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# DESIGN OF SOLAR STOVE WITH HEAT STORING MATERIAL USING PV CELLS

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## ABSTRACT

**Purpose:** This study aims to develop a cost-effective and environmentally sustainable solar cooking solution for urban and rural populations in developing nations, where the majority rely on non-commercial sources of cooking energy.

**Design/Methodology/Approach:** The research involves designing a solar stove incorporating a thermal battery, heat-storing materials, and a photovoltaic system. Experimental trials were conducted to determine the melting points and density of different heat-storing materials: potassium nitrate, sodium nitrate, and their combination.

**Findings:** The experimental results indicate that a potassium and sodium nitrate mixture provides superior heat storage and release performance compared to the individual components. This combination shows promise for maintaining the necessary temperatures for cooking even in the absence of direct sunlight.

**Research Limitation:** The study is limited to specific heat-storing materials and laboratory-scale experiments, which may differ from real-world conditions.

**Practical Implication:** It could be especially beneficial for off-grid and rural areas in developing countries where traditional fuel sources are scarce or costly.

**Social Implication:** This research offers a renewable energy-based cooking method, improving energy accessibility, health, and quality of life for low-income populations.

**Originality/Value:** It utilises a combination of heat-storing materials that enhances the efficiency and reliability of cooking during off-sunshine hours, distinguishing it from other solar cooking technologies.

***Keywords:*** *Heating coil. photovoltaic cells. solar stove. storage. sustainable*

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## INTRODUCTION

Due to the enormous disparity between energy consumption and production, several developing countries have experienced energy crises in recent years. Renewable energy sources can help reduce this problem to some degree. Solar power is the most appealing renewable energy source.

Solar energy has great promise in India. Most of India enjoys approximately 275 bright days per year and solar radiation levels between 5 kWh/$m^2$ and 7 kWh/$m^2$. Parabolic and box-style solar cookers are the two most popular solar cookers. An economical and environmentally conscious way to heat food is with solar energy. Domestic solar cookers have a sizable customer base. Sunlight and heat alone can cook food, but there are certain downsides to this method. One possible solution to these problems is to use a solar stove in conjunction with a PV cell thermal battery(Malik et al., 2020).

Solar power is abundant but not static; its strength changes with the seasons and geographical regions. Because of the problems mentioned before, solar thermal systems are not as often used or trusted as other, more conventional options. A solar thermal system's reliability can be enhanced with a well-designed heat storage system that connects energy demand and supply. Thermochemical energy, sensible heat, and latent heat are the three possible forms of heat storage.

To store heat effectively, systems can increase or decrease the temperature of the material used, which can be either a solid (like ceramics) or a liquid (like molten salt). A connection exists between latent heat storage and the storage material's phase change. Phase change materials (PCMs) physically change states from solid to liquid or back again.

High-temperature PCM-storage research focuses on structures that employ a two-phase heat transfer fluid water and steam in the absorber. Thermochemical heat storage is based on reversible thermochemical reactions. The chemical components that were used to store energy during the first endothermic process are released during an exothermic reverse reaction. Research into the possible function of hydroxide salts in CSP has focused on their breakdown into oxides and steam(Gawande & Ingole, 2019).

Due to several desirable characteristics, including chemical stability, non-corrosiveness, low vapour pressure, and low volume change during phase transformation, latent heat storage is favoured over other energy storage technologies. Multiple investigations have examined latent heat storage devices' thermal and heat transport properties, both during charging and discharging, with different geometrical designs.

Authors are developing a solar stove powered by a thermal battery using photovoltaic (PV) cells. The thermal battery, which comprises a heating coil and heat-storing material, helps cook food consistently even when the sun isn't out.

## THEORIES UNDERPINNING THE STUDY

Malik et al. (2020) found that when mixed with renewable energy sources, potash alum forms a phase transition material that can store heat at relatively low temperatures for eventual use in everyday heating needs. A parabolic dish, which also functions as a heat collector, focuses the sun's rays onto a single spot on a receiving tank. Using a pump, a heat transfer fluid is circulated from the solar collector to the storage tank. Indoor thermal energy storage and utilisation (including cooking, heating, and other uses with temperatures below 92 °C is demonstrated by the experimental results (Malik et al., 2020; Komolafe & Okonkwo, 2022a).

