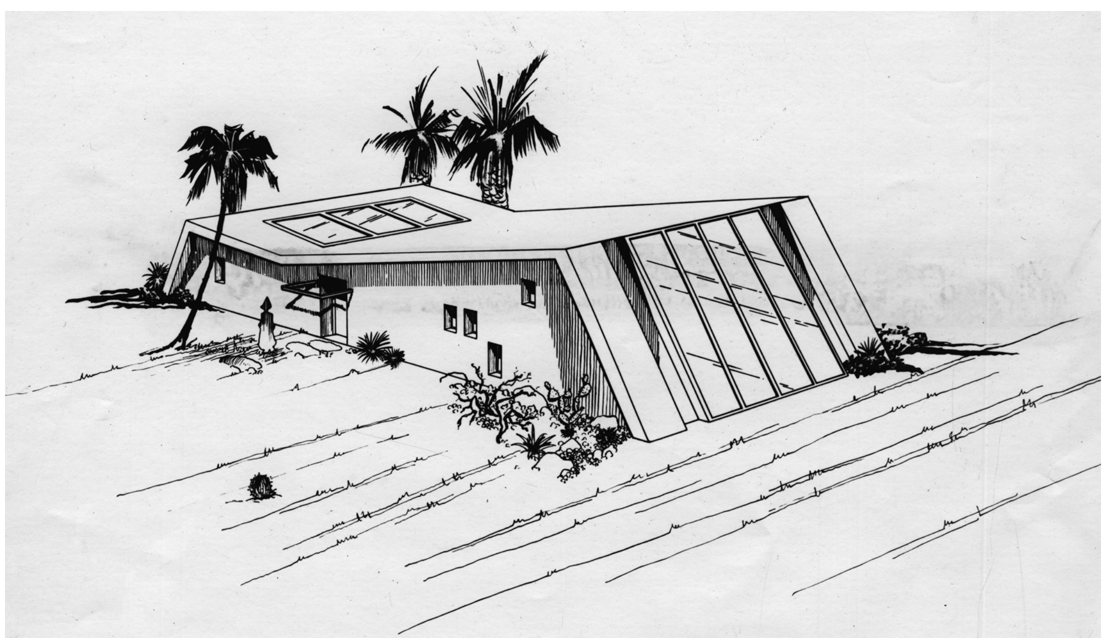
The Casablanca Solar House, by John I. Yellott and Charles Shaw, exhibited at the United States Department of Commerce Trade Fairs in Morocco in 1958, had a sloping roof to maximize solar incidence on an array of phase-change solar heating panels. *Source: Department of Archives and Special Collections, Arizona State University, International Solar Energy Society Archive.*



John I. Yellott began sketching a desert solar house when he toured with the United States Department of Commerce Trade Fair in 1957. *Source: Department of Archives and Special Collections, Arizona State University, John I. Yellott Collection.*

DANIEL A. BARBER

The Casablanca Solar House: Energy and Technological Exchange in the Cold War

From the late 1940s to the late 1950s, alternative forms of energy were on the minds of many American architects, engineers, and policy makers. With the war over, and with little knowledge of the extensive oil reserves in the Middle East, they were concerned about energy sources for future growth. Discussions led to experiments in solar energy for house heating, in wind farms, in cultivating algae as a food source, in the design and use of shading devices, and in a range of other alternative energy systems that are being explored again today.

One such experiment was a house built for the United States Department of Commerce Trade Fair in Casablanca in 1958. The Casablanca house was a solar house intended for workers in new factories being built far from the labor force of the city. It was an off-the-grid house: heated, cooled, and ventilated exclusively by solar energy. Instead of photovoltaics (which did not come into widespread use until the mid-1970s), the panels on the Casablanca house used water, chemical compounds, and pebbles as heat storage mediums — experimental processes that, in the period, appeared to offer an alternative trajectory for the development of energy technologies.

