The Promise and Perils of Nuclear:
Risk and Rewards during a Time of Climate Change and Conflict

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Good evening and thank you for the invitation to participate in this very prestigious event. When looking at the past speakers, I can say that I am truly honored to be here as your speaker. Kudos to the organizers and my gratitude to all of you who have come out this evening and for your interest in and dedication to the entire nuclear enterprise.

I want to begin with understanding my audience a bit better—something usually wiser to do BEFORE you write the speech, but here we are! I am going to ask you to "self-identify" – and feel free to raise your hand more than once. By a show of hands, can my scientists, engineers, and nuclear practitioners raise their hands? How about the nuclear policy and programmatic types? Academics? Federal government employees or contract types? Non-governmental/nonprofit folks? Interested citizens?

I ask this both to get a feel for who you are and to underscore the interrelationship among private, government, public, and nonprofit sectors in this space. I could also have asked who works in nuclear energy, nuclear research, nonproliferation, weapons programs, arms control, and safety. Or who works on domestic programs and who on international.

Why am I asking these questions? Because the risks and rewards of nuclear cut across professions and societal sectors. Past successes in mitigated risks and in reaping rewards from nuclear relied on coordinating across disciplines. Those of you who know the history, or even just saw the Oppenheimer movie, understand that theoretical physics had to meet the applied sciences facilitated by the logistical masterminds, sold to the tacticians and strategists, blessed by politicians, and funded by the elected officials to get to the endpoint desired. But because we are all comfortable in our "silos of excellence" we don't always seek to understand the goals and the concerns of our compatriots, and we sometimes see disciplines as competing factions rather than facilitating enablers. The lack of coordination among these disciplines leads to redundancy, confusion, and poor decision-making across the board.

As an aside, we also tend to lack good public relations people in nuclear…but that's probably another topic. But before I get myself into trouble, I need to start with the usual housekeeping disclaimer, my remarks here tonight are my own and do not reflect the views of the Defense Nuclear Facilities Safety Board, or the U.S. government. And I am also likely to raise more questions than I answer.

I faced a few challenges in putting together this talk. Back when I was asked to do this, and I said I could either focus on nuclear safety and some of the Safety Board's focus areas or on the cross-cutting challenges of nuclear power and the nuclear enterprise—the organizers preferred the latter. (Which, arguably, and don't quote me, is more interesting…or at least more thought provoking.) But since the time I was asked to do this a few months back and now, the

landscape has been shifting very quickly. The situation in Ukraine, Russian nuclear threats, dirty bomb accusations, North Korea's nuclear saber rattling, Iran's continuation of enrichment, an increased interest in nuclear power across the world, and an uptick in domestic interest in small modular and advanced nuclear reactors—these have been on-going for the last little while.

So, what is new? Specifically, the company Centrus started up a U.S. owned, U.S. technology-based uranium enrichment capability a few weeks ago—the first since 1954—and is poised to provide high assay low enriched uranium) (HALEU) to advanced reactor vendors. Holtec is filing with the Nuclear Regulatory Commission (NRC) to restart the Palisades NPP in Michigan. Standard Power in Ohio and Pennsylvania has selected the small modular reactor company, NuScale, to provide power to run nearby data centers. All point toward the potential rewards of a resurgence in U.S. nuclear energy leadership.

Meanwhile, China has expanded its nuclear arsenal to more than 500 nuclear warheads, an increase of 100 since last year. The Bipartisan Congressional Commission completed and released its *Report on the Strategic Posture of the United States*, including a recommendation to overhaul and expand the nuclear security enterprise. The U.S. and Saudi Arabia were working toward a deal to improve ties between Saudi Arabia and Israel, which reportedly included U.S. assistance for Saudi's nuclear program, including, potentially, enrichment technology. Then the Hamas brutally attacked Israel and kicked off the ensuing conflict that threatens to engulf Iranian-backed Hezbollah and potentially others in the region. The Russian Duma voted to revoke its ratification of the Nuclear Test Ban Treaty. And in Ukraine, winter is dictating moving some of the units of the besieged Zaporizhzhia Nuclear Power Plant from cold shut down to hot shutdown as fighting continues in the vicinity of the reactor. IAEA inspectors are on the premises monitoring the situation. All indicating some levels of peril. In short, the landscape remains…complicated and ever-changing.

