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## The North African Horizon of French Solar Architecture, 1945-1973

Paul Bouet

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### Abstract

In the years following WWII, the exploitation of natural resources in the Sahara became a major geopolitical and economical issue. The newly founded Unesco launched the Arid Zone Program, promoting international scientific cooperation for the “development” of the dry lands throughout the world, particularly in North Africa. Parallel to this program, France intensified its control over the Saharan regions under its colonial rule to prospect, exploit and secure their underground natural resources. Within both Unesco and France programs, solar energy was thought to play a key role for achieving two goals considered as complementary: the adaptation to the climatic conditions of the desert in order to exploit its resources, and the supply of “technical assistance” to local populations, judged as “underdeveloped”. Architects, scientists and engineers trained in France collaborated in this project. How were they involved in it, and what role did the Saharan territories play in their perspective?

The paper discusses two different cases. Firstly, it analyzes the research of scientist Félix Trombe, arguing that in his technoscientific view, Sahara represented a “laboratory” to initiate the development of solar energy, meant to be deployed worldwide thereafter. With his Laboratoire de l'énergie solaire, funded by the army and colonial authorities, Trombe developed solar furnaces in order to melt ores, that led to the construction of experimental buildings. Trombe also designed prefabricated houses that used solar energy to cool and warm indoor air, to adapt the climatic conditions of arid lands. Secondly, the paper analyzes the trajectory of architects Georges and Jeanne-Marie Alexandroff. Concerned with the emergence of the “Third World”, they tried to implement solar pumping technologies to provide water, at both architectural scale within community buildings and urban scale within “solar oasis”. In the Alexandroff's perspective, Sahara and Sahel represented a ground to criticize modern western architecture and to imagine its renewal based on the combination of technology and vernacular practices. Although in both cases the realizations were finally limited to local experiments (notably in Algeria and Mauritania), North Africa and its colonial condition represented a decisive horizon for the conceptualization of solar architecture, whose focus then shifted towards France and the West after both decolonization and the emergence of environmentalism.

**Keywords:** solar architecture; solar energy; arid lands; Sahara.

## Solar Energy in Sahara

In the years following the Second World War, arid lands of the world were given a particular attention. What had long been seen as remote and unproductive territories, hostile to human occupation and to life in general, came to be seen in the light of economic development (Davis, 2007, 2016). Totalizing almost one third of the continents, arid lands were designated to play a bigger role in the exploitation of natural resources in order to face population growth and to fuel postwar modernization. Both international organizations and colonial powers then acted for what they called the “development” of arid lands.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) played a prominent role in this process. Willing to establish transnational scientific research projects, the UNESCO launched the Arid Zone Program at a symposium held in Algiers in 1951 (Batisse, 2005). As defined by experts of this program, the arid zone was composed of regions that shared climatic analogies: few annual precipitations and episodes of extreme temperatures (Fig.1). It comprised regions of Central Asia, Australia, West America, the Middle East, Southern Africa, and, notably, the whole northern part of the African continent, with, at its core, Sahara (UNESCO, 1952). Life faces serious difficulties to develop in such territories, and modern science, together with a rational use of technology, was seen as a major lever to improve possibilities of inhabiting, cultivating, and exploiting natural resources in the deserts. In the course of the 1950s, the UNESCO thus organized a series of annual symposiums and financed programs in order to stimulate scientific research and international cooperation on all aspects concerning the arid zone.



Fig.1. Arid Zone Program logo (UNESCO, 1956).

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In the meantime, Sahara became a key territory for France's imperial policy. A rationale emerged within colonial discourses that called for the "mise en valeur" of Sahara. As defined by Albert Sarrault in his eponym book of 1923, "mise en valeur" combined the "*development of material wealth*" and the "*civilizing mission*" of France in its colonies (Sarrault, 1923: 20). In this scheme, the industrialization of colonized territories to exploit their resources and workforce was considered a means to produce economic wealth as well as to raise the standards of living of local populations, by getting them closer to the western way of life. By combining "economic development" and "human development", "mise en valeur" was then to benefit to the colonizer as to the colonized—even though the exchange was fundamentally unequal—; it was supposed to make economic exploitation "profitable" for both (Unger, 2018: 36). This "mise en valeur" logic was massively applied to Sahara from the 1950s onward: missions were launched to prospect mineral ores, gas and oil, leading to the discovery of important reserves in underground Sahara (Frémeaux, 2010: 229-233; Cantoni, 2017). Projects were undertaken to create industrial complexes and infrastructures in the desert. And this endeavour was not stopped by the beginning of the Algerian war of independence in 1954: the war only accelerated it, reinforcing military control over this region in an attempt to secure France's access to those strategic resources.

