MISSED OPPORTUNITY IN DECARBONIZING HEAT 77 YEARS AGO: MARIA TELKES' DOVER HOUSE AND FORWARD-THINKING VISION

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Abstract

Maria Telkes, often referred to as the "Sun Queen," was a pioneering figure in solar energy technology. This manuscript revisits her innovative contributions, focusing on the Dover Sun House, the world's first solar-heated home, and her groundbreaking work on solar desalination devices and solar ovens. Designed in collaboration with architect Eleanor Raymond in 1948, the Dover Sun House utilized Glauber's salt for thermal energy storage, demonstrating the feasibility of phase-change materials in residential heating. While operational challenges, such as material stratification, limited its success, the project laid the groundwork for future advancements in energy storage technologies. Telkes' solar desalination unit, adopted by the U.S. military, and her solar ovens for remote communities exemplify her ability to combine scientific ingenuity with practical applications. Her work addressed key challenges of energy access and sustainability long before these issues gained global prominence. This manuscript examines Telkes' legacy through a historical and technical lens, linking her pioneering efforts to modern renewable energy solutions. By critically analyzing her successes and the limitations of her designs, this study highlights the relevance of her work in addressing today's energy and climate challenges. Telkes' visionary approach and unwavering commitment to innovation underscore the enduring value of integrating science, sustainability, and practicality.

Through this analysis, the manuscript aims to inspire future research and innovation, emphasizing the importance of revisiting and learning from historical scientific contributions.

Key words*: Maria Telkes, Dover Sun House, solar desalination, phase-change materials, renewable energy*

1. Introduction

Maria Telkes, often referred to as the "Sun Queen," was a trailblazer in the field of solar energy. Her innovations during the mid-20th century, including the Dover Sun House, solar desalination systems, and solar ovens, laid the groundwork for modern renewable energy technologies. At a time when fossil fuels were becoming dominant, Telkes' work provided a forward-thinking alternative, emphasizing the untapped potential of solar energy.

Her most notable project, the Dover Sun House, constructed in 1948, was the world's first solar-heated home. This collaboration with architect Eleanor Raymond, funded by philanthropist Amelia Peabody, demonstrated the feasibility of using phase-change materials for thermal energy storage. Although challenges such as stratification in Glauber's salt hindered the system's long-term functionality, the project offered critical insights into solar heating and energy storage.

Beyond heating, Telkes developed solar-powered desalination units for emergency water purification and solar ovens for sustainable cooking in remote regions. These contributions reflect her dedication to addressing practical problems through scientific innovation. This paper explores her pioneering work, highlighting its relevance to contemporary efforts in decarbonization and renewable energy.

2. Methodology

To examine Maria Telkes' contributions, this study combines a historical and technical analysis of her projects. The methodology involves:

- Primary Sources: Patents, designs, and her published works were reviewed to understand the technical principles and innovations in her projects [1][2][3][4][5].
- Secondary Sources: Biographical texts, academic articles, and interviews provided context about her career and the socio-economic challenges she faced [6][7][8][9].

This mixed-methods approach ensures a comprehensive exploration of her work while situating it within the broader historical and technological context of renewable energy development.

3. Results and Discussion

3.1. Dover Sun House

Every solar design project has to face and solve the following challenges: The process of harnessing solar energy involves the efficient, simple, and cost-effective collecting of winter sunshine. Additionally, it is crucial to store the solar energy obtained on clear winter days in order to use it during periods of darkness. Finally, the stored solar energy needs to be distributed as needed. The accumulated thermal energy needs to be accessible upon request from a thermostatically regulated distribution system that is easy to use, requiring minimal involvement and disruption to the inhabitants [1].

The Dover Sun House (Fig. 1(a)), constructed in Massachusetts in 1948, was a groundbreaking experiment in residential solar heating. It used solar collectors on the south-facing wall to capture energy and Glauber's salt (sodium sulfate decahydrate) as a phase-change material for heat storage (Fig. 1(b)). This system aimed to provide heating for up to five consecutive cloudy days, a remarkable achievement for its time.

