PREFAB + SOLAR AT MIDCENTURY

ANTHONY DENZER
University of Wyoming

In April 1945 the New York Times announced:

> "Tomorrow, if it's a nice day in Rockford, Ill., a new house will go up.... It will combine two principles widely acclaimed as inevitable for post-war home building—prefabricated construction and solar planning."[1]

As the Times indicated, prefabrication and solar heating were the two issues that would have interested any progressive architect in the mid-1940s. Yet the two movements rarely intersected. For the most part, architects interested in prefabrication did not pursue solar heating. And vice-versa, solar architects almost exclusively designed one-off custom site-built projects. This historical paper examines those rare instances of intersection, plus the wider affinities and contradictions between prefab and solar at midcentury.

DISCORDANCE

Although the solar house[2] and the prefabricated house were timely challenges for modern architects, they were unrelated concepts and possibly seen as discordant. In his comprehensive 1951 survey The Prefabrication of Houses, Burnham Kelly reported: "Very few companies at the time of our survey were attempting any considerable use of solar radiation to heat their houses [despite the fact that] this idea has captured the public imagination of many architects and, to some extent, the public."[3]

Fundamental to the discordance was the issue of site specificity. Solar houses needed to face south and offer shading for the south-facing windows appropriate to the location. But orientation posed a problem for mass-produced prefabricated houses, since there was an implicit need to rotate the house (in plan) to accommodate different sites. Additionally, solar principles demanded different shading angles for different locations, and this would inhibit a 'generic' design strategy which was preferred by many prefabricators at this time.

Another possible conceptual inconsistency between prefab and solar would have been the issue of light- vs. heavy-construction. In particular, solar architects were beginning to recognize the need for mass floors for heat storage in the 1940s, while a commitment to prefab would have suggested to architects to make the floor in the factory, modular and lightweight. In the absence of thermal mass, light prefabricated houses would tend to severe diurnal temperature swings in winter. This would be exacerbated if the design did not include proper shading.

HISTORICAL CONTEXT

Many of the early-modern architects who pioneered prefabrication gave importance to solar orientation and solar geometry, before 'passive' solar heating was well-understood. Both Walter Gropius and Le Corbusier could point to Tony Garnier's Une Cité Industrielle proposal (1901-17) as a central influence. Garnier's sweeping plan for an industrial city has been interpreted as a "solar utopia," with houses that were "planned with equal solar access and ... spaced to prevent shading of adjacent buildings during the winter months."[4]

Walter Gropius emphasized solar access in his housing proposals of the late 1920s. At third congress of CIAM in Brussels (1930), Gropius presented a diagram (probably by Bauhaus students) which showed how housing blocks should be spaced to avoid self-shading using a low winter sun angle.[5] This diagram is sometimes misinterpreted as representing passive solar heating, but Gropius was concerned with light rather than heat—Sigfried Giedion called this the "illumination angle" years later. Ultimately Gropius aimed to show that housing in widely-spaced tall towers was the most efficient use of land.

Le Corbusier's love of the sun is well-known. His canonical prefabricated housing at Pessac (1924) provided solar access for each dwelling in the manner of Garnier. The Villa Savoye is, among other interpretations, a monument to heliotherapy, based on a tradition of sanatorium architecture. And when Le Corbusier formulated the Athens Charter for CIAM between 1933 and 1941, he wrote a central role for sunshine into the larger agenda of modern architecture and planning.

It is important to note that Garnier, Gropius, and Le Corbusier desired sunlight for heliotherapeutic reasons—for health and hygiene—rather than space heating and energy savings. Nevertheless, it remains an overarching theme that the history of prefabrication is entwined with a new movement to use scientific methods to shape architecture in relation to a new environmental concern: access to the sun.

TYPICAL PRACTICE AT MIDCENTURY

In the American discourse on prefabrication at midcentury, solar orientation is almost never discussed. In practice, the common response among prefabricators was to ignore the issue of orientation, and to design the house with relatively similar window-to-wall ratios on all four sides. This allowed the house to be 'rotated' as needed so that the front door could face the street on any type of site. This approach was handed down from an earlier generation of prefabricators such as Aladdin and Sears, and probably inherited from 19th-century pattern books.

