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Statement before the U.S.-China Economic and Security Review Commission

"U.S.-CHINA CLEAN ENERGY COOPERATION"

A Statement by

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Good morning Commissioner Goodwin and Commissioner Cleveland, and other esteemed members of the Committee. I would like to thank the Commission for the opportunity to testify about U.S.-China nuclear energy cooperation. It is an honor to participate in this hearing.

My remarks today will address the scope and status of civilian nuclear energy cooperation between the United States and China. The United States has a wealth of expertise in nuclear regulatory matters as well as strong capability in reactor design and technical innovation, yet the U.S. nuclear industry has lost the robustness it once had in manufacturing and deploying nuclear reactors. In contrast, China has a growing nuclear energy sector with a national drive to become a global reactor supplier yet is short of regulatory expertise and technological capacity. These complementary abilities provide a unique synergy and basis for growing bilateral cooperation. Today I will touch on key elements of China's nuclear energy policy and program, bilateral engagement between the two nuclear sectors as well as between the two regulatory bodies, and challenges and opportunities associated with such engagement that has been transforming from one of *co-existence* to one of *mutual dependence*. Please note that my scope does not include nuclear security or nonproliferation.

China's Nuclear Sector and Chinese Nuclear Energy Policy

China is becoming a major player in civilian nuclear energy. While the country has only 20 reactors online (accounting for about 2 percent of total generation capacity),[1] it has 29 reactors under construction, representing roughly 40 percent of reactor construction around the world.[2] Even more staggering, the World Nuclear Association has stated that an additional 58 reactors are being planned (including 24 inland units whose construction is deferred to until after 2015).[3]

[1] China Nuclear Energy Association, *Nuclear Power Operation Status for the First Quarter of 2013*, June 2013, p. 1. (2013 *nian di yi ji du he dian yun xing qing kuang*)
[2] World Nuclear Association, *Nuclear Power in China,* updated April 2014.
[3] Ibid. The construction delay for planned inland reactors stems from the public concern over how to dispel polluted water in case of a major incident.

The enormous growth in China's energy demand over the last decade has made nuclear energy expansion a practical way to address the country's growing dependence on energy imports as well as to help reduce the country's severe air pollution. Coal has been an important part of that strategy (coal accounts for nearly 70 percent of China's primary energy consumption and its electricity demand[4]), but air pollution in China has led the leadership to seek low-carbon alternatives. As a technologically proven and no-carbon source of electricity, nuclear energy has come to play a central role in China's plan to diversify its fuel mix away from coal. Consequently, the civilian nuclear sector's remarkable expansion is attributable to the strong political and policy support it enjoys.

The Chinese government approved the country's first nuclear power plant in 1982,[5] but nuclear energy was not integrated into China's overall strategic energy plan until the 10th Five-Year Plan (FYP, 2001-2005). With this strategic push, nuclear energy began expanding with the construction of four reactors during the 10FYP.[6] This was followed by the Medium- and Long-Term Nuclear Power Development Plan of 2007, which called for 40 GW of installed capacity by 2020, or about 5 percent of the total energy mix.[7] In 2008, in recognition of the rising prominence of nuclear energy, nuclear energy policymaking was moved out of the State Administration of Science Technology and Industry for National Defense[8] and became part of the National Development and Reform Commission, the powerful economic planning agency in China.

