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Abstract

2011 was a watershed for nuclear power. In March, all eyes focused on Japan, where the world's third severe accident at a nuclear plant unfolded. The accident at the Fukushima Daiichi Nuclear Power Station will have a paradigm-changing impact on the global future of nuclear energy, though its scope and direction still remain to be seen. The author reviews reassessments undertaken around the world after the accident in Japan and underlines Europe's critical role in whether the future of nuclear energy will be global. Japan's nuclear safety shock was sudden and dramatic. But 2011 also witnessed an incremental escalation of continuing crises in North Korea, Iran, and South Asia in the absence of effective global nuclear governance. The author points to the politicization of the International Atomic Energy Agency, its limited authority, and the inability of major powers to cooperate effectively as reasons that nuclear governance remains ineffective. This breakdown in global nuclear governance will also challenge the Nuclear Suppliers Group, which sets the rules for nuclear commerce. The author reflects on 2011 and highlights what to look out for in 2012.

Keywords

Fukushima, governance, IAEA, Iran, North Korea, nuclear energy, Nuclear Suppliers Group, Pakistan

The year 2011 marked the first serious accident at a nuclear power plant in a quarter century. After the previous disaster at Chernobyl, the world's nuclear industry axiomatically predicted that another accident—especially in an advanced country operating conventional light-water reactors—would spell the end of nuclear power everywhere. A year after three US-designed power reactors in Japan melted down in March, that hasn't happened, but the real impact of the accident on the future of nuclear energy worldwide has yet to be felt. The accident focused attention on Japan for nearly half a year. As the threat gradually receded, the world's focus shifted back to flashpoints where nuclear crises have been with us for a long time: Iran, North Korea, and South Asia. These weren't resolved in 2011, and all three appear to be escalating. Two years after the United States recommitted itself to multilateral nuclear diplomacy in 2009, it became apparent that its recommitment was oversold and would not suffice to bridge serious divisions besetting Washington, Beijing, and Moscow—divisions that stand in

the way of resolving nuclear crises in Iran and North Korea, or of effectively contributing to a de-escalation of an emerging nuclear arms race in South Asia.

Beyond Fukushima

The accident at the Fukushima Daiichi Nuclear Power Station will have a paradigm-changing impact on the global future of nuclear energy. But nearly a year after the accident, it isn't clear whether the net impact will be for better or worse. Certainly the accident has shaken predictions that a "nuclear renaissance" is about to bloom worldwide. China's leadership, however, immediately and sagely concluded that the accident in fact provided an opportunity for Beijing to reassess its resolve to leap into a future where the global population of nuclear reactors had been predicted to increase perhaps tenfold during the next 50 years. China is re-evaluating how to move forward with its nuclear program. The rest of the world should do the same.

Fukushima is the world's third severe accident at a nuclear power plant. All three had different root causes. That fact prompted some nuclear power advocates to explain the accident in Japan as caused by an unprecedented and unforeseen, one-off external calamity—a massive earthquake followed by a tsunami—which could be excluded in the threat assessments for most of the 435 reactors on the planet. That logic appealed to most of the 50-plus countries, which, before the accident happened, had announced plans to consider or to deploy nuclear power in the future for compelling reasons: economic growth and development, energy security, and climate change. Most of these countries have not officially veered from their plans to generate future electricity by fissioning atoms.

Political leaders in these countries, despite populations suddenly insecure and restive about nuclear safety after the accident, won't hastily foreclose future energy-generating options. But since March, governments and industry favoring nuclear power have not succeeded in returning to business as usual. While it is self-evident that China, even as it reassesses its own nuclear program, and other Asian countries for now will build most of the world's new power reactors, it is Western Europe—which produces about half its electricity with reactors—that may tip the balance on whether a sustainable global nuclear expansion goes forward.