Promotional plans for Gropius and Wachsmann's Packaged House system for General Panel Corporation (1941-52) generally did not include overhangs and did not specify orientation.[6] Lustron's lengthy "Planning Guide" (1948) did not discuss orientation or solar heat, but instead emphasized the attractiveness of the landscape and community planning issues such as access to parks, schools, and shopping centers.[7] And Carl Koch intended his Acorn 'unfolding house' (1948) to be sited 'generically'.[8] Koch's Techbuilt System (1953), which sold over 3,000 units, may have been more sensitive to solar heating issues, as it included deep overhanging eaves. Still, Koch did not discuss orientation or solar heating in his 1958 book At Home With Tomorrow.[9]

THE PREFABRICATED SOLAR HOUSE

1. Green's Ready-Built Homes

One project clearly stands out for its critical contribution in assimilating prefabrication and solar heating: the Green's Ready-Built Homes (1942-46) by Chicago architect George Fred Keck.[10] It was this project that the New York Times highlighted as combining two "inevitable" principles (see above). The Times also called the Green's model home "the first prefabricated solar house ever built."[11]

Keck, an architectural engineer, was the indisputable 'father' of the solar house. He began to experiment with solar heating and shading in the mid-1930s, and his (custom-built) Sloan house (Chicago, 1940) was the first building anywhere described as a "solar house." By the mid-1940s Keck was able to calculate gains and losses, and project to his clients how much they would save in fuel costs—the only designer in America and probably the world who could do so.

Keck gave the Ready-Built Homes a distinctive appearance by expressing the constraints imposed by prefabrication and solar geometry. The modular form was lean, shallow and long, stretched east-to-west in order to maximize the south wall. That wall, principally glass, was clearly differentiated from the mostly-opaque walls on the east, west and north. On the south, ventilating louvers provided visual texture and expressed the need for fresh air, while Keck mixed the wall panel-types to create a pleasing rhythm, avoiding the pitfalls of pure repetition. Likewise, the placement of the louvered wing walls created a rational but non-uniform system of bay widths. The unbroken horizontality of the roof plane came from the need for passive cooling (more below). Aesthetically, few houses in modern architecture were so articulate and so clear; every expressive element reflected a clear environmental purpose.

Figure 1. Green's Ready-Built Homes (1945) by George Fred Keck. (Hedrich-Blessing)

Keck gave extensive creative thought to the treatment of the glass wall and its performance. First, he was committed to using double-pane insulated glass ("Thermopane"), a relatively new technology, to minimize nighttime heat loss. Then he used fixed glass in combination with ventilating louvers, which solved a number of problems. Keck believed traditional operable windows needed to perform too many contradictory functions: first, they required insect screens which in turn interfered with a clear view; and second, they could not be left open for security reasons when the homeowners were away, or at night, thus limiting their effectiveness for ventilation. This desire to dissect a window's functions is remindful of Le Corbusier's 1929 declaration: la fênetre est faite pour éclairer, non pour ventiler ("the window is for light, not for ventilation"), which Keck certainly knew. Paul Schweikher, who shared office space with Keck for a time, recalled: "We were almost obsessed with the idea of separating the view from the circulation of air."[12]

Shading and other passive cooling methods were crucial factors in Keck's pursuit of solar heating. (Keck may have been the first architect to draw a 2D shading diagram, in 1937.) For the Ready-Built Homes the roof overhang provided a shading angle of 52°, which would fully shade the glass from about 9:30AM to 2:30PM in midsummer in Rockford, Illinois. There is no indication that the shading angle would be customized for different locations.