The role of nuclear energy was further elevated under the 11FYP (2006-2010). The mandatory 20 percent energy intensity reduction under the 11FYP provided momentum for developing clean energy sources such as nuclear power. Government-backed investment into heavy industry followed the heightened government commitment to encourage the development of nuclear manufacturing.[9] By 2009, government investment totaling about $49.2 billion (RMB 300 billion) is said to have gone into four key Chinese nuclear manufactures of reactor components like pressure vessels, steam generators, and steam turbine generators.[10]

The national efforts to raise non-fossil energy to 11.4 percent of total primary energy use and to reduce carbon intensity by 17 percent—both under the 12th FYP (2011-2015)—continue to drive nuclear energy expansion. Before the Fukushima nuclear accident in March 2011, the Chinese government had indicated that up to 86 GW by 2020 and as much as 500 GW by 2050 could be installed in the country.[11]

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[4] U.S. Energy Information Administration, *Country Analysis Brief—China*, last updated: September 4, 2012.
[5] Bo Kong, "Civil Nuclear Energy Development in China and U.S.-China Nuclear Cooperation," presentation at Brookings Institution seminar, Washington, D.C., Sept. 17, 2010.
[6] World Nuclear Association, *Nuclear Power in China,* updated April 30, 2013.
[7] World Nuclear Association, *Nuclear Power in China*, updated September 2011.
[8] Zhou, Y., et al., *Is China Ready for its Nuclear Expansion*? *Energy Policy* (2010), doi: 10.1016/j.enpol.2010.10.051, p.2.
[9] Ibid., p.6.
[10] Ibid.
[11] World Nuclear Association, *Nuclear Power in China,* updated September 2011.

Post-Fukushima Development in China

The multiple reactor meltdown accident at the Fukushima Dai-ichi Nuclear Power Station led to a pause in Chinese nuclear development, but unlike in neighboring countries, the accident did not lead to a fundamental reassessment of China's nuclear energy policy. Nonetheless, the Chinese government took the matter seriously, immediately halting approval of all reactor construction. This moratorium also affected the four approved units that were scheduled to start construction in 2011.[12] Within a week of Fukushima, the government had also ordered safety inspections of the country's 11 operational reactors and the 26 reactors that were already under construction.[13]

These safety inspections illuminated shortfalls in 16 areas that mainly concern emergency backup systems, flooding prevention, and earthquake-related safety issues.[14] Many of these safety concerns found their way into the 12th FYP (2011-2015), approved around the same time as the reactor inspection report in 2012. The plan recognized that while most Chinese nuclear plants meet existing domestic safety regulations and International Atomic Energy Agency safety standards and requirements,[15] investment of nearly RMB 80 billion ($13 billion) would be needed by 2015 to improve safety at both operating reactors and reactors under construction.[16]

Another notable development post-Fukushima was the introduction of a new government nuclear safety plan in October 2012. Unequivocally stressing the paramount importance of safety, the new plan called for domestic safety regulations to fully incorporate the internationally accepted level of safety standards by 2020, and for levels of nuclear safety-related research and development to be enhanced.[17] More significantly, the plan also recommended that older reactors be phased out in a timely manner.[18] The much stricter standards for new nuclear construction under the new nuclear safety plan—particularly the elimination of large radiation releases in units built beyond 2016—will likely accelerate the country's fleet switch away from Gen II reactors,[19] which accounted for roughly half of the units under construction and many on order in China right before the Fukushima accident.

Again, despite considerable government attention on nuclear safety issues, Fukushima did not alter the Chinese commitment to nuclear power. Although the post-Fukushima

[12] World Nuclear Association, *Nuclear Power in China*, updated March 2013.

[13] At the time of Fukushima accident, 34 reactors had construction approval, including the 26 units already being built. See World Nuclear Association, *Nuclear Power in China*, updated March 2013

[14] Report on the Status of Safety Inspections on Civilian Nuclear Facilities across the Country (*Guan yu quan guo min yong he she shi zong he an quan jian cha qing kuang de bao gao*), National Nuclear Safety Administration, National Energy Administration, and China Earthquake Administration, p. 8-9.

[15] Ibid., p. 4-5.

[16] 12th FYP for Nuclear Safety and Radioactive Pollution Prevention and Vision for 2020, Ministry of Environmental Protection, National Nuclear Safety Administration, National Development and Reform Commission, Ministry of Finance, National Energy Administration, and National Defense Science and Technology Industrial Development Bureau, p. 19, http://haq.mep.gov.cn/gzdt/201210/W020121016305772730116.pdf.

