

# NUCLEAR POWER: PREPARING FOR THE FUTURE

Tokyo  
30 November 2006

Mohamed ElBaradei  
Director General



INTERNATIONAL ATOMIC ENERGY AGENCY

## NUCLEAR POWER: PREPARING FOR THE FUTURE

It is a pleasure for me to be here at this event hosted by the Japan Atomic Energy Agency and the Tokyo Institute of Technology. The partnership between Japan and the International Atomic Energy Agency has a long history of shared objectives, ranging from the safe and secure use of nuclear power and other peaceful nuclear applications to nuclear non-proliferation and disarmament.

The two major concerns facing humanity today are the pressing need for development in many parts of the world; and the importance of ensuring an effective system of international security. What is not always understood is how these two concerns — development and security — are interlinked, and the positive influence that energy could have on addressing these concerns.

Energy is essential for development. Nearly every aspect of development — from reducing poverty and raising living standards to improving health care and agricultural productivity — requires reliable access to modern energy sources. When these development needs remain unaddressed, the resulting misery often leads to conflicts and violence, which in turn affect development efforts and impact on regional and global stability.

In this context, it is important to consider the global energy imbalance. I was personally struck by this imbalance on a visit to Nigeria in 2004, where the per capita electricity consumption was only about 70 kilowatt-hours per year. That translates to an average availability of 8 watts — less than a normal light bulb — for each Nigerian citizen.

To put this in perspective: the developed countries that make up the Organisation for Economic Cooperation and Development (OECD), on average, consume electricity at a rate per capita of 8600 kilowatt-hours per year — roughly 100 times higher. In Japan, electricity consumption per capita is about 8200 kilowatt-hours per year.

Here, in the bright lights of Tokyo, it might be easy to forget that approximately 1.6 billion people around the world lack access to electricity, or that 2.4 billion are still forced to rely on traditional biomass for cooking and heating. But

as we look to the future, ‘connecting the unconnected’ will be a key to progress.

Each year, the International Energy Agency of the OECD publishes an analysis of global energy trends. According to their *World Energy Outlook 2006*, published just last month, if current consumption trends and government policies continue, we will see a 53% increase in global energy consumption by 2030.

Two aspects of this analysis are especially interesting. The first is the expectation that 70% of the coming growth in demand will be from developing countries. The second is that, for the first time, the International Energy Agency said the increased use of nuclear power would help to meet the increase in energy demand, enhance the security of energy supply and mitigate carbon emissions.

Nuclear energy alone is not a panacea, but it is likely in the near future to have an increasing role as part of the global energy mix. Today I would like to consider why we are witnessing a resurgence of interest in nuclear power, and then review some of the challenges and opportunities that lie ahead for Japan and other countries that have chosen the nuclear energy option.

## THE CURRENT GLOBAL STATUS

As of October 2006, there were 442 nuclear power reactors in operation in 30 countries. These reactors total about 370 gigawatts of generating capacity, and they supply about 16% of the world’s electricity. This percentage has been roughly stable since 1986.

To date, the use of nuclear power has been concentrated in industrialized countries. In terms of new construction, however, the pattern is different; 16 of the 29 reactors now being built are in developing countries.

The highest percentage of existing reactors is in North America and Europe, but recent expansion has been most heavily centred in Asia. China, for example, currently has four reactors under construction, and plans a more than five-fold expansion in its nuclear generating capacity over the next 15 years. India has seven reactors under construction, and plans an eight-fold increase in capacity by 2022. Pakistan and the Republic of Korea also have plans to expand their existing nuclear power capacity.

Japan has the largest nuclear power programme in Asia, and the third largest worldwide; only France and the United States have more nuclear generating capacity. With Shika-2 beginning commercial operation this past March, Japan now has 55 reactors in operation, and plans to add 13 more reactors to the grid by 2017, which will increase the nuclear share of Japanese electricity to roughly 40%.

In the near future, we may well see additional countries in the Asia-Pacific region choosing the nuclear power option. Indonesia recently announced that it has decided to build two 1000 megawatt reactors in central Java. Vietnam has also expressed its intention to move forward with a nuclear power programme.

