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Shaping the Nuclear Future

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The Uranium Institute Symposium has become an important and unique international forum for exchanging ideas, and so I look forward to describing briefly the US Department of Energy's role and perspective in helping to shape the nuclear future. Although this will necessarily be conditioned by the United States' situation, I will certainly touch upon international considerations.

I recognise that the nuclear energy future, and its concomitant need for nuclear fuels, is the primary focus for most participants in this Symposium, and that that future today is frankly highly uncertain. But I wish to note first the broader nuclear responsibilities of the Department of Energy (DOE). Those responsibilities include: sustaining the nuclear deterrent without testing; advancing nuclear non-proliferation goals; developing a broad portfolio of energy technologies, including of course nuclear energy, aligned with market place realities and trends; maintaining our nuclear science and technology infrastructure; promoting research and development (R&D); and retaining a knowledgeable and experienced human resource base for future nuclear work.

These responsibilities obviously span both civilian and national security sectors. One of my themes is the strong linkage between our programmes in all of these sectors. For example, both the nuclear energy future and nuclear materials stockpile stewardship depend upon the human resource base, new concepts growing from research, and the existence of a nuclear infrastructure that permits development and demonstration of everything from new fuel cycles to advanced materials. We have significant concerns in all of these areas, in no small part driven by the uncertain nuclear energy future.

The divergence of views among different national communities, for example on reprocessing, is not helpful in this regard. I remind you that this divergence a quarter of a century ago had its roots in non-proliferation concerns. These concerns continue to be a principal determinant of our nuclear programmes, but less often emphasised is how the nuclear energy future itself affects strongly our constraints in pursuing non-proliferation goals. For example, the worldwide nuclear fuel situation affects our capacity to turn megatonnes into megawatts by burning weapons material (HEU or plutonium); the amount of such weapons material in turn depends on the progress of arms control negotiations. So my emphasis simply is that all of these programmes are very much linked and this affects our management of them and our perspective.

These linkages clearly guide us as a governmental entity in fulfilling our responsibilities, but I also hope that the private sector recognises its equities in this full range of linked issues. I would argue that the uncertainty of today in fact provides an opportunity, perhaps a major one, to revisit some of the fundamentals about directions in nuclear energy for decades hence. This revisiting can be productive only if public and private sectors engage together, and if we can achieve more of a convergence among international partners.

In the remaining minutes I will outline some of the externalities from a US perspective, describe some of our programmatic responses, and highlight some collaborations, particularly with Russia, that bring us to confront directly the linkages I have described.

I will start with a few words about the externalities, the broader developments in the energy picture. These include increasing electricity demand, deregulation in the electricity supply industry, the need for environmental stewardship, and the inadequacy of nuclear waste programmes today. Looking at the energy picture, obviously energy is the life blood of modern economies. It is a commodity that drives international considerations, be it security of oil supply or the global environmental consequences of energy use.

As is the case with many industrial economies, the USA is facing a particularly dynamic period in the energy sector, particularly the electricity sector, as the forces of supply deregulation and environmental protection come together. Our challenge is to align these forces to work together towards a cleaner, more prosperous and secure world. Our tools are policies, regulations, and research and development. These have not been adequately aligned over the last decades. Achieving this alignment is in many ways the principal energy task of the Department of Energy.

With regard to supply, world electricity consumption is expected to nearly double by 2020, with annual growth in the industrialised countries averaging about 1.5%. Almost half the world's increase in energy consumption is still projected to be in developing Asia. In the public sector we must continue to pave the way for deployment of a broad spectrum of energy technologies to meet these needs, including cleaner fossil fuels, nuclear and renewables. There is no silver bullet technology that will by itself meet all of our needs and aspirations. Of course how these needs will be met will be affected strongly by issues such as deregulation and environmental constraints.

Deregulation and privatisation of electricity supply systems has taken place in many corners of the globe. For example, the UK's divestiture of its energy assets was the largest privatisation in history. In the USA the electric power industry is currently in the midst of two kinds of restructuring: of the industry players themselves in response to and in anticipation of competition; and of the legal and regulatory rules of the game. Newspaper headlines almost daily announce mergers and acquisitions of electricity, natural gas and telecommunications companies, the shedding of generation assets, and new ventures in non-energy businesses among utilities.

