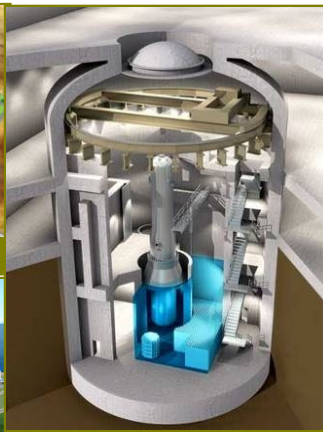
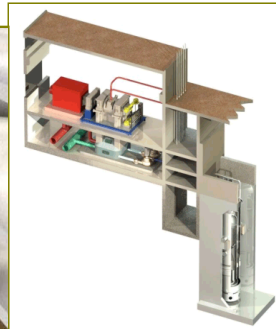




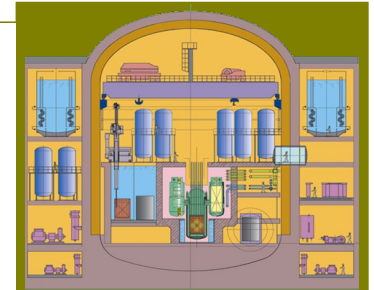
SMART



mPower



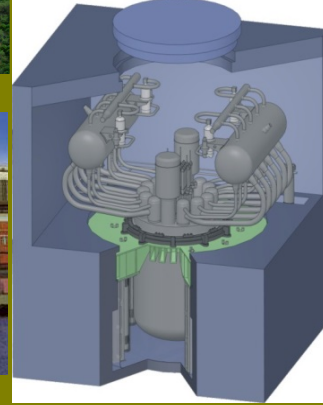
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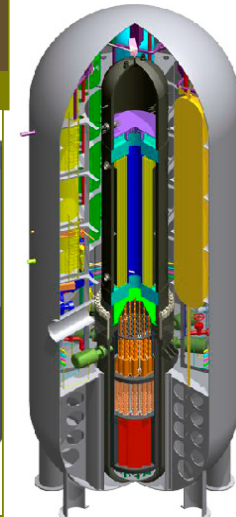
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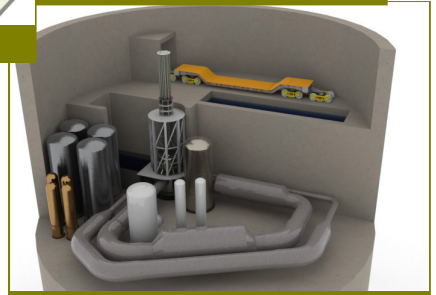
HTR-PM



SVBR-100



W-SMR



SMR-160



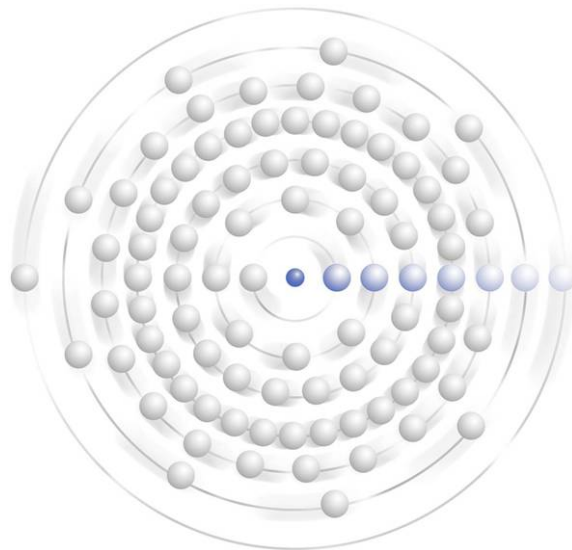
KLT-40S



CAREM



## SMR Market Outlook



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## Introduction & Overview

Small Modular Reactors or SMRs, producing between 10 MWe and 300 MWe, are not a new idea. The first ever nuclear reactors built to produce electricity were of the “small” variety. Even while the majority of the nuclear industry turned towards larger and larger reactor designs, there have always been some strong believers in the smaller designs as well. However, in the past several years, SMRs have gained tremendous attention and renewed energy in the nuclear power world, and this sector has emerged as an important new element of global nuclear expansion. Despite dimmer prospects for a nuclear renaissance in the post-Fukushima era, SMRs continue to find significant interest from all sorts of potential customers looking for new options to produce clean and reliable energy.

