CARNEGIE
INSTITUTION FOR
SCIENCE

OFFICE OF THE PRESIDENT

Richard A. Meserve
rmeserve@ciw.edu

SCIENTIFIC DEPARTMENTS

Embryology
BALTIMORE, MARYLAND

Geophysical Laboratory
WASHINGTON, DC

Global Ecology
STANFORD, CALIFORNIA

The Observatories
PASADENA CALIFORNIA AND
LAS CAMPANAS, CHILE

Plant Biology
STANFORD, CALIFORNIA

Terrestrial Magnetism
WASHINGTON, DC

Carnegie Academy for
Science Education
WASHINGTON, DC

Carnegie Institution
of Washington

1530 P Street NW
Washington, DC 20005

202 387 6400 Phone
202 387 8092 Fax

August 25, 2008

Dr. Mohamed ElBaradei
Director General
International Atomic Energy Agency
Wagramer Strasse 5
A-1400 Vienna
AUSTRIA

Dear Dr. ElBaradei:

I am writing in my capacity as Chairman of the International Nuclear Safety Group (INSAG). Our terms of reference provide that INSAG should provide "recommendations and opinions on current and emerging nuclear safety issues" to the IAEA and others. This annual letter is one of the means by which I, on behalf of INSAG, seek to discharge this responsibility.

In Part I of this letter, I shall describe the current context in which nuclear safety should be considered. Then, in Part II, I shall turn to some current issues that warrant early and special concern.

I.

There are a cluster of trends that reinforce the importance of nuclear power on the world scene. Energy is the essential underpinning for economic and societal progress and, as the developing world advances, the demand for energy is growing significantly. At the same time, the carbon-intensive sources of energy on which the world has traditionally relied – in particular, coal, oil, and natural gas – pose grave threats because the growing concentrations of carbon dioxide in the atmosphere will bring about climate change and ocean acidification. The world needs to rely increasingly on energy sources that are substantially carbon free. Nuclear power is such a source and clearly must be an important part of the world's response to these threats.

At the same time, rising and volatile fossil fuel prices, coupled with concerns about the security of supplies of oil and gas, enhance interest in sources of energy that do not pose the same costs and risks. Again, nuclear technology is attractive as an alternative energy source.

In this connection, there is increased interest in the possible use of nuclear power for purposes other than electricity generation, especially as societies seek to reduce dependence on fossil fuels. Nuclear power plants might be deployed to generate process heat that could serve a variety of purposes, including desalination, district heating, chemical processing, the development or exploitation of energy sources (oil sands/shale), or even hydrogen production (if higher output temperatures can be achieved). Thus, in addition to electricity production, nuclear technology might be applied to other activities of societal or economic importance.

As a consequence, the world is seeing a strong resurgence of interest in nuclear power. There are some 440 reactors in 30 countries today, providing about 16% of the world's electricity. Significant expansion programs are underway or are being launched in China, India, Russia, the US, Japan, South Korea, the United Kingdom and other countries. Some 34 reactors are under construction and the IAEA has estimated that there might be as many as 60 new plants in the next 15 years. As discussed in Part II, some 30 countries that do not now have a nuclear power plant are considering whether to acquire one. These facts show that we should expect a future in which there are far more nuclear power plants and many more countries that rely on nuclear power.

This situation reinforces the importance of attention to nuclear safety. The safety performance of nuclear power plants has improved significantly in recent decades, at least as revealed by objective indicators – *e.g.*, capacity factors, unplanned shutdowns, radiation exposure of workers, radiation releases to the environment -- albeit with some leveling off in performance in recent years. But, as worldwide dependence on nuclear power grows, it becomes all the more important to ensure that adequate safety performance is maintained by all. Guarding against the rare but possibly catastrophic accident requires eternal vigilance and a never-ending fight against complacency. Every user of nuclear power is hostage to some extent to the safety performance of others because of the adverse consequences (if only through heightened public concern) that would arise if there were a significant nuclear accident. In this context, improved average performance is insufficient: every country that employs nuclear power has to pursue continuous improvement in all areas related to nuclear safety and, in doing so, strive for sustained operational excellence in every plant.

Of course, the primary responsibility for safety lies with the nuclear operators, subject of oversight by vigilant national regulators. But it is appropriate to ask whether the global nuclear safety regime is able to provide an adequate backstop to reinforce the capabilities of operators and regulators. We believe that significant improvements should be pursued.