Solar cooking heat storage and transmission devices are compared in this work. Important details are covered, such as the process for creating the heat storage system, the materials needed and their characteristics, the types of insulation needed, and the requirements for heat storage. We also take a look at some of the most practical resources (Gawande & Ingole, 2019).

Among the system's appealing qualities are its adaptability, the ability to manage the flow of heat within the pots, the ability to cook indoors and at night, and the option of adding a baking oven. In Germany, the city of Juelich was home to the initial prototype of this collector-cooker system. There was much work put into the subsequent versions before they were sent to Mali and India. Africa (namely South Africa and Burkina Faso) and South and Central America also received additional systems. Roughly 250 systems of varying sizes have been constructed for private households and public agencies. The outstanding findings from the experiments are detailed in this piece (Schwarzer & Vieira da Silva, 2003a ;Balachandran & Swaminathan, 2022).

The thermal efficiency achieved after boiling water was 35.8%, and the highest cooking power was 48.4 W, according to the testing. The cooking power values for edibles ranged from 42.5 to 58.2, while the efficiency values were between 34.5 and 40.3%. The highest solar radiation levels throughout the cooking trial were 986, 975, 956, and 953 W/m2. Overall, the results show that the solar cooking system is a good substitute for the harmful traditional methods of cooking with wood and other biomass products that people in poor nations have to deal with every day (Komolafe & Okonkwo, 2022b:Missana et al., 2020).

This study uses a phase change material (PCM) heat storage tank to develop and build an urban solar food preparation system. The system was experimentally tested for thermal performance in Mumbai, India. Current research uses commercial-grade erythritol as PCM to store solar heat in the tank. Like a residential LPG cooking system, a well-designed and built heat exchanger regulates solar heat energy transfer from the storage tank to the cooking vessel. This solar cooker cooks twice daily for four family members (5000 KJ). On April 19, 2019, rice and potato were cooked in the afternoon and evening. Rice and potatoes take 22 and 29 minutes to cook, respectively. Storage tanks and cooking units were also monitored for heat transfer. Experiments demonstrate that cooking twice daily is as convenient as using LPG stoves. Additionally, it cooked food faster than previous solar cookers (Pawar et al., 2023).

Sunlight condensation-based solar ovens are promising energy-saving and sustainable solar thermal utilities. However, sunlight considerably affects solar oven temperature. This study proposes adding a phase-change heat storage layer to the solar vacuum tube collector and numerically studies its thermal performance. We examined how food beginning temperature affects heat storage layer temperature dispersion. The study found that adding a phase-change heat storage layer (φ40 mm/80 mm × 770 mm) increases the oven's inner wall temperature by 30°C to 80°C while reducing sunshine-induced temperature fluctuations from 100°C to 18°C to 35°C. With a meal beginning temperature of 10°C–50°C, the heat storage layer temperature field is scarcely affected. Analysis of heat storage performance showed that the layer has a particular capacity in all seasons and can store 2718 kJ daily (Xie et al., 2019; Min Choo et al., 2021).

A series of tests examined how HTF flow rate and temperature affect LHS charging and discharging. The radial and longitudinal temperature distributions were taken at different times during charging to study LHS heat transmission. Thermal performance is measured by cumulative energy charged and discharged during LHS charging and discharging. Experimental results suggest that the LHS can supply hot air for food drying during non-sunny hours or low solar energy intensity. Air temperature rise of 17-5°C was achieved during LHS discharge for about 10 hours (Agarwal & Sarviya, 2016).

The use of phase change materials (PCMs) as storage media for off-sunny cooking has been tested. Two concentric cylindrical jars with 2 cm spacing were used. Stearic acid or magnesium nitrate hexahydrate PCMs bridged this gap. Cooker performance is measured by PCM charging and discharging times under different situations. Cooker performance was highly influenced by sun intensity, cooking medium mass, and PCM thermophysical characteristics. The cooker's discharge efficiency was 3–4 times higher than steam and heat-pipe solar cookers, which can be used indoors (Domanski et al., 1995).