Figure 1 (a) Dover house in Massachusetts [10](b) Stacked cans of Glauber's salt [8]

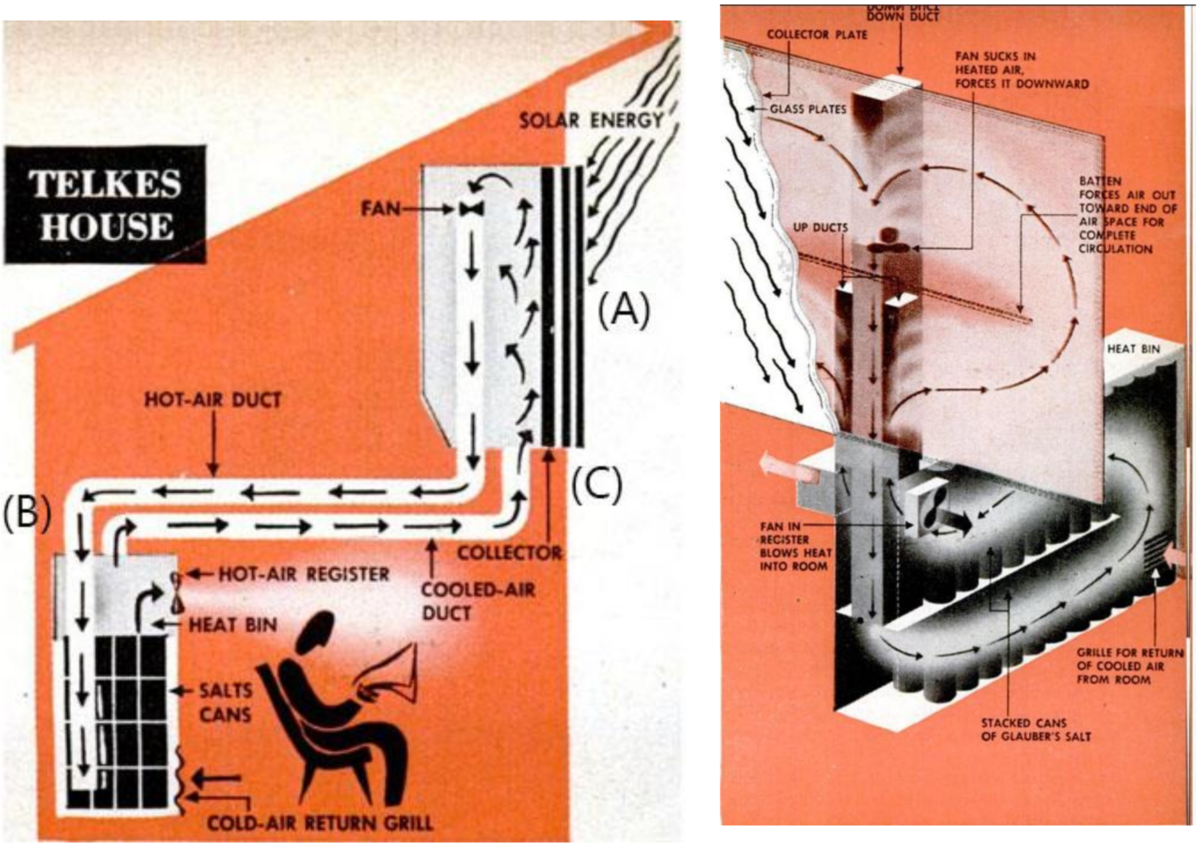


Figure 2 (a) Schematic view of solar Dover house [8](b) Details [8]

Schematic view of solar Dover house is shown in Fig. 2 (a). Air is circulated through ducts, where it absorbs heat from the collector plate (A), before continuing on to the salt-filled heat-storage bins (B) located below. Air space is located between two glasses and insulated wall 7.62 cm thick black-painted sheet steel (C). Here the air circulates around the cans of salt (see Fig 2 (b)), heating them, and returning to the collector for reheating. This circulation is continuous so long as enough solar energy is being received to keep the collector hotter than the cans. A fan register in each room warms the house. Because of the high heat-storage capacity of the salt, there is no need for other heating system. Records show that even in Boston six consecutive days of below-average sunshine occur, on an average, only once in every 14 years.

The house absorbs heat from the collectors that are positioned at the top of the house and retains it in the lower areas. The solar heating system comprises a vertical double-glazed solar air heater (66.9 m^2) installed on the south wall of the building. Additionally, storage bins (see Fig 1(b)) (13.3 m^3) are positioned between the rooms, each containing 19-liter insecticide cans filled with Glauber's salt. Fans are used to distribute the heat from the storage bins to the rooms. A total of 19 t of Phase Change Material (PCM) were present, capable of theoretically storing 1,378 kilowatt-hours (kWh) of energy. Only the ground level, about 135.3 m^2, was heated. The system was built to meet the total heating load, and the storage system is specifically designed to supply heat for a period of 5 days [11]. Telkes' system successfully harnessed and stored solar energy, which was subsequently delivered as required by fans. The storage method she used was based on chemistry. She devised a mechanism in which solar energy could be chemically stored by crystallising a solution of sodium sulphate [12].