The house combined local materials and imported technology — a model, in built form, for the global exchange of technological and design knowledge that was characteristic of this alternative energy discourse. The large stone aggregate in the concrete walls came from nearby quarries, and served to protect the interior from the harsh sun. The house was, technically, a shed: with no ceiling or partition walls, these thick piers supported the multi-faceted roof. The roof's multiple angles allowed panels to be oriented towards the ideal solar incidence for their latitude; the flexibility in the designed roof line suggested that similar houses could operate in other climates that required other angles of incidence.

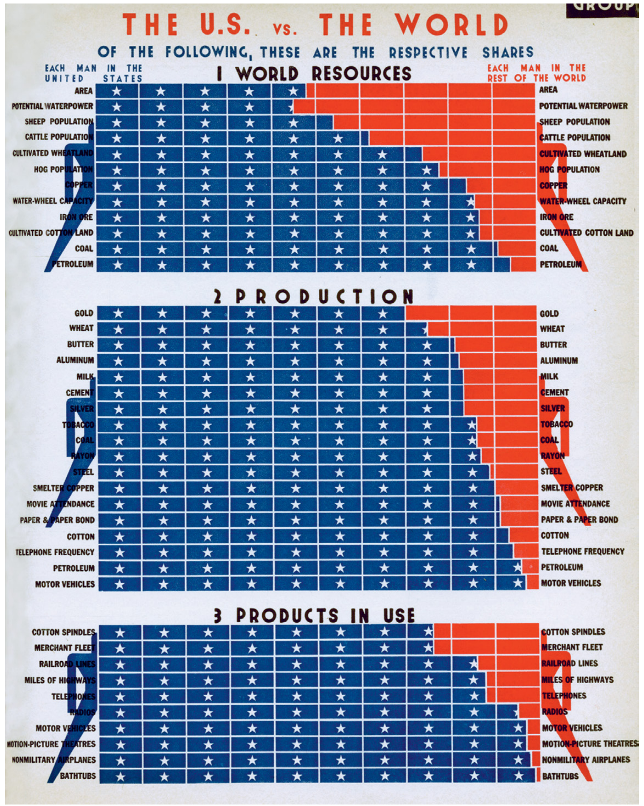
The Casablanca house used an innovative method to absorb, store, and use solar energy. In so doing it exhibited a number of technologies exported and exchanged in the period. The solar panels themselves were being proposed for a range of uses and regional conditions. These panels were multi-layered: on the top, two panes of glass allowed solar radiation to penetrate, while also providing some insulation to keep radiation in. Behind the glass was an intermediate air space to collect the heated air. The backing was a metal plate, painted with a black coating that had also been the subject of much analysis and experimentation to maximize its radiationabsorptive capacity — these "carbon black" treatments were used for solar ovens, solar water heaters, and solar desalination plants in many developing regions.

As the sun heated the air in the intermediate air space, this air was blown by fans into a series of interior columns. These columns held one of two heat storage devices — the first used smooth pebbles to absorb heat for a brief time before releasing it into the room. The second was more complex and significantly more effective: it involved canisters filled with chemical solutions that had phase-change properties. These solutions would liquefy as they were warmed by the solar-heated air, storing the heat in this liquid state. As the surrounding air cooled, the solutions recrystallized and, in the process, released the stored heat. This heat could be radiated from the storage canister, or blown into the room with electric fans. The house also had a solar-assisted cooling system: in hot weather air could be drawn over a chemical refrigerant and cooled before being blown into the room. The phase-change chemical salts could also absorb heat in the room on a hot day. There was a separate group of panels for direct solar water heating.

Phase-change systems were the subject of intensive experimentation in the immediate postwar period, with houses near Boston, Tel-Aviv, and Phoenix all using them effectively for heat absorption and storage. The system at Casablanca drew on these precedents and attempted to simplify the system for better integration into design methods for ease of installation and use. The use of pebbles as heat storage also had a number of precedents in Denver, outside Tucson, and in South Africa. Both of these storage systems exhibited technological effectiveness and ease in exportation. To a great extent, it was the idea, rather than the materials themselves, that needed to circulate. Technological exchange in solar house heating primarily required the exchange of knowledge, and relied on the circulation of experts through systems of influence, such as that provided by the trade fairs.

