Keynote Address

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"The Future of Nuclear Power: Its Significance for Addressing Climate Change and Its Evolving Technology—Small Nuclear Reactors and Advanced Reactors"

International Summit on Applications for Small Nuclear Reactors and Advanced Reactors to Promote Clean Growth

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Welcome to the Applications for Small Nuclear Reactors (SMRs) and Advanced Reactors (AR) to promote Clean Growth Summit. I am honored to address this international conference on applications for small nuclear reactors and advanced reactors to promote clean energy-based growth. And I want to thank Strategic Communications for their invitation to do so. SMR/AR development will be driven by electricity demand, climate change and clean energy policies. Also, SMRs will have special applications such as serving smaller communities; lightly populated regions, as well as remote locations. In addition, they will be useful for desalination of seawater and widespread air conditioning in demand with the advance of climate change or global warming. So this is an important subject, well worth our attention.

First, let us take a look at climate change. As a result of warming, sometimes caused by volcanic eruptions over thousands of years, the Earth has experienced five major periods of extinctions of life over the millennia. The most notorious took place some 250 million years ago as a result of a global warming of five or six degrees Celsius above what we later have called the pre-industrial norm. This was caused by the release of greenhouse gas – carbon probably – as a result of thousands of volcanic eruptions over a long period. This effect of some 10,000 years of volcanic eruptions was accelerated by the release of methane gas. All of this took place millions of years ago when there were no cities, no humans, and the oceans were a hundred feet higher. Only a small percentage of life survived, perhaps 10 percent. This percentage of survival was a little higher for land creatures than for marine life because the oceans became so hot. The other four major extinction occurrences largely had similar causes. This same phenomenon of the ocean heating up more rapidly than some land areas is occurring today.

The rate of carbon being added at the present time is being accomplished 100 times faster than at any time in human history before the beginning of industrialization and far faster than the events described previously, long ago in our geological history. There is a third more carbon in the atmosphere today than at any time in the last 800,000 years. Half of this carbon has been placed in the atmosphere in the last three decades. This is why climate change is speeding up, progressing more rapidly, not less, than predicted by scientists.

Four hundred parts of carbon per million in the atmosphere used to be considered by scientists as the bright red line that must not under any circumstance be crossed. It was crossed in 2016 and now stands at 411 parts per million. The Paris Climate Agreement identified plus 2 degrees Celsius above the pre-industrial norm level as that level when catastrophes will begin to occur. But already more than 25 percent of the Earth's surface is nearing plus 3C. In 2022, there will be a new report from the United Nations international climate scientists' group as to where we are. But the last one in 2015 asserted that even if all the commitments of the Paris Agreement are carried out—and none have been—that will nevertheless bring the world to plus 3.2C degrees of warming. This much is probably already locked in as a result of past activities emitting carbon into the atmosphere and the slowness with which this is translated by natural processes into a warming Earth.

At the Paris Agreement level, that is plus 2C average world level, the world community could begin to experience all the worst and more deleterious effects of climate change which include: rising seas which will put many island states and low lying areas generally underwater; as the oceans become more acidic and fires begin, the Earth's oxygen level will significantly decline due to the killing of the phytoplankton in the ocean—not only the primary food for fish, but one of the two principal sources of the world's oxygen—and the destruction of the Brazilian rainforest, the other principal source of the world's oxygen; the expansion of deserts, due to widespread drought in many areas resulting in the gradual disappearance of arable land and fresh water sources which could lead to many wars to protect these assets; dangerous, destructive floods where there are not droughts; and enormous and widespread wildfires, much of the world coming to look like southeastern Australia today. The repairs required by the damages created by this level of warming could be so expensive that there would be money for little else.

But, to go on with warming, the plus 4C level appears to be the real battle line that we will be facing in the future, where Earth as we have known it must make a last stand. To exceed this level of plus 4C would put the world on the course toward extinction or at least civilization destruction at plus 5, 6, 7 or 8. At these levels of heat, humans could not live outdoors.

As we proceed through these decades of warming, just one example of the many other problems that must be addressed is worth mentioning—the international estimate that there could be hundreds of millions of climate refugees fleeing parts of the Earth that have become uninhabitable in the next few decades. This is far beyond the issues at the U.S. southern border or in Europe.

The objective has been set in many minds to reduce carbon emissions for energy production by 2050. It is a laudable goal, but probably not sufficient. Many scientists now believe that the world has only about 20 years to eliminate all carbon emissions and do everything it needs to do by 2040 to have a good chance to stop the planet warming short of plus 4C and it should be kept in mind that at some point, global warming becomes irreversible so time, and what can and must be done now, is of the essence.