Nkhonjera et. al. reviews the research on solar cookers with heat storage and covers their thermal energy storage units, heat storage materials, and cooking performance. It turns out that solar cookers' heat storage mechanisms frequently use containers with a rectangular or cylindrical shape. In terms of performance, 3-stage cookers were superior to 2-stage cookers, and cookers that had the cooking containers integrated with the thermal storage unit were better than those that did not. Cookers that use sensible heat storage see an increase in cooking power when the storage medium's thermal diffusivity is low. However, cookers that use latent heat storage see a drop in cooking power. Lastly, it is demonstrated that there are still promising areas for research in heat storage for cooking, such as developing high-temperature thermal storage units and optimizing the design and heat transmission characteristics of thermal energy storage units (Nkhonjera et al., 2017).

In many parts of the globe, people have created and used solar cooking systems that either include or do not include temporary heat storage. Two primary parts comprise the system: the cooking unit and the solar collectors with reflectors. Incorporating a pebble tank into the system becomes necessary when heat storage is required. Natural thermo-siphon flow is employed to circulate the working fluid, often a vegetable oil, via the copper pipes that link the various parts. Among the system's appealing qualities are its adaptability, the ability to manage the flow of heat within the pots, the ability to cook indoors and at night, and the option of adding a baking oven (Schwarzer & Vieira da Silva, 2003b;Nooraya et al., 2018).

## METHODOLOGY

This research adopts an experimental strategy to evaluate the feasibility and performance of a solar stove integrated with a thermal battery system. The study tests different heat-storing materials and configurations for their ability to retain and release thermal energy effectively for cooking purposes. By conducting controlled experiments on a prototype solar stove, the study assesses the stove's effectiveness in capturing and storing solar energy for reliable cooking during low sunlight conditions.

The sampling technique is purposive, selecting specific heat-storing materials (potassium nitrate, sodium nitrate, and their mixture) based on their known thermal properties. This targeted approach enables a focused evaluation of materials theoretically suitable for latent and sensible heat storage, aligning with the study’s goal of optimising heat retention and transfer in a solar cooking application.

The data were analysed through a comparative analysis of the thermal performance of each heat-storing material. Key metrics included the melting point, heat retention duration, and heat transfer efficiency to the cooking vessel. Experimental results for each material were recorded under standardised conditions, and statistical analysis was conducted to determine which material or combination offered the best thermal properties. The comparative results helped identify the most effective material composition for ensuring cooking reliability during low or no sunlight periods.

Although solar energy is plentiful, it is not constant, and its intensity varies over time and across locations. My solar stove with a thermal battery uses PV cells to improve reliability for cooking and circumvent other cooking issues using solar energy, like its reliance on intensity and availability. A thermal battery contains a heating coil and some kind of heat-storing material. We incorporated latent and sensible heat storage to create this solar stove.

The components of a solar stove are a photovoltaic (PV) panel, heating coil, vessels, insulating material, and heat storage material. Two distinct vessel types, latent heat storage material and sensible heat storage material, will be used in the development and testing of the stove.

Solar photovoltaic (PV) panels collect sunlight, transform it into direct current (DC) electricity, and supply it to an enclosed heating coil in a vessel. The enclosed vessel has a heating coil and a heat storage material, with the coil directly contacting the latter. Therefore, heat-storing medium coils will be used to generate heat, which can be used for cooking during daylight hours and when the sun has set. The main benefit of this solar stove is that it can be used to cook even when the sun is not directly overhead.

Two methods will be used for the cooking:

1. To create a latent heat storage material, a heating coil warms phase-change material (PCM), causing it to change states. The PCM's latent heat will be used for the kitchen stovetop.
2. The cooking is done by using the sensible heat stored in the SHSM after the heating coil has heated it.

