



Stanford Professors Siegfried Hecker and John Lewis with North Korean scientists at the Yongbyon Nuclear Power Plant in North Korea. Photograph courtesy of the Center for International Security and Cooperation, Stanford University.

Nuclear Power without Nuclear Proliferation?

Scott Sagan, William J. Perry, Alexei Arbatov, and Thomas Isaacs

Welcome by John L. Hennessy

This panel discussion was given at the 1917th Stated Meeting, held at Stanford University on October 15, 2007.



John L. Hennessy

John L. Hennessy is President of Stanford University. He has been a Fellow of the American Academy of Arts and Sciences since 1995.

Welcome

I am delighted to see so many of my colleagues, and it is wonderful to have such a diverse audience. There are few seminars that I go to at Stanford that include psychologists, lawyers, linguists, engineers, and historians. Bringing together such a multidisciplinary group is the mark of the American Academy, and it is one of the things we celebrate here, especially when solving challenges like the one we are going to talk about today will increasingly demand cross-disciplinary collaborations.

At Stanford, the topic of today's discussion had its roots in a conversation that I had some time ago with Scott Sagan, William Perry,

and George Schultz. They came to me and said that they wanted to work on the issue of nuclear power and nuclear proliferation. Having looked at some of the data, I realized that nuclear power is perhaps the only viable short-term solution to our dependence on fossil fuel that can reach a reasonable scale quickly. I knew we had to reengage the issue of nuclear power. Nuclear power raises a number of concerns, such as licensing, safety, and waste disposal, but the towering concern is nuclear proliferation. So I am delighted to see this panel here today, and I look forward to this discussion.



Scott Sagan

Scott Sagan is Codirector of the Center for International Security and Cooperation and Professor of Political Science at Stanford University. He is also Codirector (along with Steven E. Miller) of the Academy's Global Nuclear Future Initiative.

Will it be possible to have a major expansion in the use of civilian nuclear power around the world without increasing the risk of nuclear proliferation and nuclear terrorism? The answers to this critical question will influence our environment, economy, and security for generations to come. The renaissance of interest in nuclear power around the globe has emerged, unfortunately, precisely at a time when the political regimes that have managed the spread of nuclear weapons are severely challenged. Most visibly, over the past decade, the number of countries with nuclear weapons – India, Pakistan, and North Korea – has increased; and the number of countries with suspected covert nuclear weapons programs – Iran and, as we learned this weekend, perhaps even Syria – has also increased. In addition, transnational terrorist groups have grown in size and have expressed interest in acquiring nuclear materials. In short, while nuclear power is likely to play a significant role in the global campaign to reduce global warming and produce energy security in the future, it is critical that we do not inadvertently increase the danger of nuclear weapons proliferation and nuclear terrorism.

The American Academy is launching a major initiative, designed to bring together a diverse group of technical and policy experts from the United States and abroad, to address

these issues. The goal is to produce rigorous science and social science research that will clarify and inform contemporary policy debates. Today's panel inaugurates a series of panel discussions, which we hope will galvanize interest in this Academy initiative.

Before I introduce our speakers, I want to show two charts that give a visual sense of the challenge we face. Figure 1 is a representation of the number of states in the world with nuclear weapons. The slight increase and then decrease reflects Ukraine, Belarus, and Kazakhstan inheriting nuclear weapons and then returning them to Russia for eventual dismantlement; the other decrease represents South Africa getting rid of its program and its handful of nuclear weapons. That is a measure of where we are.

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How many states have the capability to develop nuclear weapons? This is a much more complex issue because there is no single, agreed-upon measure of a nation's latent nuclear weapons capability. This is under-