Nuclear safety is one of the pillars of the IAEA and the IAEA should be appropriately proud of its many contributions to safety. But its capability needs

to be enhanced. As indicated by the *Report of the Commission of Eminent Persons on the Future of the Agency* (2008), there are many opportunities for the IAEA to upgrade its efforts. The system for exchanging knowledge needs bolstering, particularly in light of the growing demand for services that are tailored to the capabilities and needs of the new entrants. In a globally interconnected and interdependent world, increased efforts need to be made to develop common codes and standards, to share knowledge from safety assessments and experience, and to converge on common regulatory practices. In this connection, assignment of individuals from one country to operating or regulatory organizations in other countries is an effective way to transfer knowledge about safety culture, regulatory practices, and safety technologies. At the same time, there is a need to ensure effective peer review of each country's safety efforts and to nurture enhanced sophistication on nuclear safety matters. It is in the interest of all to ensure that every country with a nuclear power program has the resources, expertise, authority, and capacity to assure safety in a complete and effective manner and is committed to doing so.

Given the growth in nuclear power and the expanding need for improved safety services, the IAEA should devote increased attention to its special role in advancing nuclear safety around the globe. But the budget allocation to safety and security amounts to only 8% of the agency's regular budget and has stayed essentially flat in recent years. Indeed, given the need for enhanced efforts related to security, the allocation of funds for the IAEA's safety mission has no doubt declined in recent years. Because of the need for a sustained, long-term program for nuclear safety, the support for the IAEA's safety activities should be part of the regular budget and not dependent on voluntary contributions. We urge that the Member States support your efforts to enhance the resource commitment to this vital function in this time of growing need.

II.

Although the data suggest that high levels of safety are being achieved in civilian nuclear activities around the globe, there are important issues that deserve increased attention. We here identify a few items to expand or supplement the matters discussed in my previous letters.

1. *New Entrants*. As noted above, the construction of nuclear power plants is under consideration in over thirty countries that do not currently use nuclear power. Although these new entrants may have experience in constructing and operating large-scale industrial and infrastructure projects, they may not be fully familiar with the unique requirements of nuclear power and thus may not fully recognize the major commitments and undertakings that they must assume. In addition, an understanding of the full range of obligations may have diminished in those countries with only one or a few reactors and where nuclear construction has not been undertaken for a long time.

The decision of a country to use nuclear power entails a long-term commitment to the peaceful, safe and secure use of nuclear technology based on a sustainable organizational, regulatory, social, cultural, technological, economic, and education infrastructure. Indeed, the obligation to ensure sustained nuclear safety is a national responsibility that cannot be shirked or minimized. Experience has demonstrated that reliance on robust design and engineered safety systems alone is insufficient. A nuclear power plant is operated by people, and thus the achievement of safety requires qualified operating personnel with an appropriately embedded safety culture. Moreover, safe operation can only be ensured if there is a comprehensive infrastructure in place that is properly maintained and improved throughout the life of the nuclear power program. Thus, although foreign vendors may be responsible for the design, construction, and commissioning of a reactor, each new entrant has sweeping and difficult obligations to fulfill in assuring the capacity for continuing attention to safety over the entire life of the facility -- from before construction until decommissioning is completed.

INSAG has recently prepared a report on this subject entitled *Nuclear Safety Infrastructure for a National Nuclear Power Programme Supported by the IAEA Fundamental Safety Principles* (INSAG-22). This document seeks to relate the various elements of a new entrant's obligations at each stage of the life cycle of a nuclear power plant to the IAEA's Fundamental Safety Principles and the related safety standards. INSAG-22 serves to supplement and enhance other important IAEA documents that bear on this subject, including M*ilestones in the Development of a National Infrastructure for Nuclear Power* (2007) and *Considerations to Launch a Nuclear Power Programme* (2007).

The fulfillment of the safety obligations will be very challenging for many of the new entrants. This imposes special obligations on the vendor and regulators with experience with the vendor's design to assist a new entrant in understanding and fulfilling its safety obligations. (I am encouraged in this connection by the IAEA's recent conference addressing the responsibilities of vendors and vendor countries.) The IAEA should also help by providing review services that are configured to assist new entrants in putting in place the capabilities that will enable them to succeed in the deployment and use of nuclear power. It is in the interest of all countries to assist the new entrants in this effort. Additional resources are required and should be a high priority. Support for the enhancement of regulatory capacity will be particularly important in this connection, as operators generally receive significant assistance from vendors, while the regulators do not.

2. *Operational Experience Feedback.* Those who do not learn from the past are condemned to repeat it. The operating experience from existing plants can provide important lessons from which all should benefit; it is widely observed that serious accidents are nearly always preceded by less serious

precursor events. If the lessons can be learned from the precursors, the probability of a serious accident could be significantly reduced.

The means to provide this knowledge are national and international systems for operational experience feedback. Although some strong national systems are in place, there is a need for strengthening the international system. Indeed, the international system is an essential resource for those countries with only one or a few nuclear facilities. Although the need to enhance the system for operational experience feedback has been discussed in recent years, there is little apparent progress in reducing risks and enhancing safety on the basis of lessons from other countries' experience. This matter deserves increased attention.