Right after the Fukushima accident, a heretofore staunchly pro-nuclear German government reversed gears and ordered its 17 reactors phased out. Switzerland then made a similar decision, followed by Italy. Belgium may be next. On the horizon in 2012 are national elections in France, a country that more than any other worldwide has embraced nuclear power. Socialists and Greens aiming to topple President Nicolas Sarkozy this year, and who lead in opinion polls, vow to scale back France's nuclear program and shut down a dozen or more reactors that are already amortized. French industry officials say the shutdowns will stab France's nuclear program in the heart, handcuffing French industry both at home and worldwide.

Would the parts of Europe that have remained steadfast throughout the Fukushima crisis in their plans to build

reactors—Britain, the Czech Republic, the Netherlands—stay on track if France's nuclear program stumbles? Not necessarily. Russia's nuclear export industry, relying on Kremlin-backed bilateral trade deals, is sputtering. Japan's big plans for nuclear expansion were dramatically put on hold in March. China and South Korea will continue on their own to add reactors, but the financial markets that set the pace for investment decisions in the United States would become still less enthusiastic if Europe joins Japan in putting nuclear projects on hold.

Nuclear advocates have argued that a steady and robust increase in nuclear power generation would build public confidence and generate revenues needed to make the transition to a more advanced nuclear technology base that deploys fast reactors and complex fuel cycles. But if a major expansion doesn't happen worldwide, it's hard to see how the transition to a commercially viable, advanced technology will take place except on paper.

Shortly after the accident in Japan, China began a safety reassessment of its nuclear program. Regulators in the United States, Europe, and elsewhere ordered up stress tests for their reactors to ensure that the facilities could withstand various external impacts. Governments and industry have an opportunity to look beyond these scenarios and seriously evaluate whether their nuclear programs have hitherto undetected or unaddressed safety blind spots like those analysts are uncovering in Japan, which ultimately led to the meltdowns. A major contributor to the events in March at Fukushima was massive overconfidence by Japan's industry and government in the safety of the country's nuclear program. That confidence encouraged Japanese regulators and power plant operators for decades to brush off concerns that a serious accident could take place. Will overseers and nuclear power plant owners outside of Japan seize the opportunity to snuff out blind spots in their own nuclear programs? Or will the next serious accident occur somewhere because a chain of events unfolds—as at Fukushima—that had not been foreseen or deemed to be credible?

Finance-energy-climate conundrum

During the past decade, many of the countries that made plans to build reactors confidently expected that they would have the necessary resources: capital, know-how, and infrastructure. They weren't counting on a global financial crisis that could last for years. With bets off now, however, that a long-term global financial crisis can be averted, and in the aftermath of the Fukushima accident, the confidence of nuclear newcomers looks less justified than it did five years ago. Yet, if a significant nuclear capacity expansion does not happen, regional and global competition for other energy resources will increase and result in more greenhouse gas emissions.

Even before the Fukushima accident, the cost of building nuclear power plants began escalating due to competition for resources and manufacturing capacity. In 2002, the US Energy Department predicted an overnight cost of $1,200 per installed kilowatt (kW) for new reactors in the United States. By 2008, overnight cost estimates for the United

States made by outside consultants and potential investors were as high as just under $5,000/kW (some estimates attributed to power plant-selling companies were lower, in the range of $3,000-$4,000/kW). Just before the financial crisis, Taiwan's power-generating company anticipated facing an overnight cost in the middle of this decade five times higher than that predicted by Energy in 2002. When the costs for borrowing capital are added in, the total price tag for one pair of new power reactors in the United States—calculated just before the onset of the financial crisis—was just over $10 billion. That matched the $20 billion that the United Arab Emirates agreed to pay in 2009 for four reactors supplied by South Korean companies. Finance costs are now on the rise. An unconfirmed press report in November 2011 asserted that the cost for the UAE project has since increased by another $10 billion. The UAE has deep pockets and could shoulder project overruns. But that is not the case for many countries that during the last decade began to see nuclear power as an opportunity. And investors in developed economies will be deterred if costs increase such that the return on investment for alternative projects appears greater and less risky than for nuclear projects.

