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Nuclear power of the future and the consequences of abandoning the "Astrid" project

Model of a 4th generation reactor as part of the ASTRID project (source: Ph. Stroppa/CEA)

In an already difficult time for the nuclear industry, the announcement made in August 2019 that the construction of the 4th-generation Astrid reactor would be postponed until the end of the century has caused a stir and provoked a number of different reactions.

What were the main objectives when this project was launched ten years ago? Under what conditions was it developed and at what cost? How relevant are the justifications put forward for postponing or abandoning the project? How does this decision affect the future of the nuclear industry in France? What are the new technological avenues for nuclear power in the future? How can a long-term perspective be restored to French research on advanced nuclear power?

These are some of the questions the rapporteurs have been trying to find answers to and which lead them to suggest re-launching the democratic debate on this subject, which is vital for France's independence and sovereignty.[1]

Thomas GASSILLOUD, MP **Stéphane PIEDNOIR, Senator**

1 Report n° 4331 (XVth Term) National Assembly – n° 758 (2020-2021) Senate.

The creation of the French Atomic Energy Commission (CEA) in 1945 enabled France to acquire both nuclear weapons and the ability to develop civil nuclear technologies, particularly for electricity production, within the space of ten years.

This success was sustained in the 1970s by the accelerated deployment of nuclear power plants in the wake of the first oil crisis and the conversion of the La Hague plant for the civil sector, the first step towards a closed fuel cycle.

But the accidents at Three Mile Island, Chernobyl and Fukushima have shaken public confidence in nuclear energy and slowed its development in France and the West.

Nuclear energy, a strategic issue

The OPECST warned the government as early as 1991, and recent years have confirmed that the fact that no new reactors have been built has led to a loss of skills and expertise. In the United States, the situation regarding those traditionally involved in the nuclear industry is very similar to that in France.

While the nuclear industry was declining in the West, new leaders emerged in the East, namely the Russian Federation and China, both of which are investing heavily in R&D.

This shift in nuclear energy control carries several risks:

- international organisations being taken over by countries less concerned about non-proliferation and nuclear safety;
- China and Russia's growing influence through the export of nuclear solutions;
- the risk of becoming equally dependent if our technological expertise continues to decline;
- the latter is compounded by a likely long-term need for decarbonised, controllable energy to complement hydro and renewable energies;

- this dependency could also call into question our ability to maintain the naval component of our deterrent forces.

The rapporteurs consider that it will not be possible to reverse this decline without returning to the basic principles that have made France one of the major players in civil nuclear energy. These include investing heavily in research and innovation and motivating young people to enter one of the most demanding scientific and technical fields.

"Nuclear power of the future": a wide range of technological possibilities

The so-called 4th-generation reactors, whose developments are coordinated by the Generation IV International Forum, are the first category of future reactors that use nuclear fission, and the ASTRID reactor project corresponded to one of the 6 concepts developed as part of this.

These concepts have several advantages over existing reactors, but they also present a number of safety issues. The rapporteurs consider that safety is the main obstacle when it comes to developing these types of technologies in Western countries. An innovative reactor should have major improvements in terms of safety in order to compensate for the lack of operating experience.

Small Modular Reactors (SMRs) are the second major category of future fission-based reactors. Most are based on the operating principles of existing reactors, but are smaller in size and power.

SMRs have a number of potential benefits:

- their low power level has the potential for a breakthrough in nuclear safety;
- their modular design means that components can be standardised and mass-produced in the factory;
- building them on site will be much simpler, which will save time, reduce uncertainty and have a positive impact on funding;
- their small size and power make them more adaptable to various situations, such as remote locations, poorly developed electricity networks, limited water resources, local heat production in cogeneration for industry, urban heating, etc. - but too many sites can be detrimental to safety.

The major disadvantage of SMRs, which do not benefit from the scale effect of large reactors, is their higher production cost. But mass-producing their components and simplifying their construction on site could compensate for this unfavourable factor.

EDF, TechnicAtome, CEA and Naval Group are developing the French Nuward SMR to replace coal-fired power plants all over the world, with the aim of marketing it after 2030.

Given the large number of competing projects, some of which are several years ahead of their time, the rapporteurs believe that the development of the Nuward project should be supported, with a view to accelerating it.

However, mass producing the components of this reactor will require a factory that cannot be justified without a sufficient volume of initial orders. Therefore, the rapporteurs believe that the possibility of replacing a number of 900 MWe reactors by SMRs after 2030 needs to be assessed in terms of cost, safety and industrial development.

The success of SMRs will also depend on the possibility of harmonising their certification requirements in the different countries. The rapporteurs support the steps taken in this direction by the ASN (Nuclear Safety Authority) and IRSN (Institute for Radiation Protection and Nuclear Safety) and ask that they be given the necessary resources to successfully complete these efforts.

Finally, approximately half of the SMR projects, based on a 4th-generation reactor concept, known by the acronym AMR (*Advanced Modular Reactor*), could also use their low power to make a significant leap in safety.