In my own home town, Boston Edison has established a joint venture to provide energy management, local and long distance phone service, video and

high speed internet access, and has more or less simultaneously sold its Pilgrim nuclear power plant to a national company. In the USA, we are also both at state and federal levels dismantling the legal and regulatory structures that maintained the monopoly power of yesterday's electricity sector. Depending on how deregulation goes it may introduce a significant deployment of new energy-efficient technologies, and the widespread use of on-site generation spurred by retail competition. It may also introduce new technologies which will give us an intelligent digital grid that interacts in real time with every key part of the electricity system: the generating plant, the transmission system, and home appliances.

But end users will certainly still purchase at least part of their electricity from companies that deliver power from large baseload plants through local distribution networks. We are optimistic that the world in 2020 and 2030, while still heavily dependent on cleaner fossil fuel use, will be one in which growing demand for electricity as a preferred energy source will also see new inherently safe nuclear power designs and dramatic improvements in the economics of renewables, to provide a broad spectrum of clean, low cost, reliable electricity choices in the market place.

This takes us to another major externality that will shake this sector, the environmental constraints at all geographical scales: smog and particulates in urban environments, regional acid rain, and global warming. The manner in which global warming imperatives in particular will be implemented remains unclear. However, even in the absence of formal binding international implementation mechanisms we are seeing already many businesses begin to factor greenhouse gas emission considerations into their business plans. Indeed nuclear power is positioned to be part of the solution.

Let me focus now on nuclear power in the United States. In the competitive environment, utilities have shut down some operating plants, and more plants are likely to be closed as the system in the United States adjusts to deregulation. The DOE Energy Information Administration notes that if no new plants are built, nuclear power in the United States is likely to drop by over 40% in the next 20 years; that is, of course, with a big "if". But not all the news is bad. A larger number of existing nuclear plants produces electricity at very competitive costs. Competition in the electricity sector has led in fact to a brisk market in the sale of existing nuclear plants. Industry experts expect this trend to continue; that is, single operating units being purchased by the owners of multiple plants, leading to consolidation in the US nuclear industry. This means sustainable skilled nuclear workforces, and leaves the most efficient existing operations well positioned for deregulation.

In addition, nuclear utilities in the USA are also extending plant operating lives. This has led DOE to propose a new programme designed to help life extension and re-licensing programmes, called the Nuclear Energy Plant Optimisation (NEPO) programme. This was developed with industry, particularly with EPRI, and will be carried out in partnership. We are quite hopeful that the US Congress will provide support for the NEPO programme in the current budget process.

Up front capital costs are obviously a critical issue for nuclear power, particularly in the emerging deregulated electricity sector. In Japan, Tokyo Electric Power has reduced the construction time on its newest advanced boiling water reactor to 51 months. This is an impressive accomplishment, but there are demands for even faster construction. According to some industry experts, building a new nuclear plant in the United States may not be financially justifiable unless it can be completed in about three years or less. It is obviously unclear whether existing technologies, including the advanced light water reactor designs, could currently meet a challenge of this type. This kind of issue is itself an important one for both the technology and for our regulatory regime.

Nuclear power is clearly at a cross-roads in the USA and other parts of the world. In today's world, awash in surplus energy and short on capital for new energy development, nuclear power is competing with extremely low cost sources of electricity. Here the climate change debate is an important one, and more specifically the debate about emission constraints on energy production and use. It is a critical issue for the future of nuclear power in the United States. Most of the avoided carbon dioxide emissions over the last 20 years have come from nuclear power. In the USA today, on an annual basis, nuclear power avoids greenhouse gas emissions equivalent to burning 50 000 railroad cars full of coal.