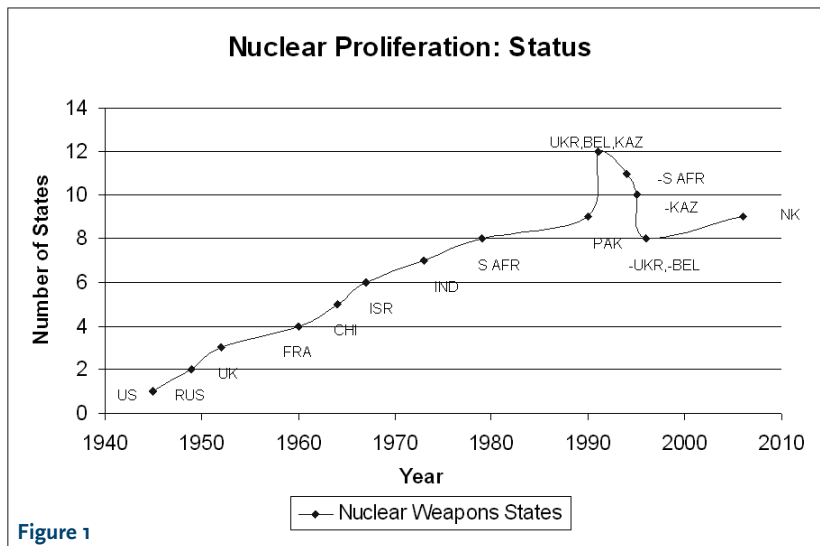


Figure 1

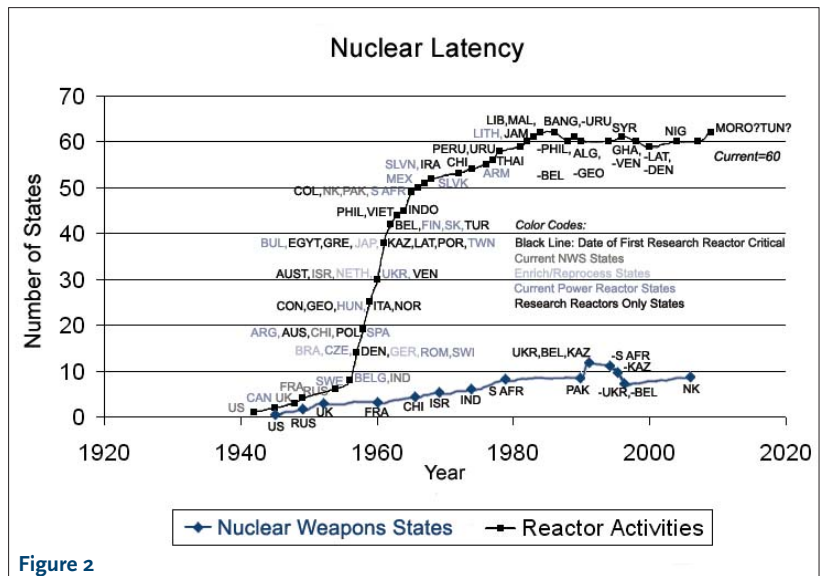


Figure 2

standable given that there are many different pathways by which one could acquire nuclear weapons, and many different technological hurdles that one has to overcome. But one factor that provides at least a minimum amount of technical knowledge and engineering experience is the operation of a research reactor. What we see in Figure 2, on the blue line, is the number, identity, and date of each state that has gone critical with a research reactor. Many of these states, as you can see by the other colors, later developed either commercial power reactors or reprocessing and enrichment capabilities. The difference between that number, now 60 and growing, and the nine nuclear weapons states is, I would argue, both a measure of the success of the Nuclear Non-proliferation Treaty regime and a measure of the challenge that we face and will continue to face as we expand nuclear power – but hopefully do not expand, and perhaps even decrease, the number of nuclear weapons states.

This meeting is dedicated to the memory of Pief Panofsky, whose death last week was a loss to both the physics and the arms control community around the world. The week before Pief died, he spoke at a CISAC workshop on nuclear power and nuclear proliferation. He warned us, using Karl Popper's metaphor that has been popularized by Nassim Taleb, to beware of black swans – namely, rare and unexpected events. Pief mentioned the possibility of another Chernobyl-scale accident, or the seizure of nuclear material in transit by a terrorist organization, or the use of a single nuclear weapon by a new proliferant. What are the effects of these black swans on our analysis? I have asked three distinguished speakers to share with us their thoughts on this topic.



William J. Perry

William J. Perry is the Michael and Barbara Berberian Professor at Stanford University, a Senior Fellow at the Hoover Institution, a Senior Fellow at the Freeman Spogli Institute for International Studies at Stanford University, and Codirector of the Preventive Defense Project at Stanford's Institute for International Studies. He served as Secretary of Defense from February 1994 to January 1997. He has been a Fellow of the American Academy of Arts and Sciences since 1989.

Two of the greatest dangers facing the world today are terrorists detonating a nuclear bomb in one of our cities and catastrophic changes in the planet's climate. A nuclear terrorist attack, of course, would not be like the holocaust we faced during the Cold War, which could have led to the extinction of civilization. But still, it would be the greatest single catastrophe we could suffer. A few months ago, the Preventive Defense Project, a research collaboration between Stanford and Harvard, held a workshop called "The Day After" to discuss what it would be like the day after a nuclear bomb went off in one of our cities. We concluded that we would have more than 100,000 casualties. But the direct and indirect economic losses would be even greater, as markets would crumble in a way that would make the collapse after 9/11 seem inconsequential. There would be political turmoil, since people would lose faith in the government's ability to protect them. That turmoil would be even greater if the target of the bomb were Washington, D.C., and a major part of our government was eliminated. The social chaos would be unimaginable. The scenario we looked at included the terrorist group announcing that it had planted

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bombs in three other cities and would detonate one every month if certain demands were not met.

We concluded that there is no way to prevent the movement of a bomb or fissile material into an American city, to defend against such an attack, or to deter such an attack. Our only hope is to keep the terrorists from getting the bomb. And that hope diminishes as more nations produce more fissile material.

The second danger I mentioned, catastrophic changes in the planet's climate, is caused by large increases in the amount of carbon emitted into the atmosphere. Any prospect of averting this catastrophe depends on stopping the increase in carbon emissions, followed by a reversal of the emissions. We understand the programs and the policies that are necessary to accomplish that, but there is no political will to undertake the huge costs that are involved. No single action can turn around carbon emissions. Multiple actions are required on a global scale, including changes in lifestyle that reduce carbon emissions; major increases in efficiency of energy consumption, such as plug-in hybrids and green buildings; and significant increases in the use of energy sources that do not emit carbon, such as solar, wind, and nuclear power.