The Glauber's salt ($Na_2SO_4 \cdot 10H_2O$) can store about 5 to 10 times as much heat as an equal volume of water can store and 15 to 30 times as much heat as an equal volume of stones can store. Such salt hydrate is ordinarily used in combination with a small amount of nucleating agent and also a small amount of a thickening agent. Regarding energy storage capacity, the phase change material outperforms rock and water storage systems, as shown in Tab. 1 [11].

Table 1 Typical latent heat storage media suitable for solar space heating and for storage of 1000 MJ

	Rock	Water	Phase change material
Specific heat (kJ/kg K)	0.8	4.2	2.1
Heat of fusion (kJ/kg)	-	-	250
Density (kg/m^3)	2240	1000	1500
Weight (kg)	62500	11900	3450
Volume (m^3)	28	12	2.3
Weight ratio	18.1	3.5	1
Volume ratio	12.2	5.2	1

Glauber's salt melts (or freezes) at about 32.2°C. During melting process, salt absorbs 354 MJ/m^3. When it recrystallizes, it gives this heat out again. The salt can soak up about seven times more heat than water. It tends to remain near 32.2°, a useful level for house heating, is comparatively cheap, and can be easily stored in metal cans.

Dr. Telkes identified multiple challenges associated with this widely recognised and cost-effective heat storing substance. Several issues were observed with sodium sulphate decahydrate and other salt hydrates investigated for solar space heating. The general issues include the tendency of crystals to precipitate and the lack of homogeneity that arises from repeated cycles of heating and cooling. Various strategies are proposed to surmount these challenges.

- Incorporate a nucleating agent, such as 3 to 5% borax/sodium tetraborate decahydrate ($Na_2B_4O_7 \cdot 10H_2O$), into sodium sulphate decahydrate.
- Utilise thickening agents with a thixotropic gel-type structure, such as clay (Bentonite, Attapulgite), in combination with sodium sulphate decahydrate to prevent solidification.

- Enclose the latent heat material in multiple shallow containers.
- Periodically stir the container containing the phase change material.
- Add additional water to the salt hydrate.

But using such material has some inherent disadvantages. It is not possible to utilize a set of shallow, sealed boxes or trays that are filled with a salt hydrate formulation that is suited for heating a house in the winter to directly chill the house in the summer. It is kept in its sealed trays at all times. It can freeze in room radiators and prevent additional flow, so it cannot be fed to them. Because of this, heat cannot be transferred by the salt hydrate; it cannot transfer heat to the rooms or retrieve heat from the collector. A solid layer may quickly form on the inside faces of a tray filled with liquid salt hydrate when a stream of cool air begins to extract heat from it. This layer may somewhat obstruct the tray's ability to extract heat further. Similarly, when heat is applied to a tray containing solid-salt hydrate, liquid film form and partially blocks the flow of more heat to the solid component of the tray's contents. However, heat transfer proceeds at a fast enough rate if—as is typically the case—the containers are made of thin, large-area trays.

Nonetheless, the Dover House relied solely on solar energy to provide heating for two and a half winters before the experiment concluded [13].

Today, current practice involves adding certain amounts of nucleating agents, thickeners, and high thermal conductivity agent to Sodium sulfate decahydrate (SSD). Dong [14] in his work examined the issues of supercooling and phase stratification by adding a nucleating agent and a thickener. An optimal material composition was obtained, i.e., SSD:$Na_2B_4O_7 \cdot 10H_2O$:CMC=100:5:3. (carboxymethyl cellulose – CMC). The supercooling degree of the SSD composite phase change material obtained by the optimized formula was only 1.5°C, and the heat release time of the phase change process was 25 minutes. Moreover, no phase stratification occurred. When the mass ratio of expanded graphite reached 9%, the reduction in the supercooling degree of the SSD composite energy storage material was small, only 1.5°C. However, the thermal conductivity was significantly increased by 3.9 times, reaching 2.13 W/(m·K). At the same time, the heat storage time of the composite material was reduced by 30.8%, and the heat release time was reduced by 37.3%, thereby enhancing the heat exchange. The SSD/expanded graphite composite heat storage material was subjected to multiple melting-solidification thermal cycle experiments. As the number of cycles increased, the supercooling degree gradually increased, and the heat release time and latent heat of the phase change process decreased. The DSC test results showed that the enthalpy of the phase transition of the material decreased by 9% after 200 heat storage and discharge cycles, and by 19% after 500 cycles. After 200 heat storage and discharge cycles, the results of the DSC method were similar to those of the step-cooling temperature curve method, and the difference between the two test methods was 3%.

