the issue of cost do tend to be considered, but primarily from a scarcity mindset - that is, how can we make the product cheaper, so the poor can afford it. However, the affordability issue is often one of the easier ones to address - it takes some creative thinking and planning. Needs that are more affective, such as the need to maintain one's dignity or cultural values are more nebulous and may not be as readily addressed.

A failure to consider local needs. If the audience has traditionally always cooked indoors, it will be asking a lot to expect them to cook outside. If they have concerns that a solar cooker is less reliable than an improved cookstove [5, 16], those concerns can only be alleviated once we understand the audience's perspective.

Moving forward demands that we actively consider and integrate local needs, culture and perspectives into our initiative's strategy. This will prove challenging. We must open our minds to and learn to work with cultures, world views and values that are quite different and possibly even in conflict with our own. Fortunately, there are things we can do to make the process far easier, which brings us to the topic of opinion leaders, influencers, gatekeepers, ideology and religion.

2.5 Observation 5 - Underuse of social leverage

In every society there are people who hold formal and informal power. This is as true in a small rural community as it is in the workplace. Although the formal leaders hold the political power, the informal leaders have enough influence that they can sway which decisions are made and which ideas that are spread. Those who adopt new innovations early and are able to get the rest of the community to do the same are known as opinion leaders.

Some of the opinion leaders may not belong to the specific community, but are very visible on social media or in the regular media. They are known as influencers and are key to creating awareness and giving the new innovation credibility. They essentially "make it cool." In the solar cooking world, there are few such influencers, but they do exist. Two of them are Faustine "Mama Solar" Wama and Pierre-André Aubert in France.

Such influencers and opinion leaders can be leveraged to spread and lend credibility to new innovations and ideas. Some of the commercial solar cooking ventures, such as Gosun and One Earth Designs have been very good at leveraging influencers to increase their visibility. However, among the projects listed on the SCI wiki, these opinion leaders and influencers do not appear to have been used very much. We can do better!

3 WHAT CAN WE LEARN FROM OTHER DISCIPLINES: DIFFUSION OF INNOVATIONS

There exists a plethora of literature on how innovations spread. One of the most influential is Everett Rogers' diffusion of innovation theory. It emphasises the role of Opinion Leaders in the diffusion of innovations [17]. According to Rogers the S-shaped innovation adoption curve, see Fig 1, is partly defined by the time when opinion leaders adopt the innovation. The earlier they do it, the faster diffusion will take place. In Fig 1 we can see the area "take-off", which is at the time where opinion leaders adopts the innovation.

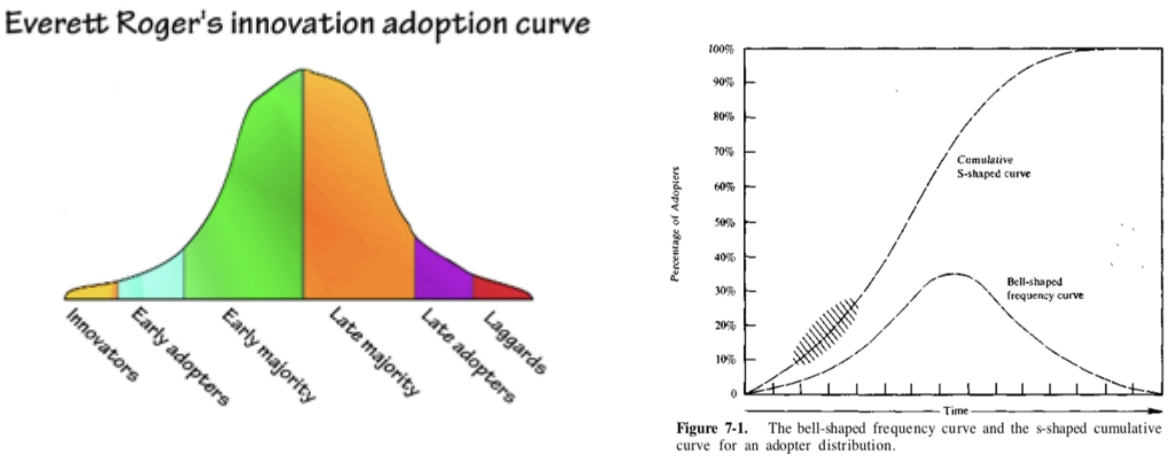

Figure 1. Diffusion is the process by which an *innovation* is *communicated* through certain *channels* over *time* among the members of a *social system.*

Some innovations will be adopted earlier than others, The "Take-Off" ("TIpping Point") is highly dependant on opinion leaders.

