*ICON: Journal of the International Committee for the History of Technology* 30, no 2 (2025): 120–153
https://doi.org/10.11590/icon.2025.2.05

# STEVE BAER AND THE DOUBLE-PLAY THERMOSIPHON:

## Tracing a Passive Solar Innovation in the Steppes of New Mexico

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*The discourse concerning the work of Steve Baer, while extensive, does not capture the full depth and trajectory of his innovations within the domain of passive solar heating and cooling. The more advanced work that he developed across his career has been broadly overlooked. This paper focuses on one such item from Baer's overlooked portfolio, a water-based thermosiphon passive heating and cooling system, which Baer would refer to as a double-play structure. It was a project that Baer was deeply invested in, starting with its development in the late 1960s, and continuing with refinements to the system that he would pursue well into the last stages of his career. This paper sheds light on how this specific innovation was seeded in the late 1960s, how it was refined across the 1980s–2010s, and where the bleeding edge of the double-play thermosiphon concept lies today.*

## Introduction

In the wake of the Second World War, two dominant societal strands emerged within the United States. The first was the shift from the pursuit of "good society" to the pursuit of "good life,"[1] as epitomised by rise of high consumerism oriented towards individual comfort. The second was the contrapuntal reaction of the counterculture movement.[2] This latter strand, in turn, unravelled into two distinct threads. One thread, the New Left, was focused on political struggle as the means of societal change.[3] The second thread, "the New Communalists," while maintaining the same focus on radically renegotiating the societal status quo,

[1] Peter Eisenman, "Lateness and the Crisis of Modernity," lecture, Architectural Association, London, UK, February 5, 2010.

[2] Fred Turner, "Technology and Counterculture from World War II to Today," lecture, The Long Now Foundation, March 20, 2020, 0:26–0:28.

[3] Turner, "Technology and Counterculture from World War II to Today."

sought to mobilise this effort via the reshaping of the material and built world, and by extension, the sociocultural layers of society.[4]

> [The New Communalists sought] to transform consciousness, transform mindset, in order to make a new kind of society. In order to do that, they wanted to adopt key technologies produced by mainstream society . . . They trusted not in politics but in design. Design was the technique by which we might build a better and different world.[5]

A significant root of the New Communalist thread traces back to Buckminster Fuller. During the First World War, Fuller, his wife, and their young daughter were living next to a large military base. When their daughter tragically died at the age of four due to infantile paralysis, Fuller believed that her death was due to the extractive nature of the military-industrial complex—specifically, that the resources required to save his daughter had been absorbed by the neighbouring military settlement. What emerged from this overwhelming trauma was Fuller's ambition to extract goods and technologies from the military-industrial complex, and redistribute them to achieve a bottom-up equitable reboot across the fabric of society.[6]

Several decades down the line, with the New Communalist wave in full swing, the American Southwest became a critical experimentative landscape for this ambition. Reaching a peak in the 1960s, various groups explored alternative modes of building and community development. Steve Baer, who passed away in May 2024 while this manuscript was being developed, was a key figure within this new societal fabric.[7]

Baer, like many, had stumbled upon the New Communalist zeitgeist after a prior life of meandering. He had studied at Amherst College, UCLA; completed a three-year stint with the US Army while stationed in Germany; and then studied engineering for a handful of years at ETH Zurich while also working part-time as a metal welder in the city.[8] Baer and his wife Holly returned to the US in the mid-1960s. After initially attempting to navigate a more-conventional lifestyle in Albuquerque, New Mexico, the couple quickly grew disenchanted with

4 Turner, "Technology and Counterculture from World War II to Today."

5 Turner, "Technology and Counterculture from World War II to Today," 0:28.

6 Turner, "Technology and Counterculture from World War II to Today," 0:30–0:32.

7 Sadler, "Drop City Revisited."

8 Mother Earth News Editors, "Steve Baer and Holly Baer: Dome Home Enthusiasts," *Mother Earth News*, July 1, 1973, https://www.motherearthnews.com/sustainable-living/nature-and-environment/steve-baer-holly-baer-dome-home-zmaz73jazraw/; Vollaard and van Andel, "Zome House Corrales."

the idea. Living off some inherited funds and additional money they had saved while in Germany and Zurich, they shifted gears, looking towards the newly emerging communal settlements in the area as a test bed for collaboration and experimentation. Immersed in this new path, Baer diverted his attention towards developing some of the unconventional construction techniques he had begun tinkering with back in Zurich and pursuing his then-fledgling ideas concerning off-grid living.[9]

In popular circles, Baer is most widely recognised for his work around polyhedral dome structures. The *Dome Cookbook*, which he published in the late 1960s, was a seminal piece of text widely distributed among his fellow *Droppers,* inhabitants of the Drop City communal settlement in Trinidad, Colorado.[10] Baer's first iterations of a zonohedron-based dome, which he referred to as a *zome,* were first built in collaboration with his peers in that landscape.[11]

As Drop City began to lose momentum by the late 1960s, Baer formed his company, Zomeworks, in Albuquerque, New Mexico, to focus on passive solar technology development. In an interview in 1973, Baer delved into the details of the worldview underpinning his work, underscoring his deep alignment with Fuller's ambitions, set in motion several decades earlier.

> At one time an individual could pretty much fix everything in his life with his thumbnail or his teeth. But now the big corporations and organizations have so much to do with everyday life . . . People begin to feel spooky and hesitate—quite rightly—to put their faith in that kind of technology and I really don't think it's necessary. I believe the ground rules can be transformed so that technology simplifies life instead of continually complicating it.[12]

The discursive landscape surrounding Baer and his work, while extensive, does not frame the full depth and trajectory of his innovations.[13] Much of the discourse predominantly focuses on Baer's initial explorations into thermal mass, passive solar heating, as well as complex geometric dome construction. The more advanced work that Baer developed across the breadth of his career, has been broadly overlooked.

The focus of this paper is one particular piece from Baer's overlooked portfolio—a water-based thermosiphon system that he started developing in the early 1970s, which he referred to as a *double-play* system. While his own work on the system fell

[9] Mother Earth News Editors, "Steve Baer and Holly Baer."

[10] Vollaard and van Andel, "Zome House Corrales," 89.

[11] Mother Earth News Editors, "Steve Baer and Holly Baer."

[12] Mother Earth News Editors, "Steve Baer and Holly Baer."

[13] See Appendix A.

slightly short of its final ambitions, what Baer meant by *double-play* was a system that could achieve both heating and cooling of an interior space, ideally in a simple, passive manner.

The double-play system was one of the concepts that Baer was most invested in,[14] and yet academic articles on this concept are effectively non-existent. The few published sources that give any noticeable insight into the double-play thermosiphon system are either pamphlets and reports from the Zomeworks Corporation, or pieces written by Baer's own hand. Framed around several phases of innovation, this paper tracks the foundations for, the conception of, and refinements to, this double-play thermosiphon system across a broad timeline of experimentation and collaboration, starting in the late 1960s, and continuing into the current day.

## Cowboys and Stock Ponds

It was at the 1968 International Solar Energy Conference in Palo Alto, California, that Steve Baer and Harold Hay first crossed paths.[15] By that point in time, Hay had already established a far-reaching career focusing on developing low-tech passive approaches to heating and cooling, stretching back to his employment as a building materials advisor to the Indian government, working under the United Nations in the 1950s.[16]

At the Palo Alto conference, Hay presented the maturation of this line of passive-solar experimentation, specifically focusing on the solar house he designed in collaboration with John Yellot, located in Phoenix, Arizona, which used roof ponds and movable insulation as a means of passive heating and cooling.[17] Hay would subsequently coin this the *Skytherm* system, after which his Los Angeles company, *Skytherm Processes and Engineering,* would also be named. The Phoenix residence was a precursor to the better-known Atascadero residence built in 1973, which also utilised the Skytherm system. The performance of this latter residence is well documented, as it was monitored by researchers from California Polytechnic State University in San Luis Obispo in the 1970s.[18]

One of the immediate stepping stones to the Skytherm system was Hay's lesser-known experiments involving Styrofoam ice chests. Baer was one of the few persons to highlight these smaller-scale endeavours by Hay.

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14 Bruce Davis (architect, New Mexico), in discussion with the author, July 2, 2024.

15 Steve Baer, "Harold Hay's Influence and the Zomeworks Corporation," location 877.

16 Skurka and Naar, *Design for a Limited Planet*, 29.

17 Baer, "Harold Hay's Influence and the Zomeworks Corporation," location 877.

18 Skurka and Naar, *Design for a Limited Planet*, 31.

> I would count [his] experiment with a styrofoam ice chest as among the most exciting and illuminating ever done. In Phoenix, Hay filled one of the insulated chests one sees in supermarkets with water. During the summer he put the lid on during the day and took it off during the night. The water stayed cool, for it was protected from the sun during the day and at night radiated heat to the night sky. During the cool months of the winter, Hay reversed it—he opened the lid during the day and closed it during the night. The water stayed warm.[19]

It was in this same period (1967–68) that Baer was working on a rather peculiar problem. A cattle rancher operating near Drop City, Colorado, had approached Baer to discuss an industry-specific situation. During the winter season, cattle ranchers spent a significant amount of time driving out to break the ice which had formed on top of their stock ponds, so that their cattle may have access to water. If there was a way to sidestep this process, the rancher indicated, it would be of great utility.[20] After chewing on the problem for some time, and conducting a few trials, Baer came up with a simple solution. [21]

Using a combination of aluminium and rubber piping, Baer created a small closed-loop system, resembling a small end table, which he filled with methyl alcohol. The loop would be placed in a stock pond so that the bottom portion sat near the bottom of the pond, while the top portion was semi-submerged in the ice at the surface. Baer presumed that the methyl alcohol would be warmed at the bottom of the pond, that it would subsequently rise via convection, release the heat into the ice, and then sink back to the bottom to be warmed up, and so forth in a continuous cycle. After the first

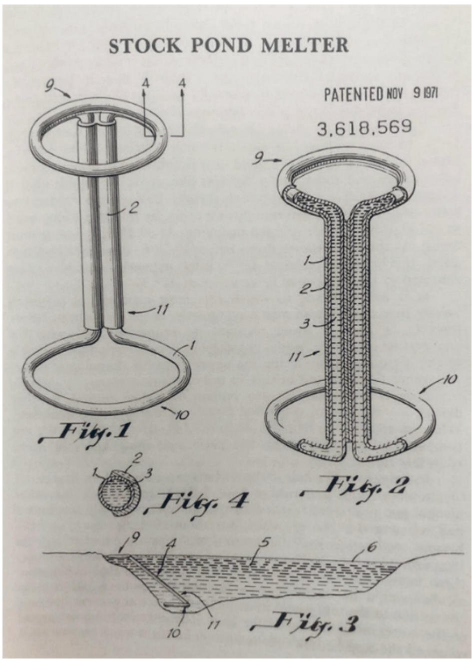



Figure 1. The stock pond melter which Baer patented on 9 November 1971 (US Patent 3,618,569).[21]

[19] Baer, *Sunspots*, 24.