There was an opportunity in the late 1950s to transform Boston's West End into an entirely solar-powered neighborhood during its redevelopment [6]. This concept, which would have represented a groundbreaking application of solar technology on a larger scale, was ultimately rejected by MIT and Hoyt Hottel. The project envisioned integrating solar energy systems across the neighborhood, demonstrating the potential of renewable energy in urban development. Moreover, the initiative would have been supported by government funding, providing a unique chance to advance solar technology through substantial public investment. This missed opportunity could have positioned Boston as a global pioneer in sustainable urban planning and accelerated the development and adoption of solar energy technologies.

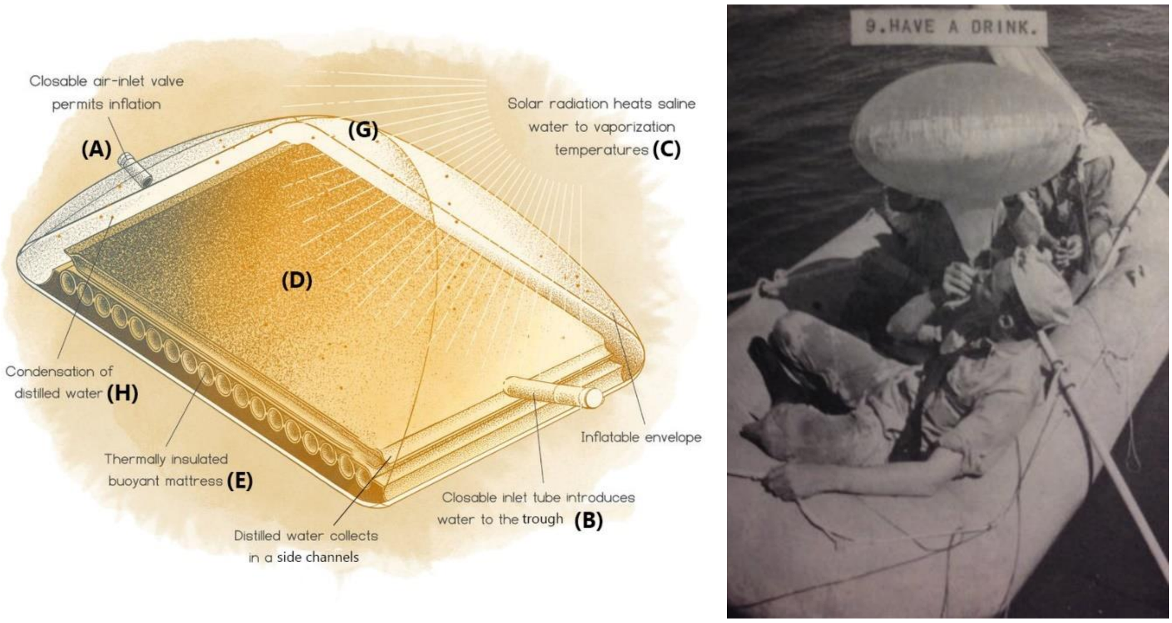
One significant critique [15] of the Dover Sun House was that the electrical costs of running the circulation fans far exceeded any potential savings on oil heating. However, it is important to contextualize this observation within the period: oil was both cheap and widely available at the time.

Today, the circumstances are vastly different. Centralized heating systems face vulnerabilities because the reliability of fuel supply can no longer be taken for granted. The uncertainty of natural gas imports from Russia has placed significant pressure on energy systems, including district heating networks in Serbia, which are heavily reliant on gas. This new reality underscores the need for decentralized and renewable heating solutions, such as solar energy systems, that are less dependent on external fuel sources and more resilient to supply chain disruptions.

3.2. Solar Desalination Devices

Telkes designed a compact solar still that used solar radiation to purify seawater, transforming it into potable water. This device became a standard component of U.S. military emergency kits during World War II.

