The future and nuclear power

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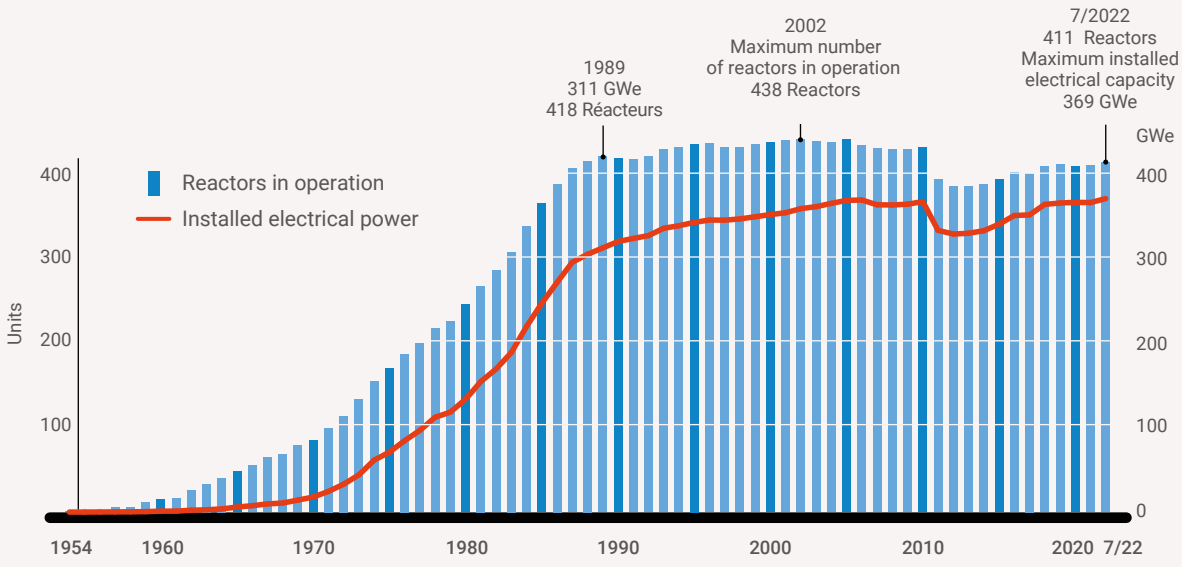
Opponents of nuclear power often claim that it is an energy of the past, with renewable energies being the future. However, this overlooks the fact that renewable energies such as wind and solar power are intermittent, and that we therefore need to be able to compensate for this intermittency either by having dispatchable sources of electricity, or be capable of directly or indirectly storing colossal quantities of electricity (see part 4) .

In 2018, at global level, dispatchable sources are totally dominant [1]: 64% rely on fossil fuels, 16% on hydro and 10% on nuclear. If we want to retain a fossil contribution, it is essential to separate and sequester the corresponding carbon dioxide: the state of the art on this subject is given in the article by F. Delprat-Jannaud (p. 78). If this storage proves impossible on a very large scale, the real question will be: can we get out of fossil fuels and nuclear power at the same time? Fossil fuels to deal with the issue of greenhouse gases, or nuclear power to satisfy the aspirations of a public opinion marked by fear? We can currently see that Germany, which is phasing out nuclear power, is still a long way from phasing out fossil fuels, and that France, which has almost phased out fossil fuels for its electricity, is still very attached to nuclear power. At European level, we often hear that it will be possible to move away from both and that the weight of nuclear power in the world will decrease. Figure 1 shows that there was indeed a saturation and then a reduction in installed nuclear capacity worldwide after the Fukushima accident, but that this trend seems to have been reversed in recent years, mainly because of China, India and the Gulf States.

The two articles that follow present two specific avenues, at different stages of maturity, for the possible development of nuclear power,



1. number of nuclear reactors in operation worldwide and installed electrical capacity (in GWe), from 1954 to July 2022 ([2], p. 45).