Also for cooling, the Ready-Built Homes included a shallow roof pool, another element Keck pioneered. By 1946 he knew that this

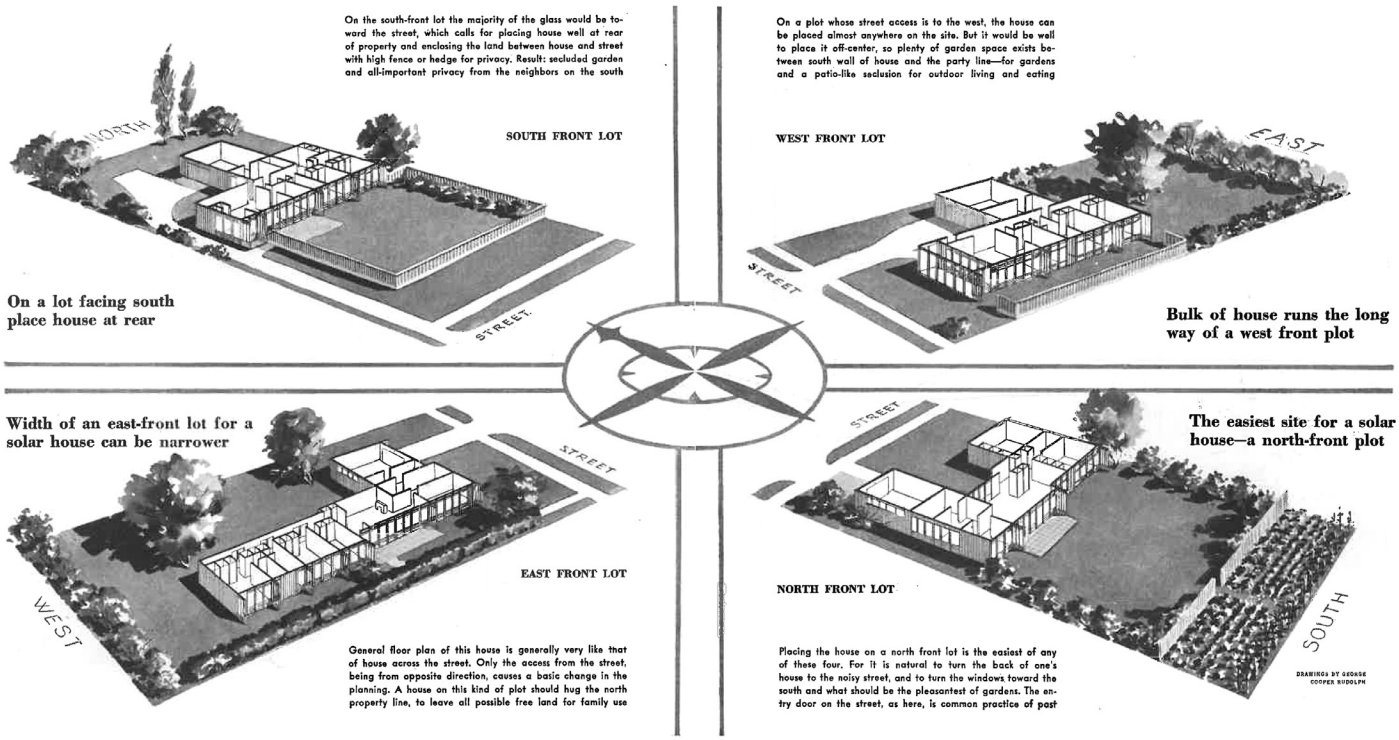

Figure 2. Green's Ready-Built Homes diagram. (House Beautiful, November 1945)

technique rejected up to 80% of the summer radiation falling on the roof.[13] When Keck explained this concept, he was fond of saying the sun cools the house by evaporation, the same way it cools a swimmer in a wet bathing suit. He also noted that ancient Egyptians had used the same idea, with dampened wool on the roof.

Because the design depended on proper solar orientation, Keck developed a remarkable method to reconfigure the plan, creating fourteen different models and accommodating four lot-types. One magazine announced: "A solar house can be planned for ANY SIDE OF THE STREET."[14] A lot with a north street-front was "easiest" because the all-glass south wall would face the back yard. The other three types required fences or hedges to create privacy. No other prefabricator is known to have made such an investigation. These studies also revealed a fundamental planning issue that frequently confronts solar designers: lots facing north or south were required to be at least 100 feet wide.[15] This was a major limitation of Keck's plan, and a principal reason that most other prefabricated houses (solar or not) were relatively square in plan.