This resurgence of interest in nuclear power is not, however, limited to Asia. Other countries such as Turkey are planning to introduce nuclear power programmes, and many others, such as Argentina, Russia, South Africa, Ukraine and the United States, are planning to expand existing programmes. It is important to understand the reasons that are driving this renewed interest.

The expanded G8 Summit in St. Petersburg this summer emphasized the importance of ‘global energy security’. During my participation at this summit, I emphasized that, in my view, *global* energy security means fulfilling the energy needs of *all* countries and peoples – including the one-quarter of our fellow human beings I just mentioned who have no access to modern energy systems.

## REASONS FOR THE RENEWED INTEREST IN NUCLEAR POWER

### *Energy Diversity and Energy Security*

For many countries, nuclear power is a way to enhance the security and diversity of their energy supplies. This was also true in the 1970s, when concerns about energy security, triggered by disruptions in oil supply, were a major cause of nuclear expansion in countries such as Japan and France.

These energy security concerns are with us again. For some, diversifying a country’s suppliers and sources of energy is an essential buffer against fluctuations in fuel market prices. For others, energy security concerns may be rooted in the potential instability of political relationships with large oil and natural gas producers.

Nuclear energy has an advantage in this respect. Fuel costs make up only

about 10–15% of the costs of nuclear generated electricity, so fluctuations in market prices are of lesser concern. And given the relatively large number of uranium producers, ensuring a reliable supply of nuclear reactor fuel has generally not been a problem.

### *Carbon Emissions and Environmental Concerns*

Another factor driving the interest in nuclear power is that it emits almost no greenhouse gases. The complete nuclear power chain — from mining the uranium and manufacturing the fuel to constructing and operating the reactor and disposing of the waste — emits only 1–6 grams of carbon equivalent per kilowatt-hour. This is about the same negligible emission rate as wind and hydropower and many times less than coal, oil and natural gas.

Increasing international attention is being given to the impacts of carbon emissions from fossil fuels, including pollution and climate change effects, which could lead to higher global temperatures, rising sea levels that would threaten to submerge coastal regions, prolonged droughts, more frequent violent storms, and threats to many species. Nuclear power is seen by many — including the International Energy Agency I just mentioned — as part of the solution.

Last month at the UN Climate Change Conference in Nairobi, ministers from many countries — as well as global business leaders — called for more vigorous action to reduce the threat of climate change. Conference participants agreed to conduct a second review of the Kyoto Protocol in 2008, and agreed on a set of measures including an “Adaptation Fund” to help developing countries adapt to the effects of global warming.

The entry into force of the Kyoto Protocol has strengthened the interest in nuclear power. In the past, the virtual absence of restrictions or taxes on greenhouse gas emissions has meant that the low emission rate of nuclear power has had no tangible economic value. The widespread, coordinated emission restrictions of the Kyoto Protocol will likely change that over the longer term.

### *Strong Performance*

A critical factor driving the renewed interest in nuclear power — and a key to its continued future viability — is its strong performance record. Nuclear power is a mature technology with more than half a century of operating experience. And the past two decades have seen significant improvements in plant reliability, lower generating costs and a progressively improved safety record.

#### KEY ASPECTS: SAFETY, SECURITY AND NON-PROLIFERATION

For nuclear power to continue to be viable as a source of energy, it is vital that nuclear operators continue this strong performance. In this context, let me turn to a number of the concerns about nuclear power, and discuss how they are being addressed.

##### *Nuclear Safety*

First, consider nuclear safety. The Chernobyl accident in 1986 was clearly a setback to nuclear power. Many lives were lost. Thousands suffered major health impacts, and there were significant environmental and social impacts. The accident was the result of less than optimal reactor design, compounded by gross safety mismanagement. But ironically, this event also prompted major improvements in our approach to nuclear safety.

A key change was the development of a so-called international ‘nuclear safety regime’. The IAEA updated its body of safety standards to reflect best industry practices. International conventions were put in place, creating legally binding norms to enhance the safety of nuclear activities. A systematic analysis of risk was used to ensure that safety upgrades would be made in areas that would bring the greatest safety return. And, importantly, both the IAEA and the World Association of Nuclear Operators created international networks to conduct peer reviews, compare safety practices, and exchange operating information to improve safety performance.