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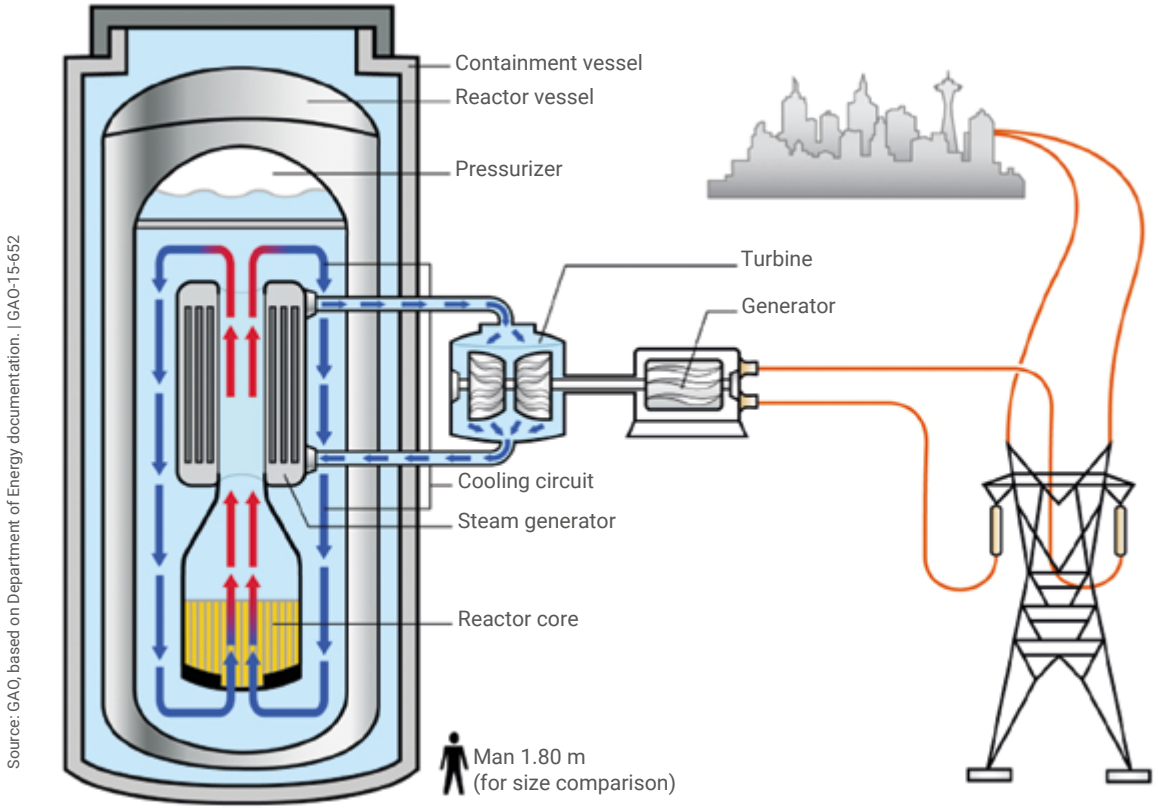

Diagram of a small modular reactor

should its development be confirmed. In the short term, currently mastered nuclear technologies (pressurised water reactors - PWRs - in particular) will be used, as is the case today. Recent or near-future reactors (the EPR, for example) are of this type. But other technologies are possible and even necessary if nuclear power is to develop over the long term [3].

Small Modular *Reactors* (SMRs) can meet local needs. They have a capacity of around 100 MW. These are small conventional reactors built in a factory and then installed on site, which reduces costs while ensuring a high level of safety (passive safety). They could be used to supply electricity or heat, or to desalinate seawater. Solutions are already being considered, particularly in the USA and Russia, to move to fast neutron technologies.

Fast neutron reactors are capable of burning uranium 238 (or natural thorium), as well as the minor actinides that make up by far the most problematic part of nuclear waste (because they are very long-lived). Their development opens the way to sustainable nuclear power, by providing fuel resources for several thousand years and considerably reducing the waste problem by closing the fuel cycle [4]. However, there is an urgent need to develop these new technologies before we run out of the fissile uranium 235 that nature has blessed us with.

The article by Elsa Merle *et al.* (p. 98) puts the spotlight on one of the solutions currently being considered for the medium and long term. The corresponding timeframe is beyond the next decade.

If we look even further ahead, nuclear fusion could become a possibility if the corresponding research (e.g. the ITER project) comes to fruition. Gérard Bonhomme's article (p. 104) provides an update on fusion by magnetic confinement. ▮

1• https://cutt.ly/wikipedia-Production

2• *The World Nuclear Industry Status Report 2022*, A Mycle Schneider Consulting Project (Paris, 2022).

3• A. Billebaud, « Les nouveaux concepts de réacteurs nucléaires », *Reflets de la physique* **60** (2018) 55-57.

4• https://cutt.ly/plan-national-gestion-radioactifs