For some companies, the SMR offers a brand new opportunity to engage with nuclear power, whereas others see the SMR as a response to the challenges that plague larger reactor designs. Of course, the reactor market is not a “zero-sum game,” and there is room in this world for both large and small reactors. SMRs may in fact provide unique benefits that no other reactor concept can offer. Still, the SMR sector is much less developed than the traditional large reactor market.

Although few actual projects for small reactor deployment exist today, many SMR designs are being proposed by both established as well as new, startup nuclear power companies. There are many reasons for this revival of the small reactor concept, especially of the factory-assembled, modular variety; however, there are also a number of unique hurdles for SMRs. The development of a new, emerging SMR industry brings up a number of questions, including:

- What are the primary drivers pushing SMRs forward?
- What are the challenges to SMR development, and how can these be overcome?
- Which companies and designs present the most promising options within the SMR market, and why?
- Who will build these SMRs, and where and when?
- What is the potential size of the SMR market?
- Is the SMR concept viable in the long-term?

UxC’s *Small Modular Reactor Market Outlook* (SMO) report responds to these numerous questions while providing an all-inclusive SMR guide for any interested party. Ultimately, this report’s objective is to offer technical, economic, and other commercial assessments of each of the SMR designs being developed in the world today. In addition, the report provides an in-depth discussion of the broader issues impacting SMRs, such as the keys to successful deployment for SMRs, comparisons with larger



reactor technologies, specific applications for SMRs, and the broader issues facing potential customers for SMRs.

Based on UxC's extensive research and analysis from many years of work in this field, the SMO is meant as an independent, unbiased assessment of all the likely SMR technologies as well as to provide unique perspectives on the overall small reactor sector. Given the breadth of content in this report, we are confident that this study can be used by any client to conduct analysis tailored to their specific needs. In addition, UxC's experts are available for additional consulting support on SMRs or related topics on request.

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## Target Audience

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The SMR market is still evolving. To our knowledge, no independent comparative analyses of the competing designs and of the broader outlook of this sector exist, and this report aims to fill this information gap. Potential uses for this study include:

- SMR vendors can gain additional insights on the outlook of this new marketplace at the international level and compare their strengths and weaknesses with those of direct competitors.
- Nations considering a small reactor-based nuclear power program can use this report to evaluate the global offering of SMRs and to better understand the unique issues presented by SMR development.
- Electric power utilities looking to build or expand nuclear capacity may use this report when considering whether the option to go with an SMR is the better fit. For those utilities that have already taken a decision in such direction, this report offers unique elements to understand which reactor design can better fit their needs.
- For those in the financial community considering investing in nuclear power, this report presents crucial perspectives on the overall prospects for SMRs as well as insights on which companies may fare better in the SMR race.
- Manufacturing and supply chain companies interested in expanding their customer base through SMR projects can gain new insights.
- Nuclear fuel suppliers eager for a new customer base from SMRs will be better informed.
- Government agencies, regulatory bodies, trade associations, and research organizations can become more educated on SMRs.

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## UxC Credentials on SMRs

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UxC has been actively tracking worldwide SMR developments for several years. In December 2010, UxC published its *Small Modular Reactor Assessments* (SMRA) report, a groundbreaking, 500+ page, in-depth assessment of SMR technologies. As part of this effort, UxC's team of reactor market analysts worked with international reactor technology and design consultants to analyze the state of SMRs at the time. Since the publication of the SMRA, UxC has continuously dedicated additional resources, time, and energy into the study of this market while relying on a broad network of experts in all of the disciplines required for these types of full spectrum reactor assessments. Over the last two years, we have developed further in-depth analyses on selected topics for these designs and acquired additional experience by maintaining contact with most of the leading players in the SMR markets, including attendance at nearly all relevant conferences and events as well as providing specific client-based support relevant to SMR analysis. Accordingly, we have continuously increased our knowledge and understanding of this rapidly changing marketplace. The 2013 SMO report is a result of this continuous learning process.