The design and technology of the Casablanca house was developed by John I. Yellott and Charles M. Shaw. Yellott was a mechanical engineer and expert on solar technology who had been traveling with the Department of Commerce fairs periodically starting in 1956; Shaw was an architect and the general contractor for the fair. Yellott was also the executive secretary of the Association for Applied Solar Energy (AFASE), an organization founded in Phoenix, Arizona, in 1954, which was one of the first international non-governmental organizations (INGOs) to take on a recognizably *environmental* set of issues. The AFASE encouraged government agencies and industry leaders to support research in solar technologies and had identified developing countries as vibrant arenas to further the goal of realizing an effective solar home.

As Yellott indicated in an article entitled "Solar Energy: Its Domestic and Foreign Implications," written around the time the Casablanca house was built, the AFASE's arguments for the importance of solar technology were focused on a careful reading of the uneven geographic distribution of energy resources, and the need to develop new technological research



When R. Buckminster Fuller was the science and technology consultant to *Fortune* from 1936 to 1942; he produced the chart showing "The U.S. vs. The World" in terms of resource use for *Fortune*'s tenth anniversary issue in 1940.

in order to secure reliable energy.[1] Yellott's article was based on a number of presentations at the AFASE's "World Symposium on Applied Solar Energy," held in 1955, and was rooted in a dynamic discussion of energy, economy, and politics occurring since the end of World War II. Architecture had an important role in this discussion, both because the technology of solar heating was seen as an immediate way to improve the quality of life in a number of regions and climates (impacting a large percentage of the global population), and also because attention to the design of the house brought cultural and social concerns into the center of these political and economic discussions. Then, as now, government agencies and INGOs saw technology as a salve to geopolitical complications, for better or worse. For a number of scientists, policy makers, economists, and others, the design of the solar house was an experimental site of great geopolitical consequence.

Thus the Casablanca solar house is evidence of a new perspective, emergent right after World War II, in which ideas and decisions about design and technology were intricately interconnected with economic policies, geopolitical alliances, and the possibility of new social formations.[2] Solar advocates and government agents framed alternative energy in

① John I. Yellott, "Solar Energy: Its Domestic and Foreign Implications," *The Analysts Journal*, vol. 14, no. 1 (February 1958): 15–20.

② This general process has been described by Michel Foucault as that of "governmentalization," through which architecture can be seen as one of many "arts of governance" — not governance per se, but a managerial disposition to the care of the population, coextensive with the cultural sphere. See Michel Foucault, *The Birth of Biopolitics: Lectures at the College de France, 1978–79* (New York: Palgrave Macmillan, 2008), 217–26.

two ways: First, as an "income source" rather than a "capital deposit"; that is, the technological development of solar energy held the possibility of expanding on an almost infinite source instead of depleting a finite one. Second, renewables were seen as a "complementary resource"—a complement to other, fossil fuel-derived sources, and a complement to a range of economic and foreign policy initiatives playing out across the sun-drenched global south. The strategy was especially potent in the context of the Cold War, allowing for an exchange by which developing regions could receive technical assistance from the United States, thereby encouraging political affiliation, while simultaneously opening new geographic regions to the exploration for and exploitation of fossil fuels by American energy corporations. The house in Casablanca, entangled with government policies, technological trajectories, and concerns over the resource-depleted future didn't *do* all of these things, but it clarified the outlines and the stakes of the discussion. Its awkward form stands as evidence that alternative energy technologies were seen as viable in the immediate postwar period—and that many different relationships between energy, technology, and social systems were still seen to be possible.

