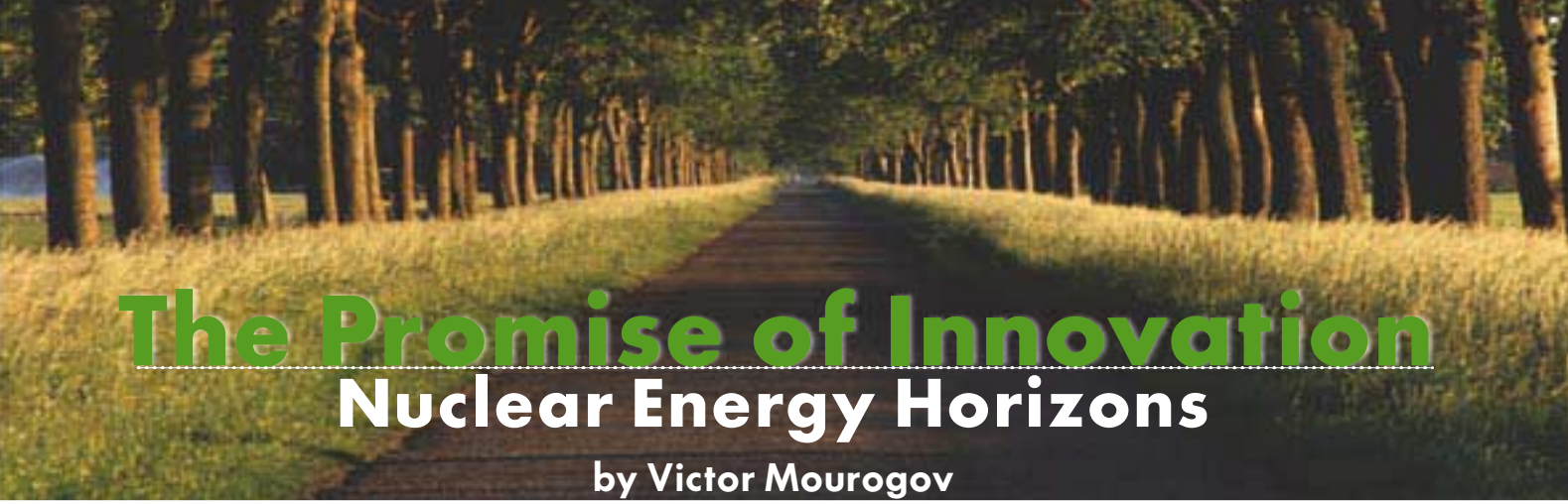

The Promise of Innovation

Nuclear Energy Horizons

by Victor Mourogov

50 years into the "atoms for peace" age, where is nuclear energy headed? Is a "greener" future down the road? Now it's time to look from "Atoms for Peace" to "Atoms for Peace and Prosperity."

While no one knows for sure, some facts cannot be disputed. One is the reality of growing world energy needs. All independent global energy forecasts predict large increases in energy demands in the decades ahead. The principal drivers are population growth and economic development, especially in developing countries where billions of people still are without electricity.

Another fact is that nuclear energy stands among tomorrow's main base load electricity options, on environmental as well as economic grounds. Today, nuclear energy produces 16% of the world's electricity. While that's a far cry from the rosier projections of the 1960s, the share is substantial and nuclear is positioned to play a bigger role in the future. Research into advanced and "innovative" types of nuclear plants is preparing for their role as multi-purpose nuclear power producing electricity, hydrogen fuel, and drinking water from oceans, for example. (See box, page 61.)

A third sign is linked to the need for cleaner, greener energy to support the goals of "sustainable development." The complete nuclear power chain, from resource extraction to waste disposal, emits only two to six grams of carbon per kilowatt-hour. That is about two orders of magnitude below coal, oil, and even natural gas and about the same as wind and solar power.

The accepted concept of sustainable development is all about expanding assets and keeping options open. Yet without innovation and political support no option is likely to survive in the evolving economic, environmental and technological climate.

The Need for Innovation

The 21st century promises the most open, competitive, and globalized markets in human history, as well as the most rapid pace of technological change ever. For nuclear energy, as any other, that presents challenges. Though the atom now supplies a good share of world electricity, its share of total energy is relatively small, anywhere from four to six per cent depending on how it is calculated. And, while energy is most needed in the developing world, four of every five nuclear plants are in industrialized countries.