[20] Baer, *Sunspots*, 34.

[21] Baer, *Sunspots*, 33.

Figures 2–5. The *Skylid* insulated louver system installed in the Baer residence circa 1973[22] (top left, figure 2); the *Sunbender* reflector/shading system installed in Bruce Davis House 2, in the summer position, circa 1990s[23] (top right, figure 3); the same *Sunbender* system at the Zomeworks Corporation headquarters, in the winter position, circa 1988[24] (bottom left, figure 4); and the UTRF-072 model of the *TrackRack* passive photovoltaic tracking system, date unknown[25] (bottom right, figure 5). (Photographs by Zomeworks Corporation.)

night of active testing, Baer was pleased to find that the loop had indeed worked, melting the ice around the rim of the loop at the top of the pond.[26] It was this stock pond melter, anchored around a closed loop thermosiphon concept, that would form the seed for the double-play system Baer would eventually conceive many years down the line. Despite the technical success however, not a single stock pond

22 Steve Baer, "Some Passive Solar Buildings with a Focus on Projects in New Mexico," presentation, Albuquerque Chapter of the AIA, January 15, 2009, 20.

23 Baer, "Some Passive Solar Buildings," 23.

24 Baer, "Some Passive Solar Buildings," 24.

25 Zomeworks Corporation, "Passive Solar Tracker for Photovoltaic Systems," Zomeworks, 2025, https://www.zomeworks.com/photovoltaic-tracking-racks/.

26 Baer, *Sunspots*, 34–35.

melter was sold. “I have come to suspect that the cowboys enjoy their winter ice-breaking expeditions,” Baer humorously remarked on the subject.[27]

In the years that followed, Baer built a range of passive solar projects and systems. These included the *Skylid* insulated louver developed in the early 1970s, the *Sunbender* reflector/shading system developed in the 1970s, his own residence located in Corrales, New Mexico (1971), the Paul Davis House also in Corrales (1972), the Benedictine Monastery in Pecos, New Mexico (1978), and the *TrackRack* passive tracking system for photovoltaic arrays that Baer developed in the early 1980s. Throughout this time period, the closed-loop thermosiphon concept underpinning the stock pond melter remained largely dormant.

## First Foundations for Collaboration

In 1974, the New Mexico Solar Energy Association (NMSEA) received a $34,000 grant (to be distributed across two years) from the Four Corners Regional Commission to construct four passive solar residential prototypes. These *Sundwellings* were to be single-storey structures, 300 square feet in size. Their construction started in 1976 in Ghost Ranch, New Mexico, where the NMSEA was headquartered. Each prototype served as a testbed for a specific passive solar strategy—namely, a direct solar gain system, a Trombe wall system, a lean-to-greenhouse configuration, and a control prototype.

Bruce Davis was a young architect from Illinois who had made the move to New Mexico in the early 1970s. He joined NMSEA in around 1973, soon after moving to the area.[28] Seeing these Ghost Ranch prototypes, Davis became eager to test a variation of these ideas as the anchor for an experimental home for himself.[29] He would also play a supportive role in the 1977 publication that came out of the Ghost Ranch prototypes, *Homegrown Sundwellings,* drawing many of the illustrations and figures of the text.[30]

The design for Davis House 1, located in Santa Fe, New Mexico, consisted of a single-layer adobe-walled dwelling leveraging direct solar gain via a heavily fenestrated southern façade. It was effectively a hybrid of the direct-gain setup and the lean-to-greenhouse system of the Ghost Ranch prototypes. Construction took place in 1977–78. Bruce Davis would spend the next fifteen years of his life in this 900-square-foot residence, incrementally refining it, inside and out.[31]

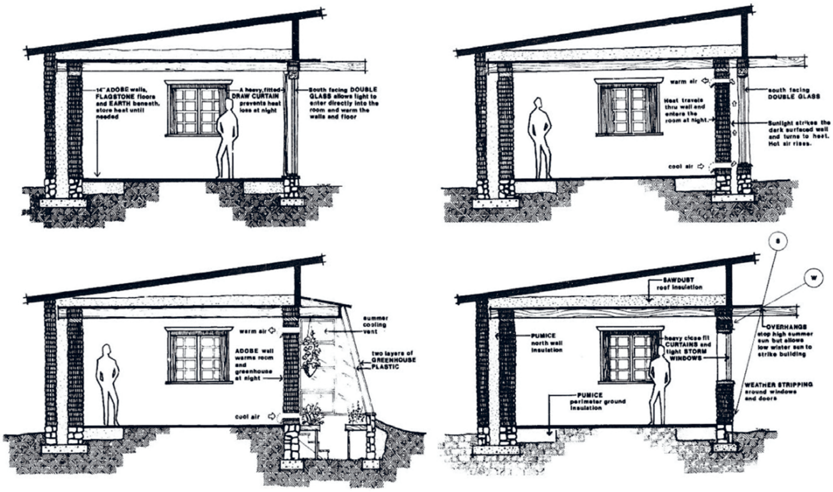
[27] Baer, *Sunspots*, 35.

[28] Bruce Davis, personal correspondence, April 21, 2025.

[29] Bruce Davis, personal interview, January 30, 2024.

[30] Peter Van Dresser, *Homegrown Sundwellings*.

[31] Davis, personal interview, January 30, 2024.




Figures 6–9. Sections of the four Ghost Ranch prototypes built in 1976. These include the direct solar gain system (figure 6, top left), the Trombe wall system (figure 7, top right), the lean-to-greenhouse system (figure 8, bottom left), and the control prototype (figure 9, bottom right). (Illustrations drawn by architect Mark Chalom.)[32]

Davis House 1 was crucial in establishing a critical collaborative connection between Bruce Davis and Steve Baer. It introduced the former to the latter as an ideologically compatible colleague, as Baer recognised Davis as a contemporary wanting to get his hands dirty, and with a proclivity for testing concepts through building (as opposed to building only when all the testing had been done).[33]

Baer was quick to note the absence of electricity in Davis House 1, and in 1978, offered to install a low-output (given the fledgling state of the technology at the time) photovoltaic system on site. This provided enough power for a water pump and a few light fixtures.[34] Interior lighting was kept to a minimum out of necessity, at least until the early 1980s when higher-quality photovoltaics became available. In 1982, Baer donated an upgraded 1-kW array to the Davis I residence.[35] This second photovoltaic array was also equipped with Zomeworks' passive solar sun-tracking systems—that is, *TrackRacks*.

32 Peter Van Dresser, *Homegrown Sundwellings*, 113–16.

33 Davis, personal interview, January 30, 2024.

34 Davis, personal interview, January 30, 2024.

35 Davis, personal interview, January 30, 2024.

Figures 10–11. The original house in Santa Fe, New Mexico, circa 1980s (figure 10, left) and the replica of the house built in 1984 per a client's request in Lamy, New Mexico (figure 11, right). (Photographs by Bruce Davis.)

The time of Davis House 1's construction, and its unique leveraging of passive solar heat gain strategies as well as a fledgling photovoltaic system, situates the project within rare company in the early roots of solar architecture innovation. Although not recognised within the literature as such, it should historically be placed alongside the seminal projects of University of Delaware's *Solar One* project from 1973 on the one hand, and the 4-kW residence built by Solar Design Associates in 1983 on the other. The layer that gives Davis House 1 an additional asterisk, is that it was entirely off-grid.[36] A near replica of the residence, with some minor refinements, was also built in 1984 for a separate client in Lamy, New Mexico.

In Davis House 1, the passive solar heating of the residence relied on a direct gain system via a large amount of southern glazing. In the summer months, a shade cloth was added to upper portions of the southern glazing to avoid heat gain during those months. The remaining northern, eastern, and western walls were composed of a single layer of adobe (not a double-adobe wall system as in the Ghost Ranch prototypes), initially without any insulation.

Without insulation, the house experienced quite vast swings in internal temperature. In the colder months, living there was more akin to "wilderness camping."[37] After the first winter, Davis added two inches of rigid polyurethane insulation board to the exterior, followed by a stucco finish. The interior adobe, later whitewashed, was left exposed to maintain maximum heat gain. Cylinders of water were also later added as an additional thermal mass for direct gain purposes.

36 Davis, personal interview, January 30, 2024.

37 Davis, personal interview, January 30, 2024.

Figures 12–13. Interior view of the eastern wall of the residence (figure 12, left), and interior view of the water cylinders facing the south-facing fenestration (figure 13, right). (Photographs by Bruce Davis, circa 1980s.)

After the insulation was added, Davis noted that the house was able to hold heat much better in the winter months, achieving interior temperatures of low 80s even in the coldest parts of the year.[38] However, the temperature was more prone to swings than Davis would have preferred. At nights, a wood-burning stove was utilised as a backup source of heat.[39]

The long-term performance of Davis House 1 served to confirm the findings of the initial Ghost Ranch prototypes—namely that the lean-to-greenhouse setup, while performing admirably in the winter months, still provided far too severe swings of temperature. Of all the Ghost Ranch prototypes, the Trombe wall system was found to best balance solar performance and the maintenance of internal temperature stability.[40] When Bruce Davis would have the chance to build his third personal residence from scratch in 2008, he would utilise this system as the main passive solar strategy. This return to the Trombe wall would help to add a critical layer of refinement to the double-play thermosiphon system.