The still (Fig. 3(a)) used a transparent cover to trap solar heat, evaporating seawater and condensing it into fresh water. The first step in the process involves inflating the desalinator using closable air-inlet through side pipe (A). The envelope is transparent and acts as a condensing surface for water vapor. Saltwater is introduced through closable inlet tube (B). Closable inlet tube is connected to the trough. Trough is painted black for better sunlight absorption. As solar radiation heats the desalinator (C), the saltwater in trough begins to evaporate (D). The bottom side of the desalinator is thermally insulated (E). Water vapour condenses as a thin film on the inner surface of the envelope (G). Distilled water is collected in side channels (H). These side channels are connected to a pipe which is placed at the bottom and fresh water can be consumed (see Fig. 3(b)) [16].



(a) (b)

Figure 3 (a) Telkes solar still [9](b) solar still in use [17]

Beyond military use, it served as a sustainable solution for water-scarce regions, underscoring Telkes' practical approach to renewable technology.

Over 50% of the world's population, around 4 billion people, live under severe water stress for at least one month each year, a situation expected to worsen with an additional 1 billion people facing extreme stress by 2050. [18] Seawater desalination is emerging as a vital solution for securing a sustainable freshwater supply, given that seawater covers about 75% of the Earth's surface, making it one of the most promising technologies.

Conventional desalination methods have long outperformed solar technologies. Mária Telkes' work focused on volumetric heating of bulk water, but this approach suffers from high heat losses. A more efficient alternative is localized heating at the evaporation interface, achieved by integrating advanced photothermal materials into solar stills, significantly improving solar-to-vapor conversion efficiency.

A major challenge in solar desalination is salt accumulation, which degrades performance by blocking light absorption and restricting vapor escape, reducing evaporation efficiency. However, various innovations are narrowing the economic gap between solar and conventional techniques:

• Thermohaline Convection-Enhanced Solar Distillation [19]: This method replaces the capillary wick with a confined saline layer as the evaporator, separated from the condenser by an air gap to enhance vapor transport while minimizing heat loss. Passive saline supply is achieved through gravity-driven flow. Thermohaline convection in the confined saline layer triggers salt rejection, enhancing water production efficiency and reliability. This improvement could lower the cost of distilled water by a factor of ten.

• Self-Rotating Solar Evaporator [20]: The cylinder is covered with a textile made from polyvinyl alcohol (PVA) and coated with carbon nanotubes (CNTs). This combination improves the fabric's properties, especially for efficient water transport. Water evaporates rapidly with minimal heat loss, while crystallized salts accumulate on the surface. When enough salt is deposited, the imbalance between gravity and buoyancy triggers the evaporator's self-rotation, dissolving the salts back into the solution and exposing a fresh evaporation surface.

• Flexible and Salt-Resistant Janus Absorbers [21]: This approach decouples solar absorption and water pumping into separate layers. A hydrophobic carbon black/poly(methyl methacrylate) (PMMA) upper layer absorbs sunlight, while a hydrophilic polyacrylonitrile (PAN) lower layer facilitates water transport.

• Osmotic Pumping and Salt Rejection via Polyelectrolyte Hydrogel [22]: A polyelectrolyte hydrogel foam (PHF) embedded in microporous carbon foam (CF) creates an ionic pumping effect, enabling high osmotic pressure for liquid transport while effectively rejecting salt.

• 3D Cup-Shaped Solar Evaporator [23]: Designed for zero-liquid discharge (ZLD) desalination, this device separates the light-absorbing surface from the salt precipitation area, preventing light blockage by salt crusts, which is a common issue in conventional 2D solar evaporators.

• Hanging Photothermal Fabrics [24]: A hydrophilic, polymer nanorod-coated fabric is suspended for indirect-contact evaporation. Water is drawn through capillary suction, while both top and bottom arc-shaped surfaces remain exposed to air, reducing heat dissipation and promoting double-sided evaporation under sunlight.

These advancements bring solar desalination closer to economic viability, addressing both efficiency and salt management challenges.

3.3. Solar Ovens

Telkes also designed solar ovens capable of reaching temperatures of 210°C, providing an eco-friendly alternative to traditional cooking methods [2].

Solar oven contains adjustable metallic reflector, door, pot and glazed glass (see Fig. 4). The sunlight rays (A) are directed using an adjustable metallic reflector (B) into the glazed glass (C). Light rays pass through glass panels (double or triple-glazed window), allowing the rays to enter and heat up the interior of the oven. As the pot absorbs the sunlight, the temperature increases, heating the contents inside. The door (D) of the oven can be positioned on the back or top of the oven based on its design.