Although we tend to think of the period following World War II as one of endless consumer growth, in fact the industrial engine for that growth, and the energy that would power it, had to be produced, experimented with, and argued for. Growth in the United States after the war was predicated on industrial expansion, full employment for returning soldiers, and a dramatic increase of the housing stock, all of which required a reliable source of energy.[3] The source of this energy was not immediately evident and there was concern that, with American oil reserves seemingly depleted by the war, fossil fuels would not be adequate.[4] The economic, political, and technological demands of developing a reliable energy source—oil, solar, or otherwise—were significant, as were the social challenges to adapting to a new global energy regime.[5]

Though much of the initial investigation into energy availability occurred in the United States, it was immediately seen as a global issue. The relationship between the United States and global energy consumption was out of balance even before the war. R. Buckminster Fuller identified this in a 1940 chart developed for *Fortune* magazine comparing "The U.S. vs. The World" in terms of energy use.[6] This data visualization indicated that the amount of energy being used far exceeded regionally available resources—an issue of special concern, as the accompanying map indicated, for the heavily populated and economically powerful East Coast of the United States.

As American policy makers, corporate researchers, economists, and others started to look around after the war, many saw this concern over energy as an opportunity to reconsider the relationship between energy, technology, and social systems.[7] Prominent industry research projects and government reports explored how to prepare for the future using different sources according to varying degrees of energy availability. Studies were written, maps drawn, and charts projected into the future in order to assess the potentials and pitfalls of these different energy trajectories.[8]

③ See Chester Bowles, *Tomorrow Without Fear* (New York: Simon and Schuster, 1946), 49 and Craufurd D. Goodwin, *Energy Policy in Perspective: Today's Problems, Yesterday's Solutions* (Washington, D.C.: The Brookings Institution, 1981), 5ff.

④ Harold Ickes, "We're Running Out of Oil!," *American Magazine* (December 1943), 38. Almost eighty percent of the oil used by the Allies was drilled from the Gulf of Mexico region.

⑤ Timothy Mitchell has recently identified both "the rapid construction of lifestyles in the United States organized around the consumption of extraordinary quantities of energy" and "the new apparatus of peacetime 'national security'" as tactics in the production of scarcity, and thus as justification for securing consistent energy availability. Timothy Mitchell, *Carbon Democracy: Political Power in the Age of Oil* (New York: Verso, 2011), 41.

⑥ R. Buckminster Fuller, "U.S. Industrialization" *Fortune* 21 (February, 1940): 50–57.

⑦ On opportunities embedded in technological trajectories, see Andrew Barry, "Technological Zones," *The European Journal of Social Theory* 9:2 (2006): 239–53.

⑧ See Julius Krug, et. al., *National Resources and Foreign Aid* (Washington, D.C.: Government Printing Office, 1947); Farrington Daniels, "Solar Energy," *Science* 109, no. 2821 (1949): 51–57; Harold J. Barnett, *Energy Uses and Supplies: 1939, 1947, 1965* (Washington, D.C.: Bureau of Mines, 1950); Palmer Putnam, *Energy in the Future* (New York: Reinhold, 1953); Hubbert M. King, *Nuclear Energy and the Fossil Fuels* (Houston, TX: Exploration and Research Division, Shell Development Company, 1956).

Eugene Ayres, a research executive for Gulf Oil, was one of these energy forecasters who became convinced that renewable sources were the best solution. Ayres was suspicious of fossil fuel resources not so much because of an anticipated doomsday date of depletion—which he saw as being far enough in the future that adequate preparations could be made—but because of the basic principle that investing in renewables would allow for wholly different kinds of economic equations. Renewables, or "income sources" as he termed them, were not subject to an economic model of extraction to depletion (however extended by technological innovation), but one of investment towards expansion.[9]

Ayres insisted that the "host of technologists" working on finding new energy supplies should "focus their efforts on income sources."[10] A chart illustrating "some possibilities in our future energy picture" indicated that research streams developed in the present would have consequences for the near and long term future—the possible extension of known fuel reserves would fluctuate according to different scenarios of alternative energy research. Technological research was itself a powerful resource, not only allowing existing energy to be used more efficiently but also allowing new sources to be developed.

