# The technological priorities of French nuclear power: the historical civil-military ties

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**During the Second World War an intense war effort led scientific research to pioneer a new form of energy, demonstrated in a radical and cataclysmic way by the American nuclear bombings. The energy of the atom has come into the world marked by the seal of geopolitics, the military and science. The subsequent development of nuclear energy in France will not escape these three determinants: throughout the years 1945 to 1970, the civil-military link is evident in the reactor technologies developed by the two major French institutions in charge of this energy, the CEA at first and EDF from the mid-1950s onwards.**

In October 1945, the provisional government created the French Atomic Energy Commission (Commissariat à l'Énergie Atomique, CEA) by decree "so that France can take its place in the field of atomic energy research" [1]. Two months earlier, the United States of America had used atomic bombs and thus placed itself in a position of power among the allies in the Second World War. Between 1940 and 1945, the Manhattan Project mobilized up to 130,000 employees [2]. French atomic scientists, who were very active in the inter-war period and among the first to begin the secret study of a nuclear weapon in 1939, were kept out of the project.

With the discovery of fission, it soon became clear that the release of nuclear energy in a chain reaction makes possible self-sustained "nuclear combustion", which can be used to run an electricity generator or an engine if combustion is controlled, or to trigger an explosion if not. To obtain the fissile isotopes that were used in the Trinity test and the Hiroshima and Nagasaki bombings, it was necessary to design and control nuclear reactors of several hundred megawatts as well as industrial processes for isotopic or chemical separation. Since the knowledge acquired by the Americans and British was protected by very strict secrecy [3], the French government decided to launch large-scale multidisciplinary scientific research, and the 1945 decree did not specify either its civil or military nature or its purpose[(a)].

The CEA was created as a hybrid organization, comprising both a scientific institution and a technical and industrial development agency. This duality is demonstrated by the management structure, with scientific decisions coming under the office of the High Commissioner for Atomic Energy, entrusted to Frédéric Joliot-Curie, and the administrative and financial organization to a "general administrator", Raoul Dautry, Minister of Reconstruction and Town Planning in the interim government. Although the military aspect was not ruled out, it seemed secondary in France to reconstruction, which was desperately lacking in technical capacity and energy resources. Though less well supplied with coal than its main European competitors, France had the uranium resources of its colonies in Africa and Madagascar at its disposal, and then the mines discovered in France itself. Nuclear research therefore held out great hope in terms of energy, technological progress and modernity, objectives which the country's main political leaders subscribed to.

In 1949 the Cold War deepened with the formation of the NATO alliance and the explosion of the first Soviet atomic bomb. From then on, the nuclear threat and the need to respond with similar weapons became a concern for all Western governments. In France, several political forces, including the communists, became increasingly opposed to the military use of the atom. Communists or sympathizers were gradually removed from the nuclear program, beginning with Joliot-Curie in April 1950. While Francis Perrin had not yet replaced the former as High Commissioner, the French Atomic Energy Commission was reorganized in early 1951, concentrating decision-making powers on the position of the general administrator [4]. After Dautry's death, his successor Pierre Guillaumat developed a program that pursued energy and defence objectives together. In 1952, Parliament approved the development of Natural Uranium fuel, Graphite moderator and Gas ($CO_2$) coolant


reactors, or NUGG. The NUGG is a first-generation reactor that has the advantage of being able to operate with raw materials that were accessible at the time. It does not require the use of heavy water[(b)], the separation of which from normal water is very costly in terms of energy, nor the use of fuel enriched in uranium-235, the fissile isotope of uranium, which at the time could be produced in France only in small quantities. A crucial characteristic of NUGGs is the possibility of their being used to produce plutonium-239: this isotope is of interest both for military use and for the prospect of fast neutrons breeder breeder reactors, considered at the time to be the most promising energy option.

Starting in 1953, the CEA built the G1, G2 and G3 reactors at Marcoule, as well as a plant for the chemical extraction of plutonium. In addition to plutonium, the three reactors also provided electrical power from the outset in collaboration with EDF, the purpose of the military plutonium remaining confidential until 1958[(c)] [4]. In the meantime, the government took successive decisions which led towards nuclear armament. At the end of 1954, shortly after the rejection of the European Defense Community by the National Assembly, Pierre Mendès-France created a specific defense branch at the CEA, the Bureau for General Studies, which in 1958 became the Military Applications Directorate (Direction des Applications Militaires, DAM), and also a Committee on Nuclear Explosives.