## The Closed Loop Thermosiphon Reborn

While Baer had patented the stock pond melter in 1971, it was only in the late 1980s that the closed-loop thermosiphon idea would re-emerge. Baer observed that telecommunications companies were extending their infrastructure to further and further remote sites. This required electronic equipment to be reliant upon battery arrays for power—battery arrays which did not react very well to the

38 Davis, personal interview, January 30, 2024.

39 Davis, personal interview, January 30, 2024.

40 Davis, personal interview, January 10, 2024.

considerable highs, lows, or sometimes both, as experienced in much of the climate in the American West and Southwest.[41] Zomeworks developed what was later to be coined the *Cool Cell* as a market response. The system it relied upon was a slightly scaled-up, and slightly more layered, version of the stock pond melter Baer had developed nearly two decades prior. Based on the literature reviews conducted for this article, there does not appear to be any single academic article that describes the system in a complete and comprehensible manner.[42]

At the heart of the double-play thermosiphon system for the Cool Cell were two interconnected arrays of water (with no air bubbles), forming a single loop. The bigger array, situated inside the Cool Cell and sized for the specific electronic components that would be inside, served as the heat sink regulating the interior temperature of the cell. The second smaller array, on the roof of the Cool Cell, served as the radiator of the system. The entire Cool Cell was white and well insulated, to block as much heat gain as possible. During the day, the interior array of water absorbed the excess heat inside the Cool Cell. At night, a form of night flush cooling took place. Since the two arrays were connected, the hotter water rose into the radiator array, as the colder water sank to the interior array. The hot water shed its heat to the atmosphere through the radiator, and then sank back to the interior array when it cooled down. The slightly hotter water in the interior array then rose to the radiator, repeating the process.[43] Across the night, this loop cycled through a few times. By daytime, the interior array had been charged with an atmospherically chilled water supply, or "coolth" as Baer would say,[44] ready to deal with the heat gain of the day. As soon as the sun rose and hit the radiators on the roof of the Cool Cell, the cycle stopped, since the water in the radiator array became warmer than the chilled water in the internal array.[45] How the arrays served to keep the interior above freezing levels on cold nights was, in turn, due to a unique property of water. On cold nights, the water in the radiator froze (since it was more directly exposed to the atmosphere), stopping the night flush process from occurring. This kept the slightly warmer water locked into the interior array, maintaining the interior compartment above frost levels.[46]

41 Davis, personal interview, January 10, 2024.

42 See Appendix A.

43 Davis, personal interview, January 30, 2024; Baer and Harrison, "Temperature Control in Electronics."

44 Davis, personal interview, January 30, 2024.

45 Davis, personal interview, January 10, 2024; Baer and Harrison, "Temperature Control in Electronics."

46 Davis, personal interview, January 30, 2024.

Figures 14–15. Opened (figure 14, left) and closed (figure 15, right) view of the High Flux Cool Cell to be deployed in Joshua Tree National Park, California, circa 2005–2006.[47]

The Cool Cell became a critical product for Zomeworks, making up approximately 70% of the company's sales for several years.[48] Baer was quite rigorous in extracting data from the performance of various Cool Cells—for example, from the Cool Cell deployed in Tucson, Arizona from 2001 to 2002[49] and from one located in Joshua Tree National Park, California from 2006 to 2008.[50] For the module located in Tucson, this simple water-based closed-loop thermosiphon system kept the interior cabinet between approximately 43.0°F and 87.0°F (6.0°C and 30.5°C) while the ambient temperature fluctuated between approximately 32.0°F and 118.0°F (0°C and 47.7°C).[51]

In 1988, Baer constructed a larger-scale version of this system in a project he referred to as *Andy Shack*. It was a 10 ft × 10 ft cabin located on the Zomeworks Company grounds in Albuquerque, New Mexico. Suspended below its ceiling, was an interconnected array of 8-in PVC pipes, 12 in on-centre, filled with water.[52] This array of pipes was connected to a simple radiator system on the roof (also filled with water, without any air gaps), composed of black pig mats. These were rubber

47 Baer and Harrison, "Temperature Control in Electronics," 3–4.

48 Zomeworks Corporation, "Zomeworks Corporation: Company Profile," accessed March 5, 2025, https://www.zomeworks.com/about-us/.

49 Zomeworks Corporation, "Independent Cool Cell™ Results."

50 Baer and Harrison, "Temperature Control in Electronics," 3–4.

51 Zomeworks, "Independent Cool Cell™ Results."

52 Baer, "Some Passive Solar Buildings," 30–35; Davis, personal interview, January 10, 2024.

mats, with a thin silicone piping system running through them, often used by pig ranchers to keep the surface upon which pigs sleep at a hospitable temperature. Below the sub-ceiling array, was a set of aluminium louvers that could be opened or closed to manipulate heat transfer rates to and from the internal array.[53]

Figures 16–17. Exterior image of Andy Shack, constructed 1988, with the rooftop radiator composed of pig mats visible (figure 16, left), and interior image depicting the sub-ceiling interconnected 8" PVC array, and the aluminium louvers in their open position below (figure 17, right).[54]

Steve Baer's cross-scalar experimentation (working with the Cool Cell and the Andy Shack in tandem) mirrored the cross-scalar Styrofoam ice chest experiments and Skytherm projects carried out by Harold Hay in the 1960s and 70s. When seen on an architectural scale, such as in the Andy Shack, the double-play thermosiphon system's connection to the work of Harold Hay is quite apparent. Hay's Skytherm was composed of a horizontal array of water reservoirs located above the ceiling.[55] The array's exposure to the atmosphere was regulated by an operable insulated roof.[56] In the Andy Shack, as well as the Cool Cell, the system at play is effectively a hybridisation of Hay's Skytherm system[57] and the closed-loop thermosiphon system of the stock pond melter.

Baer's ultimate ambition with the double-play system was to create a passive heating and cooling apparatus that would maintain an interior environment within acceptable thermal comfort levels. The Cool Cell and the Andy Shack were the first iterations of Baer's double-play thermosiphon meta-project. In the long run, the incorporation of passive heating into the system proved quite difficult for Baer. However, subsequent iterations on the concept via the collaboration between

53 Baer, "Some Passive Solar Buildings," 30–35.

54 Baer, "Some Passive Solar Buildings," 30–31.

55 Skurka and Naar, *Design for a Limited Planet*, 29–31.

56 Skurka and Naar, *Design for a Limited Planet*, 29–31.

57 Baer, "Harold Hay's Influence and the Zomeworks Corporation," location 904.

Bruce Davis and Steve Baer, and later between Bruce Davis and Karen Terry, led to more fertile grounds. The subsequent sections deal with those two stages of refinement that ensued via those collaborations.

### *Vertical or Horizontal*

In 1992–93, Bruce Davis undertook the remodelling of what was once a neighbourhood laundromat in Albuquerque, New Mexico, to create his second residence (Davis House 2). It was within the small, detached studio located on the property that the next phase of innovation relating to the double-play thermosiphon system took place.

The studio space on the grounds of Davis House 2 was created by splitting the existing garage in two. Davis would use the easterly half, which had a footprint of 236 square feet, for his architecture practice. The walls and ceiling had an insulation of R-11. Heating the space was not a concern, as the studio was occupied only during the day, and it also housed the water heater for the primary residence.[58] It was a "roasting space" in need of cooling to become suitable for habitation.[59]

Similar to Davis House 1, the architecture studio would be utilised as a live-in experiment, however this time for the double-play thermosiphon system. In 2003, Baer and Davis collaboratively designed a variation of this system for that space.[60] On the roof, an array of 12 pig mats, covering 127 square feet in total were installed upon an elevated rack to serve as the radiator.[61] The water line from the roof array was connected to an interior array of 4" PVC pipes (38 pipes in total, distributed across two walls), filled with water, which would serve as the thermal sink. The external roof radiator, linked together with this internal water array, replicated the closed loop system seen in the Andy Shack. The main difference was that the internal water array was vertical, mounted against the walls, whereas in the Andy Shack it was horizontal, sitting beneath the ceiling. Baer preferred the horizontal arrangement, but for Davis, the vertical array was a crucial requirement, as he did not want to worry about a leak that would ruin his architectural drawings.[62]

As was a habit by Baer, the performance of the system and the space was thoroughly documented. Between July 22, 2004 and August 6, 2004, the double-play system was able to keep the interior temperature of the studio between 73.5°F and 78.0°F (23.0°C and 25.5°C) while the ambient temperature fluctuated between 58.0°F and 94.5°F (14.5°C and 34.7°C).[63]

58 Davis, personal interview, July 2, 2024.

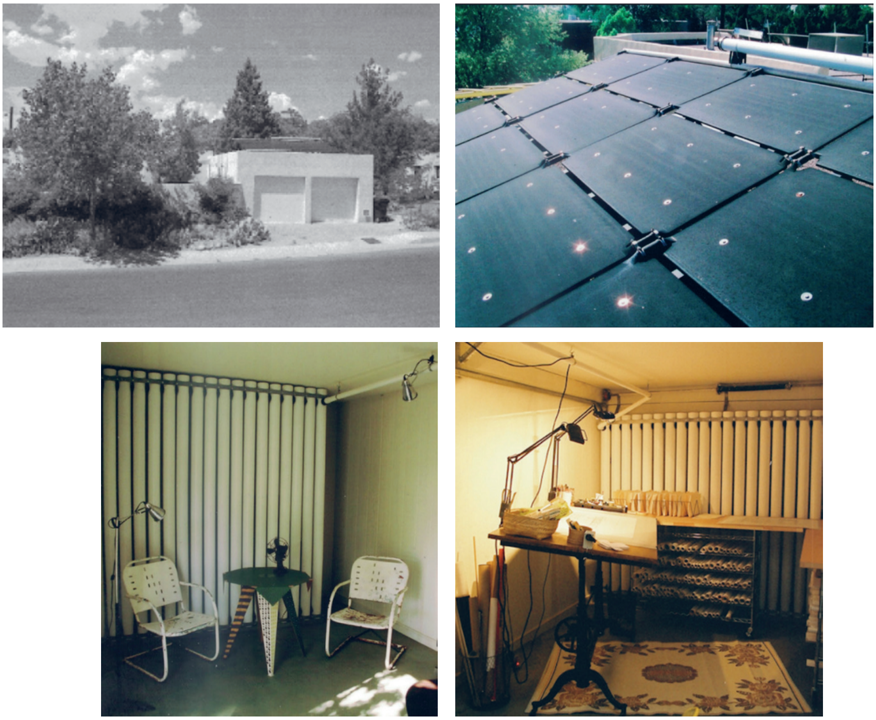
59 Davis, personal interview, July 2, 2024.