Ayres focused this rethinking of energy and economy on the solar house. At a conference on "Space Heating with Solar Energy" held at the Massachusetts Institute of Technology (MIT) in 1949, he gave an opening presentation that detailed the importance of design in this context. The Solar Energy Research Fund at MIT, led by the Department of Mechanical Engineering, had built two houses, and would build two more by the end of the 1950s. The most successful, MIT Solar House III of 1949, used a bank of water-based solar collectors atop a symmetrically sloping roof.[11] The collectors were connected to a radiant ceiling system, and stored the heated water in a heavily insulated tank in the roof structure. It worked well and was lived in by a graduate student's family until 1953. At the symposium Ayres also pointed to another house, built in Dover, Massachusetts, in 1948, designed by the architect Eleanor Raymond and the engineer Maria Telkes—the first house to use the phase-change system that would later be implemented in Casablanca.

The 1949 conference was held largely to invite architects to join the discussion on solar technology. Lawrence Anderson, a professor in the MIT Architecture department, based his senior design studio on the problem, and brought new design proposals into the MIT project. Anderson modeled solar incidence modeled solar incidence in relationship to building shape and orientation, while the engineers refined the storage of heat and worked out how to best distribute it to the house. Anderson later developed these schematics into an "idealized house" that rejected both "convention and practicality of construction" in order to "have maximum collector area with optimum tilt and minimum non-irradiated area."[12] The house had the full south façade "at optimum tilt"; in section, the north side was a semicircle, partially buried in an artificial berm to increase insulation and provide a basement heat-storage area.

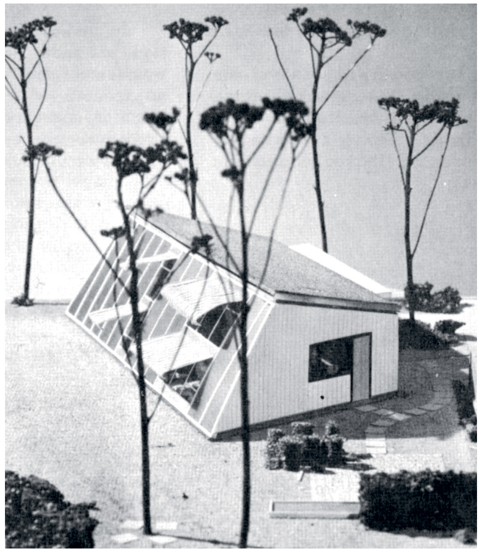
Anderson's "idealized house" captured the tenor of much of this

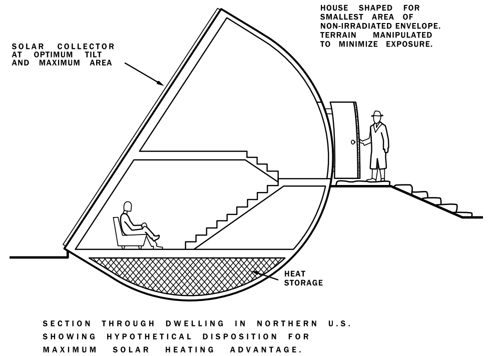
⑨ Eugene Ayres, "Major Sources of Energy" *Addresses and Reports Delivered at the Twenty-Eighth Annual Meeting, Chicago, Illinois, November 8 to 11, 1948* (New York: American Petroleum Institute, 1948), 109–44.

⑩ Eugene Ayres and Charles A. Scarlott, *Energy Sources: The Wealth of the World* (New York: McGraw Hill, 1952).