A "tipping point" is achieved where enough adopters exist that the diffusion speeds up [18]. This point is suggested to occur at 10-20 %, within the community [17]. This means it isn't necessary to reach every individual in a community to make an impact. Rather, it would be adequate to reach enough opinion leaders in a community to convince 10-20% of the community to adopt the innovation.

4 CONSIDERING A MORE HOLISTIC VIEW: MODELLING A SOCIETY

Over the years, we have used different labels for the "rich" and "poor" countries of the world. We have used the terms such as developed/undeveloped countries or Global South and Global North. The late Hans Rosling, Swedish professor of Global Health, taught us this is an outdated approach. He typically defines four levels of living standard [19] that we can find in almost every country. Each level is characterised by a particular income range that allows for a certain standard of living. How the population is distributed between these levels varies from country to country. In the below example the poorest live on less than 2 USD per day. However, the vast majority of the population is distributed between income levels 2 and 3, living on 2-8 USD and 8-32 USD per day respectively.

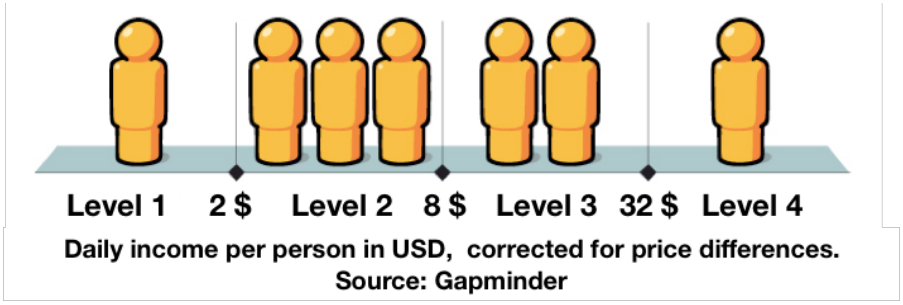

Figure 2. Population distribution over the four income levels.

Since these levels also exist in countries where solar cooking has the best chance of success, it is, indeed, a most useful model. If we want to address the image that "solar cooking is only for poor people" we need to consider and involve people at every living standard.
By doing so we also enlarge the market which will benefit every user regarding price, quality, accessibility etc.
We have chosen to use the four income levels described by Hans Rosling as the foundation of our societal model [19].

5 PROPOSED METHODOLOGY

Our proposed methodology incorporates Roslings four income levels into a social model that can be used to inform both project planning and product/solution design.

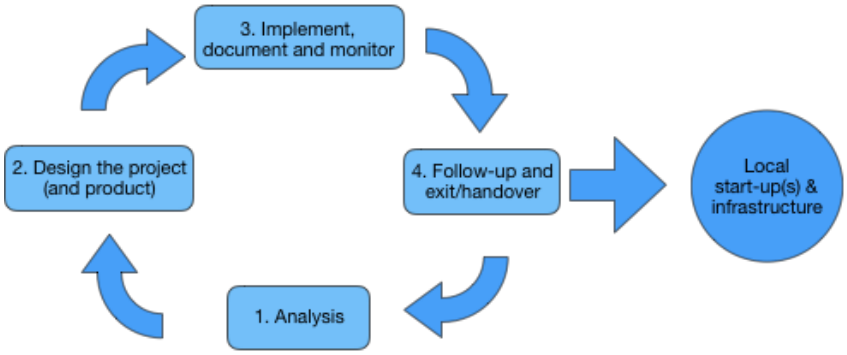

Figure 3. The project stages and its outcome

5.1 Stage 1 - Income Level Analysis

Any analysis will inform your planning and design process, but it is only as useful as the input. The Income Level Analysis identifies two key elements that make up the income level:

- Mobility between levels in the target community/country
- The affective and technical characteristics of each level in the target community/country

Define the levels and mobility

In most societies, it is possible to move between income levels. However, this can be done in different ways. In the below graphic, we can see that securing a job or starting a small business is a reliable way of moving from level 1 to level 2 in this society. Obtaining a tertiary education, such as a university degree makes people eligible for better-paid jobs in this society, giving them a pathway to the income level 3. Those who reach income level 4 in this society gain their wealth through investment in medium and large businesses.

