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A Silent Graph. Tracing the Algerian Past of French Solar Experiments

Tracé muet : le passé algérien du solaire français et ses expérimentations

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A Silent Graph. Tracing the Algerian Past of French Solar Experiments

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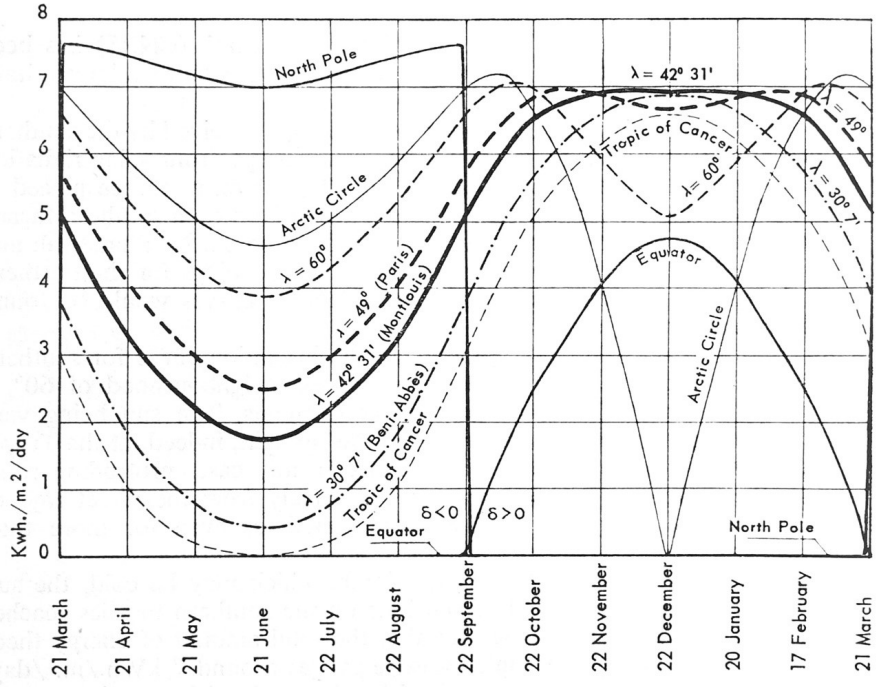
Figure 1: Félix Trombe, Solar energy collected on a south façade in the northern hemisphere.



Source: "Some aspects of the utilization of natural radiation, especially in developing countries," *Impact of Science on Society*, vol. 15, no. 4, 1965, p. 254.

2 | In his papers published throughout the 1960s, scientist Félix Trombe often began his demonstrations by showing a graph (fig. 1).[1] It represents the amount of solar energy received on a south façade in different locations of the globe. Five of them are canonical latitudes: the North Pole, the Arctic Circle, the 60th parallel North, the Tropic of Cancer, and the Equator. The three others are specific locations belonging to very different geographies and political contexts: Paris, the capital of France; Mont-Louis, a village in the French Pyrenees mountains, close to the Spanish border; and Beni Abbès, an oasis of the Algerian Sahara. The graph shows sharp contrasts: in the summer, the closer a location is to the Tropic of Cancer, the less solar energy it receives on a south façade, because the sun's position is the most vertical at the Tropic then; while in the winter, the maximum solar energy is attained for intermediary latitudes, where the sun is the lowest in the sky and hits the south façade. But the graph also highlights a similarity: the amounts of solar energy received in Paris, Mont-Louis and Beni Abbès are not so different, suggesting that they could be exploited in the same way. In Trombe's papers, the link between Mont-Louis, where his research was carried out, and Paris, where it was led by the Centre National de la Recherche Scientifique (CNRS), was quite obvious. But nothing was said about Beni Abbès and the Algerian Sahara, except for vague references to "hot regions" and "developing countries." What may seem, at first sight, a passing reference on a purely technical graph can bespeak much deeper realities for the historian who seeks to elucidate the presence of this oasis' name. Why was Beni Abbès mentioned in such a document and related to Paris and Mont-Louis? And what does it say about the research carried out by scientists on solar energy and façades in the Cold War?

