# Foreword

Global warming is a concrete reality that is experienced every day around the world and whose effects will accelerate in the years to come. The main cause, responsible for 70% of this phenomenon, is known: the immoderate use of fossil fuels, viz. the "pickaxe" culture that has led us to quench our infinite thirst for growth using energy resources from the Earth (coal, oil, and gas). The solution has also been known for years: produce less $CO_2$, and in particular stop using these fossil fuels, which are the biggest emitters.

In this context, nuclear power, the energy source that produces the least amount of $CO_2$, clearly has an important role to play. Unfortunately, current nuclear power technology suffers from serious disadvantages that prevent it from fully playing this essential role in the future of our planet. The first of these is the huge size of current reactors, which results in construction times of at least around 10 years and the requirement for very significant investments. Meanwhile, their operational complexity also limits their applicability in many countries.

Therefore, new, smaller and smarter technologies deserve a closer look, including small modular nuclear reactors such as the SMR (Small Modular Reactor), AMR (Advanced Modular Reactor), MMR (Micro Modular Reactor), or XSMR (extra Small Modular Reactor). Whatever the power generation capacity of such installations, their common feature is the industrialization of their production, the modularity intrinsic to their design, and a decentralized vision of electricity production, enabling in particular the supply of electricity to isolated regions or where the power grid infrastructure is of poor quality [1].

In addition, many countries reject nuclear power, mainly for two reasons: the risk of accidents, and the creation of very long-lived waste. However, these new types of reactors, known as fourth-generation technology, will make it possible to envisage models that could address these problems, that is, fast reactors.

Joel Guidez has written two remarkable books on reactors using this technology: one on feedback from the Phenix sodium fast reactor, and one on the achievements of the Superphenix sodium fast reactor. These books have been distributed in French and English versions and published in new editions when supplies ran out. Mr. Guidez is one of the best-known international experts in this field.

In this new book, Mr. Guidez recalls the fundamental advantages of fast reactors that make it possible to operate them using available fuels and in particular to burn long-lived waste, in order to ultimately produce only short-lived waste that is perfectly manageable. This will avoid the need for uranium mines and enrichment plants, and enable operation for thousands of years with existing stocks of these products that are already stored and available. Note that, without the hope offered by these fast reactors, such products would become long-lived nuclear waste.

One may ask why such reactors, which have been built in France (Phenix and Superphenix) as well as Germany, the United Kingdom, the United States, Russia, China, India, and Japan, have not invaded the world? An entire chapter of this book explains the reasons for this, providing the means to analyze and overcome these difficulties.

As President of the Confrontations Europe think tank and the House of Europe in Paris, I was particularly interested in the chapter on the latest studies on the European ESFR SMART project, which, based on feedback from sodium reactors, reanalyzed their design to further improve their safety. This analysis is remarkable because this improvement was achieved not by adding systems and making the reactor more complex but on the contrary by simplifying it. This leads to a reactor with very simple operation, without pressure, whose safety is ensured passively through natural convection. For example, the removal of the residual power (the cause of the explosion at Fukushima) is achieved here via natural convection, by simply opening hatches.

Note that all these simplifications in the concept are even more readily applicable to small reactors. This drive toward the SMR is already the subject of a new 4-year European program that will begin this year and should lead to versions of the SMR that could be manufactured in a factory.

However, Joel Guidez does not stop at sodium fast reactors; this book also analyzes all the possible versions of the fast reactors proposed by the Generation IV International Forum (GIF). It is concluded that fast molten salt reactors are another very interesting possibility for the future. The organization in 2018 of a 2-day seminar in Massy with all the French actors working on this subject enabled him to confirm the very significant potential advantages of such reactors in terms of safety, the ease of the fuel cycle, and waste management. In particular, regarding safety, the avoidance of the possibility of a serious accident could facilitate the social acceptance of such reactors

Unfortunately, feedback regarding experience with this type of reactor is sparse and they therefore require significant developments. These are currently underway, in particular through the French start-up NAAREA, which offers a particularly innovative double technological leap by combining SMR and Generation IV with a fast molten salt reactor.

There are therefore two technological possibilities currently: sodium reactors using proven technology, which we know how to build with all the simplifications/improvements in terms of safety, and molten salt reactors, which offer significant potential advantages (in terms of safety, cost of mass production, a simpler fuel cycle, etc.) but that lack feedback and require development.

Fast-reactor technology is therefore a real hope for humanity. It would enable the production of almost unlimited amounts of energy by burning long-lived waste but without emitting $CO_2$ or requiring uranium mines, and with a remarkable level of safety.

Let us conclude like the author: Will humanity be able to take advantage of this opportunity? The climate emergency is here [2], and the major technological choices cannot wait!

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## References

[1] Cf. Revue de l'Energie n°657, juillet-août, 2021, pp. 52–64.
[2] Dans l'urgence climatique. Penser la transition énergétique, Gallimard, 2022. mars.