The Green's Ready-Built Homes included an uncommon type of heating system, a radiant floor using cellular clay tiles that formed air ducts. A furnace could supply hot air to the floor when the solar heat was insufficient. Although Keck thought of the hollow floor tiles as prefabricated pieces, the system required a great deal of on-site construction, like brickwork. Keck did not invent this system, but he developed it to maturity and patented it. He worked with the Clay Products Association to market the system as "RadianTile."

In general Keck (working with his brother William) recognized the benefits of thermal mass and the phenomenon of lag time. They described the hollow tile floor as "essentially massive." But they did not attempt to quantify the heat storage. William later recalled: "We have only tried to take care of momentary conditions as they exist, taking advantage of a natural phenomenon."[16] With the combined effects of solar heat and the radiant floor system, Keck anticipated that the homeowners' fuel bills could be cut as much as one-third.[17]

Developer Ed Green marketed them as the 'Green Solar Homes', and he achieved some real success for a short time. After the model home was completed in April 1945, "over a hundred" were built, and sales franchises existed in at least five states. It ultimately folded due to financial problems stemming from materials shortages and problems with labor unions. Although this project is overlooked in the major histories of prefab,[18] it was not obscure. In addition to the New York Times coverage, the Ready-Built Homes received a great deal of attention from the press, including a ten-page feature in House Beautiful written by Elizabeth Gordon.

2. Wickes Corporation

The Ready-Built Homes spawned a few imitators. In 1946, the Wickes Corporation introduced a prefabricated solar house, designed by New Jersey architect Oren Thomas, which would reduce the Keck-style solar house to its absolute minimal essence in terms of expression.

Figure 3. Wickes prefabricated solar house by Oren Thomas, 1946. (Library of Congress)

The Wickes project used a square plan, but otherwise conformed to the Keck pattern, particularly in the panelized south walls of fixed glass with ventilating louvers below. Also in the Keck manner, the overhanging roof provided summer shade to the glass, and this shading angle apparently would not vary by location. Unlike Keck, Thomas employed a radiant ceiling heating system with hot water, and a modular plywood floor.

Thomas and Wickes solved the orientation problem much differently than Fred Keck and Ed Green: by fiat. They wrote into the buyer's contract a stipulation that "Wickes will control orientation of all houses so that all glass walls will face within 11 degrees of south or north."[19] It is unknown how Thomas determined that number. Obviously this restriction would have limited the market for Wickes' product; the house simply would not work on an north-facing site, while east- and west-facing sites would have been awkward.

A two-bedroom prototype was built in Camden, New Jersey, in August 1946, and the small houses intended to sell for $5,000-5,400. It is not known whether full production was ever realized, or how many were constructed.

3. Solaray Homes

The Solaray Corporation launched a venture in the Boston area in 1947 that may also have successfully married prefab and solar based on Keck's example. Architect Nathaniel Saltonstall planned and built a "solar subdivision" for a south-facing hillside apple orchard in South Natick. It is not clear to what extent these houses were prefabricated. They used "mass-assembly techniques" according to Ken Butti and John Perlin, although there is no corroborating information for prefabrication in the period literature, or mention of a factory.[20] (If the Solaray Homes were conventionally-built, they still adopted the modular aesthetic of prefabrication.)

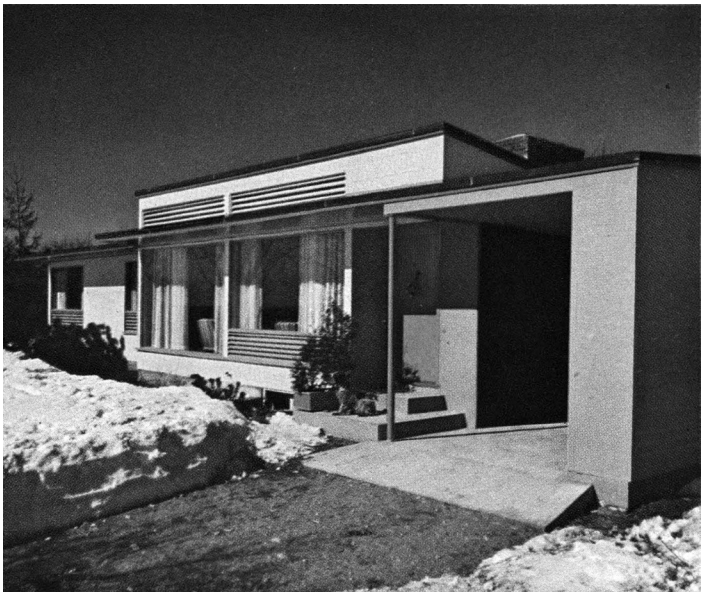

Figure 4. Solaray home by Nathaniel Saltonstall, 1947. (House Beautiful, June 1948)