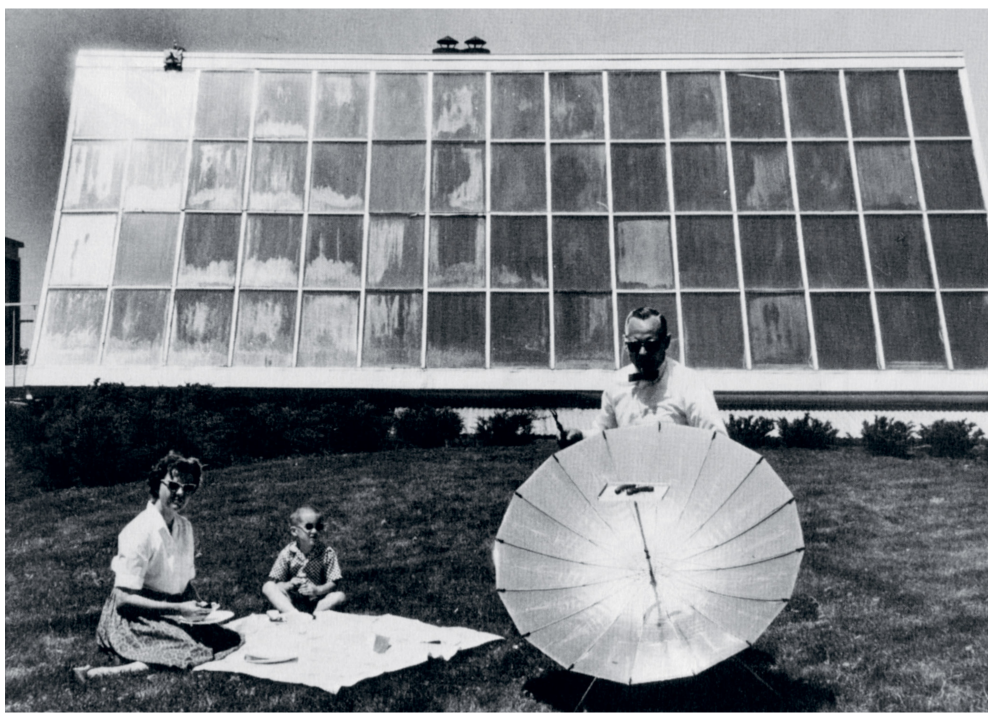
⑪ Eugene Ayres, "Windows," *Scientific American* (February, 1951): 60–65.

⑫ Lawrence B. Anderson, Hoyt C. Hottel, and Austin Whillier, "Solar Heating Design Problems," *Solar Energy Research,* eds. Farrington Daniels and John Duffie (Madison, WI: University of Wisconsin Press, 1955), 47–56; 49. Written in 1953.





Lawrence Anderson and his students produced a number of typological studies, models, and diagrams, including the "Section of an Idealized Solar House" (above, right) to assess the best design parameters for maximized solar heating.



Following years of analyses, Lawrence Anderson designed the fourth MIT solar house in 1958 with his former student Robert Pelletier. The house was built into a hill to increase insulation, with a south-facing roof to absorb solar radiation. The solar system could be switched off in the summer; in mid-winter an auxiliary system could be engaged.

solar house discussion—that design had the capacity to make a passive heating system more effective and should be considered among the technologies making existing energy supplied more efficient. He insisted that the basic premise from which an appropriate solar design can emerge required an implicit architectural understanding of the technological problem of solar energy. "Every architect," he wrote, "should know how to design for the most favorable climatic response of his enclosure so that, other factors being equal, he will minimize summer discomfort, require less fuel during temperature extremes, or extend the zones in which no mechanical equipment is required."[13] Anderson pursued typological studies of solar technology with his students. In 1957, with his former student Robert Pelletier, Anderson designed and built MIT Solar House IV, which had a sloped roof at the optimum angle and was built into a hillside to maximize insulation. It also included a solar stove, where the family that lived there cooked hot dogs in the summer.