[17] Fayen Wong, China issues nuclear safety blueprint, eyes $13 billion investment, Reuters, October 16, 2012.

[18] Ibid.

[19] Yun Zhou, "China Responds to Fukushima," *Bulletin of the Atomic Scientists*, June 28, 2012.

safety inspections temporarily slowed the pace of new builds, the October 2012 safety plan lifted the moratorium on new reactor construction and the Chinese government left its 2015 target for installed capacity unchanged at 40 GW.[20] The government also revised a 2020 target at 58 GW. Moreover, the country's White Paper on Energy Policy in October 2012 reaffirmed the central role for nuclear energy in raising the share of non-fossil fuels in the primary energy mix. The White Paper also included plans to "invest more in nuclear power technological innovations, promote application of advanced technology, improve the equipment level, and attach great importance to personnel training."[21]

Growing Commercial Engagement

With notable levels of state assistance, China is fast becoming a formidable force in the global nuclear energy industry. However, the country has struggled to achieve a balance between its stated desire for self-reliance and domestic production and its relatively limited technological capabilities. This has led to a strategy of engaging western vendors in order to accelerate its ability to strengthen its reactor design capability and to improve the safety standards of its commercial reactor fleet.

China's nuclear energy development vision has placed a strong emphasis on self-reliance. Their notion of self-reliance entails building capabilities to establish a fully integrated domestic supply chain, including self-reliance for reactor design, with the long-term objective of exporting nuclear reactors to a global marketplace. However, technology development has been a major challenge for the Chinese nuclear sector, where a select number of state-owned nuclear companies long struggled to develop advanced reactor technology based on older reactor imports—mainly from France, but also from Russia and Canada. The lack of an authoritative research and development (R&D) institution, combined with the inability of China National Nuclear Corporation to effectively coordinate nuclear research across the sector, impeded China's technology adoption.[22]

In fact, China's tendency to build older-design reactors has become a particular concern in light of its aspiration for robust fleet expansion. These older "Generation II" design reactors were originally developed in the 1960s, and do not include many advances (for example in areas such as safety, fuel technology and thermal efficiency) that now come with newer generation reactors—the so-called Generation III or III+—that were developed in the 1990s and are being built around the world today.

It was this Chinese frustration that led the State Council to establish the State Nuclear Power Technology Corp. (SNPTC) in May 2004 as the major contractor for foreign suppliers and to approve to source Generation III nuclear technology from overseas through an open bidding process.[23] After a year-long evaluation, SNPTC selected AP-

[20] The Information Office of the State Council, *China's Energy Policy 2012*, www.gov.cn/english/official/2012-10/24/content_2250497_5.htm
[21] Ibid.
[22] Zhou, Y., et al., *Is China Ready for its Nuclear Expansion*? *Energy Policy* (2010), doi: 10.1016/j.enpol.2010.10.051, p.2.
[23] World Nuclear Association, *Nuclear Power in China,* updated April 2014.

1000 reactors.[24] Among the key reasons was that AP-1000's small-modular construction may allow for rapid construction and better cost control as well as a greater degree of localization.[25]

Construction of the Gen III+ pressurized water reactor (PWR) began in 2009 at the Sanmen site in Zhejiang province and at the Haiyang site in Shandong province. The sale of AP-1000 reactors included a technology transfer agreement that has allowed SNPTC to acquire over 75,000 technology transfer documents from Westinghouse since 2010.[26] The Sanmen Unit 1 is slated to be the first operational AP-1000 reactor in China and in the world when it comes online later this decade.[27]

The AP-1000 sale was also a milestone for the U.S. nuclear industry, which gained a significant foothold in China's growing nuclear power sector. According to the Westinghouse documents, each Westinghouse project in China creates or sustains as many as 5,000 jobs in the United States. The prospect for further commercial cooperation remains strong for U.S. nuclear industry stakeholders, at least for the short to medium term, as the Chinese strive to improve their learning curve for advanced reactor manufacturing and deployment. Reportedly, China has eight new AP-1000 reactor units planned at the Sanmen and Haiyang sites[28] and several dozen additional AP-1000 units proposed for construction.[29] U.S. vendors, including Westinghouse, are expected to be involved in the future AP-1000 projects in China.