But before we dive in further, you can tell from my background that I have spent my career in the realm of nuclear both domestically and internationally—everything from nonproliferation to nuclear security/counter terrorism to nuclear energy and nuclear safety. I am not an engineer, if I were, I would be a systems engineer because I tend to focus on how the parts of the system work together (or don't in some cases). I am also not an academic (on this, my professors would all likely agree). But I am a practitioner, and I'd like to think, a pragmatic one—and in my experience, the best solution sets include a spectrum of disciplines.

Last year, I was invited to a speaking engagement for a side-event for the Non-Proliferation Treaty review conference (or the NPT RevCon for short). I don't know how familiar you are with the NPT or the RevCon, but it is salient to our discussion, so I hope you will indulge me for a moment.

The Three Pillars of the NPT

The nonproliferation treaty came into force in 1970 and is the cornerstone of nonproliferation and in some ways arms control. It is how the international community set about trying to build a framework, and honestly a fence, around the devastating impacts of nuclear weapons. It was designed to (1) **prevent the spread of nuclear weapons**, (2) to **further the**

goals of nuclear disarmament, and (3) to **promote cooperation in the peaceful uses of nuclear energy**—these are the three "pillars" of the treaty.

The three pillars—taken together—work to manage and limit the risks of nuclear while seeking to reap and expand to the rewards. It was under this treaty that a safeguards system was put into place to verify compliance with the treaty as confidence-building measures. When the treaty went into force, Article VIII of the document called for a review conference every five years to assess the procedural and substantive aspects of implementation. Due to COVID, the 2020 RevCon was delayed and just convened last August. While this may sound pretty dry it played out against the drama happening in Ukraine and the seizure of Europe's largest nuclear power plant by Russian forces and is important in regard to not only the happenings in Europe, but also in the Middle East.

I was invited to take up the topic of nuclear security within the realm of peaceful uses, while colleagues spoke on the other two pillars.

Eleven years ago, having been one of the original designers for the first Nuclear Security Summit—a first of its kind, head of state gathering of 47 countries and three international organizations—I would have spoken about the threat of nuclear terrorism, the need to protect materials from falling into the hands of NON-state actors who would use that material to terrorize a community, a nation, or the world. I would have spoken of the work of the G8 Global Partnership, under the auspices of the G8 dedicated to nuclear security and of the Global Initiative to Combat Nuclear Terrorism, an initiative co-chaired by the United States and Russia.

If I had spoken five years ago, I would have focused on the promise of nuclear energy in combatting climate change, new nuclear designs being developed, and how designers are working to DESIGN safeguards and security into the reactors helping to ensure that peaceful uses of nuclear energy can be deployed worldwide to address the global crisis of climate change without increased security risk.

Last August, however, while both of those things were STILL true, another security challenge had reared its head and complicated the landscape for peaceful uses, and that is the threat posed by armed conflict. The occupation of nuclear facilities by armed forces is a sobering thought and a frightening reality and Russia's actions to target and overtake Ukrainian nuclear power plants must not go unanswered or other countries may mimic that behavior.

And just one year later, I am again refocused on the issue of the acquisition of nuclear capabilities by nonstate actors, the potential of new nuclear nations, the use of or testing of nuclear weapons and, with a backdrop of the world recognizing the need for additional non-carbon energy and nuclear new comers—what the advent of a new nuclear age with mean for all of this as well as the pressures that climate change will have on the geopolitical climate.

So back to our treaty, Article IV of the Non-Proliferation Treaty provides a framework for states to reap the rewards from peaceful uses of nuclear energy, science, and technology. The idea was that parties would facilitate and enable the application of peaceful uses.