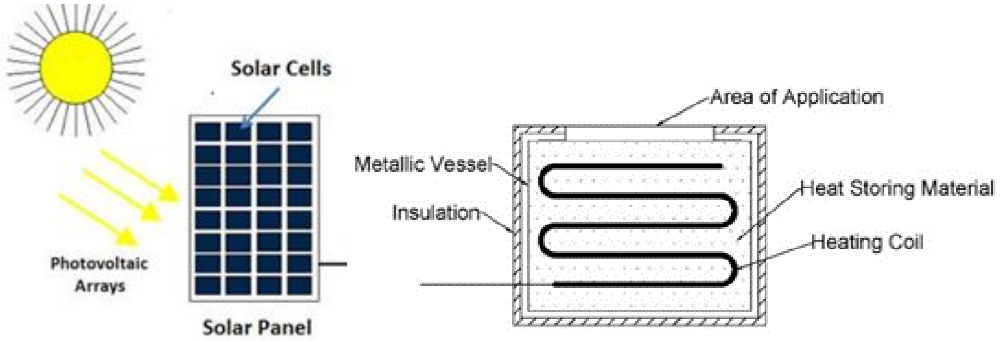

*Figure 1: Schematic Diagram of Solar stove with heat storing material using PV cell*

## Design of Solar Stove

In evaluating the daily heat load required for cooking for a family of four, a detailed calculation has been performed considering various food items and their respective heat requirements. Here is a breakdown:

1. **Rice**: The family requires 2 kg of rice for daily consumption. The heat required to cook 1 kg of rice, including the water, is 562 kJ. Therefore, the heat needed for 2 kg of rice is:

$$\text{Heat required for rice} = 2\ \text{kg} \times 562\ \text{kJ/kg} = 1124\ \text{kJ}$$

2. **Chapatti**: Each chapatti requires a heat rate of 236 watts and takes 1 minute to cook. For a daily intake of 24 chapattis (2 chapattis at each meal, twice a day), the total heat required is calculated as:

$$\text{Heat required for chapatti} = 236\ \text{J/s} \times 24\ \text{chapattis} \times 60\ \text{sec} = 340\ \text{kJ}$$

3. **Curry**: The preparation of 2 kg of goat meat curry demands a significant amount of heat. Given that 1 kg of goat meat curry requires 712 kJ, the total heat for 2 kg is:

$$\text{Heat required for curry} = 2\ \text{kg} \times 712\ \text{kJ/kg} = 1424\ \text{kJ}$$

4. **Milk**: To heat 1 litre of milk from 25°C to 100°C, where the specific heat of milk is 3.93 kJ/kg·K, the required heat is:

$$\text{Heat required for milk} = 1\ \text{kg} \times 3.93\ \text{kJ/kg.K} \times (100-25)\ ^\circ\text{C} = 295\ \text{kJ}$$

5. **Tea**: Similarly, heating 1 litre of tea from 25°C to 100°C, with a specific heat of 4.187 kJ/kg·K, requires:

$$\text{Heat required for tea} = 1\ \text{kg} \times 4.187\ \text{kJ/kg.K} \times (100-25)\ ^\circ\text{C} = 314\ \text{kJ}$$

6. **Boiling Water**: Boiling 3 litres of water from 25°C to 100°C, with a specific heat of 4.187 kJ/kg·K, requires:

$$\text{Heat required for boiling water} = 3\ \text{kg} \times 4.187\ \text{kJ/kg.K} \times (100-25)\ ^\circ\text{C} = 565\ \text{kJ}$$

Summing up all these heat requirements provides the total energy needed for daily cooking:

$$\text{Total heat required} = 1124\ \text{kJ (Rice)} + 340\ \text{kJ (Chapatti)} + 1424\ \text{kJ (Curry)} + 295\ \text{kJ (Milk)} + 314\ \text{kJ (Tea)} + 565\ \text{kJ (Boiling Water)} = 4098\ \text{kJ}$$

Since heat loss in the cooking process due to inefficiencies in utensils and methods is estimated at 40%, only 60% of the heat energy is effectively used. Thus, the total heat load required is:

$$\text{Total heat load} = 4098\ \text{kJ}0.6 = 6830\ \text{kJ} \approx 6.83\ \text{MJ}$$

Therefore, the total heat load required for cooking the daily meals for a family of four is approximately **6.83 MJ**. This calculation will inform the design and planning of cooking appliances and energy systems to meet the household's needs efficiently.

