UXC Market Outlook
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Fabrication Market Outlook

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Introduction and Overview

UxC, LLC (UxC) is pleased to present the 2023 *Fabrication Market Outlook* (FMO) report, which is the 17th annual edition in this series. This year's report builds upon the significant enhancements made in previous editions as part of our ongoing effort to improve information exchange and understanding in the all-important global nuclear fuel fabrication marketplace.

The global nuclear power industry has clearly turned a corner and the negative impacts of the 2011 Fukushima accident are now mostly behind us. Globally, trends are quickly shifting back to supporting life extensions of existing reactors and adding new units to deal with the rising challenges of energy security and climate change. While the fuel fabrication industry is still being affected by the previous premature reactor retirements in certain regions, especially in key markets in North America, Western Europe, and Japan, there have continued to be ongoing expansions of nuclear power in other key markets, such as China, Russia, South Korea, India, and parts of the Middle East. Thus, the markets for fuel fabrication are adapting to these important shifts in nuclear power around the world.

Globally, demand for nuclear fuel is now showing signs of improving growth trends over the next few decades. Many nations are pushing forward on reactor expansions, which means that the world need substantial amounts of nuclear fuel fabrication, especially in the more rapid growth regions, and thus the industry will need to respond to various competing trends on the demand side.

On the supply side, there have been numerous events affecting the future outlooks and operating structures for key fabrication vendors. In France, Framatome's fuel fabrication division is now fully integrated with the reactor construction and services divisions under EDF's ownership. Westinghouse has new owners this year comprised of Brookfield Renewable Partners and Cameco Corporation, which could lead to additional changes to the way the storied PWR reactor and fuel vendor will operate going forward. Meanwhile, the Global Nuclear Fuel (GNF) partnership is now owned by just GE and Hitachi, allowing the partners to fold the fuel fabrication business into their existing GE-Hitachi Nuclear Energy joint venture.

Russian vendor TVEL, which is still the dominant VVER fuel supplier, continues to face additional headwinds as Russia's military invasion of Ukraine has fundamentally reshaped the entire global nuclear fuel markets. Thus, despite winning a PWR fuel reload order from Sweden's Vattenfall a few years ago, the war has now fully halted TVEL's ambitions to become a supplier of western-designed PWR fuel in both Europe and the U.S. Instead, TVEL is now dealing with encroachment of both Westinghouse and Framatome in the VVER fuel market in Eastern Europe.

These collective market developments, coupled with various other issues in the nuclear industry, in general, and the fuel fabrication industry have suggested that there

could be big changes in worldwide fabrication markets. The interactions between buyers and sellers in the years ahead and our assessment of such changes are addressed throughout this FMO report.

As with previous editions, the primary focus of this report is fuel fabrication for large light water reactors (LWRs) – boiling water reactors (BWRs) and pressurized water reactors (PWRs), including VVER-type PWRs – as these comprise the vast majority of the nuclear plants currently in operation around the world and those planned for the future.

There are also several pressurized heavy water reactors (PHWRs) operating in Canada and other nations, advanced gas-cooled reactors (AGRs) in the United Kingdom, and several light water-cooled, graphite-moderated reactors (LGRs) in Russia (RBMK and EGP reactors). However, these regions/reactors represent unique fuel fabrication markets, which are covered at the end of this report.

In the chapters that follow, we address many of the diverse commercial, institutional, economic, and technical aspects of nuclear fuel, fuel fabrication, and the international fuel fabrication market. The report is intended to serve a variety of purposes:

- For those with little knowledge of nuclear fuel fabrication and its markets, the FMO serves as a primer, providing a solid background in various aspects of the industry and an understanding of how its markets function.
- For those knowledgeable in the fundamentals of fabrication, the FMO offers analyses of a variety of its aspects based on several decades of participation in the fabrication industry.
- Finally, for those who are actively involved in the industry as buyers or sellers of nuclear fuel assemblies, the FMO supplies additional up-to-date insights to assist in the improvement of existing nuclear fuel programs and in the development of new fabrication-related initiatives.

What's New in the 2023 Report?

In the 2023 FMO, we have updated all sections of the report and continued with the organization and format of the report from previous years. This includes our *FMO Reference Document*, which incorporates fabrication market discussion that are considered reference materials and do not change from year to year very much.

The FMO presents market data and analysis consistent with the style of UxC's other *Market Outlook* reports, and all the discussions and analyses have been updated to reflect the events of the past year. As part of the lead-up to this report, we have again conducted a survey of international utility attitudes toward the fabrication market.

This year's essay, titled "Recent Fabrication Market Highlights and Trends," reviews all the major new and exciting developments shaping the global fuel fabrication markets these days. This includes analysis of shifts in demand, the evolving situation in

Europe's VVER market, the latest status of new fuel designs, efforts to deploy Accident Tolerant Fuels (ATFs), High Burnup Fuels (HBFs), and LEU+ fuel, as well as various other interesting developments.