Although Félix Trombe is known in the architectural world for having invented what was probably the most popular solar heating device of the 1970s—the eponymous Trombe wall, still used today—, the architectural historian investigating this case will find no clues in the traditional sources and literature of his or her discipline. Neither the first articles published in international magazines, such as *Architectural Design* and *L'Architecture d'aujourd'hui*, which reported on Trombe's work and reproduced this same graph, nor the dozens of books presenting the Trombe wall, nor the existing scholarship on Trombe's collaboration with architects, tell anything of a link with the Algerian Sahara.[2] Tracing the history lying behind this graph requires delving into

1 Félix Trombe, "Some aspects of the utilization of natural radiation, especially in developing countries," *Impact of Science on Society*, vol. 15, no. 4, 1965, p. 247-260. URL : https://unesdoc.unesco.org/ark:/48223/pf0000012908. Accessed 7 December 2020; Félix Trombe, Albert Lê Phat Vinh and Madeleine Lê Phat Vinh, "Étude sur le chauffage des habitations par utilisation du rayonnement solaire," *Revue générale de thermique*, vol. 4, no. 48, December 1965, p. 1345-1366; Félix Trombe, "Étude sur le chauffage des habitations par utilisation du rayonnement solaire," *Chauffage, ventilation, conditionnement,* no. 2, February 1967, p. 47-58.

2 Colin Moorcraft, "Solar Energy in Housing," *Architectural Design*, vol. 13, no. 10, 1973, p. 652-653; "Utilisation de l'énergie solaire," *L'Architecture d'aujourd'hui*, no. 167, May-June 1973, p. 88-96; Marion Chauvin-Michel, *Architectures solaires et politiques énergétiques en France de 1973 à 1985*, Ph.D. dissertation, Université Paris I Panthéon-Sorbonne, Paris, 2012. However, Trombe's scientific activities in the Sahara are briefly mentioned by the historian of science and technology Pierre Teissier, in "Fours et maisons solaires de Mont-Louis-Odeillo: Interstices, intersciences et internationalismes de la recherche contemporaine," in Stéphane

sources more commonly associated with the history of science and technology, such as patents, lab reports, and scientific papers. These documents are key to understanding scientific experiments on climate during the Cold War and their architectural consequences. But scientists and engineers wrote little about the political implications of their research at the time, and the existing scholarship on the Sahara in the 1950s is scarce. Such an inquiry thus requires exploring a second body of sources, namely reports and publications produced by political institutions and various experts to understand their actions and views on the desert. It is by connecting these sources and literatures to architectural research that we can tell the story of such silent graphs, and analyze how architecture came to be envisioned as a means to control climates sharing certain similarities.

Industrializing the desert

Félix Trombe's research on solar energy began two decades prior to drawing this graph, in 1946, in his laboratory first located in Meudon, outside Paris. Wartime shortages of coal and oil had revived global interest in the use of solar energy among engineers and scientists, and France was no exception.[3] At a time when construction materials were also in short supply and investment capacity was low, concrete applications remained scarce, but Trombe and his team took on the task of research into solar energy after the war. Trained as a chemist and engineer, Trombe built two solar furnaces, using the mirrors from anti-aircraft searchlights abandoned by the German army. The mirrors were used to concentrate the sun's rays on a single point in order to obtain high temperatures, and thereby melt the refractory metals Trombe studied. Upon presenting these experiments to the Académie des Sciences,[4] Trombe was acclaimed by the scientific community and attracted the attention of military authorities. Indeed, refractory metals were used in the production of aircrafts and missiles, while solar furnaces could produce the nitric acid needed not only for fertilizers, but also for explosives.

With the support of the CNRS and the army, Trombe founded a new lab—the Laboratoire de l'énergie solaire—in the citadel of Mont-Louis, located in the southeastern Pyrenees, one of metropolitan France's sunniest regions.[5] There, he built a more powerful solar furnace and expanded the scope of his research on solar energy to cover broader applications and geographies. Trombe began promoting the use of solar energy not only in metropolitan France, but also in its North African colonies. In the report of

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Le Gars, and Guy Boistel (eds.), *Dans le champ solaire: cartographie d'un objet scientifique*, Paris: Hermann, 2015, p. 181-219.

