Preface

This book was assembled by the interdisciplinary team that organized the 2011 Advanced Summer School of Nuclear Engineering and Management with Social-Scientific Literacy held in August 2011 at the University of California, Berkeley. This was about 5 months after the Fukushima Daiichi Nuclear Power Station accident in Japan. Our team initially intended to publish a book consisting of the lectures and discussions that took place in that setting, and some chapters were submitted to the editors soon after the summer school. At that time, however, things were still evolving rapidly, and many pieces of the jigsaw puzzle were missing. We even did not know what the entire picture of the jigsaw puzzle would look like. Soon, we, the editors, realized that publishing a book by the first anniversary of the accident in March 2012 was totally unrealistic. We all were so busy in catching up with rapidly evolving situations in the aftermath of the accident.

These situations are still evolving swiftly as of March 2014, and in that regard, it became clear that time would never ripen fully for publishing a book about the accident itself. All the editors agreed, however, that now would be the best timing to compile a book focused on nuclear engineering education in the post-Fukushima era coming out of reflections on the Fukushima Daiichi accident.

The accident caused great damage and hardship in varied ways to multiple sets of stakeholders across society, including more than 100,000 citizens who are still evacuated from their homes as of March 2014. However, many of the societal damages had not been anticipated or well understood before the accident. While enormous financial and human resources have been devoted to preparedness and mitigation, their impact and effectiveness are not clear.

Historically, the level of safety that a nuclear system can achieve has been measured by the expected number of deaths from radiation. In the concept of defense-in-depth developed by International Atomic Energy Agency (IAEA), Levels 1–4 are about defense through design, construction, and operation of an engineered system to minimize the magnitude and frequency of radioactive release in a severe accident, and the fifth level defense is achieved by mitigation of radiological consequences of significant external releases of radioactive materials. Actually, because of the fact that no one died due to radiation, it is often said (mostly by nuclear engineers) that the Fukushima Daiichi accident is a good demonstration of the effectiveness of the defense-in-depth concept. While it is true that there were no deaths due to radiation from the accident, more than one thousand people died during the evacuation and while living in temporary housing as a result of various causes that were triggered by the evacuation. In addition to these deaths, thousands of families, local communities, and industries were damaged or completely destroyed. On a national scale, Japan is experiencing difficult and complicated situations in international relations and economics. On a global scale, carbon dioxide emission to the atmosphere increased significantly. These consequences should have been properly analyzed, discussed in public, and prepared for prior to the accident, but there had been serious oversight and misunderstanding about what harms must be protected against in such a severe accident. This insufficient preparedness has been compounded by the lack of an effective decision-making process with participation from a broad range of stakeholders, resulting in intolerable delays in societal recovery after the accident. Numerous cases can be found in which decisions led to greater injury due to lack of timely decision-making informed by solid scientific evaluation of various risks, including those of low-dose radiation.

The bitter reality is that severe nuclear accidents will occur in the future, no matter how advanced nuclear technologies become; we just do not know when, where, and how they will occur. Of course, we should continue our efforts to improve technologies toward minimizing the frequency and consequences of accidents as discussed in detail in Chap. 12, but, in addition, we should develop effective aftermath management for enabling swift recovery. Scientific and academic communities should start efforts for establishing the scientific bases, both natural and social, for better societal resilience. Naturally, as a part of such efforts, the education of nuclear engineering professionals at the college and graduate levels must be reinvented.

In fact, to some extent, the team responsible for the present book had shared this recognition in advance of the accident, and efforts had been started before 2011, as Chaps. 1 and 21 describe in detail. For the 4 years (2007–2010) prior to the accident, the Department of Nuclear Engineering and Management at the University of Tokyo and the Department of Nuclear Engineering at the University of California, Berkeley had already started a collaboration called GoNERI for developing advanced educational programs for nuclear engineering. The collaboration was funded by the Global Center-of-Excellence (G-COE) program of the Japan Society for the Promotion of Sciences (JSPS). GoNERI was motivated by the particular relevance and importance of social-scientific approaches to various crucial aspects of nuclear technology, such as the nuclear fuel cycle, radioactive waste disposal, implementation in rising countries, etc. Therefore, special emphasis was placed on integrating nuclear science and engineering with social science. However, at the same time, it was also recognized that we did not yet have sufficient command of the fundamentals of the social sciences (such as their domain, concepts, terminology, methodology, etc.), which limits nuclear engineers in collaborating with social scientists, and that the new generation of nuclear engineers must understand societal aspects of nuclear technologies sufficiently to serve the public good. This understanding was encapsulated in the formulation within GoNERI of PAGES, the Program for Advanced Graduate Education System for Nuclear Science and Engineering with Social Scientific Literacy. Prior to the accident, various efforts had been made in this direction, including a series of biweekly seminars and field trips to Waste Isolation Pilot Plant (WIPP) at Carlsbad, New Mexico, and Toyo-Cho and Rokkasho-Mura, Japan. The collaborating partners conducted the 2009 Advanced Summer School of Radioactive Waste Disposal with Social Scientific Literacy at Berkeley and the 2010 Advanced Summer School of Nuclear Engineering and Management with Social-Scientific Literacy at Honolulu, in collaboration with Tokai University, Japan.