60 Bruce Davis, personal correspondence, January 24, 2024.

61 Davis, personal interview, July 2, 2024.

62 Davis, personal interview, July 2, 2024.

63 Zomeworks Corporation, "Double Play Progress Report."



Figures 18–21. Images from circa 2004–2005 depicting the exterior of Davis House 2 studio with the pig mat array visible atop the roof (figure 18, left), roof-top pig mat array in detail (figure 19, right), and two interior walls where the water-filled PVC arrays were located (figures 20 and 21, bottom). [64]

Soon after, Baer experimented with a vertical internal water array within the double-play thermosiphon system developed for the Zomeworks office space in 2005.[65] However, two years later, Baer would revert to the horizontal sub-ceiling array arrangement. According to Davis, this was a configuration that Baer was intuitively drawn towards.[66] For Davis, on the other hand, the vertical array was clearly the path to pursue.

Horizontal versus vertical, seemingly quite a superficial variation—however for Baer, the horizontal array would create significant complications in achieving passive heating down the line, while for Davis, working in collaboration with Karen Terry, the vertical array would allow for a much simpler path to unfold.

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[64] Photographs taken by architect Bruce Davis, circa mid-2000s.

[65] Baer, "Some Passive Solar Buildings," 35–36.

[66] Davis, personal interview, July 2, 2024.

Figures 22–23. The double-play system built at Zomeworks in 2005, with figures depicting the rooftop radiator (figure 22, left) and a PVC water array in the interior of building (figure 23, right).[67]

## *Back to the Trombe Wall*

Between 2007 and 2012, as Baer abandoned the vertical water array and reverted back to the horizontal sub-ceiling array arrangement, Zomeworks constructed the Dave House and the Cool Cell Container on property grounds[68] to further test and refine the double-play system. With a particular focus on achieving solar heating, both projects integrated solar collectors into the southern façades. With regard to cooling, a cleaner version of the closed-loop thermosiphon system seen in the Andy Shack was utilised. While there is data on the Cool Cell Container from August to September 2015 indicating it performed quite well in the summer months, it is unclear how well the system worked in the winter months.[69]

In this same timeframe, the collaboration between Bruce Davis and Karen Terry opened up a much simpler path towards achieving the heating and cooling ambitions of the double-play thermosiphon system.

Davis and Terry first crossed paths around 1974, when Davis and a colleague were visiting Terry at the construction site of her then-future home, the Step House, designed by Architect David Wright.[70] When Wright moved to California around 1979, he asked Davis to help wrap up the project management of a residence Terry and he were working on. From that point, Davis and Terry began a collaborative relationship that would last decades, into the current day.

67 Baer, "Some Passive Solar Buildings," 35–36.

68 Zomeworks Corporation, "How to Cool and Heat with Pure Water."

69 Zomeworks Corporation, "How to Cool and Heat with Pure Water," 11.

70 Davis, personal correspondence, April 19, 2025.

Figure 24–25. The Dave House, built on Zomeworks grounds circa 2007, with 4 solar collectors on the façade and a more cleanly integrated rooftop radiator when compared to the Andy Shack (figure 24, left), and the sub-ceiling PVC array in the Dave House, with aluminium louvers below, replicating the same array seen in the Andy Shack, and marking Baer's abandonment of the vertical water array (figure 25, right).[71]

> Collaboration is a good word, but just what does that mean? I remember one time Karen saying, 'Okay. I'll draw up the design. Then you can make it better.' Sometimes I made it [better]. Sometimes there wasn't much that wasn't already just right. She was always very clear about her design philosophy. 'If you have a site, and you know the budget, that's it. The design is obvious . . . Don't worry about being original. Just worry about being good,' she would say.[72]

In the late 2000s, when Baer had reverted to the horizontal water array, two critical events took place that would put Davis and Terry on a different path. First, Davis designed his third personal residence, Davis House 3. And second, Terry and Davis began working on a lightweight, off-grid, passive solar home, later coined *the Sol-Mod*. Both these projects leaned upon the Trombe wall as their primary source of heating—the primary difference between the two projects being that Davis House 3 used infilled concrete block as the thermal mass for the Trombe wall, while the Sol-Mod used a vertical water array, as seen in the studio of Davis House 2. In the case of Davis House 3, Davis recalls that his intuitive inclination towards the Trombe wall was partially linked to the lessons learned from the Ghost Ranch prototypes and Davis House 1.[73]

Both Davis House 3 and the Sol-Mod reaffirmed the efficiency of the simple Trombe wall. Terry, while living inside the Sol-Mod for several years prior to moving to another house, indicated that the small backup stove only came on "[what felt

71 Baer, "Some Passive Solar Buildings," 37–38.

72 Davis, personal correspondence, April 19, 2025.

73 Davis, personal interview, July 2, 2024.

Figures 26–27. One of two Trombe walls in Davis House 3 (figure 26, left) and the Sol-Mod's Trombe wall seen from the outside, composed of an array of vertical PVC tubes filled with water, painted black on the outside and white on the inside (figure 27, right). (Photographs by Bruce Davis, circa 2010.)

like] once every several years."[74] An additional innovation embedded into Sol-Mod was that the vertical water array facing the southern sun was plumbed in a manner that allowed for easy drainage. This was done for the purposes of mobility, so that if one wanted to move the Sol-Mod, the water weight could be discarded prior to transport.

> The Sol-Mod came out of a conversation between my friend Karen Terry and myself. And the whole idea had to do with really an extension of the idea of my first studio. Which was how to effectively solar heat a very inexpensive, very lightweight building . . . Almost always in New Mexico the thinking has been, we have these lovely heavy walls here. It's so easy to warm them up . . . The thing is, more and more, even the people who disdain framed building, can't afford adobe . . . So, we wanted to show that it would be possible to build [an off-grid, economically-manufactured, lightweight, modular home] that could very easily be solar-heated. And by solar heated we always mean not just that it warms up during the day, but that it has a reasonably stable temperature [during the day and night]. If you go to 89 degrees by 3 in the afternoon and then it plunges back to 45 degrees, that's not solar heat.[75]

For Davis, this overlap of technical and passive solar strategies, and past recollections, triggered a brainstorm regarding the double-play thermosiphon system. In the early 2010s, he began sketching out a variation to the system which would combine the Sol-Mod with the thermosiphon system from the Davis House 2 studio.

[74] Davis, personal interview, January 30, 2024.

[75] Davis, personal interview, January 10, 2024.

Figures 27–28. The Sol-Mod interior. (Photographs by Bruce Davis, circa 2010.)

In Davis' *Double Play 2.0*, the cooling system was maintained as in prior versions. The radiator array remained on the roof. The internal water storage was composed of an interconnected array of PVC tubes. These tubes were, however, vertical in arrangement, as in the Sol-Mod, the Davis House 2 studio, and even in Davis House 1. This verticality placed a critical move at Davis' disposal. He could simply locate the array against some south-facing windows, as in the Sol-Mod, making it function as a Trombe wall. This avoided the complications of having solar collectors and a new piping network as seen in Baer's Dave House and Cool Cell Container. Since the drainage mechanism of the PVC array was also resolved in the Sol-Mod, Davis embedded the same design into Double-Play 2.0, allowing the entire system to be drained. This allowed the roof-top radiator to be emptied of liquid, while maintaining the water in the vertical internal array—through this approach, the radiator would avoid freezing, while the Trombe wall remained active. Water could then be flushed back into the system during the summer months, filling the radiators, so that the cooling function of the closed-loop thermosiphon system could ensue. To avoid overheating in the summer months, the south-facing windows would be equipped with Spanish blinds (exterior roller shades)—a simple system that Davis had forgotten about until 2024 conversations between Davis and the author of this article. These shades would allow for a functionality akin to Hay's Styrofoam experiment, replicated in another format in Baer's breadbox project,[76] to be achieved. Namely, the vertical array would be shielded from the summer sun during the day, and opened up to the chilling atmosphere at night.

Davis' Double Play 2.0 has not yet been built. Its performance therefore is not yet documented. However, it represents the bleeding edge of where the double-play thermosiphon system, originally conceived by Steve Baer, currently rests. Given the

[76] Baer, *Sunspots*, 64.