At this moment in history, many are looking toward nuclear energy applications to help transition the world to cleaner energy and low-carbon electricity to meet energy needs, for industrial applications, for hydrogen generation, and water desalination. Even our European friends, who have long been skeptical of nuclear, recognize that they may need nuclear energy to meet their climate goals AND to free themselves from being beholden to Russian gas and pipeline politics. In an important, but perhaps obscure, vote, the European Parliament voted last year to keep nuclear energy in the Complementary Delegated Act for the EU Taxonomy…meaning that it essentially classified nuclear (under certain conditions), to be considered an environmentally sustainable economic activity. But as decisions get weighed regarding technologies and energy sources, decision-makers must make not only a cost-benefit analysis but also threat and risk assessments.

Location Matters

To deal with the potential risks of nuclear expansion, there has been a great deal of talk of safeguards by design and now security by design on the part of reactor vendors—particularly as advanced reactors are coming into their own and use more exotic fuels than the traditional low enriched uranium. We should absolutely be encouraging designers to explore ways to keep material safer and more secure as they develop reactors to be widely deployed in a variety of situations. But when a design basis threat is developed—that is the general characteristics of adversaries that nuclear plant and fuel cycle facilities must defend against to prevent radiological sabotage and material theft—the design should be based on the threats and conditions of where the reactor is deployed.

In the nuclear safety world, we analyze the hazards and calculate the risk of the hazard to a *particular* facility in a *particular* place and then develop mitigation strategies. In the security world, the process is similar. In this case though, the regulator can provide some of the parameters in terms of general requirements. In the United States, the original Atomic Energy Commission ruled that nuclear plants are not required to protect against an act directed by an "enemy of the United States" but after 9/11, NRC required plants to consider threats that included adversaries that could attack at multiple points, were willing to kill or be killed, had modern weaponry, etc. Licensing requires a minimum number of security personnel.

Now when a country is considering nuclear and determining the cost/benefit analysis…and assessing the risk…it must consider safety and security. It must assure that its regulatory process is strong, that it has assessed the risks properly and mitigated them, it must have the appropriate, well-trained personnel, and it must have a robust emergency preparedness and response capability that can work with local, regional, and national responders as necessary.

As **suppliers** of nuclear technology, we must be aware of the situations into which we are introducing this technology—whether it can be exploited or diverted for nefarious means and whether corruption or other internal threats could put that technology at risk. When we think about **enabling** countries to take advantage of peaceful uses, we should be thinking about enabling them not only by providing technology but preparing them to manage risk. This is why international organizations like IAEA are so important in supporting countries embarking on

nuclear power programs. We must be sharing best practices on nuclear security, and we must help train those that are working *IN* the reactors as well as guard forces.

In light of the situation today, we must commit that nuclear facilities remain safe and secure and reaffirm that nuclear power plants shall not be made the object of attack, even where these objects are military objectives—as stated in Article 56 of the 1979 Additional Protocols to the Geneva Convention. Nuclear power plants exist in many countries with ongoing conflicts or civil unrest…Egypt, Taiwan, India, and Pakistan. In the Middle East, Iran, Israel, and the UAE have nuclear capabilities and Saudi Arabia and Jordan are actively pursuing them. Other vulnerable countries—like Sudan, Turkey, Libya, and Venezuela—are pursuing or have openly considered nuclear power programs. Without adequate protections, current and future nuclear facilities represent major international threats, should wars break out near them. And without safeguarding the fuel cycle, countries could consider breakout capabilities as a hedge in bad neighborhoods.

Operating Under Pressure

Additionally, the situation in Ukraine in which workers are trying to maintain the safety of an operating nuclear power plant under extreme duress is untenable. When we look back at the heroic efforts of the Fukushima workers, we know that fatigue, exhaustion, and stress greatly impacted those workers. In the best of circumstances, there is human error. But we can mitigate the risk through rigorous training, checks and oversight, and shift changes to alleviate overtiredness.