Deepening Safety and Regulatory Cooperation

According to a nuclear safety aphorism, "A nuclear accident anywhere is an accident everywhere." Fukushima has rightly heightened the need for higher safety standards around the world, including in China. There has been concern both within China and internationally about the growing gap between the rapid pace of Chinese nuclear expansion and the country's institutional capacity, both in terms of regulatory framework and human resources. Specifically, China's nuclear regulators are regarded as lacking sufficient authority and independence to effectively regulate the growing nuclear fleet. The regulatory body is also woefully understaffed and under-experienced. In this light, bilateral cooperation in the area of nuclear safety and regulations has become an important area of civilian nuclear energy cooperation between the two countries.

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[24] World Nuclear Association, *Nuclear Power in China,* updated March 21, 2013.
[25] World Nuclear Association, *Nuclear Power in China,* updated March 21, 2013.
[26] Westinghouse Electric gives reactor documents to China, E&E Wire, November 24, 2010.
[27] Sanmen Unit 1 was originally schedule enter operation by the end of 2014. But, according to a Chinese presentation at the International Atomic Energy Agency technical meeting, the construction is said to be at least 24 months behind and 20 percent over budget. (Shan Sun, "Challenges during construction of new NPPS," at the IAEA Technical Meeting, February 4-7, 2014. http://www.iaea.org/NuclearPower/Downloadable/Meetings/2014/2014-02-04-02-07-TM-INIG/Presentations/37_S7_China_Sun.pdf)
[28] Matthew Miller, "China seen buying Westinghouse reactors for $24 billion nuclear energy projects," Reuters, April 21, 2014. http://www.reuters.com/article/2014/04/21/china-nuclear-idUSL3N0ND1GS20140421
[29] World Nuclear Association, *Nuclear Power in China,* updated April 2014.

The Protocol between the U.S. Nuclear Regulatory Commission and China's National Nuclear Safety Administration on Cooperation in Nuclear Safety Matters, signed in 1981, governs cooperation on regulatory matters concerning civilian nuclear power plants such as assessment and inspection of construction, operation and decommissioning, emergency preparedness and radiation protection through the exchange of information and specialists, as well as collaborative research and joint seminars.[30] Personnel training by the U.S. Nuclear Regulatory Commission (NRC) has been a significant part of this engagement. Chinese regulators are allowed to accompany U.S. inspectors on operating reactor and reactor construction inspections in the United States, as well as participate in NRC staff training at the NRC's facility in Tennessee.[31] For example, under the auspices of the NRC Assignee Program, which provides foreign regulators with hands-on training in the United States for six to twelve months, the NRC has trained several Chinese regulators.[32]

Furthermore, with the Chinese approval of the AP-1000 reactor, nuclear regulatory cooperation has become a two-way street. The sale of Westinghouse AP-1000 reactors to China in 2007 ushered in a new era for regulatory engagement between the United States and China. China's decision to begin constructing the U.S.-designed advanced reactors ahead of the NRC design certification[33] provides U.S. regulators with an opportunity to learn from the Chinese experiences, which could improve their regulatory expertise concerning future AP-1000 reactor units in the United States, including the four units that received NRC approval for construction and operation in 2012. For example, during 2011-2012, two NRC resident inspectors visited China for three months and another inspector visited China as a technical reviewer for one month to engage about lessons learned from ongoing AP-1000 construction at the Sanmen and Haiyang sites.[34] During the U.S.-China Strategic and Economic Dialogue meeting in July 2013, the two governments formally reaffirmed their mutual interest in deepening personnel exchange and sharing expertise on AP-1000 construction and licensing.[35]