Many experts believe that a new generation of nuclear plants is a critical part of that solution. Even if you do not agree, it is absolutely clear that many other nations do and are already pursuing a major construction program of new nuclear plants. China is the prime example, but India will likely follow suit. The alternative program for generating more electricity in China is the large-scale construction of coal-fired generators, which would doom any attempt to reduce carbon emissions. So there is a dangerous conflict

between our need to keep nuclear bombs out of the hands of terrorists and our need to reduce carbon emissions. The global move to increase nuclear power could lead to significant increases in a terrorist's ability to access fissile material. It would not be useful, I believe, to fight nuclear power. China and India are headed that way, regardless of what we say or do. The solution must lie in establishing protocols for how nuclear plants are operated and how nuclear fuels are handled. Indeed, these protocols are desirable even if no new plants are built. But it becomes more critical as the construction of new plants accelerates. There are many alternatives but no political will to enact any of them on a global scale. I would encourage ongoing discussion on what the protocols should be.

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I am concerned with how to achieve the necessary political will so that an alternative has a chance of global acceptance. Getting to that political will is a major objective of *The Wall Street Journal* op-ed that I coauthored earlier this year. It is a major objective of the seminar CISAC is holding later this week. It was a major objective of the two Reykjavik meetings held at Stanford last year and of the one being held next week. And it is a major objective of the Nuclear Threat Initiative and its cochairmen, Sam Nunn and Ted Turner.



Alexei Arbatov

Alexei Arbatov is Scholar-in-Residence and Program Chair of the Nonproliferation Program at the Carnegie Moscow Center of the Carnegie Endowment for International Peace. He also heads the International Security Center in the Institute for International Economy and International Relationships at the Russian Academy of Sciences.

The title of our roundtable is “Nuclear Power without Nuclear Proliferation?” Both Scott Sagan and William Perry have described the general environment in which the response to this question has to be elaborated. Let me add that the generation of new nuclear energy technology will be much safer than the present one, from a proliferation point of view. The present and past generation of nuclear power plants was a by-product of nuclear weapons programs. But the employment and use of nuclear power plants to produce peaceful energy was a useful by-product of the development of nuclear weapons. I hope the next generation will be specifically designed for peaceful purposes and will have certain safeguards against the usage of the technology for military purposes.

However, the next generation of nuclear peaceful technologies, which is now discussed under the title Global Nuclear Energy Program (GNEP), may not reach an industrial scale for another 20 to 30 years. Somehow we have to live through the next 20 or 30 years with existing power plants, which are not safe. There are approximately 500 such power plants, with more than 1,700 tons of highly enriched uranium in various forms and more than 150 tons of weapons-grade plutonium. After Iran, at least seven or

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eight countries have declared their intention to go for the nuclear fuel cycle, with about 10,000 operationally deployed nuclear weapons in the existing nine nuclear weapons states. Under the best circumstances, these countries will fulfill their present obligations to reduce weapons and no new nuclear weapons states will emerge.

This is the environment in which we have to make sure that proliferation does not go further. Is it possible? As in all areas of security, the answer is not yes or no. It is simply more or less possible under various circumstances. And the response is all that more important because the next wave of proliferation will probably not be from new nuclear weapons states but rather from new non-state or sub-state organizations – in particular, nuclear terrorists. Certainly, the proliferation of nuclear weapons and technologies to new states makes it easier for terrorists to get access to nuclear materials or nuclear weapons. These two processes have a synergistic relationship. The black market of nuclear technologies and materials, which goes together with nuclear proliferation, creates a channel through which terrorists can gain access to nuclear weapons and materials.

Is it possible to alleviate this problem? My response is no under the present circumstances, especially if things continue as they are. Moreover, if the current trends continue, the employment of nuclear explosive devices in combat, by new states or by terrorist organizations, for the first time since August 1945, will not only become more probable but almost unavoidable within the next five to ten years. How do we deal with that?

The roadmap and the menu are very well known, so I will mention just a few things.

As strange as it sounds, the way to deal with nuclear weapons, nuclear proliferation, and nuclear terrorism is to start with non-nuclear weapons – in particular, to resolve the problem created by the American ballistic missile defense program and the plan to deploy it in Europe.

First, North Korea has to return to the Non-proliferation Treaty – that is, North Korea needs to follow the South African model. South Africa created six nuclear explosive devices, but in 1992 got rid of them and entered the Nonproliferation Treaty under full safeguards. Second, we have to make sure that Iran does not follow the North Korean model – that is, Iran does not create and test nuclear weapons. Third, we have to make sure that if Pakistan's present government collapses, its nuclear weapons do not get into the hands of terrorists. These three countries need to be at the center of attention. We also need to have more efficient international atomic energy safeguards, making universal the additional protocol of 1997. We need more stringent export controls and greater physical protection, accounting, and control of nuclear materials all around the world.

