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Redefining Leadership in the Global Nuclear Energy Market

Andrew Paterson and Walter Howes

Redefining Leadership in the Global Nuclear Energy Market: International Partnerships as a Strategic Path Forward

Andrew Paterson
Nonresident Senior Fellow, Energy and Environment Program

Walter Howes
Nonresident Senior Fellow, Energy and Environment Program

Substantively edited and reviewed by:
Mihaela Carstei, Deputy Director, Energy and Environment Program
Kathryn Sparks, Program Assistant, Energy and Environment Program

We would like to offer our thanks for support in the editorial process to the following:
Sydney Fields, Program Assistant, Energy and Environment Program
Mark Nicholas, Intern, Energy and Environment Program
Lucas Rogers, Intern, Energy and Environment Program

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Redefining Global Leadership in the Nuclear Energy Market

Global energy demand will increase substantially in the coming decades under pressure from global trends, including an increasing population that will reach 9 billion by 2040, and, for the first time in history, will be overwhelmingly urban.[1] Meeting basic global energy needs will require the use of all available sources of energy while addressing and minimizing environmental and climate impacts. Nuclear energy is an established part of the world's electricity mix, and provides large-scale, reliable, base-load electricity demand. As such, it seems to be well matched to fit into an increasingly urban world that aims to mediate environmental challenges.

In the United States (US), commercial nuclear energy is an integral part of addressing the country's economic, energy, and national security concerns. Further, the presence of US industry in the global market enhances both the strength of the international nonproliferation regime and the safety culture surrounding the operation of nuclear power plants. In order for the US nuclear industry to continue fulfilling these roles, it must meet the demands of a changing global nuclear marketplace, which can only be accomplished by strengthening partnerships with foreign industry and government entities.

The landscape for nuclear energy has markedly shifted since the first reactors were built in the 1960s and '70s. This issue brief recognizes the challenges facing the US nuclear industry and argues that a successful strategy to maintain a viable market share of the global electricity supply will involve strengthening international partnerships. It concludes that the US industry has several opportunities to create partnerships, and that some of the most interesting opportunities to ensure the continued viability and leadership of the industry can be found in Asia. Cooperation at both the commercial and governmental level will be critical to creating successful partnerships.

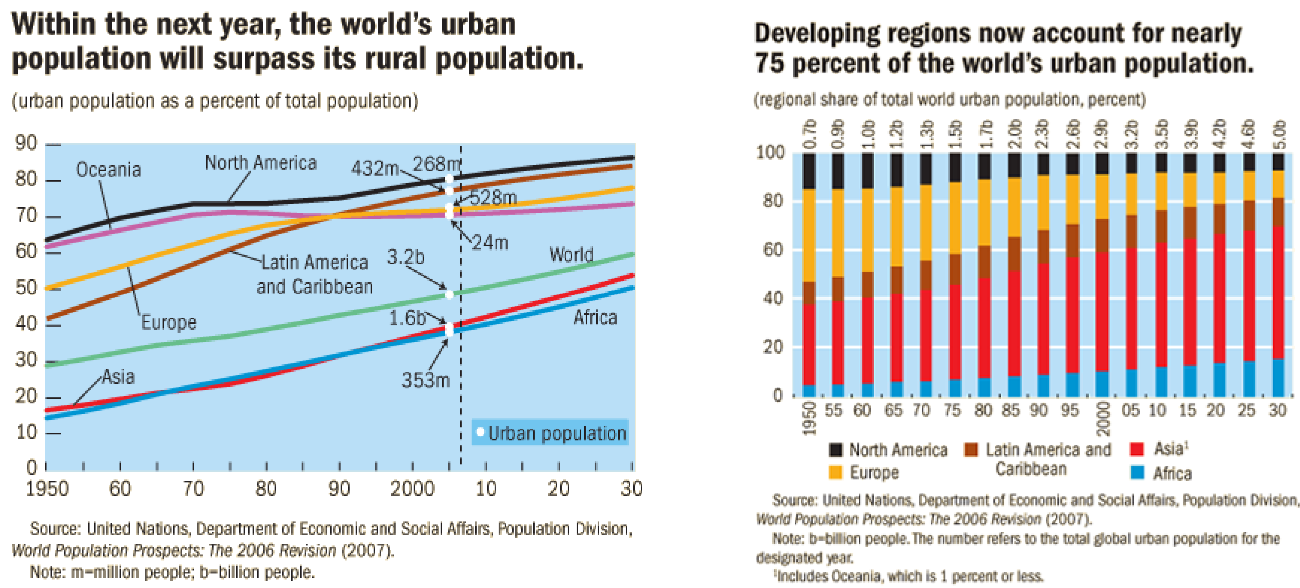
Rising Global Electricity Demand

The need for a stable energy supply stems from the intersection of population growth, an increasing standard of living, and urbanization—major global trends that will greatly increase energy demand and define the next decades. As the world continues to change, there needs to be a restructuring of its energy production and delivery to account for the great increase in energy consumption, especially in developing countries. The US Energy Information Administration (EIA) International Energy Outlook 2013 Reference case projects a thirty-year increase of 56 percent in world energy consumption, rising from 524 quadrillion Btu in 2010 to 630 quadrillion Btu in 2020, and 820 quadrillion Btu in 2040.[2] More than 85 percent of this rise in demand

1 ExxonMobil, *The Outlook for Energy: A View to 2040*, 2013, p. 3, http://www.exxonmobil.com/Corporate/files/news_pub_eo.pdf.

2 US Energy Information Administration, "International Energy Outlook 2013," http://www.eia.gov/forecasts/ieo.

Figure 1. Rising Urbanization in Developing World Surpasses Stagnant OECD



Source: International Monetary Fund, "The March of the Cities," September 2007, www.imf.org/external/pubs/ft/fandd/2007/09/picture.htm.

will occur in developing nations outside the Organization for Economic Cooperation and Development (non-OECD member countries), driven by strong economic growth and expanding populations. In contrast, OECD member countries are already more-mature energy consumers, with slower anticipated economic growth and little or no anticipated population growth.

Combine rising demand in developing countries with vast urbanization, and it is clear that current energy supplies are not sufficient to meet the projections. By 2040, 60 percent of the world's population will live in cities; the world will have a thousand cities with over one million people; and fourteen of the world's twenty largest urban areas will be located in Asia.[3] Population growth and urbanization in Asia represent the global trend of rapid urbanization occurring in the developing world, where reliable access to clean energy rarely exists. As shown in Figure 1, half the urban world lived in North America or Europe when World War II ended. By 2030, just one in five people residing in cities will live in these NATO alliance countries. Now the rest of the world needs to build clean, reliable energy sources, particularly electricity sources.

Global electricity demand will be driven by many factors in addition to those discussed earlier, including the rise of the middle class, creation of policy to reduce greenhouse gases, development of a balanced electricity-generation portfolio, and the need to provide and transport rising amounts of clean water for drinking and agriculture. After 2020, the expanding middle class's appetite for appliances and electricity, increasing use of electric vehicles and urban mass transit, along with desalination, will drive electricity demand in the global energy and water sectors. And, as shown in Figure 2, China and Asia are driving this growth.

Fulfillment of these massive electricity demands will require that all nations utilize all energy sources available while also considering environmental concerns. As an emissions-free generator of base-load electricity, nuclear energy is an important part of this mix. In June 2013, the International Energy Agency (IEA) released its Redrawing the Energy-Climate Map, noting that "nuclear remains a vital

3 Richard Dobbs et al., "Urban World: Mapping the Economic Power of Cities," McKinsey Global Institute, March 2011, http://www.mckinsey.com/insights/urbanization/urban_world.

Figure 2. Non-OECD Net Electricity Generation by Region, 1990–2040 (trillion kilowatt hours)

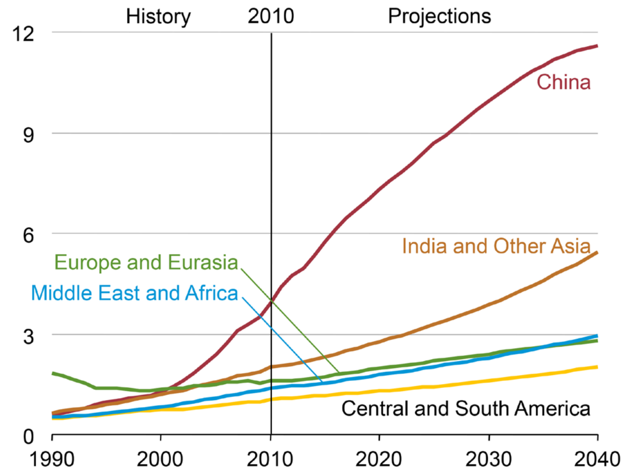
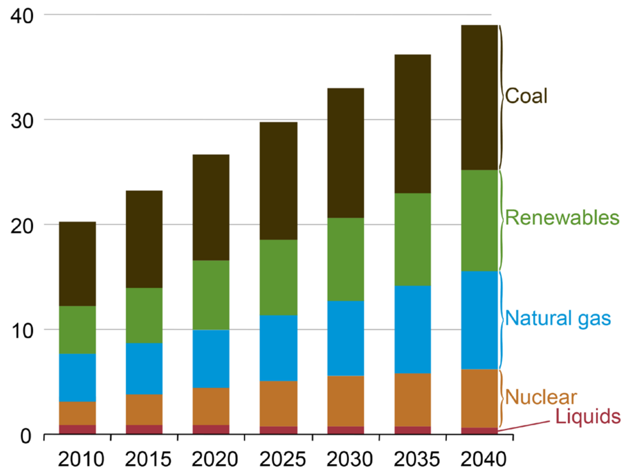