Critical problems that need to be overcome are well-known—high capital costs for new plants, and concerns over proliferation risks and safety, (including safety of waste disposal) stand high among them.

The IAEA and other programmes are confronting these problems through ambitious initiatives involving both industrialized and developing countries. They include the collaborative efforts known as the Generation-IV International Forum (GIF) and the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). They use ideas, results and the best experiences from today's research and development tools and advanced types of nuclear energy systems to meet tomorrow's challenges.

Though the market often decides the fate of new initiatives, the market is not always right for the common good. Governments, and the people that influence them, play an indispensable role in shaping progress in energy fields for rich and poor countries alike. They shoulder the main responsibilities for fundamental science, basic research, and long-term investments. For energy in particular, government investment and support will prove instrumental in the pace of innovation toward long-term options that are ready to replace limited fossil fuel supplies, and respond to the growing premium put on clean energy alternatives.

Yet governments cannot go it alone. The challenges are too diverse and complex, and public concerns—about proliferation or safety—go beyond national borders. These concerns underline the importance of broad international cooperation and the consolidation of efforts from many countries.

Designs on the Future

The IAEA project known as INPRO is a response by countries interested in solving the challenges facing nuclear energy. All IAEA Member States are eligible, and its mem-

bership is diverse—including developed and developing countries, current nuclear power countries and countries interested in the option.

The project encourages joint projects focused on designing and developing advanced nuclear power production systems for the middle of this century. They must meet "user requirements" in key areas—such as economics, environmental protection (including waste management), safety, proliferation resistance and cross-cutting issues related to technical, legal, and institutional demands.

Case studies are being done to test the reactor requirements and improve them. The research involves different types of reactors and systems in Argentina, Brazil, India, the Republic of Korea, and the Russian Federation. Additional studies, and the feedback and experience from them, are being pursued. More than 20 innovative nuclear reactor designs are currently under development worldwide.

New Directions for Nuclear Technologies

One of the first major outcomes of INPRO development is the recognition and conclusion that one core area is the nuclear fuel cycle—the chain of activities from uranium mining all the way through fuel production, electricity production, and the handling of waste. The fuel cycle poses challenges for nuclear power expansion on two counts. One relates to developing countries, where electricity needs are the greatest yet the energy infrastructures are weak. The second relates to public concerns about nuclear proliferation.

Regarding these challenges, it helps to view the reactor as just one component in the context of the larger fuel cycle. The cycle will determine the extent of fuel resources and how efficiently they are used. It will determine the extent of waste and how efficiently it is disposed of and managed. It will determine the environmental impact by which different energy systems are increasingly judged. And it will determine the ease or difficulty of reducing proliferation risks to provide the assurances that governments and the public demand.

In the long run there may well be no single nuclear fuel cycle strategy that is best for all countries. The challenges are substantial, and the chosen strategy makes a difference.

Here, too, global cooperation can pay dividends. The IAEA is currently looking at reopening dialogue on the feasibility of multilateral cooperation in key areas of the nuclear fuel cycle, particularly in view of the increasing non-proliferation, safety, security and technical challenges facing nuclear power. This could include considering the merits of restricting or adopting a multilateral approach to the use of weapons-usable material in civilian nuclear programmes. It could also include limiting the processing of such material—and the production of new material through reprocessing and enrichment—with international centres, under appropriate rules of transparency, control and assurance of supply, playing a role. Consideration should also be given to the merits of multinational approaches to the management and disposal of spent nuclear fuel and other radioactive waste.

Going further in this direction would indeed recapture some of US President Dwight Eisenhower's vision in his 1953 Atoms for Peace Speech to the United Nations General Assembly. In that historic address, he made the specific proposal that: "The governments principally involved, to the extent permitted by elementary prudence, should begin now and continue to make joint contributions from their stockpiles of normal uranium and fissionable materials to an international atomic energy agency. …The atomic energy agency could be made responsible for impounding, storage and protection of the contributed fissionable and other materials."

Working Together for Progress

The IAEA's activities on the future of nuclear power involve many players from countries around the world. Work is directed at continually expanding cooperation on initiatives that promise to make a difference in addressing the world's electricity needs.