In both UNESCO's development program and France's colonial project of "mise en valeur", solar energy was meant to play a key role (UNESCO, 1956; Le Bras, 1961). Sun radiation was not only considered a problem—the cause of aridity—, but also a solution—a potential resource. Indeed, adaptation to the extreme climate was a necessity for human occupation in arid lands, while access to energy was a key goal in those territories distant from conventional infrastructures. Abundant and immediately accessible, the sun rays could be used directly and provide energy for both industrial processes and human needs. The use of solar energy was thus seen as a perfect means to combine economic development and so-called human development, under the patronage of modern science.

Scientists, architects and engineers were involved in this project of using solar energy in the Sahara, most prominently in buildings. What was exactly their role in this project? And what represented Sahara and its Sahelian outskirts in their view? In what follows, I focus on two different cases: the experiments of scientist Félix Trombe and the projects of architects Georges and Jeanne-Marie Alexandroff. I argue that for the former, Sahara represented a technoscientific laboratory to initiate the spreading of solar technology, while for the latter, it

was notably envisioned as a ground to criticize modern western architecture and to imagine its renewal. Finally, I draw continuities with the following period by discussing how the colonial and postcolonial condition of these experiments represented a key stage for the conceptualization of solar architecture, before its deployment in the context of the environmental movements and the oil crisis of the 1970s.

## A Technoscientific Laboratory

In postwar France, Félix Trombe became one of the most active advocates of the use of solar energy in the arid zone. Trained as a physician and a chemist, Trombe had specialized in the study of refractory metals, which are materials extremely resistant to shocks and temperature. These materials were of special interest for military authorities, as some of them were components of advanced weapons. In 1946, at a time when shortages caused by the war were still in effect, Trombe and his laboratory had the idea to transform anti-aircraft projectors, taken to the German army, into solar furnaces: the sun rays were concentrated in one point in order to melt the metals they studied (Trombe et al., 1946).

With his work on solar energy and refractory metals, Trombe gained much popularity within the scientific community, and his laboratory constantly grew in size in the course of the 1950s and 1960s. The scope of his research also expanded, both geographically and in terms of applications. Indeed, following UNESCO's call to scientists, and with the support of the army and colonial authorities, Trombe focussed his research on the use of solar energy in the arid zone, and particularly Sahara (Trombe, 1953). Visiting Morocco in 1951, still under French rule at the time, Trombe advocated for the construction of industrial solar furnaces on the slopes of the Atlas Mountains<sup>1</sup>. Facing the desert at south, they would serve to transform ores extracted in the mines of manganese and other metals. In a report of 1949, he proclaimed that "*surely, North Africa will be the elected land for the development of great solar machines*"<sup>2</sup>. But what was exactly the role North Africa and Sahara should play for the development of solar energy in Trombe's view?

<sup>1</sup> Archives nationales de France (AN), 19800284/213, Félix Trombe (ca. 1951), *Compte rendu de mission au Maroc*.

<sup>2</sup> AN, 19800284/213, Félix Trombe (ca. 1949), *Le laboratoire de recherches solaires de Montlouis (Pyrénées Orientales): Organisations et recherches en 1949. Projets en 1950*.

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As other scientists of his time, Trombe thought that fossil energy sources (coal and oil) were subject to an accelerated depletion as they fuelled postwar modernization. In the end, when fossil sources would be over, this would inevitably lead to the use of renewable energy sources (Trombe, 1953). And among them, solar energy was presented as the most universal and promising one. It was to become the “*houille d’or de l’avenir*” (the golden coal of the future), after an expression forged by Trombe (Trombe, 1950). Although this transition was not to happen immediately, it was to be prepared without further delay. But according to Trombe, western industrialized countries were so addicted to fossil energies that they would not be ready to adopt solar energy. On the contrary, less industrialized regions of the arid zone—and particularly Sahara under French rule—, with fewer access to conventional energy sources, would be appropriate places to initiate the use of solar energy, contributing to their overall development. In this global project, that could be qualified as technoscientific, Sahara thus represented a “laboratory”, a land where to experiment the use of solar energy before its worldwide deployment.