If a true monetary value were established for carbon emissions, nuclear power could be the major beneficiary of an emissions credit trading market. Nuclear power advocates and environmental advocates need to play an active role in setting the still evolving regulatory framework that will advance our environmental interests. Indeed, a natural alliance of carbon-free technologies, nuclear and renewables, needs to be more active in aligning energy and environmental policies, such as advocating all-source regimes. I use the expression "natural alliance" realising of course that often these are viewed as unnatural partners. But that dialogue is extremely important in advancing things like all-source regimes.

Turning now to nuclear waste, no issue is more critical to the future of nuclear power in the United States than solving the problem of waste disposal. The US Administration continues to believe that that the overriding goal of the federal government's high level waste management policy should be the establishment of a permanent geological repository. We consider such a repository essential, not only for the disposal of commercial spent fuel, but also for high level waste and spent fuel from the clean up of the DOE nuclear weapons complex and from the US Navy's nuclear powered fleet. A permanent geological repository is also important to our non-proliferation goals: as an alternative to reprocessing for foreign research reactor fuel, and as an option for the disposition through immobilisation of surplus plutonium from nuclear weapon stockpiles.

I know that there are many advocates of reprocessing throughout the nuclear industry, and I also realise that the different energy contexts in different countries will lead to different priorities. Nevertheless, we in the United States have concluded that reprocessing continues to make little economic sense, and even less sense for our non-proliferation policies. According to a recent

Energy Resources International study, reprocessing adds about 40% to the price of nuclear fuel. But whether or not you share the US Administration's view on reprocessing, geological disposal of spent fuel and high level waste for hundreds of thousands of years is simply an issue that we all must face, and facing it together would be the preferable way to go.

Let me give you a brief update as to where we stand on the US waste programme. In December 1998, the DOE submitted to the US Congress and the President a viability assessment for a repository at Yucca Mountain. While this report revealed no technical show stoppers, it did identify additional scientific and technical work needed before a decision can be made on whether to recommend Yucca Mountain as the site for the repository. Consequently we intend to continue and indeed expand studies of the presence and movement of water through the repository block; the effects of water movement on the waste package; the integrity of the inner corrosion resistant waste package barrier; the integrity of spent nuclear fuel cladding; the geology, geochemistry and hydrology of both the saturated and unsaturated zones between the repository and the surrounding environment; and the effects of heat and the decay of radioactive materials inside the waste packages on the site's geologic and hydrologic behaviour.

We have asked for close to a US$50 million increase for site characterisation studies in fiscal year 2000. To be blunt, our request is currently in some jeopardy in the budget discussions in Congress, which could of course affect our schedule. Nevertheless, today we are on target to decide in 2001 whether Yucca Mountain is suitable to be the location of a repository, and to submit a licence application to the Nuclear Regulatory Commission in 2002. It is important to underscore that the scientific and technical work being carried out at Yucca Mountain represents cutting edge science on a first of a kind project. The licensing process for a project whose performance is to be projected over such a long time scale will also break new ground.

The DOE is very eager to expand international collaboration on the nuclear waste issue. Indeed, US Energy Secretary Richardson announced at the IAEA General Conference in 1998 that he would host a meeting, which will take place in late 1999, on geological disposal. This meeting will include a day in which government officials from many countries will come together to discuss the perspectives on high level waste and spent fuel management. A sharing of data, and the development of an international scientific consensus may well be critical for public acceptance of long term geological storage and disposal.

Let me comment now on DOE's nuclear energy R&D programmes, their goals and the potential they hold for international co-operation. Although, as I mentioned earlier, the prospect for nuclear plant construction in the USA is not promising for the next several years, we have a responsibility to develop nuclear options for the decades hence, particularly in light of the uncertain environmental constraints. Furthermore, deregulation will profoundly affect the electricity sector in the coming years, and unfortunately a common side effect of deregulation is a significant reduction in private sector R&D, particularly that focused on the intermediate to long term. This adds additional responsibility to the federal R&D portfolio.