The rapporteurs believe that this avenue of research and development should be pursued.

ASTRID: a strategic project yet to be completed

The ASTRID project provided a solution to three major challenges:

- energy independence for France by enabling it to use almost all the energy content of the natural uranium and nuclear materials available on its soil in large quantities;
- better management of the most dangerous radioactive waste, through transmutation, as provided for in the 1991 so-called 'Bataille law' and the law of 28 June 2006 on the sustainable management of radioactive waste;
- preserving research achievements, with ASTRID following on from 60 years of research into sodium-cooled fast reactors.

The ASTRID project, provided for in the laws of 13 July 2005, which set out the guidelines for energy policy, and of 28 June 2006, was launched in 2010, following a decision by French President Jacques Chirac.

The project's funding, under the PIA 1 programme (Investment Program for the Future n° 1), was around €650 million and its total cost was estimated at around €1.2 billion.

The project was governed by an agreement signed between the State and the CEA. Until 2017, it was carried out in accordance with the commitments made as part of this agreement, particularly in terms of deadlines, meeting technical objectives and securing partnerships with both French and foreign manufacturers.

But in 2017, the decision was made to divide the power of the future ASTRID prototype by 4, which meant starting again and designing a new reactor.

The decision not to continue the ASTRID project beyond 2019 by building a prototype was made public in a press article published on 29 August 2019. It was confirmed the next day by a CEA press release announcing that the construction would be postponed until the end of the century.

Two reasons were given for this decision. The first was the permanently low price of uranium, which did not justify immediate investment in new resource-efficient reactors, and the second was the need to gain more knowledge about the fuel cycle associated with the ASTRID reactor.

The long-term interests of the country, in particular its energy independence at a time when electricity will represent an increasing share of its energy consumption, do not seem to have been taken into account.

The rapporteurs feel that the lack of parliamentary involvement in this decision and the inconsistencies created by the legal framework do not guarantee the necessary consensus that must be reached on these strategic issues for the nation.

The end of the ASTRID project: the four major impacts

The rapporteurs have identified 4 major impacts of this decision:

- it casts doubt on the coherence of the approach to closing the fuel cycle that has been followed for the past 70 years and therefore on France's long-term intentions. France risks being perceived as an unreliable R&D partner. Moreover, countries wishing to purchase nuclear power plants from long-term suppliers may question France's intentions.
- ASTRID was the headline project of nuclear R&D in France. In an already difficult context, the announcement of its abandonment has had a negative impact on the attractiveness of the programme for students.
- the lack of a common nuclear project may result in the loss of 70 years of research on sodium-cooled fast reactors;
- in the longer term, the closed fuel cycle strategy could be abandoned, with potentially serious consequences for the French nuclear industry and for the geological storage of waste.

A programme-based law to overhaul the research strategy for advanced nuclear power

Considering that we need to react quickly to show that France still has a clear vision of the future of nuclear energy, the rapporteurs suggest that a research strategy on advanced nuclear power be reorganised through a programme-based bill or proposal for a law that would be the occasion for an extensive debate in Parliament.

Recommendations

1. **1.** Establish a new research strategy on advanced nuclear power to be reorganised through a programme-based bill or proposal for a law that would allow for an extensive debate in Parliament.
2. **2.** Reaffirm the closed fuel cycle strategy and the development of new 4^{th}-generation reactors which are essential for its realisation.
3. **3.** Provide a plan for developing 3^{rd} and 4^{th}-generation reactors and renovating cycle facilities and propose a long-term strategy to all players in the nuclear sector.
4. **4.** Identify the best way to exploit the achievements of the ASTRID project and previous work on sodium-cooled fast reactors in a new national, European or possibly international project.
5. **5.** Take the time to examine the status of nuclear materials in the context of a genuine democratic debate on the long-term options for ensuring the country's sovereignty and energy independence.
6. **6.** Review the infrastructures and collaborations necessary to achieve the objectives of advanced nuclear research, also taking into account the country's strategic interests, in particular in the Indo-Pacific area.
7. **7.** Define a skills development plan adapted to key disciplines by supporting the training of young people, particularly at university. In particular, initiate a programme to support nuclear training and research in universities.
8. **8.** Provide the ASN and IRSN with the necessary means to anticipate the regulatory changes required for the certification of advanced reactors.
9. **9.** Extend support for the Nuward SMR project over several years to accelerate the completion of the project.
10. **10.** Assess the alternative of deploying Nuward SMRs to replace a number of 900 MWe reactors after 2030.

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Assemblée nationale – 126 rue de l'Université - 75355 Paris 07 SP –Tel: +33 (0)1 40 63 26 81 – secretariat-opecst@assemblee-nationale.fr
Sénat - 15 rue de Vaugirard - 75291 Paris Cedex 06 – Tel: +33 (0)1 42 34 25 58 – opecst-secretariat@senat.fr