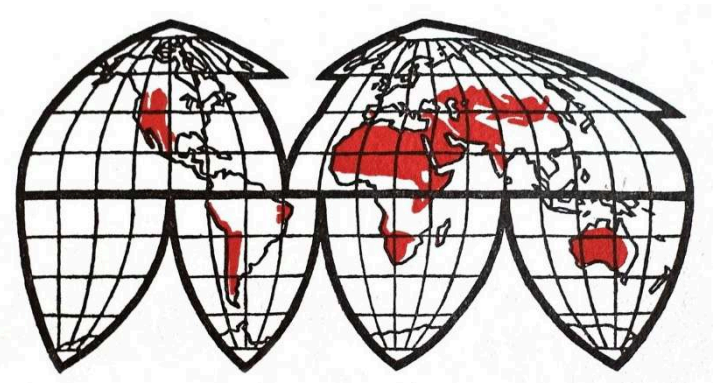
3 Maurice d'Halluin, "Actinométrie et applications de la chaleur solaire," *Le Génie civil*, no. 3075-3076, January 17, 1942, p. 25-29.

4 Félix Trombe, Marc Foëx, and Charlotte Henry La Blanchetais, "Four solaire pour la réalisation de très hautes températures," *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, 223, 1946, p. 317-319.

5 Félix Trombe, "Le laboratoire de l'énergie solaire de Mont-Louis," *Bulletin de la Société chimique de France*, vol. 20, 1953, p. 353-368.

his mission across Morocco in 1951, he advocated for the construction of solar furnaces on the slopes of the Atlas Mountains, in order to transform the ores extracted in the mines below.[6] Simultaneously, he began researching the use of solar energy not only for scientific, industrial and military goals with solar furnaces, but also for "domestic applications" that could be used to accommodate life in arid regions.

Figure 2: Logo of the UNESCO's Arid Zone program.



Source: *Wind and Solar Energy: Proceedings of the New Delhi Symposium*, Paris: UNESCO, 1956, detail of the cover.

This turn in Trombe's activity was linked to a more general reconsideration of the earth's deserts, and especially of the Sahara. In 1951, the United Nations Educational, Scientific and Cultural Organization (UNESCO) launched a research program on the "arid zone," in an attempt to develop transnational projects and to answer the growing anxiety about overpopulation and resource depletion. The arid zone, as defined by the UNESCO's experts, was composed of regions characterized by climates combining extreme temperatures and very low precipitation, with the Sahara the greatest among these (fig. 2). In these territories, long viewed as hostile to human occupation and economically unproductive, the use of modern science and technology could make the desert more habitable and unlock the exploitation of its natural resources. Over the course of the 1950s, UNESCO thus organized a series of annual symposia and financed research programs to stimulate scientific investigation and international cooperation on all aspects concerning the "development" of the arid zone.[7]

Simultaneously, the Sahara became a key territory in France's imperial policy. A rationale emerged within colonial discourses that called for the "mise en valeur" of the

6 Pierrefitte-sur-Seine (France), Archives Nationales de France, 19800284/213, Félix Trombe, "Compte-rendu de mission au Maroc," undated [probably 1951].

7 Michel Batisse, *Du désert jusqu'à l'eau, 1948-1974. La question de l'eau et l'UNESCO : de la zone aride à la décennie hydrologique*, Paris: Association des anciens fonctionnaires de l'UNESCO, 2005 (Les cahiers d'histoire/History Papers, 4). URL : https://hydrologie.org/BIB/UNESCO/Batisse.pdf. Accessed 7 December 2020; Diana K. Davis, *The Arid Lands: History, Power, Knowledge*, Cambridge, MA: MIT Press, 2016 (History for a Sustainable Future).

