Asian Innovation

Spencer Crowe

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Abstract

Nuclear power is the foundation of modern, 21st century nations, and since the end of World War II the United States has long held a position of nuclear-backed world dominance. A robust nuclear backbone has the potential to guarantee a nation's military, political, energy, economic, and environmental security - a fact which has not been lost on both the competitors and partners of the US. Two of these nations - China and India - have begun their own nuclear innovation ages at an explosive rate, growing into substantial threats to regional and global stability. From nuclear reactor exports to military overhauls, both nations have announced their presence on the world stage as true nuclear powers. While the US nuclear capability has not yet been surpassed by that of China or India, the US must take drastic measures to ensure that its national security is not put in jeopardy.

At the turn of the 21st Century, two Asian powers that historically relied on traditional defense ideas began their rise to superpower status. China and India both rely on their enormous populations to field massive armies in pursuit of their common defense, but have begun transitioning away from that strategy, realizing the necessity for nuclear innovation as a national interest. While the two have possessed nuclear programs for several decades, both are in the midst of their own nuclear innovation age, accelerating at a rapid rate. “There is a growing belief that China and India’s rising geopolitical rivalry in the Indo-Pacific region combined with their efforts to build diverse and sophisticated deterrent forces could potentially produce security dilemmas and an arms race similar to the one that enveloped the superpower rivalry during the Cold War.”[1] The nuclear competition between India and China has been described as the “epicenter of the second nuclear age,” as both countries work to improve nuclear programs that can guarantee their national security.[2] Historically, the only nuclear rivalry in the Pacific has been the India-Pakistan relationship. However, there is evidence that nuclear innovation within China and India is changing global national security.

The rivalry has been traditionally overlooked due to the presence of “louder” actors in the region drawing more attention to themselves, namely North Korea and Pakistan. The India-China “rivalry is rooted in geopolitical concerns that relate to borders, the security of the sea-lanes of communications, and military assistance to

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1. Gaurav Kampani, "China–India Nuclear Rivalry in the “Second Nuclear Age,” *Norwegian Institute for Defense Studies*, March 2014, https://forsvaret.no/ifs/Kampani-2014-ChinaIndia-nuclear-rivalry-in-the-second-nuclear-age-, 3.

2. Ashley J Tellis, "Strategic Asia 2013-14: Asia in the Second Nuclear Age," (Seattle, WA: The National Bureau of Asian Research, 2013.), 14-19.

third parties, as much as in China and India's self-identification as peer competitors and regional hegemonic powers."[3] Since the inception of both nations' nuclear programs, the consistent theme has been "catch up," with both powers devoting their resources to developing the same technology that the more advanced powers already possess. However, as they have begun devoting more assets and resources to military and civilian nuclear programs, they are on the cusp of taking the high ground in nuclear technology.

China

For China, their past nuclear developments and modernizations have always been geared toward the US, its Asian allies, and neighboring USSR/Russia, with India existing only as an afterthought in Chinese national security priorities.[4] While the two nations fought over a border dispute for 32 days in 1962, China remains unconcerned about Indian military power. China has dealt with India primarily by assisting Pakistan in their nuclear development efforts, and not much else. However, as the Indo-Pacific region has become more significant to geopolitics and global economy in the 21st century, China has recently begun viewing India as more of a threat than they have in the past. The three primary sources of Chinese unease and rivalry with India are: "(1) control over the Tibet Autonomous Region (TAR); (2) the security of the Sea-Lanes of Communications straddling the Indian Ocean region through which the bulk of Chinese global trade and energy supplies traverse; and (3) India's participation in US plans to potentially contain or at least check Chinese power in Asia and the western Pacific.