INSAG has recently published a report that outlines the changes that we believe are required. *See Improving the International System for Operating Experience Feedback (OEF)* (INSAG-23). As discussed in this report, reporting by national authorities is uneven and sometimes tardy or lacking clarity. There should be increased emphasis on identifying and distributing the important lessons to be learned and the actions to respond to those lessons, rather than simply describing the event. In fact, a truly effective program should capture information about all significant corrective actions, regardless of whether they resulted from an event, as well as important research results that identify or resolve an important safety concern. The recipients of the reports should ensure that the information is widely shared through their organizations so that all can benefit from it. Moreover, the system should include a feedback loop so that others can learn about the changes introduced by both operators and regulators to respond to the lessons.

The operational feedback system provided by the World Association of Nuclear Operators (WANO) is very useful, but the content of this system is confidential and is available only to operators. There thus needs to be an effective system to provide operational experience feedback to regulators and others through the enhancement of the Incident Reporting System (IRS) now maintained by the IAEA and the Nuclear Energy Agency (NEA). This requires investments by regulators, as well as by the international community. We believe that a comparatively slight investment in enhanced capacities could have a meaningful payoff in accident avoidance. We should exploit the knowledge that can be gained from careful and thorough efforts to learn from existing operations.

3. *Extreme External Events*. In July 2007, Japan suffered an earthquake in the vicinity of its Kashiwazaki-Kariwa nuclear power plants. The earthquake far exceeded the design basis for the reactors, reflecting the reality that our scientific understanding of the mechanisms that determine the frequency/magnitude of earthquakes in seismically active regions is very incomplete. The reactors were safely shut down and the safety-related

equipment survived the event well, thereby demonstrating that the designs had ample safety margins. However, there was moderate damage to non-safety-related equipment. As a result of the earthquake, the reactors have been subject to an extended shut down and await authorization to recommence operations. This event should lead to efforts around the world to ensure that seismic standards are adequate and that appropriate preparations are made for tsunamis. Moreover, the experience reinforces the importance of understanding the interaction of failures of non-safety-related equipment to the performance of safety-related equipment so as to assure that safety capability is maintained.

One of the predicted consequences of climate change is the increased likelihood of other types of extreme events. Large storms are predicted to become more frequent and more severe. Similarly, sea level is predicted to rise, increasing the likelihood of flooding of plants that are along coastlines. In short, climate change will result in more aggressive challenges to some nuclear plants in future years, as well as increased threats to infrastructure of all kinds. It is not too early to make sure that the implications of these changes, which were not contemplated when existing plants were originally licensed, are fully evaluated. It is essential to ensure that plants continue to have adequate safety margins or to take steps to implement measures to maintain adequate safety margins. The periodic review of existing plants that is contemplated in most regulatory systems provides a means to undertake this evaluation.

4. *New Construction.* As noted above, construction of nuclear power plants is contemplated by some 30 countries that do not currently have a nuclear power plant and extensive new construction is expected in many countries with existing reactors. For example, the US Nuclear Regulatory Commission has indicated that it expects to receive applications for licenses for some 34 new reactors by the end of 2010. It is apparent that the world-wide capacity to undertake simultaneous nuclear projects around the globe will be under considerable strain.

With the advent of the surge in new construction, we should anticipate and prepare for the fact that there will be a shortfall in trained personnel to guide the new construction. The unavailability of personnel will pose a problem for generating companies, architect-engineering firms, vendors, suppliers of all types, and regulators. While this is a problem that market forces will correct over time, there is an immediate need. The bottom line is that it is important to start now to assure that education and training capabilities relating to nuclear technologies (in particular, nuclear and civil engineers, as well as skilled craft workers) are expanded and enhanced to meet the needs and demands of both industry and regulatory organizations.

One related concern in this connection is that operators, regulators, and technical support organizations could lose focus on existing plants in light of the demands associated with new construction. One of the most important lessons

from several decades of nuclear experience is the reality that continued vigilance is required in order to sustain safe operations. The organizations responsible for the oversight, operation, or maintenance of existing plants cannot allow their attention on existing plants to waver. Because of the shortfalls in trained people in the nuclear industry, this will be a particular challenge.

Moreover, the nuclear industry is now a world-wide enterprise and, like other parts of a world economy in which production capabilities are globally interconnected, parts and components for nuclear plants may come from many parts of the world. The quality-assurance standards for nuclear plants are high, but no one regulator, vendor, or operator can readily have scrutiny over the quality of all these parts and components. As a result, there is a need for careful coordination among regulators around the globe to develop global standards and to ensure that those standards are being met. The Multinational Design Evaluation Program (MDEP), an activity for which the NEA is serving as the secretariat, is pursuing this activity, but a global reach may eventually be necessary.

