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>Thermal Food Processing

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Conference Proceedings

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INSTITUTE OF ENGINEERING; UNIVERSITY OF ALGARVE
FARO,PORTUGAL

Editors

Thomas Fasquelle

Celestino Rodrigues Ruivo

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1-Introduction

Authors were invited to submit abstracts for consideration by the *Organizing Committee*. For each accepted abstract, the authors were invited to submit a full paper and a presentation file with audio recorded to be presented in CONSOLFOOD2025.
This document contains all of the *accepted* abstracts and full-length papers submitted for inclusion in CONSOLFOOD2025. It may be updated from time to time if papers are revised, or further full-length papers arising from submitted abstracts are received.
All of the submissions have been scrutinised by one or more members of the *Organizing and Scientific Committee*, but they have not necessarily been revised to accommodate suggestions made by the reviewers. Therefore, they should not necessarily be regarded as having been subjected to strict peer-review.

2-Getting further information

Authors may be contacted via the email address that appears under the title of each abstract or full-length paper. Where several email addresses appear, it is the convention that the name of the corresponding author bears an asterisk (*). If one name has an asterisk, please only contact that author.

3-Searching this document

All received papers and abstracts are listed in their order of presentation at Conference.

4-Copyright

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8-Abstracts and papers

Session 1A

CONSOLFOOD 2025 − International Conference on Advances in Solar Thermal Food Processing
Marseille-France, 5-7 May, 2025

SOLAR DRYING OF LOCAL FRUITS & VEGETABLES

Ménar Zahira Meebed

Meem for Drying and Packaging of Local Dried Fruits, Vegetables and Herbs, Minnie's Egypt, Phone: 002 011 1104 7555, Email: minnies.egypt@gmail.com

Abstract: Solar drying is a sustainable and cost-effective method for preserving fruits, vegetables, and other agricultural products, leveraging renewable solar energy to remove moisture and extend shelf life while maintaining nutritional value. This presentation will explore the fundamentals of solar drying of Egyptian agri-products. Attendees will gain insights into the advantages of solar drying of food, from its energy efficiency and affordability to its environmentally friendly nature. The discussion will cover the step-by-step process of solar drying, highlighting best practices for preparation, drying, and storage. Case studies, including Minnie's Dried Fruits and Vegetables, will illustrate real-world applications and successes. The session will also address common challenges faced in solar drying and propose innovative solutions to overcome them. Finally, the presentation will look to the future, examining the potential advancements in solar drying technology and its role in global food preservation strategies.

APPLICATION OF THERMOSOLAR TECHNOLOGIES FOR THE SUSTAINABLE PRODUCTION OF SAFE AND WHOLESOME FISHMEAL FROM TILAPIA RESIDUES.

Herrera-Aguayo, S., Castillo-Téllez, B., Castillo-Téllez, M., González-Pérez, J., Percino-Picazo, J., Martín del Campo-Solís, M.

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Abstract: Approximately 12% of the Mexican population suffers from nutritional deficiencies, including anemia, protein shortages, and imbalances in micronutrients. These issues are particularly severe in the country´s rural areas. This study evaluates thermosolar technologies—specifically, a panel-type stove and a mixed solar dryer—as alternative methods for utilizing Tilapia (Oreochromis sp.) residues to produce fishmeal. This approach is a sustainable strategy to promote food sovereignty in Mexican fishing communities. Producing fishmeal involves cooking and drying, which typically incurs high energy costs. However, by employing thermosolar technologies, these operational costs can be significantly reduced. Results indicate that the local meteorological conditions in Colotlán, Jalisco, are suitable for achieving the necessary temperatures for efficient and safe solar cooking and drying. The fishmeal produced had a final moisture content of 4.48 ± 2.81% and a water activity (a_w) of 0.52 ± 0.01, with no detectable pathogenic microorganisms, such as total coliforms or Salmonella spp., thereby complying with official Mexican food safety regulations. The proximate chemical profile of the thermosolar fishmeal revealed 44.45% crude protein, 9.14% ether extract, and 39.47 ± 1.73% ash content. This proposal highlights the potential of renewable energies in the agri-food industry, particularly in rural Mexican communities with limited access to conventional energy sources.

Keywords: Solar energy, solar thermal technologies, solar cooker, solar dryer, fishmeal, sustainability, food sovereignty.

COMPARISON OF ANTIOXIDANT ACTIVITY OF DEHYDRATED APPLE BY THREE DRYING TECHNIQUES

Quiroz-Martínez, R.[1], Gutierrez-Villegas, J.C.[1],

Castillo-Tellez, B.[2], Guzmán-Castañeda, G.[1]

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Abstract: Solar drying is a great option for food preservation because of its low cost, helps to prolong the life of the product, facilitates transportation and storage, and is friendly with the product and with the environment; however, it has some disadvantages such as the long process time, the risk of product contamination, dependence on the climate, and sometimes it can affect the properties of the substrate. Vacuum solar drying is an option to reduce the time and temperature of the process, thus achieving better conservation of nutrients. In this work, apple samples were dehydrated by three different techniques: conventional solar drying, vacuum solar drying, and drying in an electric oven. The temperature and drying times were monitored, the drying kinetics were obtained, and the antioxidant activity of the samples was determined by the ABTS method. For all three drying techniques, the moisture content was reduced to 7% on a wet basis. The samples obtained by vacuum solar drying had greater antioxidant activity than those obtained by electric oven, but less than those obtained by conventional solar drying.

Keywords: solar, vacuum solar drying, antioxidant activity.

Multifunctional Hybrid Solar Dehydrator design within the Framework of a Frugal Innovation Process

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Abstract: This paper focuses on the redesign and optimization of a multifunctional hybrid solar dehydrator, originally developed as a sustainable solution for drying Camellia leaves. Built with a geodesic dome structure, it provides strength, uniform heat distribution, and efficient airflow, maximizing drying performance. The system has been adapted for broader agro-industrial applications, such as drying fruits, vegetables, algae, beer bagasse, and whey, highlighting its versatility in food preservation and byproduct management.

The proposed redesign addresses limitations in energy efficiency, operational control, and adaptability to diverse climatic conditions. The new modular system allows concatenating drying modules to scale capacity based on user needs, with each module having a capacity of 40 kg of wet material. Advanced control mechanisms precisely regulate drying temperatures, optimizing the process to preserve organoleptic characteristics like texture, flavor, and aroma, ensuring superior quality.

To align with Sustainable Development Goal 12 (Responsible Consumption and Production), the system includes an innovative solution to manage hot, humid air. The redesigned dehydrator incorporates a germination module that reuses the air, leveraging temperature and humidity for germination processes, reducing environmental impact and adding value.

The work involves designing an improved model based on user feedback and advancements, constructing a functional prototype, and controlled testing to evaluate efficiency and sustainability. The system prioritizes local, low-cost materials to promote accessibility and sustainable practices.

This work provides a scalable, adaptable solution for small producers and rural communities with limited access to industrial technologies. The geodesic dome structure, modular design, integrated air management systems, and optimized temperature control offer an environmentally friendly alternative for food preservation and byproduct processing. The final design promotes frugal innovation by developing low-cost, accessible, and sustainable technological solutions tailored to the needs of small producers, and environmentally neutral.

Keywords: Solar, Solar dehydrator, Frugal innovation, Scalable solution.

HARNESSING SOLAR DRYING FOR STARTER CULTURES: A NOVEL APPROACH TO BACKSLOPPING FERMENTATION

Houngbédji, M., Bangbadé, D., Dabadé, D. S., Agossevi, S. D., Agbobatinkpo, B. P., Padonou, S. W., Dossou, J., Azokpota, P., Hounhouigan, D. J.

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Abstract: The solar drying is a cost-effective and sustainable method for the preservation of food and food ingredient, particularly in West Africa. In this study, a locally constructed solar dryer was used to assess and model the drying kinetics of a previously developed backslopping culture, while also evaluating its effectiveness in cereal fermentation. The solar dryer features a pre-heating chamber with a black-lined surface under a Plexiglas cover to retain heat, a compressor for filtered and compressed air supply, and a fan-assisted airflow system for efficient moisture removal through a solar-enhanced chimney.The solar drying system significantly induced a temperature gradient between outside and inside the drying chamber, enhancing inside temperature to 45.6 – 59.8°C during the 5h drying process, while the outside temperature ranged from 30 – 33°C. Significant reduction of the moisture content of the backslop culture was observed, dropping from 52.3 ± 0.5 at the onset (0 h) to 9.2 ± 0.7 % at the end of the drying process. The final water activity of the dried culture was 0.17 ± 0.03, ensuring satisfactory survival of lactic acid bacteria (97.42 ± 0.15 % of viability) and yeast (81.05 ± 7.06 % of viability). The drying kinetic patterns showed consistent fit with Midili-Kucuk model with high reliable predictivity (R2 = 0.998) and least bias (Root Mean Square Error = 0.016), demonstrating the suitability of solar drying for small-scale production of starter culture. Similar to oven-dried and freeze-dried cultures for food fermentation, the solar-dried backslop starter culture resulted in desirable acidity and pH levels in subsequent fermented products. This study demonstrates the potential of solar drying as a sustainable, cost-effective alternative to energy-intensive methods like freeze- and oven-drying, while ensuring food safety through controlled fermentation.

Keywords: Backslop culture, solar dryer, drying kinetic model, microbial viability, energy-intensive drying.

IMPLEMENTATION OF A SOLAR CONCENTRATOR FOR THE DEHYDRATION OF FRUITS

Monica Colunga Saucedo[1], Fátima de los Santos Garcia[1], Yuri Nahmad Molinari[1]

1, Instituto de Física, Universidad Autónoma de San Luis Potosí

Abstract: Dehydration is an effective food preservation technique that offers practical and economic advantages by reducing waste associated with overproduction and allowing the safekeeping of seasonal products for later use. This paper describes the design and construction of a 0.3 m^3 capacity dehydrator equipped with a heat exchanger connected to a 1.31 m^2 solar system consisting of asymmetric plane-cylindrical mirrors with a concentration ratio of approximately 3 suns. The system has been designed to operate without solar tracking or seasonal adjustments, facilitating year-round use. In the closed cycle with forced convection, 10 L of water circulates as the working fluid, maintaining a temperature of 85 ° C for several hours. With this temperature in the fluid, sufficient heat transfer was achieved for the dehydration of fruits such as 5 mm slices of apples and mangoes, reaching temperatures in the dehydration chamber between 50 and 60 ° C. The results indicate that the system achieved a convection heat transfer efficiency of 14.92 %, demonstrating its viability as a sustainable and economical solution for food preservation. The integration of solar energy into this process offers an ecological and cost-effective alternative to improve food preservation, especially in areas with limited access to conventional technologies.