desert, that is the combination of the "development of material wealth" and France's "civilizing mission," as defined by Albert Sarraut in his eponymous book of 1923.[8] Applied to the Sahara, this policy consisted of exploiting the underground resources and local workforce of the desert to secure France's access to strategic materials and energies, in the unstable context of decolonization and the Cold War. Missions were launched to prospect for mineral ores, gas, and oil, leading to the discovery of massive reserves, especially in Algeria, while projects were undertaken to create industrial infrastructures in the desert. The beginning of the Algerian war of independence in 1954, far from halting this project, only accelerated it, leading to reinforced military control over the desert's wealth.[9]

In both UNESCO's development program and France's colonial project, solar energy was meant to play a key role. Trombe, alongside other scientists of his time, proclaimed that the sun's radiation was not only a problem—the cause of aridity—but also a solution—a potential resource. Abundant and directly accessible, solar energy could be used as an immediate alternative to fossil energies and to the heavy and costly infrastructures they required. Converted by appropriate technologies, the sun could sustain both industrial processes and human needs to take advantage of the desert's climate and spur its industrialization. Both France's colonialist rhetoric and UNESCO's developmentalist agenda assimilated this idea, and within a decade it was widely accepted that solar energy was the key to the future of the Sahara and of all arid lands.[10]

But in Trombe's mind, the development of solar energy was also a means to prepare for humanity's future at large. Since the beginning of industrialization, societies had been consuming ever-increasing quantities and sorts of fossil energies. Within a few centuries or even decades, these fuels would inevitably be depleted. Researching solar energy was therefore essential to prepare for a future without coal, oil, and even uranium. But highly industrialized societies, so dependent on fossil fuels, were not the appropriate places to pioneer these solar technologies, Trombe argued. Less industrialized countries, and especially those of the arid zone, would more easily adopt these "new sources of energy" before they could be disseminated throughout a world with diminishing fossil fuels.[11] To carry out this all-encompassing project, Trombe's laboratory in Mont-Louis became a place where solar technologies would be invented, with the intent of testing them in the Sahara. From there, they could be disseminated throughout the rest of the arid zone, and eventually, the world.

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8 Albert SARRAUT, *La mise en valeur des colonies françaises*, Paris: Payot, 1923, p. 23.

9 Jacques FRÉMEAU, *Le Sahara et la France*, Saint-Cloud: SOTECA, 2010, p. 229-233; Roberto CANTONI, *Oil Exploration, Diplomacy and Security in the Early Cold War: The Enemy Underground*, New York, NY: Routledge, 2017 (Routledge Studies in modern European History, 43), p. 76-167. On the spatial strategies of military control in Northern Algeria, see Samia HENNI, *Architecture of Counterrevolution: The French Army in Northern Algeria*, Zürich: GTAVerlag, 2017 (Architektonisches Wissen).

10 UNESCO, *Wind and Solar Energy: Proceedings of the New Delhi Symposium*, Paris: UNESCO, 1956; François LE BRAS, *L'énergie solaire au Sahara*, Paris: OCRS, 1961.

11 Félix TROMBE, "L'énergie solaire, houille d'or de l'avenir," *L'Astronomie*, vol. 64, 1950, p. 413-421; IDEM, "Le laboratoire de l'énergie solaire de Mont-Louis," *op. cit.* (note 5).

Between the Pyrenees and the Sahara

Despite their difference in latitude and their strikingly divergent landscapes, the Pyrenees mountains and the immensities of the Sahara share certain climatic similarities. Solar radiation is particularly intense in both places, because it is less filtered by the atmosphere due to their respective positions on the globe: the altitude of the Pyrenees extends above the lowest layers of the atmosphere, while the Sahara's proximity to the Tropic of Cancer means that the sun's rays hit at a more vertical angle there. As a result, temperatures can rise significantly during the day, especially in the Sahara where it can reach 50°C in the summer. But temperatures also drop at night, because in these regions with few clouds, the earth intensely radiates its energy into space. These climatic characteristics and their effects on human bodies and psyches were studied throughout the 1950s by scientists and engineers, often with the help of doctors and military staff.[12] One of the main locations for these studies was Beni Abbès, an oasis located halfway between the Algeria's northern coast and the central Sahara. There, next to the village and its palm grove, a meteorological station was established, joining the existing Centre de recherches sahariennes and a military fortress (fig. 3). The climate data collected in Beni Abbès, as in other desert locales, was compiled into tables and graphs, and could thus be compared and used from France, as with the graph introduced at the beginning. Reduced to their basic climatic parameters, the human and material specificities of these territories were often blurred, as were the relations of power that linked them.[13]