3. Tellis, "Strategic Asia 2013-14: Asia in the Second Nuclear Age," 9.

4. Kampani, "China–India Nuclear Rivalry in the "Second Nuclear Age," 7.

These three points of contention have become security concerns for China that require their attention, truly putting India in their crosshairs for the first time."[5]

With the dawn of the second nuclear age, both China and India are becoming increasingly aware of the weaknesses in their nuclear programs. India aside, China has realized that its capabilities remain incredibly vulnerable to the US and Russia. With the growing professionalization of the People's Liberation Army (PLA) - China's Department of Defense, the greater availability of funds, and the maturing of technological programs launched in the 1980s and 1990s, China has launched a broad campaign for nuclear innovation.[6] Their intention is to use nuclear innovation to bolster national defense and international security, and in turn, utilize the robust nuclear community created by that innovation to better improve and solidify their energy self-sufficiency.

To provide context, in 2008, China's nuclear arsenal was assessed as consisting of no more than 151 nuclear warheads, obsolete nuclear bombers, and a submarine fleet believed to operate without its complement of ballistic missiles.[7] Until the early 2000s China still deployed liquid-fuel missiles and stored the warheads separately from the missile systems, making a missile launch a "prolonged and detectable process."[8] Additionally, the Chinese had a very weak early warning system that left the large Chinese mainland highly vulnerable to an attack. The underwhelming capabilities of

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5. Kampani, "China–India Nuclear Rivalry in the "Second Nuclear Age," 7.

6. Kampani, 14-17.

7. Hans Kristensen, "Chinese Nuclear Arsenal Increased by 25 Percent Since 2006, Pentagon Report Indicates," *Federation of American Scientists*, Mar 2008, https://fas.org/blogs/security/2008/03/chinese_nuclear_arsenal_increa/.

8. Kristensen.

such a major power have been largely attributed to the first and second generation of leadership in China, with Chairman of the Communist Party Mao Zedong outlining a "minimum" deterrence posture that gave China just enough nuclear firepower to deter an attack, while not being a legitimate "nuclear power."

The newer generations of leadership in China have seen the weaknesses of past policies and current technologies and introduced radical change. The late 1980s and 1990s saw an overhaul of nuclear doctrine and the establishment of a legitimate Chinese nuclear community that could begin the process of innovation.[9] The first step was modernizing their delivery systems, replacing the liquid-fueled missiles with solid fuel, improving missile ranges by several-fold, developing sea-based missiles, and implementing multiple independently targetable reentry vehicle (MIRV) technology in their missiles. Nuclear innovation that has taken place in the Second Artillery Corps of the Chinese military, was legitimized by transforming into People's Liberation Army Rocket Force (PLARF), solidifying China's resolve toward nuclear weapons and placing them on the same strategic level as the Chinese Army, Navy and Air Force.[10] China's nuclear weapon innovation has gone so far as to lead the global development of hypersonic glide vehicles (HGVs), small, highly maneuverable nuclear vehicles designed to penetrate any nation's missile defense system. While missile delivery

9. Hans Kristensen, "Chinese Nuclear Weapon," *Federation of American Scientists*, November 29, 2006, https://fas.org/nuke/guide/china/nuke/index.html.

10. Alexander Koty, "China Announces Sweeping Overhaul of Government Institutions," *China Briefing*, March 14, 2018, http://www.china-briefing.com/news/china-announces-sweeping-overhaul-of-government-institutions/

systems are not strictly a facet of “nuclear innovation,” HGVs are a game-changing element in the future of nuclear deterrence.

China’s official nuclear weapons policy is one of defensive “no first use” (NFU). China will “not use atomic weapons against any non-nuclear states and would only use atomic weapons to retaliate after a nuclear first strike against China.”[11] NFU was originally put in place in response to what China perceived as American nuclear blackmail. Additionally, by adopting a NFU, China was seen as the more rational or stable nuclear power, viewed as a "leader" to the non-aligned world, which was its’ intentions when it developed the policy in 1960s. Also, due to the nation’s economic and technological limitations at the time in conjunction with a smaller arsenal, NFU just made operational sense.