The workers in Ukraine lack the "defense in depth" that we build in to maintain the safety of the plant. Even without the shelling, the risks to those reactors increased during occupation. The fact that the Russian military detained the director general of the Zaporizhzhia nuclear power plant after annexing the region surrounding the plant created additional challenges. To quote the IAEA director general, Rafael Grossi, "Such a detention of any member of the plant staff would be of grave concern in itself, but also for the psychological impact and pressure on the rest of the staff…and potential for impact on decision making at the plant."

The Russian invasion of Ukraine is not the first instance of a conflict involving two countries with nuclear installations. For instance, despite tensions, India and Pakistan have created legal protections for their nuclear facilities should a conflict break out. In 1988, the two foreign secretaries signed the India-Pakistan Non-Attack Agreement, which prohibits "undertaking, encouraging, or participating in, directly or indirectly, any action aimed at causing destruction or damage to any nuclear installation or facility in each country." The Indo-Pakistani mechanism to manage nuclear risk offers an example of regulations that effectively promote the physical protection of nuclear facilities. This bilateral treaty could provide a partial blueprint for a path forward by including its language prohibiting indirect attacks on nuclear facilities in any future multilateral regime. Given the state of affairs in the Middle East, as an example, and the complication of non-state actors and proxy organizations, such a blueprint seems not only unattainable, but also unimaginable in certain cases.

With the irresponsible behavior of Russia—a country that exports nuclear power plants and has been in commercial competition with U.S. companies to do so for many years now—how are we to look at the safety and security of newcomer nations who NEED to leapfrog old energy technologies in order to (1) continue to develop; (2) help divert a planetary climate change disaster; and (3) develop some energy security?

The Challenge of Information Sharing

The challenge going forward is how do we make sure that newcomer countries are prepared to analyze the hazards and the risks and mitigate them. One challenge we faced when convening the nuclear security summit and a source of endless debate was that security information couldn't be shared because of the vulnerabilities that sharing such information revealed. Instead, we shared best practices and methodologies. Information sharing remains a challenge. What can we share? With whom? Is there an obligation say, to share intelligence, if we believe that a nuclear site is vulnerable? How do we share it? This is another discipline that needs to be brought into the fold when examining nuclear technology risks. Whenever the United States considers a peaceful uses agreement with another nation, a nonproliferation assessment is conducted and transmitted to Congress for review. It is an unclassified document but has at least one classified annex.

As more reactor designs are developed and deployed, another risk mitigation strategy is to consider how to ensure that there is shared knowledge about those designs such that in the case of an incident or an accident, assistance can be rendered. During Fukushima, I was working for the Deputy Secretary of Energy and as soon as the news broke about the accident, Russian and French counterparts reached out to provide assistance and coordinate a response. There was a recognition of the global cost of the nuclear accident in Japan.

Just as a nuclear accident impacts the nuclear industry worldwide, any security incident, such as the one in Ukraine, also has ripple effects. Could this increase hesitancy by governments or the public to embrace nuclear power? A near-term limited nuclear contamination consequence caused by even a mitigated act of sabotage can be politically and reputationally damaging enough to cause hesitation, despite the long term GOOD of mitigating significant global warming.

The Challenges Ahead

Even in the face of the situation in Ukraine, IAEA is highlighting the importance of peaceful nuclear energy use. At a side of event of the IAEA General Conference last September, there was a focus on Africa and a new report indicated that 600 million people and 10 million small businesses in Africa have no reliable source of electricity. There are more frequent blackouts…especially in sub-Saharan Africa…causing businesses to cease activity. As climate refugees move from rural and agrarian areas where the crops no longer grow as they did and severe weather events are causing people to flee, Africa's energy demand is increasing twice as fast as the global average, due in large part to this urban population growth. IAEA is supporting around 30 so-called "newcomer" countries in Africa and around the world in their efforts to

develop safe, secure, and sustainable nuclear power programs—in other words to benefit from the Peaceful Uses Pillar of the NPT.