Can we do this? No. Both Russia and the United States are now further away from each other in their approach to nuclear weapons and their approach to nonproliferation. If that disparity widens, we will have no chance of implementing individual efforts with respect to the three countries I mentioned, or global efforts dealing with proliferation threats in general. It is strange considering that after the end of Cold War, the great powers, United States and then Russia, indulged in a sadomasochistic effort to dismantle nuclear arms control and the nuclear arms regime, which was created during 40

years of the most difficult, most complicated, and greatest negotiations in the history of mankind. If Russia withdraws from the Intermediate-Range Nuclear Forces Treaty, as it is hinting, we will be left with only the Partial Test Ban Treaty of 1963 and the Threshold Ban of 1976. And we will be unable to stop further proliferation.

As strange as it sounds, the way to deal with nuclear weapons, nuclear proliferation, and nuclear terrorism is to start with non-nuclear weapons – in particular, to resolve the problem created by the American ballistic missile defense program and the plan to deploy it in Europe, which is now a major part of the discord in the strategic relationship between Russia and the United States. President Putin's proposal is a good beginning, but unfortunately, there is too much posturing around the issue and no real attempts to negotiate. If we are successful in resolving the ballistic missile defense issue, then all of the steps necessary for an enhanced nuclear disarmament/nonproliferation regime treaty on strategic arms – to deal with tactical nuclear weapons, and then to implement the collective efforts needed to insure nonproliferation – will be possible.



Thomas Isaacs

Thomas Isaacs is Director of Policy, Planning, and Special Studies at Lawrence Livermore National Laboratory.

I would like to discuss three questions. First, will there be a resurgence of nuclear power and what might it look like? Second, what is the impact of that potential resurgence on proliferation and will it be important? Third, is there a window of opportunity and, if so, what needs to be done?

If we look out, say, 20 years, we can be somewhat confident that there is likely to be a growth and, importantly, a spread of nuclear power plants around the world.

Will there be a resurgence of nuclear power? In the past, we have not always done well at predicting the future of nuclear power growth. So we should be somewhat cautious about our ability to predict that future. But if we look out, say, 20 years, we can be somewhat confident that there is likely to be a growth and, importantly, a spread of nuclear power plants around the world.

Why? Three reasons stand out. First, energy growth and security. Many countries in the world are rapidly developing and they will require much more energy. It is not just a matter of price but also of access to the fuels

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that one needs. Having a diversity of fuel options is important to a country's long-term health and security. Keep in mind that building a new energy source whether it is a coal-fired or a nuclear plant takes many years before that plant is operational and generations before it is able to provide a full return on investment. Second, fossil-fuel plants are extremely dependent on the price of the fuel. Those prices are unpredictable and often rising. Third, of course, is global climate change. We are just beginning to see serious attention paid to this issue. Obviously, nuclear power has a number of significant advantages in minimizing the impact of fossil fuels by contributing a larger share of electrical production.

But nuclear power does not have a free ride. First, nuclear power plants are expensive to build. Finding the financing to make it a successful venture requires both access to capital and the faith that you are going to be able to run these plants and have the fuel that you need for decades. Second, safety. When it comes to nuclear power, as is often said, a safety incident anywhere is a safety incident everywhere. Third, nuclear waste. Today, there are no operating nuclear repositories anywhere in the world for the ultimate disposal of high-level waste or the spent nuclear fuel that comes out of nuclear power plants. In this country we continue to struggle at Yucca Mountain. Fourth, as has been mentioned already by President Hennessy and many others, proliferation.

So where do we stand? There are 439 nuclear power plants operating today in 30 countries. It is interesting to note that half of them, 15 countries, have fewer than five nuclear power plants. Almost all of those plants are light-water reactors. These reactors use low-enriched uranium as fuel, meaning 3 to 5 percent of the fuel is Uranium-235, the rest is Uranium-238. Since Uranium-235 is a potential weapons usable material, we are fortunate that separated Uranium-235 does not occur in nature, so the uranium has to be

enriched. The same plant that enriches the uranium could also potentially create one of the predominant weapons-usable materials, by enriching the uranium well above the 3 to 5 percent. It is important to note, however, that the enrichment plant making fuel does not produce a material that is directly usable in a nuclear weapon.

Thirty-four nuclear power plants are under construction around the world. Most are in the Far East. Worldwide, 81 have been ordered or planned, and 223 have been proposed. The most interesting statistic is that 40 countries that currently do not have nuclear power have shown some interest in developing nuclear power. They are almost all developing countries. So the growth of nuclear power is important; the spread of nuclear power is also important. Building another nuclear power plant in the United States does not change the proliferation concern. Building the first reactor in an Iran or Iraq or North Korea does.

In next 20 years, we may see small numbers of other reactor types, but the great majority will be light-water reactors. If a CEO is going to invest billions of dollars on a facility, he or she most likely will invest in technology that has already been proven, that is already licensed and running. So for the foreseeable future – that is, for the next generation – most plants will be light-water reactors, although some other types are in development.

Perhaps more interesting and important is the enrichment and reprocessing issue. As I said, weapons-usable materials do not exist in nature in directly usable form. One either has to enrich uranium, which is a difficult process, or one has to take uranium, put it in a nuclear power plant, run the power plant, pull the fuel out, and then reprocess the spent nuclear fuel (the used fuel) to remove the plutonium that has been created in the nuclear process. Plutonium is the other predominant weapons-usable material.