Emissions to power electrical grids only comprise 40 percent of the problem. Transportation is also 40 percent, this means we must have electric cars, truck and ships. But then, batteries will have to be powered. But, if 80 percent can be solved, surely the remaining 20 percent from industry and agriculture—primarily dairy—can be successfully addressed.

The answer is nuclear power and only nuclear power. Only nuclear power can save civilization and accomplish the defeat of climate change, assisted by hydropower, with renewables perhaps as an adjunct. Nuclear power operates around the clock, takes up a relatively small space compared with renewables. It is reliable and has actually powered cities for generations. We know it can do it. Renewables, that is, solar power and wind power, can remain a source of intermittent power during the critical two or three decades that lie ahead. That is when the game will be won or lost. There is no battery revolution underway at this time that can result in batteries powering all of Abu Dhabi at night. The voice of Michael Schellenberger, a Time Magazine "Hero of the Environment" and President of Environmental Progress should be listened to on this and many other related issues. He strongly asserts that "renewables can't save the planet." He mentions that a mix of renewables and nuclear power rather than just nuclear power results in more carbon emissions due to the unreliability of solar and wind. He points out that those who support renewables are suffering from an appeal-to-nature fallacy no different than when we buy food because it is labeled "natural." Also, only nuclear power—because it is entirely emission free—can successfully power the necessary negative emissions—to reduce the amount of carbon already in the atmosphere essential to stop the continued warming of the planet.

Since the beginning of the Industrial Revolution, humans, through the burning of coal, oil and gas for energy, have released approximately 545 billion metric tons of carbon into the atmosphere, which converts to 2 trillion metric tons of carbon dioxide. Annual emissions are about 37 billion metric tons of carbon per year. So, the world is now approaching over 600 billion metric tons in the atmosphere which will likely stay there for a very long time.

These phenomena have been well understood for many decades, over half a century, but little has been done about it. In 1976, a prominent scientist at the Pacific Northwest Nuclear Laboratory stated in a public paper that the human race was burning fossil fuels—coal, oil and gas at too rapid a rate and the effects on weather patterns and sea levels would be catastrophic. By the early 1980s, all of this was widely understood and serious efforts were undertaken. By the end of the 1980s, there was support for remedial measures by the U.S. President, a consensus within the U.S. government, full support in the Congress, business sector acceptance, public agreement and a world-wide common view, that the use of carbon had to be controlled in some way. Cap and trade laws were what governments had in mind. If the U.S. and other countries had moved forward then, climate change would never have happened. But, the U.S. at the last minute, backed away and without the U.S. the international consensus fell apart. The nuclear industry had deeply and unfairly been discredited by the Three Mile Island incident and so coal production and its use for power spiked. The end result was that climate change was not stopped; indeed, the situation became much worse. In the ensuing three decades, there was emitted into the atmosphere an amount of carbon equivalent to all that had been emitted in the previous nearly 200 years. So here we are today nearing the edge of the cliff.

Over the millennia world temperature and weather patterns have varied considerably, witness the Five Extinctions which took place in the distant geological past. But, for the period of 8,000 to 10,000 years prior to the commencement of industrialization in 1800, scientists believe, the global mean temperature has not varied by more than 1.1 degrees C. And any slight changes were very slow. But now, the situation is different. The planet has warmed a little more than the standard over these recent millennia, some readings as high as 1.3C or even 1.5C have been recorded, but the changes now are happening fast. They are not due to exploding volcanoes, but rather by humanity and fossil fuel use, taking place in decades, rather than millennia.

But we can defeat climate change with nuclear power. Countries have done it. Swedish energy production is virtually carbon emitting free, it is composed of 50 percent nuclear and 50 percent hydro. France is nearly as good, about 72 percent nuclear and nearly 20 percent hydro. There are no alternatives. Every time a nuclear power plant is shut down and not replaced by another nuclear plant, emissions dramatically increase. Nuclear plants have been replaced by natural gas plants in the United States recently creating significant setbacks in the struggle against climate change. Environmentalists should not like this substitution—emissions for that particular site increase from zero to half of the emissions of a coal plant—but have nothing to offer but wishful thinking. Since 2000 wind and solar power have been heavily subsidized but with very little to show for it in terms of net carbon free power. It is important to remember, climate change is not a subject to engage with purely ideological concepts. Reality has to be looked at objectively. We don't want to find out in 2050 that we made a mistake in betting on the wrong technologies. Nuclear power, like it or not, and I recognize some don't like it for both understandable and not understandable reasons, can save us; a heavy commitment to nuclear power will in fact save us, nothing else will. The world needs to use nuclear power to defeat climate change. Nuclear power is not an option for the future it is an absolute necessity.