Climate change, one of the defining challenges of this generation, will have devastating long-term impacts on weather, health, food security, and even conflict, as competition for scarce resources increases. To address widespread, rapid, and intensifying climate change, we must meet that challenge with strong, rapid, and sustained reductions in greenhouse gas emissions. We need to go on a strict fossil fuel diet to hit the 1.5 degree Celsius over pre-industrial levels target widely accepted by climate experts worldwide.

Projections show though, that instead of DECREASING carbon emissions, they are now expected to RISE 30 percent by 2030 compared to 2010, according to UN experts. Why is that? Go back to our previous conversations about Africa—countries are still working on industrializing, urban centers are growing, and the demand for energy is increasing. And with climate patterns making it HOTTER, electricity demand increases.

All credible models show that nuclear energy has an important role to play as part of our global mitigation strategies. The International Energy Agency estimates that it would cost the world an estimated $1.6 trillion more to meet climate targets without nuclear energy, and that's on the optimistic side. Today, nuclear energy makes up 10 percent of the world's electricity—with some 444 nuclear reactors. The benefits of nuclear? Low-carbon baseload, dispatchability, and reliability. The challenges? Costs and limitations of financing, project timelines, and public confidence. Nuclear makes up about 20 percent of the electricity generated in the United States from 93 reactors in 28 states…more than 50 percent of our carbon free energy. Ironically, now when we need them most, utilities in some areas are shuttering the plants amid political and economic pressures.

Risks and Rewards

This brings me back to risk and reward. Who is taking the risk? Who is getting the reward? How do we think about risk? Is it project risk? There is certainly that. Is there regulatory risk? Undoubtably. Liability risks? Of course. What about safety risk? Again, it goes back to WHAT are you building, where are you building it, who is operating it, and what can we say about the culture.

Next is SECURITY risk…there has long been a concern that countries that pursue nuclear energy can also pursue a nuclear weapon. This is where we go back to the role of the International Atomic Energy Agency and the safeguards that countries (most countries) adhere to. With a few notable exceptions, the "genie" of the nuclear weapons that we feared letting out of the bottle hasn't happened. To obtain the kinds of material one needs for a nuclear weapon, as you know, the material must be enriched (uranium) or reprocessed from spent nuclear fuel (plutonium). The United States seeks government to government assurance from countries that they will not pursue enrichment or reprocessing as a condition for supplying nuclear reactor technology. Some in industry think that puts us in an unfair situation vis-à-vis other vendors such as Russia or China. (Although I am not sure countries should be looking to Russia as a reliable partner at the moment.)

Now, as we have seen in Ukraine, there is the matter of the physical security of the facility and whether it is vulnerable to sabotage or whether it will find itself in the middle of a warzone. The U.S. government determines whether our nuclear companies can do business with foreign customers, but the companies themselves determine if it is worth their while. In my term as nuclear energy director at the National Security Council, I went on many trade missions with U.S. companies willing to sell their wares. Our technological prowess and reputation for the "gold standard" with regards to our regulatory system was attractive to other countries.

What was LESS attractive is that we had a reactor design vendor, willing to sell a reactor design, but that didn't include the construction, personnel training, and a host of other activities that newcomer nations need. We did not offer one-stop shopping. I needn't tell you that China has a very deliberate strategy with its Belt and Road and other strategies to do large infrastructure projects globally to get toeholds in international markets. And Russia, with its vertically integrated companies is ideally suited to provide soup-to-nuts projects…just sign on the dotted line. I don't need to tell you the geopolitical importance of who is building nuclear plants across the globe. This is an area in which it behooves us to have government, industry, academia, and nongovernmental organizations.

Tactical Nukes, and Other Weapons

We have talked reactors security and climate change but there has also been talk of Russia wanting to use "tactical" nuclear weapons to gain a decisive and determinative advantage in its war with Ukraine and even rumors about nuclear use in the Middle East. Let me just start by saying a tactical nuclear weapon is still a nuclear weapon. Russia has approximately 4500 deployed and reserve warheads and about 1900 of them are "non-strategic" meaning that they are low-yield…the equivalent of 10-100 kilotons of dynamite. Let me remind you that the weapons used against Hiroshima and Nagasaki were about 15 and 21 kilotons respectively.