The international nuclear safety regime has been demonstrating its effectiveness for two decades. But it would be a misunderstanding to regard nuclear safety as something that can be ‘fixed’. As Chairman Richard Meserve of the International Nuclear Safety Group wrote to me recently, “Every [nuclear] operator must establish and maintain a ‘safety culture’ in which management demonstrates

that safety is the overriding priority and in which every member of staff recognizes his or her individual responsibility for safety.”

A key aspect of an effective safety culture is taking full advantage of operating experience. Experts note that serious nuclear safety events are almost always preceded by less serious ‘precursor’ events. By taking prompt action based on the ‘precursors’, the probability of a serious accident can be reduced. But to do this effectively requires a number of things: (1) careful analysis of the root causes of events; (2) mechanisms that facilitate sharing this information with other nuclear operators worldwide; and (3) a commitment to transparency by all nuclear power countries and operators — including making use of peer review safety missions — as part of an ongoing process of mutual learning.

In that regard, I am pleased to note that Japan has requested an Integrated Regulatory Review Service mission next year. This new service combines a number of elements ranging from nuclear safety and radiation safety to emergency preparedness and nuclear security. It includes a self-assessment aspect, and permits a comprehensive, participatory approach to evaluating a country’s safety performance.

### *Nuclear Security*

Nuclear security has also become a major concern in recent years. The indiscriminate attacks by extremist groups in many regions has led to the re-evaluation of security in every industrial sector, including the nuclear sector. In the past five years, the IAEA in cooperation with many nations, including Japan, has worked on every continent to help countries better control their nuclear material and radiological sources and protect their nuclear facilities. Here, too, the international community is making good progress. While much remains to be done, nuclear installations around the world have added protective barriers and taken other measures to counter security risks and vulnerabilities.

### *Management of Spent Fuel and Disposal of High Level Radioactive Waste*

The management of spent fuel and disposal of high level radioactive waste remain a challenge for the nuclear power industry. The amount of spent nuclear fuel produced annually — about 10 000 tonnes — is actually small when contrasted with the 25 *billion* tonnes of carbon waste from fossil fuels that is released directly into

the atmosphere. Experts agree that the geological disposal of high level radioactive waste is safe and technologically feasible. But public opinion will likely remain skeptical — and nuclear waste disposal will likely remain a topic of controversy — until the first geological repositories are operational and the disposal technologies fully demonstrated.

The greatest progress on deep geological disposal has been made in Finland, Sweden and the United States. But it will still be more than a decade before the first such facility is operational.

In the meantime, the trend has been to construct and use above-ground interim storage facilities, and many countries are exploring the feasibility of interim storage for 100 years or more. An increasing number of countries are also interested in ensuring waste retrievability for future flexibility. Research is also progressing on the use of fast reactors and accelerator driven systems to incinerate and transmute long lived waste, in order to reduce the volume and radiotoxicity of waste to be sent to geologic repositories.

For some time, I have been advocating the consideration of multinational approaches to the management of spent fuel and disposal of high level radioactive waste. More than 50 countries have their spent nuclear fuel stored in temporary sites, awaiting disposal or reprocessing. Many countries do not have the technology or appropriate sites for geological disposal, and the costs for countries with small nuclear programmes would be prohibitive.

### *Nuclear Non-Proliferation*

Perhaps the most serious concern relates to the proliferation of nuclear weapons. At the same time that we are seeing rising expectations for nuclear power, we are also witnessing concerns regarding the spread of sensitive nuclear technology. Particularly sensitive are nuclear operations such as enrichment and spent fuel reprocessing — activities that are part of a peaceful nuclear programme, but also can be used to produce the high enriched uranium and plutonium used in nuclear weapons. Countries that have such operations are only a short step away from a nuclear weapons capability.

The recent nuclear weapon test by the Democratic Republic of Korea (DPRK)



has brought the need to control the spread of enrichment and reprocessing capability sharply into focus. This event also re-emphasizes the urgent need to establish a universal ban on nuclear testing. In resolution 1172 (1998), the Security Council reaffirmed “the crucial importance of the Nuclear Non-Proliferation Treaty and the Comprehensive Nuclear Test Ban Treaty as the cornerstones of the international regime on the non-proliferation of nuclear weapons and as essential foundations for the pursuit of nuclear disarmament”.