Japan has provided the world a benchmark against which the credibility and sustainability of nuclear newcomers' nuclear energy ambitions must be judged: Japan, with one of the world's most advanced nuclear programs, threw into the management of the Fukushima accident 40 years of experience in operating these reactors plus formidable logistics, money, and management resources. A significant factor in Japan's favor was the political authority commanded by its national government. The accident underlined that countries without the necessary infrastructure should not go nuclear. Many, in fact, may not.

In the short term at least, it can be assumed that foregone nuclear power investments will result in corresponding increases in consumption of fossil fuels and more carbon emissions to the Earth's atmosphere.

The Kyoto Protocol, which went into force in 1997 to provide a framework for a global effort to reduce carbon emissions, may be abandoned in 2012. The financial crisis also looms over efforts to negotiate a replacement agreement. The election of President Obama in 2008 led to optimism that the United States would join the new pact and commit the world's largest economy to reducing emissions. But the country has taken positions that reflect the Bush administration's reluctance to make binding commitments without China and India doing the same. China now emits more atmospheric carbon than the United States, and India's emissions are beginning to soar. The developing countries that overwhelmingly support a new treaty don't have to make any sacrifices. The United States and others volunteered in Copenhagen a year ago to cut their emissions, but the pledges made so far by the big emitters will not be enough to actually reduce the growth in carbon emissions worldwide. In the meantime, the World Meteorological Organization reported that between 2009 and 2010 greenhouse gas emissions reached record levels. China is currently constructing two dozen non-emitting nuclear power reactors, many of which will go online during the next half-

decade. But it is also adding to the grid one 500-megawatt, coal-burning power plant every two weeks.

Battlegrounds of global nuclear governance

During the past decade, the world's global nuclear governance has come unhinged. Beginning in 1958 and until the mid-2000s, the members of the International Atomic Energy Agency (IAEA) resolved conflicts over nuclear issues on the basis of consensus reached at the IAEA's most important decision-making body, its board of governors. About eight years ago this arrangement broke down, and the IAEA has become subject to intense politicization, which has eroded its credibility and hindered its effectiveness. In parallel, the big powers on the IAEA board and in the UN Security Council cannot agree on a common approach to solve important nuclear security issues.

The politicization at the IAEA exists for several reasons: erosion of US–Russian cooperation, cemented by the Cold War, to prevent the horizontal spread of nuclear arms; the rise of equity issues in international nuclear diplomacy; and nearly a decade of discord between the Bush administration and IAEA Director General Mohamed ElBaradei contributed. In 2009, some observers predicted that consensus would be restored with the exit of both ElBaradei and President Bush. In fact, despite Obama's resolve to rededicate the United States to multilateral nuclear diplomacy—and the intention of ElBaradei's successor, Yukiya Amano, to pull together member states drifting apart into opposing North and South blocs—the lack of consensus has continued unabated.

Obama in 2008 pledged to quickly negotiate the New START treaty with Russia, and that happened. But Obama's sought-for rebalancing of US–Russian nuclear relations has proved elusive. Major strategic issues divide the United States from both China and Russia, and this may prevent these three powers from forming a common interest in disarmament or in de-escalating nuclear crises in North Korea and Iran. New START looks like a singular event. The indefinite continuation of Cold War deterrence logic, reiterated in the 2010 US Nuclear Posture Review, reflects a strategic stalemate between US and Russian nuclear forces: Together, they have about 5,000 nuclear weapons ready to fire.

China and Russia have serious strategic differences with the West. In particular, both firmly oppose plans by the United States to deploy ballistic missile defense systems, and they are challenged by Western states' support for the political opponents who toppled Muammar Qaddafi in Libya and those who could oust Bashar al-Assad in Syria. China and Russia have had long-standing close ties to both these rulers, and they also have compelling regional security and economic interests in Iran.

Politicization of the IAEA, its limited authority, and the lack of cooperation of major powers deters effective global governance in areas of crisis that have a nuclear dimension: North Korea, Iran, and South Asia.