I am with General Mattis on this subject—there isn't a 'tactical nuclear weapon'…any use of a nuke is a "game changer" (his words, not mine). The use of a nuclear weapon anywhere, especially in Europe would be unthinkable—but I know that in defense ministries across Europe and NATO, they are thinking about this possibility. I don't want to speculate about the likelihood of this scenario. I also am not sure of how well serviced Russian tactical nuclear weapons are, whether they would work as designed or with as much impact—but any nuclear detonation or even the threat of use causes widespread panic.

How do we think about the issue of nuclear conflict as separate and distinct from the issue of nuclear power? Climate change is causing extreme weather and significant human migration, which in turn, is exacerbating strain on scarce resources and increasing tensions as climate refugees seek opportunities in Europe and the United States. Energy access has long been used as a tool of state power and coercion and states are looking not only to diversify but to become more energy independent. The world is in the midst of its first global energy crisis—a shock of unprecedented breadth and complexity. Pressures in markets predated Russia's invasion of Ukraine, but Russia's actions undermined a rapid economic recovery from the

pandemic—which strained all manner of global supply chains, including energy—into full-blown energy catastrophe.

Russia has been by far the world's largest exporter of fossil fuels, but its curtailments of natural gas supply to Europe and European sanctions on imports of oil and coal from Russia are severing one of the main arteries of the global energy trade. All fuels are affected, but gas markets are the center as Russia seeks leverage by exposing consumers to higher energy bills and supply shortages.

While the crisis demonstrated the fragility of energy markets, it also acted as a policy catalyst as decision makers look to diversify energy sources and even put into place long term structural reforms. And if we create MORE opportunity to use low-carbon electricity sources, reduce market vulnerabilities, and mitigate the impacts of climate change then nuclear power can be considered to help REDUCE conflict. That is certainly a potential part of the equation.

The situation, as I noted is changing—and it is always changing—but we have historically had success in the face of a changing landscape when we work across disciplines, and when we recognize and adapt to the situation we face. I began my career working on the Nunn-Lugar program that was put into place after the fall of the Soviet Union. At that time, we were at risk of having FOUR nuclear powers—Russia, Belarus, Kazakhstan, and Ukraine. But through great efforts of statesmen in all those nations and here in the United States—Belarus, Kazakhstan, and Ukraine gave up the weapons on their soil and the Nunn-Lugar program, which included the scientific community, the practitioners, the politicians, the linguists, the historians—helped dismantle those programs to prevent them from becoming nuclear powers. In return, their sovereignty was to have been protected. I worked on helping to dismantle those facilities. I also then spent a decade working with Russia to upgrade security at its nuclear facilities to prevent adversaries or terrorist from obtaining the materials or the know how to make a nuclear bomb. We aren't at that place anymore. But what we did served us well at that moment, and then we pivoted.

I want to leave you with another great moment in history—December 8, 1953—70 years ago. President Dwight D. Eisenhower addressed the General Assembly in New York and gave his famous Atoms for Peace speech, which captured the ever-present notion of the perils and promise of nuclear technology in what he called the "fearful atomic dilemma." His speech, born out of a media campaign, "operation candor," was meant to enlighten the American public on the fears and the hopes of a nuclear future.

From Oppenheimer, to Eisenhower, to the framers of the NPT, to Nunn-Lugar…we have managed the dilemma and have harnessed nuclear to provide electricity, advance health care, improve agriculture, and create better living conditions across the globe, while at the same time working to contain the spread and use of nuclear weapons. We did so by engaging all disciplines, working across the three pillars of the NPT, and cooperating among government, industry, academia, and our nongovernmental communities to advance our common interests in managing our nuclear future.