Having a NFU policy makes China seem much less aggressive to other countries when compared to the US and Russia. On numerous occasions, they have publicly declared that their nuclear force is simply a deterrent retaliatory force, and they would never be the first to use nuclear weapons “at any time and in any circumstance.”[12] However, Chinese analysts have been calling for China to abandon the unconditional NFU in favor of conditional first strike. “Some believe that NFU reduces the credibility of China’s already small nuclear forces, and that abandoning NFU may enhance China’s nuclear deterrent. Abandoning NFU, they argue, is the most cost-effective way to free up scarce resources from defending China’s vital strategic targets for offensive

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11. Paul J. Bolt and Albert S. Willner, *China's nuclear future*, (Boulder, Colo.: Lynne Rienner Publishers, 2006), 147.

12. Bolt and Willner, 35.

capabilities to realize China's primary strategic objectives."[13] The Chinese development of the HGV, a stealth warhead designed to penetrate radars and anti-ballistic missile (ABM) systems, hint at the possibility of an abandonment of the NFU policy as they possess more advanced technology ideal for a first strike.

The two biggest concerns that NFU brings up regarding US interests in the Trans-Pacific region is Taiwan and the Terminal High Altitude Area Defense (THAAD) system in Korea. Some scholars have questioned the applicability of Chinese nuclear weapons against Taiwan, "as it may be interpreted strictly as a domestic issue unconstrained by NFU."[14] As an important US partner in the region, it is critical to note that China may be willing to conduct a nuclear first strike on Taiwan without officially departing from their NFU policy. Secondly, the US development of anti-ballistic missile THAAD systems will eventually drive Chinese efforts to end NFU.[15] When the US and South Korea began working on an arrangement to install the system on the Korean Peninsula to deter North Korea, Chinese President Xi Jinping said that, "the U.S. deployment of an advanced anti-missile system in South Korea gravely harms the strategic security interests of China, Russia and other countries in the region."[16] With the THAAD deployment in South Korea it becomes more difficult to guarantee their

13. Nan Li, "China's Evolving Nuclear Strategy: Will China Drop "No First Use?", *The Jamestown Foundation*, 2018,, https://jamestown.org/program/chinas-evolving-nuclear-strategy-will-china-drop-no-first-use/.

14. Bolt and Willner, *China's nuclear future,* 151.

15. THAAD is a medium range ABM system designed to shoot down a warhead after it has re-entered the atmosphere.

16. Li, "China's Evolving Nuclear Strategy: Will China Drop "No First Use?".

ability to maintain a credible second-strike capability, making preemptive strike a more valid option for China, and undercutting the stability that NFU brings.

Finally, the innovation of nuclear weapons inevitably focused innovation on civilian power generation. The majority of China's electricity is produced through fossil fuels with coal as the predominantly source at 73% in 2015.[17] Rapid growth in energy demands due to a continuously growing population, general urbanization, and industrialization gave rise to power shortages and near-exclusive reliance on fossil fuels that has led to some of the worst air pollution in the world.[18] The World Bank estimates the economic loss due to pollution from fossil fuels at almost 6% of GDP, and the current leadership, under President Xi Jinping, has prioritized alternative energy sources. Wind and solar have been a point of emphasis for the new government, however, due to a poor power grid, many new projects have been put on hold or altogether cancelled. The necessity of having wind and solar in mostly unpopulated areas requires a robust power grid to transfer the power over massive areas of mainland China. However, in the coastal areas of China, where most of the population centers lie, nuclear power has been developing rapidly. China initially used mostly French nuclear technology to build its first generations of reactors, but in its push for

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17. "Nuclear Power in China," *World Nuclear Association*, January 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx.