U.S. and Chinese regulators also cooperate through the AP-1000 Workshop Group under the Multinational Design Evaluation Programme (MDEP)[36] that is designed to facilitate safety reviews of the AP-1000 design, including sharing of design information, application documents, and preliminary findings, as well as identifying significant review

[30] *Protocol between the Nuclear Regulatory Commission of the United States of America and the National Nuclear Safety Administration of the People's Republic of China on Cooperation in Nuclear Safety Matters*, signed in 2008. This protocol was amended and extended in 1986, 1993, and 1998 and renewed in 2004.
[31] Ibid.
[32] *Multinational Design Evaluation Programme Annual Report March 2011 – March 2012*, June 2012, Nuclear Energy Agency, p. 19.
[33] The NRC certified the AP-1000 design at the end of 2011.
[34] *Multinational Design Evaluation Programme Annual Report March 2011 – March 2012*, June 2012, Nuclear Energy Agency, p. 19.
[35] U.S.-China S&ED Outcomes of the Strategic Track, July 13, 2013. http://www.china.org.cn/business/2013-07/13/content_29412960_5.htm
[36] Spearheaded by the Nuclear Energy Agency, this program was established in 2006 to leverage the resources and knowledge of the national regulatory authorities that are or will be tasked with reviewing new reactor designs.

issues.[37] Additionally, the participating regulators have shared information on their construction experience and how lessons from the Fukushima accident could be applied and affect their review of the AP-1000 design.[38]

Continued Government Cooperation over Nuclear Energy Technology

The U.S. and Chinese governments also cooperate on nuclear energy technology. The research and development (R&D) cooperation in this area allows for multiplier effects in funding and human resources that may otherwise be limited or are often too vulnerable to fluctuations in public support, as well as to advance the state of nuclear energy technology through synergizing one another's expertise or comparative advantage.

For example, under the "U.S.-China Peaceful Uses of Nuclear Technology Agreement," signed in 1998, the United States and China are currently focusing on technology matters related to the current fleet of operational reactors. Since the Fukushima nuclear accident, cooperation has been renewed on probabilistic safety assessment (PSA),[39] which in fact is one of the areas identified by the Chinese government for improvement after the nation-wide reactor safety inspection. Specifically, this cooperation has yielded several PSA workshops under the technical leadership of the Argonne National Laboratory that helped the Chinese engineers to improve their understanding of risk that is informed by decision-making methodologies.[40]

More advanced and longer term cooperative R&D in nuclear energy technology is carried out under the auspices of the U.S.-China Bilateral Civil Nuclear Energy Cooperative Action Plan, signed in 2007. Designed to "explore advanced nuclear fuel cycle approaches in a safe, secure and proliferation-resistant manner,"[41] the two countries cooperate in the areas of advanced fuel cycle technology, fast reactor technology, and small and medium reactors.[42] Also, the two countries undertake R&D cooperation under the auspices of the bilateral memorandum of understanding on "Nuclear Energy Sciences and Technology Cooperation."

Additionally, the two governments are engaged in several multi-lateral nuclear energy cooperation fora, such as the GEN IV International Forum and the International Forum for Nuclear Energy Cooperation.