Figure 3. World Net Electricity Generation by Fuel, 2010–2040 (trillion kilowatt hours)



US Energy Information Administration, "International Energy Outlook 2013," July 25, 2013, p. 94, http://www.eia.gov/forecasts/ieo/pdf/0484%282013%29.pdf.

underpinning technology in the IEA's so-called 450 scenario, which seeks to limit final temperature increase to 2°C. This sees nuclear generation increasing by almost 1,800 TWh in 2035 (or about 40%) over the level achieved in the IEA 4-for-2°C scenario."[4]

Not only is nuclear energy necessary for environmental reasons, but it is also reliable. Reliability matters for high-rise buildings, mass transit systems, water treatment and delivery, office complexes, and hybrid or electric vehicles. The consequences of power disruptions to these systems were painfully evident after Hurricane Sandy in 2012, during the massive Northeast blackout of August 2003, and with numerous typhoons in Asia. Interestingly, unlike in North America, transmission lines in developed Asia (Japan and South Korea) are run underground to avoid disruption during major storms. One executive from Seoul at a recent Greater American Business Initiative meeting noted: "[W]e have millions of people living in high-rise apartments; we cannot tolerate power outages. Our civilization stops. The trains must run for cities to function."

The world's demographics are changing, and the need for stable, reliable energy is evident. Nuclear energy can provide this energy throughout the world and can support a developing Asia while reducing air emissions and maintaining a small footprint of nuclear energy where open land is in short supply. As energy needs grow and shift to developing regions, nuclear energy can provide a stable source of power to support the world's changing energy demands.

The Market Pivot to Asia

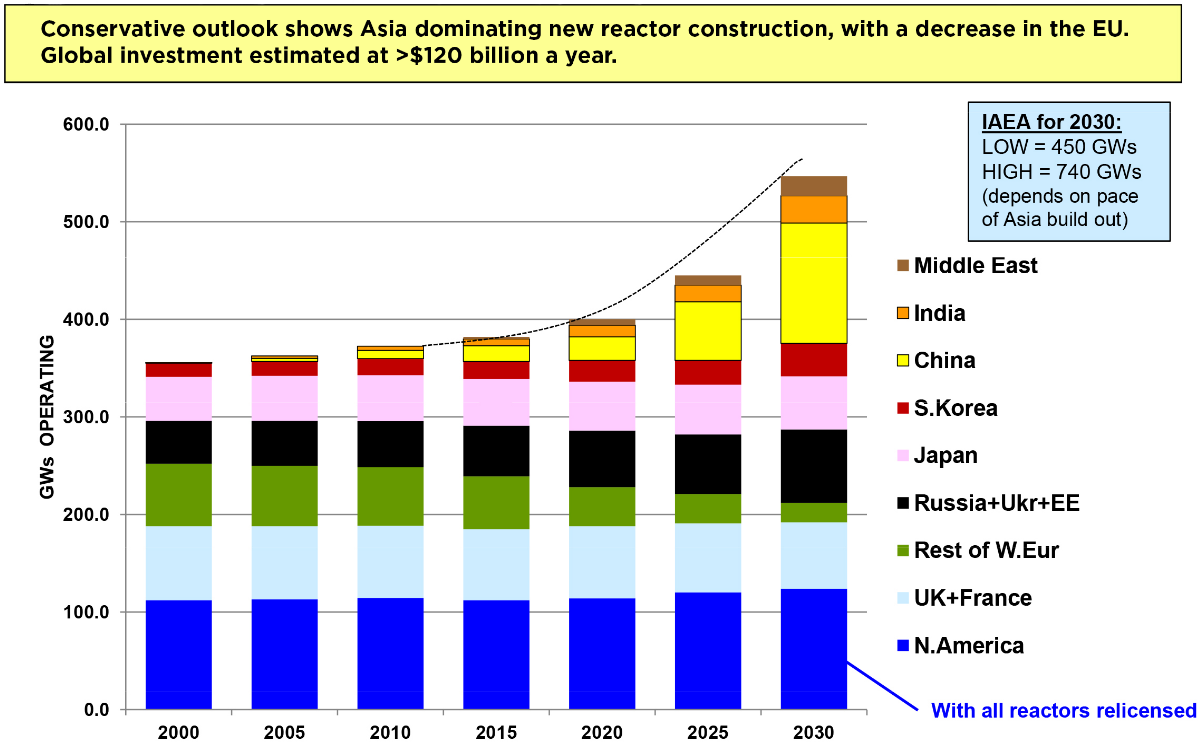
The most recent projections from the World Nuclear Association (WNA) for nuclear capacity predict that "world nuclear-generating capacity will increase from the current level of 370 GWe (including all Japanese reactors except Fukushima Daiichi 1-4) to 433 GWe by 2020 and to 574 GWe by 2030."[5] The WNA projection falls within the International Atomic Energy Agency's (IAEA) low (501GWe) and high (746) projections of global capacity by 2030.[6] The majority of growth in the nuclear industry is currently

4 International Energy Agency, *Redrawing the Energy-Climate Map*, June 10, 2013, http://www.iea.org/publications/freepublications/publication/RedrawingEnergyClimateMap_2506.pdf.

5 Nuclear Matters, "Nuclear Fuel Demand to Increase," September 2013, http://nuclearmatters.co.uk/2013/09/nuclear-fuel-demand-to-increase/.

6 International Atomic Energy Agency, "International Status and Prospects for Nuclear Power 2012," August 15, 2012, http://www.iaea.org/About/Policy/GC/GC56/GC56InfDocuments/English/gc56inf-6_en.pdf.

Figure 4. Operating and Projected Nuclear Reactors, 2000–2030: "A Pivot to Urban Asia"



Source: World Nuclear Association and International Atomic Energy Agency. Graph created for this report.

occuring in China, India, and South Korea. This shift to Asia is a dramatic change for an industry which has historically been dominated by developed economies in the West.

North America has 120 reactors in operation and Europe has 185. In Europe there are 17 units with an electric net capacity of 15 gigawatts (GWs) under construction in four countries (Finland, France, Slovakia, and Ukraine).[7] In contrast, in East and South Asia there are 119 operating plants, 49 plants under construction, and firm plans to build 100 additional plants.[8] Figure 4 illustrates the dramatic changes occurring in the global nuclear marketplace. If these projections come to fruition, US share of global capacity would slip from approximately 25 percent to below 15 percent by 2030.

The three largest factors driving the pivot to Asia are the rapid growth in electricity demand, government support of nuclear development, and the need to reduce air pollution and the carbon content of the region's electricity production.

Increased Demand for Electricity

Large populations, high levels of economic growth, and increasing urbanization are combining to create a demand for large amounts of affordable base-load electricity. The governments in India and China have recognized this need and have made nuclear power a major part of the energy mix they are developing to meet this demand. China alone is expected to have eight megacities (population over ten million) and 221 cities with over one million residents.[9] Affordable base-load electricity is crucial in order for these countries to sustain the high level of economic

7 European Nuclear Society, "Nuclear Power Plants in Europe," January 2013, http://www.euronuclear.org/info/encyclopedia/n/nuclear-power-plant-europe.htm.

8 World Nuclear Association, "Asia's Nuclear Energy Growth," updated October 2013, http://world-nuclear.org/info/Country-Profiles/Others/Asia-s-Nuclear-Energy-Growth/#.UlgpntKGYgQ.

9 Chi-Chu Tschang and Dexter Roberts, "China's Megacities: In Eight Cities, Population Will Exceed 10 Million," *Bloomberg Businessweek*, http://images.businessweek.com/ss/08/11/1112_china_megacities/.

growth they have experienced during the last decade.

Government Support for Nuclear Development

Government support has been pivotal to the accelerated growth of nuclear energy in Asia. In China and India government enterprises are responsible for the construction and operation of nuclear power plants. Government ownership mitigates the economic and financial issues that have contributed to a slowdown of new construction in North America and Europe.

Emissions Reductions

Carbon-intensive fossil fuels have driven much of the economic growth in Asia. The environmental consequences of this growth are costly, and the governments in China and India are taking steps to reduce both the hazardous air pollution and the carbon intensity of their economies. Nuclear power presents an appealing option for countries trying to meet rapid demand growth for electricity and seeking a clean and reliable source of base-load electricity.

These projections show that Asia has taken the lead in the nuclear renaissance since 2005, and, going forward, the vast majority of new construction activity will occur in this region. Over 50 GWs of the 70 GWs currently under construction are being built in Asia, and this trend will intensify after 2020, as aging units continue to retire in Europe and in North America. Maintaining a nuclear fuel infrastructure, engineering capacity, and experienced personnel for execution of safety standards requires undertaking new construction.