Again the predominant expressive features were regular modules of fixed glass with ventilating louvers and thin overhangs for shading. Saltonstall, more than Keck or Thomas, sculpted the three-dimensional massing to create dynamic solid-void and push-pull visual effects. The Solaray homes were advertised as being "scientifically calculated to most effectively harness the sun's rays."[21]

Of course orientation constrained the Solaray design. House Beautiful warned readers: "This plan will not work on the opposite side of the street because all the glass would face north, which would be catastrophic, causing undue heat loss."[22] Several basic plan-types were available, and at least 16 homes were built. Saltonstall used a similar design vocabulary for the Mayo Colony, an artists' retreat in Wellfleet, Massachusetts, in 1949.[23]

4. Evison and Evi-Sun

Another architect to dabble in the interstices between prefab and solar movements was California's Leland Evison, who produced a one-off "Prefabricated Solar House" in Pasadena in 1947. Evison's structure conformed to a modest definition of prefabrication which did not imply factory production and an industrial-scale effort. Instead, this project "carried the modular post-and-beam idea to the limit"[24] by assembling ceiling panels and portions of the skeleton off-site. In this respect, Evison's project recalled earlier experiments in southern California which pursued prefabrication at a handmade scale.[25] (Evison also believed the project to be significant for its solution to providing earthquake resistance with the ample use of glass.)

Evison said the house employed "the solar principle," which he defined as "an exposure to the South or the Southeast, and an over-hang which permits utilization of the winter sun at the right period of the

season." With only 1597 heating degree days, Pasadena was a curious site for solar heating experimentation, but apparently he was able to omit the furnace by including a fireplace. There is no evidence that Evison attempted to quantify the heat gain or energy savings.

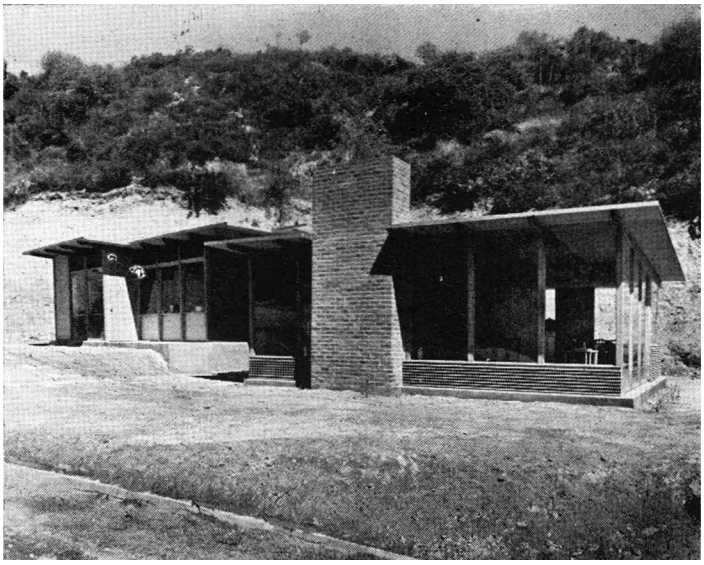

Figure 5. Prefabricated Solar House by Leland Evison, 1947. (Arts and Architecture, December 1947)

The house, only known through a single-page magazine article, indicates that Evison seems to have been informed of some of the more advanced features of solar houses, presumably having studied Keck's work. The project included Keck-style ventilating louvers below fixed panes of glass. It also featured a concrete slab-on-grade, which Keck had used in the Sloan House as well as the widely-publicized Duncan House (1941), when the solar house concept was first formed.