However, given the short time available, nuclear power deployment has to be done with the technology we now have or will have soon. Fortunately, SMRs and at least some ARs with effort can be available in time. Nuclear power is carbon emitting free, reliable and efficient. Very large numbers of deployed nuclear reactors as fast as possible: to power cities, countryside, electric vehicles, air conditioning and desalinization of water must be built. Big reactors made to power large cities are very expensive. Smaller population areas and remote areas need something cheaper. SMRs can meet these requirements. SMRs, in addition, can be used for desalinization of sea water and thus have an important role in providing the fresh water which will be in shorter supply. Widespread desalinization likely will prove to be a necessary response to this situation. SMRs are super safe. They can be built and installed at a high rate and are entirely passive (no pumps). ARs can add much as well which we will explore during this conference.

Since SMRs are a principal focus of this conference a bit more on the subject is perhaps desirable. By the term SMR, a small type of nuclear reactor is referred to, smaller than conventional reactors, manufactured at a plant and brought to the site for assembly. Modular types of SMRs permit less onsite construction as well as increased efficiency with superior materials security.

One of the principal advantages of SMRs is indeed that they can be manufactured at a central factory location. They can then be installed onsite without much difficulty. These reactors are particularly useful in more remote locations where there is a shortage of trained workers.

Shipping safety and efficiency is always a concern but onsite containment can be more cost efficient and proliferation risks lowered.

SMRs can be more flexible in that they do not have to be connected to a large power grid but can be attached to other modules to acquire more power if necessary. Electricity needs in more remote locations fluctuate and the flexibility of SMR operation is a considerable advantage. Large conventional nuclear reactors tend to be more inflexible and less well suited to serve regions distant from large urban areas.

SMRs generally have a load following design so that the reactor can easily adjust electricity production to more closely follow demand. Many SMRs are designed for use with new fuel concepts that allow for higher burnup and longer fuel cycles. Longer fuel cycles can strengthen proliferation protections. Such longer cycles help in remote areas as well where access is more difficult.

Importantly, SMRs could be used to power large production facilities or large vessels, for example, for seawater desalinization which will be much in demand in the era of climate change as mentioned earlier. Over the years the demand for power for this type of activity could increase significantly all over the world.

Ultimately SMRs may be deployed at many more sites than large power reactors. Thus, SMRs must be inherently safe. This is of course true and indeed is true of all nuclear power reactors, but this imperative is especially strong with SMRs. For example, many might be located in lightly populated or remote locations where a significant lack of trained personnel exists. Thus, many SMRs use what are called passive safety measures. Such features are engineered so that they do not require outside input to operate. Passive safety systems in a SMR require no moving parts to work. Such systems depend only on physical laws and not outside intervention.

Many different safety concepts can be involved in these SMR passive systems—coolants can use natural circulation—convection—so that there are no pumps, no moving parts that could break down. Negative temperate coefficients in the moderators and the fuels keep the fission reactions under control causing the fission reaction to slow as the temperature increases.

Nuclear proliferation is a concern for SMRs as of course for any nuclear reactor. The fact that no civilian nuclear power reactor has ever proliferated into weapons anywhere in the history of the nuclear age is something of which the nuclear industry should be justly proud. Nevertheless, sound plants and constant vigilance, hallmarks of the industry, are required. This is no less the case for SMRs. In fact, this requirement is more compelling for SMRs as they are likely to be sited in far more places than large power reactors. Some AR SMR designs, for example, are such that the individual reactors have lifetime cores so that do not need refueling. This strengthens proliferation safeguards because it means that no onsite nuclear fuel handling is required. Also the modular construction of SMRs is another important feature. Because the reactor core is, as a rule, constructed completely inside a central manufacturing facility, fewer people have access to the fuel before and after initiation.

Many countries have shown interest in SMRs. In addition to the United States which is quite actively pursuing this option, Canada, China, and the United Kingdom are seriously interested and have active programs.

All reactor systems must be built well, but with that understanding, if the world community begins building these many nuclear power plants soon, rapidly and well; promptly deploys them; and operates them safely and efficiently, the world community can and will defeat climate change. The result will be an Earth that is not badly damaged or if it is, it will be sufficiently vibrant to be repairable.

If we do not do this and continue our subservience to fossil fuels, the result will either be an Earth burnt out and broken beyond repair or one which is not even livable by humans. This must not happen.