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[37] *Multinational Design Evaluation Programme Annual Report March 2011 – March 2012*, June 2012, Nuclear Energy Agency, p. 19.
[38] Ibid.
[39] Suzhou Nuclear Power Research Institute, *The Fourth Conference on U.S.-China Peaceful Use of Nuclear Technology and Cooperation in Probabilistic Safety Assessment Cooperation as Held Successfully (zhong mei he ping li yong he ji shu he zuo he dian gai lv an quan fen xi di si ci yan tao hui shun li zhao kai)*, October 29, 2012, http://www.360doc.com/content/12/1105/08/4609583_245795800.shtml
[40] "The Fourth Conference on U.S.-China Peaceful Use of Nuclear Technology and Cooperation in Probabilistic Safety Assessment Cooperation as Held Successfully" *(zhong mei he ping li yong he ji shu he zuo he dian gai lv an quan fen xi di si ci yan tao hui shun li zhao kai)*, Suzhou Nuclear Power Research Institute, October 29, 2012, http://www.360doc.com/content/12/1105/08/4609583_245795800.shtml.
[41] United States-China: Bilateral Civil Nuclear Energy Cooperative Action Plan, p. 3. http://www.nti.org/media/pdfs/1a_1_1.pdf?_=1317157933
[42] Ibid., p. 5.

Implications for the United States: Benefits and Challenges of Cooperation

To the Chinese leadership, the expansion of nuclear power generation is a politically practical and economically viable means of moving the country away from its heavy coal dependence and attendant air pollution. China's commitment to growing its nuclear power generation is independent of U.S. action—for example the level of U.S. government support for nuclear energy or the degree to which the U.S. nuclear industry is interested in working with China. Nonetheless, cooperation with U.S. regulators and the U.S. civilian nuclear science and technology community and industry has significantly helped China narrow the gap between its robust expansion of nuclear power and its institutional and technological capacity deficit.

In turn, the enhanced nuclear regulatory capacity in China through cooperation with and assistance from U.S. regulators is in a concrete benefit to the U.S. public—i.e., the safety of U.S. nationals residing in and traveling to China as well as U.S. economic interests there. Also, Chinese success in diversifying its electricity supply mix and burning less coal would be a clear benefit for the climate. Additionally, nuclear energy technology cooperation is one valuable way for the United States to foster and preserve its domestic expertise through the access to financial resources and S&T expertise of its cooperation partner in exchange for contributing its resources and expertise. Furthermore, the active reactor build-out involving U.S.-based design provides U.S. regulators and engineers with first-hand observations and exposures that may otherwise be limited in the United States.

Bilateral cooperation is not free of challenges, both real and potential. China's industrial structure and lower manufacturing costs will likely turn the country into a fierce competitor to the U.S. nuclear industry when—rather than if—the Chinese successfully "indigenize" Gen III/III-plus technology. In fact, the Chinese nuclear sector is accelerating efforts to develop and deploy large advanced PWRs based on the AP-1000 reactor. This initiative, identified as one of the 16 "national projects" under China's Medium- and Long-Term National Science and Technology Development Plan (covering 2006-2020),[43] led to the development of advanced PWR named CAP-1400 by SNPTC and Shanghai Nuclear Engineering Research and Design Institute (SNERDI).

With its basic design approved by the Chinese government in early 2014, at least one CAP-1400 reactor unit is slated for construction later this year and targeted to come online in the 2017-2018 timeframe. More significantly, the Chinese do not intend to keep these reactors at home. According to various Chinese statements and media reports, CAP-1400 intellectual property rights reside with the Chinese entities, referring to their agreement with Westinghouse half a decade ago that reportedly gave the Chinese domestic rights to much of the core AP-1000 derivatives over 1,350 MWe. Some questions that may arise from this development include whether there is an intellectual

[43] Ministry of Science and Technology, "Zhuanxiang Jieshao". http://www.nmp.gov.cn/zxjs/ [accessed April 15, 2014] This plan aimed at enhancing economic productivity and national security using science and technology.

property rights concern and, if a dispute arose in the future, how it would affect the future scope of bilateral commercial engagement.

The Chinese nuclear market was too attractive for Westinghouse not to market its most advanced reactors, even at the price of extensive technology transfer that would bolster the technological competitiveness of Chinese vendors. Moreover, U.S. industry participants knew that even if the U.S. vendor stayed away, China would have acquired Gen III reactors from other suppliers. The sale of EPRs by Areva of France to China is a case in point: in 2007, Areva won a contract to supply two units of EPRs to be built at Taishan in Guangdong province.