North Korea

Just over a year ago, North Korea revealed that it had secretly built a gas

centrifuge uranium enrichment plant and was apparently producing uranium hexafluoride feedstock for the plant and enriching uranium. Following this, China made known that it would rebuff any attempt to bring the matter to the attention of the Security Council. Beijing also prevented a Security Council expert group monitoring international sanctions against North Korea from officially reporting to the Security Council. Before that, China's cooperation with the expert group preparing the report was limited; information obtained by the group from other countries indicated that Chinese entities had helped enable North Korea to evade sanctions and that North Korea had set up additional uranium enrichment facilities. In September, China and Russia objected to the IAEA's reporting on North Korean nuclear activities to the board of governors—anticipating their objections three months later about an IAEA report to the board on Iran—and they interfered with a Western-led effort to condemn North Korea's continued safeguards non-compliance and provocative enrichment activities.

During the last eight years, six rounds of Six-Party Talks were held, during which time North Korea may have initiated missile and nuclear cooperation with Myanmar, aided clandestine nuclear programs in Iran and Syria, and moved forward with a program to establish a self-sustaining nuclear weapons program on the basis of indigenously produced high-enriched uranium fuel. With North Korea having quit the Nuclear Non-Proliferation Treaty (NPT), efforts to defuse the North Korean nuclear crisis currently rely upon three Security Council powers plus South Korea and Japan. But North Korea has exploited differences among Security Council veto powers to avoid greater sanctions and efforts to interdict its peddling of WMD wares. A newly assertive policy by the United States in the western Pacific may halt budding cooperation between North Korea and Myanmar. But North Korea's bid this fall to return to the Six-Party Talks, sweetened by a nuclear test moratorium offer by Pyongyang, could buy North Korea more time to establish itself as a power that could deliver a nuclear payload using ballistic missiles.

Iran

The same dynamics—a politicized IAEA and big power discord—have provided Iran opportunities to prolong a crisis unleashed in 2003 when the IAEA found that for 18 years Iran had systematically failed to declare nuclear activities as required by Iran's safeguards agreement. As we now know, based on statements from previous Iranian negotiators and from ElBaradei, Iran aimed to drive a wedge between the United States and European powers in supporting and eventually agreeing to a plan brokered by Britain, France, and Germany to get Iran to suspend uranium enrichment. European powers saw Iran as a potential sphere of influence in a greater Middle East dominated by the United States. European Union members with energy interests in Iran—most importantly Italy—set the agenda in discussions on how to respond to Iran's challenge to the IAEA.

Today, tactical maneuvering by big powers still inhibits a resolution of the Iran nuclear crisis. The United States and the European veto powers are united—more than ever before—in their

resolve to ramp up pressure on Iran, on the basis of findings that Iran's military has been deeply involved in its nuclear program and that Iran over many years has carried out activities related to the development of nuclear weapons. China and Russia, however, firmly reject additional sanctions against Iran, and they opposed the IAEA's report to the board of governors on weapons-related activities.

At the IAEA, Iran has consistently mobilized support from the Non-Aligned Movement—which it will chair beginning in 2012—to oppose resolutions intended to result in more Security Council sanctions.

By the end of 2011, the Iran crisis reached a state of dangerous paralysis. Following the IAEA report released in November 2011, US allegations that Iran aimed to assassinate the Saudi Arabian ambassador in Washington, DC, and an apparently orchestrated attack on the British Embassy in Tehran, the United States and European powers have set a policy course firmly geared toward increasing sanctions and containment of Iran. This year, Republicans will pressure President Obama not to attempt a diplomatic resolution—and it appears in any case that Washington sees little prospect in negotiating with the current regime. China asserts that it favors a diplomatic resolution to the crisis but has not come forth with any constructive contribution toward a roadmap to negotiate. Russia floated a sketchy negotiating offer to Iran last summer, but the West rejected it as too conciliatory, and Iran has not actively embraced it. Iran has a policy of appearing to cooperate with the IAEA. Iran in any case now seems prevented from negotiating effectively by a power struggle going on inside the country over who leads the state. Israeli leaders in the meantime have increased pressure by threatening to attack Iran's nuclear installations unless the conflict is resolved in less than a year. In the meantime, Israel and the United States have embarked upon a cyber war and the use of sabotage to cripple Iran's nuclear program; because the West's infrastructure is far more developed than Iran's, this approach could pose great risks to the West should Iran or non-state actors on its behalf effectively retaliate.