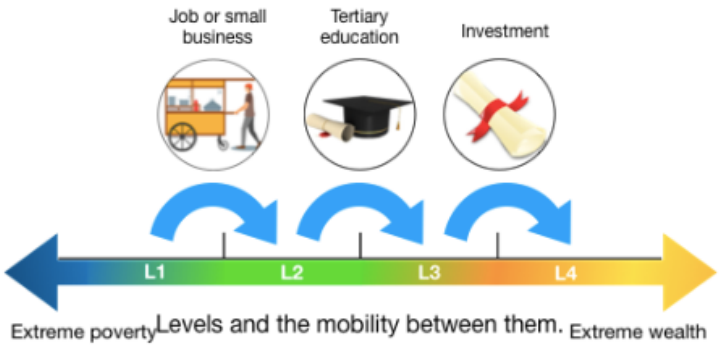

Figure 4. Moblity between income levels.

Technical and affective characteristics

According to Rosling, the living conditions and lifestyles within the same income levels are very similar across societies and countries. However, there are still cultural differences and local perspectives that we must understand before we can develop a project solution. To understand the culture and perspectives, we need to consider affective factors. These include what Otte [9] refers to as social factors, such as gender relations and motivations. For our analysis, it is also beneficial to consider influence pathways, traditions, religion and needs and desires. Of course, we still need to understand technical features of the income levels (average income, family size, education level, the local environment, climate, etc.).

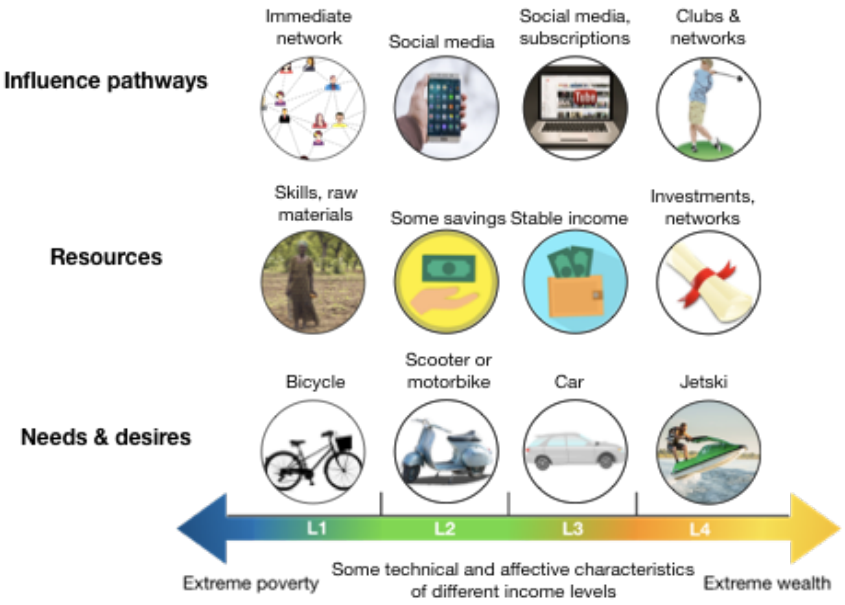

Figure 5. Some characteristics of the different income levels. There can be several more characteristics than these.

5.2 Stage 2 - Project planning and product development

Now that we have identified the key socioeconomic and cultural factors, we can develop a plan and a technical solution that is tailored to our target audience.
Providing specific project planning tools is outside the scope of this paper. There already exist many excellent methods and tools that are appropriate for project planning and product development. Some that are particularly human-centric include:

- User experience (UX) and user interface (UI) design
- Journey planning (eg. customer journey mapping)
- Stakeholder mapping
- Personas

These tools are designed to help create a positive experience and encourage happy customers to become product ambassadors. However, if you prefer a different set of tools, they are fine, too. The important thing is that your plan:

- Has an appropriate budget
- Defines its performance indicators
- Considers how the technology could be used by households at each income level
- Identifies design changes or upgrades that could make the technology attractive at all income levels
- Outline the team structure, including the local team members
- Accounts for the environmental features and climate of the target location
- Accounts for local cultural factors, audience needs and audience perspectives
- Considers the full lifecycle of any product you will (how do the users get the unit, what happens if it needs maintenance and how will it be managed at end-of-life)
- Contains an exit strategy

Use the results of your analysis to inform your planning and design process. Finally, remember to test the project plan in a made-up scenario to ensure you have a minimum viable product (MVP).

