



INTERNATIONAL
TRADE
ADMINISTRATION

2016 Top Markets Report **Civil Nuclear**

A Market Assessment Tool for U.S. Exporters

May 2016



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Jonathan Chesebro served as the lead author of this report. **William Lahneman at the U.S. Department of Energy** put in significant time to develop the methodology and draft the 2015 report. Special thanks to **Kyle Deming** for updating the country case studies and helping to finalize the 2016 report, including incorporating input from the interagency. **Jason Portner, Devin Horne, Sarah Batiuk and Jessica Huang** contributed valuable data, graphics and content for the 2015 Country Cases Studies. Thank you also to **David Kincaid** for spearheading the development of this report and providing expert advice on the methodology and report template. In addition, several insights were garnered from conversations with, and edits by the **U.S. Department of Energy, the National Security Council, the U.S. Department of State, the U.S. Export-Import Bank, and the U.S. Nuclear Regulatory Commission.**

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Executive Summary

The U.S. Department of Commerce's International Trade Administration (ITA), under its Civil Nuclear Trade Initiative (CNTI), is committed to strengthening the competitiveness of the U.S. nuclear industry by identifying the industry's trade challenges and commercial opportunities and coordinating public and private sector cooperation to address these issues. As part of the CNTI, ITA developed the *Civil Nuclear Energy Top Markets Report*, a tool for prioritizing U.S. government (USG) export promotion efforts to help target limited resources toward the civil nuclear markets and activities most likely to result in U.S. exports. The report, now in its second year, is designed to inform decision makers, managers and analysts of key trends, areas of opportunity, and important challenges facing U.S. civil nuclear energy exporters through 2030.

ITA's *Civil Nuclear Energy Top Markets Report* recognizes the growing demand for civil nuclear technologies worldwide and, with it, new export opportunities for U.S. companies. Global energy demand growth has intensified concerns about energy security, fuel price stability and carbon emissions. In response, many national governments are driven to consider building nuclear power plants as a low carbon, domestically produced, base-load solution to their electricity needs.

The intention of this report is to identify best prospect markets in the civil nuclear energy sector, including noting where USG activities can most effectively be leveraged to support the success of U.S. companies. It is not intended to be an ordering of priorities for the industry itself nor is it a direct reflection of industry priorities. U.S. civil nuclear companies represent a broad range of industry subsectors, and each has a different set of objectives. Furthermore, it is not the role of the USG to direct industry priorities but rather to identify where resources can be most effectively leveraged within current legal frameworks to support the already existing export promotion efforts of U.S. companies.

A number of important developments marked growth in the global nuclear power market in 2015. The Paris Climate Conference recognized the importance of nuclear energy to meet global carbon reduction goals. The Convention for Supplementary Compensation for Nuclear Damage (CSC) nuclear liability regime entered into force. China kept its place as the fastest growing market for nuclear energy. China brought eight reactors online in 2015, bringing its total to 30 operating reactors; China also announced plans to export its reactor technology. Meanwhile, India and the United States achieved a breakthrough in bilateral civil nuclear cooperation, including understandings reached on issues of civil nuclear liability.

With an eye on how economic and policy developments have impacted U.S. industry export prospects, ITA has updated its Top Markets rankings for nuclear power. Among other examples, Ukraine rose in the rankings due to the sale of Westinghouse fuel to Ukraine's Russian-designed reactors and indications that more U.S. industry involvement is desired to support Ukraine's existing fleet. Turkey rose due to plans at its third nuclear power plant (NPP) site that could involve U.S. reactor technology. Conversely, Saudi Arabia dropped in the rankings due to its nuclear plans not developing as quickly as expected, and Brazil dropped in the rankings due to corruption scandals that discouraged potential export opportunities for U.S. civil nuclear companies.

Countries are continuing to evaluate nuclear power as a low-carbon, reliable, high density energy source to meet their energy demands and climate change goals. Key export markets are shifting from the traditional and mature markets of North America and Western Europe to emerging markets in Eastern Europe and Southeast Asia. Challenges to global civil nuclear expansion remain, including low natural gas prices, financing, spent fuel disposal pathways and public acceptance of nuclear energy. Consequently, strong USG-industry collaboration will be essential to help U.S. companies remain globally competitive.

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Overview and Key Findings

Introduction

The U.S. and global civil nuclear energy industry remains a growing market with unique challenges and opportunities. This section explores the current state of nuclear energy in the U.S. and globally and identifies barriers to competitive U.S. export competitiveness.

For purposes of this report, the global civil nuclear industry is divided into the following five subsectors:

- 1) *Advisory and Legal Support Services*
This subsector contains companies that provide advisory and consulting services that address the development of legal and regulatory regimes, licensing support, siting, environmental impact analyses, legal advice, and tender writing and development. Standards development and trade association activities are also included within this subsector.
- 2) *Design, Construction and Operation*
Companies in this subsector are responsible for technology design and engineering, procurement, project management, site preparation, plant construction, and plant operation and maintenance. This subsector addresses all activities in the engineering, procurement and construction (EPC) phase of a project and also covers utilities that operate plants and companies that provide plant maintenance and repair.
- 3) *Components*
Companies in this subsector are generally manufacturers that seek commercial opportunities throughout a plant’s lifecycle, including parts required for operation and maintenance, uprates and upgrades. We delineate this subsector to reflect commercial opportunities for component

manufacturers independent of Nuclear Steam Supply System (NSSS) providers.

- 4) *Fuels*
The fuels subsector includes all aspects of the fuel cycle, including mining and milling uranium, enrichment, conversion, fabrication of assemblies, refueling, transportation of fuel and fuel storage.
- 5) *Back-End Services*
Companies in this subsector provide services related to plant decommissioning and used fuel management, including waste management and removal, remediation, used fuel management, interim storage and transportation, geologic disposal and reprocessing, and recycling of plant byproducts.

A number of important developments marked growth in the global nuclear energy market in 2015. The December 2015 Paris Climate Conference recognized the importance of nuclear energy to meet global carbon reduction goals. The Convention for Supplementary Compensation for Nuclear Damage (CSC) nuclear liability regime entered into force in April 2015. China kept its place as the fastest growing market for nuclear energy. China brought eight reactors online in 2015, bringing its total to 30 operating reactors; China also announced plans to export its reactor technology. Meanwhile, India and the United States achieved a breakthrough in bilateral civil nuclear cooperation, including understandings reached on issues of civil nuclear liability.

Key Findings: Top Markets and Methodology

With an eye on how economic and policy developments have impacted U.S. industry export prospects, ITA has updated its Top Markets rankings for nuclear energy. Among other examples, Ukraine rose in the rankings due to the sale of Westinghouse fuel to Ukraine’s Russian-designed reactors and indications that more

Figure 1: Top 25 Overall Ranking for U.S. Civil Nuclear Exports

1. China	8. Mexico	15. Poland	22. Finland
2. United Kingdom	9. Saudi Arabia	16. Canada	23. Sweden
3. India	10. Turkey	17. Bulgaria	24. Slovenia
4. Vietnam	11. Japan	18. Argentina	25. Kazakhstan
5. UAE	12. Brazil	19. Ukraine	
6. South Africa	13. Rep. Korea	20. Slovakia	
7. Czech Republic	14. France	21. Romania	

U.S. industry involvement is desired to support Ukraine’s existing fleet. Turkey rose due to plans at its third nuclear power plant (NPP) site that could involve U.S. reactor technology. Conversely, Saudi Arabia dropped in the rankings due to its nuclear plans not developing as quickly as expected, and Brazil dropped in the rankings due to corruption scandals that discouraged potential export opportunities for U.S. civil nuclear companies.

Methodology

ITA’s 2016 Civil Nuclear Energy Top Markets Report ranks 50 countries in terms of their readiness for nuclear energy and openness to U.S. civil nuclear exports. Individual market ratings for exports related to new builds, existing reactors and decommissioning were assessed on the basis of 19 variables encompassing qualitative and quantitative measures. A detailed description of each variable is located in Appendix 2.

The total score for a given market is computed by adding together three sub-sector scores—new builds, existing reactors, and decommissioning—that comprise the full spectrum of civil nuclear exports of goods and services. A detailed description of each sub-sector score is located in Appendix 2.

Industry Overview and Competitiveness

Status of Nuclear Energy in the United States

The United States operates the world’s largest and most efficient reactor fleet and generates the most nuclear power worldwide (98.7 GWe in 2015). The 99 currently operating reactors include 34 boiling water reactors (BWRs) and 65 pressurized water reactors (PWRs). Nuclear energy accounts for 19.4 percent of U.S. electricity production and 60 percent of carbon-free

electricity generation. Four reactor units are currently under construction, with one soon to come online. Two units at Vogtle (Waynesboro, GA) and two units at Summer (Jenkinsville, SC) are Westinghouse AP1000 reactors and are expected to be operational between 2019 and 2020. Watts Bar 2, a Westinghouse PWR in Spring City, TN, was completed in August 2015 and is expected to begin operation in 2016.

In addition to the four units under construction, combined construction and operating license applications are under NRC review for seven units. Since 1977, the NRC has approved more than 6,900 megawatts (MWe) of power uprates (equivalent to adding seven reactors to the grid). 75 reactors have received 20-year license renewals, and most are anticipated to relicense. As of March 2016, there were seven combined operating license (COL) applications under active review with the NRC (three have recently been issued).

The U.S. Department of Energy (DOE) is supporting the domestic development of the U.S. civil nuclear industry through initiatives such as the DOE loan guarantee programs, 50-50 cost share with the federal government for small modular reactor development and deployment and the recent launch of the Gateway for Accelerated Innovation (GAIN) to support advanced reactor development and deployment. DoE recently announced an award for X-Energy and Southern Company to help expedite design approval for the next generation of nuclear reactors.

Despite the DOE’s support, challenges to nuclear deployment in the United States remain, including the high capital cost to build a plant, long and uncertain construction lead-time, record low natural gas prices, preferential grid access for renewable energy-based generation and no growth in electricity demand since

Figure 2: Top 10 Ranking by Sub-sector

<u>New Builds</u>	<u>Existing Plants</u>	<u>Decommissioning</u>
1. China	1. India	1. United Kingdom
2. India	2. China	2. Japan
3. United Kingdom	3. United Kingdom	3. Germany
4. Vietnam	4. Japan	4. Canada
5. United Arab Emirates	5. Canada	5. India
6. Saudi Arabia	6. Ukraine	6. Sweden
7. Turkey	7. France	7. Russia
8. South Africa	8. Sweden	8. Switzerland
9. Poland	9. Russia	9. Belgium
10. Mexico	10. Republic of Korea	10. Hungary

2004.

Global Industry Landscape

Globally, there are currently 444 nuclear reactors with a combined 386 gigawatt (GWe) capacity operating in 30 countries and 65 reactors under construction in 15 countries. The OECD International Energy Agency 2015 Global Energy Outlook Report projects that nuclear power will have to double by 2050 for the world to meet international climate change goals and the energy needs of an expanding global population, which is expected to grow to 10 billion by 2050. Many countries continue to express interest in developing or expanding their nuclear programs, although low oil and gas prices could make it harder for governments to favor policies that encourage the use of nuclear energy and other clean energy sources.

Nuclear markets are shifting from the United States and Western Europe to East Asia, the Middle East, South America, and Eastern and Central Europe. This has important implications for the global nuclear landscape after 2030. The U.S. Department of Commerce estimates the global civil nuclear market to be valued between \$500 and \$740 billion over the next 10 years and to have the potential to generate more than \$100 billion in U.S. exports and thousands of new jobs.

Challenges and Barriers to U.S. Civil Nuclear Exports

Despite the U.S. civil nuclear industry's strengths, U.S. companies continue to lose significant market share to an ever-increasing number of foreign government-owned or led competitors, including Russia, Japan, France, China and the Republic of Korea. Unlike its foreign competitors, the USG owns no part of U.S. reactor design companies. Industry promotion is often fraught with challenges, especially as the USG seeks to provide equitable support and avoid making value distinctions among competing U.S. companies. Furthermore, unlike our foreign competitors, the USG does not provide sovereign backing for its companies, which places them at a competitive disadvantage in the areas of financing, commercial incentives and liability insurance.

Other challenges for U.S. industry include (1) a need for additional bilateral civil nuclear cooperation agreements (123 Agreements), which are required under U.S. law for U.S. companies to export significant

reactor equipment and components to a country; (2) a vital but complicated export control process, including export controls under the jurisdiction of the U.S. NRC, DOE, the State Department and the Commerce Department's Bureau of Industry and Security (BIS); (3) an inadequate global nuclear liability regime, although the April 2015 entry into force of the CSC – and its expansion – will mitigate liability risks for U.S. civil nuclear companies doing business internationally; and (4) erosion of U.S. manufacturing capacity (U.S. companies no longer manufacture reactor vessels and steam generators).

Market challenges faced by all participants in the nuclear energy sector include (1) financing nuclear power plants, which requires long construction periods and high upfront capital costs that are not recouped until the nuclear power plant begins generating electricity; (2) infrastructure research, development and demonstration (RD&D), which requires the training of a skilled workforce; a nuclear manufacturing supply chain; an effective, independent and transparent regulatory infrastructure; and adequate RD&D resources, in particular for demonstration; (3) a need for spent fuel disposal pathways, particularly for emerging and small fleet markets; (4) a recognition of nuclear energy's role in addressing climate change and (5) public acceptance of nuclear energy. Another variable impacting public acceptance is the development of new reactor designs and features that have the potential to increase interest and confidence (e.g. passively safe design features; lower water usage; smaller, scalable, in grade designs). Unfortunately, global market growth has stagnated overall due to reduced electricity growth in emerging and mature markets.

Opportunities

Despite these challenges, U.S. civil nuclear companies are leading innovators in global nuclear energy technology and have more than five decades of experience designing, constructing, up-rating,ⁱ managing and decommissioning NPPs. U.S. industry has many competitive strengths, including being an expert leader and pioneering the development of civil nuclear energy, top performing companies all along the nuclear supply chain, a nuclear industry known for supporting the development of local industry and helping to deepen long-term bilateral relationships, and a regulatory system that is recognized as the global "gold

standard” for nuclear safety.

Market Categories

Generally, each market can be categorized according to its stage of interest and readiness for a civil nuclear energy program. These categories, in turn, help determine commercial opportunities for that market and the appropriate USG support strategy. This categorization was developed through the use of a flow chart (See Appendix 1) consisting of a series of yes/no questions. These categories are listed below in Figure 3.

Figure 3: Market Category Descriptions

Newly Emerging Market

- No operating commercial nuclear plants but clear government support for a civil nuclear energy program, and the country is taking tangible steps to develop the necessary regulatory framework, has established sites for its first plant or is building its first plants.
- Top markets: (1) Vietnam, (2) UAE, (3) Saudi Arabia, (4) Poland, (5) Lithuania, (6) Turkey, (7) Jordan.
- Short-term export opportunities: advisory and legal support services, education and workforce development.
- Mid/long term export opportunities: site selection and environmental assessments; design, construction and operation; components; fuel.

Existing Market and Expanding Fleet

- Country has one or more operating commercial nuclear plants and interest in expanding its fleet. Expansion has been noted via public announcements, tenders, construction to expand an existing plant or build a new plant and projected commission dates for new nuclear plants.
- Top markets: (1) China, (2) UK, (3) India, (4) Mexico, (5) Czech Republic, (6) Bulgaria, (7) Brazil.
- Short-term opportunities: site selection and environmental assessments; design, construction and operation; components; fuels.
- Long-term opportunities: back-end services.

Mature and Maintaining Fleet

- Country has significant experience operating nuclear plants but does not have plans to expand its existing fleet. Political climate favors nuclear power.
- Top markets: (1) Canada, (2) Taiwan, (2) Spain, (3) the Netherlands.
- Short-term opportunities: plant operation and maintenance, components, fuels.
- Mid/long term opportunities: back-end services.

Mature Market and Decommissioning

- Country has significant experience operating nuclear plants and is currently decommissioning plants or has announced plans to do so. Political climate does not favor nuclear power.
- Top markets: (1) Japan, (2) Germany, (3) Switzerland, (4) Belgium.
- Short/mid/long-term export opportunities: plant operation and maintenance, components, fuels, back-end services, decommissioning and decontamination.

Country Case Studies

The following pages include country case studies that summarize export opportunities in selected markets. The overviews outline ITA's analysis of the U.S. export potential in each market. The markets represent a range of countries to illustrate a variety of points and not the top markets overall.

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Brazil

Market Type: Newly Emerging

Brazil has a promising civil nuclear energy market. The country's two nuclear reactors supply 3 percent of Brazil's energy, and there are plans for eight new reactors in operation in the 2020s, with one additional reactor currently under construction. Brazil is dependent on hydro for its electricity, and recent droughts illustrate the need for energy diversification. The Brazilian government and the general public have favorable opinions of nuclear power, but recent scandals involving industry leaders and broader political uncertainty will slow Brazil's ambitions to grow its nuclear fleet in the near future.

New Builds

12

Existing Reactors

15

Decommissioning

N/A

Overall Rank

12

U.S. Ambassador to Brazil: Liliana Ayalde
Senior Commercial Officer in Brasilia: Rick Ortiz

Approximately 3 percent of Brazil's energy is supplied by two pressurized water reactors (PWRs) at the Angra dos Reis NPP near Rio de Janeiro. Angra 1&2 have 626 MWe and 1270 MWe generating capacity, respectively. A third 1270 MWe reactor, Angra 3, is under construction and expected to come online in 2018. In May 2015, Brazil's Energy Minister stated that Angra 3 would be the last state-sponsored NPP and that Brazil would seek private investment for future NPPs.

The Government of Brazil (GOB) is very supportive of nuclear power. The Angra 3 project, which started construction in the 1970s and was suspended in 1986 due to budgetary issues, was resumed in 2010 after France's Areva signed a deal with Brazil's state-owned utility Eletronuclear to take over the project. Eletronuclear, a subsidiary of Eletrobras, is responsible for building and operating NPPs in Brazil

Recent droughts have demonstrated the need to reduce Brazil's dependence on hydropower, which accounts for a large proportion of the country's energy. In April 2015, the Ministry of Mines and Energy updated its 10-year energy plan, confirming that Brazil will continue to invest in nuclear energy and that it was evaluating sites for the development of eight new units to be built in the future. This plan, however, only contemplated the conclusion of Angra 3, which is currently under construction. Brazil's Long-Term Energy Plan (PNE 2050)

has not yet been concluded, and although new nuclear plants are expected to be included in this plan, the role that nuclear power will play in Brazil's long-term energy mix is currently unclear. Pernambuco in the northeast and Minas Gerais in the southeast have been selected as potential sites. A July 2015 bribery charge against Eletronuclear's CEO has raised doubts about the completion of Angra 3 and the commencement of any new projects.

Public opinion in Brazil regarding nuclear power is positive. After the Fukushima disaster, Globescan, a public opinion research company, found that 60 percent of those surveyed wanted to keep operating NPPs or build new NPPs, with 35 percent wanting to shut down existing plants. Public opinion is generally in favor of balancing the energy mix to include nuclear with renewables, including wind and biomass. Local populations near uranium mines, however, have expressed concerns about the feasibility of emergency plans and other nuclear-related contingencies in the event of an accident.

Planned Nuclear Energy Projects

Angra Nuclear Power Plant Expansion

Owner: State

Reactor Type: Pressurized Water Reactor

Capacity: 1405 MWe (1270 MWe net)

Value of Project: N/A

Construction Period: 2010-2017

Operation: 2018

Angra NPP: Angra 3 was originally envisioned in 1984 as a twin of unit 2. The project was suspended until the mid-2000s, and the first concrete was not laid until June 2010. Following the 2015 corruption probe, several contracts for Angra 3 were again suspended. Construction of the plant is approximately half finished.

New Northeast Nuclear Power Plant

Owner: State

Reactor Type: PWR (TBC)

Capacity: 6000-6600 MWe (four PWR units)

Value of Project: N/A

Construction Period: N/A

Operation: TBD

New Northeast NPP: Eletronuclear wants to construct two additional NPPs in Brazil: one in the northeast, and a second near Angra in the southeast. In 2013, Pernambuco-Bahia was chosen for the northeast site. All eight units will need approval by the Brazilian Congress.

New Southeast Nuclear Power Plant

Owner: State

Reactor Type: PWR (TBC)

Capacity: 6000-6600 MWe (four PWR units)

Value of Project: N/A

Construction Period: N/A

Operation: TBD

New Southeast NPP: In 2013, Minas Gerais was chosen for the southeast site.

Commercial Opportunities

Services (front-and back-end): Currently, no opportunities for decommissioning exist, as both Angra 1 and Angra 2 are expected to be granted life extensions to 2024 and 2041, respectively.

Legal and Consulting Services: There is limited potential, but opportunities exist for lifetime extension and plans for new construction.

Licensing Support: Opportunities exist to support Brazil's nuclear regulator, the National Nuclear Energy Commission (CNEN). CNEN's Directorate of Radiation Protection and Safety is responsible for licensing and supervising all nuclear facilities.

Design, Construction, and Operation: Opportunities exist for new construction of eight reactors.

Components: Moderate opportunities to supply existing plants, one of which was built by Westinghouse, with engineering support, fuel components and related materials.

Challenges and Barriers to Exports

GOB support for nuclear energy is strong. Earlier this year, the Minister of Energy and Mines confirmed that future energy plans will include new reactors. Brazil's interest in building new reactors has attracted a high level of interest from U.S. reactor vendors, as well as Areva and Rosatom. Brazil's goals remain ambitious, particularly amid a history of delays and regards to the units at Angra. cancellations in

The unfolding scandal surrounding Eletronuclear poses a challenge to civil nuclear exports. The investigation prompted the suspension of two contracts with Brazilian consortiums that were to work on the construction of Angra 3, potentially further delaying the project. The effects of this scandal on public opinion are unclear. Additionally, the proposed reactors may not be built without the approval of the National Congress, which is not guaranteed.

Financial obstacles exist for U.S. civil nuclear exports to Brazil. As the GOB no longer plans to sponsor any new NPPs, funding will have to come from the private sector. Doing business in Brazil requires a strong understanding of the local environment, as well as the direct and indirect costs of doing business, such as government procedures, local content requirements, environmental laws, insufficient infrastructure and a complex tax system.

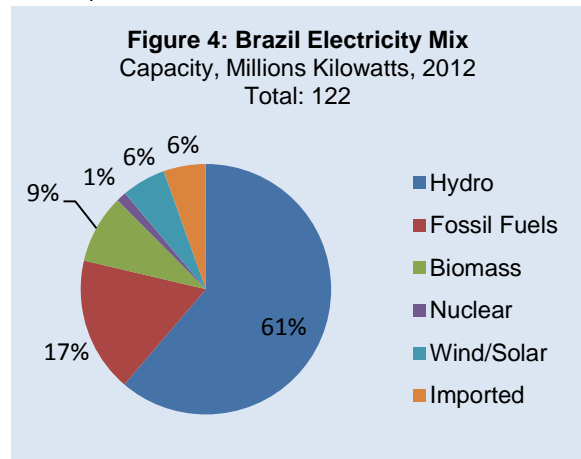
Nuclear Infrastructure

Research reactors: Brazil has four operational nuclear research reactors. In Sao Paulo, there are two research reactors (including a 5 MWe pool type reactor) and a cyclotron with radioisotope production.

Fuel: Brazil has 278,000 tons of known uranium. It is mined and used domestically, after conversion and enrichment abroad. Conversion is done by Areva in France. Most enrichment is conducted by Urenco in the United States or Europe. Efforts are underway to begin enriching uranium domestically. Currently, the Brazilian navy leases the uranium enrichment technology to

Brazilian Nuclear Industries and produces centrifuges for it.

Waste Management: Nuclear waste is disposed of in four temporary repositories. A long-term solution is still being considered. CNEN is responsible for management and disposal of radioactive wastes.



U.S. Government Collaboration

123 Agreement: Brazil has had a 123 Agreement with the United States since 1999.

Strategic Energy Dialogue (SED): SED is one of the four high-level presidential dialogues between the United States and Brazil. One of the priority areas of intergovernmental cooperation in SED is nuclear energy.

International Engagement

The first nuclear contract was awarded to Westinghouse. In 1975, Brazil was to develop two reactors with West Germany, but construction was interrupted due to economic issues. The construction of Angra 2 was eventually resumed thanks to funding from German banks and newly formed Brazilian state owned companies, Furnas and Eletrobras. Brazil signed agreements with Germany in the 1970s to transfer nuclear technology and jointly develop experimental technology to enrich uranium. The completion of the third reactor, Angra 3, was awarded to Areva in 2008, which is also being considered for supplying additional reactors.

After Eletronuclear's proposed plan to build four more reactors, Areva, Westinghouse and Rosatom expressed

interest in the projects. In June 2015, Westinghouse signed an agreement with Nuclebras Equipamentos Pesados for collaboration on fabrication of reactor components in Brazil. Rosatom offered a Build-own-operate project, which could solve the financing issue that other bidders face.

Figure 5: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	
IFNEC	
GenIV International Forum (GIF)	✓

Resources

For more information on the commercial opportunities in Brazil, contact: Brian Brisson (Minister Counselor for Commercial Affairs, Brian.Brisson@trade.gov); Regina Cunha (Senior Commercial Specialist, Regina.cunha@trade.gov).