The Benefits of Nuclear Power

If the IAEA's projections for 2030 nuclear capacity hold true, commercial nuclear power will remain a central piece of the global energy sphere. There are numerous reasons why countries will continue to choose the nuclear power option. Nuclear power provides reliable, emissions-free, base-load electricity that will be increasingly necessary to serve the highly concentrated electricity demand of megacities in the developing world. Germany and Japan have seen quantifiable increases in their greenhouse gas emissions (GHGs) as a result of their respective phaseout and shutdown of nuclear power. German emissions rose 1.6 percent in 2012, and Japan's emissions rose 4 percent, despite slow economic growth and a lack of population growth in either country. These increasing emissions explain why developing countries with greater rates of population growth, density, and economic growth are pursuing nuclear power.

In addition to security of supply and reduced carbon emissions, a healthy commercial nuclear industry supports industrial capacity, provides high quality, and has broader geopolitical benefits. The US nuclear trade laws and regulations[10] (e.g., Section 123 Agreements and Section 810 trade authorizations under the Atomic Energy Act of 1954) underpin the global nonproliferation regime, and US agreements for cooperation serve to provide access to commercial nuclear technologies while limiting access to those that might develop nuclear weapons capabilities. The US Nuclear Regulatory Commission (NRC) and the Institute for Nuclear Power Operations continuously provide information on best regulatory and operational practices that improve safety worldwide.

The New Global Commercial Nuclear Power Landscape

The last twenty years have seen a dramatic change in the global nuclear landscape. Table 1 below explains this significant shift by showing changes in demographics, geopolitical considerations, and the rise in construction in Asia that have led to the new realities of the twenty-first century. The twenty-first century supply chain has been globalized, and no nation can pride itself on remaining self-sufficient.

10 Pursuant to Section 123 Agreements and Section 810 trade authorizations under the Atomic Energy Act of 1954, the US nuclear trade laws and regulations establish cooperation agreements that advance nonproliferation principles as a prerequisite to nuclear deals between the United States and other countries. The Section 123 Agreements ensure peaceful uses of nuclear materials, while Section 810 trade authorizations provide provisions for nuclear exports.

Table 1. Shifts in the Nuclear Landscape from the Twentieth to the Twenty-first Century

20th Century, post-WWII; OECD growth	21st Century, post–Cold War; little growth in OECD
United States leads in reactor construction and operations (100 GWs built, 1960–1980s).	Asia leads in reactor construction (50 GWs of 70 GWs globally); only 4 to 8 GWs forecast in North America.
Baby boom; rising demand in America and the European Union (EU), with growth of suburbs; expanding electrification.	Limited load growth in North America and the EU as efficiencies take hold, population levels off, and competition from other supplies enters in, particularly natural gas in North America.
United States largely controls nuclear fuel and reactor technology; not dependent on foreign engineering or capital.	US nuclear vendors now foreign-owned (Toshiba-Westinghouse; Hitachi-GE)—except among small modular reactors, which represent an arena for future leadership.
P5* nations control nuclear fuel and weapons technology.	P5 oligopoly is under strain, so international partnerships are elevated in importance. Majority of reactor construction after 2010 will occur in Asia, outside NAFTA and EU.
Reactors built in "rate-base" territory, or by National Entities, and for reliability with denser urban loads.	New reactors in Asia driven by demand for energy and lower emissions in large cities (>1m), and where natural gas prices run higher than they do in United States. Sovereign ownership continues.
GHG emissions not raised as a factor before 1990; nuclear navy also being built up within United States / NATO.	Nuclear power will become more vital with wider use of electric vehicles and mass transit and with more desalination in developing world, led by Middle East and coastal cities.

* P5 refers to the five permanent members of the UN Security Council: the United States, United Kingdom (UK), France, China, and Russia.

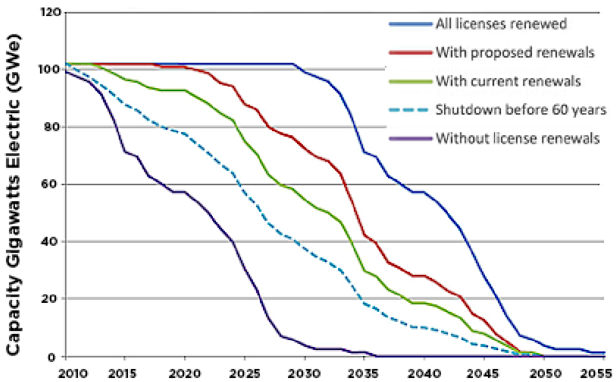
This shift is evident particularly in the United States, where Toshiba bought Westinghouse Nuclear in 2006, and Hitachi-GE was formed in June 2007. Significant changes are taking place in Asia, as well, where they currently lead the world in construction of reactors; however, it is important to note that the region still lacks a comprehensive fuel supply infrastructure. While more than 60 percent of the world's nuclear capacity today is located in five countries—the United States, China, France, South Korea, and Russia—over the next two decades, the nexus of nuclear power investment will shift.

It is evident that over the last half decade, the nuclear energy landscape has changed considerably. The events at Fukushima in March 2011, a global recession, chronic financial market stress since 2008, and the changing global oil and gas supply outlook are challenging future plans for nuclear power in many countries. In the most extreme cases, some countries—such as Germany, Italy, and Belgium—have enacted policies phasing out commercial nuclear power, even though such plans had been announced prior to Fukushima. These were sovereign political decisions, not industry decisions; in fact, industry typically opposed shutdown policies. In other countries a sense of complacency is grounded in the belief that commercial nuclear power can be left alone to market forces. Commitment in some European countries has eroded, in part because of failed political consensus and a chronic fiscal crisis.

As a consequence of these shifts, US commercial nuclear leadership is at risk. Neither domestic nor international orders are sufficient to sustain the United States' (or Europe's) industry market share.

Given these major challenges outlined in Table 1, the outlook for the US nuclear industry is

Figure 5. Declining Outlook for US Nuclear Reactor Capacity under Different Scenarios, to 2055



Source: Idaho National Laboratory, "Light Water Reactor Sustainability Program: Introduction," 2011, https://inlportal.inl.gov/portal/server.pt?open=512&objID=442&mode=2&.

already in jeopardy. When analyzing the state of current reactor renewals, the premature retirement of four reactors since 2011 leads to the possibility that by 2030, 40 percent or more of US capacity could be shut down. Proposed license renewals could push this ominous outlook back about a decade. Regardless of the outcome of these proposals, installation of many GWs of reactors and small modular reactors (SMRs) will be necessary before 2030 in order to strengthen the US nuclear industry, and to maintain the nuclear electricity share at 20 percent.

Given the long-term outlook for low natural gas prices in North America, it is evident that industry alone cannot make a stronger future for nuclear energy. In order to redefine leadership in nuclear energy, governmental policies in rate assurance and spent-fuel disposal, as well as providing significant incentives, will also be instrumental in forging a future that maintains a nuclear power base that America can use to drive international partnerships. Leadership to ensure broader implementation of safe operations will increasingly entail joint bids and arrangements with foreign partners and agencies with investment consortiums, which will all increasingly rely on global sources. These policies are crucial to ensure that the US nuclear industry does not follow the example of Great Britain, now a glaring example of a former P5 "leading" country that can no longer build—or even operate—its own reactors.

US Commercial Nuclear Industry Challenges

The US nuclear industry must address the following challenges before it can secure future partnerships and maintain global leadership:

1. Low growth in domestic demand
2. Fragmented ownership of nuclear assets
3. Competition from currently low natural gas prices in North America
4. Little value for emissions savings
5. Uncertain regulatory and policy landscape
6. Development of next-generation technologies, such as SMRs

1. Low growth in domestic demand

The EIA projects that US electricity demand is expected to grow at 0.9 percent per year through 2040.[11] Urbanization and the electrification of transport systems will drive some load growth, but increased efficiency in the production, delivery, and consumption of electricity will counteract to slow the rate of growth. As a result, most new construction of nuclear power plants has shifted to developing countries with high growth in electricity demand, such as China.[12] Some market gaps could open as aging US coal plants are retired; however, since 2010, natural gas plants have been seen as a more economical way of filling these gaps.