Keywords: Solar energy, solar drying, fruit drying, solar concentrator.

8-Abstracts and papers (cont.)

Session 1B

CONSOLFOOD 2025 − International Conference on Advances in Solar Thermal Food Processing
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SOLAR BOX COOKERS: A COMPREHENSIVE ANALYSIS OF THE IMPACT OF DESIGN COMPONENTS

Kurt Neubek

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Abstract: Solar Box Cookers: A Comprehensive Analysis of the Impact of Design Components, Kurt Neubek

The performance of solar box cookers is influenced by a complex interplay of factors, including insulation, glazing, and reflectors. While individual cookers and components have been extensively studied, a comprehensive understanding of the interactions of the key factors is not widely understood. This study aims to fill the knowledge gap by investigating the synergistic effects of insulation, reflectors, and glazing on the performance of box cookers through empirical experimentation. The author, an architect trained in passive solar building design, brings a unique perspective to the design of solar cookers. Four box cookers were constructed, beginning with commercially available sports lockers, each approximately 30 cm3. A series of controlled experiments was conducted in Houston, Texas, USA (30° latitude) over several months, systematically varying insulation, reflectors, and glazing materials. Temperature data for both air and water inside the cookers, along with solar irradiance measurements, were collected using digital sensors and a pyranometer. The results demonstrate that increased insulation, reflectors, and glazing layers generally enhance thermal performance, as expected. The key contribution of this study lies in the systematic analysis of multiple configurations, which provides a detailed comparison of how each design variable impacts thermal performance. The findings offer valuable insights for solar cooks, designers, and policymakers, suggesting strategies to optimize box cooker performance, extend usability, reduce energy consumption, and promote sustainable cooking. Future research will explore additional configurations and environmental conditions to further validate and expand the usefulness of these results.

EXPERIMENTAL PERFORMANCE CHARACTERIZATION OF A 30-60º BOX SOLAR OVEN

Apaolaza-Pagoaga, X.[a)], Carrillo-Andrés, A.[a)], Rodrigues-Ruivo, C.[b,c]

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Abstract: The 30-60º box solar oven features a clever design that can adopt two different inclinations of the collecting window to the horizontal, just flipping the surface used as a base. This allows the device to better adapt to the different seasonal solar altitudes. The oven is very stable, the cooking vessel is always in a horizontal position, and no moving parts are required. Despite its interest, and the fact that it is a design known for a long time, to date no rigorous characterization of the performance of this solar oven has been carried out.

This work presents results from an experimental characterization of a 30-60º box solar oven, hand made mostly with local materials. The tests were carried out in Málaga, Spain (lat. 36.7 N). Some tests were conducted with a water load, according to the corrected ASAE S580.1 standard, and others with unloaded pots. Standardized cooking power of the 30-60º solar oven is determined and compared with the performance of other, well know, family-sized, solar cookers.

Keywords: Solar box oven, 30-60 º solar oven, solar altitude, experimental characterization

SOLAR COOKING TO STOP DEFORESTATION AND GENERATE EMPLOYEMENT IN BURUNDI

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Abstract:
Burundi is a small country in the heart of Africa with 13 million inhabitants and a population density of 500 inhabitants/km², which implies a high pressure on the environment. The

source of energy used for cooking is firewood or its transformation into charcoal; its consumption causes deforestation problems that lead to erosion and loss of fertile soil.

In addition to these problems, which are not exclusive to Burundi, there are humanitarian consequences in areas at food risk due to lack of cooking fuel. For this reason, one of the strategic lines on the country's agenda is the search for alternative forms of cooking that do not depend on firewood or charcoal.

72% of the population is under 35 years old and 40% is between 15 and 35 years old with high unemployment rates. Burundi's industrial infrastructure is mostly composed of small workshops with limited capacity.

The proposal from the Erasmus+ project “VET (Vocational and Educational Training) TO STOP DEFORESTATION” (V2SDF) is the use of solar stoves in Burundi through vocational training. V2SDF is a project in the modality “Capacity building in the field of VET” focused on improving vocational training in countries not associated to the Erasmus+ program.

The objective of V2SDF is to design a rapid vocational training course adapted to the Burundian educational system, taking the European Qualifications Framework (EQF) as a reference. This is intended to provide Burundi with professionals capable of supplying the local and regional market with solar stoves manufactured in the country, while boosting the local economy.

V2SDF involves vocational training institutions and schools from Spain, Turkey and Burundi.

V2SDF's work strategy is to design the curriculum of the vocational training course for the manufacture of solar stoves and a prototype classroom workshop adapted to the professional realizations that make up the course. From here, the prototype workshop will be implemented, Burundian teachers will be trained to teach the course, and didactic support materials will be designed to support the delivery of the course.

Meetings in Bujumbura and A Coruña have served to: show different models, study characteristics and procedures for use; elaborate local recipes, even in unfavorable weather conditions; analyze the possibilities of developing and elaborating models adapted to the country's circumstances; develop theoretical and methodological support materials.

The success of this project could be the first step for Burundi to become a reference for other countries.

Keywords:
Vocational and Educational Training (VET). Deforestation. Solar cooking Burundi. Resource economy.

FUNNEL SOLAR COOKERS MODEL FB

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Abstract: Every teacher tries to answer a recurring question: How to facilitate and stimulate students' learning? Solar stoves are an exceptional teaching tool.

More than 30 years studying, using and teaching solar cookers of very different models in terms of design, construction materials, behavior, performance, etc. offers a clear vision of their potential capabilities, both for food preparation and as a teaching resource in different training areas.
At the same time, being born and growing up in a home where solar cookers are part of everyday life allows for an in-depth learning process that is completely normal.
The FB -Funnel Bello- model is a further step in the design of funnel-type solar cookers.
Designing a solar cooker based on an extremely simple construction process to answer the following questions:
Economic resources: using recovered or very low-cost materials, it has been achieved at a cost of less than €1 in Spain.
Time to make it: between two people, following basic instructions, it can be made in 30 minutes.
Access to complex materials: cardboard recovered from packaging, aluminum foil and glue for school use
Knowledge to interpret plans and draw: the design is so simple that it is within the reach of anyone, even untrained people. Measurements are easy to understand and remember.
Tools needed: a tape measure, a straight-sided, smooth-surfaced piece of wood or similar, an all-purpose cutter, a paintbrush and a cloth are sufficient.
Manufacturing infrastructure: for a few units, a flat surface such as a table, or even the floor, is sufficient.
Manual skill: no great dexterity is required, the process is so simple that it is within the reach of any interested person.
When and where it can be used: it is possible to use it all year round in a wide range of geographical latitudes.
Transport and storage: different possibilities of folding and grouping of several units.
Replicable: easy to reproduce the model.
Scalable: FB50, FB55, FB60, FB65, FB70...
Transformable: Travel versions to convert them into suitcases with cabin or checked-in dimensions.
Easy to use: a few basic notions are enough to get started in its use.

Simple and affordable cooking containers: black metal pots, glass jars...
Greenhouse effect: glass bowls, plastic bags, plastic jugs, large glass jars...
More sophisticated materials can be used to improve durability and performance.

Keywords: Educational resources. Recycling. Reuse. Economical Solar Cooker. Simple Solar Cooker

Developing PARABOLIC TROUGH SOLAR OVEN/COOKER "Sun Arc Oven"

Inventor David Henri is a retired Solar Electric Technician, former Weaving Machine Technician, and Past President of The Solar Energy Association of Connecticut USA

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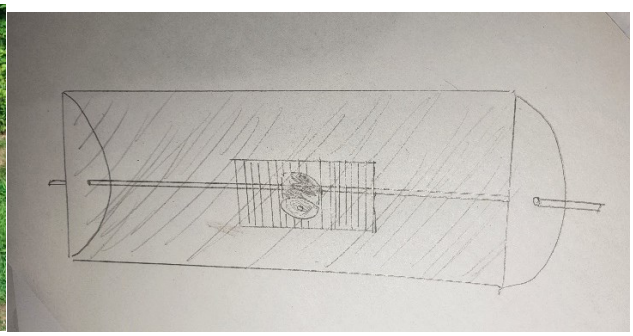

Abstract: The Sun Arc Oven uses a linier reflective parabolic trough to concentrate sunlight onto a metal receiver pipe, thereby collecting thermal energy. The trough is enclosed on ends, glazed on top and insulated, creating a greenhouse type solar oven space. The receiver pipe is within the oven and has a pot rack grate attached. The receiver pipe radiates heat into the oven and conducts heat through pot rack to pots. Trough rotates on the focal point of the stationary receiver pipe to facilitate tracking.

The purpose of this abstract is to showcase and highlight the unique design of this solar cooker. Trough style solar cookers without vacuum tubes are rare in the solar cooking world. The Sun Arc Oven has some promising attributes. It is robust and minimally susceptible to solar degradation. The internal one-piece parabolic reflector resists wind and dust.

If the engineering solar cooking community views the Sun Arc Oven design as promising, David Henri invites student groups to build and test his design. This would be beneficial, as currently there is only limited performance data available. The test prototype oven has routinely reached 250 F during the summer at 46 degrees north latitude. We have successfully cooked many times, including roasting 12 ears of corn at one once. The Sun Arc Oven prototype is still being incrementally developed and currently has a dual tracker in the works. Experimental tests would validate the solid scientific and engineering principles used in this solar cooker.

Keywords: Solar, trough, cooker, oven, receiver pipe, thermal energy

CONSOLFOOD 2025 − International Conference on Advances in Solar Thermal Food Processing
Marseille-France, 5-7 May, 2025

USING CARBON CREDITS TO MAKE SOLAR COOKING IN REFUGEE CAMPS PROFITABLE

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Abstract: Cardboard "CooKit" solar cookers have been used for cooking in Touloum Refugee Camp in Chad for around 25 years. In 2019, Fair Climate Fund, a Netherlands carbon credits company, obtained certification from the Gold Standard and has been earning carbon credits from the use of CooKits in the Camp. However, the CooKits are not durable, and require the use of plastic bags, which must be replaced often. Accordingly, Fair Climate Fund sought a replacement for the CooKits and purchased 6,000 Haines Pop Open Solar Cookers to replace them. The company expects the new Haines Cookers to earn sufficient carbon credits to pay for the cost of the project plus a profit—demonstrating that distributing solar cookers in refugee camps can be profitable.