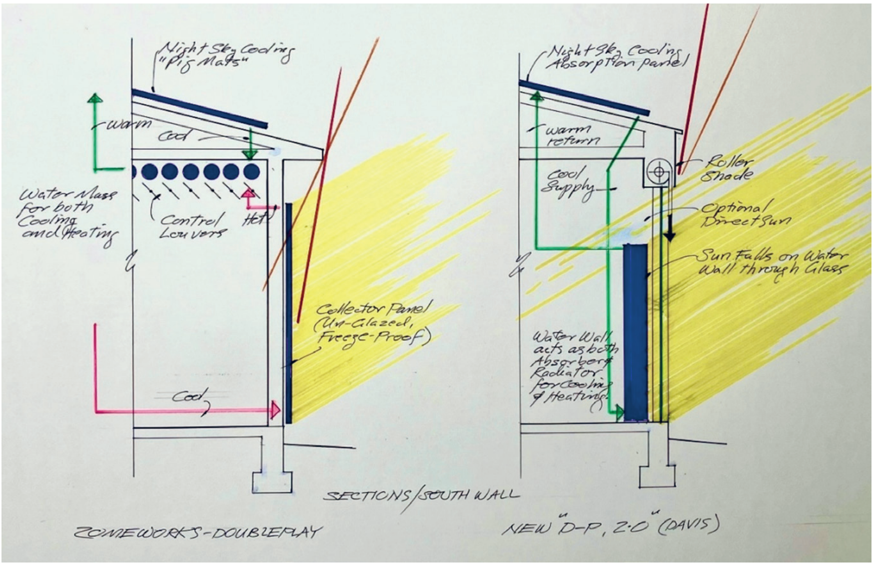


Figure 30. A 2024 drawing by Bruce Davis depicting the system in the Dave House (left), compared to the proposed *Double Play 2.0* by Davis (right).

longitudinal tests of Davis and Terry's Sol-Mod as well as the thoroughly verified cooling capacities of the closed-loop thermosiphon system in all of the projects in which it was utilised, it is reasonable to extrapolate that this hybridisation should achieve comparable levels of performance.

## Conclusion

How do ideas move, stall, and mutate? What triggers their motion or lack thereof? In studying this particular timeline of experimentation, refinement, and trial and error, a range of intriguing insights into how innovation takes place, and how innovation is stalled, begin to emerge.

Baer developed the closed-loop thermosiphon idea with the stock pond melter in the late 1960s, but then the idea remained dormant for a decade. It was only after Baer started working at an industrial-design scale with the Cool Cell, that the leap to extrapolate the thermosiphon system to the building scale was achieved. Similarly, Davis and Baer collaborated on the Davis House 2 studio in 2003. Davis worked in the studio space for five years, looking at and sitting next to the vertical water array on a daily basis. Yet, it was only until the early 2010s, after having collaborated with Karen Terry on the Sol-Mod, that Davis was able to make the leap that would hybridise the double-play thermosiphon system with a Trombe wall configuration. And finally, while Baer was clearly a person of immense intellectual flexibility and ingenuity, as clearly signified by the range of inventions he discussed in his 1975 text *Sunspots*, it was seemingly because of quite a small decision that he was significantly hindered in refining the double-play thermosiphon system beyond a certain point. Baer insisted on maintaining a horizontal sub-ceiling water array, perhaps due to some intellectual inclination tied back to the configuration of Hay's Skytherm system. This led Baer to pursue rather complex combinations of solar collectors and additional piping networks to attempt to resolve the issue of winter heating within the double-play framework. Oddly enough, a vertical water-based Trombe wall system was within Baer's reach, since such a Trombe wall was the cornerstone of his own residence.[77] For whatever reason, Baer was not able to hybridise the Trombe wall and double-play thermosiphon system, while Davis' own trajectory had laid the foundations for him to be able to make that leap, leading to the Double Play 2.0.

The double-play thermosiphon system is a concept that has been incrementally refined and innovated upon for over 60 years—starting with its initial conception via the stock pond melter developed by Baer in the late 1960s and patented in 1971; moving to the Cool Cell and Andy Shack projects of Baer and Zomeworks in the late 1980s (building on the Skytherm projects of Harold Hay and John Yellot in the decades prior); continuing through the innovations achieved via the collaboration between Davis and Baer in the Davis House 2 studio in the early 2000s; and culminating in the Double Play 2.0 system developed by Davis in the mid-to-late 2010s, building on the fruits of collaboration between himself and Terry.

Yet, the discursive landscape concerning the double-play thermosiphon system is effectively barren. While there are some mentions and hints as to what the ambitions of this concept were, there are no academic pieces which even fully explain what the double-play thermosiphon system was. This paper attempts to address this discursive gap, seeking to explain how the extant variations of this system actually function, to trace the intellectual lineage of this concept back through multiple decades, and to pinpoint where the process of continued innovation rests in the current day.

Above all, however, the uncovered storyline anchored around this specific passive solar technology indicates that a more rigorous dive into the innovations in sustainability that were achieved in the 1950s through the 1980s may be of significant use. Many innovations from this time period have not garnered much scholastic, let alone widespread popular recognition. This is particularly intriguing in terms of the innovations that achieved or outperformed their expected outputs, such as Baer's double-play system. In part, this is likely tied to the anti-marketing

77 Baer, *Sunspots*, 97.

stance held by those who embraced the New Communalist or, more broadly, the countercultural, zeitgeist—as was the case with Baer.[78] This lack of recognition is also likely tied to the difficulties of patenting low-tech systems that, in turn, makes them difficult to commodify through conventional avenues within the free market. A final wrinkle is that the growing efficiency and capacity of photovoltaic systems has come hand-in-hand with a comparable decline in interest in passive solar heating and passive cooling systems.[79] Regardless of the causal mechanisms at play, a critical loss of knowledge is likely on the horizon as aging generations of innovators and tinkerers continue to pass into history. Deep investigative research into this time period may help not only curtail this, but also clarify where the precipice of innovation in built environmental sustainability actually lies.

> That is the job of those who follow, to keep evolving the potentials of an idea. We can create tools and equipment that extend our use of the sun and can provide liberty and freedom instead of dependence on government hierarchies and power grids.[80]

## Biography

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[78] Davis, personal interview, July 2, 2024.

[79] Davis, personal interview, July 2, 2024.

[80] Baer, "Harold Hay's Influence and the Zomeworks Corporation," 35–42.

## Bibliography


Auther, Elissa, and Adam Lerner, eds. *West of Center: Art and the Counterculture Experiment in America, 1965–1977.* Minneapolis: University of Minnesota Press, 2012. https://doi.org/10.5749/minnesota/9780816677252.001.0001.

Baer, Steve. "Harold Hay's Influence and the Zomeworks Corporation." In *Activism in Architecture: Bright Dreams of Passive Energy Design*, edited by Margot McDonald and Carolina Dayer. London: Routledge, 2018. Kindle edition.

Baer, Steve. "Some Passive Solar Buildings with a Focus on Projects in New Mexico." Presentation, Albuquerque Chapter of the AIA, January 15, 2009.

Baer, Steve. *Sunspots: Collected Facts and Solar Fiction.* Albuquerque: Zomeworks, 1975.

Baer, Steve, and D. Harrison. "Temperature Control in Electronics." In *INTELEC® 2008*, pp. 1–5. Albuquerque: Zomeworks Corporation, 2008. https://doi.org/10.1109/INTLEC.2008.4664065.

Baweja, Vandana. "Sustainable Architecture: A Short History." In *Routledge Handbook of the History of Sustainability*, pp. 273–95. London: Routledge, 2017. https://doi.org/10.4324/9781315543017-17.

Booth, David. "The New Zome Primer." In *Fivefold Symmetry.* Singapore: World Scientific, 1992, 221–33. https://doi.org/10.1142/9789814439497_0014.

Bothwell, Keith. "Sustainable Architecture." In *Routledge International Handbook of Sustainable Development*, pp. 147–63. London: Routledge, 2015.

Bryan-Wilson, Julia. "Handmade Genders: Queer Costuming in San Fransisco Circa 1970." In *West of Center: Art and the Counterculture Experiment in America, 1965–1977*, edited by Elissa Auther and Anam Lerner, pp. 76–93. Minneapolis: University of Minnesota Press, 2011.

Burch, Jay, Craig Christensen, Jim Salasovich, and Jeff Thornton. "Simulation of an Unglazed Collector System for Domestic Hot Water and Space Heating and Cooling." *Solar Energy* 77, no. 4 (2004): 399–406. https://doi.org/10.1016/j.solener.2003.12.014.

Campbell, Paul J. "Lesson Plans / Zome Primer / Zometool Manual." *Mathematics Magazine* 73, no. 3 (2000): 246–47. https://doi.org/10.1080/0025570X.2000.11996849.

Castillo, Greg. "Salvage Salvation: Counterculture Trash as a Cultural Resource." In *The Routledge Companion to Architecture and Social Engagement.* London: Routledge, 2018, 306–21. https://doi.org/10.4324/9781315712697-23.

Charbonneau, Benoit, and Spencer Whitehead. "Studying Wythoff and Zometool Constructions Using Maple." In *Maple in Mathematics Education and Research*, pp. 65–76. Cham: Springer International Publishing, 2019. https://doi.org/10.1007/978-3-030-41258-6_5.

Davis, William Benjamin. *A Design Guide for the Use of Solar Energy as Residential Space Heating.* San Luis Obispo: California Polytechnic State University, 1975.

Day, James Spencer. *Towards a Synthesis of Energy, Form and Use: New Forms of Solar Space Conditioning Made Possible by the Use of New Materials.* PhD diss., Massachusetts Institute of Technology, 1977.

De Castro, Luis S. Villacañas. "Dewey, Hippie Communes, and Education." *Education and Culture* 37, no. 1 (2021): 94–120.

Denzer, Anthony. "Banham's Gamble." Paper presented at the Society of Architectural Historians 67th Annual Conference, 2014.

Díaz, Eva. "Dome Culture in the Twenty-First Century." *Grey Room* 42 (2011): 80–105. https://doi.org/10.1162/GREY_a_00020.

Dutto, Andrea Alberto. "Shelter Oddity." *sITA: Studii de Istoria şi Teoria Arhitecturii* 10 (2022): 25–40. https://doi.org/10.54508/sITA.10.03.

Eisenman, Peter. "Lateness and the Crisis of Modernity." Lecture, Architectural Association, London, February 5, 2010.

Felter, Patricia Elaine. *Consumer Acceptance of Passive Solar Retrofitting.* PhD diss., Texas Tech University, 1980.

Fernández-González, Alfredo. "Analysis of the Thermal Performance and Comfort Conditions Produced by Five Different Passive Solar Heating Strategies in the United States Midwest." *Solar Energy* 81, no. 5 (2007): 581–93. https://doi.org/10.1016/j.solener.2006.09.010.

Fontenot, Richard J., Daniel J. Lockwood, Jonathan M. Allison, Daniel J. Preston. "A Review and Outlook on Osmotically Driven Heat Pipes for Passive Thermal Transport." *Applied Thermal Engineering* 248, Part A (2024): 123097. https://doi.org/10.1016/j.applthermaleng.2024.123097.