In response to the occurrence of the Fukushima Daiichi nuclear power station accident on March 11, 2011, we decided that the 2011 summer school should focus on reflections on the accident. This accident raised many fundamental and controversial questions about the traditional approach of nuclear engineering and its utilization in society, as described above. The 2011 summer school provided an arena for the discussions to find and create a renewed platform to renovate engineering practices, and thus nuclear engineering education, which are required in the post-Fukushima era nuclear scene. We offer this book to document and share our approaches, with the goal of spurring wider discussions and changes.

This book includes most of the lectures given in the 2011 summer school as well as additional chapters to fill in gaps that could not be filled 3 years ago. Chapters written right after the 2011 summer school were once returned to the authors in order to supplement their accounts with any developments over the past 3 years. Chapter 1 is the introductory chapter, which provides the perspectives and aims that were set in GoNERI activities and the 2011 summer school. The following chapters are grouped into five parts.

Part I is about "what happened." Chapter 2 provides information for the reader to understand what happened in the damaged reactors. Chapters 3 and 4 focus on consequences of the accident observed in the area exterior to the Fukushima Daiichi site, including environmental contamination and remediation. Chapter 5 discusses impacts of the accident on national economy, particularly energy demand and supply in Japan. Chapter 6 gives a brief summary of the deadlocked situation after the accident for conventional nuclear fuel cycle policy, while in Chap. 7, observations are given from a European viewpoint.

Part II is about "why this accident occurred." Observations and discussions are made from regulatory systems by focusing on the defense-in-depth concept (Chap. 8), ethical and cultural factors (Chap. 9), and social and organizational systems (Chap. 10). Chapter 11 provides the historical perspective by comparing the Three Mile Island and Fukushima Daiichi accidents.

Part III gives collective bases necessary for considering a better "system." Here, the "system" includes different aspects. Chapter 12 discusses potential improvements for engineering, operation, and maintenance of nuclear reactors. Chapter 13 summarizes the state of the art for the effects of low-dose radiation on human bodies, which the aftermath of the Fukushima Daiichi accident once again has indicated to be crucial for restoring damaged communities. Improvements should be made in the regulatory systems, the subject of Chap. 14. Because the accident generated new categories of radioactive wastes, we need to improve waste management schemes, and the accident also let us notice that the traditional approach for radioactive waste management needs to be rethought, as discussed in Chap. 15. Chapter 16 is a speech given at the dinner at the 2011 summer school by the then vice chair of the Atomic Energy Commission of Japan.

Part IV is a collective view of students and mentors who participated in the 2011 summer school. The student group included students from nuclear engineering as well as from social science, from the US, Japan, and other Asian countries. Each student chose a question of interest from those suggested by the lecturers and wrote his/her essay in response. Their essays are collected in Chap. 17. Part IV also includes Chaps. 18–20 made by three younger scientists who mentored students' discussions. They played the important role of catalyst between the professors and the students. If we raise one most important key factor for the success of this summer school, it is excellence of the mentors.

Chapters in Part V offer thoughts and recommendations for new nuclear engineering education. Chapter 21 was contributed by a historian as a reflection on the challenges of implementing social-scientific literacy for nuclear engineers. The following two chapters discuss importance of social-scientific literacy to implement diversity and independence in nuclear engineering from viewpoints of sociology (Chap. 22) and communication with the public (Chap. 23). Bridging those observations made by the preceding three chapters, Chap. 24 focuses on the overall concept of resilience engineering as a new horizon of systems safety.

Regardless of whether a country is launching a new nuclear program, maintaining its current fleet of nuclear reactors, or heading toward phase-out, we need nuclear engineers who are technically competent and trusted in society, for which suitable education must be provided. We hope that this book will provide useful materials for conducting constructive discussions and development of future generations.

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http://www.springer.com/978-3-319-12089-8

Reflections on the Fukushima Daiichi Nuclear Accident
Toward Social-Scientific Literacy and Engineering Resilience

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2015, XV, 454 p. 95 illus., 77 illus. in color., Hardcover
ISBN: 978-3-319-12089-8