Trombe acted intensively to fulfil this goal, getting financial support from French colonial, military and scientific authorities. In 1950, his research laboratory was transferred from Meudon, near Paris, to the citadel of Mont-Louis, in the Pyrenees Mountains—a much sunnier place. There, his Laboratoire de l’énergie solaire developed two types of applications of solar energy (Trombe, 1953) with the intention of transferring them to Sahara. On the one hand, the team of scientists continued researching on industrial solar furnaces. They built the biggest solar furnace in the world within Mont-Louis citadel between 1950 and 1952. It was supposed to melt greater quantities of metals, so as to achieve economic viability. On the other hand, Trombe and his team began researching on the use of solar energy for domestic applications. Within the citadel, they experimented various devices: greenhouses to purify water and cultivate plants; blackened pipes on roofs to produce warm water; sun-powered refrigerators to provide ice; glazed boxes on facades to warm indoor air; and small containers that used terrestrial radiation to produce cold air. All these devices had one goal: to adapt the extreme climatic conditions of the desert, which shares some characteristics with the sunny Pyrenees Mountains (Bouet, 2017: 33-37).

Developed in Mont-Louis, these devices were then tested in southern Algeria. In 1958, a miniature house was manufactured in France and transported to Colomb-Béchar, an Algerian city of northern Sahara. There, it was assembled within the Centre d’Essais d’Engins

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Interarmés, a military base where missiles were tested. Despite technical complications, the results of this experiment proved good, as the device allowed for a reduction of indoor temperature up to 12° C compared to outside temperature (CNRS, 1961: 653-680). On this basis, other experiments were envisioned in Algerian Sahara under French rule. At this time, Trombe's laboratory gained support from the Organisation Commune des Régions Sahariennes (OCRS), a political and military institution created by France in 1957 so as to secure its access to resources in Sahara, while insurgency for independence was getting more intense in northern Algeria. In this context, building housing and facilities to serve in the industrialization of Sahara became a major goal for the OCRS. In 1960, Trombe and his team projected to build a large greenhouse to purify water and cultivate plants, based on their previous experiments. They also conceived two houses to test devices meant to alternatively cool and warm air<sup>3</sup>. Cooling was much needed during very hot days in the desert, while warming was needed during cold nights, when temperature could get very low. The Laboratoire de l'énergie solaire even planned to build a monumental solar furnace in Algerian Sahara, more than ten times bigger than the one in Mont-Louis, so as to operate in industrial processes (Trombe, 1964).

All these ongoing and planned experiments were brutally stopped by the end of the Algerian war of independence in 1962. Even though France negotiated a special access to Saharan Algeria during the years after the war, especially to continue its nuclear activities and the exploitation of oil, solar experiments were stopped. From that moment on, the Laboratoire de l'énergie solaire carried on its research in France. The monumental solar furnace was built not on the slopes of the Atlas Mountains, but in Odeillo, near Mont-Louis. It was designed by the national architectural and engineering office of Aéroport de Paris, and conceived as a scientific and architectural symbol of postwar modernization in France (Bouet, 2017: 44-57). While research on cool houses were progressively reduced, research on warm houses gained much importance. In the course of the 1960s, a series of experimental houses warmed by the sun were built, also in Odeillo (Fig.2). Trombe then collaborated with architect Jacques Michel, a disciple of Le Corbusier, to adapt his technology to various housing projects and promote it through spectacular designs. Despite the withdrawal of France colonial power from North Africa,

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<sup>3</sup> Félix Trombe papers, private collection of Michèle Lhermitte, Félix Trombe (ca. 1960), *Rapport sur la climatisation des maisons dans les pays à ciel clair*.

Trombe's technoscientific project to use Sahara as a laboratory to initiate the deployment of solar energy had begun to realize.



Fig.2. Experimental solar house, Odeillo, France, 1961-62 (Félix Trombe papers, private collection of Michèle Lhermitte).