As you may be aware, the DOE has introduced a new R&D initiative in 1999, called the Nuclear Energy Resource Initiative (NERI). This is designed to address the future use of nuclear power by supporting innovative research at national laboratories and universities, and by private industry. We have solicited research proposals in the areas of proliferation-resistant reactors and fuel technology; new reactor designs with higher efficiency, lower costs and improved safety; lower output reactors; new technologies for managing nuclear waste; and advanced nuclear fuel. The programme is starting with a rather modest funding of US$19 million, although we are requesting substantial growth for the years ahead. In this first round of proposals in fact over US$300 million worth of work was proposed, so we can see the huge suppressed need for resuming nuclear R&D, at least in the USA. Of course I might add that growing this programme will be critically important for maintaining a high quality nuclear science and technology workforce, including the development of young people in our universities.
The first round of awards was made in mid 1999. The programme offers a rejuvenation of fuel cycle research in our universities and national laboratories. Several activities already have international partners and we hope that such collaborations will grow dramatically. Ultimately, of course, we hope that research developed under the NERI programme will produce technologies that will help us achieve our goal of an energy future where nuclear remains a competitive option.

I will turn now to nuclear non-proliferation and collaboration with Russia. Our programmes with Russia are driven by our non-proliferation goals, stewardship of nuclear materials, and stewardship of the nuclear complex during a period of economic and political transition. However, the linkages that I emphasised earlier imply an inevitable coupling between our non-proliferation objectives and the current and future condition of nuclear power. Our work with Russia engages the full spectrum of issues. The first phase of the work in, for example, stewardship of nuclear materials, often focuses on stabilisation, such as protecting special nuclear materials in place. The second phase then focuses on reversal of some Cold War realities, in this case for example, burning the vast stores of excess weapons useable material.

The first phase in these programmes typically involves tens of millions of dollars, a scale that is non-trivial but nevertheless is within the reach of public expenditures. Many of our programmes in Russia entail this level of expenditure. But the second phase, the one that involves in some sense walking back from the Cold War realities, typically involves resources on the billion dollar scale. This is not surprising, given the scale of the Cold War investments that got us into the present situation on both sides in the first place. This billion dollar scale suggests the importance of engaging the private sector in a way that links commercial interests with non-proliferation objectives, because frankly it is only in commerce that resources of that scale can be made available.

One particular focus of our joint efforts in the DOE's work with Minatom of Russia has been to reduce the amounts of special nuclear material, and to increase security and accountability of the material that remains. Commercial nuclear power plants are key to this programme, since that is where the weapons material is ultimately burned. The US-Russia HEU Agreement

involves the purchase by the USA over 20 years of the LEU extracted from 500 tonnes of HEU from Russian weapons, for use in civilian power reactors. This is an approximately US$12 billion agreement financed almost entirely by commercial transactions. It is probably the most significant non-proliferation action to date involving nuclear power.

In March 1999 Secretary Richardson and Minatom Minister Adamov signed agreements in conjunction with the signing of a commercial contract between Russia and three major uranium companies (Cameco, Cogema and Nukem). Together, these agreements provide for stable long term sales of Russia's natural uranium from the original HEU agreement. As a result the entire agreement is again functioning, returning much needed revenue to Russia, turning megatonnes into megawatts, and demonstrating our ability to confront and overcome the most difficult of challenges to the implementation of the agreement in a lasting manner.
This is good for non-proliferation, and I think it is good for nuclear power. I would like to commend Cameco, Cogema and Nukem for their positive role and their commitment to serving non-proliferation goals within their business plans. Again, I think having both government and private sector recognising the linkages and working together will be to the ultimate long term benefit of the entire field of nuclear activity.

On plutonium disposition, we share a national security interest in working with Russia to ensure that material removed from nuclear warheads is removed from weapons applications. Of course, there is no simple blending operation that will convert weapons plutonium into material that could not be used for weapons without major effort. US co-operative efforts with Russia on plutonium disposition are premised on a two track approach, including immobilisation and burning as mixed oxide (MOX) fuel in reactors. The USA recognises Russia's energy interest in MOX fuel and seeks Russia's reciprocal participation in an approach that puts that interest in the service of disposition to the spent fuel standard.