Trombe and his team used such climate tables and graphs to conceive a whole range of solar applications in their laboratory in the Pyrenees, with the intent of transferring them to the Algerian Sahara. Besides solar furnaces for scientific and industrial purposes, they developed a series of domestic applications: greenhouses to purify water and cultivate plants; roof-mounted solar heaters to produce hot water; sun-powered refrigerators to provide ice; glazed boxes on façades to warm indoor air; and small containers that used terrestrial radiation to produce cold air (fig. 4).[14] All these technologies

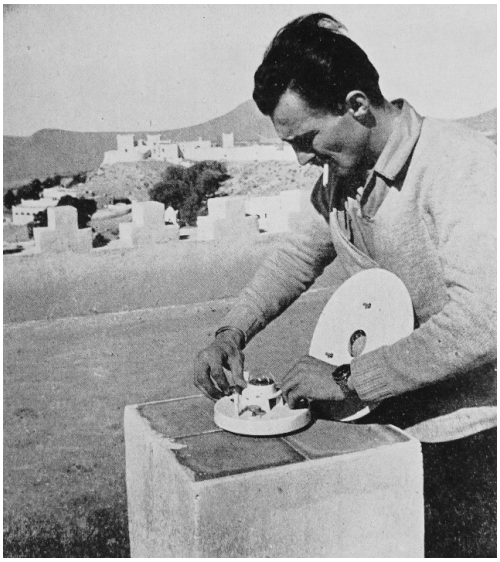
12 Jean Dubief, *Le climat du Sahara*, Alger: Université d'Alger: Institut de recherches sahariennes, 1959 (vol. 1), 1963 (vol. 2). On the importance of meteorological data and climate models in the Cold War, see Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*, Cambridge, MA: MIT Press, 2010.

13 These climate tables and graphs were instrumental in the conception of the Sahara as a laboratory where scientific experiments could be conducted and technologies developed, before potentially finding larger applications, including in the metropole. The conception of colonized territories as scientific and urban laboratories has been discussed in Gwendolyn Wright, *The Politics of Design in French Colonial Urbanism*, Chicago, IL; London: University of Chicago Press, 1991; Helen Tilley, *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950*, Chicago, IL: University of Chicago Press, 2011.

14 Félix Trombe (ed.), *Applications thermiques de l'énergie solaire dans le domaine de la recherche et de l'industrie: Mont-Louis, 23-26 juin 1958*, Paris: Centre national de la recherche scientifique, 1961 (Colloques internationaux du Centre national de la recherche scientifique, 85), p. 653-680; Nato, *Proceedings of the United Nations Conference on New Sources of Energy : Solar Energy, Wind Power and geothermal Energy, Rome, 21-31 August 1961= Actes officiels de la Conférence des Nations Unies sur les sources nouvelles d'énergie: énergie solaire, énergie éolienne et énergie géothermique, Rome, 21-31 août 1961*, New York, NY: United Nations, 1963-1964,

had one goal: to adapt human settlements to the climatic conditions of the desert, and thereby boost its industrialization.

Figure 3: Geophysicist measuring solar radiation in the fortress of Beni Abbès, Algeria, January 1950.



Source: photograph by Raymond S. Kleboe; Ritchie Calder, *Men Against the Desert*, London: G. Allen & Unwin, 1951, p. 16.

