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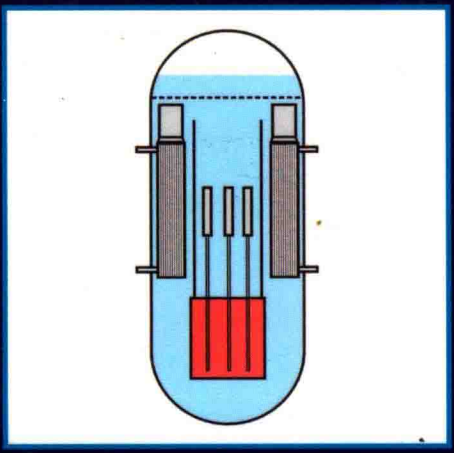

Handbook of Small Modular Nuclear Reactors

Edited by Mario D. Carelli and Daniel T. Ingersoll

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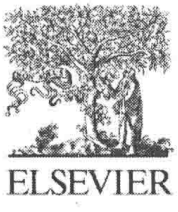

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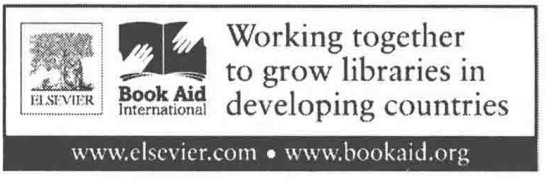

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Preface

For the reader interested in small modular reactors (SMR), this Handbook provides a thorough and authoritative introduction to today's hottest new development in nuclear plant design and deployment. Building on the success of the large nuclear plants, SMRs offer the potential to expand the use of clean, reliable nuclear energy to a broad range of customers and energy applications.

The early commercial nuclear power reactors designed and built from the 1950s to the mid-1970s were low-power plants (up to a few hundred megawatts) and were built to demonstrate the commercial viability of nuclear energy. These plants were comparable to their fossil-fuelled counterparts, both in output and construction time (a few years). They were moderately successful; however, their unit capital costs ($/kW) were substantially higher than for comparable fossil plants. As the nuclear plant cost (numerator) kept increasing to improve performance and safety, it became necessary to also increase the output power (denominator); thus the plant size increased rapidly from a few hundreds of megawatts to nearly 2000 MWe today. Such a drastic increase had several effects: only a few manufacturers, either large conglomerates or state-owned enterprises, remained in operation worldwide; plant costs became stratospheric, creeping into tens of billions of dollars; and the time from contract signing to initiating power production exceeded a decade.

Thus, looking to the past for help in finding the answers to a troubled present, the SMRs have become the nuclear power version of *Back to the Future*. Started in the 1990s, new SMR designs emerged worldwide and have gained increasing momentum in the new millennium. The new small plants have several traits in common with earlier designs, such as: size (from tens to a few hundreds of megawatts), relative simplicity, and a reasonably short construction time. Also, SMRs can cover a wide range of applications and deployment times. Those proposed for power producing applications in the short term are designs of the light water reactor (LWR) type, while SMRs best suited for other applications such as fuel breeding and waste burning employ different coolants and are deployable over the long term.

The developers of SMRs, even the near-term LWRs, are for the most part quite different from the large LWR manufacturers. They include smaller sized manufacturers as well as new enterprises. For example, the two leading SMR vendors in the United States are currently Generation mPower, a subsidiary of Babcock and Wilcox, which is an established reactor manufacturer but no longer active in the large LWRs market, and NuScale Power, an entirely new enterprise. Both of these vendors were recently selected by the US Department of Energy to receive major federal funding to facilitate licensing of their SMR designs. Holtec International, which is an established company but novel to the reactor design arena, is also working to bring its SMR product to the market.

This Handbook is composed of 20 chapters structured into four parts, each chapter being authored by a known expert in the field.

- Part One (Fundamentals of small modular nuclear reactors) provides a comprehensive introduction to SMR technologies, existing commercial designs, and fundamental design strategies. The three authors contributing to this section have been eminent proponents of SMRs since the 1990s and have led the development of integral pressurized water reactor (iPWR) designs, which is the prevailing design strategy for SMRs and the focus of this Handbook. Part One is articulated over three chapters: 1. Small modular reactors (SMRs) for producing nuclear energy: an introduction 2. Small modular reactors (SMRs) for producing nuclear energy: international developments and 3. Integral pressurized water reactors (iPWRs) for producing nuclear energy: a new paradigm.
- Part Two (Small modular nuclear reactor technologies) reviews the key technologies which are fundamental to the iPWR design, focusing on what is new and different, while also providing insight on potential opportunities and challenges. Six chapters individually address the following technologies: reactor core and fuel; key reactor system components; monitoring and control; instrumentation and control technologies for small modular reactors; human–system interfaces; safety; and proliferation resistance and physical protection. The six authors of this part are internationally recognized authorities in their field and are not associated with any of the current iPWR designs.
- Part Three (Implementation and applications) addresses four key areas critical to successful deployment of SMRs: economics and financing; licensing and manufacturing methods; hybrid energy systems using SMRs. As was the case in Part Two, the four authors of Part Three are recognized authorities in their field.
- Part Four (International R&D and deployment) provides an overview of the worldwide deployment of SMRs. The first six chapters focus on countries that are most active in the development and deployment of SMRs: the United States, the Republic of Korea, Argentina, the Russian Federation, China, and Japan. The authors are directly involved in their country's activities. Finally, the last chapter addresses how SMR development and deployment can represent a key contribution to the growth of developing countries. It is a reminder that SMRs promise to be not only a better, more economic machine, but also promote improved living conditions and quality of life.

It is hoped that this Handbook will be useful to those with a general interest in SMRs, as well as to those looking for more specific information. It is further hoped that this Handbook will serve as a guide, through its copious references, to further learning.

Mario D. Carelli and Daniel T. Ingersoll

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