For more information on the civil nuclear industry in Brazil, contact: CNEN website (<http://www.cnem.gov.br/>)

Sources

CIA Factbook, United Nations, World Nuclear Association, and our contacts at the US Embassy in Brasilia.

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Bulgaria

Market Type: Existing and Expanding

Bulgaria is considering expanding its current fleet of two reactors, but negotiation breakdowns and cancellations have delayed construction plans. Russia's presence in Bulgaria's nuclear sector represents a challenge for U.S. exporters, as does Bulgaria's financing and business environment. Public and political support for nuclear energy remains strong, however.

New Builds

13

Existing Reactors

24

Decommissioning

17

Overall Rank

17

U.S. Ambassador to Bulgaria: Eric Rubin
U.S. Commerce Attaché to Bulgaria: Maria Galindo

Bulgaria currently has two operational Russia-designed VVER reactors and four additional VVER reactors that are permanently shut down. All reactors are located at the Kozloduy site. Bulgaria considered building a new nuclear power station at Belene, but the project was abandoned in February 2013 after several years of negotiations with Russia. In March 2015, Bulgaria delayed its plan to build a new reactor at Kozloduy after a suspension in negotiations with Westinghouse.

Bulgaria's National Energy Strategy, published in 2011, indicates that Bulgaria is strongly considering extending the life of Kozloduy units 5 and 6 as well as building new units. The main activities in the nuclear energy field are safety operation of the existing two units (2000 MW capacity), construction of up to two new reactors at Kozloduy and construction of a dry spent fuel storage facility.

Public support for nuclear energy is strong in Bulgaria. In January 2013, a public referendum showed 61 percent of voters supporting the construction of a new NPP; however, turnout for the vote remained low—21 percent—making the vote non-binding but large enough to spark debate and discussion in parliament. A January 2009 gas shortage prompted Bulgarian citizens to take to the streets in support of restarting reactors at Kozloduy. Political movements within Bulgaria have also

tied nuclear energy to Bulgaria's emergence as a technologically advanced nation.

Kozloduy units 5 and 6 are undergoing an upgrade and modernization program. They are currently licensed through 2017 and 2019. Kozloduy Nuclear Power Plant plc signed a contract with Rosenergoatom and EDF to extend their lifetimes from 30 to 50 years. In October 2015, parties reached an agreement for Rosatom to modernize unit 5 by May 2018 with a project cost of €24.7 million. The Government of Bulgaria (GOB) is under pressure to modernize the units in order to keep electricity prices low.

Planned Nuclear Energy Projects

Owner: State or shared

Reactor Type: PWR AP 1000 *Capacity:* 1,000MW

Capacity: 1,000 MWe

Value of Project: N/A

Construction Period: Not started – potentially 2020

Operation (tentative): 60 years

Kozloduy NPP: New Build EAD, the state-controlled project company, was granted permission by the Bulgarian Nuclear Regulatory Agency (NRA) to select the location of a planned nuclear generation facility. NRA official permission marks the beginning of the licensing procedure for the construction of a new NPP in Bulgaria. The project has been on hold since the March 2015 expiration of Westinghouse's Shareholder's Agreement with BEH. The GOB is seeking a strategic investor for the project.

Commercial Opportunities

Services (front-and back-end): Limited opportunities for decommissioning, though Russian technology of Kozloduy 1-4 will make it harder for U.S. companies to play a large role.

Legal and Consulting Services: Many opportunities exist. Several U.S. companies have consulted with the GOB on Belene NPP. Further opportunities exist for Kozloduy units 5 and 6's lifetime extension and plans for new construction.

Licensing Support: The Bulgarian NRA is the only state body that can issue, amend, modify, renew, suspend and revoke licenses and permits for the safe conduct of NPP activities in Bulgaria.

Design, Construction, and Operation: Opportunities exist for new construction at Kozloduy, but new projects have been placed on hold following a breakdown in negotiations with Westinghouse.

Components: Moderate opportunities exist for operating plants. Reactor vessels, core, refueling machinery, turbines, storage equipment, etc. are manufactured in Russia.

Challenges and Barriers to Exports

Bulgaria's initial 2013 decision to sole-source Westinghouse for the Kozloduy extension project indicated significant potential opportunities for U.S. industry in this market, which has been difficult to enter due to its fleet of Russian reactors. Despite the failure in talks, the GOB remains hopeful that a deal can be reached with Westinghouse.

Government support for nuclear energy is strong and public opinion is supportive, but several obstacles exist that could delay Bulgaria's new build plans or add additional challenges to U.S. industry engagement.

Bulgaria remained on USTR's Special 301 Watch List in 2015 for only taking limited steps to address persistent U.S. concerns regarding IPR infringement, making it challenging for U.S. companies to cooperate with Bulgarian companies on big projects such as new reactor builds.

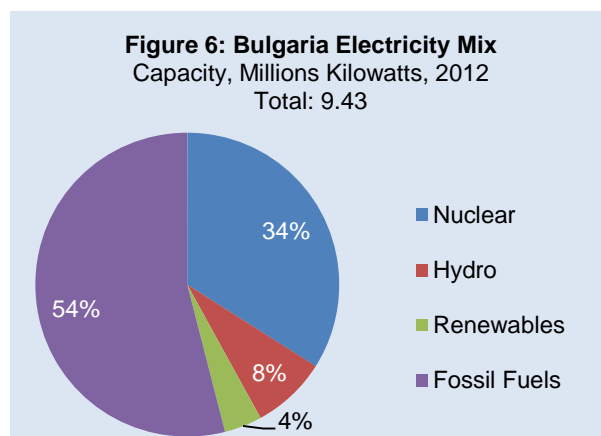
Financing new nuclear power projects is also a key obstacle for Bulgaria. Bulgarian debt owed to the United States and other countries makes provision of Ex-Im Bank financing a challenge. Bulgaria receives a low score on Ex-Im Bank's long-term exposure fee level and also has a relatively low score on World Bank's Ease of Doing Business Indicator.

Nuclear Infrastructure

Research Reactor: The Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences in Sofia operates Bulgaria's sole research reactor. The reactor's original capacity was 1 MWe in 1959 and was increased to 2 MWe in 1970, but the reactor was shut down in 1989. Currently the reactor is being modified to operate on low enriched uranium (LEU) at a 2kW capacity. Bulgaria returned its highly enriched uranium (HEU) to Russia in 2003, with used HEU and LEU following in 2008.

Fuel: All front end fuel cycle services in Bulgaria are provided by Russia's TVEL through Technobexport.

Waste Management: State Enterprise Radioactive Wastes (SE-RAW) oversees the majority of Bulgaria's waste management. A 2002 agreement between Bulgaria and Russia established payment of USD 620,000 per ton of spent nuclear waste sent to Ozersk, Russia for reprocessing. Recent funds from the European Bank for Reconstruction and Development (EBRD) have enabled the construction of a dry fuel storage facility (DFSF) for 2800 VVER-440 used fuel assemblies near Kozloduy. Nukem Technologies and Gesellschaft für Nuklear-Service (GNSmbH) partnered to construct the facility. Current plans foresee expanding capacity to accommodate 8000 VVER-440 and 2500 VVER-1000 assemblies. The facility opened in May 2011 with the ability to store 5200 fuel assemblies in 72



casks. The Bulgarian government is also pursuing a national low and intermediate level waste disposal facility to be built on a site adjacent to Kozloduy.

U.S. Government Collaboration

123 Agreement: Bulgaria has a 123 Agreement with the United States through Euratom.

Agreement for Cooperation: The United States and Bulgaria signed an Agreement for Cooperation in the Field of Peaceful Uses of Nuclear Energy in June 1994, and it entered into force in March 1996.

June 2013 Legal Review and Legislative Drafting Workshop: The U.S. Department of State's Preventing Nuclear Smuggling Program (PNSP) and the Government of the Bulgaria organized a successful workshop in Sofia to assess how Bulgarian authorities would prosecute nuclear and radiological smuggling cases under existing criminal laws.

Technological Exchange: The U.S. Nuclear Regulatory Commission and Bulgaria's NRA have an arrangement for the exchange of technical information and cooperation in nuclear safety matters.

U.S. Export Support: Ex-Im Bank has supported U.S. civil nuclear exports to Bulgaria with a \$77 million facility in July 2000 for the upgrade of the Kozloduy Nuclear Power Plant.

Figure 7: Additional Agreements

Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	✓
Convention on Supplementary Compensation for Nuclear Damage (CSC)	

Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	

International Engagement

Bulgarian Energy Holding Company (BEHC)—a 100 percent state owned energy holding company—reached an agreement with France's AREVA in April 2011 as part of Bulgaria's commitment to developing low-carbon energy projects. The memorandum of understanding (MOU) identifies plans for cooperation on new nuclear projects on the Kozloduy and Belene sites. The agreement also identifies fuel management policies and responses, such as spent fuel recycling as well as meeting international standards for nuclear safety. The agreement with AREVA provides BEHC access to AREVA's portfolio of Generation III nuclear reactor, which guarantees higher safety levels.

Resources

For more information on the commercial opportunities in Bulgaria, contact: Thomas Bruns (Senior Commercial Officer in Sofia, thomas.bruns@trade.gov) Emily Taneva (Commercial Specialist in Sofia, emily.taneva@trade.gov); I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov).

For more information on nuclear energy in Bulgaria, see: Bulgarian Energy Holding: <http://www.bgenh.com/>

Sources

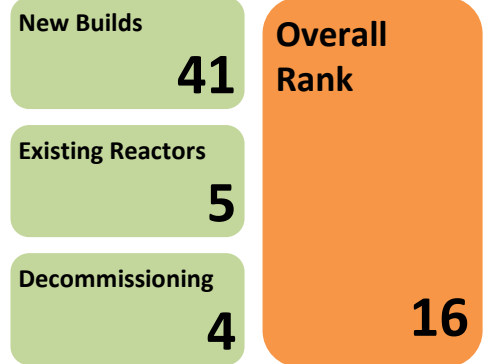
CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and contacts at U.S. Embassy Sofia.

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Canada

Market Type: Mature and Maintaining

While Canada has delayed plans to build additional domestic reactors, it is a competitor of the United States in international markets. Canada's ongoing decommissioning and refurbishing projects offer some opportunities for U.S. exporters, although a robust Canadian nuclear industry and lower electricity demand will limit U.S. participation in new builds.



U.S. Ambassador to Canada: Bruce A. Heyman
U.S. Commerce Attaché to Canada: Lucy Latka

Canada has 19 operational and six shut down or decommissioned nuclear reactors. Four nuclear generation stations house Canada's 19 reactors, which provide 16.15 percent of Canada's total electricity. Nuclear power ranked second in Canada's 2014 energy mix behind hydro (63.32 percent) and ahead of coal (14.65 percent).

The four main reactor sites are Bruce Power Nuclear Generating Station (NGS) on Lake Huron (190 km from Toronto), Darlington NGS on Lake Ontario (60 km from Toronto), Pickering A NGS on Lake Ontario (30 km from Toronto) and Point Lepreau NGS in New Brunswick (30 km southwest of Saint John).

All of Canada's operational reactors are CANDU (Canadian Deuterium Uranium) PHWR-type reactors designed by Atomic Energy Canada Ltd (AECL) of Mississauga, ON, in cooperation with GE. GE also supplies reactor systems, including the radioactive combustible loading/unloading in the reactor. In October 2011, the commercial reactor business of AECL was sold to SNC-Lavalin, which established Candu Energy Inc. as a subsidiary. The federal government continues to own and operate other parts of AECL, including the research reactors, mainly the Chalk River facilities, under the name of Canadian Nuclear Laboratories (CNL), which are managed by a consortium called Canadian Nuclear Energy Alliance (CNEA). The

Canadian nuclear industry is a \$6.6 billion industry and is a global leader in uranium mining and fuel supply, reactor exports and medical isotope production.

Canadian reactors are undergoing an extensive refurbishment program aimed at enhancing safety, uprating and extending operational lifetime. To date, seven reactors have completed refurbishment. Large cost overruns and schedule delays with several of these projects have caused operators and investors to reevaluate plans for other reactors, resulting, in some cases, in scaling down the extent of refurbishment or shutting down plants rather than refurbishing them. Plans for refurbishing reactors at Pickering B, Bruce B and Darlington are under review and may extend over the next 10 years. In December 2015, the Ontario Energy Ministry announced the approval of the long-term contract that will allow Bruce NGS to refurbish six reactor units. Bruce Power will invest CD\$13 billion to refurbish the plants. In January 2016, the Ontario Energy Ministry approved Ontario Power Generation's plans to refurbish two nuclear reactor units at Darlington NGS.

Three reactors are undergoing decommissioning. The extent of other opportunities for decommissioning contracts will depend on plans for refurbishing Canada's remaining three currently shut down reactors. In 2016, the decommissioning of Gentilly 2 will be decided, as it remains in a safe storage mode since ceasing operations in 2012. Of those units that have already undergone

refurbishment, the first planned closure will occur in 2018.

Canada has largely deferred its new reactor builds. In November 2013, the Ontario government indefinitely deferred plans for constructing two new reactors at Darlington, citing a slowdown in electricity demand growth. The leading contenders for the new reactors were Westinghouse (AP1000) and SNC-Lavalin/Candu Energy Inc. (Enhanced Candu-6 (EC6)); both had submitted detailed construction plans, schedules and cost estimates before the decision to defer construction plans was made.

Additional plans for reactor projects have been pursued by the governments of New Brunswick and Alberta over the last 10 years, but since 2011, all plans have been put on hold.

Canada continues to market CANDU reactors abroad in both newly emerging and mature markets; such potential new builds present opportunities for U.S. industry engagement.

Planned Nuclear Energy Projects

New Build

Owner: Ontario Power Generation (OPG) (government-owned crown corporation)

Reactor Type: undetermined

Capacity: up to 4800 MWe

Value of Project: N/A

Construction Period: indefinitely deferred in November 2013

Operation (tentative): N/A

Notes: The project has been deferred in favor of refurbishing existing plants through 2026. Reactor projects at Point Lepreau in New Brunswick and Peace River in Alberta have been proposed but have not moved forward.

Refurbishments

Owner: OPG

Reactor Type: two CANDU reactors and related facilities at Darlington NGS

Value of Project: CD\$13 billion

Construction Period: start 2016

Owner: Bruce Power

Reactor Type: six CANDU reactors at Darlington NGS

Value of Project: CD\$13 billion

Construction Period: start 2020

Commercial Opportunities

Services (front- and back-end): Opportunities for decommissioning.

Legal and Consulting Services: Limited.

Licensing Support: Limited.

Design, Construction, and Operation:

Opportunities exist for U.S. content in CANDU new build abroad, but there are no new build plans in Canada.

Components: Significant opportunities will exist for the announced refurbishments of existing plants in Canada and moderate opportunities for CANDU reactors abroad.

Challenges and Barriers to Exports

The main barrier for new build contracts in Canada is the stagnant demand for electricity and more than sufficient existing capacity. That, combined with a very safe and clean generation mix relying on over 60 percent hydro, is driving government policies, which have recently deferred all plans for new reactor construction. Even if new construction is pursued, it would be difficult for a supplier other than Candu Energy to win new build contracts because of the confidence and synergies resulting from having practically the same supplier for all of Canada's existing reactors, in addition to the very large integration and local contribution in the design, manufacturing, installation, commissioning, operation and maintenance, which cannot be matched by other suppliers. Candu Energy and its parent, SNC-Lavalin, have access to high-level decision makers in the provincial and federal governments and is the largest EPC company in Canada.

The same obstacle exists for U.S. exports to Canada's existing fleet, though much less so. There is a high degree of integration between the U.S. and Canadian civil nuclear industries for goods and services to Canada's reactor fleet and nuclear facilities. There are also opportunities for U.S. content in CANDU reactors abroad, including upgrades to operating plants and new builds.

Energy drivers are another challenge. Low projected electricity demand was the reason cited by the Ontario government for deferring plans for the Darlington expansion project. Canada's vast reserves of natural gas and current low natural gas prices may further dampen its perceived need for new nuclear capacity.

Canada remained on USTR's Special 301 Watch List in 2015, mainly due to border enforcement issues of pirated and counterfeit goods and for patent regulation issues chiefly related to the pharmaceutical industry. Canada scores highly in all financial and infrastructure factors, and its commitment to accede to the CSC is welcome news.

Nuclear Infrastructure

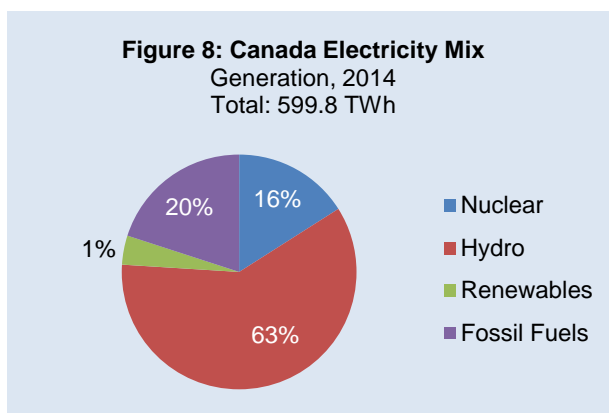
Research Reactor: A 60 MWe WR-1 research reactor was built by GE at Whiteshell Laboratories and started up in 1965. The original purpose of the unit was as a test reactor for a proposed organic-cooled CANDU power reactor. When that program ceased in 1972, it was used for other R&D until it was shut down in 1985. Six other research reactors were built and continue to operate on university campuses. Five of these are SLOWPOKE-2 units, low-energy pool-type reactors designed by AECL with passive cooling and safety systems.

Fuel: Canada is the world's second largest exporter of uranium, accounting for 15 percent of world output, and 15 to 20 percent of Canadian uranium production is consumed domestically. All Canadian uranium mining currently takes place in northern Saskatchewan. Cameco Corporation and AREVA Canada Resources Inc. (AREVA) are the majority owners and operators of the uranium mines and mills now in operation. Cameco owns and operates the Rabbit Lake mill and the Eagle Point mine. It is also the joint venture operator of the McArthur River mine and the Key Lake mill. AREVA is the operator of the McClean Lake mine and mill.

At its Port Hope, Ontario facility, Cameco has about one-quarter of the western world's uranium hexafluoride (UF6) conversion capacity and provides the only commercial supply of fuel-grade natural (unenriched) uranium dioxide (UO2). The UF6 is enriched outside Canada for use in light water reactors, while natural UO2 is used to fabricate fuel bundles for CANDU reactors in Canada and abroad. Two fuel fabrication plants in Ontario process some 1,900 tons of

uranium per year to UO2 fuel pellets, mainly for domestic CANDU reactors.

Waste Management: Canada's nuclear regulator is the Nuclear Fuel Waste Bureau from Natural Resources Canada. The Nuclear Waste Management Organization (NWMO), together with Candu Energy, are responsible for storage and disposal of high-level wastes. Nuclear utilities and AECL are responsible for low and intermediate-level wastes. A deep geological repository for high-level wastes is currently under advanced approval process for Tiverton, ON with input/approval from host communities. NWMO expects the repository to begin operation in 2035. Low and intermediate-level wastes are stored above ground. A Deep Geologic Repository is in the planning stage and is subject to further approval.



U.S. Government Collaboration

123 Agreement: Canada's 123 Agreement with the United States expires on January 1, 2030 with rolling five-year extensions thereafter.

International Engagement

The GOC cooperates with many countries for R&D and commercial engagement and promotion. Most recently, in July 2014, SNC-Lavalin signed two cooperation agreements with China National Nuclear Corporation (CNNC) to jointly develop reactors using CANDU technology and to collaborate on uranium mining projects in China. The GOC is active in multilateral organizations, including the IAEA and IFNEC.

In April 2015, Cameco signed a uranium supply contract with India's Department of Atomic Energy. Its first

shipment arrived in December, ending a bilateral nuclear cooperation hiatus that lasted over 41 years.

Figure 9: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
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Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	✓

Resources

For more information on commercial opportunities in Canada, contact: Stefan Popescu (Commercial Specialist in Toronto, stefan.popescu@trade.gov); Cindy Biggs (Principal Commercial Officer in Calgary, cindy.biggs@trade.gov); I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov).

For more information on nuclear energy in Canada: Atomic Energy of Canada Ltd: <http://www.aec.ca/en/home/default.aspx>

Canadian Nuclear Safety Commission
<http://nuclearsafety.gc.ca/eng/>

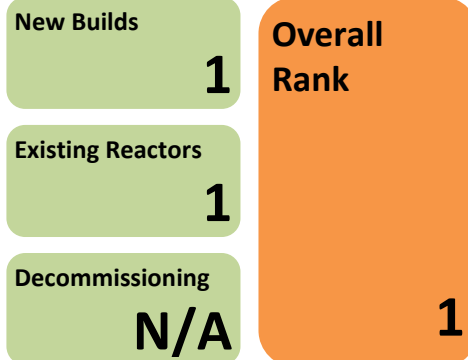
Sources

CIA Factbook; United Nations; World Nuclear Association; Asian Development Bank, and our contacts at the US Embassy in Ottawa and the US Consulate in Toronto.

China

Market Type: Existing and Expanding

China is aggressively expanding its nuclear fleet to reduce air pollution from coal-fired power plants and keep pace with economic growth, but electricity demand growth slowdowns have partially delayed new reactor construction. While technology indigenization, local content requirements and self-sufficiency limit foreign participation, nuclear sector growth in the next decade will ensure commercial opportunities for U.S. civil nuclear exporters.



U.S. Ambassador to China: Max Baucus
U.S. Commerce Attaché to China: Sarah Kemp

China has 33 operational nuclear reactors with a total installed capacity of 28.31 GWe. Of these, two are Russian VVER models, two are Candu PHWRs and the rest are Chinese designed PWRs that are chiefly derived from French models. 22 reactors are under construction with a total installed capacity of 26.72 GWe. China ranks first in the world for number of units under construction. In 2015, eight new reactors were connected to the grid, and nuclear power accounted for about 3.01 percent of the country's generating capacity.

In October 2012, China's former Premier, Wen Jiabao, outlined a post-Fukushima approach to nuclear power development, which consists of China employing a steady pace in its effort to build new nuclear power plants (NPPs) while complying with new generation safety standards. In recent years, China has tried to reduce its nuclear capacity target to 58 GWe by 2020 from the previous goal of 80 GWe, but this still represents a remarkable tripling of existing capacity. Also in October 2012, the State Council approved the "12th Five-Year Plan for Nuclear Safety and Radioactive Pollution Prevention and Vision for 2020," in which China delineated its plans to spend RMB 80 billion (\$13 billion) to improve nuclear safety at 41 operating and under construction reactors over the next three years. Such actions in response to the Fukushima accident highlight a perceived need to improve the reputation of Chinese firms on issues regarding safety and quality as

well as the increasing strain on the Chinese nuclear regulator to enlarge its ranks of experienced personnel to meet rapid expansion.

During the 13th Five-Year Plan (2016-2020), China will focus on constructing coastal NPPs; building indigenous nuclear demonstration projects; completing Sanmen and Haiyang AP1000 projects; building Fuqing, Fangchenggang Hualong One demonstration projects; starting construction of Rongcheng CAP1400 demonstration project; accelerating construction plans for Tianwan units 5 and 6; active preparation of inland NPPs; accelerating and facilitating large commercial reprocessing plant construction; and strengthening its nuclear fuel security system.

China aims to become a reactor design exporter and compete alongside established companies for reactor tenders worldwide. Its policy of indigenizing foreign technology, though helping to expand China's reactor design and engineering capabilities, has thus far limited China's ability to export its designs, as its technology transfer agreements—with Westinghouse for the AP1000, for example—prohibit China from exporting indigenized designs below a specified power threshold. China has recently developed two designs for export: the ACC1000 (also known as the Hualong One, a recent merger of the ACP1000 and ACPR1000 designs) and the CAP1400, which is based on the Westinghouse AP1000 model but scaled to a power capacity allowing China export rights. China National Nuclear Corporation (CNNC) and China General Nuclear (CGN) signed a joint

venture to promote the Hualong One and export Generation III reactors globally. Construction on the first reactors for each design has been delayed twice but is scheduled to begin for Fuqing-5 and Fuqing-6 in May 2016 and December 2016.

In January 2015, China announced an incentive and financial program for nuclear exports. A few months later, an agreement was signed with Argentina to build two reactors mostly financed by China. The first reactor is a Candu type reactor to be delivered in 2016 while the second is a Hualong One reactor.

China is supporting civil nuclear projects in the UK, including CGN's 33.5 percent ownership in the Hinkley Point C site and 20 percent ownership in the EDF-controlled Sizewell site. EDF's European Power Reactor (EPR) is to be built at both sites. In exchange for Chinese funding, EDF will take a 33.5 percent stake in the Bradwell site, where the Chinese designed Hualong One reactor will be built. This will be the first Chinese-designed reactor to be built in a Western country.

China has a vast R&D portfolio that includes all aspects of the fuel cycle. It is pursuing fast reactor, HTGR, and SMR demonstration projects as well as expanding its capabilities for uranium mining, enrichment, fuel fabrication and reprocessing. In nearly all of these areas, China is developing its own technology as well as partnering with foreign governments and industry to import technology.