18. Official measurements of fine particles in the air rose to a record 993 micrograms per cubic meter in Beijing in 2013, compared with World Health Organization guidelines of no higher than 25

nuclear innovation, began developing its own reactor designs, with the goal of nuclear export capabilities.[19]

Prior to 2008, the government had initially planned to increase nuclear capacity to 40 GWe by 2020, with a further 18 GWe under construction.[20] However, projections for nuclear power then increased to 70-80 GWe by 2020, 200 GWe by 2030, and 400-500 GWe by 2050. In April 2015 the Chinese Nuclear Energy Administration (CNEA) declared that by 2030, actual installed nuclear capacity would be 160 GWe, providing 10% of all Chinese electricity, and by 2050, an installed nuclear capacity 240 GWe would provide 15% of electricity, decreasing coal to 50.5%.[21] To put things into perspective, in 1995, the US nuclear power industry produced approximately 100 GWe from 109 reactors, and China produced 2.1 GWe from 3 reactors. In 2017, the US produced 99 GWe from 99 reactors with two additional reactors stalled under construction, while China produced approximately 40 GWe from 38 reactors, with 20 more under construction.[22] In China, almost 70% (865 GWe) of its power plants were built within the last decade, whereas in the US, approximately half of the infrastructure (580 GWe) is over 30 years old.

The massive shift in China toward nuclear innovation demonstrates just how much of a factor nuclear power is playing in 21st century national security. While Russia

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19. "Nuclear Power in China."

20. "Nuclear Power in China." GWe is the abbreviated form of Gigawatt electrical and refers to the electric power produced by a generator.

21. Sources suggest that the post-Fukushima slowdown may mean that the 2030 figure is only about 120 GWe.

22. "Nuclear Power in China."

has been the primary rival of the US since the end of WWII, China's nuclear capabilities are on a trend that already appears dangerous for US national security. China's nuclear innovation age is still in its very early stages, but once the government perfects their strategies it will be nearly impossible for the US or any nuclear power to compete with China's first-rate industrial capabilities and economy.

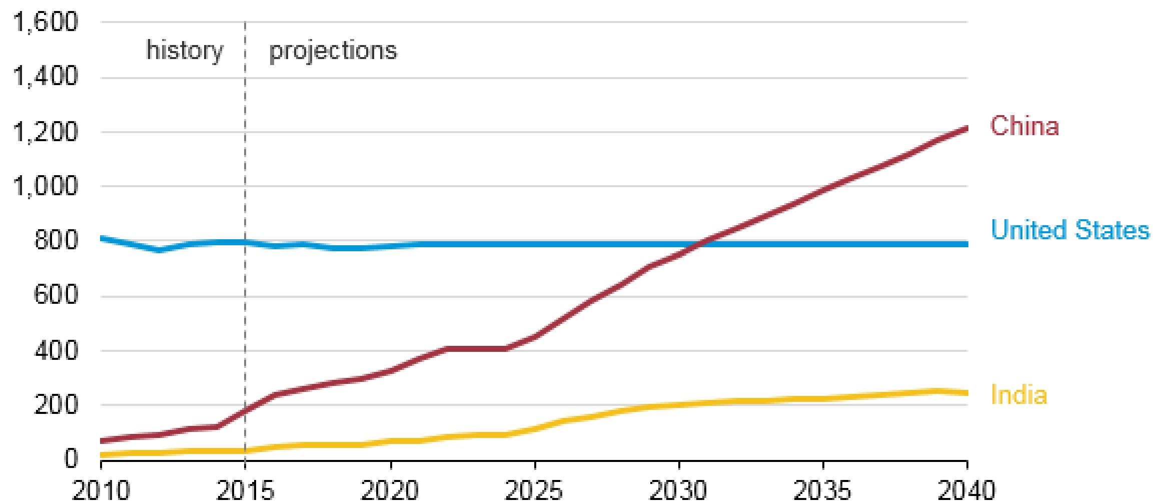

Figure 1 Projected Nuclear Electricity Generation (2010-2040)[23]

India

For India, China has long been a major focus of national security concern. "India's nuclear quest was triggered by the humiliating defeat of its military during the 1962 war with China along the Himalayan border, not by a rivalry with Pakistan."[24] While India believes an immediate nuclear threat comes from Pakistan, India's national security apparatus maintains that the real long-term threat comes from China. A major

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23. "China Expected to Account for More than Half of World Growth in Nuclear Power Through 2040," *Energy Information Administration*, Sept 2016, https://www.eia.gov/todayinenergy/detail.php?id=28132.