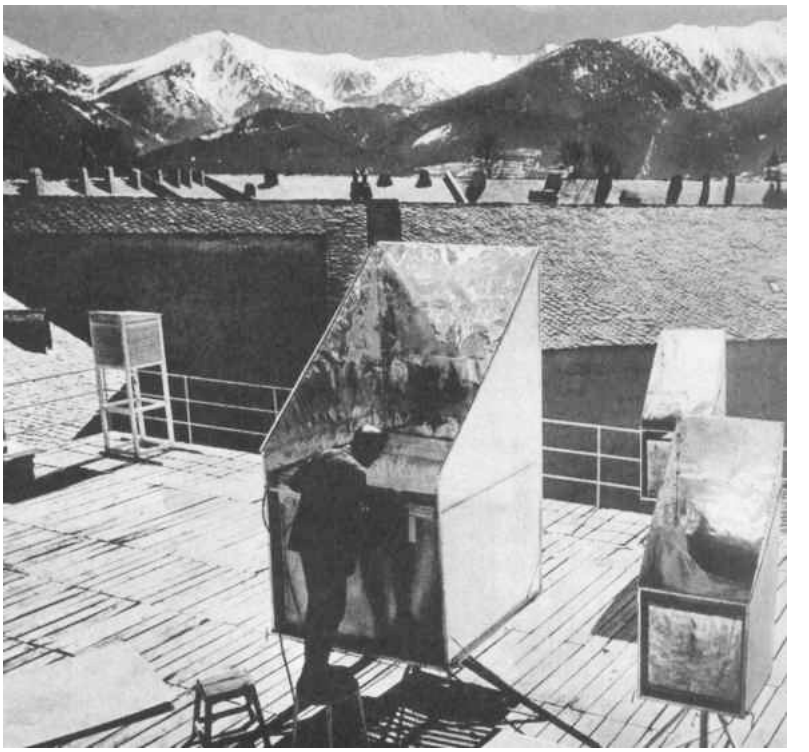
Developed in Mont-Louis, these technologies were then tested in the Algerian Sahara. In 1958, a miniature house equipped with the cooling device was manufactured in Mont-Louis and transported to Colomb-Béchar, an Algerian city functioning as a transportation hub between the urbanized North and the Saharan territories to the South. There, this self-cooling house was assembled in the Centre d'Essais d'Engins Interarmés, a French military base where new types of missiles and rockets were tested. Despite technical complications, the experimental miniature house was successful, since it managed to reduce indoor temperatures by up to 12° C in comparison to outdoor temperatures.[15] On this basis, other experiments were envisioned in the Algerian Sahara, with the support of the Organisation Commune des Régions Sahariennes (OCRS), a political and military institution created by France in 1957 to reinforce its control over the desert

vol. 6, p. 98-121. These technologies departed from the dominant way of dealing with solar energy in tropical and hot arid climates. Trombe focused less on how to avoid solar radiation and provide shading to reduce the heat, as was the case in the contemporary work of architects Jane Drew and Maxwell Fry in the British Empire, or of Henri-Jean Calsat in the French Empire, but rather put emphasis on using solar and terrestrial radiation to air-condition buildings and provide water supplies. See Maxwell Fry and Jane Drew, *Tropical Architecture in the Humid Zone*, London: Batsford, 1956; Henri Calsat, "Problèmes d'habitats européens dans les pays intertropicaux," *Techniques et Architecture*, no. 7-8, special issue *Le Soleil*, July-August 1943, p. 217-220.

15 Félix Trombe's papers, private collection of Michèle Lhermitte, "Rapport sur la climatisation des maisons dans les pays à ciel clair," undated [probably 1960], p. 23-24.

and secure the metropole's access to strategic resources. In 1960, Trombe and his team planned to build two houses that would alternately cool air during the day and warm it at night, along with a large greenhouse to produce pure water and grow vegetables, to be assembled in the oasis of Touggourt.[16] They also planned to build a monumental industrial solar furnace in Colomb-Béchar, to melt the ores extracted in the surroundings.[17] Beyond the research carried out by the Laboratoire de l'énergie solaire, other institutions began developing and testing solar technologies in the desert, generating a wave of enthusiasm for the promises offered by this energy.[18]

Figure 4: Manipulation of a cooling container in Mont-Louis, France, undated.



