Making Nuclear Power **Sustainable**

The world's development depends on energy, and there is no single answer

by Bertrand Barré

Even though it is almost 35 years old, there is a picture which still cannot be seen without emotion: the first photograph of the Earth shown as a modest white and blue dot in the black sky, beyond the barren desolation of the Moon in the foreground. This tiny planet, surrounded by the fragile bubble of its atmosphere, is our only home, and it will be eons, if ever, before humans can find another place to live. And our home is endangered. Let's state the facts:

❶ Today over 6 billion human beings inhabit the earth, many of whom do not have enough available energy to enjoy a decent life. Tomorrow, there shall be 9 billion of us.

❷ Within a mere century, we have pumped so much carbon dioxide and other greenhouse gases (GHGs) into the atmosphere that their concentration exceeds by far any level ever experienced by humans since their mastery of fire, half a million years ago.

❸ All the available models predict that if we do not curb drastically our GHG emissions, we are bound for a catastrophe with dire consequences, a catastrophe which may be irreversible by human standards.

In summary, we must double our energy production while dividing by a factor of two our GHG emissions, knowing that today, 80% of our energy comes from the combustion of coal, gas and oil, all of which produce CO_2 released in the atmosphere. This is the toughest challenge facing us in the next few decades, and I include the water challenge, since producing drinking water will also increase our energy needs.

The future role of nuclear energy

This formidable challenge will not be easily met. No magic bullet is in sight, not even a nuclear bullet. To have any chance of success, we must actually implement all the available measures, and invent some more. In fact, we shall certainly need a three-pronged approach:

❶ Increase energy efficiency to limit energy consumption in our developed countries;

❷ Diversify our energy mix to reduce the share supplied by fossil fuels—and that translates into increasing nuclear and renewable energy sources;

❸ Trap and sequester CO_2 wherever and whenever economically possible.

Without commenting further on the other measures, I will focus now on the nuclear issue. According to International Energy Agency (IEA) statistics, nuclear energy accounts today for 6.8% of the world energy supply[1]. Is it realistic to expect this share to grow, when many forecasts (including IEA's own) predict a slow reduction? The future is not engraved in marble, it is ours to make; the future role of nuclear power will depend on the results of our present efforts to expand or overcome its limitations.

Let's have a dream: It is quite possible that, within four decades, 40% of the electric power generated in all OECD (Organisation for Economic Cooperation and Development) countries, plus Russia, China, India and Brazil, comes from nuclear reactors. It is not far-fetched, when you consider that it took only two decades for France to increase its nuclear share of electricity from 8% to 80%. More ambitious, let's assume that in the same timeframe and within the same countries 15% of the fuels for transportation come from nuclear-produced hydrogen and that 10% of the space heating is supplied by nuclear heat. With more than 20% of the total energy generated by nuclear energy, even its most adamant adversaries could not pretend its role is marginal for sustainable development. The niche is there: will we be able to fill it?

The limits to nuclear growth

Economics need not be a problem: Internalising the costs of fossil fuels to even a small fraction of the environmental detriment of CO_2 will easily reinforce the competitiveness of nuclear power. One should nevertheless seek to reduce nuclear plant construction times and the level of initial investment.

Mineral resources, abundant under present growth assumptions, would limit a high nuclear growth scenario, unless we "rediscover" breeding fuel from uranium or thorium or both. It is not a mystery why four or five out of the six candidate concepts selected by the Generation IV International Forum are based on such recycling of fuel.

Today probably the strongest limitation to a high growth scenario is public acceptance. The memory of Chernobyl is still vivid, and the delays in the decisions concerning the disposal of high-level radioactive wastes spread the idea that it is an intractable problem. It should however be pointed out that, since the Chernobyl accident, 8,000 reactor years have been accumulated without any reactor accident, and that much progress has been achieved in the waste disposal area—the operation of the Waste Isolation Power Plant (WIPP) in Carlsbad, USA and the overwhelming vote by the Finnish Parliament to build a repository, to name a few. Mitigation of the consequences of severe accidents is already a prominent feature of some "next generation" reactors.

Working together to overcome limitations

To make nuclear power sustainable, we have to overcome limits to its growth. In the past few years, several international initiatives were taken to that end. Let me evoke them in alphabetic order:

➤ GIF: the Generation IV International Forum

At the initiative of the US Department of Energy (USDOE), since 1999, ten countries have worked together to select a few model concepts for future nuclear systems, and to define and perform the research and development (R&D) necessary to make them ready for possible commercialization after 2030. Criteria for selection included sustainability (fissile resources utilization, waste minimization, proliferation resistance and physical protection), safety and reliability (radiation-protection, reactivity control, heat removal, mitigation features) and economics.

The six model concepts selected are:

❶ Supercritical Water Cooled Reactor System;
❷ Very High Temperature Reactor System;
❸ Sodium Cooled Fast Reactor System;
❹ Lead Alloy Cooled Fast Reactor System;
❺ Gas Cooled Fast Reactor System;
❻ Molten Salt Reactor System (this concept, the most futuristic, is not supported by some members).

➤ INPRO: International Project on Innovative Nuclear Reactors & Fuel Cycles

In 2000, the IAEA initiated the INPRO Project in which fifteen Member States have worked to define "User Requirements" for innovative nuclear energy systems in the area of economics, sustainability and environment, safety, waste management, proliferation resistance and some cross-cutting issues. They have also developed a methodology of assessment for such systems.