Planned Nuclear Energy Projects

China is targeting 58 GWe of installed nuclear capacity by 2020, and further increases are planned thereafter. Domestic designs will make up the majority of new reactors, but China will continue to engage with U.S., French, Russian and Canadian industries for others. The Chinese government and state-owned enterprises work directly with international vendors for planning new reactors rather than conducting an open bidding process.

Commercial Opportunities

Services (front-and back-end): Opportunities for probabilistic risk assessment and regulatory advisory services

Licensing Support: Opportunities to support China's National Nuclear Safety Administration (NNSA).

Design, Construction, and Operation: Significant opportunities for new nuclear plant construction. Components: The interim portion of the NPP supply chain represents the largest current opportunity for U.S. exporters. Under China's mammoth nuclear energy expansion, China is building plants of two basic types. The first are Generation II reactors based on technology already mastered by Chinese domestic producers. The second are Generation III reactors for which China is still largely dependent on foreign suppliers. Currently, China plans to manufacture 50 to 60 percent of the units domestically, based on the older Generation II technology, leaving 40 to 50 percent of the market for Generation III nuclear equipment imports, an estimated \$15 billion in market value. In the downstream market, similar to the interim market, the quality of products produced by most Chinese domestic manufacturers does not meet the demand of Chinese buyers. The best prospects for U.S. exporters in the downstream market are nuclear pumps and valves, breakers, large forging parts and other accessories.

Fuel Management: China is not fully self-sufficient in the upstream market of raw materials used in NPPs. Chinese mines produce 70 percent of the uranium used in Chinese reactors. Chinese imports of U.S. graphite moderator rods recently increased. China is now the third largest buyer, after Japan and Canada, of U.S. graphite.

Challenges and Barriers to Exports

Local content requirements are a key barrier for U.S. civil nuclear exports. China has an explicit policy of technology transfer, and it has become increasingly self-sufficient. It has gained experience in constructing new reactors and other fuel cycle facilities, to the effect that new reactor builds in the near future may contain as much as 85 percent local content. Strong foreign competition is also a challenge and will limit market access for U.S. industry. Nonetheless, the size of China's market is so large and the pace with which it is building new reactors and facilities is so swift that China will remain a strong and dynamic market for U.S. exports for years to come for all areas of the civil nuclear sector.

Government support is strong mainly due to intense pressure to find new sources of clean electricity, and it

appears unlikely at this time that government policy will significantly change. Public opinion regarding nuclear energy in China is complex. On the one hand, a few cases of public opposition to new nuclear plants have caused delays or halts to planned projects, most noticeably with the postponement of construction at new inland sites. On the other hand, strong public sentiment toward achieving clean air goals may make the public more supportive of nuclear energy. It is unclear how much public opinion influences China's central government-driven policy decisions, though the government has recently shown a marked increase in public outreach regarding nuclear policy.

Liability is a concern. China has not committed to signing the CSC. With Japan's ratification and the CSC entry into force, however, China may have a bigger incentive to adopt it, and government officials have indicated an interest in reviewing current policies to determine their compatibility with the CSC.

China's response following Fukushima has helped instill faith in the country's regulatory and safety regimes, and the slow pace (albeit the fastest in the world) of new construction will help ensure it can maintain financial capability to handle its plans.

China remained on the USTR 301 Priority Watch List in 2015 due to a lack of effective protection of IPR, including patents, copyrights, trademarks and trade secrets. Although China has been taking steps to overhaul its IPR laws, this continues to be a challenge to doing business in China and puts a strain on U.S. industry relations with Chinese entities.

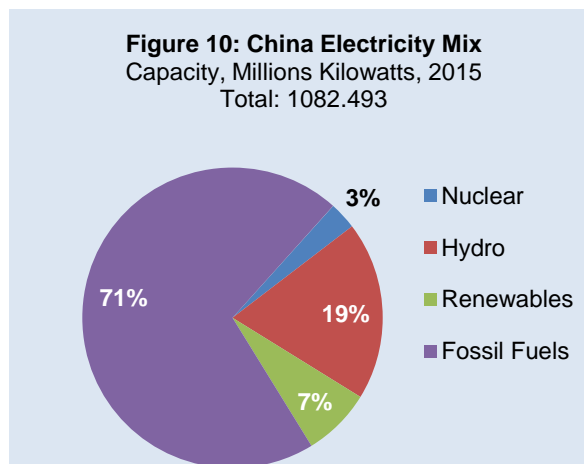
Nuclear Infrastructure

Research Reactor: China has 19 research reactors. The China Institute of Atomic Energy (CIAE) is the leading organization for basic nuclear science research and runs the China Experimental Fast Reactor.

Fuel: CNNC is responsible for domestic production and overseas development of uranium. More than 2 million tU of potential resources have been identified in China, but current production (1,800 tU per year) cannot meet China's current and future needs. Even with increased production, China will need foreign imports to meet demand. China imports uranium from a variety of countries, mainly Kazakhstan, Canada and Australia, and

has acquired equity in uranium mines in Kazakhstan, Namibia, Niger and Uzbekistan.

Waste Management: A centralized fuel storage facility has been built at Lanzhou Nuclear Fuel Complex. Regional storage centers are under development. Construction on a geological repository is planned for 2040 to open by 2050. Site selection is currently underway.



U.S. Government Collaboration

123 Agreement: The successor 123 Agreement with the United States entered into force in November 2015.

May 2013 Trade Mission: In May 2013, then DOC Undersecretary for International Trade led a delegation including senior U.S. government officials from DOC, DOE, Ex-Im Bank and U.S. industry to work with the Chinese government on U.S.-China nuclear power cooperation.

Peaceful Uses of Nuclear Technology (PUNT) Agreement: United States and China meet annually on nonproliferation and nuclear energy cooperation topics, including joint work on probabilistic risk assessment training for Chinese operators.

International Engagement

China has extensive international engagement. It signed an agreement with Areva and EDF in 2013 on reactor development and is taking partial ownership of the planned reactors at Hinkley Point in the UK. It recently signed a deal with Russia for more VVERs at Tianwan

and for fast breeder reactors. It has also expanded ownership in uranium mines in Africa. In 2015, state owned China General Nuclear Power Group signed a Memorandum of Understanding with Kenya as well as a contract with Argentina to deliver two reactors.

Figure 11: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	✓

Resources

For more information on commercial opportunities in China, contact: Sarah Kemp (Senior Commercial Officer in Beijing, sarah.kemp@trade.gov); Commercial Specialist Hongying (Sherry) Cai, Hongying.Cai@trade.gov; I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov).

Sources

CIA Factbook; United Nations; World Nuclear Association; Asian Development Bank, and our contacts at the U.S. Embassy and U.S. Consulates in China.

Czech Republic

Market Type: Newly Emerging

The Czech Republic has six operating nuclear reactors and plans to build at least two additional units. Despite the cancellation of a tender for new reactors in April 2014, the Czech government has signaled its intention to continue developing its nuclear industry. Financing and recent policy uncertainty regarding energy subsidies are the main challenges to U.S. exports, along with competition for new builds from China and South Korea.

New Builds

11

Existing Reactors

14

Decommissioning

14

Overall Rank

7

U.S. Ambassador to Czech Republic: Andrew H. Schapiro

The Czech Republic currently has six operating nuclear reactors, all Russian-designed. Four reactors (model: VVER-440 V-213) are located at the Dukovany plant and two (model: VVER-1000 V-320) are located at the Temelín plant. The majority state-owned Czech Energy Works (ČEZ) owns and operates both plants.

In April 2014, the Czech government decided to postpone a tender for new reactors at Temelín, citing difficulties in setting future electricity price guarantees. Toshiba-Westinghouse and a Russian consortium were the final bidders in the tender, proffering the AP1000 and MIR-1200 designs, respectively. ČEZ had originally wanted to choose a winner by November 2013, but the date was postponed due to the July 2013 resignation of the Czech prime minister and cabinet amid bribery and power abuse scandals.

Korea Electric Power Co (KEPCO) announced that it would pursue the 2015 Temelín bid, leading to a December 2015 nuclear cooperation agreement with South Korea. In June 2015, the Czech government approved a nuclear industry strategy from the Ministry of Trade and Industry, which included a plan for one new unit at Dukovany and three additional units. A feasibility study for a new reactor at Dukovany is underway, with construction estimated at 2025 at the earliest. ČEZ also maintains a 49 percent share in a joint

venture project for a new reactor at Bohunice in Slovakia as part of the New Bohunice Block.

All Dukovany and Temelin units have undergone uprates in the past 10 years, and further uprates are under consideration. The lifetime of the four Dukovany units were extended by 10 years, with the first closure now due in 2025. ČEZ is reviewing plans to extend the lifetimes by an additional 20 years.

Planned Nuclear Energy Projects

Owner: Czech Energy Works
Reactor Type: PWR
Capacity: 1x 1200+ MWe
Value of Project: N/A
Construction Period: 2025-2034
Operation (tentative): 2035

Owner: Czech Energy Works
Reactor Type: PWR
Capacity: 1x 1200+ MWe
Value of Project: N/A
Construction Period: 2025-2034
Operation (tentative): 2035

Dukovany Plant Extension: A lifetime extension to 60 years is being considered for the Dukovany NPP.
Temelín Expansion: A new unit at the Temelín site is planned to be put into operation around 2026 to 2028.

Final solution of radioactive waste management: Proposed construction to start 2050 and be in operation starting 2065.

Commercial Opportunities

Design, Construction, and Operation: Tender for one new reactor at Temelín has been postponed, but a new plan for reactor development will be published soon.

Licensing Support: The Czech licensing agency (SÚJB) may require consulting assistance during the licensing phase of the Temelín tender. Due to the delay in the tender, however, opportunities for such support may not exist until 2017.

Fuel Management: There is potential for a tender for enriched uranium for the first cores of the two proposed new reactor units (3 and 4) at Temelín. Due to the delay in the design and construction tender, this will be delayed as well.

Waste Management: ČEZ is currently in pre-tender qualification period for the design, licensing and supply of dual-purpose storage and transport metal casks and related equipment for an on-site dry storage facility for storage of used nuclear fuel.

Challenges and Barriers to Exports

Financial challenges and recent political instability are the main obstacles to civil nuclear exports to the Czech Republic. Westinghouse's recent success in the Temelín tender has shown that U.S. industry can be highly competitive in this market, but the postponement may result in the Czech government giving a fresh look to other foreign bidders in the next round. Market access relating to the country's existing fleet is limited due to the preponderance of Russian design reactors.

Government support for new nuclear power has become more questionable in the past year. The July 2013 resignation of the Prime Minister and cabinet forced the country to push back its decision on the Temelín tender, and the April 2014 announcement to postpone and redo the tender introduces more uncertainty toward the Czech government's commitment to expanding the Temelín plant. Renewable energy subsidies, enacted by the former government, resulted in spikes in consumer electricity prices and have created a backlash in public opinion

toward price guarantees. This experience has made the current government reluctant to engage in a similar scheme regarding new nuclear power. Public opinion toward nuclear power, however, has remained favorable in recent years.

Moreover, the government has signaled its intention to develop its nuclear industry. In January 2016, the government created a new coordinating committee for nuclear energy under the Prime Minister. The Commission for Nuclear Energy is expected to be appointed in the coming year. New construction, supply chain, waste management and nuclear-related legislation will be centered in this new committee. Furthermore, the country's 2015 national energy policy repeated earlier commitments for reactor construction, promising reactors at Dukovany and Temelín. A National Plan for Nuclear Energy Development is due by December 2016.

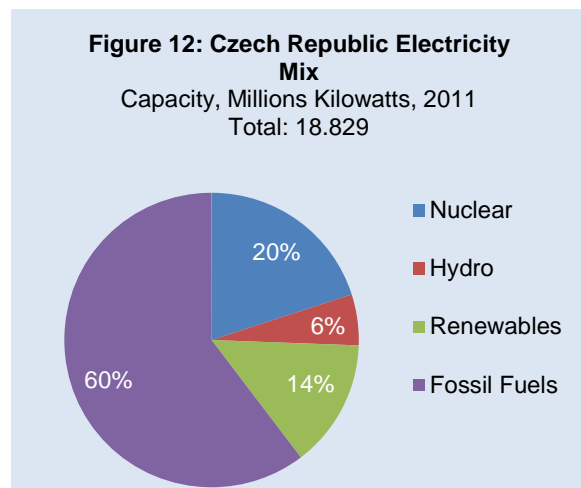
Financial challenges remain strong, as the Czech government is unwilling to provide any financing guarantee. It has reached out to foreign partners, including the United States and Russia, for assistance in financing its planned new nuclear reactors. Financing pledges will likely be an important component in future tenders.

Nuclear Infrastructure

Research Reactor: The Rez Nuclear Research Institute currently has two research reactors in operation, and the Czech Technical University in Prague operates a third research reactor.

Fuel: Fuel for Dukovany and Temelín are both supplied by TVEL, though Temelín was supplied by Westinghouse until 2010. The Czech Republic's mine at Rožná—the only operational uranium mine in Central Europe—is nearing depletion, and the government is considering reopening a uranium mine near Jihlava, which is estimated to have 3,000 to 4,000 tons of uranium ore.

Waste Management: Used fuel storage and management is the responsibility of ČEZ until it is handed over to the Radioactive Waste Repository Authority (RAWRA) for storage in one of three interim dry-storage facilities. RAWRA is in charge of siting and building a high-level waste repository. Construction will start after 2050 with operation beginning in 2065.



U.S. Government Collaboration

123 Agreement: The Czech Republic has a 123 Agreement with the U.S. through Euratom; it will expire April 12, 2026 with rolling five-year extensions thereafter.

Joint Declaration on Civil Nuclear Commercial Cooperation: In December 2010, the Department of Energy (DOE) and the Department of Commerce (DOC), together with the Czech Ministry of Industry and Trade (MOIT), signed a Joint Declaration Concerning Industrial and Commercial Cooperation in the Nuclear Energy Sector.

July 2011 Trade Policy Mission: In July 2011, former DOC Under Secretary Francisco Sánchez led a civil nuclear trade policy mission with 11 U.S. civil nuclear companies to the Czech Republic, Poland and Slovenia.

Civil Nuclear Cooperation Center: In April 2012, DOE signed an MOU on nuclear energy R&D cooperation, and in 2014, it helped establish a Civil Nuclear Cooperation Center in Prague. DOC also maintains an Economic and Commercial Dialogue with MOIT.

U.S.-Czech Technical Cooperation Arrangement: The NRC and the Czech Republic State Office for Nuclear Safety (SÚJB) are signatories to this arrangement, which was renewed at the 2014 International Atomic Energy Agency's General Conference.

U.S.-Czech Implementing Agreement: The NRC and Czech Republic State Office for Nuclear Safety (SÚJB) are signatories to a 1999 Implementing Agreement Relating to Participation in the USNRC Program of Severe Accident Research.

U.S. Export-Import Bank (Ex-Im) Financing: Ex-Im is prepared to lend Czech power group CEZ around half the cost of enlarging its Temelín NPP if U.S. bidder Westinghouse wins a tender to build it.

R&D Cooperation: The United States and Czech Republic signed an agreement for a joint civil nuclear co-operation center in Prague. The United States has pledged \$500,000 (£319,476) in funding via contributions to the International Atomic Energy Agency's (IAEA) Peaceful Uses Initiative for regional activities to be performed in collaboration with the Centre, including R&D workshops, seminars, training activities and academic exchanges.

International Engagement

The four central European nations make up the Visegrad Group, also known as the V4. The June 16, 2013 Warsaw summit, which was attended by the countries' prime ministers, commemorated the 10th anniversary of V4-Japan cooperation. In a joint statement, the parties expressed their intention to further strengthen their ties in a range of areas as well as recognize the "attractive opportunities" represented by the V4's markets for Japanese companies. The participants formally expressed their "great interest in deepening mutual cooperation" in nuclear energy, environment, energy saving and renewable energy, and Japan reaffirmed its "duty" to contribute to worldwide nuclear safety by sharing knowledge and lessons learned from the 2011 accident at the Fukushima Daiichi nuclear power plant.

Figure 13: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	✓
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	✓

Resources

For more information on the commercial opportunities in the Czech Republic, contact: Hana Obrusnikova (Commercial Specialist, Hana.Obrusnikova@trade.gov); Jonathan Chesebro (ITA Civil Nuclear Team, jonathan.chesebro@trade.gov).

For more information on the civil nuclear industry in the Czech Republic, contact: MOIT website (<http://www.mpo.cz/>); ČEZ website (www.cez.cz); SÚJB website (www.sujb.cz)

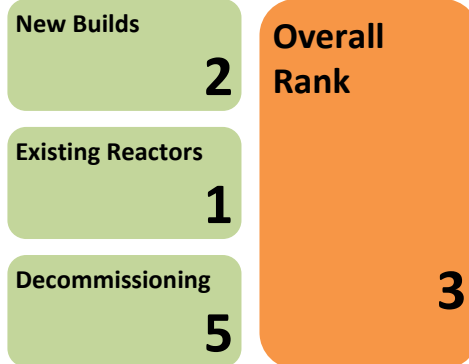
Sources

CIA Factbook, United Nations, World Nuclear Association and our contacts at the US Embassy in Prague.

India

Market Type: Existing and Expanding

India has a large nuclear power program with substantial political support and aims to supply 25 percent of its energy from nuclear power by 2050. This expansion presents significant opportunities for U.S. industry, especially as the Indian government works to engage foreign firms in its plans. Nevertheless, ownership limitations and nuclear liability concerns remain serious barriers for U.S. civil nuclear exports.



U.S. Ambassador to India: Richard Rahul Verma
U.S. Commerce Attaché to India: John M McCaslin

India has a rapidly growing nuclear power program, with 21 operating nuclear reactors, six under construction and 22 additional reactors planned. The Nuclear Power Corporation of India (NPCIL), the state-owned operator of India's reactor fleet, supplies 5.3 GWe of nuclear capacity, 3.5 percent of India's current electricity generation. India aims to increase nuclear generation to 25 percent of its energy mix by 2050. India's current nuclear power market is estimated at \$150 billion and will grow further if its expansion plans are realized.

The Government of India (GOI) is supportive of nuclear power due to the country's growing electricity demand and shortage of fossil fuels. Because India is not a signatory to the Nuclear Non-Proliferation Treaty (NPT), it was excluded from nuclear trade for 34 years, which limited its nuclear energy development to mostly indigenous designs. Since 2008, when U.S.-led efforts lifted Nuclear Supplier Group (NSG) trade restrictions, India has worked with other countries (primarily Russia, France and the U.S.) to develop its program. NPCIL is responsible for design, construction, commissioning and operation of plants but views international cooperation as an opportunity to expand its domestic program and eventually become an exporter of reactor technology.

To expand its program, India plans to build nuclear parks, with supply from foreign companies. Each park is

to have 8 to 10 GWe of generation capacity – an impressive increase from the current capacity of any single site currently operating in India. U.S., French and Russian companies have been in talks and, in some cases, have reached deals to build nuclear reactors. India's limited uranium reserves have led it to pursue a long-planned three-stage program to support a thorium fuel cycle.

Public opinion regarding nuclear power is generally positive. Following Fukushima, public concern triggered protests against new reactors. Within a year, however, poll numbers bounced back, showing a growing approval for nuclear energy. In 2012, British polling firm Ipsos Mori found that 75 percent of Indians supported nuclear energy. In response to Fukushima, NPCIL implemented safety upgrades at all of India's operating NPPs.

Before 2008, when India's nuclear market was cut off from nuclear trade, India's nuclear power plants (NPPs) operated under capacity due to a shortage of uranium fuel. The 2008 U.S.-India nuclear deal has since removed sanctions against India, enabling India to import uranium and construct large foreign-built nuclear reactors. Currently, 40 percent of India's nuclear capacity operates under the IAEA safeguards and uses imported fuel.

Planned Nuclear Energy Projects

India is currently planning to build 22 reactors at 15 sites. The next project to start construction will be the Kudankulam 3 and 4 plants in Tamil Nadu, which are scheduled to begin construction in 2016 and 2017 with operation to begin in 2022 to 2023. In total, India is planning to build 21,300 MWe of nuclear power.

As part of the 2008 U.S.-India nuclear deal, two prospective sites in Gujarat and Andhra Pradesh will involve U.S. reactor vendors Westinghouse (WEC) and GE-Hitachi (GEH). In March 2009, GEH signed an agreement with NPCIL and Bharat Heavy Electricals to build its advanced boiling water reactor (ABWR) at Kovvada in Andhra Pradesh. Also in 2009, WEC signed a memorandum of understanding (MOU) to build its AP1000 reactor at Mithi Virdi in Gujarat, in cooperation with NPCIL and India's Larsen & Toubro. In December 2015, WEC and NPCIL announced expanded plans to build six reactors in India by 2030. WEC negotiations with NPCIL are more advanced than those of GEH, primarily due to the fact that GEH's ABWR is not yet licensed by the U.S. NRC.

In March 2016, NPCIL and France's EDF signed an MOU to construct six European Pressurized Reactors (EPR) of 1650 MWe each at Jaitapur in Maharashtra. Russia's Rosatom is currently constructing its VVER-1000 reactor at Kudankulam 2 and has announced plans to build six NPPs (VVER-1200 reactors) in India over the next 20 years.

All plants are owned and operated by NPCIL, except for a planned fast breeder reactor handled by the specialist fast breeder division Bhavini.

Commercial Opportunities

Services (front-and back-end): Moderate opportunities for feasibility studies and infrastructure development at India's planned NPPs.

Legal and Consulting Services: Moderate opportunities to advise NPCIL and DAE on new plant projects.

Licensing Support: Opportunities to support the Atomic Energy Regulatory Board (AERB), India's nuclear safety regulator.

Design, Construction, and Operation: Opportunities exist for new construction of 22 reactors, along with many others proposed. Foreign companies are only allowed minority stakes, however, as the 1962 Atomic Energy Act prohibits private control of nuclear power generation.

Components: Opportunities may exist for future plants.

Challenges and Barriers to Exports

While GOI support for nuclear energy is strong and the government wants foreign company involvement in the expansion of its nuclear program, there are several obstacles for U.S. civil nuclear exports. First, India's plan to build nuclear parks is moving forward at a slower pace than anticipated. Additionally, India has signed a civil nuclear cooperation agreement with United States but not with Japan, which may limit some technology use involving Japanese firms (India has agreed to a civil nuclear agreement with Japan in principle). Lastly, India's 1962 Atomic Energy Act prohibits private control of nuclear power generation, which may limit U.S. company involvement in India's nuclear projects.

Liability is another concern. India ratified the Convention on Supplementary Compensation for Nuclear Damage (CSC) in February 2016, and the U.S. government and the GOI have agreed that India's 2010 domestic Civil Liability for Nuclear Damage Act (CLND) is compatible with the CSC. Some U.S. suppliers, however, still have concerns about the interpretation of the CLND and its channeling of liability exclusively to the operator. To alleviate supplier concerns, India has created an insurance pool for nuclear operators in India and for foreign suppliers with a liability cap of 15 billion Indian Rupees (\$226 million).

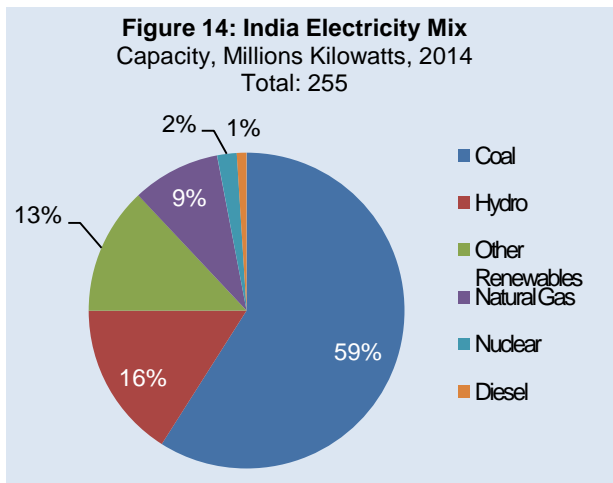
Nuclear Infrastructure

Research reactors: India has four research reactors. The Bhabha Atomic Research Center (BARC) operates two, while the Indira Gandhi Center for Atomic Research operates two others.

Fuel: Expertise exists in all areas of the nuclear fuel cycle, including exploration, mining, heavy water production, fabrication and reprocessing. India's long-term goal is to develop an advanced heavy-water thorium cycle. India has some domestic uranium mining handled by the Uranium Corporation of India, Ltd (UCIL)

but relies on 40 percent imported uranium to fuel its growing reactor fleet.

Waste Management: Waste is treated and stored at each NPP site. Waste immobilization plants are in operation. BARC is conducting research on final disposal of waste in a geological repository.



USG Cooperation

123 Agreement: The U.S.-India 123 Agreement entered into force in 2008. This made India the first country with known nuclear weapons and that is not a member of the NPT to engage in international nuclear commerce.

U.S.-India Civil Nuclear Contact Group: In January 2015, President Obama and Prime Minister Modi reached a bilateral “mutual understanding” that seeks to set a framework for the U.S. nuclear industry to enter commercial talks on building reactors in India by resolving concerns regarding liability and inspections. The U.S.-India Civil Nuclear Contact Group, made up of officials from the USG and the GOI, was charged with overcoming remaining obstacles to U.S.-India civil nuclear cooperation.

