Nuclear Energy Between Two Energy Crises: Lessons from the Past and Imperatives for the Future

Editorial

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The history of nuclear energy development is closely linked to major energy crises. The first major expansion of civilian nuclear programs was driven by the oil shocks of the 1970s, when the vulnerability of energy systems dependent on imported fossil fuels became evident. The sharp increase in oil prices and the resulting geopolitical uncertainty prompted many countries to seek energy sources capable of providing long-term energy security, strategic independence, and economic stability. Nuclear energy emerged as one of the few viable solutions available at the time.

More than fifty years later, the world is once again facing a period of energy instability. The conflict in Ukraine has exposed the fragility of natural gas supply chains, while tensions in the Middle East and risks affecting global oil markets continue to generate uncertainty. At the same time, international climate commitments are accelerating the phase-out of coal-fired power plants, further reducing the flexibility of energy systems.

In this context, nuclear energy is re-emerging as a fundamental component of the future energy mix. Unlike the situation in the 1970s, however, today's challenge is not limited to energy security; it also encompasses the deep decarbonization of the global economy. Although variable renewable energy sources have expanded significantly, the deployment of energy storage technologies remains insufficient to support a rapid and complete replacement of conventional generation. Technological, economic, and supply-chain constraints suggest that large-scale energy storage will remain a major challenge for decades to come.

Furthermore, current levels of electrification are still insufficient to support both climate neutrality objectives and resilience against major energy supply disruptions. Transportation, heavy industry, and numerous industrial processes continue to rely heavily on fossil fuels. The energy transition therefore requires not only the replacement of existing electricity generation sources but also a substantial increase in overall electricity production.

Within this framework, the debate between Small Modular Reactors (SMRs) and Large Reactors (LRs) is becoming increasingly relevant. Large reactors continue to offer economies of scale and significant generation capacity, making them essential for the decarbonization of national energy systems. At the same time, SMRs can address specific needs that are difficult to meet efficiently with conventional nuclear projects, including deployment in remote locations, replacement of retiring coal-fired plants, integration with industrial facilities, and the provision of process heat for non-electric applications.

The opportunity for nuclear technologies is further reinforced by the emergence of new categories of energy consumers. The rapid development of artificial intelligence and the expansion of data centers are generating unprecedented demand for reliable, around-the-clock, low-carbon electricity. Simultaneously, many industrial sectors require cogeneration solutions and high-temperature process heat, areas in which nuclear energy can provide significant competitive advantages.

For Romania, this new energy reality represents not only a challenge but also a strategic opportunity. Few European countries simultaneously possess operational nuclear experience, industrial capabilities, specialized human resources, and ongoing development programs. While many nations are attempting to rebuild nuclear competencies lost over recent decades, Romania benefits from a functioning nuclear ecosystem built around the CANDU units at Cernavodă, a well-established nuclear industry, and the research capabilities developed by the Romanian nuclear research community.

The completion of Units 3 and 4 at Cernavodă has the potential to significantly strengthen both national and regional energy security. At the same time, the SMR initiative at Doicești positions Romania among the first European countries seeking to capitalize on the opportunities offered by the next generation of modular nuclear technologies. These investments should not be viewed as competing alternatives, but rather as complementary components of a robust energy strategy capable of addressing both present and future challenges.

Beyond deployment projects, Romania also has the opportunity to contribute to the development of advanced nuclear technologies. The ALFRED (Advanced Lead Fast Reactor European Demonstrator) project represents one of Europe's most ambitious initiatives in the field of lead-cooled fast reactors and has the potential to transform Romania from a technology user into a significant contributor to the development of Generation IV nuclear systems. In a world where competitive advantage is increasingly linked to innovation capacity, participation in advanced reactor development may generate benefits that extend far beyond the energy sector itself.

From this perspective, Romania's challenge is not limited to building new generation capacity. It also involves developing a long-term vision for the role of nuclear energy within the broader economy and society. Educating the next generation of specialists, supporting research and innovation, strengthening industrial supply chains, and integrating nuclear energy into industrial decarbonization strategies will become just as important as investments in physical infrastructure.

Paradoxically, today's challenges increasingly resemble those that stimulated the expansion of nuclear energy half a century ago, although their scale is considerably greater. The discussion is no longer limited to securing energy supplies; it concerns the transformation of the entire global energy system. *In this process, nuclear energy should not be viewed as an alternative to renewable energy sources, but as an indispensable partner in achieving energy security, economic competitiveness, and climate neutrality simultaneously.*

If the first oil crisis gave rise to the modern nuclear era, the current convergence of geopolitical risks, climate pressures, and rapidly growing electricity demand may mark the beginning of a new phase of nuclear development. For Romania, this period offers a rare opportunity not merely to observe global transformations, but to actively contribute to shaping the future of the European energy landscape.

In this context, our journal is oriented to publish meaningful results oriented to reflect the efforts of the research and development, education and training, academia and industry, and also the efforts to build sustainable decisions by involving the diversity of the stakeholders.

Dear readers and dear potential contributors, you are welcomed in our journal to participate to a balanced debate on the nuclear issues and moreover to contribute with innovative and valuable solutions to the nuclear development in the context of the modern society sustainable development.