2. Fragmented ownership of nuclear assets

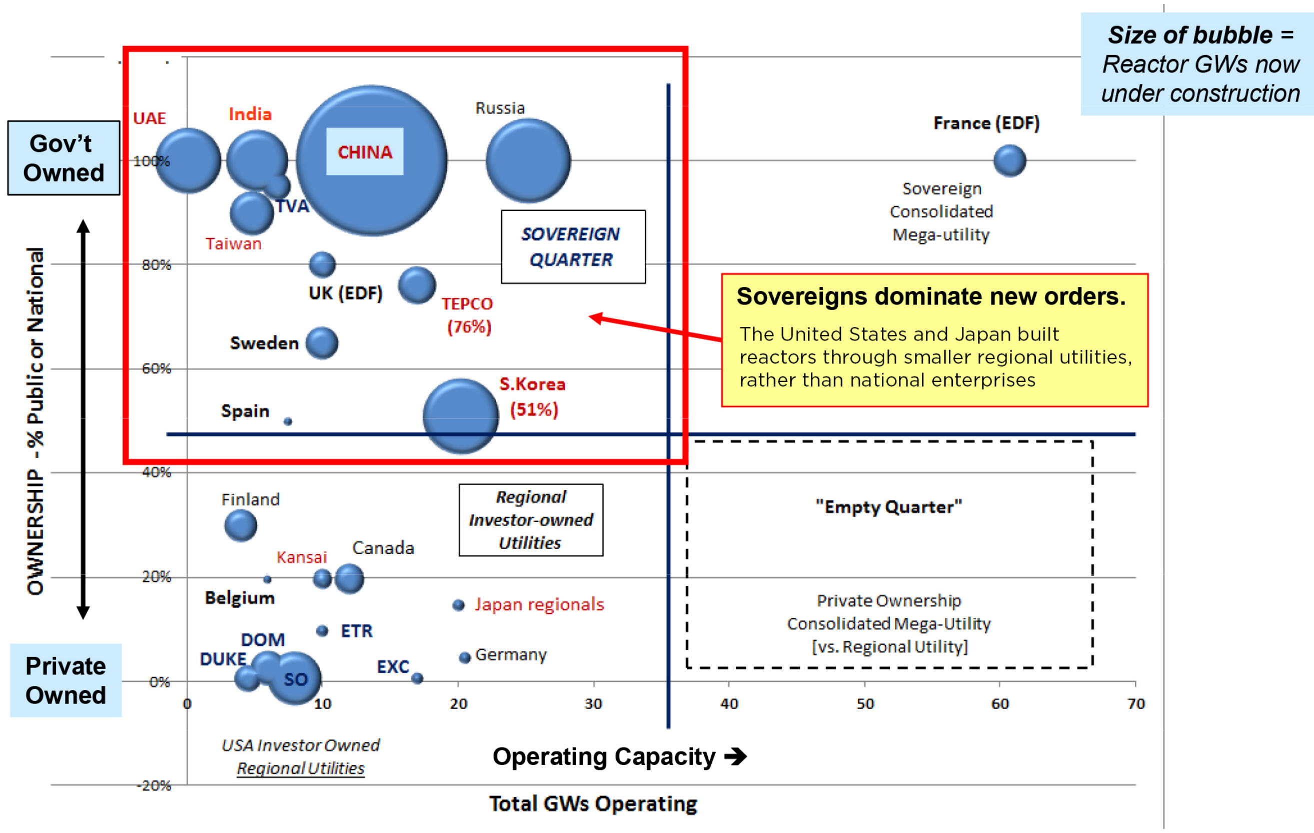
Electricity production in the United States is divided between over 3,000 enterprises, including over 25 nuclear operators.[13] Producers

11 US Energy Information Administration, "Annual Energy Outlook 2013 with Projections to 2040," April 2013, p. 71, http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf.

12 USEIA, "International Energy Outlook 2013."

13 Nuclear Energy Institute, "US Nuclear Power Plant Operators, Owners, and Holding Companies," May 2013, http://www.nei.org/Knowledge-Center/Nuclear-Statistics/US-Nuclear-Power-Plants/US-Nuclear-Operators,-Owners-and-Holding-Companies.

Figure 6. Nuclear Entitities: Ownership, Operating GWs + Under Construction



US entities: TVA = Tennessee Valley Authority; DUKE = Duke Energy; DOM = Dominion Power; ETR = Entergy; EXC = Exelon; SO = Southern Company. EDF = Électricité de France.
Source: World Nuclear Association, NEI-UK, EIA; Graph constructed for this report.

include large, investor-owned utilities, independent power producers, and smaller, public power entities and rural cooperatives. In contrast, nuclear plants in the UK, France, Russia, China, and India are operated by one or two operators. Japan and the United States are the only countries with regional investor-owned entities that operate reactors. Most US utilities lack the assets to build new reactors, making federal loan guarantees like those in the Energy Policy Act of 2005 critical to underwriting new construction.[14]

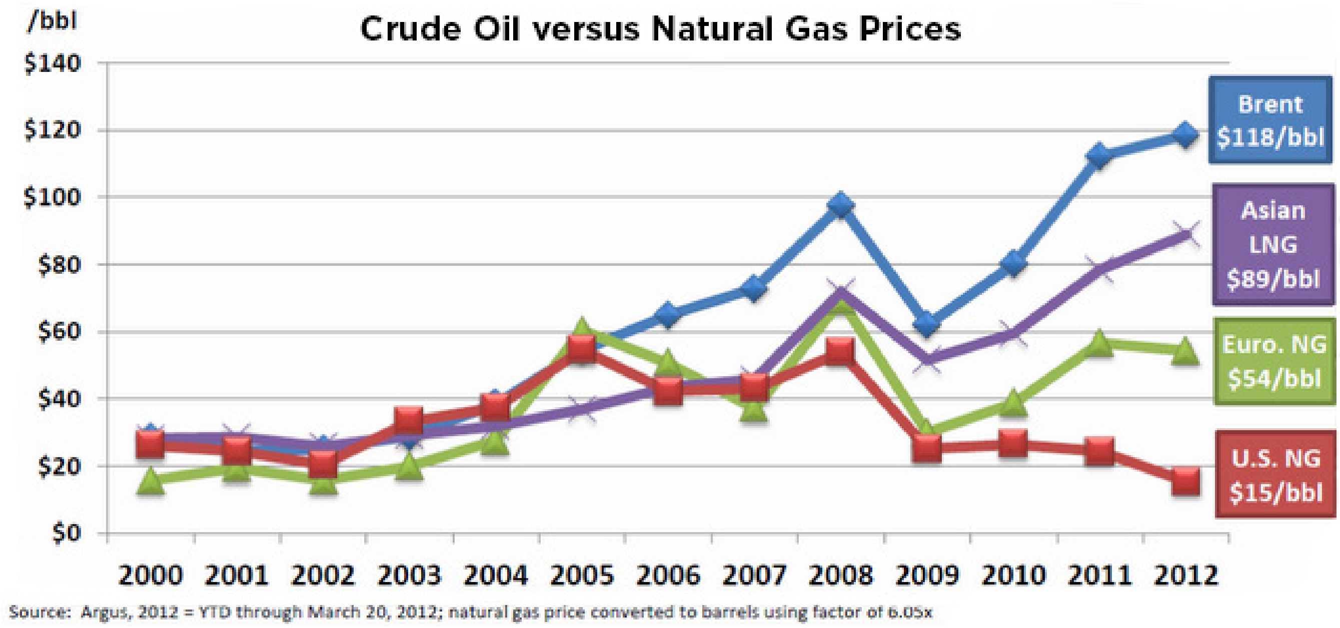
14 The largest US investor-owned power company has a market value of approximately $50 billion. Most US companies in the sector are significantly smaller. By comparison, European electric companies are two or three times larger and are better able to finance large-scale projects on their balance sheets. Major oil companies are five to ten times larger. They routinely undertake $6 to $7 billion projects, but they have the financial strength and balance sheets to support them. See Nuclear Energy Institute, "Testimony for the Record for the Energy Tax Reform Working Group, Committee on Ways and Means," April 15, 2013, www.nei.org/Issues-Policy/Policy-Resources/Testimony/Testimony-for-the-Record-for-the-Energy-Tax-Reform.

Public vs. Private: Divergence in Ownership for Nuclear Reactor Capacity

In contrast to the investor-owned entities in the United States and Japan, nuclear reactors in most of the large producers of nuclear power are owned wholly, or in a majority position, by the national government. This sovereign ownership mirrors the increasing ownership of global oil and gas resources by state-owned enterprises. Only the federally chartered Tennessee Valley Authority (TVA; 6,600 megawatts [MWs] nuclear capacity) resembles the ownership structures seen abroad. The chart above depicts the ownership structure for nuclear utilities in different countries versus the GWs of capacity operated currently. (Note: Size of bubble shows current construction of new reactors in GWs.)

It is notable that there are no privately held "mega-utilities" (lower right quadrant of Figure 6). The largest nuclear utilities are sovereign

Figure 7. Decoupling of Natural Gas Prices since 2009—
Regionally and from Crude Oil Prices



Source: Argus, 2012, http://www.sec.gov/Archives/edgar/data/1035002/000119312512496021/d451265dex9901.htm.

enterprises such as EDF, Nuclear Power Corporation of India, Ltd., and China National Nuclear Corporation. In recent years these government-owned utilities expanded beyond their borders (e.g., EDF's acquisition of British Energy in 2008).

3. Competition from currently low natural gas prices in North America

The accelerated production of natural gas from unconventional reserves in the United States has resulted in a rapid decrease in domestic natural gas prices. Natural gas prices have fallen from a high of $12 per Mbtu (1,000 British thermal units) in 2008 to below $4 per Mbtu since 2010. These low prices challenge the continued operation of older nuclear plants located in unregulated markets, as well as the economic viability of new orders. In late 2011, Mexico scrapped state plans to build up to ten new nuclear plants by 2030 due to the extended outlook of cheaper natural gas in North America.[15] Additionally, two reactors started in 1990 at Veracruz (GE BWRs, 800 MWs each) have no plans for expansion. However, because natural gas markets are still regional, increased natural gas production in the United States has not had the same implications for new nuclear orders in Asia, where natural gas prices have remained high.