The solar heating discussion in the late 1940s and early 1950s had many other consequences, a number of which can be read in the Casablanca house. Around the same time as the MIT conference, policy and industry interest in solar house heating technology increased. At the United Nations Scientific Conference on the Conservation and Utilization of Resources—a wide ranging, three-week conference addressing a number of global resource concerns held in 1949—both the MIT House III and the Raymond/Telkes house were discussed at length. Solar house heating was seen to be one of a number of means by which the conference intended to integrate concerns of "less developed countries" into the research practices of the "economically advanced countries."[14] This integration—of American technological experiments, new forms of energy, and the needs of developing economies—was also the explicit project of a 1952 report by President Truman's "Materials Policy Commission." The commission had been formed to analyze "the combined material requirements and supplies of the entire free non-Communist world," as well as the government policies and corporate practices affecting them, in order to outline a system of extraction and distribution that could provide for the "common welfare, common growth, and common security of these countries."[15]

The issue was not only to map existing resources, but also to develop a new global system of energy use and supply, coordinated by the United States. The policy question in 1952 was how to encourage private capital to flow into underdeveloped countries at a rate sufficient to develop the resource deposits that industrialized nations required, and to do so while expanding the economic and political influence of the United States.[16] Technological efforts to use resources more efficiently, and in particular to encourage the use of income sources, were seen as an important element of how the United States could encourage a country's political affiliation in the midst of Cold War tensions.[17] Concerns over resources were also political issues regarding territorial control and global economic systems, in which issues of technological and design expertise were intricately embedded.

⑬
Ibid., 48.

⑭
United Nations Department of Exact and Natural Sciences, "Memorandum on The Scientific Conference on Resource Conservation and Utilization," (Lake Success, NY: UNESCO, 10 November 1948), 4.

⑮
President's Materials Policy Commission, *Resources for Freedom: Summary of Volume I of a Report to the President* (Washington, D.C.: US Government Printing Office, 1952), 2–4.

⑯
Alfred E. Eckes, *The United States and the Global Struggle for Minerals* (Austin, TX: University of Texas Press, 1979), 185.

⑰
See David S. Painter, *Oil and the American Century: The Political Economy of the U.S. Foreign Oil Policy, 1941–1954* (Baltimore, MD: Johns Hopkins University Press, 1986).

These concerns came to the fore in the organization of the Association for Applied Solar Energy (AFASE), and especially in its sponsorship of the Casablanca house. The AFASE was founded by economists and technological researchers who had been part of Truman's Materials Policy Commission, with financial and logistical support from the Ford Foundation and the Stanford Research Institute.[18] Following Ayres' imperative, the AFASE was interested in how to direct research streams into renewable resources — not out of a fear of impending scarcity, but out of the assumption that such research would eventually bear fruit, and would make economic sense over the long term.

Like Ayres, the AFASE was very interested in the potential of the solar house. A solar house competition, led by Anderson, was envisioned as a prominent part of the World Symposium on Applied Solar Energy, a showcase of solar technology held in the summer of 1955. While the competition ended up being too costly as a first step, discussion of the design and technology of solar housing took up a large part of the conference. After the World Symposium, the solar house was again identified as a promising site for research. At the same meeting John I. Yellott — the co-designer of the Casablanca house — was named executive secretary of the Association. Yellott had already been involved with the design of solar buildings in Madras, India, and Albuquerque, New Mexico, and was anxious to continue these experiments.

The United States Department of Commerce Trade Fairs offered Yellott an ideal opportunity. The fairs were already heavily loaded with concerns over the exchange of technology, economics, and politics. United States involvement in the fairs had been initiated by Eisenhower in 1955 to encourage "two-way trade and better understanding of the United States."[19] Positioned as a battleground in the Cold War, Eisenhower saw the trade fairs as an opportunity to demonstrate how American ingenuity could improve quality of life and accelerate economic development, especially in countries under threat of Communist influence. As the *New York Times* indicated, Eisenhower was sending these "official exhibitions…[to] places where the United States sees political advantage to be gained among the people or with their government."[20] The AFASE was one of many beneficiaries of "seed money" that the federal government distributed to corporations and agencies to work on projects especially for the fair.