U.S.-India Strategic & Commercial Dialogue (S&CD): In September 2015, the previous U.S.-India Strategic Dialogue was elevated to the S&CD with the primary focus of advancing shared objectives in regional security, economic cooperation, defense, trade and climate challenges.

U.S.-India High Technology Cooperation Group (HTCG): Established in 2002 to promote bilateral high technology commerce (specifically dual-use items) in partnership with the private sector. The HTCG is led by DOC’s Bureau of Industry & Security (BIS).

U.S.-India Energy Dialogue: Launched in 2005 and led by the U.S. Department of Energy (DOE), this dialogue includes a Civil Nuclear Working Group that guides bilateral civil nuclear R&D efforts.

Global Center for Nuclear Energy Partnership: Established in 2010 by DOE’s National Nuclear Security Administration (NNSA) and the GOI, the center focuses on bilateral nuclear security cooperation and other capabilities to secure vulnerable nuclear materials.

Figure 15: Additional Agreements

Non-Proliferation Treaty	
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	✓
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	

Resources

For more information on commercial opportunities in India, contact: John M. McCaslin (Senior Commercial Officer, John.McCaslin@trade.gov), Parthasarathy Srinivas (Commercial Officer, P.Srinivas@trade.gov) I&A

Civil Nuclear Team: Jonathan Chesebro
(jonathan.chesebro@trade.gov).

For more information on nuclear energy in India, see:
India Department of Atomic Energy: <http://dae.nic.in/>

Atomic Energy Regulatory Board:
<http://www.aerb.gov.in/>

Nuclear Power Corporation of India Ltd (NPCIL):
<http://www.npcil.nic.in/>

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and our contacts at the U.S. Embassy in New Delhi and U.S. Consulates in India.

Japan

Market Type: **Maturing and Decommissioning**

Japan's civil nuclear program has undergone tremendous changes since the March 2011 Fukushima Daiichi accident. All of Japan's 43 operational reactors are offline as of early 2016, and the government is struggling to find a politically acceptable plan for restarting them. While new builds do not appear likely in the near-term, viable opportunities for U.S. exports exist for decontamination and remediation services at Fukushima, decommissioning, as well as other goods/services for Japan's existing reactor fleet.

New Builds

43

Existing Reactors

4

Decommissioning

2

Overall Rank

11

Japan has 43 operational reactors, according to the IAEA Power Reactor Information System (PRIS) database, making up a net capacity of 42.6 GWe, but following the March 2011 Fukushima accident, all reactors were taken offline as Japan revised its nuclear safety regulations. Subtracting out the six reactors on the Fukushima Daiichi site, Japan has 43 reactors potentially available for restart.

Loss of nuclear power has caused hardship to Japan's trade balance, energy security and economy. To make up for the loss of nuclear generated electricity, Japan was forced to boost imports of oil and gas, and its dependency on fossil fuels rose from 60 percent before the earthquake to 90 percent afterward. As a result, in 2011, Japan had a trade deficit for the first time in over 30 years, and the deficit has increased each year since then. Recent estimates have placed Fukushima related losses for the Japanese nuclear industry at \$50 billion.

Given these challenges, the Government of Japan (GOJ) has prioritized restarting part of its nuclear reactor fleet. The government's fourth Strategic Energy Plan, released in April 2014, recognized the role that nuclear energy must play in a diversified, secure and efficient energy supply. Though it did not specify targets for nuclear energy or renewables, it explicitly stated the government's intention to focus on restarting reactors in the near-term while also noting the need to reduce dependence on nuclear energy. Several plants have applied for restart but are currently facing legal and public opinion challenges. On July 16, 2014, Japan's Nuclear Regulatory Authority (NRA), set up in 2012 to

replace the Nuclear and Industrial Safety Agency (NISA) and the Nuclear Safety Commission (NSC) to oversee nuclear safety regulation, approved the restart of the Sendai plant in Kagoshima Prefecture. On November 7, 2014, regional authorities approved the restart, and it resumed operation on August 11, 2015.

Aside from reactor restarts, the government's main focus has been the cleanup and policy response to the Fukushima accident. The International Research Institute for Nuclear Decommissioning (IRID) was established in August 2013 to research and develop technologies to assist with nuclear decommissioning, promote cooperation with international and domestic organizations on nuclear decommissioning and develop human resources for R&D. Over the past year, the GOJ has increasingly sought international assistance to address contaminated water issues at the Fukushima Daiichi Nuclear Power Station and advice on decommissioning and decontamination projects.

Japan is building several fuel cycle facilities in an attempt to achieve commercial-scale capabilities in all aspects of the fuel cycle. Current construction projects include a MOX fuel fabrication plant at the Rokkasho site. After years of delay, Japan recently completed construction of the Rokkasho commercial-scale reprocessing facility, although it has yet to begin commercial operation. Japan has converted several reactors to be MOX fuel bearing and plans to convert others. The government has operated a prototype fast reactor, Monju, though it was recently placed in long-term shutdown, so its future is uncertain.

Commercial opportunities

Services (front-and back-end): Advisory services for decommissioning and decontamination and assistance with safety upgrades to reactor fleet.

Legal and Consulting Services: Advisory assistance with Fukushima cleanup and public relations in line with NRA guidelines.

Design, Construction, and Operation: Limited due to post-Fukushima halt of new nuclear construction.

Licensing Support: Potential for advisory assistance to electric utilities.

Fuel Management: Limited potential.

Waste Management: Limited potential.

Challenges and Barriers to Exports

Reduced market access, government policy and public opinion are significant challenges to U.S. civil nuclear exports to Japan. In its response to the Fukushima accident, Japan has shown a limited inclination to seek help from industry abroad, preferring to keep tight control on managing contaminated water leaks and other challenges related to the decontamination and decommissioning of the site. Recently, Japan has made more of an effort to seek international assistance, which could result in more opportunities for U.S. industry involvement.

The restart of Japanese reactors could produce export opportunities for U.S. goods and services, particularly as Japanese reactors undergo safety improvements and the nation continues to adapt to its post-Fukushima regulatory and safety policies. While the current government is in favor of reactor restarts, opposition from the Japanese public, often acting in tandem with the courts, has caused significant delays, and it is unclear how successful the government's restart policy will be. Even if Japan overcomes these hurdles to revitalizing its civil nuclear program, U.S. content for civil nuclear projects in Japan will be limited due to the strength, experience and capability of Japan's industry. U.S. industry also faces strong competition from other countries, such as France and Russia, for other areas of the fuel cycle, such as fast reactors, MOX facilities and reprocessing technology.

Japan scores highly in nearly all financial and infrastructure indicators. The November 2014 Diet ratification of the CSC liability regime and the implementing legislation are positive developments.

Despite the above challenges, the U.S. and Japanese civil nuclear industries remain highly integrated and have years of experience collaborating on projects. Japan is and will remain an important partner for the United States in the civil nuclear sector. USG support for U.S. civil nuclear exports is essential, particularly as Japan continues to pursue its post-Fukushima priorities.

Nuclear Infrastructure

Research Reactor: The Japan Atomic Energy Agency (JAEA) manages an extensive R&D program throughout the country and runs several research reactors and experimental test facilities.

Fuel: Japan has no indigenous uranium. Uranium imports come primarily from Australia, Canada and Kazakhstan; Japanese companies are increasingly taking equity in overseas uranium projects, including in Kazakhstan, Australia and Namibia.

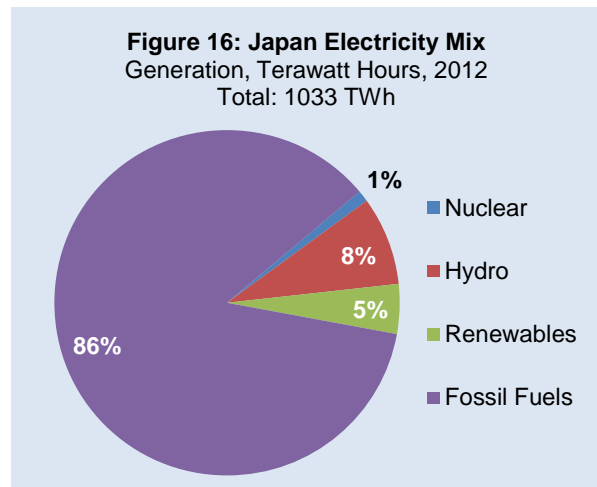
Fuel Cycle: Japan has fuel cycle facilities, though not yet at commercial scale. Japan Nuclear Fuel Ltd (JNFL) operates a commercial enrichment plant at Rokkasho, though much enrichment is still imported. A new enrichment plant in Japan using Russian centrifuge technology is planned under an agreement between Rosatom and Toshiba.

Several fuel fabrication facilities exist to supply Japan's fleet of PWRs, BWRs and, in a limited capacity, HTRs, as well as a MOX fuel-bearing reactor for R&D purposes. A new 600 tU/yr plant is planned by Areva and Mitsubishi Nuclear Fuel (MNF). JNFL is building a MOX fuel fabrication plant in Rokkasho, known as J-MOX, though due to construction delays most MOX is fabricated in France using Japanese fuel.

A commercial scale reprocessing facility at Rokkasho has recently finished construction but is awaiting the start of commercial operation. The Japan Atomic Energy Agency (JAEA) recently announced that it will permanently shut down the Tokai pilot reprocessing plant, which has stood idle since 2006.

Waste Management: Japan's first high-level waste (HLW) interim storage facility opened in Rokkasho-mura

in 1995. A permanent HLW storage facility is part of the 2014 energy strategy. Facility siting is a major challenge.



U.S. Government Collaboration

123 Agreement: Japan's 123 Agreement with the United States will expire on July 30, 2018 but will remain in force until terminated by either party.

U.S.-Japan Fukushima Recovery Forum: In February 2015, the U.S. and Japan organized the third Fukushima Recovery Forum in Tokyo to identify bilateral activities for the U.S. to assist Japan in its decommissioning, decontamination, and remediation efforts.

U.S.-Japan Bilateral Commission on Civil Nuclear Energy Cooperation (BLC): Established in April 2012, the BLC serves as a forum to foster a strategic dialogue and joint activities related to the safe and secure use of civil nuclear energy and the response to Fukushima. The BLC includes five working groups: (1) Nuclear security, (2) Civil nuclear energy research and development, (3) Safety and regulatory issues, (4) Emergency management, and (5) Decommissioning and environmental management.

Regulatory Cooperation: The U.S. NRC and Japan's NRA have a long-standing arrangement for the exchange of technical information and cooperation in nuclear safety and security matters. In addition, the NRC and NRA have semiannual Steering Committee meetings to provide direction for upcoming collaborative activities between U.S. and Japanese national nuclear regulatory agencies, facilitate information sharing related to mutually beneficial nuclear safety and security regulatory issues, and incorporate lessons learned from the Fukushima-Daiichi accident.

Figure 17: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	✓
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	✓

International Engagement

Japanese government officials have been actively marketing Japanese reactors around the world during diplomatic visits, particularly in regions such as Southeast Asia, Africa and the Middle East.

In October 2010, Japan and Vietnam signed an agreement for construction of a nuclear power plant in Vietnam at Vinh Hai in Ninh Thuan province. In July 2011, Hitachi was chosen to build Lithuania's proposed nuclear reactor at Visaginas. In 2011, JAPC signed agreements with Electricity of Vietnam to build two nuclear reactors in Ninh Thuan province.

Japan's civil nuclear industry has extensive ties to U.S. and French industry. Toshiba owns 87 percent of Westinghouse Electric Company; Hitachi and GE have a joint venture partnership, and MHI partners with Areva.

Japan engages with many countries on advanced civil nuclear R&D in all parts of the fuel cycle, including

laboratory-to-laboratory R&D as well as planning and constructing test and demonstration facilities.

Resources

For more information on the commercial opportunities in Japan, contact: Andrew Wylegala, Senior Commercial Officer in Tokyo, andrew.wylegala@trade.gov; Takahiko Suzuki (Commercial Specialist in Tokyo, takahiko.suzuki@trade.gov); Helen Hwang (Principal Commercial Officer in Osaka, helen.hwang@trade.gov); Jonathan Chesebro (ITA Civil Nuclear Team, jonathan.chesebro@trade.gov)

For more information on the civil nuclear industry in Japan, see:

U.S. Commercial Service Japan - Market Alerts on nuclear remediation and decommissioning

opportunities in Japan:

<http://www.export.gov/japan/fukushima/index.asp>

JAEA: <http://www.jaea.go.jp/>

NRA: <http://www.nsr.go.jp/>

IRID: <http://irid.or.jp/en/>

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and our contacts at the U.S. Embassy in Tokyo and U.S. Consulate in Osaka.

Malaysia

Market Type: Newly Emerging

Malaysia has initiated feasibility studies and has expressed interest in developing a civil nuclear program to diversify its energy sources. While the country currently lacks a liability regime and does not have a 123 Agreement with the United States, a more firm commitment by the Malaysian government could position the country as a growing market for U.S. civil nuclear exports.

New Builds

17

Existing Reactors

N/A

Decommissioning

N/A

Overall Rank

26

U.S. Ambassador to Malaysia: Joseph Y. Yun
U.S. Commerce Attaché to Malaysia: Catherine Spillman

Malaysia does not currently have any operational nuclear power plants, and it is not building any.

The Malaysian government has established a nuclear agency charged with planning for new nuclear power development, and it has stated its intention to strongly consider nuclear energy as an alternative to coal. Plans for a nuclear plant, however, have been delayed several times and are still at the feasibility stage. If plans went ahead, construction would be unlikely to begin before 2025.

In late 2013, Malaysian officials announced plans to slow Malaysia's move to nuclear power. The Minister of Energy indicated during the World Energy Congress that widespread support did not yet exist for nuclear power and that current plans would be "kept in view" until further notice.

In 2015, the Malaysia Nuclear Power Corporation (MNPC) noted that it had signed non-disclosure agreements with eight potential partners, including Westinghouse and China National Nuclear Corporation (CNNC). In addition, the CEO of MNPC stressed the country's current focus on crafting a domestic legal framework for nuclear power.

Planned Nuclear Energy Projects

Owner: Government of Malaysia
Operator: Malaysia Nuclear Power Group
Reactor Type: Enriched Uranium (possible)
Capacity: N/A
Value of Project: 42.3 billion (2010 est.)
Construction Period: 10 years, unlikely to start before 2020
Operation (tentative): 2030

Commercial Opportunities

Services (front-and back-end): No immediate opportunities; possibilities for future feasibility studies and infrastructure development

Licensing Support: Potential support for Malaysia's Atomic Energy Licensing Board

Design, Construction, and Operation: New reactors are under consideration.

Components: Study phase

Fuel Management: Study phase

Waste Management: Study phase

Challenges and Barriers to Exports

The lack of a strong government commitment to building new nuclear power is the chief obstacle to U.S.

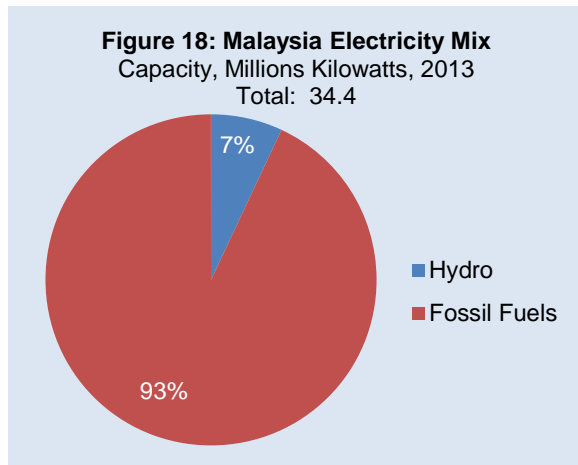
civil nuclear exports. Despite some statements in the late 2000s in support of nuclear power development, the Malaysian nuclear program has not progressed beyond exploratory feasibility studies. More recent policy statements have been muted, detailing a more cautionary, long-term approach.

If government support increased and solid plans took shape, Malaysia would be positioned as a key market prospect for U.S. exports. The lack of a liability regime and a 123 Agreement are current barriers, but Malaysia is better placed to overcome financial obstacles than other newcomer countries.

Nuclear Infrastructure

Research Reactor: The 1 MWe Reactor TRIGA PUSPATI (RTP), which started operation in 1982, is the only nuclear research reactor in Malaysia. It is managed by the Malaysian Nuclear Agency (Nuclear Malaysia).

Waste Management: The Waste Technology Development Centre (WasTeC-Nuclear Malaysia) has been given the responsibility of managing radioactive waste throughout the nation.



U.S. Government Collaboration

123 Agreement: Malaysia does not have a 123 Agreement with the United States.

Figure 19: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	
Joint Convention on Safety of Spent Fuel Management	
Convention on Nuclear Safety	
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	

Resources

For more information on the commercial opportunities in Malaysia, contact: I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov); CS Kuala Lumpur: Commercial Specialist Randall Liew (Randall.liew@trade.gov), Commercial Specialist Joanne Looi (Joanne.Looi@trade.gov).

For more information on nuclear power in Malaysia:

Nuclear Malaysia: <http://www.nuclearmalaysia.gov.my/>

Malaysia Economic Transformation Programme: http://etp.pemandu.gov.my/11_January_2011-@-Malaysia_Nuclear_Power_Corporation.aspx

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and Commerce Department contacts at the U.S. Embassy in Kuala Lumpur.

Mexico

Market Type: Existing and Expanding

Mexico maintains two operational GE-designed BWR reactors at Laguna Verde. The Mexican government is interested in constructing new nuclear reactors as well as an expansion of the Laguna Verde plant. If these plans move forward, U.S. civil nuclear companies will be in a strong export position due to Mexico's close proximity and long-standing ties with Mexico's nuclear industry. American companies also remain uniquely primed to supply goods and services for the existing Laguna Verde reactors.

New Builds

10

Existing Reactors

12

Decommissioning

N/A

Overall Rank

8

U.S. Ambassador to Mexico: Roberta Jacobson
Minister Counselor for Commercial Affairs: Brian Brisson

Mexico currently has two operational GE-designed Boiling Water Reactors (BWR) at Laguna Verde. The two plants supply about 4 percent of the nation's electricity. For several years, the Government of Mexico (GOM) has considered building new nuclear power plants (NPPs), beginning with additional units at Laguna Verde. Mexico has also considered utilizing small modular reactors (SMRs) for power generation and seawater desalination.

In mid-2015, Mexico's Development Program of the National Electric System listed plans for new capacity via two NPPs, with commercial operation slated for 2026 and 2027. Despite being a net energy exporter, Mexico wants to develop nuclear energy to reduce its carbon emissions and its dependence on hydrocarbons. Low gas prices have buoyed this reliance, and Mexico's Federal Electricity Commission (CFE) has invested in new gas-fired plants, retrofitting of coal-fired plants for natural gas and new natural gas pipelines. These CFE fossil fuel projects and low natural gas prices could delay Mexico's nuclear energy plans.

Between 2007 and 2013, the Federal Electricity Commission (CFE), the state-owned electricity company that owns the Laguna Verde plant, contracted with Spain's Iberdrola Engineering and France's Alstom to replace components and uprate both reactors, resulting in a 20 percent increase in net power capacity.

Operating licenses for Laguna Verde Units 1 and 2 expire June 2020 and April 2025, respectively; CFE is expected to request license extensions, but no formal application has been filed to date.

Mexico's Energy Transition Law (passed in December 2015), the last major remaining legislative piece of the comprehensive energy reform, codifies the framework for Mexico's transition to a cleaner energy matrix, including nuclear energy, with interim targets and formalization of a clean energy certificate program. The reform also transforms CFE into a "state productive enterprise" that will sell electricity to the national grid, which could accelerate Laguna Verde expansion plans.

Planned Nuclear Energy Projects

Additional Laguna Verde Reactors

Owner: Mexico's Federal Electricity Commission (CFE)

Reactor Type: BWR

Capacity: 1,000 MWe (2 units)

Value of Project: \$11 billion (estimated)

Construction Period: TBD

Operation (tentative): 2026 and 2027

Comment: An international tender could be released soon. Competitors for the project include the United States, Russia, France, Japan and Korea.

Commercial Opportunities

Services (front-and back-end): Possibilities for feasibility studies and infrastructure development for Laguna Verde expansion.

Licensing Support: Limited opportunities. Design, Construction, and Operation: Opportunities once new reactors are under consideration.

Components: Potential with new reactor builds.

Fuel Management: Limited opportunities. Waste Management: Potential services for future disposal site.

Challenges and Barriers to Exports

Mexico's potential expansion of the Laguna Verde NPP presents a great opportunity for U.S. industry. Beyond this project, however, the overall prospect for U.S. civil nuclear exports remains limited. Mexico cut back on its nuclear development plans in response to the Fukushima accident, and it has now tentatively committed to building only two additional reactors. Details on Mexico's nuclear energy policy will be needed before a more robust assessment for U.S. exports can be made.

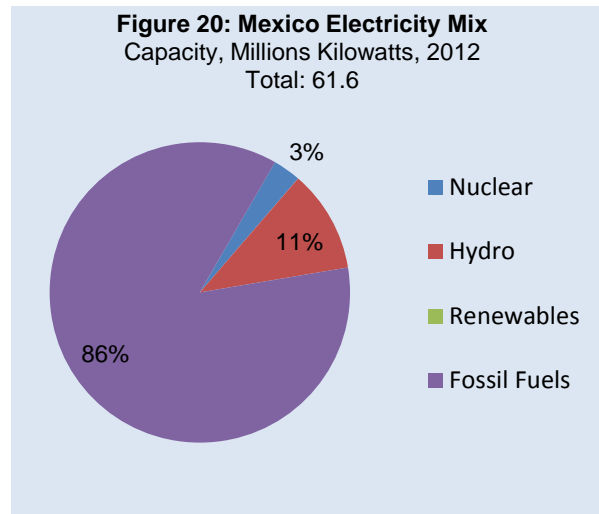
Financing will be a key challenge, as it is for most countries seeking to build new NPPs. Mexico's strong relationship to U.S. industry through the Laguna Verde plant and its good U.S. Ex-Im Bank rating should help with overcoming this challenge.

Nuclear Infrastructure

Research Reactor: Mexico operates three research reactors. The National Nuclear Research Institute (NNRI) operates a 1 MWe Triga Mk III that has been operational since 1968; the University Autonoma de Zacatecas has had a subcritical Chicago Modelo 900 assembly used for training since 1969; there is a Chicago Modelo 2000 at the Instituto Politécnic Nacional (National Polytechnic Institute).

Fuel: Mexico's Secretariat of Energy (SOE) delegates to the Mineral Resources Board the responsibility for uranium mining and prospecting policy. Two-thousand tons of uranium reserves have been identified in Mexico but have been too expensive to exploit at current prices.

Waste Management: The SOE is responsible for used fuel storage and disposal. A collection, treatment and storage center for LLW has operated at Maquixco since 1972.



U.S. Government Collaboration

123 Agreement: Mexico does not have a 123 Agreement with the United States, although discussions are underway regarding a future 123 Agreement. A project supply agreement between Mexico, the United States and the IAEA enables U.S. cooperation and trade with Mexico relating to the Laguna Verde NPP. The existing PSA will not apply to the potential Laguna Verde expansion.

Regulatory Cooperation: Extensive cooperation with the U.S. NRC, including a bilateral arrangement for the exchange of technical information and cooperation in nuclear safety and research (renewed in 2012); a memorandum of cooperation (MOC) between the CNSNS and the NRC for import and export of certain radioactive sources (2012); CNSNS participation in the Code Applications and Maintenance Program (CAMP) and the Cooperative Severe Accident Research Program (CSARP) since 2009.

U.S.-Mexico High Level Economic Dialogue (HLED): Established in 2013, the HLED is chaired by the U.S. Departments of Commerce and State the Mexican Ministry of Finance, with the goal of promoting bilateral economic competitiveness. Energy is one of the six HLED priority areas.

U.S.-Mexico Energy Business Council: In February 2016, the U.S. Department of Commerce announced the

establishment of the U.S.-Mexico Energy Business Council. The Council will bring together representatives of the U.S. and Mexican energy industries to discuss ways to strengthen commercial ties between energy industries in the two countries and communicate actionable, non-binding recommendations to the U.S. and Mexican governments.

Figure 21: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	✓
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	

International Engagement

The U.S. and Mexico have had a bilateral science and technology agreement since 1972. Nuclear energy engagement is primarily with the IAEA.

Resources

For more information on the commercial opportunities in Mexico, contact: Francisco Ceron (Senior Trade Specialist, francisco.ceron@trade.gov); John Howell (Principal Commercial Officer in Monterrey, john.howell@trade.gov); Jonathan Chesebro (ITA Civil Nuclear Team, jonathan.chesebro@trade.gov)

For more information on the civil nuclear industry in Mexico, contact: SOE website (www.sener.gob.mx); CFE website (www.cfe.gob.mx); CNSNS (www.cnsns.gob.mx)

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and Commerce Department contacts at the U.S. Embassy in Mexico City.

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Poland

Market Type: Newly Emerging

The current binding Polish Nuclear Power Program (PNPP) approved by the Polish government calls for construction of two NPPs comprising 6 GWe capacity by 2030. A recent four-year postponement of the first tender could prove beneficial to U.S. industry since it will give the Polish utility PGE more time to pursue viable financing options, which continue to be the biggest challenge to building nuclear power plants in Poland. To assist U.S. industry, the U.S. government should help steer Poland away from the build-own-operate model, which it has shown interest in pursuing.