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## Qualifying Statements

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At the outset, it is important to highlight the limitations inherent in this type of study and the approaches used by UxC to handle them. First, as indicated above, the primary purpose of this report is to provide new and unique perspectives on the SMR market. This is first and foremost an analytical report, as opposed to some of the broader public reports on this same topic. As such, this report is not meant to duplicate the expansive work done by organizations like the IAEA, DOE, NRC, ANS, and others, who fill important roles in promoting or describing SMR technologies.

Secondly, UxC made a decision when beginning this project to base the analysis in this report mostly on public data, as opposed to requesting information from the various vendors of SMR designs. The primary reason for this has been to allow UxC to remain independent, unbiased, and fair, since opening the door to direct input by the SMR vendors unavoidably would lead to variations in the depth of coverage of designs due to the different amount and type of information that would be made available by each company/organization. Some SMR designers may choose to be very forthcoming with us, while others may decide to not interact at all. To avoid this discrepancy, we decided to go with public information, which for most designs is still extremely rich in content and technical depth – especially through such documents as filings with the U.S. Nuclear Regulatory Commission (NRC).

As described, the intent of this SMO report is to provide thorough and critical analysis. In doing so, the purpose is not to diminish any company or organization's efforts in deploying SMRs, but rather to highlight areas that may need further work or analysis. Still, given UxC's position as an independent consultancy, we see no reason to "pull our punches" or not point out clear discrepancies or issues with specific SMR designs when we see them.

Finally, we acknowledge at the outset that certain answers to questions on SMRs may not be covered in this report. In some instances, information or analysis has been withheld purposefully to allow for an even level of coverage of the different SMR designs. In addition, given the newness of the market and the fact that it is continuously evolving, many questions remain unanswered, and even with our extensive efforts in researching and ferreting out information on different SMRs, there are still a number of open items. However, a major purpose of this report is to provide a frame of reference by which information that becomes subsequently available can be evaluated and incorporated into a broader understanding of the current and future SMR market.

Accordingly, it is UxC's intent to publish the SMO annually in order to update our clients of the most recent developments and provide them with additional analyses and discussions pertaining to the latest status of the international SMR marketplace.

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## Structure of Report

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In addition to this **Introduction & Overview**, individual chapters are presented in three main parts of the report as described below.

### Part 1: SMR Market Overview

Part I includes Chapters 1 to 5 and sets the stage for the analyses presented later in the report. It provides an overview and introduction to the overall SMR market as well as a general description of the characteristics of this technology associated with its potential deployment. UxC's views on the business case and economics of SMRs and ideas to facilitate their deployment are also presented. Specific chapters in Part I are as follows:

**Chapter 1 – SMR Background** provides an historical context for SMRs and the main characteristics and advantages of this technology. Moreover, the reasons for the recent resurgence of interest in SMRs are identified.

**Chapter 2 – Global Nuclear Power after Fukushima** provides UxC's view of the current and potential outlook for nuclear power worldwide based on our latest *Nuclear Power Outlook* (NPO) forecasts. Additionally, post-Fukushima commercial and technical considerations as they relate to SMRs are also discussed.

**Chapter 3 – Challenges for SMR Deployment** reviews the main obstacles for the deployment of SMRs. Accordingly, technical, commercial, regulatory, and operational hurdles as well as other issues are discussed.

**Chapter 4 – SMR Business Case** analyzes the economic case for SMRs and compares the potential costs of these technologies with larger nuclear power plants. Moreover, we identify the keys for SMR commercialization as well as a number of business models that might be adopted to facilitate SMR deployment.