Givoni, Baruch. "Heating and Cooling via the Utilization of Natural Energies." In *Settling the Desert*, edited by L. Berkofsky, D. Faiman and J. Gale, pp. 241–70. London: Routledge, 2019. https://doi.org/10.4324/9780429287886-18.

Givoni, Baruch. "Integrated—Passive Systems for Heating of Buildings by Solar Energy." *Architectural Science Review* 24, no. 2 (1981): 29–41. https://doi.org/10.1080/00038628.1981.9696464.

Glass, Christopher. "Leonardo's Successors." *Nexus Network Journal* 10, no. 1 (2008): 129–48. https://doi.org/10.1007/s00004-007-0059-5.

Glass, Christopher. "The Pythagopod." *Nexus Network Journal* 4 (2002): 33–44. https://doi.org/10.1007/s00004-001-0003-z.

Gonzalo, Roberto, and Karl J. Habermann. *Energy-Efficient Architecture: Basics for Planning and Construction.* Berlin: Walter de Gruyter, 2012.

Gropp, L. "Ninety Metal Drums Collect and Store Heat." In *Renewable Energy* 2, edited by Bent Sørensen, pp. 449–54. London: Routledge, 2018. https://doi.org/10.4324/9781315793245-74.

Haggard, K. "Passive Solar Architecture." In *Solar Architecture: Proceedings of the ASC/AIA Forum '75, November 26–29, 1975, Arizona State University, Tempe.* Tempe: Arizona State University, College of Architecture, 1976.

Hargittai, Balázs. "Zometool: The 31-Zone Structural System by Biocrystal Inc." *Leonardo* 26, no. 4 (1993): 327–29. https://doi.org/10.2307/1575924.

Hart, George. "The Joy of Polar Zonohedra." In *Bridges 2021: Mathematics, Art, Music, Architecture, Culture*, edited by David Stewart, Frank Farris, and Eve Torrence, pp. 7–14. Phoenix: Tessellations Publishing, 2021.

Hildebrandt, Paul, and Clark Richert. "Domes, Zomes, and Drop City." In *Proceedings of Bridges 2012: Mathematics, Music, Art, Architecture, Culture*, edited by Robert Bosch, Douglas McKenna, and Reza Sarhangi, pp. 545–48. Phoenix: Tessellations Publishing, 2012.

Itani, Mariam. "Case Study Analysis of the Baer House." In *Studies in the History of Services and Construction: Proceedings of the Fifth Annual Conference of the Construction History Society*, Edited by J. Campbell *et al.*, pp. 87–100. Queens' College Cambridge, 6–8 April, 2018.

Kallipoliti, Lydia. "History of Ecological Design." *Oxford Research Encyclopedia of Environmental Science* (2018). https://doi.org/10.1093/acrefore/9780199389414.013.144.

Kappraff, Jay. *Connections: The Geometric Bridge Between Art and Science.* 2nd ed. Singapore: World Scientific, 2001. https://doi.org/10.1142/4668.

Keller, Merily H. *Passive Solar Heating and Cooling.* Los Alamos, NM: Los Alamos National Laboratory, 1976.

Khaled-Khodja, Ghania. *Energy Conservation in Buildings: Passive Solar Designs.* Master of Architecture thesis, University of Glasgow, 1986.

Klijn, Olv, and Eric Frijters. "I Think It Is Finished Now...: 'Volgens mij is het nu af….'" *DASH | Delft Architectural Studies on Housing* 4, No. 07 (2012): 62–70.

Kumar, Rakesh, and Marc A. Rosen. "Review of Solar Water Heaters with Integrated Collector-Storage Units." *International Journal of Energy, Environment and Economics* 21, no. 4 (2013): 343.

Latka, Jerzy F. "Paper Structures: Case Studies." *A+BE | Architecture and the Built Environment* 19 (2017): 165–266. https://doi.org/10.59490/ABE.2017.19.3758.

Lechner, Norbert. *Heating, Cooling, Lighting: Sustainable Design Methods for Architects.* 4th ed. Hoboken, NJ: John Wiley & Sons, 2015.

Lifschutz, Alex, ed. *Loose-Fit Architecture: Designing Buildings for Change.* Hoboken, NJ: John Wiley & Sons, 2017.

Liu, Xiangfeng, Miao Xu, Juanli Guo, and Renjie Zhu. "Numerical Study on the Energy Performance of Building Zones with Transparent Water Storage Envelopes." *Solar Energy* 180 (2019): 690–706. https://doi.org/10.1016/j.solener.2019.01.044.

Lopez, Fanny. "Self-Sufficiency in Architectural and Urban Projects: Toward Small-Pipe Engineering?" In *Infrastructures in Practice*, edited by Elizabeth Shove and Frank Trentmann, pp. 58–74. London: Routledge, 2018. https://doi.org/10.4324/9781351106177-7.

Lopez, Fanny. "The Self-Sufficient City." In *Dreams of Disconnection*, pp. 223–51. Manchester: Manchester University Press, 2021.

Lopez, Fanny. "Toward Energy Emancipation." In *Dreams of Disconnection*, pp. 105–50. Manchester: Manchester University Press, 2021.

Luckhurst, Roger. "Utopian Spaces." In *The Cambridge Companion to American Utopian Literature and Culture Since 1945*, edited by S. Vint, pp. 201–6. Cambridge: Cambridge University Press, 2024. https://doi.org/10.1017/9781009180078.012.

Maclay, Bill. *The New Net Zero: Leading-Edge Design and Construction of Homes and Buildings for a Renewable Energy Future.* White River Junction, VT: Chelsea Green Publishing, 2014.

Maniaque, Caroline. "Presenting Another Profile of Architecture: Alternatives to Museographical Canonization." *ABE Journal: Architecture Beyond Europe* 1 (2012). https://doi.org/10.4000/abe.78.

Maniaque, Caroline. "The American Travels of European Architects, 1958–1973." In *Travel, Space, Architecture*, edited by Jilly Traganou and Miodrag Mitrašinović, pp. 189–209. London: Routledge, 2009.

Maniaque-Benton, Caroline. *French Encounters with the American Counterculture 1960–1980.* London: Routledge, 2016. https://doi.org/10.4324/9781315254982.

Marinakis, Yorgos, Rainer Harms, and Steven Thomas Walsh. "Zomeworks Corporation: Design Driven Innovation." Research paper, 2014.

Martin, Craig. "'Everything Can Always Be Something Else': Adhocism and J. G. Ballard's *Concrete Island*." *Literary Geographies* 2, no. 1 (2016): 79–95.

Matthews, Mark. *Droppers: America's First Hippie Commune, Drop City.* Norman: University of Oklahoma Press, 2012.

McDonald, Margot, and Carolina Dayer, eds. *Activism in Architecture: Bright Dreams of Passive Energy Design.* London: Routledge, 2018. Kindle edition. https://doi.org/10.4324/9781315182858.

McLean, William, and Pete Silver. *Environmental Design Sourcebook: Innovative Ideas for a Sustainable Built Environment.* London: Routledge, 2021. https://doi.org/10.4324/9781003189046.

Meneghetti, Leila Cristina, Fernando Simões, Estevão Laurito, Ruy Marcelo Pauletti and Arthur H. Lara. "Free Explorations of the Polar Zonohedron Domes." In *Proceedings of the IASS 2024 Symposium: Redefining the Art of Structural Design*, *August 26–30*, 2024.

Miller, Timothy. "New Mexico's New Communal Settlers." *New Mexico Historical Review* 87, no. 1 (2012): 4.

Miller, Timothy. *The 60s Communes: Hippies and Beyond.* Syracuse, NY: Syracuse University Press, 1999.

Mortensen, Peter. "Tools of Transformation: Appropriate Technology in U.S. Countercultural Literature." *American Studies in Scandinavia* 44, no. 2 (2012): 75–93. https://doi.org/10.22439/asca.v44i2.4917.

Narath, Albert. *Solar Adobe: Energy, Ecology, and Earthen Architecture.* Minneapolis: University of Minnesota Press, 2024.

Poisson, Leandre, and Gretchen Vogel Poisson. *Solar Gardening: Growing Vegetables Year-Round the American Intensive Way.* White River Junction, VT: Chelsea Green Publishing, 1994.

Ponte, Alessandra. "Garbage Art and Garbage Housing." *Log* 8, no. 8 (2006): 99–111.

Price, Roberta. *Across the Great Divide: A Photo Chronicle of the Counterculture.* Albuquerque: University of New Mexico Press, 2010.

Sadler, Simon. "Diagrams of Countercultural Architecture." *Design and Culture* 4, no. 3 (2012): 345–67. https://doi.org/10.2752/175470812X13361292229195.

Sadler, Simon. "Drop City Revisited." *Journal of Architectural Education* 59, no. 3 (2006): 5–14. https://doi.org/10.1111/j.1531-314X.2006.00029.x.

Schoenefeldt, Henrik, and James Campbell. "Introduction to Studies in the History of Services and Construction." In *History in the Study of Services and Construction*, pp. 1–10. Cambridge: Construction History Society, 2018.

Setiawan, Arief. "Memories and Performance." *ARCC Conference Repository* (2014). https://doi.org/10.17831/rep:arcc%y256.

Skurka, Norma, and Jon Naar. *Design for a Limited Planet.* New York: Ballantine Books, 1976.

Sugarman, Ever. *Neon Mirage: Utopian Visions of Burning Man.* MS thesis, Pratt Institute, 2024.

Turner, Fred. "Technology and Counterculture from World War II to Today." Lecture, The Long Now Foundation, March 20, 2020.

Van Andel, Frederique, Dick van Gameren, Dirk van den Heuvel, Jacques Vink, and Piet Vollaard. "Plan Documentation: The Eco House." *DASH | Delft Architectural Studies on Housing* 07 (2012): 71–73.

Van Dresser, Peter. *Homegrown Sundwellings.* Santa Fe: The Lightning Tree, 1977.