New Builds

9

Existing Reactors

N/A

Decommissioning

N/A

Overall Rank

15

U.S. Ambassador to Poland: Paul W. Jones

Poland currently has no operating nuclear power plants. Construction on four Russian VVER units began in the 1980s at Zarnowec in northern Poland, but they were cancelled in 1990.

The current Polish Nuclear Power Program (PNPP) approved by the Polish government calls for construction of two NPPs comprising 6 GWe capacity by 2030. State-owned utility Polska Grupa Energetyczna (PGE) is doing site and characterization analysis for the first nuclear power plant at two locations in northern Poland: Zarnowec and Lubiatowo-Kopalino. PGE will make the final site selection decision in 2018. The significantly delayed technology tender, originally planned to be announced by the end of 2012, is still to be announced.

PGE set up the company PGE EJ1 to build and run the first plant. In September 2013, PGE entered into a shareholder agreement with the utilities Tauron Polska Energia and Enea as well as copper supplier KGHM Polska Miedz, wherein PGE holds 70 percent of PGE EJ1 and the other companies each hold 10 percent. A follow-on agreement with similar terms was signed in September 2014. In November 2015, PGE EJ1 said five companies had shown interest in the tender: GE-Hitachi (U.S.), KEPCO (ROK), SNC-Lavalin (Canada), Westinghouse (U.S.), and EdF/Areva (France).

Poland has also expressed interest in participating in an international project for the near-term deployment and

commercialization of a high temperature gas cooled (HTGR) reactor. A HTGC would be cheaper than building a large reactor and could provide electricity generation and process heat for industrial use.

Planned Nuclear Energy Projects

First Nuclear Power Plant

Owner: PGE EJ1 consortium

Reactor Type: undetermined: technology selection by late 2016

Capacity: 3000 MWe

Value of Project: \$15 billion

Construction Period: Unit 1: Beginning in 2019

Operation (tentative): Unit 1: 2024

Second Nuclear Power Plant Project

Owner: PGE consortium

Reactor Type: undetermined

Capacity: 3000 MWe

Value of Project: \$15 billion

Construction Period: late 2020s to early 2030s

Operation (tentative): 2035

Commercial Opportunities

Services (front- and back-end): Feasibility studies; environmental analysis; regulatory assistance; infrastructure development; human resource development.

Legal and Consulting Services: Potential for pre-construction services.

Licensing Support: Potential for pre-construction services.

Design, Construction, and Operation: By mid-2017, the Polish government is expected to select the technology for its first NPP.

Components: None currently

Fuel Management: None currently

Waste Management: None currently

Challenges and Barriers to Exports

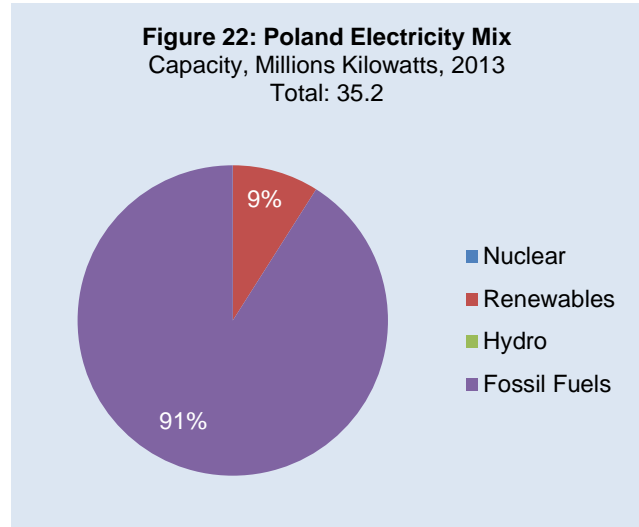
Poland's first reactor tender will attract stiff competition, but U.S. industry is well-positioned. The significant postponement of the country's first tender could prove to be beneficial to U.S. industry, as it will give PGE more time to pursue viable financing options, which continues to be the biggest challenge to building NPPs in Poland. Poland's plan to structure its first nuclear power project using a build-own-operate (BOO) model is a challenge for U.S. industry since it requires multiple companies to bid as a consortium, while state-owned/controlled competitors' vertically integrated industries do not face this challenge. Interested bidder consortia will be asked to include the following in their offers: reactor technology for two or three units with EPC services, operations and management (O&M) support, equity interest of a strategic partner, including energy off-take, ECA or commercial bank financing and fuel supply. The GOP has expressed a desire for support in integrating the design and engineering aspects of the project.

GOP commitment towards NPP construction is unclear given the new government's priorities for coal sector restructuring and investment in high efficient coal fired power plants. Public opinion is moderately favorable toward the country's nuclear build plans. The country faces numerous challenges in the energy sector, including falling electricity prices and changes in European energy market regulation.

Poland's ratification of the 1997 Protocol to the Vienna Convention will help reduce liability concerns for U.S. industry, and its favorable Ex-Im Bank Long-Term Exposure Fee rating should provide a boost for U.S. industry competitiveness.

Nuclear Infrastructure

Research Reactor: The research reactor Maria, used also for production of medical radioisotopes and operated in Swierk (National Centre for Nuclear Research) is the only operating nuclear facility in the country.



U.S. Government Collaboration

123 Agreement: Poland has a 123 Agreement with the United States through Euratom.

Regulatory Cooperation: In September 2010, Poland's National Atomic Energy Agency (PAA) signed an Arrangement with the NRC for technical information exchange and cooperation in nuclear safety matters. The PAA has signed agreements securing access to the Code Applications and Maintenance Program (CAMP) and the Cooperative Severe Accident Research Program (CSARP).

Joint Declaration on Civil Nuclear Commercial Cooperation: In July 2010, the Department of Commerce (DOC) and Poland's Ministry of Economy signed a Joint Declaration Concerning Industrial and Commercial Cooperation in the Nuclear Energy Sector. July 2011 Trade Policy Mission: In July 2011, former DOC Under Secretary for International Trade led a civil nuclear trade policy mission with 11 U.S. civil nuclear companies to Poland, the Czech Republic and Slovakia.

U.S.-Poland Economic and Commercial Dialogue: Initiative between DOC and the Polish Ministry of Economy to promote bilateral trade and investment

and further bilateral economic and commercial relations.

Figure 23: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	✓
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	

International Engagement

PAA is an active participant in the IAEA Regulatory Cooperation Forum (RCF). It has extensive international collaboration through the Visegrad Group (also known as the V4), which consists of Poland, Hungary, the Czech Republic and Slovakia. The V4 formally expressed their “great interest in deepening mutual cooperation” in nuclear energy, environment, energy saving and renewable energy, with Japan during a 2013 Japan-V4 summit. Japan also reaffirmed its “duty” to contribute to worldwide nuclear safety by sharing knowledge and

lessons learned from the 2011 accident at the Fukushima Daiichi nuclear power station.

Poland has been involved in several regional nuclear projects, including the Olkiluoto 2 NPP project in Finland and a joint NPP project with Latvia, Estonia and Lithuania. PGE withdrew from the latter initiative in December 2011 to focus on its own NPP development. In March 2015, Ukrenergo (Ukraine), Energoatom (Ukraine), and privately-owned Polish company Polenergia signed an agreement to export Ukrainian nuclear energy in support of the Ukraine-European Union “energy bridge” project. Revenues from the exports will fund nuclear power plant projects in Ukraine.

Resources

For more information on the commercial opportunities in Poland, contact: William Czajkowski (Senior Commercial Officer in Warsaw, william.czajkowski@trade.gov); Kenneth Duckworth (Commercial Officer in Warsaw, Kenneth.duckworth@trade.gov); Aleksandra Prus (Commercial Specialist in Warsaw, aleksandra.prus@trade.gov).

For more information on the civil nuclear industry in Poland, contact: PGE website (<http://www.gkpge.pl/>); PAA website (<http://www.paa.gov.pl/>)

Sources

CIA Factbook, United Nations, World Nuclear Association and our contacts at U.S. Embassy Warsaw.

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Saudi Arabia

Market Type: Newly Emerging

Saudi Arabia has ambitious plans to diversify its energy sources by 2040, possibly including the construction of large nuclear reactors. Since 2010, Saudi Arabia has expressed interest in nuclear power for electricity generation, desalination and long-term R&D, as well as small and advanced reactor designs. Goals for nuclear energy, however, have not progressed beyond the planning stage, and the lack of a 123 Agreement hinders U.S. exports.

New Builds

6

Existing Reactors

N/A

Decommissioning

N/A

Overall Rank

9

U.S. Ambassador to Saudi Arabia: Joseph W. Westphal
U.S. Commerce Attaché to Saudi Arabia: Douglas Wallace (Riyadh)

Saudi Arabia currently has no nuclear reactors in operation or under construction but is considering building an unspecified number of reactors and adding nuclear power to its power generation mix by 2040. The King Abdullah City for Nuclear and Renewable Energy (KA-CARE) has stated that the country's goals for developing a civil nuclear program are to meet its growing electricity requirements, produce desalinated water and reduce reliance on hydrocarbons. The Saudi Arabian government's Power Sector Generation Strategy calls for 3 GW of nuclear energy by 2040.

Saudi Arabia hired WorleyParsons in 2011 to conduct an analysis of potential sites and assist with preparing a tender. Three potential sites were short-listed in September 2013.

Saudi Arabia's nuclear build plans have attracted significant interest internationally. In September 2013, GE-Hitachi and Toshiba-Westinghouse signed contracts with Exelon to pursue reactor construction in Saudi Arabia. In January 2014, Areva and EDF signed agreements with Saudi Arabia's Global Energy Holding Company (GEHC) to conduct a feasibility study for an EPR.

Saudi Arabia has expressed interest in cooperation on small reactors and Generation IV designs. In March 2015, KA-CARE signed a memorandum of understanding with the Korea Atomic Energy Research Institute (KAERI)

to investigate co-developing and building two 100 MWe SMART reactors. In September 2015, the two partners further signed a cooperation agreement and contracts to start a three-year preliminary study to review the feasibility of constructing SMART reactors in Saudi Arabia. In January 2016, KA-CARE and China Nuclear Engineering Corporation (CNEC) signed a memorandum of understanding on the construction of a high-temperature gas-cooled reactor, although no agreements or contracts have yet been signed.

Commercial Opportunities

Services (front- and back-end): Possibilities for additional site selection and feasibility studies, regulatory assistance, infrastructure development, human resource development.

Legal and Consulting Services: Potential for pre-construction services.

Licensing Support: Potential for pre-construction services.

Design, Construction, and Operation: First tender is expected in the next few years. Currently, GE-Hitachi, Toshiba-Westinghouse, Areva/EDF, Rosatom, KEPCO and CNNC have shown interest in competing for this project.

Components: Opportunities once reactor technology has been chosen.

Fuel Management: None currently.

Waste Management: None currently.

Challenges and Barriers to Exports

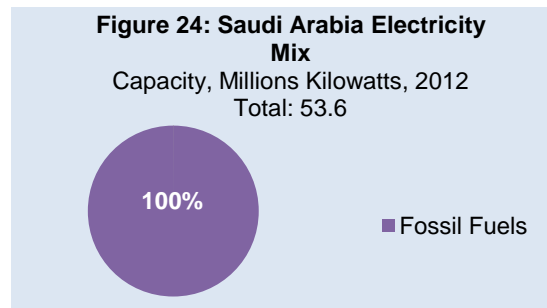
Market access is a challenge due to the strength of foreign competition. France, China, the Republic of Korea and Russia have shown interest in Saudi Arabia's expected tenders and have signed cooperation agreements for feasibility studies, regulatory assistance, training and R&D. Saudi Arabia's plans for nuclear power could be scaled up quickly depending on how it pursues its goal of diversifying its energy mix.

The government is committed to establishing a nuclear regulatory authority. This effort is headed by KA-CARE, which works with the Finnish safety authority, STUK, as its strategic partner.

Saudi Arabia is party to the 1997 Protocol to the Vienna Convention on nuclear liability. The current lack of a 123 Agreement dampens prospects for U.S. exports. Saudi Arabia scores high on all financial indicators.

Nuclear Infrastructure

Research reactors: None at present, although KA-CARE has agreed to buy a small research reactor from Argentina.



U.S. Government Collaboration

123 Agreement: Saudi Arabia does not have a 123 Agreement with the United States.

Bilateral Engagement: Interest in exports and cooperation in the nuclear sector date to 2008, when the U.S. and Saudi Arabia signed a MOU on Civil Nuclear Energy Cooperation. In November 2012, the U.S. Chamber of Commerce and the U.S.-Saudi Business Council sent a delegation to Saudi Arabia to discuss nuclear and solar technology developments.

Figure 25: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	

International Engagement

Saudi Arabia is cooperating with Argentina on a small scale reactor for research and desalination. It has signed cooperation agreements with France, China, Finland, Hungary and the Republic of Korea and is pursuing agreements with Russia, Czech Republic and the UK.

Resources

For more information on the commercial opportunities in Saudi Arabia, contact: Mr. Jesse Lapierre (Principal Commercial Officer in Dhahran, Jesse.lapierre@trade.gov); Fred Aziz (Principal Commercial Officer in Jeddah, Fred.Aziz@trade.gov); I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov)

For more information on Saudi Arabian civil nuclear energy, consult: K.A. CARE website: <https://www.kacare.gov.sa/en>

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and our contacts at the U.S. Embassy in Riyadh and U.S. Consulates in Dhahran and Jeddah.

South Korea

Market Type: Existing and Expanding

The Republic of Korea (ROK) has indigenized its nuclear power industry to the extent that new builds no longer rely heavily on U.S. content. The ROK has emerged as a leading competitor after it won a bid for the Barakah plant in the United Arab Emirates. Despite domestic self-sufficiency, a long history of cooperation with U.S. industry ensures future export opportunities.

New Builds

25

Existing Reactors

7

Decommissioning

12

Overall Rank

13

The Republic of Korea (ROK) currently has 25 operational nuclear reactors with a net capacity of 23.01 GWe. Three reactors consisting of an additional 4.20 GWe are under construction. Korea's reactors are located at four sites; all new builds are expected to be at these sites.

From Korea's first reactor, which achieved commercial operation in 1978 to the late 1990s, Korea's reactor fleet consisted of a variety of foreign designs: six Westinghouse PWRs, four Candu PHWRs, two Framatome (now Areva) PWRs and two Combustion Energy (C-E, now owned by Westinghouse) PWRs. In 1987, Korea began a 10-year technology transfer plan with C-E. The resulting design, the OPR-1000, was largely based on C-E's System 80 model and became the sole design for Korea's subsequent new builds. Ten OPR-1000s have become operational since 1998, with the latest entering operation in July 2015.

The Generation-III APR-1400, based on the C-E System 80+ model, is the successor to the OPR-1000. Three APR-1400s are under construction in Korea with the first to be operational in 2017. Korea is marketing the APR-1400 for export, citing its superior safety features, low generation cost per kilowatt-hour and short construction time, which, according to the Korea Atomic Power Company (KEPCO), has been reduced to 41 months. Four APR-1400s are currently being built in UAE at Barakah, with the reactors entering service between 2017 and 2020.

A series of corruption scandals in 2012 and 2013 regarding falsified quality assurance certificates for

reactor components caused President Park Geun-hye to pledge a review of all reactors and a probe into the state-run Korea Hydro & Nuclear Power Co. (KHNP). A total of five reactors were taken offline temporarily, and three that were under construction were delayed while parts that failed testing were replaced, in part by U.S. suppliers. In December 2013, the Korean government announced a reduction of its new nuclear construction goals to 29 percent of its energy mix by 2035, down from the previous goal of 41 percent by 2030. This still represents a marked increase in its current nuclear power generation capacity.

The Korea Atomic Energy Research Institute (KAERI) is developing a 100 MWe SMR, called SMART (System-integrated Modular Advanced Reactor), that it intends to market for export. It has entered discussions with Saudi Arabia to build a SMART reactor in cooperation with KA-CARE.

Planned Nuclear Energy Projects

Construction on six new reactors is planned over the next five years: four at Shin Kori and two at Shin Hanul. All will be the APR1400 design. In 2015, KEPCO announced that a plant was planned for construction at Cheonji, with two APR+ 1500 MWe reactors projected to come online around 2027.

Commercial Opportunities

Design, Construction, and Operation: Mostly concentrated with local companies.

Components: Mostly concentrated with local companies.

Challenges and Barriers to Exports

The ROK's policy of technology transfer and indigenization has greatly reduced market access for U.S. industry, particularly for new builds. Korea was once a premier destination for U.S. civil nuclear exports, as U.S. reactor vendors joined those of France and Canada to supply Korea with 14 of its first 15 reactors. Korea now exclusively relies on indigenous designs for its new reactor builds, and the amount of local content on these reactors has become high. Recently, Korea's growing capabilities and export ambitions have turned it into a direct competitor with U.S. industry for exports to third countries, most noticeably with UAE, where a Korean consortium beat out GE-Hitachi and Areva for the Barakah tender.

In this respect, Korea's civil nuclear program has served as a model for China, whose program is enacting a similar strategy of technology transfer and indigenization. One of the chief differences, however, is that China's plans for new nuclear power are so vast that China is still reaching out to foreign vendors to supply some of its new build capacity, albeit with high local content quantities. Korea is no longer doing this.

Despite Korea's achievements in self-sufficiency, U.S. industry has strong ties to the Korean civil nuclear market, and there are still ample opportunities for exports of goods and services. Westinghouse, for example, is supplying up to \$2 billion in components and technical support for the Barakah nuclear power plant in UAE. Westinghouse is also involved in a joint venture with KNFC to make control element assemblies for combustion engineering-designed power reactors in the ROK. More recently, several U.S. companies won contracts with KHNP for technical advisory services for re-verification of equipment and material procurement processes following the false certification scandal.

Government support for the country's nuclear program remains high. Official targets for future nuclear generating capacity, though reduced from a year earlier, still represent strong growth of nuclear power in Korea for years to come, and plans for exporting do not appear to be diminished. Korea scores highly on all financial indicators. Liability, however, continues to be an issue. Despite efforts by U.S. government and industry, Korea has not yet agreed to adopt the CSC.

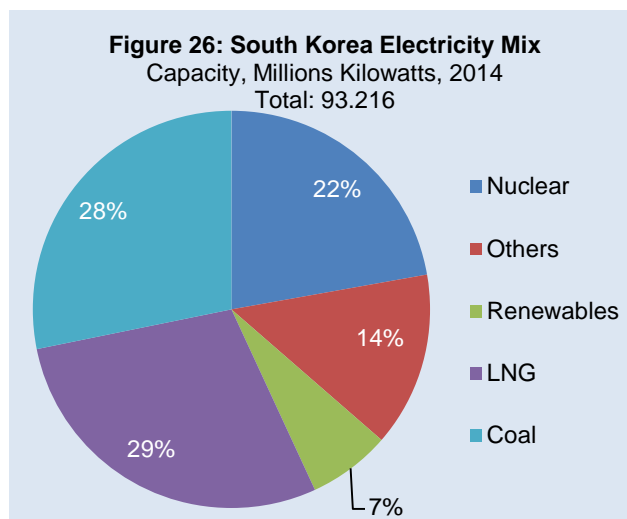
Nuclear Infrastructure

Research Reactor: KAERI has a 30 MWt research reactor that started operation in 1995. It is the basis for the research reactor it is exporting to Jordan.

Fuel: Fuel for Korea's reactors comes from overseas, including Kazakhstan and Canada. Korea has a small quantity of uranium deposits, and mining at the Daejeon site is planned for the near future.

Waste Management: Low and intermediate-level wastes are stored at each reactor site. A central disposal repository is being built at Gyeongju. The Korea Radioactive Waste Management Co. Ltd (KRWM) was set up early in 2009 as an umbrella organization to resolve South Korea's waste management issues and waste disposition and, in particular, to create a national consensus on high-level wastes.

In 2020 nuclear capacity of 27.3 GWe is expected to supply 226 billion kWh - 43.4 percent of electricity - before rising to 48 percent in 2022, though some recent projections suggest 50 percent by 2020, with the use of gas strongly reduced. By 2030, the government expects nuclear to supply 59 percent of the power (333 TWh) from 41 percent of the installed capacity.



U.S. Government Collaboration

123 Agreement: The United States and the ROK signed a new 123 Agreement on June 16, 2015.

U.S.-ROK High-Level Bilateral Commission (HLBC): established in March 2016 under the U.S.-ROK 123 Agreement as a forum to handle follow-on cooperation

on assured fuel supply, spent fuel management and joint export promotion.

U.S.-ROK Joint Standing Committee on Nuclear Energy Cooperation (JSCNEC): U.S. State Department led cooperative initiative in the areas of nuclear energy, nonproliferation, nuclear safety, safeguards, export controls and nuclear security, and emergency preparedness.

International Engagement

In December 2009, the ROK won a bid to build four nuclear reactors in the United Arab Emirates worth \$20 billion. It is actively seeking other export opportunities for its APR1400 design and SMART SMR design. Korea is highly engaged with other countries for R&D, training and resource development. In 2011, it signed agreements with India and Saudi Arabia for nuclear energy cooperation covering joint work on R&D, design, construction, operation, maintenance and development of NPPs.

Resources

For more information on the commercial opportunities in the Republic of Korea, *contact*: Commercial Officer Keenton Chiang (Keenton.Chiang@trade.gov); SB Shin (Commercial Specialist in Seoul, sb.shin@trade.gov); I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov)

For more information on nuclear energy in the ROK: KEPCO website
<http://home.kepco.co.kr/kepco/EN/main.do>

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and our contacts at the U.S. Embassy in Seoul

Figure 27: Additional Agreements

Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	✓

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Turkey

Market Type: Newly Emerging

Turkey is planning to build 12 reactors at three sites. A Russian consortium was chosen to build the first four reactors on a build-own-operate model, and a Mitsubishi-Areva consortium is in discussions for the next four reactors. China's SNPTC and U.S. firm Westinghouse are in discussions for the third project. The potential for U.S. exports will depend on Turkey's plans for its third plant.

New Builds

7

Existing Reactors

N/A

Decommissioning

N/A

Overall Rank

10

U.S. Ambassador to Turkey: John R. Bass
U.S. Commercial Counselor: Larry Farris

Turkey currently has no operating nuclear power plants, but it plans to begin construction in order to meet growing electricity demand and reduce dependence on imported energy (largely coming from Russia and Iran). It is currently planning 12 reactors at three sites: Akkuyu on the Mediterranean coast, Sinop on the Black Sea coast and İğneada near the Bulgarian border

A Russian consortium will build four VVER-1200 reactors at Akkuyu on a build-own-operate (BOO) model to include fuel supply and spent fuel take-back. Russia has pledged to fully finance the project at over \$20 billion. In April 2015, the groundbreaking for Akkuyu took place. While the first unit was expected to go online in 2022, tension in Russia-Turkey relations has delayed the project, and it is unlikely to begin operation by then.

Turkey is working with a consortium led by Mitsubishi and Areva to build four Atmea1 reactors at Sinop, totaling 4800 MWe. Construction on the first unit could begin in 2017 with operation in 2023. Feasibility studies and due diligence are still in progress.

On November 24, 2014, Westinghouse (WEC) signed an agreement with China's State Nuclear Power Technology Corporation (SNPTC) and Electricity Generation Company (EÜAŞ), Turkey's largest electric power company, to enter into "exclusive negotiations"

to develop and construct an additional nuclear power station in Turkey. It is assumed that the first two units at the plant will be AP-1000 reactors, with Chinese CAP-1400 reactor technology being utilized for the subsequent two units. In October 2015, the likely site was identified as İğneada, a town on the Black Sea near the Bulgarian border, although other sites are still under evaluation.

Planned Nuclear Energy Projects

Akkuyu Nuclear Power Plant

Owner: Akkuyu NPP JSC (Russia majority controlled as a BOO model)

Reactor Type: VVER-1200 (AES-2006) with a 60-year lifetime

Capacity: 4800 MWe (4 units, 1200 MWe each) Value of Project: \$20-25 billion dollars; \$1.3 billion was budgeted for 2013

Construction Period: 2015-2023 (four-year construction period per reactor according to recent estimate by Turkish government)

Operation: 2023

Agreements with Russia Regarding Akkuyu: Russia will be responsible for obtaining licenses and permits, financing, training of Turkish personnel, design, construction, operation and maintenance, supply of equipment and material, and supply of nuclear fuel.

There is a take-back option for the reprocessing of spent fuel by Russia. Turkey is responsible for the allocation of the plant site with its current license without any cost and purchasing electricity according to a Power Purchase Agreement. The Rosatom agreement

for Akkuyu also provides for setting up a fuel fabrication plant in Turkey. Recent tension over the geopolitical crises in Ukraine and Syria have raised questions about the future of cooperation on this project. In April, Rosatom announced that it was selling up to 49 percent of its shares in Akkuyu given its financial struggles.