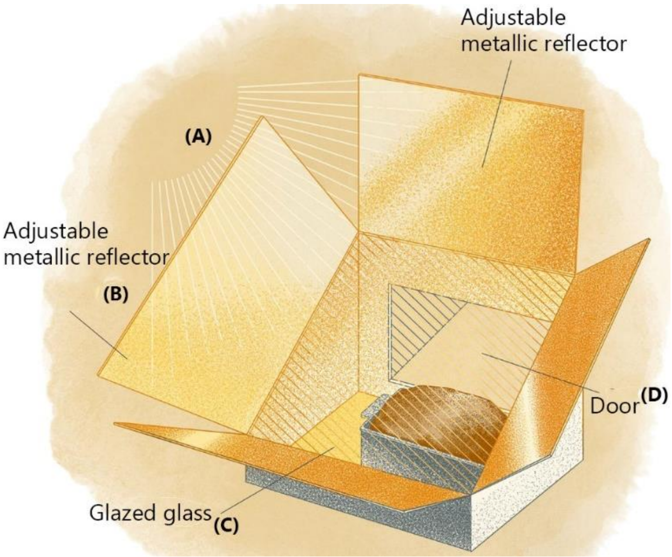


Figure 4 Solar oven [9]

Telkes' solar oven was put into use in Africa. Daniel Kammen, a physicist from Princeton University, has conducted workshops on constructing and utilizing solar ovens in Central America and Africa since the mid-1980s. Kammen characterizes Telkes' design as remarkably straightforward, workers prefer to construct a container resembling a large microwave oven from a plywood sheet measuring 2.4 by 1.2 meters. The upper part comprises two layers of transparent glass, while the lower part, serving as a support for cooking pots, consists of a black-painted metal sheet. Aluminum foil covers both the inner walls and a protective front lid that opens above the oven. Access is provided through a hinged door in the front wall [25].

These ovens:

- Reduced Environmental Impact: Eliminated the need for wood fuel, preserving forests and reducing indoor air pollution.
- Improved Nutrition: Retained more nutrients in food compared to conventional cooking techniques.

Her designs, such as triangular and cylindrical ovens, were tailored for tropical regions and aimed to promote sustainability in low-income communities.

In low-income societies, cooking is a fundamental and energy-intensive activity. However, the widespread use of polluting fuels like wood and cattle manure leads to severe health and environmental issues. Building on the work of Maria Telkes, advancements in solar ovens have continued [26].

One study [27] explores solar cooking at night using phase change materials (PCMs) such as stearic acid and magnesium nitrate hexahydrate (MNHH). It was found that most foods cook below

100°C, with meat becoming tender at 75°C. Cooking time is another important parameter; during the solidification of MNHH, a cooking time of approximately 70 minutes is achieved, is suitable. Generally, cooking time depends on the mass and initial temperature of the cooking medium, as well as the solidification temperature of the PCM. The melting point of MNHH, at 89°C, is suitable for this purpose. Additionally, with magnesium chloride hexahydrate ($MgCl_2 \cdot 6H_2O$), which has a melting point of 116.7°C, even boiling water is achievable.

Another study [28] examines transparent insulation materials (TIMs) to reduce heat loss in solar cookers. Testing in a solar simulator showed that a 40 mm TIM layer increased stagnation temperature to 158°C, improving efficiency from 15.7% to 30.47%. However, increasing TIM thickness to 100 mm provided little additional benefit.

Research [29] investigates the use of SiO_2/TiO_2 nanoparticles in a stepped solar box cooker (SSBC). These nanoparticles, applied in coatings from 5% to 25%, improved thermal efficiency, with 15% yielding a 31.42% increase. The best performance was observed at 15% doping, significantly enhancing heat absorption and cooking efficiency.

SUNTASTE solar oven, [30] constructed from cork agglomerate for both insulation and structural integrity. This design supports food preparation, dehydration, and dairy production.

Another low-cost solution is the Kyoto Sunlight Cooker, made from materials like cardboard and sawdust. Properly sized mirrors significantly improve its efficiency.[31]

Following previous low-cost approach, [32] discusses the "Copenhagen" sunlight cooker, which can be disassembled to fit within a compact mailing package.

3.4. Broader Impacts

Telkes' work reflects her commitment to integrating science with societal needs. Her use of phase-change materials and solar technology prefigured modern advancements in thermal energy storage and renewable energy applications.

As one of the few women in a male-dominated field, Telkes faced significant challenges, yet her persistence inspired generations of scientists.