Keywords: Solar, solar cooker, solar oven, carbon credits, refugee camp, cookstove, Haines, Fair Climate Fund.

8-Abstracts and papers (cont.)

Session 2B

NECESSARY BUT NOT SUFFICIENT: CONSIDERING CURRENT AND AS YET UNTRIED MEANS OF SOLAR COOKER DISTRIBUTION AND PROMOTING ADOPTION

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Abstract: The author collects classic and contemporary solar cookers. Through the author's Museum of Solar Cooking he also collects the histories of solar cooker fabrication and promotion. In the process of collecting for the Museum, many cooker manufacturers' and distributors' stories suggest a catalog of strategies for distribution of solar cookers. Some find that most strategies for encouraging continued use of their cookers fail to result in the routine adoption of the cookers as a necessary appliance in households or communities.

For the Museum's video series, guests were asked open-ended questions, including, "What do you see as the future of reaching those not familiar with solar cooking, and increase the use of solar cookers?" The Museum's Earthwide Solar Cooking Forum was relaunched in 2024 to discuss and document successes and failures of these activities.

Many of these intrepid advocates expressed their best recommendations for promoting solar cookers in any region of the world. Most also lamented the overall low rate of adoption of solar cookers especially in areas with the most urgent needs. International conference presenters have affirmed this concern for decades.

From their responses several best practices --used and proposed-- will be presented. The author's experience as a community organizer will inform the possibility of strategies not yet attempted. Further, information mined from reliable solar cooking organizations, vendors, and power-users will be included and assessed for their value for measuring adoption, or the lack thereof.

All proposed promotional constructs will be examined for their potential to improve on our network's distribution of solar cookers, while increasing the likelihood that recipients of these cookers will actually make use of them in their daily lives.

Conclusions will be presented, including quotes and annotated video from the Museum's series and unpublished visits and correspondence. Finally, we will update the community on Museum

projects launched or developed in collaboration with leaders in the movement. These projects are intended to further the cause by encouraging best practices, and deferring the least effective.

Keywords: Solar Cooking, Solar Cookers, Solar Cooking Adoption, Solar Cooker Promotion, Solar Energy, Appropriate Technology

CONSOLFOOD 2025 − International Conference on Advances in Solar Thermal Food Processing
Marseille-France, 5-7 May, 2025

ALBERA, A NEW SOLAR CONCENTRATOR WITH CONSTANT-HEIGHT FOCUS

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Abstract: After testing his "metallic lens" at Sorède in 1900, Father Himalaya concluded that the shift of focus during the day led to very high positions at the beginning and end of the day. This made loading and unloading, monitoring and handling of materials cumbersome and complicated. Father Himalaya has therefore designed a system in which the focus always remains in the same horizontal plane and only has a movement along a circular path when the concentrator follows the Sun. This system was patented in 1901, and a 80 m² solar furnace based on this principle operated in Lisbon in 1902. Since then, the principle has of course been taken up and improved by other solar energy promoters. *Les Amis du Padre Himalaya* have also built an improved version on a smaller scale (4 m²) of such a solar furnace with constant-height focus. This version, designed to be mobile, is mounted on a standard car trailer. This paper describes its main features and manufacturing process.

Keywords: Father Himalaya, solar furnace, focus accessibility.

CONSOLFOOD 2025 − International Conference on Advances in Solar Thermal Food Processing
Marseille-France, 5-7 May, 2025

PROBLEMS AND SOLUTIONS IN THE DEVELOPMENT OF SOLAR COOKERS WITH STORAGE FOR INDOOR COOKING

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Abstract: In an international research project, four different solar cookers were developed and built. During the development and testing phases, various problems had been identified for which solutions had to be found. The first solar cooker was designed with PV modules, an electric heater, a sand-gravel thermal energy storage (TES), two fixed double-walled pots and one fixed frying pan. The second solar cooker deploys flat-plate collectors with double glazing, side mirrors and back mirrors, a gravel-oil TES, an oil pump, two fixed double-walled pots and one fixed frying pan (no electrical components are used). The third solar cooker is hybrid using a flat-plate collector (as described above), a PV module, electric heater, a pump as well as two fixed double-walled pots. All above described solar cookers have piping through which the heat transfer fluid (plant) oil is circulated, which is heated by the flat-plate collector or PV powered electric heater and passed through the double-walled pots and pans, thereby providing heat for cooking. The fourth solar cooker is fully electric with PV module, battery, electrical controllers and two cooking hobs/plates (for cooking with ordinary flat-bottom pans and frying pans).

The thermal solar cookers all had the issue that contrary to the past decades, identifying suitable and commercially available double-walled pots proved to be difficult. The chosen pots had a very thin wall thickness, which made it very difficult to attach connector fittings for the oil piping inlet and outlet. Moreover, the gap of the double-wall was so small that the piping had to be attached at a less favorable position, leading to increased hydraulic pressure losses. As piping material, copper pipes were used. For a future version of these solar cookers, flexible (corrugated) pipes are preferred which can be connected with screw fittings (without soldering). Another design improvement is to use flat-plate heat exchangers as cooking hobs, which can also be connected with screw fittings. This allows the use of ordinary flat-bottom pans and frying pans.

Regarding the fully electric solar cooker, a problem with the insulation was discovered and improved. Heat losses during heating were found to be significant. With the presence of specific insulations for these plates, experiments with the cooker show that the maximum heating temperature of the plate is improved by 20 %, and the boiling time of water is reduced by 50 %.

In the paper, more details about design problems and solutions will be given.

Keywords: Thermal solar cookers, Thermal Energy Storage, Electric PV cooker, Battery, Insulation of heating plates.

Preliminary comparison of Scheffler concentrators for solar cooking

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Abstract: In general, Scheffler concentrators used in solar cooking feature a deported and fixed focal point, by a deformable structure to adapt its curvature to each day of the year. The objective of the present work is to compare the performance of two of them. The first Scheffler is in Malaga (Spain, lat. 36.72° N) and has 2.5 m² of reflective area made with mirror-polished aluminium sheets. The second Scheffler in Marseille (France, lat. 43.35° N) and has 8 m² of reflective area made of mirrors. The comparison will be realised based on the standard test adapted to both situations. This work represents a preliminary study to optimize both cooking systems by considering different designs on secondary reflectors and cooking hob, allowing further consistent comparisons based on a custom test procedure, inspired in the ASAE S580.1 standard framework, but using a linear performance model analogous to the Hottel-Whillier-Bliss formulation.

Keywords: Solar cooking, Scheffler concentrator, Standard test, experimentation

Optimization of the secondary reflector for solar cooking in a restaurant using a Scheffler concentrator

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Abstract: Numerous solar cookers (box, dish, funnel, etc.) have been developed and studied to meet small needs, for instance those of a family. However, when it comes to larger-scale cooking requirements, such as those found in a restaurant, few studies have been carried out. The aim of this work is therefore to study the set-up of a solar restaurant using a Scheffler reflector with several types of secondary reflectors. The study was conducted using SolTrace software, and the results met the requirements of the chefs as well as the geometric requirements imposed by the building, the size and shape of the receiver, and the design of the Scheffler reflector. The output parameters of interest are total power, average flux density, maximum flux density, and the final position of the focal image. The optimal solution and its potential applications, including the prospect of thermal optimization of the hob, will be presented.

Keywords: Solar, Solar cooking, Ray-tracing, Secondary reflector, Optimization

8-Abstracts and papers (cont.)

Session 2C

EXPERIMENTAL ASSESSMENT OF THERMAL ENERGY STORAGE USING SUNFLOWER OIL IN KENYA

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Abstract: The use of solar cookers is hindered by the intermittency of sunshine. Thermal Energy Storage (TES) models that directly store energy for later use can bridge the gap. This study focuses on the experimental assessment of sunflower oil as heat-capturing medium in a cylindrical TES system, which can be used as a cooking plate after charging. Specifically, the study assesses the energy storage potential of the unit, its heat retention level, and the cooking potential with a water load. The model is evaluated in controlled laboratory conditions in Belgium, and in field experiments in Kenya. The laboratory experiments are monitored during a charging phase when the TES system is placed on a pre-heated electric heater that supplies a heat flux of about 1.1 kW to mimic a parabolic solar concentrator. The temperature changes of the oil and outside air are measured with K-type thermocouples. A Keysight 34972A LXI data acquisition unit is used for digital data reading and logging. The discharge phase begins when the heated unit is off-loaded from the heat source and only temperature values greater than 90 ^{o}C are considered in the analysis. Results show that the oil can reach a temperature of 157 ^{o}C after 1.5 hours and during discharge, a temperature of 90 ^{o}C is obtained after 2.5 hours. Field testing was done in Kenya with a concentrating parabolic solar cooker. The dimensions of the stainless-steel TES were reduced to align with the size of the cooker, and 3.65 liters of oil is filled in the system. Three K-type thermocouples are fixed through the side of the model to measure oil temperature at different depths, and one was attached to the lid of a cooking pot filled with 0.5 liters of water that was only placed on the TES during discharge. One thermocouple was left to measure the outside air temperature, which was on average about 28 ^{o}C, and the wind speed was very weak. Temperatures and solar radiation measurements were stored using a CRX1000 data logger. The field experiment results during the charging phase indicate a maximum oil temperature of about 161 °C with a total energy storage of about 894 kJ, with an average global horizontal solar irradiance of 518 W/m^2 during 3.5 hours of charging. During the subsequent discharging phase, where the cooking pot was put on the TES, the sunflower oil sustained a temperature above 90 ^{o}C for 2 hours and 20 minutes. During this discharge, the water in the cooking pot attained a maximum temperature of 51.3 °C in 1.5 hours. During that period, the energy transferred to the water was about 50 kJ, about 12% of the energy released by the oil. The results indicate that the TES does not allow energy-intensive operations

such as heating water, for which direct solar cooking is more appropriate. However, the high oil temperatures during discharge allow for low heat simmering of various food items. A study on the possibilities of this will be done in future work.

Keywords: Thermal Energy Storage, Solar Cooker, Sunflower Oil, Kenya.