The solar exposition that Yellott had developed — largely drawing on the technology exhibited at the World Symposium — included solar ovens and stoves, solar water desalination, solar algae growth, solar furnaces, solar clocks, and many other systems and devices. It proved to be such a popular aspect of the fair that Yellott proposed, with the architect Shaw, to build a solar house that could simultaneously demonstrate the potential of solar heating and cooling as well as house this range of experimental devices. In Casablanca from May 4th to the 19th, 1957, and then in Tunis from October 19th to November 3rd of the same year, Yellott's popular exposition was given center stage, with the solar house right next to a geodesic dome. Local industrialists along with

⑱ The Commission was dissolved after issuing its report, though many working on the project formed the think-tank Resources for the Future. This group, which still exists today, hosted the conference "The Nation Looks at its Resources: The Midcentury Conference on Resources for the Future" in 1954. The idea for the AFASE was hatched in a panel on solar energy.

⑲ "U.S. Expands Role in Trade Exhibits" in the *New York Times* (January 3, 1957).

⑳ Ibid. According to the *Times* the fairs featured "typical American homes, voting machines, 'atoms for peace' applications, US farm production, 'do-it-yourself' workshops, American art and design, electronic devices and automated factories."

visiting corporate and government leaders were led through the exhibition. Demonstrations were made both to indicate the potential of solar technologies and to suggest their relevance to a range of social and economic concerns. Not unlike other demonstration houses of the postwar period, the Casablanca house was a site for the exchange of ideas — ideas about architecture, and, in this case, about how design methods and strategies could be integrated with a range of economic and political aspirations.

The Casablanca solar house stands out not only for its willingness to alter its design dramatically to maximize radiation exposure, but also for its clear expression of the potentials and pitfalls of the emergent postwar energy condition. While the immediate concern over resource scarcity largely had dissolved by the mid-1950s as US economic, military, and diplomatic power managed to secure foreign oil resources for the growing demands of domestic industries, the persistent dynamism of the solar energy discourse late into the decade suggests some of the tensions that lay beneath these new systems of economic and energy exchange. The promise of the solar house, as a complementary resource, was simultaneously economic, social, and political, and was also rooted in an anxiety about how shifts in the global energy metabolism could have negative and unanticipated consequences in the future. As one writer put it, anticipating much of the environmentalist tensions of the 1970s: "there is more than one way of saving ourselves from a future in which the world is long on population and short on everything else."[21] In other words, while by the late 1950s much of the rhetoric around "income energy" experimentation was focused on its applicability to developing economies, implicit in the discourse was how these strategies would, eventually, be imported back to developed northern economies to save them from themselves.

Soon after Yellott returned to the United States, the AFASE finally initiated a competition to design a demonstration solar house.[22] Entries were received from around the world and the winning house was built outside Phoenix in 1959. The competition stands, like the Casablanca house, as an important symbol of the increasingly global character of architecture in the 1950s — and as a symbol that this global engagement was in large part based on the capacity of design innovation to intersect with a number of professional fields and social concerns. Inside the carefully designed panels and piers of the Casablanca solar house, a space was created not only for the exchange of energy and design technologies, but also for the exchange of anxieties and aspirations about the inevitable complications of energy futures.

㉑ Eric Hodgins, "Power from the Sun," *Fortune* 43 (September, 1953), 194.

㉒ John I. Yellott, *Living With the Sun: Volume I: Sixty Plans Selected From the Entries in the 1957 International Architectural Competition to Design a Solar-Heated Residence*. (Phoenix, AZ: The Association for Applied Solar Energy, 1958) and Daniel A. Barber, *A House in the Sun: Modern Architecture and Solar Energy in the Cold War* (New York: Oxford University Press, forthcoming 2015)