Since MOX fuel is not economically competitive with LEU fuel, this programme will require subsidy on non-proliferation grounds. The next two or three years will be a critical period in US-Russian relations concerning the disposition of surplus weapons plutonium. The US is proceeding with research, design and licensing activities for disposing of surplus US plutonium, but in order to not be placed at a strategic disadvantage will not begin construction of the facilities for US disposition unless there is significant progress on plans for plutonium disposition in Russia. The initial commitment is for each side to dispose of tens of tonnes of plutonium, the equivalent of many thousands of weapons.

But here again comes a linkage: the estimated annual capacity of existing Russian reactors (seven VVERs and one BN600) to consume plutonium is two tonnes per year. This would entail a very long programme. Our goal is to increase this rate of plutonium disposition in Russia to five tonnes per year, through the expansion of the plutonium conversion and MOX fuel fabrication facilities, and the identification and utilisation of additional reactor capacity, whether inside or outside Russia, to consume MOX fuel fabricated from

withdrawn plutonium. So again it is clear that the future of nuclear power is a principal determinant of how we can address our non-proliferation goals.

US$200 million was appropriated by the US Congress to help jump start the on-going negotiations with Russia, but ultimately more funding will be needed to create the necessary infrastructure in Russia to dispose of at least 50 tonnes of surplus plutonium, and eventually more as arms control progresses. International co-operation is essential. Japan will assist Russia by facilitating plutonium disposition as fuel in the BN600 fast reactor. We look forward to integrating European programmes as well into this plutonium disposition MOX fuel effort.

As I said, a key factor limiting Russia's ability to consume MOX fuel is the limited number of existing Russian reactors suitable for this task. The US government provided US$5 million in 1999 to serve as seed money to fund joint US-Russian development of high temperature gas reactor (HTGR) technology to dispose of plutonium. A working group under the joint US-Russian steering committee on plutonium disposition has been formed to prepare plans for the design of a HTGR reactor. The advantage of such a reactor, in addition to special safety features, is that it would offer a significant net reduction of plutonium. On the other hand, it is estimated that the development and construction of a prototype HTGR would cost roughly a billion dollars, in line with the scale of expenditure I mentioned earlier. The extent to which the electricity produced could be marketed to offset the cost is clearly significant.

One of our objectives is to help Russia as it attempts to restructure its nuclear weapons complex, to "right-size" it to the new era, and to provide opportunities for its scientists and nuclear workers to redirect their talents to non-weapons applications. Right-sizing the weapons complex is a critical issue for arms control and START negotiations that aim for a dramatic reduction in the number of nuclear weapons, and thus would provide more material to burn in reactors. The work on HEU, plutonium, and associated advanced reactors promotes our shared goals of fewer weapons and more secure weapons grade material; that is, more security and more energy.

Our work with Russia as I have said involves a focus on non-proliferation objectives, but there are inevitably strong links to the nuclear power sector. I mentioned gas reactors, but there are obviously many other possibilities. We have recently agreed with Minatom to produce jointly some papers on spent fuel management, including international consolidated storage; proliferation-resistant fuel cycles, starting out with a definition of what those words mean; and nuclear safety. As I mentioned, we are hosting a conference involving Russia and other governments to talk about spent fuel issues. We will also be holding a workshop in Moscow later in 1999 to discuss the scientific basis of radionuclide transport in sub-surface environments.

Although in our case these activities are driven by a non-proliferation agenda, it is one which nevertheless has us revisiting and re-energising a broader discussion on future nuclear fuel cycles. I think international engagement in this kind of activity is very important. In fact, it may provide an opportunity to reverse the divergence on fuel cycle policy which we have had for the last

quarter century, potentially to a convergence that would be tremendously important in shaping the nuclear future. I hope that our programmes with Russia can help seed this broader discussion.

In conclusion, let me say that nuclear energy must be part of a comprehensive integrated discussion about addressing our national and multinational goals in energy supply and security, environmental stewardship, and economic development. Many energy decisions will still have to be made on a national basis, taking into account the unique resource and industrial concerns in each country, but there is much that can be done co-operatively on regional, continental and transcontinental bases that can alleviate national constraints and optimise our use of energy resources.