1. Introduction

Solar cookers have been promoted as an alternative to unsustainable but popular biomass-energy cooking technologies because they can reduce emissions from greenhouse gases, protect the environment, and prevent illnesses and deaths related to indoor air pollution (Otte, 2013). However, the uptake of solar cookers is partly hindered by the intermittent patterns of solar radiation which makes them unreliable to use when the sunshine is not available either at night or at cloud cast (Nkhonjera et al., 2017; Nydal, 2023). Also, for the option of more efficient but complex designs, the cost may be prohibitive for most of the populations who live off-grid (Nydal, 2023) .

Thermal Energy Storage (TES) systems, which can store thermal energy and directly supply it outside the sunshine hours, have been suggested to be an economically viable option for increased reliability over complex designs that rely on heat transfer fluids, which may increase the cost (Nydal, 2023). Similarly, many researchers have explored the potential for using sunflower oil as an energy storage material, both theoretically and experimentally and recommended it over phase change materials (PCM) because of the limitations of subcooling and phase segregation in the latter material (Mawire et al., 2020; Vanierschot & Mawire, 2023; Abedigamba et al., 2023). Compared to PCMs, sensible heat storage materials such as rocks, pebbles, water and vegetable oils are easily available in the context of this research, i.e. implementation in developing countries. Using PCMs may also be less cost effective, especially for low volume use. Additionally, vegetable oils including sunflower oil can store thermal energy above their boiling point without any problems of pressure built up compared to other available sensible heat energy storage materials, such as water, whose use beyond the boiling point invites higher costs to withstand the increased pressure (Abedigamba et al., 2023). Also, sunflower oil is readily available and considered less toxic compared to other phase change materials and may be safe for integrating in a cooking system (Abedigamba et al., 2023).

Studies evaluating designs that combine sunflower oil with a simple dual-purpose TES, i.e. a TES with a compartment of energy storage and an integrated cooking pot, have been reported and experimentally tested under controlled laboratory as well as in field experiments (Mawire et al., 2020; Vanierschot and Mawire, 2023). The model suggested by Mawire et al. (2020) is theoretically analyzed and validated experimentally to provide insights into the heat transfer mechanism (Vanierschot & Mawire, 2023). These experimental and theoretical studies of dual-purpose TES that can also serve as a cooking pot indicated the low performance of sunflower oil in heat transfer with a low energy storage efficiency of up to 29% as reported by Vanierschot & Mawire (2023). Hence, they recommended the optimization for increased total energy storage, heat transfer, and energy utilization in the cooking pot. Further, field cooking experiments evaluating the performance of this dual-purpose thermal energy storage unit were

performed by Mawire et al. (2022) in South Africa. Their study compared heat storage and heat utilization with sunflower oil and erythritol thermal materials during the charging and discharging period. The findings indicated a higher temperature attained by sunflower oil during the charging phase than that of erythritol, but a longer heat retention by the pot with erythritol compared to one with sunflower oil.

Contextual field experiment assessments to evaluate the performance in East Africa or tropical geographical areas may yield different results with the assumption that the abundance of sunshine varies with the variation in latitude. Such investigations have been reported in Uganda comparing the thermal performance of sunflower oil and roki vegetable oil, indicating a higher utilization rate and a maximum average energy storage performance of the latter compared to the former after a given time (Abedigamba et al., 2023). This was attributed to the higher thermal conductivity of roki oil over sunflower oil.

This work focuses on assessing the field application of a thermal energy storage system designed as a cylindrical container filled with oil as energy storage material. The model is meant to be used like a hot plate after heating up by a parabolic mirror and discharged when off-loaded to release energy to a separate cooking pot placed on top of the model. The work choses sunflower oil over roki oil for testing in the Kenyan Lake Victoria Basin where sunflower oil is more readily available. The specific objective is to determine the total energy storage of the sunflower oil after charging in the sun in the field ambient condition, to determine the heat retention rate of the thermal energy storage unit during the discharging phase and to determine the total heat utilization by a water load.

2. Materials and Methods

2.1 The Experimental Setup

The laboratory experiment was conducted in Belgium while the field experiment was conducted in Bondo, Kenya. The setup is a single-walled cylindrical-shaped TES made of aluminum, measuring 76mm high and 400 mm in diameter with a detachable top lid measuring 456mm in diameter, and a thickness of 30mm. For the laboratory set-up, the unit is filled with five liters of sunflower vegetable oil reaching a height of 40mm and 36mm depth of air in the

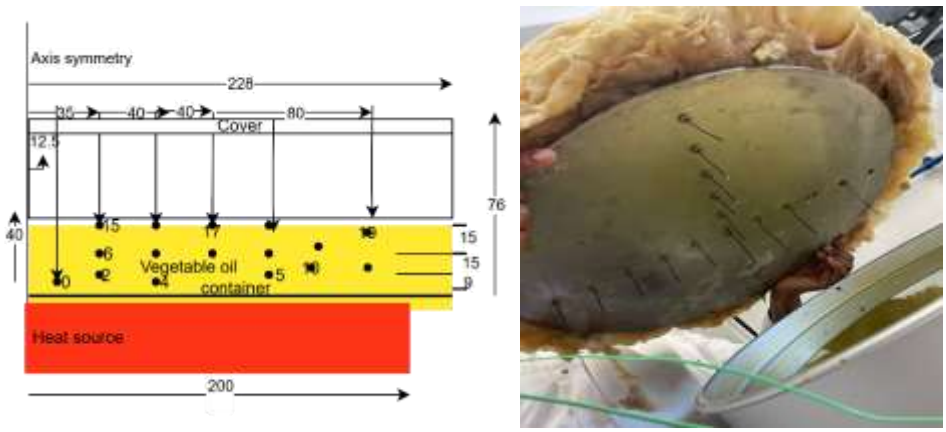

Figure 1: Schematic (left) and pictorial (right) of thermocouple positions (mm) used for measurements of oil temperatures.

Figure 2: Thermal energy storage on a solar cooker during charging (left) and discharge cycles (right).

unit (Figure 1). Seventeen different calibrated type-K thermocouples were placed to measure oil temperature at three levels of depth, as shown in Figure 1 (black dots) and two other thermocouples were left to measure the room temperature outside the oil.

For the field experiment, a similar TES unit made from food-grade stainless steel was fabricated and assessed with a Yamo-Dudo parabolic mirror as a heating element. There was also a slight modification of the TES dimension from the lab setup (diameter reduced to 26 cm) to align with the parabolic mirror receiver. The volume of oil filled in the unit was 3.65 liters. Three omega K-type thermocouples with an accuracy of ±2.2 ˚C are placed at equal distance but diagonally to measure the temperature profile at varying depths on the side of the wall of the unit. One thermocouple was used to measure ambient air temperature, and two others were placed on the surface of the solar cooker and through the lid covering the cooking pot to measure the water load during discharge. To read and record the temperature changes, a Keysight 34972A LXI data acquisition unit is used for the lab experiments, and temperatures are sampled every 2 seconds. For the field experiments, the global solar radiation was measured using a pyranometer model SMP3-A, Class C and temperature data are collected and stored using a CRX1000 data logger to provide real time data at a time stamp of 10 minutes.

Both experiments (lab and field) have two phases. The heating or charging phase and the cooling/discharging phase. During the charging phase, the TES unit is placed on a heat source (a pre-heated electric heater that supplies a 1.1kW heat flux for the lab experiment or a parabolic mirror measuring 140cm in diameter for the field experiment) and the oil gets heated up to target the maximum temperature. Precautions are taken not to go beyond the smoke temperature of 232°C. This means that the maximum heating temperature is restricted at 180°C. In the field, during charging, the parabolic mirrors requires manual tracking. This means rotating it some intervals to align with the changing position of the sun throughout the day (Mawire et al 2020). A clear interval for the adjustment was unknown for this location but was observed on a necessity basis whenever the focal point was not aligned to the bottom of the TES. This called for frequent monitoring of the direction of the radiation. During discharge, the heated TES

model with oil content is off-loaded and placed on top of a thermal fire brick and insulated to avoid heat loss and an insulated aluminum pot holding 0.5 liters of water is loaded on top of the TES to heat up. The field experiment was conducted on 19/10/2024 (day 1) and 21/10/2024 (day 2) from 11.09am until 16.30pm but only day 1 results are used because of less disturbance encountered while solar tracking (Figure 5).

2.2 Thermal Performance Analysis

The parameters of analysis entail temperature rise during the charging phase and temperature drop during discharge over time, the total energy storage (Q_{us}), the utilized energy (Q_{ut}) and heat utilization efficiency (η_{ut}).

$$Q_{us} = \sum mc\Delta T, \tag{1}$$

where m is the mass of the oil, c is the specific heat capacity and ΔT is the moving average temperature between the next and the previous reading in the sequence of time steps.

$$Q_{ut} = \sum m_w c_w \Delta T, \tag{2}$$

where m_w is the mass of water that is loaded on a separate cooker and c_w is the specific heat capacity of water.

$$\eta_{ut} = \frac{Q_{ut}}{Q_{us}}, \tag{3}$$

where Q_{ut} is the total heat utilization and Q_{us} is the total energy stored.

3. Results and Discussion

3.1 Ambient Conditions in the Field Experiment

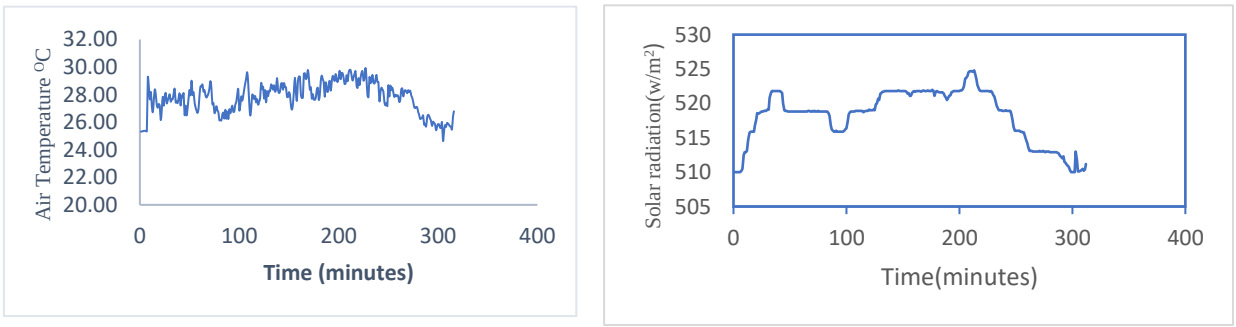

Figure3: Air temperature at the experimental site (left) and solar radiation at the experiment site on 21st , October 2024.