5.3 Stage 3 - Implementation, documentation and monitoring

Once the project plan is ready, it's time to bring it into the wild.
There are a few things that need to be achieved in this step:

- Test the MVP
- Validate your model
- Identify a viable value chain that includes both tangible and intangible infrastructure
- If it has not already been done - finalize the local team
- Connect with local key stakeholders, gatekeepers and influencers

If solar cookers are to be provided to the community a local value chain will be needed to provide service, parts, knowledge, etc. Tangible infrastructure implies physical resources like factories, transport services and roads. Intangi-

ble infrastructure implies non-physical resources, such as knowledge, connections and values. A sustainable value chain requires both.

Having the initial members of the local team ready when you arrive will save a lot of trouble. It will help you get started quickly. The local team will be in a better position to identify the local infrastructure that could make up a viable value chain for solar cooker production and distribution. By having your team involved from the very beginning, the exit or handover will be smoother and simpler when the time comes.

5.4 Stage 4 - Follow-up and exit/handover

The importance of documenting one's exit/handover can not be overstated. It helps ensure any lessons learned can be used to improve future projects. An well-organized handover/exit also reduces the chance of any negative environmental impacts resulting from scrap materials, trash or abandoned solar cookers.

There are many options for exit strategies. Some examples of an exit strategy could be:

- Complete handover of the project to a local team/stakeholder/business
- Partial handover of the project to a local team/stakeholder/business
- Winding up and closure of the project
- Pausing of the project

The authors encourage a handover process that involves the local team, stakeholder or business. Ideally, these team members would have been part of the project from the outset. Assuming the necessary knowledge has been transferred to the local team, the handover should require little more than winding down of activities, handing over resources and packing anything that is to be returned with the project organizer.

It should be possible to follow up on the local team's progress through email, chat or social media. They should continue to track the same performance indicators that were used in Step 3. This way, it will be possible to assess the long-term impact of the project.

6 LIMITATIONS OF THIS PAPER

This paper has limited itself to those cases presented on the SCI wiki - and only the ones available in English. Since other projects have been run - several of which were documented in languages other than English. There may thus be both successes and failures that we have not considered due to not being aware of them.

Furthermore, our methodology is at an early stage and needs to be further refined in the field. The authors of this paper wish to invite our fellow solar cooks to try out our concepts for themselves.

7 CONCLUSION

Solar cooking concerns everyone, because everyone has the potential to become a solar cook, though to varying degrees due to different conditions. Those of us who create technology also share a responsibility to set an example that influences how the rest of the world perceives it.

Both diffusion theory and contemporary marketing theory state that how the target audience perceives the technology is just as important to adoption as it's price or practical utility. What stands out is it's perceived return on investment, it's perceived relevance to the customer's needs and desires and the perceived impact on the customer's social status. Our hypothesis thus becomes that if solar cooking technology is perceived as "technology for poor people", this will create an obstacle to adoption as significant as that of an excessive price or legal barrier. Yet, this aspect appears to have been overlooked in several solar cooking diffusion projects, resulting in failure to secure adoption over the long term.

Numerous solutions to this dilemma have been proposed - improve the technology with thermal storage or hybrid technology and creative funding strategies. However, we propose a method for the full life of the distribution project that better accounts for these intangibles, has the potential to set realistic expectations and change unfounded negative preconceptions about the technology.