We have classified the world's fabricators into three categories: the Mega-Vendors, very large and diversified suppliers active in multiple markets; International Suppliers, larger suppliers with both large domestic and international fuel sales; and the smaller regional and national suppliers. Analysis of each vendor's current situation and potential future developments in terms of market access and technical developments are presented in detail.

All data and forecasts in the new 2023 FMO again extend all the way to 2040. This year's fuel fabrication demand projection is drawn from our proprietary *UxC Requirements Model* (URM), which, starting with UxC's own internal forecasts for nuclear power capacities, calculates demand on a reactor-by-reactor, cycle-by-cycle basis. We continue to refine and improve our reactor forecasts and the URM and believe the current version of the URM produces more accurate forecasts than in prior years. UxC's nuclear growth forecasts are updated quarterly, and the fabrication demand projections used in this report reflect our latest analyses in this regard. In this 2023 edition, we present extended supply and demand as well as price forecasts through 2040.

The FMO provides analyses of the current and future markets for fuel for LWRs, i.e., BWRs and PWRs; however, we also include an updated and expanded discussion of the fabrication markets for non-LWR fuel (e.g., PHWRs, AGRs, and LGRs). Special efforts have been made to enhance our analysis of the PHWR fuel fabrication market, which represents about 11% of the world's reactors today. In addition, we include a brief review of the potential fuel fabrication market for small modular reactors (SMRs) and other advanced reactors, although the future of SMRs and other advanced reactor designs remains in flux at this time.

Finally, as part of our continuing efforts to improve and enhance the analysis of the fuel fabrication markets, UxC made efforts to engage with global fuel fabricators, as well as their customers, to obtain the most accurate and up-to-date information possible. For this year's Utility Fabrication Market Survey, we received many excellent responses from utilities around the world.

- **FMO Reference Document**

The FMO report is split into two documents. The first is this main FMO report, which includes all the chapters described in the following **Structure of Report** section. Second, to make the FMO more user-friendly, and to reduce the total volume of the main report, we have extracted sections of previous FMOs that have remained relatively constant over the years and put them into a separate *FMO Reference Document*. This reference document is available to all FMO subscribers and can be accessed as a PDF file downloadable from the UxC Client Site (note that subscriber

login credentials are required).[1] The *FMO Reference Document* includes the following sections:

- Nuclear Fuel Fabrication Market Primer
- History of the Nuclear Fuel Fabrication Industry
- Utility Procurement Approaches and Contracting Issues
- Typical Fuel Fabrication Service Contracts
- Fuel Assembly Design and Manufacture
- Nuclear Fuel Performance

Structure of Report

This year's edition of the FMO continues our efforts to create a user-friendly text with each chapter containing clear and distinct information. The reader is encouraged to begin at **Chapter 1**, as there is intended to be a continuous and logical flow to the report; however, each individual chapter provides unique topical coverage that can also be considered independently from the rest of the report's contents. The report is structured as follows:

This year's in-depth topical essay in **Chapter 1 – Essay: Recent Fabrication Market Highlights and Trends** examines numerous key developments and trends that have been shaping the fabrication market over the past year. These trends affect both supply and demand of fabrication as well as the products offered in the market and the overall market structure.

Chapter 2 – Reactor Developments and Demand Outlook begins our review of the fabrication market fundamentals with a look at current and future demand. This chapter presents UxC forecasts for nuclear power growth through 2040 from our *Nuclear Power Outlook* (NPO) and the resulting fabrication demand projection through 2040 using our *UxC Requirements Model* (URM).

Chapter 3 – Results from UxC Utility Fabrication Market Survey presents the results of our latest utility market survey and analyzes the latest trends in utility views on the fabrication market.

The supply side of the equation is addressed in **Chapter 4 – The World's Nuclear Fuel Fabricators**. This chapter includes in-depth profiles of each of the world's LWR fuel suppliers, their production facilities, their products, the markets they serve, and additional items of interest.

[1] Access to the FMO subscriber website is at: https://www.uxc.com/c/MktRptEssays.aspx?rpt=fmo

Chapter 5 – Supply and Demand Analysis combines all the preceding discussions with a comparison of supply and demand for LWR fuel through 2040 on a global level as well as in each of the principal geographic market segments.

Since the market for fabricated LWR fuel is segmented both geographically and technically, each of these individual market segments is discussed and analyzed in **Chapter 6 – Global and Regional Market Analysis**.

Chapter 7 – Nuclear Fuel Fabrication Prices discusses the factors affecting current and future LWR fuel prices and presents UxC's latest projections for both PWR and BWR fuel fabrication prices in different regional markets through 2040.

Finally, in **Chapter 8 – Non-LWR Fuel Fabrication Markets**, we present a discussion of the unique fuel fabrication markets for PHWRs, GCRs, and LGRs. Fuel developments for SMRs and advanced reactors are also addressed at the end of this chapter.

The report also contains a series of appendices and a glossary, which provide background information and other useful items on the fabrication market. The following are found at the end of this report:

Appendix A – UxC 2023 Fuel Fabrication Market Survey Sample

Appendix B – Fuel Fabricator Contact Information

Glossary