The radiation is quite constant with an average value over the entire period of 518 W/m^2. The solar cooker is estimated to produce an average heat flux of 797 W. The air temperature was on average 28 °C, with a range from 25.34 to 29.93 °C and no significant wind blowing was observed.

3.2 Temperature Profiles for Field Exp, Day 1

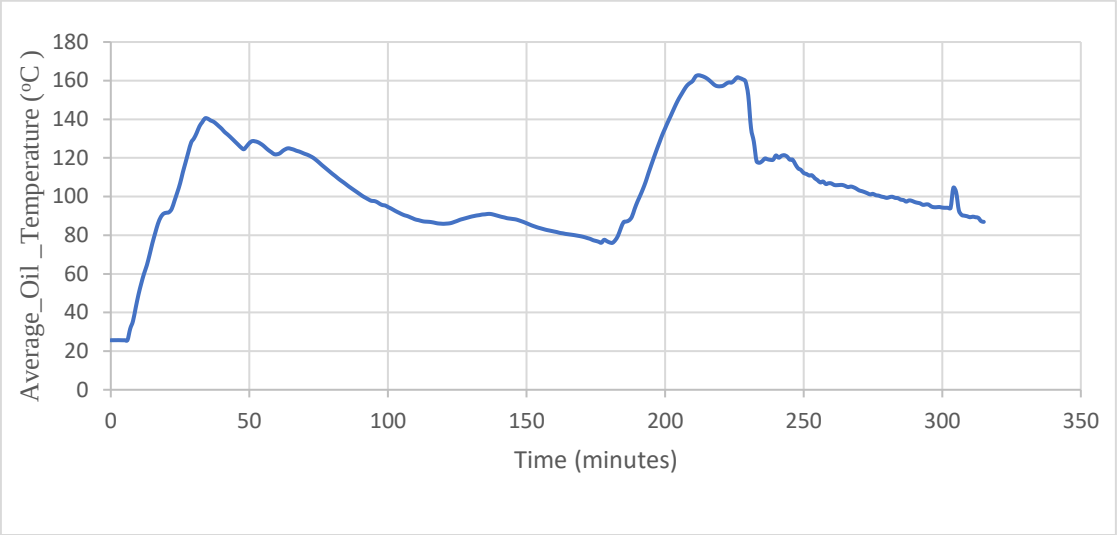

Figure 4: Combined Charging and Discharging Temperatures for the field experiments.

Similar like the solar radiation pattern (Figure 3), the temperature of the oil peaks twice after 33 minutes (137 °C) and after 3 hours and 30 minutes of charging (161 °C) with in between a decrease from 50 to 177 minutes (Figure 4). While there are similarities in the pattern of peak and dips with the solar radiation, there are instances when the oil temperatures deviate significantly from the pattern of the radiation and the ambient temperatures during the temperature dip. This can be explained by the influence of non-ambient conditions such as delayed manual tracking of the parabolic mirror to ensure its accurate alignment with the direction of the sun to achieve optimal focus of solar radiation onto the bottom of TES unit (Mawire et al., 2020). This was possible since the intervals between which tracking was required for parabolic cookers in this location was less understood. The observed two peaks of oil temperatures that aligns well with the time for peak for solar radiation however indicates the period of clearer skies but the decay starting after 230 minutes is attributable to the discharge phase.

The heat retention or rate of heat loss in both cases is well explained with an exponential decay graph pattern (R^2=0.992, for lab, and 0.9453 for field) with a smooth decay for the laboratory and some data variability in the field experiments. Both cases exhibit a decay rate of 0.004 per minute. For the laboratory experiment, temperatures above 90°C (useful for cooking) are sustained for about 2 hours and 15 minutes while those in the field for 1 hour 20 minutes (day 2) and 2 hours and 20 minutes (day 1). The difference in time is explained by the initial temperature at discharge and the ambient conditions such as the slight wind, which may affect the field experiment more. This indicates the potential for using the TES for low heat simmering cooking that is applicable for rice and fish cooking. This may form a basis for future cooking experimental work (Nydal, 2023).

3.3 Heat Retention for Sunflower Oil

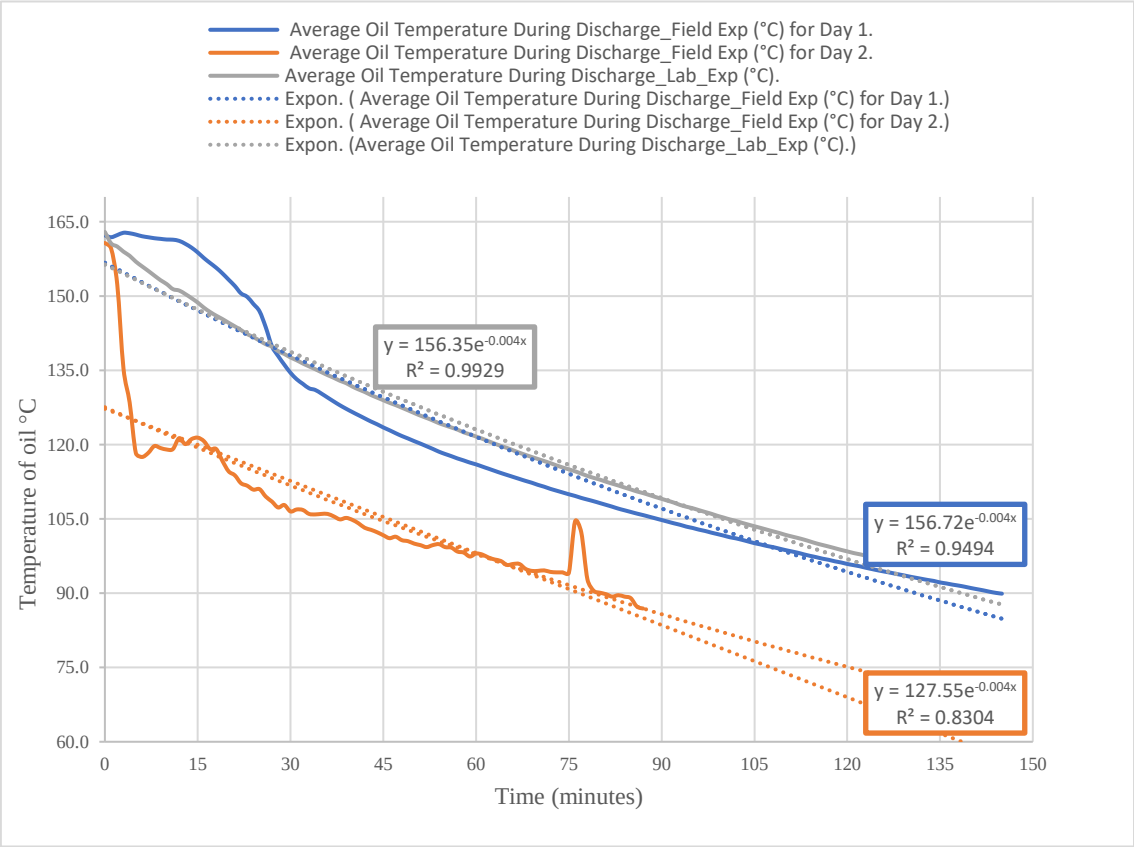

Figure 5: Cooling phase of the thermal energy storage.

3.3 Thermal Energy storage and Utilization Efficiency

The energy storage during sunflower oil on day one is 894 kJ and that released during discharge is 426 kJ, i.e. 47.7% of the energy stored. While the energy absorbed by the water after 1.5 hours discharge is only 50.15 kJ (11.7%) of the energy released by the oil. This is a bit lower compared to the 15% average energy efficiency obtained by Mawire et al. (2020). The temperature attained by the water is low, about 51.3^{o}C considering the higher boiling point of water of 100^{o}C. The low utilization efficiency is partly attributable to the higher specific heat capacity of water, heat loss from the lid of the cooking pot, and the possibility of low thermal conductance from the oil and the contact TES lid into the cooking pot. The 47.7% release of energy from the oil is also attributable to the lower thermal conductivity of the oil (Abedigamba et al., 2023).

Table 1: Thermal energy storage for sunflower oil during charging and discharging.

Properties	Sunflower oil	Water
Specific Heat capacity (J/kg.K)	2115.00 + 3.13T	4200
Density (kg/m^3)	930.62 + 0.65T	995
Energy stored (kJ)	894	50.15
Volume (liters)	3.65	0.5
Maximum temperature charging (^{o}C)	161.7	51.3
Initial temperature (^{o}C)	25.6	28
The energy released by the oil (kJ)	426	NA
Utilization Efficiency by water		11.7%

4. Conclusion

This work investigates the possibility of using sunflower oil as thermal energy storage medium in solar cookers. Lab experiments in combination with field experiments were performed to characterize the thermal performance. In the field experiments, it is possible to reach a maximum oil temperature of 160 ^{o}C (894 kJ of energy stored) after 3.5 hours of charging. The duration of charging can be shortened significantly through timely tracking of the parabolic mirror. During discharge, 47.4% of the energy stored is released at a rate of 0.004 per minute in a period of two hours. This can sustain low heat (90 ^{o}C) simmering cooking of food with a low specific heat capacity. A low heat utilization of 11.7% of the released heat for a 0.5 liters water load can be enhanced through improved thermal conductivity of the oil material, and other contact materials (top lid and cooking pot) that ensures transfer of heat from the TES, in combination with improved insulation of the top lid to avoid heat losses and increased contact of the pot with the thermal material. Cooking experiments while discharging sunflower oil with other food like rice could be evaluated. Also, a thermal material with a higher thermal energy density and conductivity than sunflower oil could be tested.