The DPRK nuclear test is a clear setback to the nuclear non-proliferation regime — and while the test is a matter of deep concern and regret, it unfortunately came as no surprise. The IAEA first notified the Security Council of the DPRK’s noncompliance with its non-proliferation commitments in 1992, and again in January 2003, after our inspectors were forced to leave the country and the DPRK announced its withdrawal from the NPT. The case of the DPRK underscores the importance in such cases for the international community, including all parties concerned, to engage in an immediate and sustained dialogue to address the situation and its underlying causes.

I am pleased to note the recent agreement to resume the six-party talks. The IAEA stands ready to work with the DPRK — and with all others — towards a solution for this issue that would make use of the Agency’s verification capability to assure the international community that all nuclear activities in the DPRK are exclusively for peaceful purposes. Equally, this solution would seek to address the security, economic and other concerns of the DPRK. Bilateral concerns, such as the tragedy of the Japanese abducted persons that has resulted in so much anguish, will also need to be addressed.

The IAEA plays an important role in curbing nuclear proliferation. Under NPT safeguards agreements, we inspect countries to verify that their peaceful nuclear programmes are not used as a cloak to divert material to non-peaceful uses. However, the extent of the Agency’s authority remains uneven from country to country. Safeguards agreements are now in force in the vast majority of States Party to the NPT. But 30 States still have not fulfilled their legal obligation to conclude a comprehensive safeguards agreement — and over 100 States have yet to bring an

additional protocol into force.

As more countries industrialize, controlling the spread of technology is becoming increasingly difficult. And changing times requires that we adapt our strategies accordingly. For some time, I have been advocating that we consider a multinational approach to enrichment and reprocessing — to ensure that no one country has the capability to independently produce sensitive nuclear material. This would occur in two steps.

The first step would create a mechanism for the ‘assurance of supply’ of nuclear fuel, possibly including a fuel bank to be managed by the IAEA. For countries that use nuclear fuel for electricity generation, this mechanism would serve as a supplier of last resort, thereby removing the risk of having their fuel supply interrupted for non-commercial reasons. It would also reduce the motivation, and the justification, for new countries to invest in these proliferation sensitive operations.

The second step would seek to bring any new operations for uranium enrichment and plutonium separation under multinational control. Over time, these multinational controls would also be extended to facilities that already exist — to ensure that *all* countries are treated equally in terms of their nuclear capabilities, and to de-link these fuel cycle operations from possible use as a strategic deterrent.

Several countries, while supportive of the overall concept, want to be sure that it would not disrupt the functioning of the existing nuclear fuel market. Countries that already have some enrichment capacity, such as Japan, hoped that a new mechanism would not disrupt their ability to build up a national fuel reserve, or their capacity to export fuel. Many others felt that, as long as other countries have national enrichment or reprocessing facilities, their right to have their own similar facilities should not be curtailed.

The IAEA Secretariat is considering those insights and concerns and aims to develop a set of ideas to present to our Member States. I look forward to working with all Member States to move this concept forward. The result will help to ensure the long-term viability of nuclear power for all interested countries, and will bring greater security for all by strengthening the nuclear non-proliferation regime.

## TECHNOLOGICAL INNOVATION

The future of nuclear power will also be greatly impacted by technological innovation — the development of new reactor and fuel cycle technologies. Current nuclear R&D projects are naturally focused on enhancing nuclear safety, reducing proliferation risks and improving economic performance.

Japan is a member of the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles. INPRO works to ensure that the future needs of all countries, in particular developing countries, are understood and taken into account when innovative nuclear systems are evaluated and developed.

Other nuclear innovation projects are also progressing. The Generation IV International Forum, of which Japan is also a member, has selected six innovative nuclear systems for collaborative R&D and is exploring their technical and commercial viability. INPRO and Generation IV exchange information on relevant topics, and the Agency is collaborating with Generation IV on some safety and technical research initiatives. The United States also recently launched its "Global Nuclear Energy Partnership", focused on developing proliferation-resistant recycling technologies and reactor systems.