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*Table 1: Totalheat load calculation as per the requirement to cook food*

| Sr. No. | Type of food | Required quantity of food in kg or item | Heat required to cook per kg of food or per unit of item | Total heat required to cook food |
|---|---|---|---|---|
| 1 | Rice | 2 kg | 562 kJ/kg | 1124 kJ |
| 2 | Chapatti | 24 | 14.16 kJ/kg | 340 kJ |
| 3 | Curry | 2 kg | 712 kJ/kg | 1424 kJ |
| 4 | Milk | 1 ltr | 295 kJ/kg | 295 kJ |
| 5 | Tea | 1 ltr | 314 kJ/kg | 314 kJ |
| 6 | Boiling water | 3 ltr | 188.3 kJ/kg | 565 kJ |
| | | | Total | 4062 kJ |

**Power Source Calculations:**
Power source for storing heat,
For negligible operating costs, the solar power source is preferable.
For solar panels (photovoltaic cells),
The average intensity of solar radiation in India is 680 $watt/m^2$
Average Efficiency of solar panels = 20 %
Therefore for 6.77 MJ heat storage in standard sunlight for approximately 6 hours (from 10 am to 4 pm)

$$Area\ of\ solar\ cells\ required = \frac{Total\ heat\ to\ store}{Eff.of\ solar\ panel\ \times Time\ \times Solar\ radiation} = 2.3\ m^2$$

Also, If the capacity of solar panels is 150-watt then,

$$No.of\ solar\ panels\ required = \frac{Total\ heat\ required}{Solar\ panel\ capacity\ \times time} = 2.01\ \cong 3$$

According to the calculation of the power source, 3 solar panels with a 150-watt capacity are required.

**Design for Pot**

Several key criteria must be met in selecting mild steel for the containment of phase change materials (PCM) and sensible heat storage materials (SHSM). The material should be non-reactive with both the PCM and SHSM to avoid chemical interactions that could compromise the system. Additionally, the material must resist corrosion to ensure longevity and maintain structural integrity over time. It is also crucial for the material to possess sufficient strength to withstand the thermal stresses induced by temperature fluctuations. Cost-effectiveness and ease of availability are practical considerations, making mild steel a suitable choice. Furthermore, a lighter weight is advantageous for ease of handling and installation.

Despite its properties, mild steel is chosen for this application based on these criteria. Its melting point is 1550 °C, ensuring it remains solid and stable under the system's operational conditions. The carbon content of mild steel ranges from 0.05% to 0.25%, and it contains about 0.4% manganese, contributing to its strength and durability. The ultimate tensile strength of mild steel is 250 MPa, and its Poisson ratio is 0.303, which indicates its ability to endure deformation under stress.

The selected PCM is stable up to 900 °C, and assuming the gas inside the pot can be approximated as an ideal gas, the pressure within the pot at 560 °C can be calculated under constant volume conditions. According to the ideal gas law, which states that pressure and temperature are directly proportional at constant volume, the pressure at 560 °C can be derived from the known pressure at a different temperature. This approach assumes the system behaves ideally, simplifying the analysis but providing a reasonable estimate for practical purposes.
For constant Volume,

$$\frac{P1}{T1} = \frac{P2}{T2}$$

$P1 = 1.01325$ Bar, $T1 = 273 + 27 = 300\ ^\circ\mathrm{C}$ and $T2 = 273 + 560 = 833\ ^\circ\mathrm{C}$

Therefore, $P2 = \frac{1.01325 \times 833}{300} = 2.813 \cong 3\ Bar = 0.3\ MPa$

For ductile material, using Clavarino's and Birnie's equation for thickness,

$$t = \frac{Di}{2}\left[\sqrt{\frac{\sigma + (1 - 2\mu)Pi}{\sigma - (1 + \mu)Pi}} - 1\right] = 1.41 \cong 1.5\ mm$$

$\mathrm{t} =$ thickness of pressure vessel
$\mathrm{Di} =$ internal Dia. of Pressure vessel
$\mu =$ poisson's ratio
$\sigma =$ tensile stress
$\mathrm{Pi} =$ Internal pressure of vessel
But for avoiding accidents and safety purposes multiplying the thickness by factor of safety 2.67,
Final thickness $= \mathrm{t} \times 2.67 = 1.5 \times 2.67 = 4\ \mathrm{mm}$