References

Abedigamba, O. P., Mndeme, S. F., Mawire, A., & Rukaaya, M. (2023). Heat Utilization Characteristics of Two Sensible Heat Storage Vegetable Oils for Domestic Applications. *Sustainability*, *15*(8). https://doi.org/10.3390/su15086825

Mawire, A., Lentswe, K., & Owusu, P. (2022). Performance of two solar cooking storage pots using parabolic dish solar concentrators during solar and storage cooking periods with different heating loads. *Results in Engineering*, *13*. https://doi.org/10.1016/j.rineng.2022.100336

Nkhonjera, L., Bello-Ochende, T., John, G., & King'ondu, C. K. (2017). A review of thermal energy storage designs, heat storage materials, and cooking performance of solar cookers with heat storage. *Renewable & Sustainable Energy Reviews*, *75*, 157–167. https://doi.org/10.1016/j.rser.2016.10.059

Nydal, O. J. (2023). Heat Storage for Cooking: A Discussion on Requirements and Concepts. *Energies*, *16*(18). https://doi.org/10.3390/en16186623

Odoi-Yorke, F., Opoku, R., Davis, F., & Obeng, G. Y. (2023). Optimization of thermal energy

storage systems incorporated with phase change materials for sustainable energy supply: A systematic review. *Energy Reports*, *10*, 2496–2512. https://doi.org/10.1016/j.egyr.2023.09.044

Omara, A. A. M., Abuelnuor, A. A. A., Mohammed, H. A., Habibi, D., & Younis, O. (2020). Improving solar cooker performance using phase change materials: A comprehensive review. *Solar Energy*, *207*, 539–563. https://doi.org/10.1016/j.solener.2020.07.015

Otte, P. P. (2013). Solar cookers in developing countries—What is their key to success? *Energy Policy*, *63*, 375–381. https://doi.org/10.1016/j.enpol.2013.08.075

Vanierschot, M., & Mawire, A. (2023). Heat-Transfer Mechanisms in a Solar Cooking Pot with Thermal Energy Storage. *Energies*, *16*(7). https://doi.org/10.3390/en16073005

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Prototyping a solar canteen for the schoolyard

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Abstract: The aim of this research is to adapt the uses of the solar cooker to the school canteen. This study is based on a practical example with a specific public school in Vienna which has an open classroom. The experience is a two-week accompaniment to the regular school programme, where pupils cook normally, with gas and wood. The Study will demonstrate that through solar cooking, the knowledge about healthy food and energy saving in the school canteen will improve and create an impact on the school community by linking traditional knowledge with modern ecological practices, as well as relate it to playground projects, such as the vegetable garden and open space activities and connection with the environments around the school. This research will also be supported within the framework of the Erasmus+ eduLANDs project by promoting cooperation with schools and associations that are working with solar cooking in Spain, Austria and Italy.

Keywords: Solar cooking, thermal cooking, energy-saving cooking box, fermentation, transdisciplinarity and sustainability, learning communities, energy transitions, food sovereignity

SUSTAINABLE COOKING TECHNOLOGIES: ASSESSING NUTRITIONAL QUALITY AND ENVIRONMENTAL IMPACT OF SOLAR OVENS VS. TRADITIONAL METHODS

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Abstract: This study analyses and compares meals prepared using traditional cooking systems and solar ovens, focusing on their chemical, nutritional and environmental aspects. The primary objective is to evaluate the advantages and limitations of each cooking method. The key research questions include: What are the differences in the chemical composition of foods prepared in solar ovens versus traditional methods? How are nutrients retained or degraded in each method? And what are the relative environmental impacts of these cooking approaches? To address these questions, an interdisciplinary approach was employed, integrating food chemistry, nutritional science, and environmental assessment. Representative balanced meals were selected and prepared using both conventional cooking systems and solar ovens. Chemical analyses were conducted using advanced techniques such as chromatography, mass spectrometry, and spectroscopy. The study also evaluated energy efficiency and environmental impacts by calculating the carbon footprint, greenhouse gas emissions, and resource utilization for each method. The results revealed significant differences in nutrient retention and food composition between the two cooking methods. Solar ovens were found to have a notably lower carbon footprint and reduced environmental impact compared to traditional systems. These findings offer valuable insights into the promotion of sustainable cooking technologies and may inform public policies and strategies for implementing environmentally friendly solutions.

Keywords: Solar Cooking, Solar Energy, Health, Food, Nutrition;

History of Sam Erwin and the Solar Chef and StarFlower

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Abstract: The goal of this presentation is to honor the lifetime achievement of a pioneer in the field of solar cooking, Sam Erwin. The talk begins with a brief overview of Sam's accomplishments during the 1970s when he invented, patented, copyrighted and manufactured his solar oven which he called the Solar Chef, in Sedona, Arizona. The talk will be accompanied by Sam's original pictures of the beginning years of 1975 to 1976 when Sam manufactured 73 Solar Chefs and sent them to 14 states in the US, During those beginning years, he promoted solar cooking in many places in Arizona and beyond. As he moved through the years, Sam continued to develop and to improve the Solar Chef to the newest model, the StarFlower, which we have on display here at the conference. Sam's personal goals, his dreams and his accomplishments are highlighted in this talk as a tribute to the legacy that this solar oven innovator has left in the solar cooking world. The presenter also explains how she became personally involved with the help of Sam Erwin in manufacturing the Solar Chef in 1998 in Lubbock, Texas and of her business interactions with Sam and his inventions over 19 years until his death in November of 2019. Sam bequeathed all his Solar Chef jigs, prototypes and manufacturing equipment to the presenter and she moved all of his legacy from Tracyton, Washington to her solar shop in Lubbock, Texas two weeks after his death. Four of Sam's StarFlower prototypes have been on display in the foyer of her shop for 5 years, and she uses them to promote the idea of solar cooking to her solar energy customers daily.

Keywords: solar chef, solar cooking. Sam Erwin, StarFlower

HOW SOLAR COOKING AND ITS OUTREACH CONTRIBUTES TO HEALTH IN WORK AND EDUCATIONAL ENVIRONMENTS IN VOCATIONAL EDUCATION.

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Abstract: Sustainability has (theoretically) reached companies and is beginning to make its way into the field of occupational risk prevention. Precisely the *One Health* concept coined by the World Health Organisation in 2022 replaces the WHO's own traditional concept of health - bio-psycho-social well-being and not just the absence of disease - in such a way that, from this perspective, human health would not be considered without animal health or environmental health. Therefore investing in '*One Health'* actions would contribute to improving the health of workers and the planet. From this approach, reducing the carbon footprint of people and organisations is an essential action.

For these reasons, the outreach and use of solar cookers are actions that contribute to the health of the planet and, therefore, to everything that One Health stands for. Also to well-being at work and to the deepening of sustainability in educational environments.

In this respect, the didactic department of *Training and Occupational Guidance* (F.O.L.) with teaching competence in occupational health and safety, in all vocational training courses, is obliged to teach content and knowledge related to sustainability. It is a different matter whether this is done and whether it is standardised.

Precisely for this purpose, the F.O.L. department of IES Noroeste (island of Gran Canaria) has organised the *II Occupational Health Day* of IES Noroeste whose programme includes the conference entitled *'Cooking with the sun. A didactic commitment to sustainability'*. This intervention, which emphasised sustainability in the context of occupational risk prevention, was complemented by various practical workshops on the construction of solar cookers.

The aim of this paper is to highlight environmental sustainability within the framework of health and safety at work, as well as the opportunity offered by the introduction and standardisation of solar cookers in business and educational environments, in order to contribute to the sustainability of the planet.

Keywords: solar cooking, occupational health, One Health, WHO, working environments, education, sustainability

DESIGN AND CONSTRUCTION OF A HIGH-TEMPERATURE, SINGLE-REFLECTION SOLAR FURNACE.

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Abstract:

Most solar concentrators that achieve high concentrations use double-reflection systems – e.g. Montlouis or Odeillo. Simple single-reflection concentrators by Dando 1998, and Lytefire 2012 are easily able to bake bread and pizza, but do not allow concentrations in excess of 200 suns, as there are problems with accurate aiming of the reflected beams with variations in solar elevation, as shown in a previous study (Dando, 2024). With greater solar concentration, much higher temperatures can be reached, so that metal forging, glassmaking, and pottery become possible. For the high-temperature concentrator presented here, new kinematics have been designed to drive the mirrors without aiming errors, whatever the solar elevation. Thermoforming mirrors into parabolic shapes also enhances concentration. A concentration of 2,000 suns is now conceivable, making it possible to exceed 1,000°C. Detailed explanations of the kinematics are described, which will place this innovation in the public domain. A description of the optical modelling, using free *Solstice* software, is included, along with a sensitivity analysis of slope error. The receiver, insulated with 20 cm of wool, is expected to reach temperatures of around 1000°C. Future plans and further experiments are discussed.

Keywords: High solar concentration, high temperature, experiments, kinematic model, thermal model, craft applications,

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CONTINUITY: 15 YEARS OF TAMERA'S SOLAR KITCHEN

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Abstract: Since 2010, a changing group of cooks, scientists, activists and visionaries have held a solar/biogas community kitchen cooking for 40-50 people, 6-8 months a year, in the Solar Testfield of the community of Tamera, in Southern Portugal. The ongoing experiment is intended to field-test solar cooking technologies, techniques and practices within a context of an intentional community. The solar kitchen has become a source of pride within the community and an attractor for visitors. It is also one of the main kitchens of the community and has relevance as its continuing function is vital to the residents. The equipment used includes a Scheffler mirror, other paraboloid and parabolic trough cookers, funnel, box and hybrid cookers. This overview paper considers both the long-term viability of the equipment and the social dynamics around solar cooking that become visible in this context. Some of the cookers are in daily use while others are less frequently or rarely used. Equipment usage reflects contextual ease and practicality of use, as well as differences in cooking style, willingness to engage with unfamiliar apparatus and a range of levels of commitment between cooks. This paper surveys some of the key practical learnings and insights from the last 15 years and closes with an outline of current directions bringing kitchen and garden closer together to reinforce regenerative cycles.

Keywords: Solar kitchen, biogas, field study, community, Scheffler mirror

CLEAN COOKING IN BOLIVIA: TECHNOLOGIES, ACCESS, AND SOCIOECONOMIC CONTEXT

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Abstract: Access to clean cooking technologies remains a critical global challenge, impacting public health, environmental sustainability, and socioeconomic development. Globally, approximately 2.3 billion people still rely on solid fuels, such as firewood and charcoal, burned in open fires or inefficient stoves, leading to severe indoor air pollution and 3.3 million premature deaths annually, particularly among women, children, and vulnerable populations. The emissions from traditional cooking methods, including CO_2, PM2.5, and black carbon, contribute significantly to climate change and environmental degradation, comparable to emissions from major industries.