Fortunately, the number of countries that have uranium enrichment and reprocessing facilities is small. And the major ones are the weapons states, for obvious reasons. There are some others as well, like Japan. But the real challenge comes as we start to diversify and spread nuclear power plants. As we start to see more countries looking for energy se-

curity, not in terms of 5 or 10 years but 20 or 50 years, they are beginning to say, "Maybe I need to assure my own fuel supply. Maybe I need my own enrichment plant. Maybe if I am going to have a large nuclear infrastructure, I also want to be able to reprocess that nuclear fuel so I can get back the unused uranium and the created plutonium." Those are the concerns. We have known from the start that enrichment and reprocessing plants can make nuclear fuel but also weapons-usable material.

It is also important to know that we are not starting from zero. There are more than 250,000 metric tons of spent fuel around the world that have been in and now out of nuclear power plants. And there are hundreds of metric tons of plutonium sitting in that spent fuel. The good news is that it is self-protecting. Those spent fuel elements are highly radioactive. They are hot, big, and bulky. The bad news is that over many de-

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cadecades and generations, a fuel element will lose much of that self-protection and become more accessible. There are already 250 metric tons of separated commercially produced plutonium in the world, largely in the United Kingdom, France, and now in Japan, that has been reprocessed. That material is being separated faster than it is being used in nuclear power plants, and we are seeing more separated plutonium sitting in storage around the world. This is a bad trend, because the material is directly "misusable." It is also important to note that large quantities of high-enriched uranium are coming out as excess from weapons programs. That material is being blended down to low-enriched uranium so that it cannot be used for weapons but can be used for fuel. Lastly, there are 284 research reactors in 56 countries, many of which are fueled with high-enriched uranium.

And there are programs in place now to replace that high-enriched uranium fuel – even though it is in relatively small amounts in most reactors – with low-enriched uranium.

What is the impact on proliferation? As we already heard, the title of this meeting is “Nuclear Power without Nuclear Proliferation?” We could say that another interesting topic would be to reverse the title and say nuclear proliferation without nuclear power. It is important to remember that proliferation to date has not been predominantly the result of misuse of the civilian nuclear fuel cycle. It has been from dedicated, covert programs by some countries. This does not relieve us of the proliferation concerns that will come with the spread of nuclear power, but it is important to keep in mind.

It is important to remember that proliferation to date has not been predominantly the result of misuse of the civilian nuclear fuel cycle. It has been from dedicated, covert programs by some countries.

As I have already mentioned, you have to make weapons-usable materials. They do not exist in nature. With regard to proliferation, we must recognize that over the last 50 years or so a series of barriers has made us feel, legitimately or not, more comfortable with how difficult it would be for people to get their hands on nuclear weapons. I am going to read a small list of these barriers. What I want you to note is that every one of these items has essentially been eroded now.

First, we thought that there were relatively small quantities of special nuclear materials, or weapons-usable materials, and that they were in a very small number of locations. The United States had a small supply and kept it hidden. And the Russians and the Chinese had a small supply. That is no longer the case. Second, we thought that the design of a nuclear weapon was a closely held secret, and that it was difficult to make a weapon.

Countries who want access to nuclear power plants at market prices ought to be able to have it, if they have the capability and the infrastructure to take care of them, show that they can deal with them safely and securely, and meet international standards.

We had a degree of comfort that, even if a country or a sophisticated subnational group somehow got their hands on the material, they would not be able to make a weapon. We now expect that they have some chance of making a nuclear weapon. Third, we used to believe that terrorists did not have a motivation for using weapons of mass destruction. As Brian Jenkins of RAND Corporation used to say, “What terrorists want is not a lot of people dead. They want a lot of people looking.” That was the pre-9/11 world. The post-9/11 world is different. We also used to believe that terrorists were unwilling to sacrifice themselves, so surely they are not going to detonate a nuclear weapon or develop one if there is any risk to them. This is no longer the case. We used to believe that terrorists cannot attract sophisticated people; they can convince only teenagers to strap something to their backs and blow themselves up. Clearly this is not the case. Very sophisticated and educated people are now part of subnational groups. And last, we used to believe that terrorist groups had to be very small and isolated or else they would get discovered. That was the intelligence mantra of 20 years ago, when we first had the rise of international terrorism. The single strongest remaining barrier is to prevent adversaries from acquiring the necessary weapons usable materials.

Thus, the importance of getting our hands around enrichment and reprocessing capabilities, which are the techniques necessary to get weapons-usable material. Getting that under control should be the central focus of the coming 20 years.

Finally, is there a window of opportunity and what needs to be done? We need to ask ourselves, are we going to be incremental or are we going to be guided by a vision? In 1953 President Eisenhower launched the Atoms for Peace initiative. A lot of what he said did not come to pass, but it began an international engagement. It started a dialogue, which led to a number of things, among them the Nonproliferation Treaty and the International Atomic Energy Agency (IAEA), which inspects countries to see if they are using their nuclear facilities and materials properly. Although there are limitations with IAEA inspections, all but a very few countries have signed on. The nuclear weapons states said that they would help the non-nuclear-weapons states get access to peaceful nuclear technology and that they would move toward ultimate disarmament. The non-nuclear-weapons states pledged not to move toward nuclear weapons. It has not worked perfectly, but in terms of proliferation, it has worked pretty well so far.