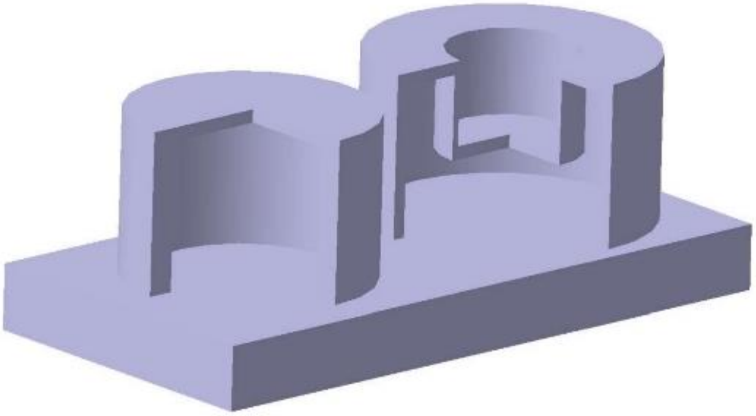

*Figure 2: Cylindrical and pot in pot geometry for PCM and SHSM containing pot*

## MATERIAL TESTING

Various types of molten salts are available in the market. The best suitable material has been identified after studying various salts and collecting standard data from various literature. Due to the following characteristics, a Eutectoid mixture of potassium nitrate and sodium nitrate is finalised for use.

- Low melting point suitable for cooking application
- Good heat capacity
- High energy density
- Low latent heat of fusion
- Easily available in bulk quantity
- Low cost

Once a suitable phase change material is selected, a sample is ordered, and a test is conducted on it. The sample is tested to compare its actual properties to the standard specification of the material, which will also ensure the quality of the material ordered.

Testing procedure:

First, the density of each substance is determined by taking their measurements. Two substances are combined in a 60/40 ratio: 60% $NaNO_3$ and 40% $KNO_3$. The next step is to determine the mixture's density.

It is heated using induction after estimating its density to determine the material's melting points. Start by heating potassium nitrate independently and noting its results. The sodium nitrate is heated before heating a mixture of potassium nitrate and sodium nitrate.

Plates 1 (b) and 3 (c) show results from testing a eutectoid mixture of potassium and sodium nitrate.

(a) Sample material (b) Before Heating (c) After heating (molten form)

*Plate 1: Test result of sample material before and after heating*

## RESULT AND DISCUSSION

The investigation confirmed that a eutectoid mixture of potassium nitrate and sodium nitrate is the most suitable material for thermal storage in the solar stove due to its optimal thermal properties, cost-effectiveness, and ease of availability. The testing results are summarised in Table 2, where the mixture demonstrated distinct advantages over the individual components.

*Table 2: Parametric investigation of potassium nitrate, sodium nitrate and its mixture*

| S/N | Parameters | Potassium nitrate | Sodium Nitrate | Mixture of Potassium Nitrate and sodium Nitrate |
|---|---|---|---|---|
| 1. | Density | 2110 kg/m$^3$ | 1201 kg/m$^3$ | 1750 kg/m$^3$ |
| 2. | Actual Density | 2200.2 kg/m$^3$ | 1355.6 kg/m$^3$ | 1640.4 kg/m$^3$ |
| 3. | Melting Point | 334ºC | 308ºC | 222ºC |
| 4. | Actual Melting point | 329ºC | 315ºC | 229ºC |

### Density Analysis

The density of potassium nitrate and sodium nitrate alone was analysed in a 60/40 mixture. Potassium nitrate had a density of 2110 kg/m$^3$, and sodium nitrate had a density of 1201 kg/m$^3$. The mixture's density was recorded at 1750 kg/m$^3$, closely aligning with expectations, while actual densities slightly deviated due to variations in sample purity or minor experimental conditions. The mixture achieved a moderate density of 1640.4 kg/m$^3$, making it manageable for thermal storage without adding excessive weight to the system.