Vink, Jacques A., Dirk van den Heuvel, Dick van Gameren, and Piet Vollaard. *DASH 07: The Eco House / Het Ecohuis: Typologies of Space, Production and Lifestyles.* Rotterdam: NAi Uitgevers, 2012.

Vollaard, Piet, and Frederique Van Andel. "Zome House Corrales, New Mexico." *DASH | Delft Architectural Studies on Housing* 07 (2012): 88–95.

Wu, Ting, and Chengwang Lei. "A Review of Research and Development on Water Wall for Building Applications." *Energy and Buildings* 112 (2016): 198–208. https://doi.org/10.1016/j.enbuild.2015.12.003.

Zomeworks Corporation. "Double Play Progress Report." Albuquerque: Zomeworks, 2004.

Zomeworks Corporation. "How to Cool and Heat with Pure Water, Without Using Any Energy or Moving Parts." Albuquerque: Zomeworks, ca. 2007–2012.

Zomeworks Corporation. "Independent Cool Cell™ Results: Tucson, Arizona." Albuquerque: Zomeworks, 2002.

## Appendix A: Methodology and Literature Review

The investigative work underpinning this paper was structured around a historical research methodology, leaning on primary and secondary sources. Secondary sources included peer-reviewed academic articles, conference proceedings, books, as well as theses/dissertations written at the graduate and doctoral level. Primary sources included: (1) governmental reports from the 1970s and 80s, authored by the Department of Energy, as well as the Subcommittee on Energy Research, Development, and Demonstration, operating under the broader aegis of the Committee on Science and Technology active during that time; (2) publicly accessible corporate documents, reports, and advertising material from and pertaining to the Zomeworks Corporation; and (3) interviews and back-and-forth correspondence conducted with colleagues and associates close to Steve Baer, most critically New Mexico architect Bruce Davis from January 2024 to April 2025. It is with deep regret that Steve Baer himself passed away during the development of this manuscript. Karen Terry, another person of critical importance to this manuscript, could not be reached due to certain medical complications.

In March 2025, an extensive literature review concerning the topic at hand was conducted. A search for academic articles containing the terms "Steve Baer" and "Zome" within the body or title of the text produced 69 relevant articles.

While there were overlaps between the areas of interest covered by these texts, they broadly fell across four categories.

The first category consisted of articles tapping into the discourse of concern primarily via a focus upon the Zome House, Steve and Holly Baer's primary residence—specifically delving into issues of how thermal mass was leveraged for the purposes of passive solar heating and cooling, the spatial and geometric layers of the house, and how the project evolved over time. This category consisted of 25 texts.[81]

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[81] These texts include:

1. Keith Bothwell, "Sustainable Architecture," in *Routledge International Handbook of Sustainable Development* (London: Routledge, 2015), 147–63.
2. James Spencer Day, *Towards a Synthesis of Energy, Form and Use: New Forms of Solar Space Conditioning Made Possible by the Use of New Materials* (PhD diss., Massachusetts Institute of Technology, 1977).
3. Anthony Denzer, "Banham's Gamble," paper presented at the Society of Architectural Historians 67th Annual Conference, 2014.
4. Alfredo Fernández-González, "Analysis of the Thermal Performance and Comfort Conditions Produced by Five Different Passive Solar Heating Strategies in the United States Midwest," *Solar Energy* 81, no. 5 (2007): 581–93, https://doi.org/10.1016/j.solener.2006.09.010.
5. Baruch Givoni, "Heating and Cooling via the Utilization of Natural Energies," in *Settling the Desert* (London: Routledge, 2019), 241–70, https://doi.org/10.4324/9780429287886-18.

6. Roberto Gonzalo and Karl J. Habermann, *Energy-Efficient Architecture: Basics for Planning and Construction* (Berlin: Walter de Gruyter, 2012).
7. L. Gropp, "Ninety Metal Drums Collect and Store Heat," in *Renewable Energy* 2 (London: Routledge, 2018), 449–54, https://doi.org/10.4324/9781315793245-74.
8. K. Haggard, "Passive Solar Architecture," in *Solar Architecture: Proceedings of the ASC/AIA Forum '75, November 26–29, 1975, Arizona State University, Tempe* (Tempe: Arizona State University, College of Architecture, 1976).
9. Mariam Itani, "Case Study Analysis of the Baer House," in *Studies in the History of Services and Construction* (Queens' College Cambridge, 2018) 87.
10. Merily H. Keller, *Passive Solar Heating and Cooling* (Los Alamos, NM: Los Alamos National Laboratory, 1976).
11. Ghania Khaled-Khodja, *Energy Conservation in Buildings: Passive Solar Designs* (Master of Architecture thesis, University of Glasgow, 1986).
12. Olv Klijn and Eric Frijters, "I Think It Is Finished Now...: 'Volgens mij is het nu af…,'" *DASH | Delft Architectural Studies on Housing* 4, no. 07 (2012): 62–70.
13. Jerzy F. Latka, "Paper Structures: Case Studies," A+BE | *Architecture and the Built Environment* 19 (2017): 165–266, https://doi.org/10.59490/ABE.2017.19.3758.
14. Xiangfeng Liu, Miao Xu, Juanli Guo and Renije Zhu, "Numerical Study on the Energy Performance of Building Zones with Transparent Water Storage Envelopes," *Solar Energy* 180 (2019): 690–706, https://doi.org/10.1016/j.solener.2019.01.044.
15. Fanny Lopez, "Self-Sufficiency in Architectural and Urban Projects: Toward Small-Pipe Engineering?," in *Infrastructures in Practice* (London: Routledge, 2018), 58–74, https://doi.org/10.4324/9781351106177-7.
16. Fanny Lopez, "Toward Energy Emancipation," in *Dreams of Disconnection* (Manchester: Manchester University Press, 2021), 105–50.
17. William McLean and Pete Silver, *Environmental Design Sourcebook: Innovative Ideas for a Sustainable Built Environment* (London: Routledge, 2021), https://doi.org/10.4324/9781003189046.
18. Albert Narath, *Solar Adobe: Energy, Ecology, and Earthen Architecture* (Minneapolis: University of Minnesota Press, 2024).
19. Leandre Poisson and Gretchen Vogel Poisson, *Solar Gardening: Growing Vegetables Year-Round the American Intensive Way* (White River Junction, VT: Chelsea Green Publishing, 1994).
20. Henrik Schoenefeldt and James Campbell, "Introduction to Studies in the History of Services and Construction," in *History in the Study of Services and Construction* (Cambridge: Construction History Society, 2018), 1–10.
21. Arief Setiawan, "Memories and Performance," *ARCC Conference Repository* (2014), https://doi.org/10.17831/rep:arcc%y256.
22. Frederique Van Andel, Dick van Gameren, Dirk van den Heuvel, Jacques Vink, and Piet Vollaard, "Plan Documentation: The Eco House," *DASH | Delft Architectural Studies on Housing* 07 (2012): 71–73.
23. Jacques A. Vink, Dirk van den Heuvel, Dick van Gameren, and Piet Vollaard, *DASH 07: The Eco House / Het Ecohuis: Typologies of Space, Production and Lifestyles* (Rotterdam: NAi Uitgevers, 2012).

The second category consisted of articles connected to the narrative of Steve Baer as a countercultural figure and his involvement in the grassroots, anti-consumerist, self-build zeitgeist which flourished in the post-Second World War American Southwest. These articles also frequently referenced the Drop City settlement active in Trinidad, Colorado, between the late 1960s and early 1970s. This category consisted of 21 texts.[82]

24. Piet Vollaard and Frederique Van Andel, "Zome House Corrales, New Mexico," *DASH | Delft Architectural Studies on Housing* 07 (2012): 88–95.
25. Ting Wu and Chengwang Lei, "A Review of Research and Development on Water Wall for Building Applications," *Energy and Buildings* 112 (2016): 198–208, https://doi.org/10.1016/j.enbuild.2015.12.003.

[82] These texts include:

1. Elissa Auther and Adam Lerner, eds., *West of Center: Art and the Counterculture Experiment in America, 1965–1977* (Minneapolis: University of Minnesota Press, 2012), https://doi.org/10.5749/minnesota/9780816677252.001.0001.
2. Julia Bryan-Wilson, "Handmade Genders: Queer Costuming in San Fransisco Circa 1970," in *West of Center: Art and the Counterculture Experiment in America, 1965–1977* (Minneapolis: University of Minnesota Press, 2011), 76–93.
3. Greg Castillo, "Salvage Salvation: Counterculture Trash as a Cultural Resource," in *The Routledge Companion to Architecture and Social Engagement* (London: Routledge, 2018), 306–21, https://doi.org/10.4324/9781315712697-23.
4. Luis S. Villacañas De Castro, "Dewey, Hippie Communes, and Education," *Education and Culture* 37, no. 1 (2021): 94–120.
5. Andrea Alberto Dutto, "Shelter Oddity," *sITA: Studii de Istoria şi Teoria Arhitecturii* 10 (2022): 25–40, https://doi.org/10.54508/sITA.10.03.
6. Fanny Lopez, "The Self-Sufficient City," in *Dreams of Disconnection* (Manchester: Manchester University Press, 2021), 223–51, https://doi.org/10.7765/9781526146908.
7. Roger Luckhurst, "Utopian Spaces," in *The Cambridge Companion to American Utopian Literature and Culture Since 1945* (Cambridge: Cambridge University Press, 2024), 201, https://doi.org/10.1017/9781009180078.012.
8. Bill Maclay, *The New Net Zero: Leading-Edge Design and Construction of Homes and Buildings for a Renewable Energy Future* (White River Junction, VT: Chelsea Green Publishing, 2014).
9. Caroline Maniaque, "Presenting Another Profile of Architecture: Alternatives to Museographical Canonization," *ABE Journal: Architecture Beyond Europe* 1 (2012), https://doi.org/10.4000/abe.78.
10. Caroline Maniaque, "The American Travels of European Architects, 1958–1973," in *Travel, Space, Architecture* (2009), 189–209.
11. Caroline Maniaque-Benton, *French Encounters with the American Counterculture 1960–1980*(London:Routledge,2016),https://doi.org/10.4324/9781315254982.
12. Craig Martin, "'Everything Can Always Be Something Else': Adhocism and J. G. Ballard's *Concrete Island*," *Literary Geographies* 2, no. 1 (2016): 79–95.
13. Mark Matthews, *Droppers: America's First Hippie Commune, Drop City* (Norman: University of Oklahoma Press, 2012).