### **A Ground to Criticize Modern Western Architecture**

The Algerian war of independence and the overall process of decolonization also played a key role in the second case analyzed in this paper, although not in the same perspective. The interest of Georges and Jeanne-Marie Alexandroff for solar energy and Africa grew during their studies in the Section d'architecture of the École des Beaux-Arts de Paris. In 1958, at the age of 27, Georges Alexandroff, then a remarkable student, had to stop the course of his studies to serve in the army<sup>4</sup>. At that time, military service had been extended to almost three years because of the intensification of the war in Algeria. Georges Alexandroff was integrated in a section of the engineering corps; but we ignore whether or not he was effectively sent in Algeria, as most of the conscripts were, or if he served in other countries where the French army was present. In any case, as historian Ludivine Bantigny has argued, the Algerian war of independence profoundly marked a whole generation of young men and women, appalled by France's action in Algeria and

<sup>4</sup> AN, AJ52/1353, Capitaine Romary (January 23, 1958), *Certificat de présence au corps de Georges Alexandroff*, Auneau.



terrorised by the attacks perpetrated by the Organisation de l'Armée Secrète in metropolitan France (Bantigny, 2007).

At his return to the École des Beaux-Arts de Paris in 1961, Georges Alexandroff together with his wife Jeanne-Marie got interested in the issue of third world development and the role architecture could play in it. In the French context of the 1960s, issues of development were particularly discussed by agronomist René Dumont. In his book of 1962, provocatively—and quite ambiguously—entitled *L'Afrique noire est mal partie*, Dumont argued that colonization had left African countries profoundly disorganized, particularly in the agricultural sector (Dumont, 1962). To avoid starvations and conflicts, Dumont pleaded for an intense agricultural modernization based on western knowledge but adapted to local conditions. He notably called for the creation of experimental villages in the Sahelian zone, where villagers would be taught modern agricultural practices, including the massive use of irrigation. And at that time, as we have said, solar energy was commonly presented as a mean to “develop” the arid zone, including Sahara and Sahel, by UNESCO and various scientists (Perrot, 1963).

With these considerations in mind, Georges Alexandroff chose to dedicate his diploma project to a “solar village”. Presented at the École des beaux-arts in 1965, it was awarded the Guadet prize for the best diploma project of the year (École nationale supérieure des beaux-arts, 1965). Drawn in the spectacular manner of the Beaux-Arts tradition, the project was set in a fictitious site, although located somewhere in the Sahelian zone, between Senegal and Chad. It was composed of four different programs: housing for thirty families, community services, a training centre and agricultural facilities. All these programs were organised under a repetitive roof profile composed of solar panels. Solar energy was used to pump underground water and irrigate fields around the village in this semi-arid zone.

Elaborating on this project, the Alexandroff conceptualized what they named “solar architecture”, and doing so, they clarified the role given to Sahara and Sahel in their perspective. For them, solar architecture consisted in integrating solar technologies in projects to be built in third world countries (Alexandroff, 1968). It was a means to provide technical assistance based on western technologies to populations in rural regions considered as underdeveloped. For the Alexandroff, solar architecture was thus “*a tool of development . . . that should be generalized in the third world*”. Implementing it in Sahara and Sahel had also a particular political and historical significance for them: it was an attempt—and possibly a naïve one—to reverse the relationship between France and its former African colonies in the postcolonial period.

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Besides this development goal, Sahara and Sahel had also a critical function in the Alexandroff's perspective. Solar architecture, as they stated, relied on western technologies but had to integrate and celebrate characteristics of local architecture. "Vernacular" architecture, as it was qualified, represented a model of vitality and inventiveness that they opposed to the monotony and abstraction of modern architecture that triumphed in the West at that time, particularly in the French *grands ensembles* as they pointed (Alexandroff, 1968: 7). This function of critical model is particularly emphasized by a spectacular photograph reproduced on one of Georges Alexandroff's diploma panel. Initially taken by French ethnologist Marcel Griaule, it represents a Dogon village built on the cliffs of Bandiagara, in today's Mali, with its profusion of constructions and raw materials set in apparent disorder. It is worth noting that at the very same moment, Bernard Rudofsky showed the same photograph in his most famous exhibition and book *Architecture Without Architects* (Rudofsky, 1964: 40). For the Alexandroff as for Rudofsky, the intention was similar: to make vernacular architecture a critical model opposed to modern western architecture. And for this critique, Sahara and Sahel represented a particular ground.