What might be some of the key components of a new arrangement for the coming decades? Countries who want access to nuclear power plants at market prices ought to be able to have it, if they have the capability and the infrastructure to take care of them, show that they can deal with them safely and securely, and meet international standards – like adhering fully to IAEA membership requirements, meeting IAEA safeguards, and signing up for additional protocols, which allow for additional inspections. Nuclear power plants themselves are not a major proliferation concern. The fuel that comes in is low-enriched uranium. True, when it comes out of being irradiated in the reactor, it contains some plutonium. But the spent fuel elements are highly self-protecting.

Second, countries will need assured fuel supplies. As I mentioned, these plants have to run for decades. U.S. nuclear power plants were licensed for 40 years. They are now being relicensed for 60 years, and current research is leaning toward 80 years. That is the stability it takes to get the kind of return on investment that is necessary.

Third, weapons-usable materials inventories should be driven down toward zero. In my view, the safest place for excess plutonium is

in the core of a nuclear power plant, where it is producing energy and becoming radioactively self-protecting. If we can find ways to keep it in there long enough so that what comes out is not weapons-usable, even if reprocessed, that would be a wonderful thing.

Fourth, we need to eliminate the rationale for countries to have national enrichment and reprocessing. We need to lead by example, and we need to do it in a regional and international framework. The only way this is going to work is if spent fuel is returned either to the country of origin or to a third country for eventual disposal in a repository. It is difficult to build repositories. We need to find a way to turn the argument around, from repositories being a garbage dump for our nation's nuclear waste to repositories being an integral part of a national security regime that builds national well-being and international stability.

So is it business as usual or do we need to do something? One can make an argument that we have a window of opportunity here. We need to be proactive. We need to partner with the developed world and start listening to the developing world. We need to give the developing world an opportunity to grow and improve their standard of living while at the same time improving U.S. and world security. We need to give them a stake in the future; otherwise it is going to look like the "haves" are continuing to try to keep the "have-nots" out of the business. I believe a new vision, a new partnership, a new bargain will not be easy or happen quickly. But success would leave the world a much better place.

Questions and Answers

Question: I have been listening with great interest. I am a historian, and not a political scientist or a physicist. How do we control the states that have joined the treaty for nonproliferation? I am thinking, of course, of Iran. It seems to me that, in dealing with that situation, which has been approved, presumably, by the International Atomic Energy Commission, we have refused to talk to Iran about proliferation and threatened them instead. This is creating strain between Iran and the rest of the world. Iran is very adamant. They are threatening, too.

There is a tension between the United States policy of regime change and our policy of nonproliferation.

We have, of course, ships there that are ready to take action against this threat. And we have Israel, which for its own reasons, and very good reasons, is going to make a surgical strike, which will affect atomic energy, and even atomic weapons perhaps, in Iran. And Israel has struck against a treaty nation, Syria, very recently. Neither side will admit it happened, but it's been treated as a strike by intelligence here in the United States. How have nations agreed to follow through on the arrangements for the Nonproliferation Treaty other than threatening each other?

Perry: Any way of dealing with Iran requires two broad approaches. First, we must isolate Iran, so that they are the deviant. The only way the United States can do that is to reduce its own emphasis on nuclear weapons. That was the theme of this op-ed that we published in *The Wall Street Journal* earlier this year. The United States has to be moving seriously toward nuclear weapons elimination. If we do that and get most of the rest of the world to join us, then the rationale that Iran uses for going forward is greatly diminished.

Second, if that is not enough, we have to be prepared for what I would call coercive diplomacy. In my judgment, the most effective coercion against Iran would be economic coercion. It will not work if we are the only ones trying to apply it. But if we can get a serious buy-in from the European countries, including Russia, then we have substantial leverage to use against Iran, without entailing military threats.

Arbatov: I would add that, since collective action is needed, the United States has to take into account the objections of other nations and international politics. The Iranian nuclear program was started under Shah with great help and prompting from the United States. The program that was planned under Shah was even bigger than the present program that Iran is planning, and included large-scale enrichment. Then the regime

changed. Americans do not like the present regime. But other countries have a different attitude. They may dislike it, but not so much as to go to war or to sustain very painful economic sanctions, like an oil embargo. Many countries, including some American allies, are importing oil from Iran and depend on Iran. In Russia, Iran is a matter of concern, but not the primary concern. You would be surprised if you read present-day Russian official documents and political statements, in particular, the military literature. When they are listing the threats Russia is facing internationally, the number one threat would be American deployment of ballistic missile defenses, followed by American deployment of new nuclear weapons and new conventional weapons, such as precision-targeted weapons; and the extension of NATO to the east, toward Russian borders, toward post-Soviet space. And way down on the list would be Iran, proliferation, and terrorism. In order for Russia to cooperate genuinely with very painful and radical measures against Iran, the United States has to do something with respect to the issues that concern Russians. You cannot tell Russians: "Join us in a blockade or military action. As for the extension of NATO and ballistic missile defense, you are wrong in your concerns. We are not going to take it into account." This is not going to work.