There also may be a need to insure that there is effective communication about "lessons learned" during construction. For example, at least three plants under construction (Lungmen, Olkiluoto-3, and Flamanville-3) have had problems/deficiencies arise in safety-related structures (*e.g.*, concrete quality, rebar) that have required significant rework. The anticipated surge in new construction demands an effective and efficient means for disseminating information that arises during these activities so as to ensure, to the extent possible, that the same mistakes are not repeated. This is an area in which the IAEA should expand its services.

5. *Safety-security synergy*. The security of nuclear power plants has appropriately received greatly increased attention in the aftermath of the terrorist attacks in New York, London and Madrid. It is important to recognize, however, that there can often be conflicts between plant features and operational practices that result from safety considerations with those that serve security purposes. The two objectives can reinforce each other in some circumstances: the massive structures of reinforced concrete and steel serve both safety and security objectives. Indeed, common principles apply to both, such as a philosophy of multiple barriers. But the objectives can, in some cases, have antagonistic effects on each other. Access controls that are imposed for security reasons can inhibit safety through limitations on access for maintenance or surveillance activities or on egress to escape a fire or explosion. If there were an attack, safety considerations may require access to an area at exactly the time that the security forces might seek to deny access. Similarly the shutdown of equipment for safety reasons might, on occasion, inappropriately disable security-related equipment, such as equipment for security-related monitoring.

In short, there can be a synergy or an antagonism between safety and security that requires careful evaluation.

This reality has implications for operators, regulators, and international bodies. Ideally, although the evaluation of security threats might appropriately be the responsibility of an intelligence or police organization, the determination of actions to ensure the achievement of both safety and security should be vested in a single body so that both responsibilities can be weighed at the same time and an appropriate balance can be found. INSAG is evaluating this matter further and plans to provide further guidance on the safety/security interface in the near future.

6. *Digital Instrument and Control*. Most of the existing nuclear power plants were constructed before the advent of digital instrument and control (digital I&C), with the result that these plants rely on analog equipment. It is increasingly difficult to find analog equipment so, as time goes by, analog equipment in existing plants is being replaced with digital equipment. Moreover, all of the plants under construction will rely on digital I&C, reflecting the revolution in such equipment in recent decades.

The application of digital I&C offers great opportunities to improve control systems and to facilitate the design of control rooms that facilitate appropriate operator action. Nonetheless, there are challenges as well. There may be undetected bugs in software and the failure modes and interactions among various pieces of software and hardware may not be well understood. In fact, recent tests and experiences have shown that there is the risk that failures in non-nuclear digital I&C systems might spread in some circumstances to vital protection systems if there is not strict separation of the sensors and signal paths of the different systems.

In short, the use of digital I&C presents a challenge in assuring the availability of redundant and reliable control systems. Extensive work is being done in many countries to develop standards and protocols for assessing the safety and reliability of these systems, but there would be great benefit in mounting an international effort that is directed at this challenge. This matter is being addressed in the Multinational Design Evaluation Program (MDEP), but the need is broader than just the MDEP participants. A comprehensive program is needed to understand the vulnerabilities and risks associated with such systems and to develop harmonized approaches for the application of digital I&C. Extensive R&D in this area is needed. And the IAEA, in harness with the existing MDEP effort, should pursue the development of standards that are guided by the R&D results and the experiences of the Member States.

7. *Plant Aging*. Many of the currently operating plants were built years ago and are nearing the end of their originally anticipated lifetime of 40 years or so. The plants have had the benefit of continuing detailed surveillance,

maintenance, and replacement of components and many of these plants are running reliably and economically. As a result, operators in many countries are seeking to extend operations to 60 years and, indeed, some are raising the prospect of operation for as long as 80 years. But aging plants present unique safety challenges because plant and equipment can deteriorate over time through mechanisms that may not be fully understood (*e.g.*, stress corrosion cracking), spare parts may be difficult to find, and older plants may not have all the safety features of more modern designs. The continuing operation of aging plants thus requires careful attention to aging mechanisms, with heightened attention over time to surveillance, preventive maintenance, and component replacement. Both operators and regulators need to ensure that safety margins are maintained; maintenance, replacement, and surveillance practices appropriate for a new plant may need to be significantly augmented as that plant ages. There is also a pressing need for expanded research to develop an understanding of the aging mechanisms that can affect these older plants and to identify appropriate responses to them.

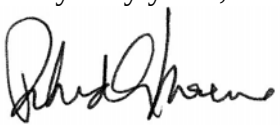
* * *

In sum, the state of nuclear safety is strong. But there are issues, such as those highlighted here, demonstrating that there are significant challenges that we must address if we are to maintain the largely commendable recent safety record of the nuclear enterprise.

I hope that these insights are helpful to you. As always, INSAG would be happy to respond to questions or to assist on particular issues that are of concern to you.

Best regards.

Very truly yours,



Richard A. Meserve

cc: Tomihiro Taniguchi
INSAG members