Many developing countries have been particularly interested in efforts to develop small and medium-size reactor designs. These designs allow a more incremental investment, provide a better match to grid capacity in developing countries, and are more easily adapted to a broad range of industrial settings and applications — such as district heating and seawater desalination. Many countries are currently working on developing new reactor designs in this size range, which may well be in high demand.

### *ITER*

The world's largest fusion facility — ITER — is to be built in Cadarache, France. A formal agreement among the parties, including Japan, was signed at a ministerial meeting earlier this month. Japan will contribute 20 per cent of the ITER research staff, and another research facility for the project will be built in Japan. ITER is to provide a scientific and engineering demonstration of fusion technology in conditions relevant to operating a fusion reactor for power production. The IAEA is the depository of ITER related agreements. Of course it is likely to be many years before fusion technology can be harnessed as a viable source of energy. Nonetheless,

the benefits would be substantial. Fusion uses a relatively abundant fuel source, produces only minimal amounts of long lived radioactive waste, and is based on a nuclear reaction that is inherently safe.

## PUBLIC PERCEPTIONS OF NUCLEAR POWER

I would note one final aspect that will be important in determining the future of nuclear power. That aspect is public perception.

The public's perception of risk has a strong influence on a country's energy choices. As with civil aviation, bioengineering, or any other advanced technology, nuclear power does not come with absolute safety guarantees. What is important is that the risks and benefits are clearly understood.

All members of the nuclear community — scientists, operators and safety regulators — should make every effort to provide accurate and easily understood information to improve public understanding of the risks and benefits of nuclear energy. Common misconceptions can be of great influence in shaping public acceptance of nuclear power. How a given nation balances the risk of a nuclear accident against other factors — such as air pollution, dammed rivers, mining accidents, or dependency on foreign fuel supplies — is already a matter of complexity and legitimate debate. It is essential that the nuclear community be seen as transparent and open in its activities, to increase understanding and confidence in the safe operations of nuclear facilities.

## JAPAN AND THE IAEA: PARTNERS FOR COMMON OBJECTIVES

For many years, Japan has been a strong and supportive partner of the IAEA. Japan is a contracting party to all of the nuclear-related safety and security conventions. Japan has been a regional and global leader in assisting other countries — both directly and through the Agency — with peaceful nuclear applications in fields such as human health, agricultural productivity, water management and environmental protection. Japan also serves as a hub for the Asian Nuclear Safety Network, which aims to pool and share existing and new technical knowledge and practical experience to further improve the safety of nuclear installations in Asia.

Japan has the largest nuclear programme under IAEA safeguards, which provides continuing assurances about the peaceful nature of Japan's nuclear

programme. The Rokkasho Reprocessing Plant will be the largest facility ever placed under IAEA safeguards. Japan is also one of the countries in which we implement integrated safeguards — which involves integrating traditional nuclear material verification activities with new strengthening measures for greater effectiveness and efficiency.

Last year, the United Nations Panel on Global Security singled out the IAEA as “an extraordinary bargain” for its work on nuclear non-proliferation. Naturally we are pleased with such recognition, but the truth is that our budget is stretched quite thin. The IAEA budget for its global verification mandate is a mere \$120 million per year, which is less than the budget of a municipal police force. It is inevitable, as our responsibilities continue to grow, that our resources must grow. The IAEA is somewhat unique among international organizations, in that we deal with issues vital to international security — issues that in some cases can make the difference between war and peace. It is in the interest of all that we have the resources to enable us to adequately fulfil our mandate.

## CONCLUSION

In closing: as you may be aware, the IAEA assists countries not only in the area of nuclear power, but in many other peaceful nuclear applications. This assistance ranges from the use of radiotherapy in Ghana to the development of more productive rice varieties in Vietnam; from efforts in Ethiopia to eradicate the tsetse fly that harms both humans and livestock, to managing water resources more effectively in Latin America. These and other nuclear applications transform nuclear science into an effective tool for development.

Today I have tried to outline the conditions under which nuclear power could continue to contribute to development and security. At the IAEA, we stand ready to assist Japan and our other partners around the globe in finding solutions that are best suited to their needs and priorities.