Source: Pierre de Latil, "Froid gratuit pour pays chauds," *Science & Vie*, n° 548, May 1963, p. 116.

16 Pierrefitte-sur-Seine (France), Archives Nationales de France, 20111003/115, "Comité directeur du Laboratoire de l'énergie solaire de Mont-Louis," 23 juin 1962, p. 19.

17 Félix Trombe, "Captage des énergies naturelles. Rayonnement solaire et rayonnement terrestre," *Journal des recherches du CNRS*, n° 65, December 1964, p. 527-551.

18 Gaston Bétier, "Les recherches sur l'utilisation de l'énergie solaire en Algérie," *Bulletin de l'Unitec Algérie*, n° 50, July 1959, p. 13-15.

Legacy

The mirage of this Saharan project vanished with the end of the Algerian war of independence in 1962. Even though France negotiated special access to the desert in the years following the war, with the aim of continuing its nuclear activities and the extraction of oil, solar experiments were halted. From that moment on, the Laboratoire de l'énergie solaire carried on its research in metropolitan France only. Experiments on cooling and purifying water continued for a few years, but their applications were now more vaguely envisioned for "developing countries" or "scientific cooperation," and not for the establishment of French settlements in the Algerian desert. Research into heating assumed greater importance in the more temperate climate of France. Over the 1960s, a series of experimental houses were built in Odeillo, near Mont-Louis, to test the solar heating device invented by Trombe in the previous decade (fig. 5). It allowed to harness the energy received on a south façade in the winter to directly warm indoor air, while storing part of this energy in a masonry wall to release it during the night. This use of the south façade was an explicit departure from the research carried out in the United States, which privileged solar roofs and more complex systems to distribute warmth, as analyzed by architectural historian Daniel A. Barber.[19] It was this precise heating device which became hugely popular in the 1970s, during the oil crisis and the rise of environmentalism. Counterculture activists and ecologists saw it as a most simple and efficient way to use solar energy in architecture, and christened this device with the name of its inventor: the Trombe wall.[20]

The graph with which we began was used in this context: to promote the devices developed by the Laboratoire de l'énergie solaire, which had previously been invented at the crossroads of UNESCO's "development" program on the arid zone and France's colonial attempts to exploit the Sahara's resources. But any hint of these origins was now missing from Trombe's explanations and the more general discourses on solar energy. Only surreptitious signs remained of this past: old scientific publications, sparse administrative archives, and the mention of a Saharan oasis on a graph which continued to be published to explain the logic of the Trombe wall. This document was just a small disturbance in the process of silencing the first period of the history of French research on solar energy and its architectural applications. But it also acted as an invitation for the historian to delve into the Algerian past of these techno-scientific experiments, and to participate in exploring the colonial roots of projects, technologies, and theories of architecture's adaptation to climate.[21]

19 Daniel A. Barber, *A House in the Sun: Modern Architecture and Solar Energy in the Cold War*, New York, NY: Oxford University Press, 2016.

20 Paul Bouet, "Le mur Trombe," in François Jarrige, and Alexis Vrignon (eds.), *Face à la puissance: Une histoire des énergies alternatives à l'âge industriel*, Paris: La Découverte, 2020, p. 249-263. The device is sometimes referred to as the "Trombe-Michel wall," after the name of Jacques Michel, a modernist architect who collaborated with Trombe between 1967 and 1974.

21 For perspective on this topic in the English-speaking world, see Jiat-Hwee Chang, *A Genealogy of*

Figure 5: Experimental solar house, Odeillo, France, 1962-1963. South façade with Trombe wall.

Source: Félix Trombe's papers, private collection of Michèle Lhermitte, Paris (France).

Geographical index: Afrique, Afrique du Nord, Algérie
People index: Trombe, Félix (1906-1985)

Tropical Architecture: Colonial Networks, Nature and Technoscience, London; New York, NY: Routledge, 2016 (The Architext series).