South Asia

A growing disequilibrium between India's development into a global power and Pakistan's myopic focus on its bilateral contest with India is driving what looks like a destabilizing and dangerous arms race in South Asia. Pakistan sees itself as surrounded by adversaries in Afghanistan and India, pinned down by domestic extremists; its relations with the United States are at an all-time low, its civilian government is weak, and its economy is failing. India's surging development and its growing ties with the West mean that, in addition to the manpower advantage India's military has always enjoyed, India will have modern weapons systems.

Both sides are augmenting their nuclear weapons inventories. Since 2010, the two states together have added over 50 nuclear weapons. Pakistani perception of its growing vulnerability to India's conventional plus nuclear arsenal has prompted R&D efforts to develop battlefield nuclear weapons based on plutonium. These could be deployed in a crisis should Pakistani surrogates launch a terrorist

attack against India or should conflict in Kashmir again erupt and escalate into an Indian military incursion into Pakistan that Pakistani conventional forces fail to halt. Previous military encounters over a 30-year period suggest that the probability that India or Pakistan will miscalculate during such a crisis is considerable. Pakistan's plutonium-production capabilities in recent years have been rapidly expanding; it has added a second reactor at its Khushab complex in the Punjab and is building two more units there.

Both countries developed nuclear weapons capabilities over a period of four decades. India's effort was largely indigenous. Pakistan relied on some assistance from China until the 1990s. So far, there is no coordinated effort by the Security Council veto powers to intervene diplomatically to de-escalate the nuclear arms buildup in the region. At the UN Conference on Disarmament, Pakistan refuses to negotiate terms of a treaty to ban the production of fissile material for nuclear weapons, known as the Fissile Material Cut-off Treaty (FMCT); and it is quietly supported by Beijing, which may harbor concerns that, should China not resolve ongoing strategic issues with the United States, it may at a future time need to produce more nuclear weapons fuel. It is also possible, even likely, that India would not agree to an FMCT. And neither India nor Pakistan will join the Comprehensive Nuclear Test Ban Treaty.

Right now, nearly 40 percent of the world's population lives in China and India, two of the three nuclear-armed states that are members of the Non-Aligned Movement. Of all nuclear-armed states, only two countries in the movement—Pakistan and India—are presently engaged in an arms race. Since the big powers have failed to deter them from accelerating their nuclear weapons programs, it would be desirable and may be possible for the Non-Aligned Movement to intervene diplomatically. In recent years, the movement has raised its profile in international nuclear matters, setting up a chapter in Vienna in addition to those it has in Geneva and New York; it has also raised its voice, challenging the United States and Russia on disarmament issues and the United States and other Western states on nonproliferation issues, including Iran. If the movement were to be actively engaged on the South Asian nuclear buildup, it would establish greater credibility outside of its own membership.

The nuclear trade regime

The breakdown in global nuclear governance has also played out among countries that participate in the Nuclear Suppliers Group (NSG), which sets the rules for global nuclear commerce. During the last decade, in a deal worth $700 million, Russia supplied nuclear fuel to India, contravening rules that it and the others had established not to export nuclear items to states with nuclear weapons programs outside the NPT. In 2008, Russia and France joined the United States in persuading the NSG to grant India an exception in principle from that rule. And last year, China confirmed it is now prepared to export power reactors to Pakistan.