Evison then may have embarked on a more ambitious campaign to market the system as "Evi-Sun" homes. Architectural historians Barbara Lamprecht and Daniel Paul mentioned this initiative after interviewing Evison's son, and they called the Evi-Sun homes "prototypes of what would now be called 'sustainable' dwellings."[26] No additional information has been located, and it is not clear that any Evi-Sun homes were built.

Evison remained interested in solar heating. In 1957, he submitted an entry to the Living with the Sun competition organized by the Association for Applied Solar Energy (AFASE). This competition required architects to integrate 'active' solar technologies (hot-water heating and cooling) for a suburban Phoenix site. Evison's design, with Jack Lester and A. L. Ottum, proposed parabolic collectors and radiant ceiling panels for a (non-prefab) ranch-style house oriented diagonally to the cardinal points. The house also included several passive cooling strategies, including considerable shading of the envelope, mass walls, and an extensive landscape plan with water features.[27]

5. Solar Homes Company

One additional project offers a few provocative suggestions that it may have participated in the effort to incorporate prefab and solar principles. An organization called the Solar Homes Company of Brattleboro, Vermont, was listed among active prefabricators in the mid-1940s. Their houses were reported to have "used warm air circulated in the space between the floor," suggesting another instance of the Keck influence. Little other information about this company has been located at this time.[28]

MISSED OPPORTUNITIES

In the broader context of the prefabrication movement, two architects in particular seem to have been poised to offer new ideas based on their close connections to the developing science of solar heating, but they did not.

First, Howard T. Fisher remains one of the most interesting and successful pre-war prefabricators. Fisher organized General Houses in 1932, and this name reflected his goal to become the equivalent in housing to General Motors in automobile manufacturing. It may be less well-known that Fisher also wrote one of the earliest articles to explore solar geometry and its effects on building facades. His "A Rapid Method for Determining Sunlight on Buildings" (1931)[29] may have been inspired by the Bauhaus building spacing diagrams discussed above, and again seems to have been more concerned with providing therapeutic sunshine rather than winter heat and summer shading. Nonetheless, Fisher understood solar geometry, and therefore it is disappointing that the General Houses, particularly the model shown at the 1933-34 Century of Progress exposition, did not include overhangs or shading devices and used about the same amount of glass on all four elevations, as if orientation did not matter.

Second, some of William Wurster's work may be discussed loosely within the context of prefabrication and solar principles, although he never used the term 'solar house' and did not speak of the benefits of solar heating. Wurster surely understood the emerging science; he was close friends with Fred Keck. (In fact he stayed at Keck's residence whenever he visited Chicago.) Additionally, Wurster's wife Catherine Bauer had included a section called 'Heliotropic Housing' in her seminal Modern Housing of 1934, though like Le Corbusier and Gropius, Bauer referred to therapeutic uses of sunlight rather than heat and energy.[30]

In the Carquinez Heights Experimental Housing (Vallejo, CA, 1941) Wurster seems to have designed in sympathy with solar fundamentals; the model included large south-facing windows with deep balconies and overhanging roofs providing summer shade. Some of the units even included wing walls for late-afternoon shading, a technique. Yet when the site plan was developed most of the 25 units did not have a south-facing orientation.[31] Similarly, Wurster's Prebilt House (with Theodore Bernardi and Ernest Kump, 1944-

46) included large south-facing windows under a shading porch; it appeared to be more site-specific than the typical prefabricated house.[32] It is not clear if Wurster and his team intended the house to be rotated for different sites.

After Wurster moved to the Massachusetts Institute of Technology (MIT), he supervised the Westgate housing project on campus (1945). The project included 100 temporary prefabricated housing units for war veterans, but period photographs show identical units deployed across the site in four orientations. The Westgate project represented an irony, or missed opportunity, because MIT was well-known for solar house experiments by engineer Hoyt Hottel, and Hottel would begin collaborating with MIT's architecture program just a few years later for Solar House III. Finally, Wurster did not mention orientation in a major theoretical text in 1948.[33]