In the years that followed their diploma project and first articles, the Alexandroff had the opportunity to give shape to their ideals. They became members of the *Coopération Méditerranéenne de l'Énergie Solaire*, a group founded by scientists aiming at promoting research on the use of solar energy around the Mediterranean Sea, beyond historical and political conflicts. At the COMPLES meetings, they met Jean-Pierre Girardier, an engineer and business owner who had studied solar pumping technologies in Dakar University. The Alexandroff and Girardier associated to develop a project in Chinguetti, Mauritania (Fig. 3). In this city located in West Sahara, with no access to conventional energy sources, they implemented a solar pump within a community building (Brabyn, 1974). Again, this project was typical of the development policies of that time, as well as of the Alexandroff's conception of solar architecture. Solar panels formed the roof under which children, who had not to pass their day getting water anymore, could be educated in classrooms. The pump itself was set in the tower, the design of which was inspired by the nearby mosque. Solar components came from France, while the rest of the building was made of local materials and building techniques. Completed in 1973, this project was followed by other designs based on the same principles to build "solar oases" in the Saharan regions, including Algeria, Niger and Tunisia.

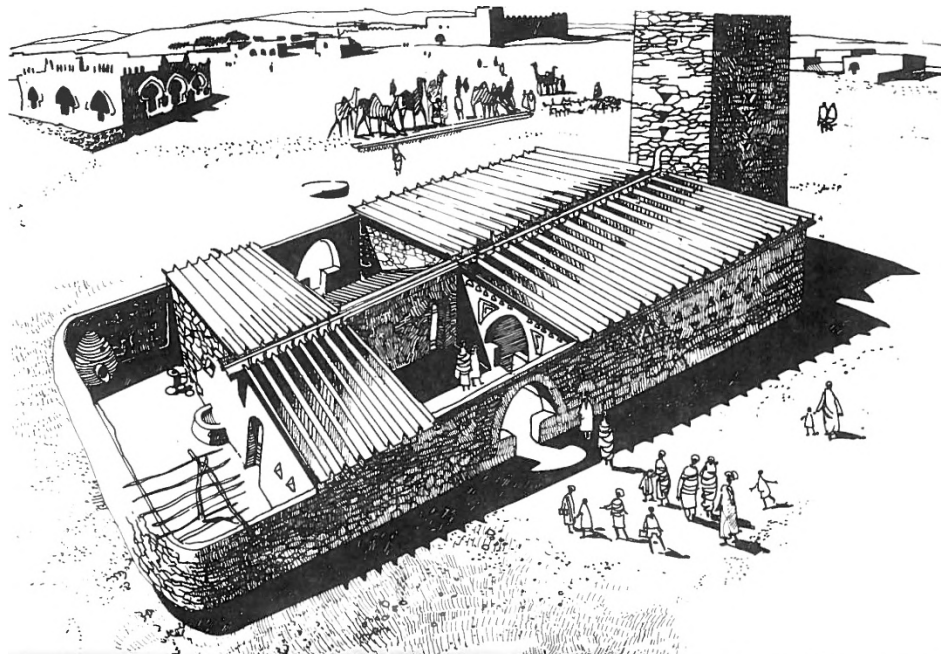


Fig.3. Georges and Jeanne-Marie Alexandroff, solar community building, Chinguetti, Mauritania, 1973 (Brabyn, 1974).

## Conclusion

Although different in perspective, Trombe's and the Alexandroff's conceptions of Sahara and Sahel shared a fundamental characteristic: they were in very large part imaginary, idealized visions of a land seen from the West, and that they knew only little in reality, as pointed in the classical *saïdian* theory. Indeed, this gap between local realities and ideal conceptions was in large part responsible for that most of the experiments that were conducted in those territories ended up failing. Nevertheless, research undertaken in Sahara and Sahel were then continued in France and other western countries in the context of the rise of environmentalism and the oil crisis of the 1970s. They served as a basis to develop the use of solar energy within buildings and to theorize the adaptation of architecture to climate. Technologies such as the Trombe wall, first imagined for Sahara, became very popular among counter-cultural builders on both sides of the Atlantic. Actors such as the Alexandroff became central figures of the debate on the use of renewable energies in architecture. But, in that second period, the North African horizon of early French solar architecture remained largely ignored.

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