Westinghouse is believed to have decided that there was more to be gained than lost by establishing a presence in China's nascent yet growing market. In fact, the AP-1000 sale has accorded the U.S. nuclear industry not only financial gains but also valuable insights into the capacity of Chinese nuclear sector, such as the maturity level of its supply-chain and various non-hardware capabilities, that may otherwise be inaccessible.

Whether nuclear energy cooperation in the commercial sphere could yield greater long-term challenges than advantages to the U.S. economy is a question that has no simple answer. The globalization of civilian nuclear capabilities renders the task of quantifying the exact scope of economic benefit to the U.S. nuclear sector remarkably challenging regardless of the pace of successful "indigenization" by the Chinese nuclear sector. In fact, the supply chain for nuclear projects in China had globalized since before the May 2013 announcement by Westinghouse to launch a joint venture with SNPTC to develop a global supply chain for the AP-1000 reactors. For example, the equipment and components for the initial four AP-1000 units in China include pressure vessels from Doosan of South Korea, steam turbine generators from Mitsubishi Heavy Industries of Japan, steam generators from ENSA of Spain, as well as reactor coolant pumps by Curtiss-Wright of the United States. Also, under a $35 million contract, signed in 2011, Westinghouse will begin technology transfer to China Baotou Nuclear Fuel whereby the company will "design, manufacture and install fuel fabrication equipment that will enable China to manufacture nuclear fuel" for AP1000 units being built in China.[44] While the Westinghouse announcement strongly indicates that China Baotou's facility will supply only to AP-1000 units in China, it remains unclear whether the Chinese would be explicitly barred from supplying fuels to future AP-1000 reactor units in the United States or elsewhere outside China.

The increasingly globalized supply-chain, however, does not negate the need for U.S. regulatory expertise or undermine the value of bilateral cooperation. In fact, such globalization could heighten the stake of U.S. nuclear regulators and industry in the qualitative aspects of the Chinese nuclear industry development. According to the World Nuclear Association, the number of Chinese manufacturers of nuclear-grade components

[44] "Westinghouse in Contract to Provide Fuel Fabrication Equipment to China," PRNews, January 18, 2011. http://www.prnewswire.com/news-releases/westinghouse-in-contract-to-provide-fuel-fabrication-equipment-to-china-114162809.html. Note that Westinghouse is to supply the initial fuel load and some re-loads of the initial four AP-1000 units in Sanmen and Haiyang.

that are accredited by the globally recognized American Society of Mechanical Engineers grew from only six at the end of 2009 to 26 by the end of 2011.[45] Moreover, globalization could accelerate to expand a range of Chinese supplies for nuclear power plants in the United States. For example, if the aforementioned fuel fabrication technology transfer to China leads to Chinese supplying nuclear fuels to future AP-1000 in the United States, U.S. nuclear regulators would have a vested interest in ensuring that fuels meet its technical perimeters as fuel integrity is the first line of defense for safe operation of nuclear power plants.

The modernization of Chinese nuclear reactor fleet—facilitated by growing U.S.-China cooperation—is improving nuclear safety and in turn affirming the viability of nuclear energy as a fossil alternative in China. Moreover, engagement with China's growing nuclear sector gives the United States valuable opportunities to further its regulatory and nuclear engineering expertise. Nuclear energy technology cooperation between the U.S. and Chinese nuclear sectors goes hand-in-hand with robust cooperation between nuclear regulators from the two countries. Both are indispensable if bilateral nuclear energy cooperation is to be sustainable as much as if nuclear energy is to remain part of the national energy mix for the United States and China, respectively.

[45] World Nuclear Association, *Heavy Manufacturing of Power Plants*, updated January 2014.