4. Little value for emissions savings

Nuclear power offers a significantly cleaner option for electricity production than thermal electricity production from fossil fuels. However, the absence of a market mechanism that forces fossil fuel–reliant generators to internalize the negative environmental externalities of their production puts producers of emissions-free electricity at a competitive disadvantage. A carbon tax or cap-and-trade mechanism would make nuclear more cost-competitive with natural gas and coal. In addition, Renewable Portfolio Standards—policies requiring utilities to obtain a certain percentage of their electricity from low-carbon sources—have not included nuclear energy as

15 Carlos Manuel Rodriguez, "Mexico Scraps Plans to Build 10 Nuclear Power Plants in Favor of Using Gas," Bloomberg, November 3, 2011, http://www.bloomberg.com/news/2011-11-02/mexico-scraps-plans-to-build-as-many-as-10-nuclear-plants-focus-on-gas.html.

a low-carbon electricity source.[16] Uncertainty regarding the future of US carbon policy increases the perceived risk of new nuclear power plants. Recent government incentives for nuclear energy have come in the form of loan guarantees, insurance against delays not caused by utilities, and production tax credits for the first 6 GWs of new plants (Energy Policy Act of 2005).

For comparison, the EU framed a cap-and-trade scheme in 2006 to offer incentives for emissions savings. However, in the wake of a chronic recession, carbon prices plummeted from nearly 25 euros per ton to below 5 euros a ton in early 2013. In other countries where reactors are owned by a sovereign national entity, such tax subsidies are moot. While the UN Clean Development Mechanism could provide some marginal incentive for power plant development, nuclear energy cannot qualify under the current provisions despite the carbon savings.

5. Uncertain regulatory and policy landscape

Compounding the problem of little value for emissions savings are policy uncertainties that impact the financing for very long-term assets with large amounts of debt, such as a nuclear power plant. Policy uncertainties exist around the duration of various building and operating incentives, as well as the timing of air regulations on coal plants. Also, regulated rates, such as those seen in the southeastern US states, provide a higher degree of certainty on rates for construction of nuclear plants. As such, the status of market restructuring and market liberalization has a direct impact on financing new construction. In the United States, some development uncertainties were removed by the Energy Policy Act of 1992, with early site permits, design certification for reactors, and a combined construction and operating license.[17] However, these legislative measures only addressed licensing issues, not market factors or the value of emissions savings.

The lack of policy progress made on the disposal of spent fuel creates additional uncertainty in the nuclear energy production process. Nine US states currently have laws prohibiting the construction of new nuclear plants until certain conditions for dealing with waste are met.[18] Until progress is made toward better interim storage—and, eventually, toward permanent storage—industry will struggle to develop new nuclear plants.

Government versus Industry Leadership on Major Issues to Mobilize Financing

The importance of clear policies and regulations underscores the essential role of governments in creating an environment where the construction of new nuclear power plants is feasible. In May 2012, the International Framework for Nuclear Energy Cooperation (IFNEC; a compact of sixty countries active in nuclear energy) concluded that clear national policy on regulation, incentives, and risk-sharing are required in order to mobilize debt in international capital markets. In countries where the development of nuclear energy is currently growing, governments have chosen to be the investor and owner of the reactors. While government ownership and operation may not be a realistic option in all cases, government agencies can work together with the commercial nuclear industry to create a regulatory framework that addresses the issues discussed above.

Table 2 illustrates the areas where industry leaders and policymakers must take the initiative and where it is most important for them to cooperate.

As seen above, in the major challenges for policy leadership in nuclear power, industry can take the lead on construction engineering, costs,

16 Massachusetts Institute of Technology, "Update of the MIT 2003 Future of Nuclear Power Study," 2009, p. 9, http://web.mit.edu/nuclearpower/pdf/nuclearpower-update2009.pdf.

17 US Nuclear Regulatory Commission (NRC) Code of Federal Regulations [10 CFR 52], "Part 52—Licenses, Certifications, and Approvals for Nuclear Power Plants," www.nrc.gov/reading-rm/doc-collections/cfr/part052/.

18 Center for Strategic & International Studies, "Restoring US Leadership in Nuclear Energy: A National Security Imperative," June 2013, p. 66, http://csis.org/files/publication/130614_RestoringUSLeadershipNuclearEnergy_WEB.pdf.

Table 2. Major Challenges for Policy Leadership in Nuclear Power

Government	Industry	Major Challenges Raised (IFNEC Finance Workshop, May 2012)
0	+	1. Substantial construction cost escalation and risk of delays in construction, some tied to rising material costs, others to contingencies needed by construction engineering teams.
+	0	2. Market pricing risk in liberalized electricity markets, versus territories with regulated rates and long-term power purchase agreements, which then hinders lending terms. [Government decides degree and pace of liberalization, or regulation of electric rates.]
+	0	3. Lack of market value for carbon emissions savings with reactors versus fossil-fired sources. [EU and a few nations offer incentives, but a global regime is lacking.]
+	0	4. Few financial incentives for public goods associated with nuclear power, e.g., lower hazardous emissions near urban areas, domestic fuel sourcing, and reliability in bad weather.
n/a	0	5. Mismatch in timing between the asset life and commercial lending tenures: Few lenders will go out past fifteen or twenty years on loans, but reactors run for more than fifty years. Short loan tenors on multibillion-dollar projects may make projects uneconomic.
+	0	6. Nuclear accident liability [in the United States, this is covered by the Price-Anderson Act; in other countries, the national government takes on this risk].
+	—	7. No real progress on addressing long-term spent-fuel disposal and management.
0	0	8. Currency risk in emerging markets and on electricity revenues if financed abroad.
+	+	9. Uranium fuel supply and pricing [government engaged in licensing or owning mines].
0	+	10. Worker training and engineering capacity [government agencies may subsidize schooling].

Key: + = leading role; 0 = support role; — = little or minimal role.

Source: International Framework for Nuclear Energy Cooperation (IFNEC) Finance Workshop, *IFNEC Finance Workshop: Final Summary Report*, October 4, 2012, http://www.ifnec.org/Portals/0/Docs/IFNEC/Appendicies/IFNEC_Finance_Workshop_Final_Summary_Report_-_October_4_2012.pdf.

fuel supply risks, and worker training. However, governments need to make progress on siting, licensing, and defining policies for spent-fuel storage and disposal. In addition, policies that monetize emissions savings and energy security benefits could provide additional incentives for the development of nuclear energy.

6. Development of next-generation technologies, such as SMRs

Another dimension of redefining leadership in nuclear power lies in successfully developing smaller (<300 MW) modular reactors with superior safety and fueling features, as well as markedly decreased use of water. These new technologies provide both industry and governments with tremendous opportunities for maintaining the share of nuclear energy in the global portfolio, which also poses unique development and implementation challenges.

Earlier this year, the US Department of Energy (DOE) issued an award to co-fund the licensing of the first modular reactors in the United States to a team led by Babcock & Wilcox, with TVA as a host site. Other bidders included Westinghouse (Toshiba) with Ameron, NuScale-Fluor, Holtec, Gen4 (formerly Hyperion), and the GE PRISM (with Hitachi). TerraPower looks to engineer reactors fed by spent fuel while breeding new fuel, with a first unit proposed for Asia. Among countries that are venturing forth to develop these new technologies, South Korea is moving ahead with a SMART reactor (110 MWs) by undertaking the early licensing steps. Given the variety of efforts from industry and governments, building the first SMRs could be a joint activity through international partnerships.

With the great majority of future reactor construction unfolding overseas, and especially in Asia, the US agencies (DOE, Department of State) and industry must actively redefine leadership in nuclear energy. By bringing expertise, regulatory practices, increased safeguards, and joint technology into international partnerships, the United States can remain the active leader in the rapidly changing global nuclear energy landscape. This changing landscape requires a reorientation of fundamental thinking regarding nuclear energy practices and realities, as US vendors are no longer solely owned by US investors; instead, international bids are now won by multinational teams, with a multitude of syndicated investors arranging financing. The UK is a prominent example of how quickly nuclear infrastructure, engineering resources, and assets can erode with diminished national commitment and investment in nuclear power. As Rhian Kelly, director for business environment policy at the Confederation of British Industry, said recently:

> Nuclear [energy] will be a vital player in achieving a balanced low-carbon energy mix, and with commercial opportunities worth billions of pounds at home and overseas, it is a sector that can bring real economic benefits. We urgently need to get the right market framework in place, and the strategy should build on this to ensure [that] the UK is well placed to benefit from growth in new nuclear over the coming decades. The UK already has significant expertise in civil nuclear, but we cannot rest on our laurels, and this strategy lays out a pathway to greater R&D investment and tackling skills shortages.[19]

If the United States hopes to avoid a similar fate a decade from now, a reorientation of strategic priorities around nuclear energy is critical. Nuclear energy *is* a strategic priority, and lack of action will threaten America's standing worldwide—not just economically, but also politically. The United States is no longer self-sufficient in nuclear power; its future rides on its ability to skillfully negotiate and execute "Enhanced Cooperation" via international agreements with long-standing allies (see Figure 9: Outcomes Matrix).