The third category was composed of articles focused on the mathematical, spatial, and historical-theoretical details behind dome design and construction, particularly polar zonohedron domes (i.e., *zomes*). These articles frequently touched upon Baer's Zome system, the Zome toolkit, or the ZomeToy which evolved from these explorations. This category consisted of 14 texts.[83]

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14. Timothy Miller, *The 60s Communes: Hippies and Beyond* (Syracuse, NY: Syracuse University Press, 1999).
15. Timothy Miller, "New Mexico's New Communal Settlers," *New Mexico Historical Review* 87, no. 1 (2012): 4.
16. Peter Mortensen, "Tools of Transformation: Appropriate Technology in U.S. Countercultural Literature," *American Studies in Scandinavia* 44, no. 2 (2012): 75–93, https://doi.org/10.22439/asca.v44i2.4917.
17. Alessandra Ponte, "Garbage Art and Garbage Housing," *Log* 8 (2006): 99–111.
18. Roberta Price, *Across the Great Divide: A Photo Chronicle of the Counterculture* (Albuquerque: University of New Mexico Press, 2010).
19. Simon Sadler, "Drop City Revisited," *Journal of Architectural Education* 59, no. 3 (2006): 5–14, https://doi.org/10.1111/j.1531-314X.2006.00029.x.
20. Simon Sadler, "Diagrams of Countercultural Architecture," *Design and Culture* 4, no. 3 (2012): 345–67, https://doi.org/10.2752/175470812X13361292229195.
21. Ever Sugarman, *Neon Mirage: Utopian Visions of Burning Man* (M.S. thesis, Pratt Institute, 2024).

[83] These texts include:

1. Vandana Baweja, "Sustainable Architecture: A Short History," in *Routledge Handbook of the History of Sustainability* (London: Routledge, 2017), 273–95, https://doi.org/10.4324/9781315543017-17.
2. David Booth, "The New Zome Primer," in *Fivefold Symmetry* (Singapore: World Scientific, 1992), 221–33, https://doi.org/10.1142/9789814439497_0014.
3. Paul J. Campbell, "Lesson Plans / Zome Primer / Zometool Manual," *Mathematics Magazine* 73, no. 3 (2000): 246–47, https://doi.org/10.1080/0025570X.2000.11996849.
4. Benoit Charbonneau and Spencer Whitehead, "Studying Wythoff and Zometool Constructions Using Maple," in *Maple Conference* (Cham: Springer International Publishing, 2019), https://doi.org/10.1007/978-3-030-41258-6_5.
5. Eva Díaz, "Dome Culture in the Twenty-First Century," *Grey Room* 42 (2011): 80–105, https://doi.org/10.1162/GREY_a_00020.
6. Christopher Glass, "The Pythagopod," *Nexus Network Journal* 4 (2002): 33–44, https://doi.org/10.1007/s00004-001-0003-z.
7. Christopher Glass, "Leonardo's Successors," *Nexus Network Journal* 10, no. 1 (2008): 129–48, https://doi.org/10.1007/s00004-007-0059-5.
8. Balázs Hargittai, "Zometool—The 31-Zone Structural System by Biocrystal Inc.," *Leonardo* 26, no. 4 (1993): 327–29, https://doi.org/10.2307/1575924.
9. George Hart, "The Joy of Polar Zonohedra," in *Bridges 2021: Mathematics, Art, Music, Architecture, Culture* (Phoenix: Tessellations Publishing, 2021): 7–14.

The final category, which is of greatest relevance to this article, consisted of texts focused on the specifics of the passive heating, cooling, and tracking technologies developed by Steve Baer and his associates at Zomeworks from the late 1960s onwards. This category consisted of 10 texts.[84]

Even within these latter 10 articles, however, the specifics of Baer's double-play thermosiphon system are never fully detailed. Within the compendium of

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10. Paul Hildebrandt and Clark Richert, "Domes, Zomes, and Drop City," in *Proceedings of Bridges 2012: Mathematics, Music, Art, Architecture, Culture* (Phoenix: Tessellations Publishing, 2012), 545–48.
11. Lydia Kallipoliti, "History of Ecological Design," *Oxford Research Encyclopedia of Environmental Science* (2018), https://doi.org/10.1093/acrefore/9780199389414.013.144.
12. Jay Kappraff, *Connections: The Geometric Bridge Between Art and Science* (Singapore: World Scientific, 2001), https://doi.org/10.1142/4668.
13. Alex Lifschutz, ed., *Loose-Fit Architecture: Designing Buildings for Change* (Hoboken, NJ: John Wiley & Sons, 2017).
14. Leila Cristina Meneghetti, Fernando Simões, Estevão Laurito, Ruy Marcelo Pauletti and Arthur H. Lara, "Free Explorations of the Polar Zonohedron Domes," in *Proceedings of the IASS 2024 Symposium* (2024).

[84] These texts include:

1. Jay Burch *et al.*, "Simulation of an Unglazed Collector System for Domestic Hot Water and Space Heating and Cooling," *Solar Energy* 77, no. 4 (2004): 399–406, https://doi.org/10.1016/j.solener.2003.12.014.
2. William Benjamin Davis, *A Design Guide for the Use of Solar Energy as Residential Space Heating* (San Luis Obispo: California Polytechnic State University, 1975).
3. Patricia Elaine Felter, *Consumer Acceptance of Passive Solar Retrofitting* (PhD diss., Texas Tech University, 1980).
4. Richard J. Fontenot *et al.*, "A Review and Outlook on Osmotically Driven Heat Pipes for Passive Thermal Transport," *Applied Thermal Engineering* (2024): 123097, https://doi.org/10.1016/j.applthermaleng.2024.123097.
5. Baruch Givoni, "Integrated—Passive Systems for Heating of Buildings by Solar Energy," *Architectural Science Review* 24, no. 2 (1981): 29–41, https://doi.org/10.1080/00038628.1981.9696464.
6. Rakesh Kumar and Marc A. Rosen, "Review of Solar Water Heaters with Integrated Collector-Storage Units," *International Journal of Energy, Environment and Economics* 21, no. 4 (2013): 343.
7. Norbert Lechner, *Heating, Cooling, Lighting: Sustainable Design Methods for Architects*, 4th ed. (Hoboken, NJ: John Wiley & Sons, 2015).
8. Yorgos Marinakis, Rainer Harms, and Steven Thomas Walsh, "Zomeworks Corporation: Design Driven Innovation," research paper, 2014.
9. M. McDonald and C. Dayer, eds., *Activism in Architecture: Bright Dreams of Passive Energy Design* (London: Routledge, 2018), Kindle edition.
10. Norma Skurka and Jon Naar, *Design for a Limited Planet* (New York: Ballantine Books, 1976).

McDonald and Dayer,[85] Baer is mentioned in quite a few moments; however, the focus is placed upon his work leveraging water as thermal mass, and this approach's relationship to the prior work of Harold Hay. Within Davis,[86] Skurka and Naar,[87] Felter,[88] and Lechner,[89] Baer's innovations around convective heating loops are homed in upon, but once more, the specific double-play thermosiphon system is not noted. Fontenot *et al*.[90] focus on the osmotic thermosiphon systems proposed by Baer, which can be traced back to Baer's own 1975 text, *Sunspots*.[91] However this is quite a different "heat transport device" altogether.[92] Kumar and Rosen[93] focus on Baer's *breadbox* invention, a precursor of sorts to the double-play thermosiphon structure, but do not delve into the actual double-play system of concern.

It is only in two specific texts that the double-play thermosiphon system is noted. These are by Marinakis *et al*.[94] and Burch *et al*.[95] Marinakis *et al*.[96], for instance, refer to a "thermosiphon-type solution" composed of "circuits of pipe inside which hot water rises and cold water sinks." However, no further explanation is given beyond this. Burch *et al*.[97] begin to get into more detail, noting a looped system that has rooftop collectors for the rejection of heat during the night. However, how this system actually works, specifically without any active mechanical components, is not described in depth.

Further searches into articles containing the words "Steve Baer" and "thermosiphon," or "Zomeworks" and "thermosiphon," or "Steve Baer" and "radiant cooling," or "Zomeworks" and "radiant cooling," were also conducted. No additional relevant articles were uncovered.

Based on this literature review, it is apparent that there is a significant gap in the discourse surrounding the double-play thermosiphon invention of Steve Baer. While there are two texts that refer to the double-play thermosiphon system

85 McDonald and Dayer, *Activism in Architecture*, locations 1016–33.

86 Davis, *A Design Guide for the Use of Solar Energy*, 17–21.

87 Skurka and Naar, *Design for a Limited Planet*, 50.

88 Felter, *Consumer Acceptance of Passive Solar Retrofitting*, 27–28.

89 Lechner, *Heating, Cooling, Lighting*, 192.

90 Fontenot *et al.*, "A Review and Outlook on Osmotically Driven Heat Pipes."

91 Baer, *Sunspots*.

92 Baer, *Sunspots*, 36.

93 Kumar and Rosen, "Review of Solar Water Heaters."

94 Marinakis *et al.*, "Zomeworks Corporation."

95 Burch *et al.*, "Simulation of an Unglazed Collector System."

96 Marinakis *et al.*, "Zomeworks Corporation," 1–2.

97 Burch *et al.*, "Simulation of an Unglazed Collector System," 399–400.

directly,[98] there is no clear and detailed discursive thread that a reader may follow to understand what this system actually was, how it functioned, and more importantly, whether it was at all successful as a passive system. This paper aims to fill that gap.

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[98] Burch *et al.*, "Simulation of an Unglazed Collector System"; Marinakis *et al.*, "Zomeworks Corporation."