Sinop Nuclear Power Plant

Owner: Mitsubishi (Japan)-AREVA (France) joint venture: both companies are state-owned; GdF-Suez would be the operator of the eventual plant
Reactor Type: ATMEA1 with a 60 year lifetime; these will likely be the first ATMEA1 units built
Capacity: 4800 MWe (4 units)
Value of Project: \$22-25 billion
Construction Period: First unit 2017-2023; other units TBD.
Operation (tentative): First unit in 2023
Agreements with Mitsubishi-AREVA Regarding Sinop: Turkey signed an agreement with Japan in 2013 giving Japanese government exclusive negotiating rights for building the plant. The agreement was approved by Turkish President Erdoğan in April 2015 after being ratified by the Parliament a month earlier.

İğneada NPP

Owner: TBD. Turkish utility EÜAŞ is in discussions with China's SNPTC and U.S. firm Westinghouse.
Reactor Type: TBD. Early indications are for two WEC AP1000s and two SNPTC CAP1400s.
Capacity: 4800 MWe (4 units)
Value of Project: Unknown
Construction Period: Unknown
Operation: Unknown
Agreements with SNPTC and WEC Regarding İğneada: In November 2014, SNPTC, WEC and EÜAŞ signed an agreement to begin "exclusive negotiations". During a March 2016 visit to China, Turkish Energy Minister Albayrak toured the AP1000 under construction in Haiyang and was briefed on the CAP1400 design. Discussions are ongoing.

Commercial Opportunities

Services (front-and back-end): Limited potential for site selection or other advisory services

Legal and Consulting Services: Moderate potential for regulatory consulting related to Akkuyu project

Licensing Support: Moderate potential to support the Turkish Atomic Energy Agency (TAEK), Turkey's nuclear safety regulator

Design, Construction, and Operation: Opportunities exist for site surveys, preliminary and detailed design, environmental impact assessment study, feasibility study, financing and auxiliary equipment production and supply.

Fuel Management: None currently

Waste Management: None currently

Challenges and Barriers to Exports

Despite Turkey's new build plans, opportunities for U.S. industry have been limited. Turkey's insistence on a spent fuel take-back option for Akkuyu forced out all competitors except the Rosatom consortium that eventually won the bid. For Sinop, Turkey has negotiated directly with countries or companies rather than launch an open bid. These have included Korea and Canada (both of whom withdrew over financing issues), China and Mitsubishi-Areva, who is now expected to build the plant. The November 24, 2014 agreement between WEC, SNPTC and EÜAŞ is a positive development for U.S. industry participation in Turkey's third plant. Turkey presence on USTR's 301 Watch List due to lack of IPR enforcement puts an additional strain on civil nuclear exports and U.S.-Turkey trade in general.

Turkish government support for new builds is strong, though Turkey is taking a measured pace toward projects beyond Akkuyu and Sinop. A 123 Agreement exists between the United States and Turkey, and Turkey is party to the Paris Convention for nuclear liability.

Financing, however, is a challenge. Turkey has limited means for financing nuclear power projects on its own, as evidenced by the BOO model it has agreed to for Akkuyu. U.S. Ex-Im Bank financing will be challenging, given Turkey's low score on Ex-Im's long-term exposure fee level. In addition to financing issues, there are concerns about earthquake damage to reactors and political instability in eastern Turkey.

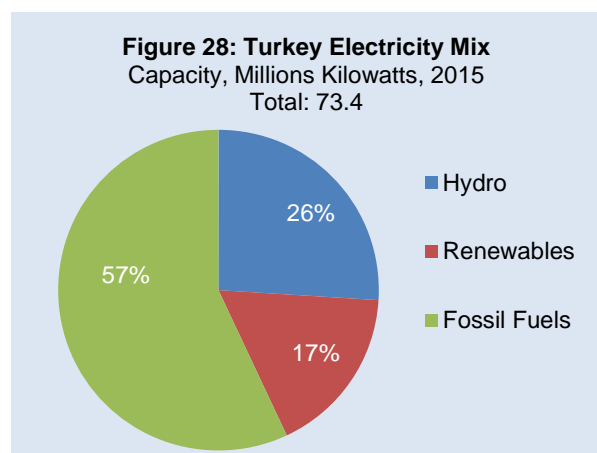
Nuclear Infrastructure

Research Reactor: Turkey has a small Triga research reactor at Istanbul Technical University. It has operated

since 1979 and is regulated by the Turkish Atomic Energy Authority.

Fuel: Turkey possesses approximately 7,400 tU of uranium resources. The government is evaluating the mining operation license application of a U.S. firm which has found reserves of uranium in the province of Sivas. Developing its own domestic resources has been an emphasis of the Turkish government. Production at the Temrezli uranium project could begin in late 2016.

Waste Management: Waste management is mainly limited to radioactive waste arising from the industrial and medical applications of nuclear technologies, and there is a facility for interim storage of these wastes. This storage facility was built and has been operating, since 1989, in the ÇNAEM. Compaction, cementation and precipitation processes have been carried out at this facility.



U.S. Government Collaboration

123 Agreement: The 123 Agreement with the United States will expire in June 2023 with rolling five-year extensions to follow.

Regulatory Cooperation: The NRC and the Turkish Atomic Energy Authority (TAEK) signed an Arrangement for the Exchange of Technical Information and Cooperation in Nuclear Safety Matters in 2012.

International Engagement

Turkey has voluntarily accepted to join the EU stress tests program, demonstrating Turkey's commitment to

the adoption and implementation of the most rigorous safety standards in the construction and operation of its nuclear power plants. In June 2010, Turkey and Korea signed a nuclear cooperation agreement, and in April 2012, two such agreements with China were signed. The Turkish Atomic Energy Authority (TAEK) is participating in the IAEA-coordinated International Project on Innovative Nuclear Reactor Technologies and Fuel Cycles (INPRO). TAEK also contributes to the studies and projects of the OECD/NEA working groups. Turkey has an observer status for CERN, the European Organization for Nuclear Research, which is the world's leading laboratory for particle physics. All activities in Turkey are coordinated and sponsored by TAEK. Turkey is a member of the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), an international scientific research center under construction near Amman, Jordan.

Figure 29: Additional Agreements

Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	✓
Vienna Convention on Civil Liability for Nuclear Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	✓
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	

Resources

For more information on the commercial opportunities in Turkey, contact: Larry Farris (Commercial Counselor in Ankara, michael.lally@trade.gov); Serdar Cetinkaya (Senior Energy Specialist in Ankara,

serdar.cetinkaya@trade.gov); Jonathan Chesebro (ITA Civil Nuclear Team, jonathan.chesebro@trade.gov)

For more information on the civil nuclear industry in Turkey, see: EÜAŞ website (<http://www.euas.gov.tr/>); ETKB website (<http://www.enerji.gov.tr/>); TAEK (<http://www.taek.gov.tr/>)

Sources

CIA Factbook, United Nations, World Nuclear Association and the U.S. embassy in Ankara.

Ukraine

Market Type: Newly Emerging

Ukraine possesses a robust civil nuclear energy program, which accounts for almost half of its energy. Ukraine relies heavily on Russia for most aspects of its program. The Ukrainian government, however, is attempting to expand its energy supply by seeking non-Russian sources of nuclear fuel and construction materials for fuel fabrication plants. Ongoing Ukrainian-Russian tension has increased Ukraine's efforts to reduce its dependence on Russia, which could offer opportunities for U.S. industry.

New Builds

30

Existing Reactors

6

Decommissioning

11

Overall Rank

19

U.S. Ambassador to Ukraine: Geoffrey R. Pyatt

Almost half of Ukraine's energy is generated by its 15 Russian-designed nuclear reactors located at four plants: Khmel'nitsky, Rivne, South Ukraine and Zaporozhe. The reactors are operated by the country's state-owned nuclear power utility, NNEGC Energoatom. Ukraine is prioritizing foreign involvement in its nuclear sector to reduce dependence on Russia.

Most of Ukraine's nuclear fuel and nuclear services are supplied by Russia. In the last few years, Ukraine has diversified its fuel supply by purchasing fuel from Westinghouse. In April 2015, Energoatom signed a memorandum of understanding with Areva to cooperate on safety upgrades, lifetime extensions and performance optimization of the existing fleet and future nuclear power plants (NPPs). The new Ukrainian government has shown considerable interest in prioritizing Western-designed nuclear reactors. Due to the long construction time required for new reactor construction and high government debt levels, however, refurbishment and lifetime extensions of the current fleet are more likely.

Ukraine expects to increase the share of nuclear power in its electricity mix from 48 percent to 52 percent by 2020. In 2006, following disruptions in its natural gas supply, Ukraine decided to double its nuclear capacity to ensure greater energy security. The new nuclear power strategy focused on finishing construction on Khmel'nitsky 3 and 4, which were restarted in 2011 after a contract was signed with Russia's Atomstroyexport. The project was delayed, however, after the

intergovernmental agreement was revoked and Parliament repealed the law on construction based on Atomstroyexport's non-performance.

Planned Nuclear Energy Projects

Khmel'nitsky Nuclear Power Expansion

Owner: State

Reactor Type: V-392

Capacity: 2000 MWe (2 units, 1000 MWe each)

Value of Project: N/A

Construction Period: N/A

Operation: N/A

Khmel'nitsky NPP: Two reactors at the Khmel'nitsky site have been under construction since 1986. Construction stopped in 1990 after the Chernobyl accident led to a moratorium on new NPP construction in Ukraine. Construction restarted in 2010 after a new deal was signed with Russia. This deal has since been suspended, and Ukraine is seeking to transfer the contract to the Czech Republic's Skoda JS.

Commercial Opportunities

Services (front-and back-end): Although 3 nuclear plants are scheduled to close in 2016 to 2017, life extensions are more probable. Few decommissioning opportunities exist beyond ongoing Chernobyl activities.

Legal and Consulting Services: Opportunities exist as Ukraine tries to meet new European NPP safety standards and works toward introducing more foreign companies into its nuclear industry.

Design, Construction, and Operation: Opportunities may exist for construction of reactors, particularly with ongoing tension between Ukraine and Russia. Value added can be found in upgrading, rehabilitation and life extension of existing plants.

Fuel: Significant opportunities to supply fuel to Ukraine's current fleet as it seeks diversification away from Russian sources.

Components: Some opportunities exist for supplying the current Russian-designed fleet.

Challenges and Barriers to Exports

The primary challenge to U.S. civil nuclear exports is the strong presence of Russia in the Ukrainian market. All of Ukraine's 15 reactors are of Russian design, and the country has historically been dependent on Russia for nuclear. The growing Ukrainian government debt may pose a challenge to nuclear exports given that Energoatom is state-owned.

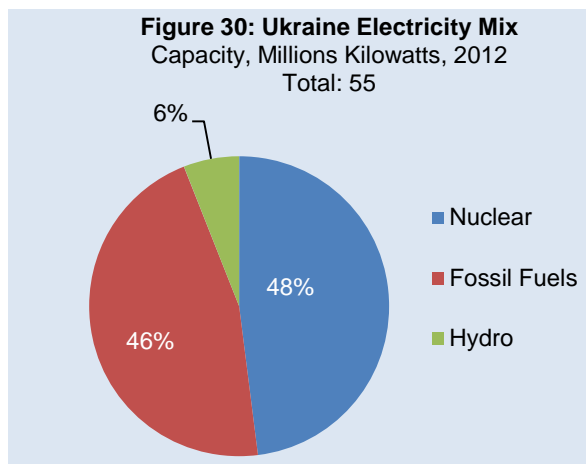
Nuclear Infrastructure

Research reactors: There are two pool type research reactors in Ukraine. The Kyiv research reactor belongs to the Ukrainian Academy of Sciences and has 10 MW nominal capacities. The Sevastopol research reactor belongs to the Sevastopol National University of Nuclear Energy and Industry and has 200kW capacity, but it is located in the disputed territory of Crimea. Energoatom stated that it cannot accept responsibility for the reactor as it no longer has access to it.

Fuel: Ukraine does not convert, enrich or fabricate its own fuel. There are mining and uranium resources, including approximately 2 percent of the world's uranium reserves. Uranium concentrate and zirconium alloy are sent to Russia for enrichment and further production of nuclear fuel, which is then shipped back to Ukraine. Ukraine and Russia have continued this arrangement, though Ukraine has attempted to buy more of its fuel from non-Russian sources.

Waste Management: Ukraine has an open fuel cycle. It has two storage facilities for spent fuel, dry at the Zaporozhye plant and wet at the Chernobyl plant. Spent fuel is also sent back to Russia. Plutonium and high-level waste were expected to be returned to Ukraine from Russia, but this has not yet taken place. In January 2015, Energoatom and U.S. firm Holtec signed a contract to

construct a central used fuel storage facility in the Chernobyl Exclusion Zone.



U.S. Government Collaboration

123 Agreement: Ukraine has a 123 Agreement with the United States, which entered into force in May 1999 and is due to expire on May 28, 2029.

Department of Energy-to-Ministry Agreement: The U.S. Department of Energy's Office of Nuclear Energy (DOE/NE) provides assistance to Ukraine through the Ukraine Nuclear Fuel Qualification Project (UNFQP), which started in 1998.

U.S.-Ukraine Energy Security Working Group: DOE/NE acts as the head of the civil nuclear energy sub-group within the larger working group under the U.S. Department of State and the Ukrainian Ministry of Energy and Coal Industry (MECU).

Memorandum of Understanding: The U.S. and Ukraine have a memorandum of cooperation on several energy issues, including nuclear security.

Figure 31: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	✓
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	

Resources

For more information on the commercial opportunities in Ukraine, contact: James Lindley (Senior Commercial Officer in Kiev, james.lindley@trade.gov); Myroslava Myrtsalo (Commercial Specialist, myroslava.myrtsalo@trade.gov); Jonathan Chesebro (I&A Civil Nuclear Team, jonathan.chesebro@trade.gov)

For more information on the civil nuclear industry in Ukraine:

Energoatom: <http://www.energoatom.kiev.ua/>

SNRC: <http://www.snrc.gov.ua/>

MECU: <http://mpe.kmu.gov.ua/>

Sources

CIA Factbook, United Nations, World Nuclear Association, and our contacts at the U.S. Embassy in Kiev.

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United Arab Emirates

Market Type: Newly Emerging

Since initiating its nuclear energy program in 2008, the UAE has moved swiftly to work with foreign exporters for its first nuclear power plant. A deal with a KEPCO-led consortium is providing the UAE's first four reactors at Barakah. The chief obstacle for U.S. civil nuclear companies in the UAE is robust and well-established foreign competition, but U.S. industry is well-positioned overall to provide well-financed subcontracting services.

New Builds

5

Existing Reactors

22

Decommissioning

N/A

Overall Rank

5

U.S. Ambassador to the United Arab Emirates:

Barbara A. Leaf

U.S. Commerce Attaché to the United Arab Emirates:

Nasir Abbasi (U.S. Commercial Attaché, Dubai), Dao M. Le (U.S. Commercial Counselor, Abu Dhabi)

The UAE is currently building its first four nuclear reactors at the Barakah site. The reactors are of the Korean design, APR-1400. The first will come online in 2017, with the final plant completed by 2020.

UAE's electricity demand is growing rapidly, about 9 to 10 percent per year, and the country is making strategic investments in new generating capacity. Almost all of its current electricity generation comes from fossil fuels, and its development of nuclear energy is an attempt to reduce its dependence on oil and gas for domestic consumption. Nuclear energy is expected to make up a substantial portion of the country's electricity generating capacity by 2030, requiring additional reactors beyond the four at Barakah. The UAE plans to export its nuclear-generated electricity as well.

The Federal Authority of Nuclear Regulation (FANR), established in October 2009, is the country's regulator. In November 2009, the UAE established the Emirates Nuclear Energy Corporation (ENEC), a public entity, to implement its civil nuclear plans and conduct site evaluations, technology selection and submission of the construction license application for the Barakah site.

Planned Nuclear Energy Projects

Owner: KEPCO-led consortium

Reactor Type: Type: APR-1400 reactors

Capacity: 5600 MWe (1400 x 4 reactors)

Value of Project: \$20.4 billion, with a high percentage of the contract being offered under a fixed-price arrangement. The consortium also expects to earn another \$20 billion by jointly operating the reactors for 60 years. In March 2010, KEPCO awarded a \$5.59 billion construction contract to Hyundai and Samsung for the first plants.

Construction Period: Construction began on one reactor per year from 2012 to 2015.

Operation: First reactor projected to come online in May 2017, with an additional reactor coming online each year through 2020.

Agreements with U.S. Industry: U.S. firms are providing significant support to the UAE's civil nuclear program. Westinghouse is part of the winning KEPCO team and is providing major components, instrumentation and control equipment, and design technical and engineering support services. Lightbridge Corporation has provided consulting services to the UAE on the design, development and management of the key elements required to implement a nuclear energy program based on the highest international standards. CH2M Hill won a 10-year contract to manage the UAE's nuclear program in October 2008. Paul C. Rizzo Associates is working on site placement and engineering during the planning process and quality assurance and control for ENEC.

Commercial Opportunities

Services (front-and back-end): Limited potential for site selection, regulatory assistance or other advisory services

Legal and Consulting Services: Limited potential

Licensing Support: Limited potential

Design, Construction, and Operation: Opportunities for future NPP sites and small modular reactors (SMRs)

Challenges and Barriers to Exports

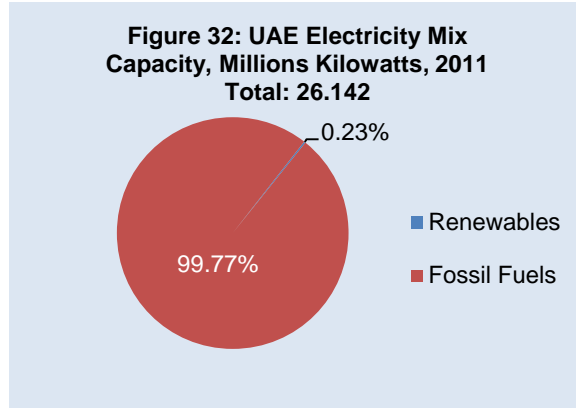
The UAE has moved swiftly and assuredly to implement its nuclear energy program. From the announcement of its first nuclear energy policy in 2008 to the awarding of the Barakah tender to KEPCO in December 2009 to the beginning of construction in 2012, the UAE government has shown strong support for nuclear energy development and has relied heavily on foreign industry for a variety of goods and advisory services. Despite losing the reactor technology bid for the Barakah plant, U.S. industry has had a high level of involvement. This promises to remain the case for years to come, especially if the UAE builds additional plants.

UAE scores highly on virtually all infrastructure and financial criteria, and public opinion is highly favorable toward nuclear energy development. The chief barrier to civil nuclear exports is the considerable strength of foreign competition.

Nuclear Infrastructure

Fuel: Canada-based Uranium One, UK-based Rio Tinto, France's Areva and Russia's Technobexport (Tenex) supply uranium concentrates to the UAE. Conversion services are to be carried out by Converdyn, Tenex and Areva. Enrichment will be done by Urenco, Areva and Tenex, and the fuel assemblies will be done by KEPCO.

Waste Management: The UAE is pursuing a national storage and disposal program as well as exploring regional cooperation options for radioactive waste management.



U.S. Government Collaboration

123 Agreement: The agreement will expire December 17, 2039. The 123 Agreement requires that the UAE permanently forgo domestic enrichment and reprocessing capabilities, a commitment which was implemented as domestic legislation in 2009.

Barakah Plant Financing: The Ex-Im Bank approved \$2 billion in financing for the Barakah plant in September 2012 for U.S. sourced components from Westinghouse and services from it and two other firms. Most of it was for coolant pumps and controls.

International Engagement

The UAE is cooperating with numerous countries in its nuclear program development. It has signed cooperation agreements with the United States, Republic of Korea, UK, France, Canada, Russia, Argentina, Japan and Hungary. In November 2015, the UAE finalized a framework for cooperation with Australia to import fuel.

Figure 33: Additional Agreements	
Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear Damage	✓
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	✓
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	

Resources

For more information on the commercial opportunities in the United Arab Emirates, contact: Dao Le (Senior Commercial Officer, Abu Dhabi, dao.le@trade.gov), Gary Rand (Commercial Officer, Abu Dhabi, gary.rand@trade.gov); Nasir Abbasi (Principal Commercial Officer, Dubai, nasir.abbasi@trade.gov), I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov).

Emirates Nuclear Energy Corporation:

<http://www.enec.gov.ae/>

Federal Authority for Nuclear Regulation:

(<https://fanr.gov.ae/en>)

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and our contacts at the U.S. Embassy in Abu Dhabi and the U.S. Consulate in Dubai.

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United Kingdom

Market Type: Existing and Expanding

Strong political support and plans for expansion mark the UK as a significant opportunity for U.S. civil nuclear exports. Prospects for services beyond new plant construction, particularly decommissioning, plutonium disposition and advanced reactor development, remain positive and are growing. UK government interest in small modular reactor designs will also be a key opening for U.S. companies. Robust foreign competition and financing are the chief obstacles for U.S. industry.

New Builds

3

Existing Reactors

3

Decommissioning

1

Overall Rank

2

U.S. Ambassador to the United Kingdom: Matthew Barzun

U.S. Commerce Attaché to the United Kingdom: John Simmons (London)

The UK currently has 15 operational nuclear reactors, comprising 10.0 GWe of capacity. Four of these are expected to be shut down by 2024. The UK is planning to build new nuclear reactors to replace its existing fleet and make up for diminishing reserves of oil and natural gas. Though no official targets have been set, UK government officials have called for 16 GWe of installed nuclear capacity by 2030.

France's EDF Energy is planning to build four European Pressurized Reactors (EPRs) at Hinkley Point in Somerset and Sizewell in Suffolk. Startup for the first reactor at Hinkley Point C is expected in 2025, although the beginning of construction is subject to postponement (first by European Community approval, then by delayed follow-through by EDF). China's state-owned China General Nuclear Power Corporation (CGN) will take a 33.5 percent stake of the Hinkley Point C project and 20 percent at the planned EDF controlled Sizewell site. In return, EDF will grant CGN a controlling stake in a third site at Bradwell, where it will build and operate the Chinese designed Hualong One reactor (the first Chinese designed and built nuclear reactor in the West). A final investment decision by EDF is expected in May 2016.

To support the Hinkley Point C project, the UK government agreed to an investment agreement with

EDF Energy in October 2013 that included a 35-year Contract for Difference with a guaranteed electricity "strike price" subsidy. In September 2015, the UK government announced a £2 billion loan guarantee to support the project.

The Hitachi-GE-controlled Horizon Nuclear Power consortium plans to build four ABWR reactors at two sites: Wylfa in northern Wales and Oldbury in Gloucestershire. Construction on the first unit at Wylfa is planned for 2019, with startup expected in 2025.

The NuGeneration (NuGen) consortium (60 percent owned by Toshiba and 40 percent by Engie) plans to build three AP1000 reactors at Moreside, just north of the Sellafield site in Cumbria. The first unit is expected to become operational in 2024.

The British Department of Energy and Climate Change (DECC) is currently examining the feasibility of its policy for managing the UK's large civil plutonium (Pu) stockpile, which involves reuse as mixed oxide fuel (MOX) and would require procurement of a new MOX plant. GE's PRISM fast reactor and Candu's EC6 heavy-water reactor have been proposed as solutions. In January 2014, following the conclusion of a two-year review of disposition options, the Nuclear Decommissioning Authority (NDA) said it will take an additional one to two years to conduct further technical studies and that it may seek a "multi-track" approach. Regardless of the chosen solution, the UK will need to dispose of some Pu in a repository or other long-term storage location because of the various Pu grades it

possesses, a portion of which is not suitable for use in any type of reactor.

Small modular reactors (SMRs) have been the subject of recent interest in the UK with the government's March 2016 publishing of the first phase of a competition to identify the best value SMR design for the country. In November 2015, the government announced a £250 million nuclear R&D program through DECC, with half that amount dedicated to the SMR competition. NuScale and Westinghouse are among several parties interested in winning the competition. If the competition is successful, an SMR project could move forward in the next decade.

Planned Nuclear Energy Projects

Hinkley Point C and Sizewell C NPPs

Owner: EDF Energy: EdF majority-owned, 33.5 % CGN, 66.5% EdF; French government owns 85% of EdF, and Chinese government owns all of CGN.

Reactor Type: EPR

Capacity: 3240 MWe (2 units) at each plant

Value of Project: £24.5 billion total (\$17.6 billion per plant)

Construction Period: First unit 2019-2025

Operation (tentative): Hinkley C-1 and C-2 are planned for 2025 and 2026, with Sizewell C-1 and C-2 undetermined as of yet.

Wylfa and Oldbury B NPPs

Owner: Horizon: Hitachi-GE-controlled, other investors TBD.

Reactor Type: ABWR

Capacity: 2760 MWe (2 units) at each plant

Value of Project: \$13-14 billion per plant

Construction Period: First unit 2019-2025

Operation (tentative): First unit in 2025

Moorside NPP

Owner: NuGen: 60% Toshiba, 40% GDF Suez.

Reactor Type: AP1000

Capacity: 3400 MWe (3 units)

Value of Project: \$20-24 billion

Construction Period: First unit 2019-2024

Operation (tentative): First unit in 2024

Bradwell NPP

Owner: Joint Venture (66.5% CGN, 33.5% EDF)

Reactor Type: Hualong One (UK version)

Capacity: 2100 MWe (2 units)

Value of Project: unknown

Construction Period: TBD

Operation (tentative): TBD

Commercial Opportunities

Services (front-and back-end): Potential for back-end services, decommissioning and plutonium disposition

Legal and Consulting Services: Limited potential

Licensing Support: Limited potential

Design, Construction, and Operation: U.S. industry heavily engaged in Wylfa, Oldbury and Moorside plants.