References

1. Krämer, Paul (2010) Why are solar cookers still unpopular among development experts. Journal of Engineering Science and Technology Vol. 5, 2010 No. 1, pp.75 - 84. Accessed from http://jestec.taylors.edu.my/Vol%205%20Issue%201%20March%2010/Vol_5_1_75-84_Kramer.pdf
2. SCI Wiki, https://solarcooking.fandom.com/wiki/Most_significant_solar_cooking_projects ADES – energy efficient cookers distributed 2001 – 2015. Found on https://vignette.wikia.nocookie.net/solarcooking/images/c/ce/ADES_cooker_output_2015.pdf/revision/latest?cb=20160805172230, 2019-12-08
3. Ten years with Energy Hunters of Nepal in Bamti Bhandar 2013. Found on https://vignette.wikia.nocookie.net/solarcooking/images/1/1f/Ten_years_with_Energy_Hunters_of_Nepal_in_Bamti_Bhandar_2013.pdf/revision/latest?cb=20131002192227, 2019-12-08.

4. Global GOLD: Alternative cooking technology, Namibia, found on http://archive.is/20121225183554/emugoldalumni.wordpress.com/2011/05/02/global-gold-alternative-cooking-technology
5. L. Ieasa, Y.A. De Vries, C.E. Swinkels, M. Smiths, C.A.A. Bujin. What's cooking? Unverified assumptions, overlooking of local needs and pro-solution biases in the solar cooking literature. Energy Research & Social Science, Elsevier, averrable at https://www.sciencedirect.com/science/article/pii/S2214629617301019.
6. Integrated Solar Cooking as a Social Business. SCK Webinar in August 2017. Available at youtube, https://www.youtube.com/watch?v=gw2VurmCF-U&feature=youtu.be&eType=EmailBlastContent&eId=ed19c766-b724-4446-b89e-b511eb2dac76 (2019-11-25).
7. MacClansy J. Solar cooking: why isn't it yet global? Earlier version of publication in: 'Food, culture and society' 17: 2 (2014)
8. Otte, Pia. What I learned from cooking with the sun. Tedx, available at youtube link:https://www.youtube.com/watch?v=ddjRSo8LSh4 (2019-11-25).
9. Pia Piroschka Otte. Solar cookers in developing countries—What is their key to success? Department of Sociology and Political Science, Norwegian University of Science and Technology (NTNU), EdvardBullsveg 1 Dragvoll, 7491Trondheim, Norway, Energy Policy 63 (2013), 375-381.
10. Narayanswamy S. Making the Most of Sunshine: A Handbook of Solar Energy for the Common Man. Sangam Books Ltd, 2001. Available 2019-12-08 at https://www.amazon.es/Making-Most-Sunshine-Handbook-Energy/dp/8125910867
11. Bauer, MW, Allum, N, Miller, S (2007) What can we learn from 25 years of PUS research? Liberating and widening the agenda. Public Understanding of Science 15(1): 1–17.
12. Akin, H., Scheufele D. A. (2017) Overview of the Science of Science Communication. In Jamieson, K. H., Kahan, D. and Scheufele, D. A. [eds] (2017) The Oxford Handbook of the Science of Science Communication. Oxford University Press: New York
13. Bauer, M. W. (2016) 'Results of the essay competition on the 'deficit concept'', Public Understanding of Science, 25(4), pp. 398–399. doi: 10.1177/096366251664065
14. Simis, M. J. et al. (2016) 'The lure of rationality: Why does the deficit model persist in science communication?', Public Understanding of Science, 25(4), pp. 400–414. doi: 10.1177/0963662516629749.
15. Earls, M. Herd, How to Change Mass Behaviour by Harnessing our True Nature, Wiley, ISBN: 978-0-470-74459-8
16. The Mekhe Solar Project in Senegal, UNDP/SGP. Empowering Women - One Community at a Time, Evaluation report,. Found on https://vignette.wikia.nocookie.net/solarcooking/images/4/4b/The_Mekhe_Solar_Cooker_-Case_Study-_Senegal_-_CC_2014.pdf/revision/latest?cb=20140624171928, 2019-12-08.
17. Rogers, M Everett. Diffusion of innovations (Third edition). The Free Press (New York 1983).
18. Gladwell, M. The Tipping Point, How Little Things Can Make a Big Difference, Gladwell, M. Back Bat Books, Little, Bown and Company, London, p 259
19. Rosling H. et al. Factfulness. Natur & Kultur, 2018. Available in several languages, gapminders.org.