**Chapter 5 – SMR Country Profiles** provides individual profiles of the SMR industries in major countries (i.e., U.S., Russia, South Korea, China, Japan, Argentina, India, France, and South Africa).

## Part 2: SMR Design Evaluations

Part II, which encompasses Chapters 6 to 8, focuses on profiling all SMR designs around the world and provides an in-depth analysis of what we have selected to be the ten leading SMR designs. A less detailed profile for the remaining SMR designs is also provided. Specific chapters in Part II are as follows:

**Chapter 6 – Overview of SMR Technologies** introduces the different kinds of SMR technologies being developed around the world, with generalized explanations of the three primary reactor classifications: pressurized water reactors (PWRs), high temperature reactors (HTRs), and liquid metal reactors (LMRs).

**Chapter 7 – Detailed Analysis of Leading SMR Designs** then goes into a detailed analysis of the world’s ten leading SMR designs. Comprehensive commercial and technical reviews along with independent assessments of the pros and cons of each design and outlooks for deployment are provided for the following top ten SMR designs listed in Table 1.

Table 1. Current Ten Leading Global SMR Designs				
Design	Company	Country	Type	MWe (net)
mPower	Babcock & Wilcox	U.S.	PWR	180
W-SMR	Westinghouse	U.S.	PWR	225
NuScale	NuScale Power Inc.	U.S.	PWR	45
SMR-160	Holtec International	U.S.	PWR	160
SMART	KAERI	South Korea	PWR	100
CAREM	CNEA	Argentina	PWR	27
VBER-300	OKBM Afrikantov	Russia	PWR	295
KLT-40S	OKBM Afrikantov	Russia	PWR	35
SVBR-100	AKME Engineering	Russia	LMR	101
HTR-PM	Tsinghua INET & HSSNPC	China	HTR	200

Since there are more than just ten SMR designs being considered internationally, **Chapter 8 – Additional SMR Designs** includes descriptions and basic analysis of the remaining SMRs developed worldwide. The reader is also invited to refer to UxC’s SMR Research Center<sup>1</sup> for additional information and useful material.

<sup>1</sup> See <http://www.uxc.com/smr/>

### Part 3: Outlook for Deployment, Competitive Analysis, and Forecasts

Part III, which includes Chapters 9 to 12, offers the broader analysis of the future outlook for the SMR market. Here, we focus on next steps for SMR deployment and offer UxC's views on potential customers for SMRs, the competitive position of SMR vendors, and our own SMR deployment forecasts through 2040. Specific chapters in Part III are as follows:

**Chapter 9 – Global Outlook for SMR Deployment** identifies potential SMR customers and their rationales behind the deployment of this technology. A list of potential SMR projects around the world is also provided. Finally, this chapter includes a detailed discussion on what it takes to deploy SMRs in new nuclear countries.

**Chapter 10 – Competitive Analysis of the SMR Market** discusses the competitive position of SMR vendors in the U.S. and at the international level by looking at what the SMR vendors have to offer and how these compare with potential SMR client selection criteria.

**Chapter 11 – UxC SMR Forecast** presents UxC's overall forecast for the deployment of SMRs around the world through 2040. This includes specific forecasts for the ten leading SMR designs as well as three scenarios for the global SMR forecast. We end this chapter with a look at what the potential market size on a U.S. dollar basis may be for the SMR market through 2040.

**Chapter 12 – Summary and Conclusions** provides our final thoughts and considerations on this extensive analysis of the global SMR market.

In addition to the main chapters, a number of useful items to support the analyses conducted throughout this report and allow for comparative analysis of the ten leading SMR designs are found in the accompanying **Appendices** as follows:

- **Appendix A – Comparative Data for Ten Leading SMR Designs**
- **Appendix B – Pros & Cons Comparisons for Ten Leading SMRs**

Finally, in order to help the reader decipher the large number of technical, regulatory, and nuclear industry terms used in this report, a **Glossary** is provided.