19 Confederation of British Industry (CBI), "CBI Responds to Nuclear Industrial Strategy Launch," March 26, 2013, http://www.cbi.org.uk/media-centre/press-releases/2013/03/cbi-responds-to-nuclear-industrial-strategy-launch/.

International Partnerships as a Strategic Path Forward

A Focused Partnership Strategy to Reinvigorate US Role in Global Nuclear Energy

The new reality is that while US utilities remain a leader in operating nuclear plants, this status may be short-lived, as US companies will not lead the construction of new nuclear power plants. New domestic orders for plants will be few and far between until electric demand rebounds in the United States, and there is greater certainty about the price of gas in the longer term. In the interim, foreign orders can help the US nuclear industry maintain the infrastructure and adequate workforce necessary to meet domestic demand when it resurfaces. Furthermore, the US government's stake in ensuring that industry successfully participates in the global nuclear market will guarantee that existing high safety and security standards are upheld.

Looking to the future, the US nuclear industry has a unique opportunity to forge new and deep partnerships with industries in key ally countries throughout all areas of the nuclear supply chain, not just in reactor construction. Nuclear leadership will soon be redefined in light of the changing global market landscape. It will be defined by the number of public-private partnerships US companies will develop to ensure satisfaction of regional marketplace demands, not by the sheer number of reactors a country maintains. Toshiba-Westinghouse and GE-Hitachi are prime examples of international partnerships that have successfully participated in constructing reactors outside the United States. Following this lead, US companies need to expand their efforts to partner with other foreign, government-owned organizations.

A recent example of such an undertaking is the Shaw Group, with 25,000 employees ($6 billion in 2012 revenues) who just sold itself to Chicago Bridge & Iron (CB&I; $8 billion in 2012 revenues). Which strategic partners to choose, and what the best attributes these potential partners should have, will be the primary questions for the US industry's nuclear future. The necessary safeguards and engineering standards will be enforced and implemented through international partnerships, a change from the current system of top-down, nation-by-nation enterprises.

Globally, industry actions are well under way, with plans to form strategic international partnerships. Building new nuclear plants today entails financing in the tens of billions of dollars, so globally active construction firms and vendors must form transnational teams that can manage projects of this scale, as well as serve multiple projects at the same time worldwide. As depicted in the photos below, a team led by KEPCO-Doosan incorporates Westinghouse reactor design and engineering support at Barakah, United Arab Emirates (UAE) (four APR1400 reactors). For the Southern Company project at the Vogtle site in Georgia, Toshiba-Westinghouse and CB&I/Shaw Group are also engaged in the construction of two Westinghouse AP1000s.

Table 3. Examples of International Partnership Arrangements for Nuclear Reactor Construction

Country	Reactor Project	Owner	Reactor	Team Lead	Start	Open
Taiwan	Lungeman	Taipower	ABWR(1350)	Hitachi-GE	1997	2015
Finland	TVO-5	TVO	EPR1500	Areva (FRA); Siemens turbines	2005	2013
China	Sanmen	China NNC	AP1000	Toshiba (JPN) - W. House (USA)	2008	2014
USA	Vogtle 3 & 4	Southern Co.	AP1000	Toshiba (JPN) - W. House (USA)	2010	2016
Japan	Oma Aomori	J-Power	ABWR(1350)	Hitachi-GE	2010	2016
UAE	Barakah 1-4	UAE	APR1400	KEPCO-Doosan (KOR)	2012	2016
Czech Republic	Temelin	CEZ	TBD	Rosatom vs. Toshiba-W.House	2014	2020
Turkey	Sinop	Turk Elec./GDF	PWR(4)	MHI-Itochu (JPN); Areva (FRA)	2014	2020
Source: World Nuclear Association and International Atomic Energy Agency. Table created for this report.						

Other Examples of Multinational Partnerships

Table 3 shows other reactors under construction or in bid negotiations, highlighting even more multinational partnerships occurring in the global supply chain. In few of these multinational bids or projects is a US firm in the lead role. US engineering firms are thinly capitalized, and US utilities traditionally do not bid on foreign construction projects in the manner that KEPCO or EDF have done. The smaller size of US utilities relative to non-US and sovereign electric utility companies poses a challenge, especially because project costs run in the $5 billion to $15 billion range.

Such a situation occurred in the UK, where British Energy—the owner of the UK's aging fleet of eighteen reactors—was fully acquired by the French conglomerate EDF in September 2008. The UK had consolidated all reactors under British Nuclear Fuels Ltd. (BNFL) in the late 1990s, which also acquired Westinghouse Nuclear and ABB's residual nuclear business in 1999. However, by 2006, BNFL was broken up; the Westinghouse Nuclear unit was sold to Toshiba, and as of 2009, BNFL ceased to exist. Without a long-term investment strategy, the UK has lost much of its nuclear engineering and operating expertise, and all reactors are now owned by EDF, a foreign company.

Success Factors for Nuclear Energy: Supply-Side and Demand-Side Drivers

A key question going forward will be how to define the best strategic partnership opportunities. A rubric to gauge the potential for these opportunities is critical in order to provide policymakers with the tools they need to determine the areas that require increased focus. In the past, as seen in Figure 8, the United States and Europe had the most favorable supply-side opportunities, while Southeast Asia and the Middle East provided very scarce and weak opportunities. While the factors included in the graph are not exhaustive in their ability to identify all potential aspects involved in driving strategic partnership opportunities, these factors do provide a strong framework for increased examination of the subject.

The relative strength of each country or mini-region was assessed on a relative basis (scaled from 1 as low value, to 5 as high value). The combined ratings were then indexed to the highest entity in the evaluation. The chart shows to what degree demand-side factors have emerged as key drivers for new reactor construction going forward compared to the supply-side factors that drove construction among OECD countries during the last few decades. On the supply side, the United States possesses superior ratings in (S1) the presence of military industrial bases for a nuclear navy, (S2) the current reactor operating base, (S3) regulatory practices, (S4) nuclear engineering talent, and (S8) access to low-cost financing. In contrast, China lacks the operating base of leaders in comparison to the EU, while China, India, and Southeast Asia see higher demand-side factors associated with rapid population

Figure 8: Supply and Demand Factors for Successful Nuclear Energy Programs and Partnerships

		USA	EU	Russia	Japan	S.Korea	China	India	SEAsia	MidEast
	Population (2010)	310	500	140	130	50	1,340	1,210	610	620
	SUPPLY SIDE FACTORS									
S1	Military industrial base for nuclear navy	5	4	4	2	1	3	2	1	1
S2	Current reactor operating base	5	4	4	3	4	2	3	1	1
S3	High quality nuclear regulatory practices	5	5	3	3	3	2	3	1	1
S4	Nuclear engineering talent (univ. programs, firms)	5	5	4	5	4	3	4	1	1
S5	R&D Reactors, Univ. programs, Nat'l Labs	4	4	4	4	4	3	3	1	1
S6	Engineering firms with recent construction experience	4	5	4	5	5	4	3	1	1
S7	Access to low cost debt financing, capital (public or private)	5	3	4	5	4	5	4	2	3
S8	Nuclear fuel infrastructure and ore supply	4	5	5	3	3	3	3	1	1
		37	35	32	30	28	25	25	9	10
	Indexed value	100%	95%	86%	81%	76%	68%	68%	24%	27%

Major shift from supply-side drivers for new reactors to demand-side drivers.

	DEMAND SIDE FACTORS	USA	EU	Russia	Japan	S.Korea	China	India	SEAsia	MidEast
D1	Growing population overall	3	2	1	1	2	4	5	4	5
D2	Current dense, urban electric loads	3	4	3	5	5	5	5	5	4
D3	Advanced industrial and manufacturing base	4	4	3	5	5	5	3	2	1
D4	Future growth in urban load	3	2	2	3	4	5	5	4	4
D5	Rising per capita energy use (vs. OECD average)	2	1	2	1	2	5	5	5	5
D6	Higher natural gas prices (nuclear competitiveness)	1	3	1	5	5	5	5	5	1
D7	Significant air pollution (need for clean energy options)	3	2	2	2	2	5	4	3	2
D8	Policies and regulations favoring reduced emissions	3	5	1	3	3	2	1	1	1
	Indexed value	22	23	15	25	28	36	33	29	23
		61%	64%	42%	69%	78%	100%	92%	81%	64%

Regions shown comprise 70 percent of world population.

growth and urbanization (D1, D2, D4, D5, D7), as well as higher natural gas prices.

During the expansion era of nuclear power construction, from the 1960s to the 1980s, the United States led the world in many of the key supply-side success factors.