Many of her ideas, such as combining solar power with innovative materials, remain relevant in addressing today's climate and energy challenges.

4. Conclusion

Maria Telkes' contributions to solar energy exemplify the intersection of innovation, resilience, and foresight. Projects like the Dover Sun House, solar desalination units, and solar ovens highlighted her ability to combine scientific principles with practical solutions for pressing societal needs.

Her visionary outlook is encapsulated in her 1951 statement: *"Sunlight will be used as a source of energy sooner or later anyway. Why wait?"* This sentiment remains strikingly relevant as the world grapples with the dual crises of climate change and energy sustainability.

Maria Telkes' work exemplifies the persistent pursuit of innovation despite technical and societal challenges. Her words at a symposium encapsulate the essence of her approach: *"The problem of the sun-heated house cannot be solved by one or two experimental houses. But each new house is another experimental stepping stone toward the use of the sun as a fuel resource."* This perspective underscores the importance of continuous experimentation and gradual progress in the development of renewable energy technologies.

Telkes' legacy serves as a reminder that addressing global challenges requires perseverance, creativity, and a willingness to take risks. By revisiting her work, we not only honor her achievements but also draw inspiration for future innovations in renewable energy.

Further research could delve deeper into the modern applications of her methodologies and the lessons her career offers for integrating science and policy in tackling today's environmental challenges.

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References

[1] Telkes, M., A Review of Solar House Heating, Heating and Ventilating Reference Section, Sept. 1949, pp. 68-74, [Online]. Available: https://fedora.phaidra.univie.ac.at/fedora/get/o:134295/bdef:Content/get . [Accessed: Dec. 17, 2024].

[2] Telkes, M., Andrassy, S., Practical solar cooking ovens, UN Conference on New Sources of Energy, Rome, 21-31 August 1961, 8 pp. [Online]. Available: https://digitallibrary.un.org/record/3833442?v=pdf . [Accessed: Dec. 17, 2024].

[3] Telkes, M., Fresh water from sea water by solar distillation, *Industrial & Engineering Chemistry*, 45 (1953), 5, pp. 1108-1114

[4] Telkes, M., Collapsible solar still with water vapor permeable membrane, US Patent 3415719, May 11, 1966. [Online]. Available: https://patents.google.com/patent/US3415719A/en. [Accessed: Dec. 17, 2024].

[5] Telkes, M., Method for storing and releasing heat, US Patent 2856506A, Oct. 14, 1958. [Online]. Available: https://patents.google.com/patent/US2856506A/en?oq=US2856506A. [Accessed: Dec. 17, 2024].

[6] Pollak, A., Director, The Sun Queen, PBS - American Experience. [Film]. United States: WGBH Educational Foundation, 2023.

[7] Nemethy, A., In 1948, we were human guinea pigs in the strangest house in Dover, *Boston Globe*, Mar. 23, 2019. [Online]. Available: https://www.proquest.com/newspapers/1948-we-were-human-guinea-pigs-strangest-house/docview/2196117928/se-2. [Accessed: Dec. 17, 2024].

[8] Howe, H., Sun Furnace in Your Attic, *Popular Science*, May 1949. [Online]. Available: https://books.google.rs/books?id=lSQDAAAAMBAJ&lpg=PA106&pg=PA106&redir_esc=y#v=onepage&q&f=false. [Accessed: Dec. 17, 2024].

[9] Butler, K., The Marvelously Inventive Life of Mária Telkes, PBS, Mar. 17, 2023. [Online]. Available: https://www.pbs.org/wgbh/americanexperience/features/sun-queen-marvelously-inventive-life-maria-telkes/. [Accessed: Dec. 17, 2024].

[10] Raymond, E., Dover Sun House, *Architectuul.*, [Online].Available: https://architectuul.com/architecture/dover-sun-house. [Accessed: Dec. 17, 2024].

[11] Garg, H. P. , *Advances in Solar Energy Technology Volume Industrial Applications of Solar Energy, Volume 2*, D. Reidel Publishing Company, Dordrecht, Holland, 1987.

[12] Cooke, B. H., Design And Performance Of An Integrated Heat Pump - Latent Heat Store Water Heating System, Ph. D. thesis, Edinburgh University, Edinburgh, UK, 1987.

[13] Sherburne, M., The House of the Day After Tomorrow, *MIT News*, (2010), Jul./Aug., [Online]. Available: https://www.technologyreview.com/2010/06/22/202508/the-house-of-the-day-after-tomorrow/. [Accessed: Dec. 17, 2024].