Based on similar analyses and motivations, the work of GIF and INPRO are not identical: GIF partners are mostly suppliers, and their work will steer the R&D, while INPRO expresses mostly the requirements of potential future users. Each group is quite aware of the other's results. Formulating future requirements and developing future concepts would be useless if, in the meantime, the main ingredient of excellence were lacking: trained and competent human resources. Such is the rationale behind the third initiative.

➤ WNU: the World Nuclear University

During the last decade, enrolment in nuclear engineering courses has been declining in many countries (although it appears that the trend is presently reversing in the USA). To counter this trend, several projects are creating regional networks of universities and institutes. In Europe, for instance, 25 academic institutions have founded the European Nuclear Education Network (ENEN), organized within the European Commission's 6th Framework Program, and a new "European Master's Degree" in nuclear engineering has been created recently. South Korea has been very active in proposing an Asian network, and several US universities have assembled such a network together with the main national laboratories of the DOE.

To expand this concept on an international scale, the IAEA, World Nuclear Association (WNA), World Association of Nuclear Operators (WANO) and the Nuclear Energy Agency (NEA) inaugurated last September the World Nuclear University (WNU). The WNU endeavors to promote academic rigor and high professional ethics in all phases of nuclear activity. Its agenda involves coordinating curricula, harmonizing degrees, promoting exchanges of students and teachers and facilitating distance learning. (See box on the WNU, page 56)

Energy fuels development

Fifty years after the famous words of President Eisenhower to the UN General Assembly, the nuclear community is now working together to make nuclear power sustainable for the benefit of mankind. Let's hope that this cooperation will be fruitful because we know that without enough energy, there is no development. We know that nuclear power cannot be *the* answer, but we also know that there is probably no answer without nuclear power.

Bertrand Barré is President-elect, European Nuclear Society. E-mail: Bertrand.Barre@areva.com

[1] *Having reached such a figure in 50 years is no trivial achievement: to generate the same amount of electricity that nuclear reactors do today, one would have to burn in modern oil-fired plants more than the total oil production of Saudi Arabia. But expectations were much higher a few decades ago.*

WORLD NUCLEAR UNIVERSITY

ATOMS FOR SUSTAINABLE DEVELOPMENT

Half a century after "Atoms for Peace," a new initiative was launched in 2003: "Atoms for Sustainable Development." The World Nuclear University (WNU) was thus created to promote the spread of expertise in nuclear technology around the world. As Hans Blix, the Chancellor of the University says, "This theme—our need for energy to save the planet—was the idea that sparked the new university's genesis..."

At the WNU's inauguration in London in September 2003, representatives of the global atomic energy industry expressed their concerns and hopes for the next fifty years. Following are a selection of excerpts from those presentations:

John Ritch

Director General, World Nuclear Association

"Perhaps the greatest irony of nuclear power is that its environmental virtue contributes directly to its political weakness. The huge multiplier that works to convert so little uranium into so much energy with so little waste works in reverse when it comes to political power. The nuclear fuel cycle produces a full one-sixth of world electricity, but gives rise to neither jobs nor wealth on a massive scale.

If nuclear energy had political influence commensurate with its genuine value in terms of health, environment or security, the argument over energy would have been over long ago.

That our industry is less about a commodity—and more about a highly sophisticated technology—is what brings us here today."

Hans Blix

Chancellor, World Nuclear University

"Our somewhat grandiose-sounding name, World Nuclear University, needs to be understood as an ambition to include people and certainly not as a bid to exclude others. The idea is not to supplant already-developed patterns of exchanges or erect some kind of supervisory body interfering with the activities of free, mature institutions. Our ambition, which is only as great as the participants make it, is to provide a clearinghouse, an instrument to expand and enrich cooperation among existing institutions."

Mohamed ElBaradei

Director General, International Atomic Energy Agency

"The IAEA, with its constituency of 135 Member States, is hopeful that this will truly become a World Nuclear University. Almost 2 billion people, nearly one-third of the population of the planet, remain without access to modern energy supplies—a shortfall that could be addressed, at least in part, by nuclear energy. But any major expansion in the future use of nuclear power will only be feasible if the nuclear industry is successful in developing innovative reactor and fuel cycle technology—as well as operational and regulatory approaches—that effectively address concerns related to cost competitiveness, safety and security, proliferation resistance and waste disposal."

James Lovelock

Author of the Gaia Theory and Pre-eminent Environmental Leader

"...we have few alternatives but greatly to reduce the proportion of energy we take from the unsafe practice of burning carbon fuel. It would be wonderful if we could maintain civilization by renewable energy sources alone, but it is foolish fantasy to think that we could do it soon enough to avoid risking a greenhouse catastrophe. The only sensible and practical option is to use nuclear energy to supplement the meager supplies of energy from foreseeable renewable sources. Nuclear electricity is now a well-tried and soundly engineered practice and is both safe and economic; given the will, we could apply it quickly. Yet disinformation about its dangers persists and sustains a climate of ignorance, which artificially inflates the cost of nuclear energy and of waste disposal."

For the full text and more remarks, please visit www.world-nuclear-university.org