Key factors included:

S1. *Military industrial base for nuclear navy:* US nuclear power expertise and a commitment to light water reactors (LWRs) began with the construction of the nuclear navy, from the 1950s to the 1970s. Today, the United States wields ten nuclear-powered aircraft carriers and approximately eighty nuclear submarines. No other country is comparable to this arsenal in terms of sheer size. In the early stages of the civil nuclear program, many retired officers from the US nuclear navy were hired as managers at nuclear utilities, bringing reactor management knowledge to the commercial sector. Both the US fueling infrastructure and experience with naval reactors contributes to US engineering capacity.

S2. *Current reactor operating base:* Despite the recent shutdown of four reactors, US reactor capacity leads the world with 100 reactors operating in 2012,[1] as compared to France (58 reactors) and Japan (51), the only other countries with more than 50 reactors installed.

S3. *High-quality nuclear regulatory practices:* The NRC continues to provide high benchmarks for nuclear regulation, and national nuclear regulators now meet frequently at international forums and via the IAEA to share best practices. Regulatory practices for emerging nuclear users are paramount to ensure implementation of

1 World Nuclear Association, "Nuclear Power in the USA," updated October 2013, http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/USA--Nuclear-Power/#.UlhDSNK-rwo.

safeguards, reliable operations, and emissions savings.

S4. *Nuclear engineering talent and skilled labor (college programs, technical firms, union training):* Almost half of the US nuclear engineering programs at universities closed in the 1980s when demand slumped after the Three Mile Island incident (1979) and after the Clinton administration cut funding for the DOE. In 2010 US colleges graduated more than 450 nuclear engineers (BS degrees), with just as many master's degrees and PhDs awarded—a significant rise from below 300 in the late 1990s. This rise in skilled labor and additional union training plays a major role in precision construction for reactors. While this escalation in numbers of graduates is positive news for long-term US nuclear engineering development, South Korea, Japan, France, Russia, China, and India still produce more nuclear engineering graduates than the United States.

S5. *Research and Development (R&D) Reactors, National Labs:* The DOE continues to fund a significant network of national laboratories with nuclear expertise (weapons, fuel, and reactors). Other P5 countries also maintain such R&D infrastructure and programs, but the most robust programs in the P5 can be found in China, Japan, and South Korea. Britain's nuclear engineering establishment has been hollowed out after two decades of inactivity.

S6. *Engineering firms with recent construction experience:* Since the acquisition in 2006 of Westinghouse Nuclear by Toshiba and the formation of Hitachi-GE Nuclear (2007), engineering firms in Asia (SK, Doosan, Hyundai, Mitsubishi, Shanghai Engineering) currently have the most construction experience going forward. Others, such as Fluor, Areva, and CB&I/Shaw, are seeking work in Asia in an attempt to keep pace.

S7. *Access to low-cost debt financing, capital (public or private):* Most of the P5 countries, along with Japan, South Korea, and India, are positioned with a unique advantage when compared to Europe in regard to access to low-cost debt financing. With the euro crisis still posing daunting fiscal challenges, the ability for these P5 countries to retain access to low-cost capital—particularly for sovereign entities and national utilities in global bond markets—puts the P5 countries far ahead of other countries and mini-regions.

S8. *Nuclear fuel infrastructure and ore supply:* Russia and France lead in offering the full slate of fuel cycle services, including enrichment and reprocessing. In comparison, the United States does not reprocess spent fuel by law; however, for the past two decades, the "Megatons to Megawatts" program converted Russian nuclear warheads to reactor fuel, the latter program ending in 2013. China and India are taking note of successes primarily in France, where 17 percent of their national power generation comes from recycled nuclear fuel,[2] by developing reprocessing expertise and capacity. For example, URENCO, a consortium with $2.1 billion in annual revenues[3] owned by the governments of Germany, The Netherlands, and the UK, provides enriched nuclear fuel worldwide. Southeast Asia (not including China) and the Middle East lack most of the key supply-side factors for nuclear power, but are rated quite high on demand-side factors, particularly on population growth and urban demand, with much faster growth in electricity consumption and demand for freshwater. The profound shift currently under way in commercial nuclear partnerships is being driven, in part, by demand-side factors in rapidly developing urban areas in Asia.

Due to these developments, demand-side market factors will favor construction at a larger scale in markets going forward.

D1. *Growing population overall:* Unlike Japan or Europe, Asia and the Middle East currently see much higher population growth rates.

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2 World Nuclear Association, "Nuclear Power in France," updated September 2013, http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/France/#.Ulb0G9K-rwo.

3 Stanley Reed, "Powerhouse of the Uranium Enrichment Industry Seeks an Exit," *Dealbook, New York Times*, May 27, 2013, http://dealbook.nytimes.com/2013/05/27/powerhouse-of-the-uranium-enrichment-industry-seeks-an-exit/?_r=0.

The North American Free Trade Agreement (NAFTA) region is also growing faster than Europe, and will surpass it in population before 2030.[4] In Mexico, national revenues and energy supplies have been declining with the erosion of oil production since 2005. The realization not fully grasped by policymakers in Mexico is that the strain on energy supplies is the primary factor triggering continued fiscal shortfalls in Mexico. This strain may create a situation where increased attention will have to be paid to the need for investment in Mexico in order to avoid a sovereign crisis (see Greece, Portugal, Spain). Since 2000, Mexico's population has been increasing at a rapid rate; it will add another 30 million people to its population before 2030, creating demand for more energy within the NAFTA bloc.

D2. ***Current dense, urban electric loads:*** The United States and Europe only have three or four cities with more than five million people, whereas, Asia—principally, China and India—will see dozens of cities that size by 2030. More than a thousand cities worldwide will top one million residents before 2040, about 60 percent of them in Asia, thus creating significant strains on electricity output in these cities.

D3. ***Advanced industrial and manufacturing base:*** An advanced industrial base requires high-quality and reliable electricity. OECD countries have that electricity, but since more "off-shoring" started to take place, beginning in 2000, China, India, and Southeast Asia have built up their manufacturing capacity considerably by undertaking intensified industrialization policies. Some factory capacity is migrating back to North America due to the presence of cheap natural gas feedstock prices and reliable energy; however, these same cheap natural gas prices also make nuclear energy less competitive.

D4. ***Future growth in urban load:*** While the largest cities in North America are seeing steady growth, they are being far outpaced by urban centers in Asia, primarily in China and India. For example, China alone will see 200 cities with more than 1 million people by 2030.[5] India's urban population in 2030 will be around 600 million, more than double the population in 2001.[6]

D5. ***Rising per capita energy use (vs. the Organisation for Economic Co-operation and Development [OECD] average):*** OECD countries, as developed countries, have maintained relatively steady per capita energy use, with a bit of decline. Asia, on the other hand, is industrializing, and private vehicle use will increase exponentially over the next decade. By 2025, new car sales in China may double that of US sales.[7] Because oil is priced globally, this demand will raise oil prices unless more electric vehicles are sold. Charging such electric vehicles will increase urban electricity demand even more, increasing the strain on already-fragile electrical grids.

D6. ***Higher natural gas prices (nuclear competitiveness):*** While there have been increased efforts to export LNG to markets in Asia, costs are expected to stay high for the foreseeable future.[8] With natural gas prices in Asia almost three times higher than prices in North America, nuclear energy in Asia remains highly competitive. Despite higher construction costs seen in the most recent reactor projects, nuclear power remains a preferable energy source due to its relativity quick build time and the low costs of energy production.

4 United Nations, "World Population Prospects: The 2012 Revision," 2013, http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2012_%20KEY%20FINDINGS.pdf.

5 Jonathan Woetzel et al., "Preparing for China's Urban Billion," McKinsey Global Institute, February 2009, http://www.mckinsey.com/insights/urbanization/preparing_for_urban_billion_in_china.

6 Sanjoy Chakravorty, "The Future for Urban India," *Live Mint* & *Wall Street Journal*, August 13, 2009, http://www.livemint.com/Opinion/EjKILTsXIPx6HoNN8DlcKO/The-future-for-urban-India.html.

7 Agence France Presse, "China's Booming Auto Market Will Nearly Double by 2019," *Business Insider*, August 30, 2013, http://www.businessinsider.com/chinese-auto-market-to-double-by-2019-2013-8.

8 Anastasia Gnezditskaia, "Asian Gas Prices Will Drop Fast in Response to US LNG Exports: Analyst," Platts / McGraw Hill Financial, July 9, 2013, http://www.platts.com/latest-news/natural-gas/washington/asian-gas-prices-will-drop-fast-in-response-to-21262349.

D7. *Significant air pollution (need for clean energy options):* Due primarily to their prolonged and continual rising reliance on coal-firing power plants, China and India are looking with an increased focus to nuclear energy as an alternative power source in an attempt to reverse their severe air pollution. As the most recent summer heat wave in Asia has shown, these aims are critical to ensure habitability of these large urban centers. While other approaches such as increased emissions standards have seen significant benefits in fighting urban pollution in China and India, nuclear power remains a strong candidate for a technology that could vastly improve air quality.

D8. *Policies and regulations favoring reduced emissions:* Nuclear energy will become more competitive in countries that have implemented more-stringent emissions standards and/or have provided significant subsidies to nuclear energy producers. Due to the zero GHG emissions benefits of nuclear energy, countries with higher emissions regulations will continue to drive significant innovation and the development of nuclear energy portfolios. However, political will may also reflect citizen concerns regarding nuclear power. In these situations, cooperative partnerships with other energy producers may yield the greatest potential for nuclear energy development.