In Bolivia, while urban areas benefit from widespread access to natural gas and electricity, rural and peri-urban regions remain heavily dependent on biomass fuels. Around 31% of rural households rely on firewood, which exacerbates indoor air pollution, health risks, and deforestation. Women and children bear the brunt of fuel collection, spending up to five hours daily on this task. Bolivia has seen efforts to introduce improved cookstove technologies—ranging from efficient biomass stoves to solar cooking solutions—tailored to the country's cultural, climatic, and economic diversity. Technologies such as clay fixed Malena stoves, portable metal rocket stoves, solar cookers, and PV cookers have demonstrated significant fuel savings and health benefits. However, challenges persist, including high production costs due to the lack of a domestic metallurgical industry, limited access to financing, and regulatory barriers.

This article explores the energy landscape and the adoption of clean cooking technologies in Bolivia, analyzing their health, environmental, and socioeconomic impacts. It also identifies barriers to widespread adoption and proposes strategies to accelerate the transition to sustainable cooking solutions, aligning with Sustainable Development Goals (SDGs) 3 (Health), 7 (Clean Energy), and 13 (Climate Action).

Keywords: clean cooking technologies, sustainable development, health, air pollution, energy, solar cookers, Bolivia

8-Abstracts and papers (cont.)

Session 3B

SOLAR COOKER PERFORMANCE: COOKING TIMES WITH VARYING SUNSHINE LEVELS AND METEOROLOGICAL CONDITIONS

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Abstract: This project examines the practical performance of two solar cookers—the 10m² Scheffler Solar Cooker and the Prince 15 Solar Cooker—on a children's school campus at Vatsalya. A logbook records the type of dishes cooked, the time required for cooking, and the corresponding global horizontal solar irradiance, ambient temperature, wind speed, humidity levels and relative barometric pressure during the cooking period. Data is collected daily from December 2024 to April 2025, providing a simple yet informative approach to understanding the relationship between sunshine levels and solar cooking times. The study focuses on real-world observations, including the time taken to cook common dishes like rice, lentils, and vegetables under varying solar conditions. This practical approach demonstrates the feasibility and reliability of solar cookers in everyday use, the findings highlight how solar energy can be integrated into daily life, making the concept accessible and relatable for children and the community.

Keywords: Solar cooking, solar cooker performance, global horizontal solar irradiance, Scheffler solar cooker, Prince 15 solar cooker, Solar Irradiance, solar thermal food, vegetarian food solar cooking

Holistic and Collaborative Solutions for Scaling Solar Cooking Impact

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Abstract: Solar Cookers International (SCI) empowers communities to adopt sustainable solar cooking solutions through practical tools, policy analysis, and collaborative project implementation.

SCI's capacity building strategy emphasizes collaboration with local partners to develop tailored projects that enhance best practices. In a recent initiative in Yemen, SCI collaborated with Diakonie Katastrophenhilfe (DKH) and Nahda Makers Organization (NMO), to support a pilot program aimed at improving livelihoods and reducing risks for women. The program delivered awareness campaigns, needs assessments, training, 100 household solar cookers, 70 household solar dryers, and 6 communal dryers. SCI's contributions laid the foundation for subsequent vocational training and the scaling of production by Self-Help Groups (SHGs).

Recognizing that successful solar cooking projects require both community engagement and policy support, representatives from NMO joined SCI at COP28 to share their stories and advocate for stronger commitments to clean cooking. Policy progress depends on knowledge sharing, well-documented projects, and a clear understanding of the broader landscape. To inform and guide action, SCI maintains a global solar cooker distribution map—tracking over 4.1 million solar cookers—and produces Economic Impact Summaries, estimating that a worldwide shift to solar cooking could save over $1.36 trillion annually in avoided healthcare and environmental costs. SCI also analyzes Nationally Determined Contributions (NDCs) under the UNFCCC, uncovering a growing recognition of the harms of polluting cooking fuels. These insights help identify high-impact regions for project implementation and strengthen advocacy at forums like the UN Climate Conferences (COP).

By combining well-designed projects like the Yemen initiative with rigorous analysis, SCI has been able to engage decision-makers and catalyze large-scale opportunities. This approach has led to a new collaboration with the Climate Technology Centre and Network (CTCN) to expand solar cooking solutions in Mali and the Central African Republic, where less than 2% of the population has regular access to clean cooking fuels. SCI is now working to meet government requests for technical assistance, focusing on research, training, and the development of local manufacturing capacity.

SCI's work underscores the critical link between technical solutions and an enabling policy environment in scaling solar cooking. By integrating solar cooking into national and international climate policies, SCI's holistic, collaborative model can be expanded to other regions facing similar challenges.

Keywords: solar cooker distribution map, economic impact summaries, Nationally Determined Contributions (NDCs), capacity building, collaborative project implementation, Yemen, Climate Technology Centre and Network (CTCN), Mali, Central African Republic

UPDATE AND IMPROVEMENT OF THE ITALIAN WIKIPEDIA WEBPAGE OF "SOLAR COOKER"

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Abstract: To date, the webpage for "Solar cooker" in the Italian version of Wikipedia is inadequate and virtually devoid of useful information, unlike the corresponding webpages available in other Countries. Among its main scopes, the Italian Solar Cooking Association (AICS) was founded to promote the knowledge, study and utilization of solar cookers, including the techno-scientific fundamentals of the conversion of solar energy into thermal energy that can be used for cooking purposes. For this reason, a working group of AICS has started working on the update and improvement of the Italian Wikipedia webpage of "Solar cooker". The main objective of the AICS working group is to make the Italian webpage a useful and rigorous source of information for all the Italian people that are interested in learning more about solar cooking. Specifically, the webpage will include: an exhaustive definition of solar cooker; the history of solar cookers, with particular reference to Italian contributions; the working principle; a classification of solar cookers; the main available projects and literature works.

Keywords: Solar cooker, Wikipedia, AICS, update, improvement.

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We need more good pictures of solar cookers in the public domain.

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Abstract: Most people could not identify a solar cooker if they saw one. Publicising the existence of solar cookers, and what they can do, is the very first step in disseminating this technology. Youtube videos, web pages, books, magazine articles, and press articles about solar cooking all exist, but solar cooking has not yet been publicised widely enough to ensure recognition. Over the years, both authors have been approached by journalists wanting information about solar cookers. It is in the interests of the solar cooking community to provide information and illustrative pictures to make it easy for journalists, and others, to write about solar cookers This brief paper examines the availability of high quality, free-to-use pictures of solar cookers that might be used by videographers, writers and journalists. Current sources of free, and paid-for pictures are examined and evaluated. Various forms of legal licensing are examined, and a decision tree provided. Finally, a call to action is included, inviting all members of the solar cooking community to make their best pictures available and accessible.

Keywords: Solar cookers, licensed photographs,

DESIGN OPTIMIZATION OF A FOLDABLE AND PORTABLE SOLAR COOKER FOR HUMANITARIAN AND REFUGEE CAMP DEPLOYMENT

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Abstract: Solar cookers are considered an efficient and environmentally friendly alternative to the traditional cooking methods used in humanitarian contexts to prevent harmful effects on health and environment. Recently, a foldable, easy-to-transport, and low-cost solar cooker was specifically developed by Demissie et al. [1] to be deployed in humanitarian and refugee camps. The experimental results showed that the prototype had good thermal performance and was able to cook tomatoes, rice, and potatoes in less than two hours. However, the original study highlighted some limitations about its thermal performance, portability, and usability. For this reason, an improved version of the solar cooker was developed to enhance its thermal performance and complete portability. From the preliminary experimental tests carried out without load using a solar simulator, the new prototype achieved higher values of stagnation temperature and performance parameters with respect to the original version. These results prove the design enhancements ensure performance improvement.

Keywords: Solar cooker, foldable, adjustable reflectors, solar simulator.

[1] Demissie, T. N., Tomassetti, S., Paciarotti, C., Muccioli, M., Di Nicola, G., & Ruivo, C. R. (2024). Experimental characterization of a foldable solar cooker with a trapezoidal cooking chamber and adjustable reflectors. Energy for Sustainable Development, 79, 101409.

SOLAR COOKING FOR PEOPE ENGAGEMENT IN SUSTAINABLE TRANSITION: AN EXAMPLE IN SOUTHER ITALY

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Abstract: Solar cooking is an innovative practice capable of combining science, education, social aggregation, environmental sustainability, and agroecology. Besides having a direct impact on the fossil fuels consumption and individual ecological footprint, it has huge potential as tool to engage people in the sustainable transition. Ecomunera has led a two-years project in southern Italy promoting solar cooking in rural areas with deep depopulation trends. Through workshops, demonstrations, and public events, the project has strengthened social cohesion, bringing people together to collaborate on sustainability efforts. By reinventing local recipes for solar cooking, participants explored new connections between regional agro-ecological products, local identities, and innovative low-carbon practices. This hands-on experience has raised awareness about both the potential and limitations of solar energy while encouraging individuals to rethink their relationship with the environment. In this way, Ecomunera has created a space for learning, cooperation, and cultural exchange, empowering local community for a more sustainable future.

Keywords: Solar, solar cooking, people engagement, sustainable transition, local communities

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Modular design of a single axis Solar Tracker.

Seggy T Segaran

SF Innovations – York, UK

www.sf-innovations.co.uk

Abstract: When solar cooking in the temperate regions of the world, it's necessary to make frequent adjustments to follow the sun across the sky. This is particularly important when the cooking time is expected to be a few hours in a box cooker. A single axis solar tracker will automate the process of following the sun across the sky and allow the person cooking to carry out other tasks. This is also the case when using a solar box cooker for drying. Most tracker designs are DIY and outside the scope of those with no electronic knowledge. We look at a modular design, consisting of a control box, driver motor and platform. The control box includes two solar panels to sense the position of the sun, a microcontroller, electronics and the power source (a 9V PP3 battery). This simple low-cost design allows the average solar cooker enthusiast to build their own single axis solar tracker. Full design details including schematics, parts lists and assembly details are described.

Keywords: Solar cookers, solar tracker

SHAPE OF PARABOLA INFLUENCES COOKING AND SAFETY. MATERIALS USED IN SOLAR COOKERS HAVE ENVIRONMENTAL AND HEALTH IMPACT.