24. Samit Ganguly, *Fearful Symmetry: India-Pakistan Crises in the Shadow of Nuclear Weapons*, (Seattle, WA: University of Washington Press, 2015).

concern for India is that, in the China-India rivalry, nuclear innovation clearly favors China. China has already developed three generations of nuclear warheads – fission, thermonuclear and enhanced radiation. China has tested and “may” possess tactical nuclear weapons, has a four-decade lead over India in the development, deployment, and operations of ballistic missiles, and has procedures and training protocols for deployment and use of nuclear weapons.[25] While China has historically remained behind the curve in nuclear innovation, they still possess a nuclear infrastructure and community.

With India’s formal declaration as a nuclear state in 1998, its leaders have realized that India must dramatically improve its nuclear capabilities to prevent becoming a victim of nuclear blackmail by its neighbors. India has relied heavily on nuclear demonstrations to guarantee their national security, calculating that nations will be deterred from attacking them simply due to their possession of nuclear weapons. However, their nuclear capability is so outdated that a demonstration is essentially the extent of their capabilities. Like China, past political leaders pushed ideology that favored minimal operational capabilities, with a primarily political role for nuclear weapons over a warfighting one.[26]

India’s 15-year role as a “nuclear fence sitter” existed because its’ nuclear weapons program was run by civilian scientists instead of military leaders. Furthermore, since India is not a signatory of the Non-Proliferation Treaty (NPT) there was significant international pressure, mainly from the US, to prevent India from acquiring any dual-use

25. Enhanced radiation refers to a neutron bomb.

26. Kampani, "China–India Nuclear Rivalry in the Second Nuclear Age," 23.

technology.[27] International pressure forced the Indian government to bury many elements of their program in order to maintain relations with the international community. Like the Chinese Second Artillery Corps, though, India finally placed their nuclear program under military control in 2002, four years after officially declaring itself a nuclear state. This transfer from civilian to military control released its nuclear program from the difficulties brought on by secrecy and isolation. The introduction of the military into the nuclear program also shifted the focus from an unsubstantial gunboat diplomacy strategy to a focus on technical numbers and statistical damage.

Since 1998, light, rugged fission bombs have been the backbone of India's nuclear arsenal. On several occasions Indian scientists have claimed to possess thermonuclear weapons, however, their claims have been proven inaccurate. Since officially outlining their nuclear triad in 1999 India's military has relied most heavily on the air component, although they lack the actual range to conduct effective attacks against Chinese targets without modern airframes and tankers. During this time the Indian military has invested heavily in developing more advanced missile systems and sea-based capabilities in order to maintain relevancy in the 21st century. As their focus on innovation continues to intensify they have devoted significant resources to a land-based Intercontinental Ballistic Missile (ICBM, 3,400mi minimum range), moving away from reliance on Cold War era aircraft. Focus on ICBMs, of which they have developed three, "afford advantages of longer ranges, easier storage, maintenance and mobility."[28]

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27. Components that can be used in both civilian and military nuclear programs.

28. Tellis, "Strategic Asia 2013-14: Asia in the Second Nuclear Age," 111

Much of the early nuclear innovation that began in India was only at a strategic and doctrinal level, not at an actual scientific level. Due to a number of complicated laws and agreements any forward movement for the Indian nuclear program was severely impaired. In response to the first Indian nuclear test in 1974, an organization called the Nuclear Suppliers Group (NSG) was founded by Canada, West Germany, France, Japan, the USSR, the UK and the US to further limit the sale of dual-use nuclear technology to specific nations. For India, this agreement made any future development and innovation extremely difficult, as well as isolating them from the nuclear powers.