In the days and years ahead, important strides will be made through multinational activities and initiatives tackling all issues critical to nuclear power's future contribution. How far we have come, and where we are headed, will be reviewed by global experts in mid-2004 at the IAEA-sponsored International Conference on Fifty Years of Nuclear Power, hosted in Obninsk by the Russian Federation.

Not everyone will always agree on the exact steps forward. But I believe all countries share the view that the world's development goals depend on energy, and that reaching them demands broad and fruitful cooperation for many years to come.

The work ahead goes beyond technological innovation. As IAEA Director General Mohamed ElBaradei has noted, collaboration must touch upon policy, public acceptance, and economic issues, and all stakeholders will have to be engaged in fairly evaluating different energy options. "If nuclear power is to play a major role in meeting the world's demands for more energy," he has emphasized, "it will require innovative approaches—both technological and otherwise—to match the needs of people in industrialized and developing countries alike."

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On the Energy Rich Road to "Hydricity"

Experts Eye Nuclear Power for Producing Hydrogen Fuel

It's no quick route, though fast becoming a yellow brick road to an energy wonderland. From Iceland to Japan, hydrogen for power—through fuel cells for automobiles, pipelines for industries, and generating stations for electricity—is enticing visions of new "clean and green" technologies down the line.

At the IAEA's Scientific Forum 16 September, 2003, energy experts took stock of the rising hydrogen economy, including the fuel's future production by advanced "next generation" nuclear power plants. One big issue is how best to produce enough hydrogen affordably, and fossil fuels, renewables, and nuclear power are all in the running as options.

The reason is that making hydrogen takes energy, lots of it. Though the most plentiful gas on earth, hydrogen rarely exists by itself. Instead it binds with other elements, like it does with oxygen to form water molecules. Hydrogen's attraction is clear—it has the highest energy content of any known fuel and when it's burned, the "waste" is water, with no carbon dioxide or carbon monoxide as unwanted byproducts.

Growing Market in Industries

Today most commercial hydrogen is produced from water using a process called electrolysis. Research is heavily focused on other methods, including advanced systems producing very hot heat and steam.

Virtually all hydrogen marketed now—about 50 million tonnes a year worldwide—is made from natural gas, not without drawbacks. One problem is the emission of carbon dioxide linked to global warming. Nuclear power, essentially carbon-free, is seen as a prime alternative producer, if the costs are right.

"Some are calling it 'hydricity'," says Prof. K.L. Peddicord, Vice Chancellor for Research and Federal Relations at Texas A&M University in the USA, in describing nuclear production of both electricity and hydrogen. "Multiple approaches are being looked at today. Over the coming years, the need to develop energy strategies to substitute for oil and gas will become increasingly acute."

Though electricity from nuclear power already can be used for hydrogen production, the focus is on developing new plant designs to produce the huge amounts of hydrogen that will be needed. In the USA, a leading driver is the initiative called Generation IV for research and development of advanced nuclear plants called high-temperature gas reactors.

"Hydrogen is a commodity and the market is expanding rapidly," says Prof. Peddicord, who surveyed developments at the Scientific Forum's session on innovative nuclear energy systems. Main customers include oil refineries, where hydrogen is needed for processing heavy crude oils to make

gasoline and other oil products. Hydrogen pipeline networks increasingly link refineries near Houston, Texas, and other parts of the country, he notes, a sign of the oil industry's rising demand for hydrogen.

High Stakes, Rich Rewards

The stakes are high, from energy, economic, and environmental standpoints, and potential rewards rich. Countries are working together, given the investment costs. In early 2003, for example, the USA and European Union forged an agreement on hydrogen fuel cell development. US Secretary of Energy Spencer Abraham is bullish on the future, placing all options for hydrogen production from renewable, fossil, and nuclear energy on the table.

"We are optimistic about the prospects for hydrogen," he says, "not just as the transportation fuel of the future, but also for its potential to generate electricity to heat and power our homes and businesses. We are so confident and committed that over the next five years the Department of Energy will invest $1.7 billion in research and development of hydrogen vehicles and hydrogen infrastructure technologies." A string of new research grants has been made to Texas A&M and other US universities.

Other countries are investing in hydrogen as well. They include Iceland's ambitious programme, and programmes in Japan, the United Kingdom, the Republic of Korea, and France, which hosted the first European Hydrogen Association conference.

—this report, by Lothar Wedekind, IAEA Division of Public Information, first appeared on the IAEA's web site at www.iaea.org.