China's challenge to the NSG's discipline and credibility is just one of a number of issues it must face in 2012 and beyond in anticipation that the

volume of nuclear trade—and the number of actors involved—will significantly increase. Originally a club of seven advanced and likeminded nuclear states, the NSG's membership is now 46; and in coming years, it could include for the first time a large number of developing states, many of which are members of the Non-Aligned Movement and wary of efforts by the Western powers to curtail nuclear trade due to proliferation concerns. The group also must derive a strategy to respond to a nuclear trading world that is extensively globalized, featuring complex transactions, electronic-technology transfers, and greater participation by brokers and other intermediaries. For several decades until 2003, non-state actors operating in over 30 countries proliferated uranium enrichment know-how and related equipment from Europe to Pakistan and from there to Iran, Libya, North Korea, and perhaps beyond.

In 2011, the NSG concluded a seven-year negotiation on new rules for commerce in enrichment and plutonium separation-related items. A bigger group of states, divided on North-South lines, might fail to agree on any future global rules.

The year ahead

As of yet, the Fukushima accident has not resulted in a dramatic halt to nuclear power programs worldwide. Many countries are hedging their options because they face serious energy security challenges. And though the accident may prompt governments and industry to improve the safety case for nuclear energy, they have little time: In 2012, French elections could be a tipping point on whether nuclear power has a truly global future. The Fukushima accident is already contributing to a slowdown in anticipated reactor construction worldwide, since it will add to investors' concerns about risk and return on investment. Fossil fuel investments will substitute for shuttered nuclear plants and foregone nuclear investments, marginally contributing to growing greenhouse gas emissions, which continue to rise to record levels.

Global nuclear governance will continue to be an issue throughout 2012, especially in Iran, North Korea, and South Asia. Multilateral diplomacy on North Korea has not interrupted—and may have indirectly abetted—Pyongyang's drive toward de facto nuclear weapons power status. As on Iran, the policy of the United States and its allies on North Korea is a policy of containment. The Western shift in progress toward a policy of greater pressure on Iran may put the United States and European powers on a collision course with China and Russia, and suggests that some Western powers might favor some kind of regime change in Iran over a negotiation that could result in the lifting of sanctions against an Iran under its current leadership that retains its nuclear assets and enriches uranium. In 2011, Iran's nuclear crisis advanced to an unprecedented acute level as a result of Israeli threats, Iran's paralysis, and the upcoming US presidential election. In South Asia, a nuclear arms race is getting underway, fueled by a growing political, economic, and strategic divergence between Pakistan and India, as Pakistan continues to decline and India reaches for global power status. Little so far has been done by outside powers to arrest these destabilizing developments.

In 2012 and beyond, nuclear supplier countries must make decisions to effectively respond to the challenge of a rapidly evolving globalized trading environment. The NSG may have less than a decade to make critical necessary adjustments to forestall a wave of proliferation that could accompany the continued spread of nuclear technology into new markets.

The most challenging nuclear events in 2011 transpired at different speeds. Fukushima was a sudden and dramatic shock. The deterioration of the nuclear security environment in Iran, North Korea, and South Asia happened in slow motion. The cumulative impact of these developments, however, will make the world's nuclear future more uncertain.

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Author biography

Mark Hibbs is a senior associate in Carnegie's Nuclear Policy Program, based in Bonn and Berlin. Before joining Carnegie, for over 20 years he was an editor and correspondent for nuclear energy publications, including *Nucleonics Week* and *Nuclear Fuel*, published by the Platts division of the McGraw-Hill Companies. From the late 1980s until the mid-1990s, he covered nuclear developments in the Soviet bloc, including research on the USSR's nuclear fuel cycle facilities and its nuclear materials inventories. Since the mid-1990s, his work has focused on emerging nuclear programs in Asia, including China and India. Since 2003, he has made many detailed findings about clandestine procurement in Europe related to gas centrifuge uranium enrichment programs in Iran, Libya, North Korea, and Pakistan. His Carnegie report, "The Future of the Nuclear Suppliers Group," was published in December.