Opportunities in other sub-sectors, such as decommissioning, also exist. In March 2014, for example, Fluor was part of a joint venture that won a 14-year, \$11 billion contract to decommission 10 Magnox power plants and two research facilities. Plutonium disposition provides a unique opportunity for U.S. exports but, at this point, is dependent on government policy decisions regarding technology selection. The NDA's draft Strategy and Business Plan (2016 to 2019) earmarked spending of £3.2 billion in financial year 2016/17. The NDA budget accounts for 60 percent of DECC funding and is ring-fenced from cuts.

Challenges and Barriers to U.S. Exports

The UK's extensive plans to build new nuclear reactors have attracted high levels of interest from France, Germany, Japan, China, Russia and the United States. Despite heavy competition, U.S. industry has many opportunities for civil nuclear exports to the UK. This has become more evident as Hitachi and Toshiba have taken majority stakes in Horizon and NuGen, respectively, and will build up to four ABWRs and three AP1000s at three sites.

Bipartisan government support has been consistently strong since it adopted a pro-nuclear energy policy in 2006, and public opinion of new nuclear has remained favorable as the UK's plans have become more firm. While political support is strong, finding equity to finance projects without a state-backed nuclear energy corporation has proven difficult.

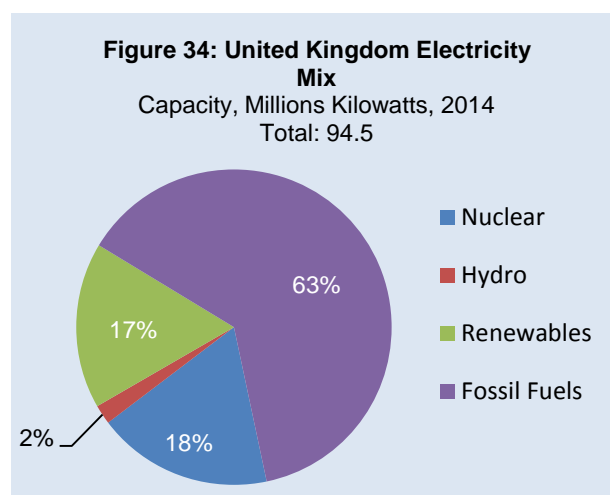
Nuclear Infrastructure

Research Reactors: Only one research reactor, the Rolls Royce zero-power Neptune reactor in Derby, remains operational. Announced during the rollout of the Hinkley Point plant agreement, the UK and China

resolved to cooperate on a £50 million Joint Research and Innovation Center in Cumbria.

Fuel: Apart from raw uranium mining and uranium ore purification, the UK has an independent nuclear fuel cycle capability and offers services domestically and to international markets. The UK has several known small deposits of low-grade uranium, but none have been determined to be economically feasible to mine.

Waste Management: The Radioactive Waste Management Directorate (RWMD) is charged with developing plans for a Geological Disposal Facility (GDF) set to begin operation in 2040. Site selection is expected to take place by 2025.



U.S. Government Collaboration

123 Agreement: The United States has a 123 Agreement with the UK through EURATOM. It will expire in 2026 with rolling five-year extensions from thereafter.

Radioactive Waste Management: The U.S. Department of Energy's (DOE) Office of Environment Management and the British Nuclear Decommissioning Authority cooperate on radioactive waste management technology. This was initiated by a February 2012 Statement of Intent. In 2014, this Statement of Intent was amended to include the UK National Nuclear Laboratory Limited. DOE and DECC also signed an MOU in April 2012 for broader energy-related cooperation.

International Engagement

The UK continues to solicit international partners to achieve its civil nuclear plans. In 2013, it formally gave a Chinese consortium a 33.5 percent stake in Hinkley

Point, and in November 2015, it signed a Commercial Strategic Investment Agreement with China that will allow France's EDF and China's CGN to build NPPs at Hinkley Point and two other sites in the UK. In September 2013, the UK and Russia signed a nuclear cooperation agreement, and Russia has expressed interest in UK new build investments. The UK has welcomed international investment for decommissioning and operation of its current reactor fleet.

Figure 35: Additional Agreements

Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	✓
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	✓
Vienna Convention on Civil Liability for Nuclear Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	✓
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	✓
OECD/NEA	✓
IFNEC	✓
GenIV International Forum (GIF)	✓

Resources

For more information on the commercial opportunities in the United Kingdom, contact: Claudia Colombo (Commercial Specialist in London, Claudia.colombo@trade.gov); John Simmons (Minister Counselor for Commercial Affairs John.Simmons@trade.gov) I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov).

For more information on nuclear power in the United Kingdom, see: Nuclear Decommissioning Authority website

(<https://www.gov.uk/government/organisations/nuclear-decommissioning-authority>), Office for Nuclear Regulation website (<http://www.onr.org.uk/>)

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and our contacts at U.S. Embassy London.

Vietnam

Market Type: Newly Emerging

To help satisfy booming electricity demand, Vietnam is projected to be the first country in Southeast Asia with a civil nuclear energy program. Two proposed plants in Ninh Thuan province are being built by Russia and a Japanese-led consortium, with up to 10 reactors planned for deployment by 2025. Future sector growth offers opportunities for American exporters.

New Builds

4

Existing Reactors

N/A

Decommissioning

N/A

Overall Rank

4

U.S. Ambassador to Vietnam: Ted Osius

U.S. Commerce Attaché to Vietnam: Stuart Schaag

Vietnam is the first country in Southeast Asia moving forward on developing a peaceful nuclear power program. In late 2009, the National Assembly approved plans to construct Vietnam's first two nuclear power plants (NPPs) in coastal Ninh Thuan province by 2025 with two turbines of 1000 MW each. The Government of Vietnam (GVN) has awarded contracts to Russia's Atomstroyexport and a Japanese consortium to each build a two-reactor NPP. Russia has agreed to fully finance its plant, and Japan will likely finance up to the Organization for Economic Co-operation and Development's (OECD) limit of 85 percent. Russia and Japan have a head-start over the United States in terms of reactor projects in Vietnam, primarily due to both countries' ability to provide government-backed finance and other incentives.

The GVN plans to develop the Ninh Thuan 1 and 2 NPPs with a total of eight 1000 MWe reactors coming on line annually from 2020 to 2027, although these plans will likely be delayed up to four years due to ongoing negotiations on technology and financing. Vietnam has announced plans to build up to 13 NPPs with a total capacity of 16,000 MWe over the next two decades. These announcements present rapidly emerging opportunities for the U.S. civil nuclear industry. Vietnam's civil nuclear market is currently estimated to be worth \$10 billion and is expected to grow to \$50 billion by 2030. As of March 2016, Vietnam plans to supply 5.7 percent of its electricity through nuclear energy by 2030 and 25 percent by 2050.

Planned Nuclear Energy Projects

Ninh Thuan 1 Nuclear Power Plant (Phuoc Dinh)

Owner: Atomstroyexport-ROSATOM (Russia): state-owned

Reactor Type: VVER-1000 reactors, later specified as AES-91 power plants

Capacity: 4 units x 1000 MW (2 planned, 2 proposed)

Value of Project: A finance agreement of up to \$9 billion was signed in November 2011 with the Russian government's state export credit bureau, and a second agreement for a \$500 million loan covered the establishment of a nuclear science and technology center.

Construction Period (tentative): To begin in 2020 as a turnkey project.

Operation (tentative): 2028 for the first two reactors, with two more proposed coming online at a later date

Cooperation with Russia Regarding Ninh Thuan 1: Russia's Ministry of Finance is prepared to finance at least 85 percent of the first plant. For the first two reactors, Russia's policy for building NPPs in non-nuclear weapons states is to deliver on a turnkey basis, including supply of all fuel and repatriation of used fuel for the life of the plant. The fuel is to be reprocessed in Russia and the separated wastes returned to the client country eventually. Russia has also agreed to build a new 15 MW research reactor at Da Lat, starting in 2017, for operation in 2023.

Ninh Thuan 2 Nuclear Power Plant (Vinh Hai)

Owner: JINED consortium including METI, nine utilities (led by Chubu, Kansai and Tokyo Electric Power

Company) and three manufacturers (Mitsubishi Heavy Industries, Toshiba and Hitachi)

Reactor Type: Construction has been delayed beyond the initial plan of 2015, creating uncertainty around the type of reactor to be built. WEC's AP1000 and Mitsubishi/Areva's Atmea1 are being considered as reactor types.

Capacity: 4 units x 1000 MW

Value of Project: \$10 billion

Construction Period: To begin in 2020.

Operation (tentative): 2028-2029

Cooperation with Japan Regarding Vinh Hai: EVN signed agreements with Japan Atomic Power Corporation (JAPC) in 2011 for consulting services to help with site selection and a \$26 million Japanese government-funded feasibility study, completed in May 2013, that included technology selection with economic and financial analysis. Japan has committed to train about 1,000 staff for Ninh Thuan 2. A financial agreement between Vietnam and the Japanese government is still in negotiation.

Commercial Opportunities

Services (front and back-end): Second tender for Owner's engineering service for Ninh Thuan 1 and 2 projects will be issued after selecting the EPC contractor in 2019.

Legal and Consulting Services: Many opportunities for assisting with front-end services, including site selection, licensing, liability and project management.

Design, Construction, and Operation: Vietnam has not yet selected a reactor technology. Currently, Westinghouse-Toshiba (AP1000) and Mitsubishi/Areva (Atmea1) are competing for a project.

Waste Management: The Russian government has committed to assist the GVN in waste management. In March 2013, JINED organized a workshop to introduce how Japanese NPPs manage waste to Vietnamese ministries and Electricity of Vietnam Corp.

Challenges and Barriers to Exports

Vietnam's decision to contract with Russia and Japan for its first two reactor projects presents great challenges for U.S. industry to enter the market. The GVN has recently courted other countries, particularly the Republic of Korea, for bilateral civil nuclear cooperation, highlighting the high-level of foreign competition in this market. Despite strong foreign competition, U.S.

government and industry remain highly engaged with Vietnam, and the U.S.-Vietnam 123 Agreement will enable broader and deeper cooperation, strengthening the U.S.-Vietnam bilateral relationship for civil nuclear energy. If the GVN stands by its nuclear development plans, U.S. industry will have great opportunities for exports.

GVN support for nuclear energy is strong, though its January 2014 announcement to postpone construction of its first two projects for up to four years brings into question the GVN's commitment to meeting its ambitious goals for nuclear energy development. If it follows through with its plans to build additional reactors, U.S. industry will have significant chances to compete for tenders and other contracts.

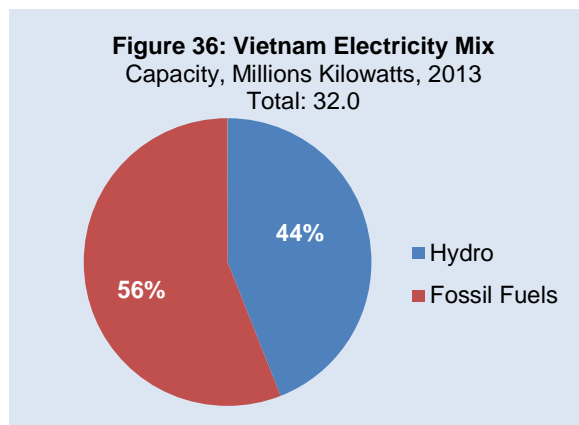
Liability continues to be a major obstacle. Efforts by the U.S. government and industry to promote the CSC have increased the GVN's awareness of the need for strong liability protections and have resulted in the GVN making tentative commitments to signing it. Vietnamese ratification of the CSC would greatly improve the prospects of U.S.-Vietnam civil nuclear trade.

Financial obstacles exist for civil nuclear exports to Vietnam. Russia and Japan won their construction contracts in part due to the significant financial incentives they offered, including financing deals. Vietnam scores low on both the Ex-Im Bank Long-Term Exposure Fee level and the World Bank Ease of Doing Business Indicator, potentially hampering U.S. industry's ability to offer similar incentives. Additionally, U.S. industry's inability to offer BOO construction or, as Russia has done, to take back and reprocess spent fuel may put U.S. industry at a disadvantage for future tenders.

Nuclear Infrastructure

Research Reactor: Vietnam has a 500 kW research reactor at Da Lat that has been operational since 1984. It is operated by Vinatom and was converted to run on low-enriched fuel in 2007 in partnership with the United States.

Fuel: Vietnam's Ministry of Natural Resources & Environment is working with Canadian company NWT Uranium Corp to exploit a uranium deposit in Quang Nam province that is believed to have about 7000 tU in 0.05 percent ore. Despite this development, Vietnam plans on importing all fuel for its planned reactors.



U.S. Government Collaboration

123 Agreement: Agreement entered into force in October 2014.

Cooperation and Information Exchange: The National Nuclear Security Administration (NNSA) is involved in 11 programs affiliated with Vietnam and has engaged in workshops with Vietnam in a variety of topics including reactor licensing, nuclear forensics, and nuclear safeguards infrastructure development.

May 2013 Trade Mission: In May 2013, the then DOC Undersecretary for International Trade led a delegation of senior U.S. government officials from DOC, DOE, Ex-Im Bank and U.S. industry to work with the GVN on bilateral nuclear energy cooperation. DOC and FCS Vietnam organized a workshop in which U.S. firms shared their experience in nuclear power development with Vietnamese ministries and industry.

Figure 37: Additional Agreements

Non-Proliferation Treaty	✓
IAEA Comprehensive Safeguards Agreement & Additional Protocol	✓
Joint Convention on Safety of Spent Fuel Management	
Convention on Nuclear Safety	✓
Convention on Early Notification of a Nuclear Accident	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	✓
Paris Convention on Third Party Liability in the Field of Nuclear Energy	
Vienna Convention on Civil Liability for Nuclear	

Damage	
Joint Protocol Relating to the Application of the Vienna Convention and Paris Convention	
Convention on Supplementary Compensation for Nuclear Damage	
Organization Membership	
IAEA	✓
Nuclear Suppliers Group	
OECD/NEA	
IFNEC	✓
GenIV International Forum (GIF)	

International Engagement

In recent years, Vietnam has signed nuclear cooperation agreements with Russia, France, China, South Korea, Japan, Canada and the United States. In addition to the reactor deals with Russia and Japan detailed above, Vietnam has asked the Republic of Korea to conduct a feasibility study for a possible Korean NPP in Vietnam.

Resources

For more information on the commercial opportunities in Vietnam, contact: Stuart Schaag (Senior Commercial Officer in Hanoi, stuart.schaag@trade.gov); Elizabeth Shieh (Principal Commercial Officer in Ho Chi Minh City, Elizabeth.shieh@trade.gov); Tuyet Trees (Commercial Specialist in Hanoi, tuyet.trees@trade.gov); I&A Civil Nuclear Team: Jonathan Chesebro (jonathan.chesebro@trade.gov)

For more information on the nuclear energy industry in Vietnam, see:

Ministry of Industry and Trade website (<http://www.moit.gov.vn/en>)

Sources

CIA Factbook, United Nations, World Nuclear Association, Asian Development Bank, and officials at the U.S. Embassy in Hanoi.

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Addendum: Resources for U.S. Exporters

The U.S. government has numerous resources available to help U.S. exporters, including: market research, guides to export financing, overseas trade missions, and staff around the country and the world. A few key resources are highlighted below. For additional information about services from the International Trade Administration (ITA), please visit www.export.gov.

Country Commercial Guides

<http://export.gov/ccg/>

Written by U.S. Embassy trade experts worldwide, the Country Commercial Guides provide an excellent starting point for what you need to know about exporting and doing business in a foreign market. The reports include sections addressing market overview, challenges, opportunities and entry strategies; political environment; selling U.S. products and services; trade regulations, customs and standards; and much more.

Basic Guide to Exporting

<http://export.gov/basicguide/>

A Basic Guide to Exporting addresses virtually every issue a company looking to export might face. Numerous sections, charts, lists and definitions throughout the book's 19 chapters provide in-depth information and solid advice about the key activities and issues relevant to any prospective exporter.

Trade Finance Guide: A Quick Reference for U.S. Exporters

<http://www.export.gov/tradefinanceguide/index.asp>

Trade Finance Guide: A Quick Reference for U.S. Exporters is designed to help U.S. companies, especially small and medium-sized enterprises, learn the basics of trade finance so that they can turn their export opportunities into actual sales and achieve the ultimate goal of getting paid—especially on time—for those sales. Concise, two-page chapters offer the basics of numerous financing techniques, from open accounts to forfaiting, to government assisted foreign-buyer financing.

Trade Missions

<http://www.export.gov/trademissions/>

Department of Commerce trade missions are overseas programs for U.S. firms that wish to explore and pursue export opportunities by meeting directly with potential clients in their markets.

Trade missions include among other activities: one-on-one meetings with foreign industry executives and government officials that are pre-screened to match specific business objectives.

Certified Trade Fairs

http://www.export.gov/eac/show_short_trade_events.asp?CountryName=null&StateName=null&IndustryName=null&TypeName=International%20Trade%20Fair&StartDate=null&EndDate=null

The Department of Commerce's trade fair certification program endorses overseas trade shows that are a reliable venue and a good market for U.S. firms to sell their products and services abroad. These shows serve as a vital access vehicle for U.S. firms to enter and expand to foreign markets. The certified show/U.S. pavilion ensures a high-quality, multi-faceted opportunity for American companies to successfully market overseas. Among other benefits, certified trade fairs provide U.S. exhibitors with help facilitating contacts, market information, counseling and other services to enhance their marketing efforts.

Upcoming TFCs include:

- World Nuclear Exhibition: Paris, France
June 28-30, 2016

- Asia Nuclear Business Platform: Hong Kong
May 18-19 2016

International Buyer Program

<http://export.gov/ibp/>

The International Buyer Program (IBP) brings thousands of international buyers to the United States for business-to-business matchmaking with U.S. firms exhibiting at major industry trade shows. Every year, the International Buyer Program results in millions of dollars in new business for U.S. companies by bringing pre-screened international buyers, representatives and distributors to selected shows. U.S. country and industry experts are on site at IBP shows to provide hands-on export counseling, market analysis and matchmaking services. Each IBP show also has an International Business Center where U.S. companies can meet privately with prospective international buyers, prospective sales representatives and business partners and obtain assistance from experienced ITA staff.

The Advocacy Center

<http://www.export.gov/advocacy/>

The Advocacy Center coordinates U.S. government interagency advocacy efforts on behalf of U.S. exporters bidding on public-sector contracts with overseas governments and

government agencies. The Advocacy Center helps to ensure that sales of U.S. products and services have the best possible chance competing abroad. Advocacy assistance is wide and varied but often involves companies that want the U.S. government to communicate a message to foreign governments or government-owned corporations on behalf of their commercial interest, typically in a competitive bid contest.

U.S. Commercial Service

<http://www.export.gov/usoffices/index.asp>

With offices throughout the United States and in U.S. Embassies and Consulates in nearly 80 countries, the U.S. Commercial Service utilizes its global network of trade professionals to connect U.S. companies with international buyers worldwide. Whether looking to make their first export sale or expand to additional international markets, companies will find the expertise they need to tap into lucrative opportunities and increase their bottom line, including trade counseling, actionable market intelligence, business matchmaking and commercial diplomacy.

Appendix 2: Methodology

ITA's 2016 Civil Nuclear Energy Top Markets Report ranks 50 countries in terms of their readiness for nuclear energy and openness to U.S. civil nuclear exports. Individual market ratings for exports related to new builds, existing reactors and decommissioning were assessed on the basis of 19 variables encompassing qualitative and quantitative measures.

Quantitative data was obtained from a variety of sources including the Energy Information Administration (EIA), Office of the U.S. Trade Representative (USTR), the World Nuclear Association (WNA), the World Bank, the International Atomic Energy Agency (IAEA), the International Energy Agency (IEA), the U.S. Census Bureau, and the U.S. International Trade Commission (ITC). Qualitative analysis was informed by company consultations, U.S. Commerce Department Civil Nuclear Trade Advisory Committee (CINTAC) input, unclassified USG cables, USG analyst expertise, and questionnaires distributed to ITA staff at U.S. Embassies and Consulates in countries that have indicated an interest in expanding or developing their nuclear energy programs.

The total score for a given market is computed by adding together three sub-sector scores—new builds, existing reactors, and decommissioning—that comprise the full spectrum of civil nuclear exports of goods and services. Each of these sub-sector scores are discussed below.

New Builds

The new build sub-score includes a variety of goods and services that accompany contracts for the construction of new nuclear reactors, including construction equipment, reactor components, fuel for initial core loads, site selection studies, safety training and human resource development services, and regulatory and licensing advisory services. Market opportunities for advanced reactors, such as small modular reactors (SMRs) and high-temperature gas-cooled reactors (HTGRs), are included in this sub-sector.

The new build sub-score is computed by the multiplication of the following factors (see Appendix for more information on methodology):

- Market Access: measures strength of bilateral relationship with U.S., foreign competition, and local content.
- Potential Market Size: score is weighted to measure size of market opportunity.
- Government and Political Support for New Builds: measures strength of host-country government support.
- IAEA Milestones Factors: includes measurements for financial fitness, energy drivers, and accession to necessary international agreements.

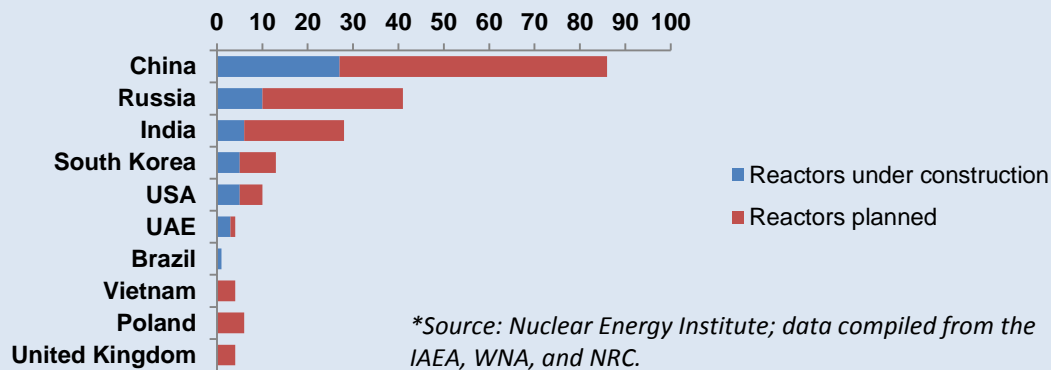
Each of the four factors above is considered essential for new build export opportunities, such that a zero value for any single factor would negate the prospect of new build exports. This is why a multiplication formula was chosen. Thus, a market that is virtually closed to U.S. civil nuclear exports—such as Russia, due to a robust domestic industry and Russian government policy—or one with publically stated government opposition to new nuclear reactors—such as Germany—would receive scores of zero for new builds, regardless of how well it scores in other factors.

The new build score is given the most weight in computing the total score due to two main assumptions. First, the new build sub-sector is assumed to have the largest potential for exports, both in dollar value and number of

Figure 38: Methodology Used to Rank Civil Nuclear Export Markets



Figure 39: Reactors Under Construction, by Country



contracts. This reflects the fact that a win for a U.S. reactor vendor often results in numerous additional contracts for U.S. goods and services, engages the U.S. civil nuclear supply chain, and can result in a long-term relationship with the market leading to future projects.

This assumption also recognizes that even in cases where a foreign reactor vendor is awarded a new build contract, export opportunities exist through sub-contracts or partnerships with foreign companies, thus adding to the potential value of U.S. exports in the new build sub-sector. Second, the study assumes that USG support is most needed in the new build sub-sector because the chief competition for reactor tenders comes from foreign state-backed companies that put U.S. industry at a competitive disadvantage. This is true for new build contracts more so than existing reactor or decommissioning contracts, which entail far lower financing barriers and often have the benefit of existing corporate relationships.

Existing Reactors

Exports related to existing reactor fleets include reactor components, fuel and a variety of services, such as safety training, human resource development and used fuel management. This sub-sector is assigned the second highest weight for computing the total score.

The sub-score for existing reactors is computed by multiplying two factors:

- **Market Access:** includes strength of bilateral relationship, foreign competition, local content requirements and an assessment of whether the current reactor fleet includes technology that is compatible with U.S. industry expertise.
- **Size of Existing Reactor Program:** export opportunities assumed to be directly related to size of existing fleet.

Decommissioning

This sub-sector includes decommissioning and decontamination of goods and services and related advisory services. It is given the smallest weight of the three sub-sectors in computing the total market score, reflecting the current dollar value and number of opportunities for decommissioning exports. As reactor fleets age and more countries—whether for political, economic or technological reasons—decide to shut down plants, the size of this sub-sector will expand. In addition, recent events, such as the March 2011 Fukushima accident and subsequent decisions of several nations to shut down, reactors early or phase out their reactor fleets have brought about a renewed focus on decommissioning and decontamination export opportunities. This highlights the need for sustained, long-term USG support for export opportunities in this sub-sector.