## Melting Point Analysis

One of the primary objectives was to identify a material with a low melting point suitable for cooking applications. Potassium nitrate and sodium nitrate, in isolation, displayed melting points of 334°C and 308°C, respectively, with actual melting points recorded as 329°C and 315°C. The eutectoid mixture significantly reduced the melting point to 222°C, with an actual measured melting point of 229°C, making it highly advantageous for storing and releasing thermal energy at temperatures optimal for cooking. This lower melting point reduces energy demands and enhances the mixture's effectiveness as a phase-change material in the thermal battery.

## Heat Capacity and Energy Density

The eutectoid mixture exhibited high heat capacity and energy density, which is ideal for retaining heat over extended periods. These characteristics enable the solar stove to provide reliable cooking even during low sunlight. Although the latent heat of fusion was low, it proved sufficient for sustained thermal retention. The choice of this mixture thus balances cost, thermal efficiency, and storage capacity, achieving energy storage suitable for solar cooking applications.

The study outlined in this project closely aligns with the findings of previous literature, particularly those of (Xie et al., 2019) and (Schwarzer & Vieira da Silva, 2003). The work of (Xie et al., 2019) emphasised the importance of phase-change heat storage for solar ovens, explicitly highlighting the role of materials like potassium nitrate and sodium nitrate in improving thermal performance. The current study's findings on the eutectoid mixture of potassium nitrate and sodium nitrate, which significantly reduces the melting point to 222°C, reinforce the thermal advantages of using such mixtures for solar cooking systems. This reduction in melting point, as observed in the present study, aligns with Xie et al.'s conclusion that phase-change materials can significantly enhance the efficiency of solar cooking systems by enabling effective heat storage and release at optimal temperatures for cooking. Moreover, both studies note the practicality of using materials that offer low-energy demands, making the system more sustainable.

Schwarzer and Vieira da Silva (2003) discussed solar cooking systems with and without heat storage, emphasising their applicability in family and institutional settings. Similarly, this project’s focus on integrating heat storage materials into the solar cooker adds a critical layer of energy management, essential for ensuring consistent cooking even under fluctuating solar conditions. The density and heat capacity analysis presented in the current study further supports the viability of using potassium nitrate and sodium nitrate mixtures, as these materials provide a low melting point and exhibit a desirable balance of density and energy storage. As shown by the data, these characteristics are crucial for ensuring that the thermal storage system does not add excessive weight or cost while maintaining effective thermal retention, thereby ensuring the system's practicality for widespread use.

Regarding practical implications, the thermal storage system described here and the solar cooking applications discussed by Schwarzer and Vieira da Silva could be particularly beneficial for rural areas, where biomass fuels and firewood use have been identified as significant health risks. By adopting solar cooking systems with phase-change materials, such as those discussed in the literature and validated by this study, communities could mitigate these risks while improving energy efficiency and sustainability. The novel approach of integrating tracking technology, heat storage, and efficient cooking methods presented in this study thus adds to the growing body of literature on solar cooking systems, providing a robust solution to both energy and health challenges.

## CONCLUSION

This project develops a solar cooking system with a tracking device and heat storage materials (potassium nitrate and sodium nitrate) to reduce reliance on firewood and biomass in rural households. The system was built using local resources and tested for cooking efficiency. Key findings include a 4 mm pot thickness, accelerated melting near the top due to buoyant effects, and a reduced melting point of the nitrate mixture to 222°C. Three 150-watt solar panels provided sufficient energy for six hours of cooking. The system offers a sustainable alternative to biomass fuels, improving public health and promoting cleaner cooking practices. Its integration of solar tracking and phase-change materials optimises cooking efficiency, addressing energy and health challenges.

This project develops and tests a solar cooking system with a tracking device and a eutectoid mixture of potassium nitrate and sodium nitrate as a heat storage material, enabling cooking even during low sunlight. The system's design, which includes three 150-watt solar panels, is efficient and cost-effective, making it suitable for rural households. Key findings include a reduced melting point for the heat storage mixture, faster melting due to buoyancy effects, and enhanced cooking performance with higher sunlight intensity. This solar cooker reduces reliance on firewood and fossil fuels, improving indoor air quality and reducing health risks associated with biomass smoke. The system's novelty lies in its optimised thermal storage, local material use, and adaptability to rural needs, promoting cleaner, sustainable cooking alternatives.

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