The interaction of these supply-and-demand factors constitutes a dynamic landscape within which transnational, public-private partnerships are becoming increasingly important. Because no single country is self-sufficient, and regions with the highest demand factors are not those with historically strong supply factors, it appears that the best strategic opportunities for US industry may reside in countries with:

- a robust track record of current operations of nuclear reactors (S2);
- high-quality nuclear regulatory capacity, with strong ties to IAEA and NRC (S3);
- superior engineering, skilled labor, and manufacturing in nuclear supply chain (S4, S5, S6);
- access to low-cost capital for financing for capital-intensive nuclear plants (S7);
- clear regimes of asset control for nuclear facilities (e.g., military bases, secured sites); and
- a strong presence in Asia.

Conclusion

The path forward entails deeper and broader international cooperation between all interested parties: governments, regulators, suppliers, operators, and capital markets.

The United States has a range of choices when it comes to deciding how to proceed in the face of increased demand for nuclear power in many countries that have concluded that a balanced energy portfolio will be essential over the longer term. Leadership in the nuclear landscape of safeguards, regulatory policy, and competition no longer means selling or operating more reactors than the next country; instead, it will increasingly be executed through international cooperative agreements and by multinational consortiums and investments, supported by government policies mindful of long-term benefits, such as energy security and emissions reductions.

Possible Outcomes for International Cooperation

Lack of international cooperation among governments and industry alike: Lapsed international accords could hurt US influence in the longer term; for example, in regulatory practice and the upgrading of safeguards, especially now, with increased construction of new reactors in Asia. As the new projects in the southeastern region of the United States are completed, future opportunities for US firms will unfold overseas, particularly in Asia, as summarized in the section on "demand factors," moving business away from the United States.

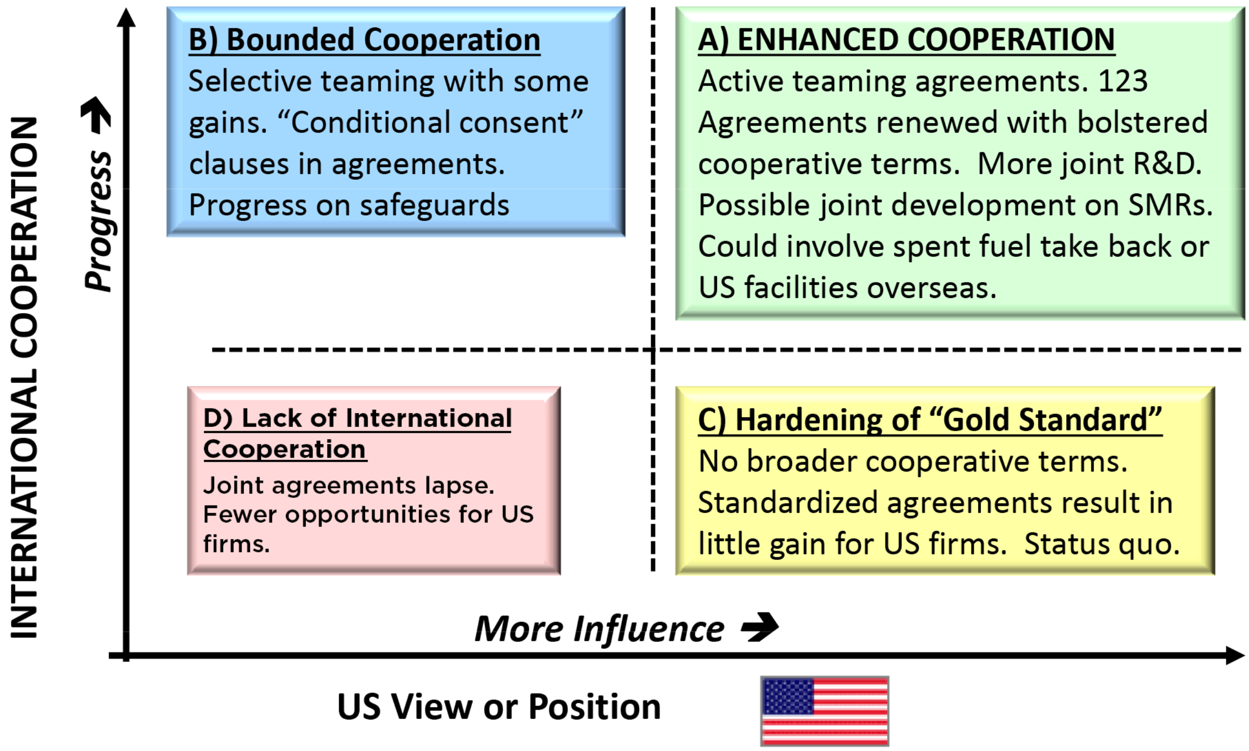
Hardening of "Gold Standard" approach could lead to lack of progress: The United States will need to increase international cooperation in order to maintain high standards of regulatory practice and nuclear safeguards, because the actual volume of construction will continue to surge outside of North America. Continuing a rigid Gold Standard approach to international agreements could erode US influence in safeguards and regulatory practices overseas if agreements lapse; if more countries individualize and "go their own way;" or if US companies continue to lose market share.[1] A recent letter (January 2012) to Congress by Deputy Secretary of Energy Daniel Poneman and Undersecretary for Arms Control and International Security Ellen Tauscher pointed out this potential detrimental scenario and proposed a "case-by-case" approach to 123 Agreements and international cooperation.[2]

The renewal of pending 123 Agreements would be bureaucratically easiest, but such an outcome would not address key concerns, such as dealing with spent fuel and further development of reactor technologies. In addition, just the renewal of agreements might not allow US companies to fully participate

1 A joint letter from the US Chamber of Commerce, the US National Association of Manufacturers, and the Nuclear Energy Institute (NEI) in July 2013 highlighted the importance and necessity of expanding cooperation via 123 Agreements in order to maintain US influence.

2 Elaine M. Grossman, "Administration Letter Promises 'Case-by-Case' Approach to Nuclear Trade Deals," Nuclear Threat Initiative, January 23, 2012, http://www.nti.org/gsn/article/administration-letter-promises-case-case-approach-nuclear-trade-deals/.

Figure 9. Outcomes Matrix for International Cooperation Scenarios in Global Nuclear Energy



in emerging opportunities in Asia, where the market for nuclear energy will clearly be expanding for the next several decades. On the current path, North America offers little opportunity, with few new orders.

Bounded Cooperation resulting in some progress: Limited cooperation by governments and industry partners toward technology advancement in the fuel cycle and in reactor design, including small modular units, could benefit the United States, its foreign bilateral partners, and potentially third-party countries, such as emerging nuclear users in the Middle East. Some amendments to 123 Agreements could incorporate "conditional consent" provisions for aligning progress with safeguards, as was the case in the nuclear cooperation agreement renegotiated with India in 2006. Ultimately, these agreements could allow for more US engagement in projects that call for construction of newer reactors and implementation of better safeguards in growth markets.

Enhanced Cooperation: The outcome with perhaps the greatest potential for international partnerships lies in broader cooperation and partnerships within and beyond 123 Agreements. Joint R&D and engineering in other technologies, such as grid reliability, are not subject to 123 Agreement restrictions, but could benefit multiple parties internationally. For example, Westinghouse continues to benefit from its engagement in the $20 billion construction project for four reactors at Barakah, UAE, led by the KEPCO-Doosan team. Other US manufacturers and engineering service firms could likewise benefit. Redefining leadership requires active engagement outside of North America.

Furthermore, the shifting global nuclear landscape has allowed other countries, such as South Korea, to move ahead with new technologies, e.g., modular reactors. Under such circumstances, a technology transfer would benefit the US industry in areas where domestic innovation has stalled. Joint research and advanced engineering would be beneficial to multiple, well-defined international partnerships and would pave the way for leadership in nuclear energy.

In conclusion, the US nuclear industry should seek reliable and technically advanced partners that share the same vision and commitment to strengthen the nonproliferation regime and spread the highest levels of operational safety globally. While US companies will develop partnerships tailored to local market opportunities in order to compete globally, Asian markets seem to offer some of the best opportunities in the near term:

- The United States stands to gain by developing and nurturing a few select partnerships with critical private-sector companies and governments.
- The United States stands to gain by expanding its joint activities with Asian industry participants.
- The United States should aim to develop a more-sophisticated joint approach to the global nuclear marketplace.

In seeking to maintain a meaningful role in the global development of nuclear power, the United States should seize the opportunity arising from the expiration of existing agreements and the need to negotiate new agreements with a continuously expanding list of potential nuclear commercial partners. Failure to maintain flexibility while pursuing proliferation safeguards and strong construction and operating standards could lead to diminished US influence.

Global prosperity depends on many factors, but the availability, affordability, and accessibility of adequate electricity and clean water is critical. Nuclear energy presents a good means to meet a significant portion of global power requirements, and the United States has a responsibility to see that the industry remains viable and an important player in the world's energy portfolio.

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