Sagan: I would just add one very brief point. In an article called "How to Stop Tehran from Getting the Bomb," in *Foreign Affairs* last year, I laid out an argument saying that there is a tension between the United States policy of regime change and our policy of nonproliferation, because the political interest in Iran in getting a nuclear weapon is largely because they feel threatened by us. So while I agree with the notion that we may have to move toward even more coercive economic diplomacy, through the United Nations and through our European allies, we have to make our threats conditional upon their not agreeing on the nuclear program. But if they do agree, we have to reverse course in a credible manner and stop threatening to use force against them for regime-change purposes. It is a tough balancing act that we are going to face. Right now, we are seeing the worst of both worlds. We are not having effective coercion, and we are threatening them in ways that build up their interest.

The United States has to be moving seriously toward nuclear weapons elimination.

Perry: I would like to agree with what Scott just said but also build upon what Alexei said, which is the importance of getting Russian cooperation. In that first chart, which showed the number of nuclear nations, you saw a big bump and then a great drop. I was Secretary of Defense during the years that we had that drop. I know exactly what was entailed in making that happen: full and deep technical and diplomatic cooperation between the United States and Russia. Without that cooperation, none of that would have happened. Today, I cannot even imagine getting that kind of cooperation, even though it is in both Russia's and America's national interests. Today, the antagonism between the two countries is too great. But we must get that cooperation in order to have success in this area.

Question: My question is about credible fuel-supply guarantees. I was wondering if any or all of the panelists could elaborate on what some sort of multilateral system might look like. In one of the earlier rounds of negotiations with Iran, just as Russia was trying to convince Tehran that they would provide a consistent flow of fuel for the nuclear program, the flow of natural gas, I believe it was, to Europe suddenly stopped. My other question is whom would the United States entrust to provide a guaranteed supply of nuclear fuel to us, if we were forced to practice what we preach?

Isaacs: First, a number of initiatives – one by President Bush, one by Director General of the IAEA Mohamed El Baradei – are all looking at ways to provide an assurance of adequate fuel supply for decades, in return for countries forgoing national enrichment and/or reprocessing plants. How do you provide assurance to a country that is about to invest several billion dollars in a nuclear power plant that the world will provide them the fuel that they are going to need for the next 80, or even just 40, years for that plant? It is a tall assignment considering what these small countries want: a marketplace where they can go for their fuel. They do not want

a cartel for this fuel, which is the way our assurances have sounded: We will take care of you. Trust us.

Right now there is a marketplace. In fact, there are more enrichment services right now than necessary. So the small countries have what they want. Enrichment prices have risen dramatically, but since fuel is a small part of the cost of a nuclear power plant – constructing it is the big part – the price of fuel has to get very high before it becomes a pain. So how are you going to provide assured fuel supplies? I do not have the answer. A lot of people are looking carefully at this issue right now. But part of the answer is to internationalize or regionalize or 'multiparty-ize' the nuclear fuel assurances: we have to move, in my view, beyond a small number of nuclear fuel suppliers to some kind of mechanism whereby both the developed countries and the developing countries have a stake in providing fuel assurance, if they meet a certain number of criteria – for example, showing that they have a track record of adhering to IAEA safeguards, a track record of transparency, etc. Over time, countries should be able to earn their way into having those sensitive parts of the fuel cycle. Right now, Japan is the only non-nuclear-weapons state that has the full fuel cycle. They are just now opening their Rokkasho plant, a \$20 billion plant to reprocess their spent nuclear fuel. This is a huge investment on their part, made largely for energy security. You cannot say it is based on short-term economics. It is probably costing them a fortune. But they want to be able to dictate their own future.

So there is no short, easy solution. There is an adequate supply of uranium for the next 20 or more years, without going to reprocessing. Ultimately, if we see the kind of growth in nuclear power that we are likely to see, we will witness more impetus toward more reprocessing. And after 20 years, we will have to start addressing the issue of putting various kinds of technology in place and preventing people from misusing that technology and getting plutonium out of it. But for the foreseeable future there is enough uranium, enough enrichment services, out there. We ought to be moving, as I said, by example to provide countries in good standing with the opportunity to have a piece of that action.

Perry: On this question, the Nuclear Threat Initiative, which I mentioned earlier, believes that this is a key to being able to achieve the goals we are talking about, to have an international supply – a bank, you might say – that guarantees an assured supply at reasonable prices. They have convinced Warren Buffett to put forward \$50 million to set up that bank. Operated by the International Atomic Energy Agency, it would offer guaranteed fuel at reasonable prices to all countries willing to forgo making their own fuel supply. This is far from operational at this stage, but that is the direction they are headed.

The Russian-Siberian town of Angarsk, Russia, together with Kazakhstan, is building a multilateral reprocessing plant, which is supposed to provide assured supplies of low-enriched uranium to countries that are not developing their own uranium enrichment technology.

Sagan: We have heard the example of Russia, which on the one hand is trying to convince Iran to buy enriched uranium from them, and at the same time cutting off other fuel supplies. Alexei, could you comment on the Russian perspective on guarantees of fuel supplies?

Arbatov: Russia is now in the process of implementing this idea. The Russian-Siberian town of Angarsk, Russia, together with Kazakhstan, is building a multilateral reprocessing plant, which is supposed to provide assured supplies of low-enriched uranium to countries that are not developing their own uranium enrichment technology. President Putin, today visiting Tehran, will continue his efforts to persuade Iran to join this project and to stop its own uranium enrichment program.