In December 1954, Mendès-France also asked the CEA to develop a submarine reactor. The *Nautilus*, an American submarine, had just been inaugurated. A little later, in 1958, it achieved the feat of reaching the North Pole under the Arctic ice pack. Directly inspired by the *Nautilus* nuclear boiler, the CEA's Onshore Prototype at Cadarache is a second-generation reactor running on pressurized light water and uranium enriched in uranium-235. In 1957, the Americans agreed to supply fuel for the Onshore Prototype. In the same year, the French Parliament also approved funding for an isotope separation plant at Pierrelatte. Enriched uranium, crucial for thermonuclear weapons and naval propulsion, is, like plutonium, a strategic objective.

Contrary to the image that has long prevailed of a deterrence project promoted solely by de Gaulle and his supporters after they took power, changed the Constitution and founded the "Fifth Republic" in 1958, it was in fact the leaders of the Fourth Republic who were responsible for military nuclear development between 1950 and 1958[(d)] [3], while at the same time pursuing the energy objective [4]. In the last years of the Fourth Republic, military nuclear projects were intensified and developed in a tripartite approach with West Germany and Italy [3]. In April 1958, Félix Gaillard, Prime Minister, decided to test a French bomb. De Gaulle confirmed the decision to build and test the bomb as well as to develop nuclear submarine "missile launchers". Stopping the planned military nuclear cooperation with Italy and West Germany, he took a diplomatic approach of bilateral cooperation with the European allies. However, France and its neighbors are now members of the European civil collaboration *Euratom*, whose activity since 1958 has been focused on the development and implementation in Europe of the light water and enriched uranium technology known at the time as the Light Water Reactor (LWR) and nowadays as the Pressurized Water Reactor (PWR). It is directly inspired by

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submarine boilers, as is the American Shippingport reactor. The latter is a prototype energy reactor built by Westinghouse, inaugurated by President Eisenhower in 1954 and which became the spearhead of his *Atoms for peace* policy.

Under the fifth Republic, the CEA continued to develop NUGGs at Marcoule, for plutonium-239 and power, as well as PWRs and uranium enrichment for naval propulsion. EDF, associated with the CEA since the early 1950s, developed its own NUGGs at Chinon and then Saint-Laurent des Eaux, and its PWRs first of all through the European *Euratom* collaboration.

At the end of the 1960s, France opted for electrical energy shared between these two reactor technologies, both of which had originally been designed and developed for military use, either for nuclear weapons or propulsion. Much has been said and written about the now famous « Guerre des Filières » (war of the sectors), which was also a long struggle between and within EDF and the CEA [4,5]. The main argument in favor of PWRs over NUGGs at the end of 1969 was their economic superiority, but this has since been questioned [6]. However, as naval propulsion is probably a much more demanding application than plutonium production, PWRs have benefitted from major development and improvement efforts[f]. Naval propulsion is still a widespread use of nuclear energy: the largest number of nuclear reactors until the end of the Cold War was at sea - mainly in warships, surface ships or submarines - and not on land [7]. When the oil crisis occurred in 1973, the technical justifications for favoring PWRs in 1969 were still valid, hence the PWR is the only reactor in the Messmer plan dedicated to civil nuclear power since 1974 [5].

As they were designed and built at the time when France acquired nuclear weapons and nuclear submarines, French reactors for energy are therefore marked by civil-military duality. The first-generation reactors were first optimized for the production of military plutonium; the second-generation reactors were primarily designed for naval propulsion. This duality is still present in the current fleet of PWRs which are similar to naval boilers. ▮


Translation: Nuclear: the zero-carbon asset

a. Beyond "pursuing scientific and technical research for the use of atomic energy in the various fields of science, industry and national defence" [1].

b. Heavy water $D_2O$ is the moderator used in the first French "atomic pile", ZOÉ, which operated from 1948 to 1976 in the CEA's Fontenay-aux-Roses center.

c. G1, air-cooled, then G2, cooled with pressurized $CO_2$, and therefore the first of the NUGG type, were ready to supply plutonium 239 for the first French nuclear test at Reggane in 1960.

d. Some even speak of a taboo, on the right as well as on the left, regarding the decisions of the fourth Republic about military nuclear power [3]. The Gaullists would like to magnify the role of the General, whilst the non-communist left would like to conceal its pioneering role. This taboo would be preserved by closing government archives.

e. Throughout the period under consideration, the CEA grouped together all its nuclear programs, whether scientific or industrial. These activities were not separated until the 1970s. Meanwhile, EDF worked on the design and construction of NUGG power plants with CEA, and PWRs with the Franco-American company Framatome, a joint subsidiary of Westinghouse, Schneider and Merlin-Gérin.

f. See also the article by J. Bordé and M. Leduc (p. 37).

## References


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