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Abstract: The author attempted to make a first parabolic reflector in the late eighties. In 1991, he built a shallow parabola with a long focal length. To demonstrate its power, he ignited balls of paper in 10 seconds. He found it dangerous, so he built and cooked with several styles of box cooker, for three years in Costa Rica and then 5 years in France. Practical lessons from this period are described

In 1999, he recognized the many disadvantages of using shallow parabolic reflectors, and conceived a deep parabolic solar cooker These advantages are discussed. 2008 the author created the SUNplicity a durable foldable parabolic cooker made from solid aluminium which has since cooked over 500 000 meals world wide from Norway to the Equator. This is produced locally in France, has sold around 3000 units, and won several awards and a label.

The long and short-term environmental and health impacts of the various materials chosen to construct solar cookers are discussed, along with other manufacturing decisions.

Keywords: Solar cooking, Parabolic solar cooker, foldable parabolic solar cooker, deep parabolic, compound parabolic, plastic pollution, micro plastic, phthalates, BPA

8-Abstracts and papers (cont.)

Session 3C

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Marseille-France, 5-7 May, 2025

Bi-energy oven prototype

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K. Loslé, Lytefire, Grenoble-INP Oxalis

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Abstract :

Since 3 years, the non-profit organization Low-tech Lab Grenoble promotes solar concentration to run artisan businesses (bakeries, brewries, restaurants, building materials manufactures, …). The organization builds solar systems, organizes workshops to promote DIY construction and tends to design new solar concentration technologies (5 to 15 m²).

After discussing with several bakers, people of the organization understood that artisans really wish to evolve towards solar concentrator but remain doubtful to run a busyness completely on solar energy. Some of them asked for an oven running on wood energy and solar energy. Instead of having two differrent ovens, and thus having 2 heavy investments, they could have just one oven running with two energy.

To answer to this need and to support them, the organization developped a bi-energy oven prototype. This oven runs with wood-energy and solar concentrated energy.

After one year of research (computation and conception) with Grenoble-INP engineering school, the organization made a prototype in september 2024.

The oven design is based on a Lytefire oven design (Lytefire patent). The wood burner is made with the super efficient Oxalis burner design. This burner is entirely open source. Inside the oven, a heat exchanger enables the oven to see no smokes of the combustion. The exchanger has been made by the organization. The exchanger's design is entirely open source.

The design makes it super efficient : wood combustion releases invisibles smokes (800°C combustion in the insulated burner) and consume few wood logs. The exchanger optimizes the performance : heat extraction permits to have low temperature exhausts (150°C). In a wood-energy mode, the oven reaches 250°C in 45 minutes. This is quite fast for a wood energy oven. Furthermore, the oven remains performant with a 5 m² Lytefire solar concentrator (to be tested soon).

Next step of this project is to lend the prototype to a baker in order to have some feedback (performance, ergonomy, practicality, …). Then the diffusion through the wiki plateform of the Low-tech Lab network.

This design enables artisan to run their business whatever the weather is and so encourage the shift to solar energy.

Keywords : solar, solar concentration, artisans, experimentation, prototype, oven, hybrid, wood combustion, wood energy.

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STUDY OF HYBRID ELECTRIC- SOLAR OVEN CUM DRYER IN THE CLIMATE OF COSTA RICA

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Abstract: Solar Cookers/ ovens are studied by this and many other authors in many countries. The author has been studying and using it at home since 1979 for heating and cooking meals. At the same time author observed the need of drying domestic products because of many advantages, like extending life by removing moisture that can cause spoilage, reduce weight for easy to store, maintains most vitamins, minerals, and more important dried products can be used in various recipes, from snacks to soups etc., all due to minimizing the effect of high humidity in Costa Rica, ranging between 70 to 90% due to its tropical climate. Simple domestic passive Solar Dryer (without fan) was made at home and different products like vegetables, fruits and even herbs have been dried. Also drying needs lower temperature (50-70 ℃) and thus lower solar intensity as compared to cooking meal (90 ℃ or more), thus Solar drying can be done for a greater number of days, as compared to solar cooking. Although most of the time Costa Rica has sunny climate, many times climate is changed without any notice and the user gets frustrated when cooking and/or drying is not completed. Being actively involved in research on Solar Energy, the author decided to combine both devices and at the same time the combined device is hybrid using electricity as secured fuel. As expected, the hybrid multipurpose device works throughout the year with minimum quantity of electricity.

Keywords: Solar cooker, solar drier, hybrid solar-electric device, energy saving.

TO WHAT EXTENT CAN SOLAR OVENS BE USED BY FRENCH BAKERIES?

Guillet G.

Abstract: In France, bakeries suffered particularly badly of the global energy crisis during the winter of 2022-2023. Some bakeries saw their energy costs, usually around 5 % of their turnover, rise to over 50 %. Although intermittent, solar energy can be harvested locally and is therefore not dependent on the market price. Driven by the Neoloco solar bakery and the Le Présage solar restaurant, demand for solar systems for the craft industry is growing. The aim of this work was to discuss the extent to which concentrating solar ovens without heat storage are an answer now and in the future to the needs of French craft bakeries and the demands of their customers. This study gathers information from various market studies and on-site interviews with bakery and oven manufacturers. It confronts them with the constraints associated with the use of solar concentration ovens. Several results can be highlighted. Firstly, at least 54 % of French bakeries are located outside city centres and potentially have open space and access to the sun. Secondly, a secondary source of energy may be needed because ‘traditional’ and ‘classic’ baguettes, the bread preferred by 61 % of French people, are rapidly perishable products that cannot be stored to compensate for the intermittent nature of solar energy. Finally, concentrating solar power systems can be financially competitive in the long term, especially if the cost of energy remains higher than it was before the crisis. On the basis of these results, it appears interesting to develop high-performance hybrid solar systems in order to develop the solar bakery market.

Keywords: solar energy, solar concentrating system, solar bakery, market study

HARNESSING SOLAR CONCENTRATOR TECHNOLOGY FOR SUSTAINABLE MASS COOKING IN THE AMARNATH YATRA, HIMALAYAS

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Abstract: The Amarnath Yatra, an annual Hindu pilgrimage in the remote Himalayas, attracts over a million devotees, presenting significant logistical and environmental challenges, particularly concerning fuel consumption for mass cooking. Traditional reliance on fossil fuels and firewood contributes to air pollution, increases the valley's temperature, and exacerbates the impact on the fragile glacial ecosystem. Recognizing the urgent need for sustainable alternatives, Swaaha Resource Management Pvt Ltd, an Indian start-up, pioneered the implementation of parabolic solar concentrator technology along the Amarnath Yatra route for the first time in its history.

This paper presents a case study of the successful deployment of Scheffler Solar Dishes, a type of parabolic solar concentrator, for community and mass-scale cooking during the Amarnath Yatra. Two models, a community kitchen and a domestic variant, were installed as an initial experiment, demonstrating the capability to efficiently boil water, stew, and cook staple foods like lentils, rice, potatoes, and beverages such as tea and milk. In one base camp alone, this eco-friendly solution facilitated the preparation of meals for approximately 90,000 pilgrims over a 45-day period.

The solar concentrators, with individual installations featuring two 16-square-meter reflective plates, harness solar energy by concentrating sunlight at a focal point, achieving temperatures up to 700°C. This technology effectively replaces the need for conventional fuels, thereby directly contributing to glacier preservation by mitigating the increase in valley temperature and significantly reducing greenhouse gas emissions and smoke pollution along the 16 km and 40 km pilgrimage routes. Furthermore, the initiative empowers local communities in Jammu and Kashmir by introducing them to a reliable and renewable source of energy for cooking, fostering local participation in the operation and maintenance of these systems.

The success of this pilot project has led to plans by the government to scale up the adoption of solar cooking solutions across all 400+ kitchens along the Amarnath Yatra route, signifying a major step towards making the pilgrimage smoke-free and environmentally sustainable. This initiative aligns with the United Nations Sustainable Development Goals 20-30 and showcases a practical, large-scale application of solar thermal technology in a challenging high-altitude environment. The findings of this deployment offer valuable insights into the potential of solar concentrators for sustainable mass cooking in remote areas and at large gatherings globally, demonstrating a pathway towards environmental stewardship and community empowerment through innovative renewable energy solutions.

Keywords: Solar Concentrator, Solar Thermal Cooking, Mass Cooking, Sustainable Development, Eco-Friendly, Amarnath Yatra, Himalayas, Glacier Preservation, Community Kitchen, Renewable Energy

BOX TYPE SOLAR COOKER COMPONENTS ROLE IN IMPROVING PERFORMANCE FOR SOCIETY ACCEPTANCE

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Abstract: Box Cooker Consists of in side box and out side box in between the box thermal insulation. By reducing surface area inner box the temperature inside box increases. The inner box is of shape compound paraboloid cross section in square(two parabolas focal axis is perpendicular).This shape useful in reflect/deflect sun ray/radiations and surface heating of cooking vessel in addition to top lid heating. This shape useful in receiving vertical rays of sun noon period . Approximate curved reflector made from half pyramid(two sides of pyramid) tied to outer box with flexible rope to with stand wind load and for tilt adjustment also .It covers 2 sides of box and reflects sun light in to box cooker through top cover glasses in inclined portion of sun light. Reflector used is mirror segments. 14 nos mirror segments reflections are overlaps and higher temperatures generates to boil/ frying / drying food. This reflector tracks sun. Only at noon to be rotated to once in a day for tracking. This ensures improved performance of cooker and acceptance solar cooking in society increases

Key words: compound parabolic trough, approximated curved of pyramid reflector, increased society acceptance

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The Importance of Promoting Solar Cookers as part of an Integrated Cooking System

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Abstract:

Keywords: Integrated cooking, solar parabolic, solar box and solar panel cookers, biomass stoves, retained heat containers, hay boxes, simmer function,

There are two simple technologies that can cook food using no fuel at all: 1. A solar cooker; and 2. A hay box (*a well-insulated container stuffed with dried grass, cloth, or crumpled paper*). Well-made hay boxes can significantly reduce fuel usage on cloudy days (when solar cookers don't work) by simmering pots of food for several hours after they've been brought to a boil over a fire for 15-20 minutes. Hay boxes can also keep solar cooked food hot for hours after the sun has set, allowing families to enjoy hot meals in the evening. Solar cookers used in some countries are still today presented as a replacement for biomass and other stoves. Since the sun doesn't always shine, this is simply not possible. I urge vendors and instructors to always present solar cookers as part of a three-pronged, integrated cooking system. Once customers understand how this system works, they will be able to cook food (and save fuel) no matter what the weather.