2016 Top Markets Report Civil Nuclear

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.

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	

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 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

Figure 2: Top 10 Ranking by Sub-sector

New Builds	***Existing Plants***	***Decommissioning***
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

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 2004.

Global Industry Landscape

Globally, there are currently 444 nuclear reactors witl combined 386 gigawatt (GWe) capacity operating in 3 countries and 65 reactors under construction in 15 countries. The OECD International Energy Agency 201 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 ener needs of an expanding global population, which is expected to grow to 10 billion by 2050. Many countri continue to express interest in developing or expandi 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.

[i] "Uprating" refers to the process of increasing the licensed power level of a commercial nuclear power plant.

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.