In late 2008, this all changed for India when the US, under President Bush's direction, organized an international effort to release India from their ban from nuclear technology. In order to allow India the ability to purchase much-needed technologies, while maintaining the integrity of the international laws, the International Atomic Energy Agency (IAEA) granted an unprecedented safeguards agreement to India. The IAEA would conduct routine inspections of Indian nuclear sites and, in exchange, would allow international civilian nuclear cooperation. Additionally, the US approached the NSG to grant India a waiver to resume civilian nuclear trading. The group agreed to the waiver, making India the only non-NPT signatory with permission to conduct legitimate nuclear commerce. Due to the nature and size of such an agreement, the details are still being actively negotiated, with unsurprising push-back from China on India's waiver. However, while all the regulations have not yet been lifted and with most of the import/export bans gone, India could officially and legally begin their nuclear innovation age.

China has focused on nuclear innovation to further national defense and international relations, while India is far more interested in using nuclear innovation to guarantee their self-sufficiency, evidenced by the fact that the majority of their modern nuclear innovation has come in the form of nuclear reactors. In 2017, British Petroleum projected India's energy consumption rising by 129% between 2015 and 2035, with a very heavy reliance on fossil fuels (86%).[29] This 129% increase does not take into account that, in 2014, 20% or 260 million Indians still did not have access to electricity, putting the nation at the same energy availability level as Yemen and Ghana.[30] The power crisis in India hit its peak in July 2012 when India's Northern power grid failed while carrying a full load in the early morning. The following day, the Northern grid plus parts of two other grids failed, causing over 600 million people, or 11% of the entire world's population, to be without power.

The government began taking action and penned the nation's 12th five-year plan for 2012-17, which included the addition of 94 GWe of power, costing $247 billion. The IAEA predicts that India will need $1.6 trillion of investment in power generation, transmission and distribution to meet 2035 estimates.[31] In addition to the aging power infrastructure, the nation's shortage of fossil fuels is driving the need for nuclear innovation as the government has set a 25% nuclear power goal for 2050, when 1094 GWe of total base-load capacity is expected to be required.[32] In May 2017, the

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29. "Nuclear Power in India," *World Nuclear Association*, October 2017, http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx.

30. "Access to Electricity (% of Population)," *World Bank*, 2016, https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS. Up from 55%.

31. "Nuclear Power in India."

32. Current installed baseload capacity as of June 2017 is 330GWe

government approved the construction of ten 700 MWe reactors in addition to the 6 already under construction.

Unfortunately, India is a country almost entirely void of the Uranium required to produce nuclear power, making massive fuel imports a necessary evil for the nation. While Indian engineers work to provide a viable, reliable power grid for the nation, scientists are working on their nation's resource problem. India's nuclear innovation has come in the form of alternative fuel sources. Due to the lack of Uranium, scientists have been forced to look at different nuclear fuel sources to power their reactors and achieve self-sufficiency. The fast breeder reactor (FBR) at Kalpakkam is part their nuclear innovation toward self-sufficiency.

After the conclusion of the WWII, the new US Air Force was envious of the Navy's pressurized water reactor and called upon the nuclear community to build an unpressurized, safer nuclear reactor that could power its long-range strategic bombers. Oak Ridge National Laboratory undertook the project and created a 7.4MW test reactor that used Thorium, a black rock named the Norse god, Thor, as its primary fuel.[33] Instead of using water, the reactor used air that was blown over radiators, in conjunction with a system that cooled and recirculated the liquid nuclear fuel as its cooling systems. This eliminated the need for unsafe high pressures. Additionally, due to new designs combined with the unpressurized nature of the reactor, the reactor could regulate its own temperature, meaning that it could not melt down. If the reaction gets too hot, the expanding liquid fuel will be forced out of the reaction chamber into the circulating

33. Richard Martin, *Superfuel: Thorium, the green energy source for the future*, First edition. ed., (New York: Palgrave Macmillan, 2012), 10-11.