The decommissioning sub-score is computed by the multiplication of two factors:

- *Market Access*: includes strength of bilateral relationship, foreign competition and local content requirements.
- *Decommissioning Projects and Plans*: announced or active decommissioning projects.

Description of variables for new builds:

Category	Variable	Description
Market Access	Foreign Competition	Measures on a scale of high to low the strength of foreign competition for new builds. Assessment takes into account a country's political relationship with the United States and the likelihood of the market to favor U.S. companies.
	Localization	Measures on a scale of high to low the estimated quantity of localized content for a new build.
Market Size	Number of proposed new builds	Measures number of proposed new builds over the next 15 years.
Government and Political Support	Government Support for New Nuclear Power Plants	Qualitatively assesses strength of government support for building new reactors. Assessment includes factors such as public statements from government officials, program and policy consistency (or, conversely, history of policy changes and delays), interactions of industry and government staff with foreign officials, and political stability.
	Public Opinion	Measures favorability of public opinion toward nuclear power and new builds. Sources include opinion polls and survey results from U.S. Embassies, as available.
	Plans for New Nuclear Power Plants	Assesses official national policies for new builds according to time horizon and steps taken to implement plans. This variable is distinct from that of "government support" above, as this variable assesses official plans, whereas the "government support" variable attempts to measure the probability of a government following through on its plans. For example, a market scoring high in "government support," but whose national policy envisions beginning new construction more than ten years in the future, will score low in this category.
	Current Construction	Considers whether reactors are currently being built. Current reactor construction will boost a country's score since it attests to the market's ability and intention to build new reactors.
Infrastructure, Financial Factors, and Energy Drivers	Liability Framework	Assesses whether a nation adheres to a formal liability regime. Nations adhering to the CSC, 1997 Protocol to the Vienna Convention, or 2004 Protocol to the Paris Convention receive higher scores.
	123 Agreement	Assesses whether a 123 Agreement has been signed with United States or is under discussion.
	Projected Electricity Demand Growth	Assesses the scale of increasing demand for electricity over the next 15 years.
	Domestic Energy Availability	Assigns a score, from low to high, on whether a market is a net coal and/or natural gas exporter, a net total fossil fuel exporter, or a net energy importer. A net coal and/or natural gas exporter receives the lowest score because coal and natural gas are direct competitors with nuclear energy, while other fossil fuels compete less.
	U.S. Ex-Im Bank Long-Term Exposure Fee Level	Rates market according to current U.S. Ex-Im Bank Long-Term Exposure Fee Level: http://www.exim.gov/tools/exposurefees/longtermfinancing/ .
	Ability to Self-Finance	Qualitative assessment of a market's ability to finance a new nuclear power plant without assistance from other countries.
	GDP	Rates each market according to GDP in relation to other markets. Higher GDP receives higher score.
	World Bank Ease of Doing Business Indicator	Rates each market according to rank in the World Bank Ease of Doing Business Indicator.

Description of variables for existing reactors:

Category	Variable	Description
Market Access	Foreign Competition	Measures on a scale of high to low the strength of foreign competition for existing reactor contracts. Assessment takes into account the technology composition of existing reactor fleet and gives a higher score for the presence of Western designs.
	Localization	Measures on a scale of high to low the estimated quantity of localized content for contracts relating to existing reactors.
Size of Existing Reactor Program	Reactor Fleet Size	Measures size of existing reactor fleet. Reactors currently under construction are included in this measurement because it is assumed they will become operational within the next 15 years and thus fall within the scope of this report.

Description of variables for decommissioning:

Category	Variable	Description
Market Access	Foreign Competition	Measures on a scale of high to low the strength of foreign competition for decommissioning contracts. Assessment takes into account the technology composition of existing reactor fleet and gives a higher score for the presence of Western designs.
	Localization	Measures on a scale of high to low the estimated quantity of localized content for contracts relating to decommissioning.
Decommissioning Plans	Decommissioning Plans	Measures the number of reactors that will need decommissioning services within 10 years and opportunities for decontamination services.

Appendix 3: Top 50 Overall Markets for U.S. Civil Nuclear Exports

1. China
2. UK
3. India
4. Vietnam
5. UAE
6. South Africa
7. Czech Republic
8. Mexico
9. Saudi Arabia
10. Turkey
11. Japan
12. Brazil
13. ROK
14. France
15. Poland
16. Canada
17. Bulgaria
18. Argentina
19. Ukraine
20. Slovakia
21. Romania
22. Finland
23. Sweden
24. Slovenia
25. Kazakhstan
26. Malaysia
27. Hungary
28. Egypt
29. Australia
30. Jordan
31. Germany
32. Lithuania
33. Indonesia
34. Russia
35. Switzerland
36. Philippines
37. Spain
38. Netherlands
39. Belgium
40. Nigeria
41. Taiwan
42. Kuwait
43. Bangladesh
44. Belarus
45. Chile
46. Kenya
47. Ghana
48. Mongolia
49. Niger
50. Uzbekistan

Appendix 4: Subsector Definitions

The U.S. civil nuclear energy supply chain spans reactors, fuel services, nuclear engineering, procurement and construction, and advisory services to meet the needs of the global expansion of nuclear power. Below is further detail on each subsector's specialty.

Advisory and Legal Support Services

This subsector contains companies that provide advisory and consulting services that address the development of legal and regulatory regimes, licensing support, siting, environmental impact analyses, legal advice and tender writing and development. Standards development and trade association activities are also included within this subsector.

Design, Construction and Operation

Companies in this subsector are responsible for technology design and engineering, procurement, project management, site preparation, plant construction and plant operation and maintenance. This subsector addresses all activities in the engineering, procurement and construction (EPC) phase of a project and also covers utilities that operate plants and companies that provide plant maintenance and repair.

Components

Companies in this subsector are generally manufacturers that seek commercial opportunities throughout a plant's lifecycle, including parts required for operation and maintenance, uprates and upgrades. We delineate this subsector to reflect commercial opportunities for component manufacturers independent of Nuclear Steam Supply System (NSSS) providers.

Fuels

The fuels subsector includes all aspects of the fuel cycle, including mining and milling uranium, enrichment, conversion, fabrication of assemblies, refueling, transportation of fuel and fuel storage.

Back-End Services

Companies in this subsector provide services related to plant decommissioning and used fuel management, including waste management and removal, remediation, used fuel management, interim storage and transportation, geologic disposal and reprocessing and recycling of plant byproducts.

Appendix 5: Role of U.S. Government Agencies in Civil Nuclear Energy

The U.S. government supports the expansion of safe and secure nuclear power worldwide through a variety of bilateral and multilateral mechanisms, including areas such as nuclear financing, nuclear trade promotion, safeguards and security of nuclear materials, research and development, and management of nuclear waste and storage. The descriptions below provide more detail on the responsibilities of each U.S. Government Program.

Export-Import Bank of the United States (Ex-Im Bank)

Ex-Im Bank is the official export credit agency of the United States. Its mission is to help create and maintain American jobs by supporting the export of U.S. goods and services to international markets. Ex-Im Bank provides working capital loan guarantees (pre-export financing), export credit insurance, and loan guarantees and direct loans (buyer financing).

Ex-Im Bank has provided financial support for numerous nuclear power plants in multiple countries. Ex-Im Bank can provide special extended repayment terms of up to 18 years to support the export of U.S. goods and services required for nuclear power plants. For all financing requests, Ex-Im Bank performs due diligence on the financial, legal, technical and environmental aspects of the proposed project. In addition, the technical, environmental and safety-related performance of all nuclear projects financed by Ex-Im Bank is monitored through the full term of Ex-Im Bank's financial support.

On June 27, 2013, Ex-Im Bank released its updated Environmental and Social Due Diligence Procedures and Guidelines, which detail environmental and safety guidelines for nuclear power plants (www.exim.gov).

U.S. Department of Commerce

International Trade Administration (ITA)

ITA strengthens the competitiveness of U.S. industry, promotes trade and investment and ensures fair trade through the rigorous enforcement of trade laws and agreements. ITA works to improve the global business environment and helps U.S. organizations compete at home and abroad. ITA supports President Obama's recovery agenda and the National Export Initiative to sustain economic growth and support American jobs. Several ITA offices support the civil nuclear industry.

Industry and Analysis (I&A) Office of Energy and Environmental Industries (OEEI)

I&A's OEEI is dedicated to promoting trade, investment and commercial partnerships for the energy and environmental sectors. I&A works to expand trade and investment in these sectors by participating in trade negotiations, organizing trade capacity building programs and evaluating the impact of domestic and international economic and regulatory policies. OEEI's Civil Nuclear Energy Team works with other USG agencies to develop a public policy environment that advances and promotes civil nuclear engagement with our global trading partners. In October 2008, OEEI launched the Civil Nuclear Trade Initiative (CNTI) to increase the commercial benefits from civil nuclear cooperation with other countries. The CNTI coordinates USG civil nuclear activities through the Atoms for Prosperity interagency mechanism (led by the White House Director for Nuclear Energy Policy) and the Trade Promotion Coordinating Committee (TPCC), an interagency task force that ensures the coordination and development of a government-wide export promotion plan.

For more information, please visit www.trade.gov/mas/ian/nuclear/index.asp.

U.S. Commercial Service (CS)

Every year, the CS helps thousands of U.S. companies export goods and services worth billions of dollars to destinations around the world. Located in over 100 cities across the United States and in U.S. Embassies and Consulates in more than 70 countries, its global network of trade professionals is

dedicated to opening doors for U.S. business. Whether U.S. companies are looking to make their first export sale or expand to additional international markets, the CS offers trade counseling, market intelligence, business matchmaking, trade promotion events and commercial diplomacy designed to help U.S. companies succeed internationally.

For more information regarding assistance and in-country contacts, please visit www.export.gov.

Advocacy Center

ITA's Advocacy Center coordinates USG resources in order to level the playing field on behalf of qualified U.S. nuclear business interests as they compete against foreign firms for specific international nuclear contracts or other U.S. nuclear export opportunities. Specifically, the Advocacy Center advocates on the behalf of approved U.S. civil nuclear companies that are competing for nuclear power tenders abroad by garnering support from USG officials as they interact with foreign government decision makers.

For more information about ITA's Advocacy Center, please visit www.trade.gov/advocacy.

Bureau of Industry and Security (BIS)

The Bureau of Industry and Security (BIS) in the U.S. Department of Commerce is charged with the licensing, development, implementation and interpretation of U.S. export control policy for dual-use commodities, software and technology. See Appendix 5 (Key Trade Policy Issues in Civil Nuclear Energy, Export Controls) below for more information on BIS.

For more information on BIS, please visit www.bis.doc.gov.

U.S. Department of Energy (DOE)

Office of Nuclear Energy (NE)

NE advances nuclear power as a resource capable of meeting energy, environmental and national security needs by resolving technical, cost, safety, proliferation resistance and security barriers through research, development and demonstration (RD&D). NE conducts civil nuclear energy RD&D to support the safe and reliable operation of the current nuclear power reactor fleet, to develop advanced reactor designs and sustainable nuclear fuel cycles, and to minimize the risks of nuclear proliferation. In all these efforts, NE collaborates with other USG agencies, DOE's National Laboratories, U.S. industry and universities, and international partners. NE has a robust program of international engagement. Bilaterally, NE collaborates on RD&D through a variety of mechanisms, including action plans and working groups, R&D agreements and the International Nuclear Energy Research Initiative. Multilaterally, NE cooperates with international partners through the International Atomic Energy Agency (IAEA), the Generation IV International Forum, the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD/NEA), and the International Framework for Nuclear Energy Cooperation. In addition, NE leads the development of international commercial back-end fuel services concepts.

For more information about NE, please visit www.energy.gov/ne/office-nuclear-energy.

NE/NNSA Comprehensive Engagement for Emerging Nuclear Energy Programs

NE also works closely with DOE's National Nuclear Security Administration (NNSA) on an integrated engagement approach to support countries with emerging nuclear energy programs to assist them in developing the necessary nuclear infrastructure, safety, security, safeguards and emergency response capabilities. NE and NNSA seek to address these issues in a comprehensive way as early as possible in the planning process before the design and construction of these new nuclear energy systems begin. To this end, NE and NNSA have compiled a list of necessary activities and have identified existing DOE training and technical assistance programs that can support a country's specific needs at various stages in the development of its nuclear energy program. NE and NNSA also closely coordinate to support the IAEA's efforts to assist member states in the development of safe and secure nuclear energy programs.

National Nuclear Security Administration (NNSA)

In addition to its cooperation with NE, NNSA, through its Office of Defense Nuclear Nonproliferation, works closely with a wide range of partners to detect, secure and dispose of dangerous nuclear and radiological material and related Weapons of Mass Destruction (WMD) technology and expertise. NNSA supports the safe and secure expansion of nuclear power by assisting the U.S. Department of State in negotiating agreements for cooperation (123 Agreements), reviewing export applications for nuclear-specific and WMD-related dual-use equipment, and controlling the export of unclassified U.S. nuclear technology and assistance. NNSA also engages with the IAEA and other international partners to strengthen civil nuclear safeguards and security infrastructure.

NNSA is also responsible for the management and security of the nation's nuclear weapons and naval reactor programs and responds to nuclear and radiological emergencies in the United States and abroad. Additionally, NNSA federal agents provide safe and secure transportation of nuclear weapons and components and special nuclear materials along with other missions supporting national security.

For more information about NNSA's Office of Defense Nuclear Nonproliferation, please visit www.nnsa.energy.gov.

Office of Environmental Management (EM)

EM's mission is to complete the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research. EM's capabilities include tank waste management, deactivation and decommissioning, nuclear material disposition, and soil and groundwater remediation. EM invests in research and technology development in all of these areas to improve the efficiency and cost-effectiveness of addressing unprecedented environmental challenges. It also collaborates closely with international and U.S. partners in industry, government, academia and national laboratories to share technical knowledge and best practices for meeting regulatory and site cleanup requirements while protecting human and ecological health.

For more information on EM, please visit www.energy.gov/em/office-environmental-management.

U.S. Department of State

Bureau of International Security and Nonproliferation/Office of Nuclear Energy, Safety and Security (ISN/NESS)

ISN/NESS develops U.S. policy relating to peaceful nuclear cooperation, nuclear safety, nuclear export controls and the physical protection of nuclear materials and facilities, in furtherance of U.S. nuclear nonproliferation goals concentrating on technical aspects of nuclear technology and the dangers of nuclear proliferation. It works bilaterally, negotiating 123 Agreements and implementing nuclear cooperation programs, and multilaterally, interacting with the IAEA, the OECD/NEA and the Nuclear Suppliers Group. ISN/NESS also coordinates interagency efforts to implement the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and to promote entry into force of the Convention on Supplementary Compensation for Nuclear Damage and the Convention on the Physical Protection of Nuclear Material.

For more information about the ISN/NESS, please visit www.state.gov/t/isn.

Bureau of Energy Resources (ENR)

ENR ensures that U.S. diplomatic relationships advance U.S. interests in having access to secure, reliable and ever-cleaner sources of energy. The ENR focus is to manage the geopolitics of today's energy economy through diplomacy; to enable global energy transformation through energy policy that stimulates market forces for alternative energy, clean electricity, development and reconstruction; and to expand good governance, increase transparency and improve commercially viable and environmentally sustainable access for the 1.3 billion people without access to electricity and the 2.7 billion people without access to modern energy services.

For more information on ENR, please visit www.state.gov/e/enr.

U.S. Nuclear Regulatory Commission (NRC)

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency charged with oversight of U.S. commercial nuclear activities in order to protect the public health and safety, promote the common defense and security, and protect the environment.

NRC executes this important duty by licensing and regulating the nation's civilian use of byproduct source and special nuclear materials. NRC's regulations are designed to protect both the public and workers against radiation hazards from industries that use radioactive materials.

NRC's scope of responsibility includes regulation of commercial nuclear power plants; research, test and training reactors; nuclear fuel cycle facilities; medical, academic and industrial uses of radioactive materials; and the transport, storage and disposal of radioactive materials and wastes. In addition, NRC licenses the import and export of radioactive materials and works to enhance nuclear safety, safeguards and security throughout the world.

NRC adheres to the principles of good regulation—independence, openness, efficiency, clarity and reliability. The agency puts these principles into practice with effective, realistic and timely regulatory actions, consistent with our organizational values and our open, collaborative work environment.

NRC supports U.S. interests abroad in the safe and secure use of nuclear materials and in guarding against the spread of nuclear weapons. NRC actively participates in international working groups and provides advice and assistance to international organizations and foreign countries to develop effective regulatory organizations and enforce rigorous safety standards.

NRC has bilateral programs of assistance or cooperation with 43 countries, Taiwan and the European Atomic Energy Community. NRC's international exchange programs provide joint cooperative activities and assistance to other countries to develop and improve regulatory organizations. Two of these programs are the International Regulatory Development Partnership (www.irdp-online.org) and the Radiation Sources Regulatory Partnership (www.rsrp-online.org).

NRC's information exchange arrangements with foreign regulatory authorities establish the framework for NRC to gain access to non-U.S. safety information that can (1) alert the United States of potential safety problems, (2) help identify possible accident precursors, and (3) provide accident and incident analyses, including lessons learned, that could be directly applicable to the safety of U.S. nuclear power plants and other facilities. They also serve as vehicles for the health and safety assistance that NRC supplies to emerging countries in their efforts to develop and enhance their regulatory capabilities and their nuclear safety infrastructure. Thus, the arrangements facilitate NRC's strategic goal to support U.S. interests in the safe and secure use of nuclear materials and in nuclear nonproliferation both at home and abroad.

For more information, please visit the NRC's website at www.nrc.gov.

Appendix 6: Key Trade Policy Issues in Civil Nuclear Energy

U.S. Department of Commerce Civil Nuclear Trade Initiative:

In December 2008, the Department of Commerce launched the Civil Nuclear Trade Initiative (CNTI) to strengthen the competitiveness of the U.S. nuclear industry as it endeavors to rebuild its manufacturing base by capturing opportunities abroad. The Initiative, developed and administered by the Industry & Analysis (I&A) unit within the International Trade Administration, identifies the industry's most pressing trade challenges and most promising commercial opportunities and coordinates public and private sector efforts to address these issues. The Initiative aims to demonstrate and provide strong USG support for the U.S. civil nuclear industry to create an environment where U.S. companies can compete successfully and on a level global playing field, particularly against the state-owned competition.

The Initiative involves four areas of work:

- 1) The Trade Promotion Coordinating Committee's (TPCC) Civil Nuclear Trade Working Group - an interagency working group that coordinates USG policy and activities affecting U.S. civil nuclear trade
- 2) Commerce's Civil Nuclear Trade Advisory Committee (CINTAC)
- 3) Trade policy and promotion activities, including, among others, a U.S. Industry Program at the annual International Atomic Energy Agency (IAEA) General Conference, trade missions to best prospect markets, nuclear standards workshops and bilateral declarations on nuclear commercial cooperation
- 4) Stakeholder resources, including a civil nuclear trade web portal ([trade.gov/civil nuclear](http://trade.gov/civil_nuclear)), an on-line nuclear export controls guide, a small modular reactor commercial outlook report and other promotional materials

Liability - Convention on Supplementary Compensation for Nuclear Damage (CSC):

One of the biggest impediments to nuclear suppliers' pursuit of global opportunities is concern about potential legal liability in the event of a nuclear accident. Nuclear suppliers are reluctant or unwilling to participate in nuclear projects in countries where liability for a nuclear accident is NOT channeled exclusively to the operator of a nuclear facility or in countries where the operator may exercise a right of recourse against suppliers. U.S. nuclear suppliers also are concerned that, in the event of an accident outside the U.S., suppliers, as well as the operator, could be sued in U.S. courts that would apply normal tort law. In all these cases, suppliers would be subject to unlimited liability for which insurance is not available.

The best way to address the concern about potential liability is the establishment of a global nuclear liability regime based on the international nuclear liability principles, including channeling all liability exclusively to the operator and granting exclusive jurisdiction over claims arising from a nuclear accident to the courts of the country where the accident occurs. The IAEA-sponsored CSC is designed to be the basis for a global nuclear liability regime. Specifically, the CSC requires members to have national law consistent with the international principles either through membership in one of the existing international nuclear liability regimes (the Paris Convention or the Vienna Convention) or through adoption of national law consistent with the provisions of the Annex to the CSC. Members of the CSC also must agree to contribute, in the event of a nuclear accident, to an international fund to compensate victims of nuclear damage. Countries with and without nuclear power facilities can become parties to the CSC.

With the ratification of the CSC by Japan in January 2015, the CSC entered into force in April 2015. India ratified the CSC in February 2016. The U.S. government is now working to encourage more countries to ratify the CSC.

Peaceful Uses of Nuclear Energy Cooperation Agreements—123 Agreements

Nuclear cooperation agreements are required in order for the U.S. industry to export nuclear material, nuclear reactors and major reactor components. The United States currently has 22 123 Agreements in effect with more than 47 countries (28 through the Euratom Agreement, which includes all member states of the European Union), the IAEA and Taiwan. 123 Agreements must comply with the requirements of

U.S. law, in particular, section 123 of the U.S. Atomic Energy Act of 1954 (AEA), as amended, which authorizes agreements for cooperation in the peaceful uses of nuclear energy.

123 Agreements are negotiated by the U.S. Department of State, with technical assistance from the U.S. Department of Energy (DOE) and concurrence from the U.S. Nuclear Regulatory Commission (NRC). DOE negotiates and implements administrative arrangements to the 123 Agreements. The NRC reviews and approves license requests for all nuclear material and equipment to be exported subject to 123 Agreements.

Section 123 of the AEA requires the following:

- safeguard guarantees for all non-nuclear weapons states on all transferred nuclear material and equipment;
- full-scope safeguards (non-nuclear weapon states only);
- peaceful uses assurances;
- right of return to the United States in the event the other party detonates an explosive device or violates/terminates an IAEA agreement for safeguards;
- no alteration in form or content, including reprocessing and enrichment, without U.S. permission;
- no retransfer without U.S. permission;
- physical security guarantees; and
- U.S. prior approval of storage facilities for certain types of special nuclear material.

Transfers of components that do not require a 123 Agreement are licensed by the NRC. Nuclear-related dual-use exports, e.g., computers, simulators, detectors and other dual-use items, such as non-nuclear grade graphite for non-nuclear use, are licensed by the U.S. Department of Commerce. For more information, please visit DOE/NNSA's website at <http://go.usa.gov/DxjR>.

Export Controls

Part 810 Licenses

10 CFR Part 810 implements section 57 b. of the AEA, which controls the export of unclassified nuclear technology and assistance. Specifically, section 57 b. of the AEA prohibits any U.S. person from directly or indirectly engaging in the production of any special nuclear material outside of the United States except in cases where the U.S. Secretary of Energy has made a determination that the transfer is not inimical to the interests of the United States. These regulations enable peaceful nuclear trade by ensuring that nuclear technologies and assistance exported from the United States will be used for peaceful purposes.

Part 810 licenses are issued pending the official concurrence of the U.S. Department of State and in consultation with the U.S. Department of Commerce, the U.S. Department of Defense and the NRC. Countries that would receive the technology transfer may be asked to provide government-to-government assurances that the technology provided will be used solely for civil nuclear activities and not for any nuclear explosive device, or other military purpose, and not retransferred from the territory of that state without prior U.S. consent. Such assurances confirm that the recipient government is aware of the transfer and guarantees that the technology will be used for peaceful purposes. The assurances usually take the form of a diplomatic note through the U.S. Embassy in country to the Department of State, which then provides the assurances and formal concurrence in the transfer to the U.S. Secretary of Energy.

For more information, please visit DOE/NNSA's website at <http://go.usa.gov/DxDm>.

Part 110 Licenses

The NRC has the responsibility and authority under the AEA to regulate the export and import of nuclear equipment and materials. These regulations are codified in 10 CFR Part 110 and apply to all individuals in the United States who export and import nuclear equipment, material or components subject to NRC licensing authority. Unless the export or import transaction falls under an exemption by the NRC, it must

be authorized by an appropriate NRC license. NRC issues two types of export and import licenses, general and specific.

For more information, visit the NRC website at <http://go.usa.gov/DxDJ>.

Dual-Use Civil Nuclear Licensing

The Bureau of Industry and Security (BIS) in the U.S. Department of Commerce is charged with the licensing, development, implementation and interpretation of U.S. export control policy for dual-use commodities, software and technology. Dual-use items subject to BIS regulatory jurisdiction have predominantly commercial uses but may also have military, nuclear, missile, chemical, biological and weapons applications. The statutory authority for Commerce to regulate dual-use exports is the Export Administration Act of 1979 and is implemented through the Export Administration Regulations.

For more information, visit the BIS website at <http://go.usa.gov/DY5A>.

ⁱ “Up-rating” refers to the process of increasing the licensed power level of a commercial nuclear power plant.

Industry & Analysis' (I&A) staff of industry, trade and economic analysts devise and implement international trade, investment, and export promotion strategies that strengthen the global competitiveness of U.S. industries. These initiatives unlock export, and investment opportunities for U.S. businesses by combining in-depth quantitative and qualitative analysis with ITA's industry relationships.

For more information, visit
www.trade.gov/industry

I&A is part of the International Trade Administration, Whose mission is to create prosperity by strengthening the competitiveness of U.S. industry, promoting trade and investment, and ensuring fair trade and compliance with trade laws and agreements.



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