With respect to gas supplies, Russia behaved in a very rude manner toward transit coun-

tries, which are post-Soviet states. That is mostly because Gazprom – the state monopolist in Russia that handles all gas extraction, transportation, and supply – has its own predatory economic policy. I do not approve of that. And I do not approve of the way it was done, especially with respect to Ukraine, the transit country, and to Georgia, the buying country. But having said that, I want to make it absolutely clear that Russia did not place an embargo. It was simply trying to make Ukraine pay world prices for gas. Before, Ukraine was supplied with natural gas at much lower prices, in line with previous agreements and treaties. Eventually Russia decided, “Why should we provide all those countries – former Soviet republics – with discounted gas and oil prices, and make our taxpayers pay for their energy?”

So Russia did this to Ukraine, which the United States likes very much; and Belarus, which the United States dislikes; and Georgia, which the United States likes; and Armenia, which Russia likes very much. It was not political blackmail; it was just the economic policy of Gazprom, which said to the Russian government, “Let’s stop those subsidies. Let’s charge them world prices because we are not getting anything from them in return. Why should we play this new imperial game of providing economic benefits in return for political loyalty? Let’s stop all that.” I think that is a healthy policy. The only negative was the way in which the policy was carried out. But the fact that it was bad for all those countries is a sign that it was not politically motivated. It was economically motivated, and economic policy is quite rude and predatory.

Now, with respect to international enrichment cycles, I would like to say only one thing. The idea is wonderful. But as always happens, the devil is in the details. The logic is that we will build international enrichment plants and provide an assured supply of low-enriched uranium to countries that do not build their own enrichment capabilities. Now, if we were to provide them with this low-enriched uranium at average world prices, what is the incentive for them to buy it? They could buy it on the free market or they could build their own enrichment facility. If they invest in their own facility, they could eventually get low-enriched uranium at a much lower price. So we have to provide

I believe the lynchpin potential here is not just to provide them fresh fuel assurance but to link it with spent fuel take back, so that we provide these countries with a full ability to take advantage of nuclear power.

them with an economic incentive. We have to provide them with fuel, or low-enriched uranium, at much lower prices. But how do we define who is eligible to receive that? The moment we start this operation, all countries that have at least one – even one – research reactor will say, “We want to get a low-cost assured supply. Otherwise, we will go for our own enrichment capability.” And you will not be able to deny them that. So basically, you are talking about an internationally established assurance of supply to all countries of the world, provided they do not develop their own enrichment capability. And that effectively cancels the international market in this particular area. We could retain markets in other nuclear areas. But in that supply of fuel, or low-enriched uranium, we are doing away with the market. We are starting a long program of state-regulated or internationally regulated prices to all countries of the world that have at least one reactor.

Isaacs: I agree with what Alexei said about this issue. You have to provide the developing world with something that they need. If you asked the developing world how this scheme looks, those countries would say that it looks like the developed world, and the United States in particular, is trying to establish a cartel rather than trying to give the developing world a hand. What they need much more is help with the backend of the fuel cycle, dealing with the spent nuclear fuel.

Here is the win-win possibility. Right now 85 percent of the nuclear power in the world is in the developed world. Only a small fraction at the moment is in the developing world. Those countries are all going to have to develop their own repositories. I do not believe it is going to happen. Those facilities are in-

credibly expensive. They are very difficult to site, and they take decades to build. As I mentioned, that is the reason 15 of the 30 countries right now have fewer than five reactors. They are going to have to go through the same agony we are going through for Yucca Mountain for very small amounts of fuel. So I believe the lynchpin potential here is not just to provide them fresh fuel assurance but to link it with spent fuel take back, so that we provide these countries with a full ability to take advantage of nuclear power. They will not have to deal with that nuclear waste. We will.

This is a huge leap for us. We cannot even handle our own waste right now, let alone the political problem. But the only reason to do it is because it makes sense. It is not going to happen in two or five years, but we have to find a way. First, we are taking away spent fuel with plutonium in it. So it is in our security interest. Second, we are going to have to deal with a small amount of the spent fuel. All the major nuclear-developed countries, and Australia and Canada, who supply all the uranium, have some obligation for what happens to that material after it has been processed. So this is a potential win-win situation if we frame this problem appropriately.

Arbatov: I agree that that is a great incentive. Unfortunately, it is a great incentive for all countries except those who want to develop nuclear weapons. Because those who want nuclear weapons will want to keep the irradiated fuel to extract plutonium. And you are designing this program in order to prevent proliferation. This is a Catch-22.

Isaacs: I do not see it as a Catch-22. In fact, it will help us separate out the countries that are planning to build nuclear weapons.

Sagan: You have seen some of the major debates that will be occurring and the need for social scientists and physical scientists and engineers to work together, because of the complicated nature of these problems. The problems in this area are not divided by the disciplines with which we divide our universities. I would like to thank our panelists for addressing these issues today. ■

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Academy Meetings



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Sidney Drell (Stanford University) and James Gaither (Sutter Hill Ventures)



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