system, decreasing the amount of fuel and cooling down the reaction. If too much fuel is pushed out and the power begins dropping, the lack of liquid in the chamber causes more space in the core, which means less moderation and more reactivity, causing the power to rise again. The cycle constantly repeats itself, always regulating itself for the optimal temperature.[34]

There are a variety of theories as to why the US did not pursue this technology after the nuclear aircraft project was cancelled. These theories boil down to the fact that this technology wasn't an effective method for producing nuclear weapons. In the 1960s, when the US was trying to produce as many weapons as possible, Thorium simply wasn't a viable option, and so the technology was pushed aside for the more dangerous and complicated pressurized water reactors, which were good at producing the materials for nuclear weapons.

India, which has the largest supply of Thorium in the world, has embraced the research conducted at Oak Ridge and invested heavily in Thorium-powered reactors. The Oak Ridge reactor type, called a Molten Salt Reactor (MSR), after the liquid fuel used in it, has played heavily into the future of the Indian nuclear program. They have begun developing different variants of the MSR-type reactors, some that rely on Thorium, and some that rely on Uranium-238.

If India is successful in their implementation of this new generation of nuclear reactor, it could change power and energy throughout the world. A nation crippled by a

34. Badawy Elsheikh, "Safety Assessment of Molten Salt Reactors in Comparison with Light Water Reactors," *Journal of Radiation Research and Applied Sciences*, (October 2013), https://www.sciencedirect.com/science/article/pii/S1687850713000101.

lack of power could begin exporting both power and technology. Nations without access to large bodies of water could begin building safe, proliferation-resistant nuclear power plants to provide access to their people. An additional benefit of MSRs is that, instead of Thorium, nations can also use depleted Uranium or Uranium from disassembled weapons as fuel, eliminating the need for nuclear waste repositories like the one at Yucca Mountain in Nevada.

India is an important strategic partner of the US and while their growing power is not a direct threat to the US, it is a growing threat to regional and global stability.[35] While the India-China rivalry is a fairly conventional, historical rivalry, the Indian military was soundly defeated in the Sino-Chinese war, which demonstrated the weaknesses in their military structure and technology, leaving unresolved conflict between the two. Border friction between the two nations exists to this day, and if India improves their infrastructure and technology, innovation could mean a new confidence for India, which could drive a renewed conflict between the two nations. As a close ally, the US would be placed in a destabilizing situation as it would be forced to choose to either join in what could realistically become a world war or abandon its ally to face the Chinese alone.

Nuclear power is the foundation of modern, 21st century nations. Without nuclear weapons and a willingness to improve its atomic technological capabilities, a nation is irrelevant, and their national security is at risk. Global, 21st century national security has transitioned away from large conventional forces to a national defense guaranteed by nuclear power and atomic weapons. Due to military modernization and weaponization of

35. Kampani, "China–India Nuclear Rivalry in the Second Nuclear Age," 25.

their nuclear programs, India and China have taken the lead on atomic innovation, beginning a second nuclear innovation age, as both see nuclear innovation as a major factor in guaranteeing national security again. China has begun developing new nuclear weapons and large-scale nuclear reactors hoping to enhance their national security position vis-à-vis major competitors. India, due to a lack of uranium, has invested heavily in emerging technologies that would provide safer, more efficient power for the nation’s rapidly expanding population.

Although China could surpass US nuclear capabilities, time has not yet run out for saving US national security. If the US is willing to break some of the norms that it has established over the last 60 years and begin innovating again, it could correct its course. Investing in private nuclear industries, Thorium research, and new nuclear weapons, while limiting the NRC and ABM investments would substantially bolster US national security to a point where it is no longer in peril. The nation needs innovative minds like Ernest Rutherford and Robert Oppenheimer to lead the country out of their nuclear apathy and back to a place where the government and public alike can see the value in securing the nation from external threats.

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