DISCUSSION

Say, for example, that you owned a suburban lot in 1947, and you were interested in purchasing a prefabricated house. This is quite plausible. Would you be interested in solar heating? Perhaps. The 'solar house' concept was widely promoted (with help from glass manufacturers). More to the point, the promise of saving a significant percentage of fuel would have appealed to anyone who had lived through wartime rationing. Much of everyday life in the early 1940s involved negotiations over one scarcity or another, and a mood of uncertainty prevailed. Harold Ickes, the longtime Secretary of the Interior, wrote an article entitled "We're Running Out of Oil!" in 1943.[34] Many of this generation were frugal by habit, having matured during the Great Depression. These observations correspond to Daniel Barber's argument that both the solar house and the prefabrication movements (among others) appealed during a time of "wartime anxiety" because they could "mitigate the unpredictability of both geopolitical and geophysical forces."[35]

To extend the thought experiment, say your lot was a standard width: You would find Keck's house to be too wide to fit. Say your lot faced north: The Wickes house would not appeal, because its backside would face the street and it could not be rotated. It seems likely that you would quickly become tempted to abandon the solar house. A Lustron or a General Houses model would fit the bill, because of their 'generic' nature, capable of being oriented in any manner to fit on your site or face the street.

This exercise shows how a prefabricator's decision to ignore orientation would widen consumer appeal. Market concerns seemingly trumped environmental design. This certainly corresponds to the dominant practice in tract homebuilding and to the wider trend for architecture to become increasingly dependent on mechanical methods of heating and cooling at midcentury, unconcerned with issues of energy consumption. In this line of analysis, the architects who assimilated prefab and solar—Keck in particular—can be seen as either critically resistant to larger capitalist forces, or simply naïve to them.

Finally, return yet again to your imaginary identity as a 1947 property owner. Say you purchased the Lustron home and oriented it facing the street. You might have proudly seen yourself as socially or scientifically progressive for participating in the prefabrication movement. But soon you would find the rear walls and windows, without overhangs or shading devices, collecting direct sunlight all summer long. By the 1950s, when air conditioning became generally available and affordable, you could hardly be blamed for adding mechanical cooling to your poorly-oriented hotbox. (To be fair, you might have purchased canvas awnings, or planted trees.) The probability that you would have spent many summer afternoons wishing your house had been designed with proper shading and orientation, and that you might have spent many winter days wishing your fuel bills were lower, are considerations that should not be missed by historians of prefabrication. Historians and architects in general should learn to speak more forcefully about how differently the American built environment might have evolved if the interior environment and 'passive' strategies were given a higher priority at midcentury.

ENDNOTES

1 Mary Roche, "Houses Warmed by the Sun," *New York Times* (April 15, 1945), SM17.
2 This paper uses the term 'solar house' as it was popularly defined in the 1940s: large south-facing windows, summer shading based on solar geometry, and perhaps thermal mass—what we now call 'passive solar' strategies. Although 'active' solar technologies (flat-plate collectors heating water or air) did exist in embryonic form in the 1940s, there were no examples of prefabricated houses with active systems during this period.
3 Burnham Kelly, *The Prefabrication of Houses* (Cambridge: MIT Press), 1951, 272.
4 Richard Hobday, *The Light Revolution: Health Architecture and the Sun* (Findhorn: The Findhorn Press), 2006, 94.
5 *Rationelle Bebauungsweisen* (Stuttgart: J. Hoffman), 1931.
6 Gilbert Herbert, *Dream of the Factory-Made House: Walter Gropius and Konrad Wachsmann* (Cambridge: MIT Press), 1984. Note that Gropius knew better; his Aluminum City Terrace housing project of 1942–44 included overhangs and shading devices.
7 Douglas Knerr, *Suburban Steel: The Magnificent Failure of the Lustron Corporation, 1945-1951* (Columbus: Ohio State University Press), 2004, 134-37.
8 "Unfolding House," *Life* 26:4 (January 24, 1949), 70-72.
9 Carl Koch and Andy Lewis, *At Home With Tomorrow* (New York: Rinehart & Company), 1958.
10 This section is revised and extended from Anthony Denzer, *The Solar House: Pioneering Sustainable Design* (New York: Rizzoli International Publications), forthcoming, 2012.
11 "Solar House Built Totally in Factory," *New York Times* (April 19, 1945), 24.
12 "Oral History of Robert Paul Schweikher," interviewed by Betty J. Blum, *Chicago Architects Oral History Project* (Chicago: The Art Institute of Chicago), 1984, rev. 2000, 201.
13 "Water Cooled Roofs," *Architectural Forum* 84 (June 1946), 165-69.
14 *House Beautiful* 87:11 (November 1945), 130-31.
15 Elizabeth Gordon, "The First of the Postwar Prefabricated Houses" *House Beautiful* 87:11 (November 1945), 127-37.
16 William Keck, "Potentialities in Solar Heating," undated manuscript (probably 1976), George Fred and William Keck papers, Wisconsin Historical Society Archives, Madison, M86-464, Box 26.
17 Robert P. Boyce, *Keck and Keck: The Poetics of Comfort* (New York:

Princeton Architectural Press), 1993, 85.

18 See Colin Davies, *The Prefabricated Home* (London: Reaktion Books), 2005; Barry Bergdoll and Peter Christensen, *Home Delivery: Fabricating the Modern Dwelling* (New York: Museum of Modern Art), 2008; and Ryan E. Smith, *Prefab Architecture: A Guide to Modular Design and Construction* (Hoboken: Wiley), 2010.

19 "Wickes, Inc...." *Architectural Forum* 86:1 (January 1947), 98-100.

20 Ken Butti and John Perlin, *A Golden Thread: 2500 Years of Solar Architecture and Technology* (New York: Van Nostrand Reinhold), 1980.

21 [Classified Ad], *Boston Globe* (October 12, 1947), C36. See also "Harnessing the Sun," *Boston Globe* (February 9, 1947), 22A.

22 Jedd S. Reimer, "You Can So Have a Solar House in a Cold Climate," *House Beautiful* 90:6 (June 1948), 84-91.

23 David Fixler, "Revolution in the Dunes: Modernism on the Outer Cape," *ArchitectureBoston* 7:2 (May/June 2004), 36-38.

24 "Prefabricated Solar House," *Arts and Architecture* 64:12 (December 1947), 36.

25 See, for example, *Gregory Ain: The Modern Home as Social Commentary* (New York: Rizzoli International Publications), 2008.

26 Barbara Lamprecht and Daniel Paul, National Register of Historic Places nomination, Cultural Resources of the Recent Past, City of Pasadena, Los Angeles County, California, 2008.

27 *Living with the Sun* (Phoenix: Association for Applied Solar Energy), 1958, 23. See also Anthony Denzer, "The Solar House in 1957," *Solar 2009* conference proceedings (Boulder: American Solar Energy Society).

28 Kelly, *The Prefabrication of Houses*, 271. The Solar Homes Company is also mentioned (without detail) in Harold Putnam, "Veterans' Forum: Prefabricated Builders," *Boston Globe* (October 26, 1946), 6. There may be additional information about this company in the Records of the Albert Farwell Bemis Foundation, Massachusetts Institute of Technology.

29 Howard T. Fisher, "A Rapid Method for Determining Sunlight on Buildings," *Architectural Record* 70:12 (December 1931), 445-454.

30 Catherine Bauer, *Modern Housing* (Boston: Houghton Mifflin), 1934, 182-83.

31 See Marc Treib, ed., *An Everyday Modernism: The Houses of William Wurster* (Berkeley: University of California Press), 1995, 54, 148-51.

32 "Prefabrication for Flexible Planning," *Architectural Record* 98:2 (August 1945), 96-98.

33 William W. Wurster, "Architecture Broadens its Base," *Journal of the American Institute of Architects* 10:1 (July 1948), 219-226.

34 Ickes, "We're Running Out of Oil!" *American* (December 1943), 37-43. See also L.M. Fanning, "A Case History of Oil-Shortage Scares," in *Our Oil Resources* (New York: McGraw-Hill), 2nd ed., 1950, 306-406.

35 Daniel A. Barber, "The Modern Solar House: Architecture, Energy, and the Emergence of Environmentalism, 1938-1959," (Ph.D. dissertation, Columbia University), 2010, 63-64.