[14] Dong, X., Mao, J., Geng, S., Yong, L., Hou, P. and Lian, H., Study on performance optimization of sodium sulfate decahydrate phase change energy storage materials, *Journal of Thermal Analysis and Calorimetry*, 143 (2020), 6, pp. 3923-2934.

[15] O'Riain, M., 1948: The Dover Sun House, *Passive house +*, (2018), Apr. 30, [Online]. Available: https://passivehouseplus.ie/blogs/1948-the-dover-sun-house

[16] Midcoast Green Collaborative, Solar Stills,[Online]. Available: http://www.midcoastgreencollaborative.org/articles/solar_stills.html. [Accessed: Dec. 17, 2024].

[17] ***, Picture of a soldier, [Online]. Available: https://twitter.com/paulcoxon/status/940590345179553792. [Accessed: Dec. 17, 2024].

[18] ***, 25 Countries, Housing One-Quarter of the Population, Face Extremely High Water Stress, [Online]. Available: https://www.wri.org/insights/highest-water-stressed-countries [Accessed: Mar. 3, 2025]

[19] Gao, J. et al., Extreme salt-resisting multistage solar distillation with thermohaline convection, *Joule*, 7 (2023), 10, pp. 2274–2290. doi: 10.1016/j.joule.2023.08.012.

[20] Xia, Y. et al., A self-rotating solar evaporator for continuous and efficient desalination of hypersaline brine, *Journal of Materials Chemistry A*, 8 (2020), 32, pp. 16212–16217. doi: 10.1039/d0ta04677a.

[21] Xu, W. et al., Flexible and Salt Resistant Janus Absorbers by Electrospinning for Stable and Efficient Solar Desalination, *Advanced Energy Materials*, 8 (2018), 14. doi: 10.1002/aenm.201702884.

[22] Zeng, J. , Wang, Q. , Shi, Y. ,Liu, P. and Chen, R., Osmotic Pumping and Salt Rejection by Polyelectrolyte Hydrogel for Continuous Solar Desalination, *Advanced Energy Materials*, 9 (2019), 38. doi: 10.1002/aenm.201900552.

[23] Shi, Y. et al., Solar Evaporator with Controlled Salt Precipitation for Zero Liquid Discharge Desalination, *Environmental Science & Technology*, 52 (2018), 20, pp. 11822–11830. doi: 10.1021/acs.est.8b03300.

[24] Liu, Z. , Wu, B., Zhu, B. , Chen,Z., Zhu, M. and Liu, X. , Continuously Producing Watersteam and Concentrated Brine from Seawater by Hanging Photothermal Fabrics under Sunlight, *Advanced Functional Materials*, 29 (2019), 43. doi: 10.1002/adfm.201905485.

[25] Tyson, P., Solar ovens heat up in the tropics, *MIT Technology Review*, 97 (1994), 4, p. 16-17.

[26] Sarangi, Ab., Sarangi, As., Sahoo, S. S. , Nayak, J. and Mallik, R. K., Advancements and global perspectives in solar cooking technology: A comprehensive review, *Energy Nexus*, 13(2024), p. 100266. doi: 10.1016/j.nexus.2023.100266.

[27] Domanski, R., Cooking during off-sunshine hours using PCMs as storage media, *Energy*, 20(1995), 7, pp. 607–616, doi: 10.1016/0360-5442(95)00012-6.

[28] Nahar, N. M., Marshall, R. H. and Brinkworth, B. J., Studies on a hot box solar cooker with transparent insulation materials, Energy Conversion and Management, 35(1994), 9, pp. 787–791, Sep. 1994. doi: 10.1016/0196-8904(94)90107-4.

[29] Thamizharasu, P. et al., Improvement of Thermal Performance of a Solar Box Type Cooker Using SiO2/TiO2 Nanolayer, Silicon, 14 (2020), 2, pp. 557–565. doi: 10.1007/s12633-020-00835-1.

[30] ***, Forno solar Suntaste, [Online]. Available: https://ppl.com.pt/prj/forno-solar-suntaste [Accessed: Mar. 2, 2025].

[31] ***, Solar Cooking Wiki, [Online]. Available: https://solarcooking.fandom.com/wiki/Kyoto_Box [Accessed: Mar. 2, 2025].

[32] Clausson, S.L., A Comparison of Copenhagen Solar Cookers With Other Similar Sized Solar Cookers, Consolfood, 2018, pp. 22–24, 2018.

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