1 The ethics of nuclear energy: an introduction

Behnam Taebi and Sabine Roeser

1.1 Introduction

On March 11, 2011, a large earthquake struck off the coast of the Fukushima prefecture in Japan. Less than an hour later, a massive tsunami wave rumbled off Japan's northwestern coast and damaged, among other things, the nuclear energy reactors in Fukushima Daiichi. While the damage to the reactors by the earthquake was relatively small and could, in principle, be managed, the ensuing tsunami exacerbated the damage substantially by deactivating all emergency cooling systems. The lack of cooling led to several meltdowns, both in the reactor cores and in the drained spent fuel pools, which again led to several explosions and release of radiotoxic material into the surrounding environment. Three and half years later, it is still unclear how long the decommissioning of the reactors and the complete cleanup of the region will take, but it will in any case take several decades (ANS 2012). The catastrophic events in Fukushima Daiichi have brought back an old stalemate concerning the desirability of nuclear energy to the forefront of controversy. While Japan is trying to avert further disaster, many nations are reconsidering the future of nuclear energy. Germany was among the countries that quickly responded to this event; the Merkel administration decided to shut down half of the older energy reactors immediately and not to extend the lifetime of the other half beyond 2022. In addition, a number of countries such as Switzerland and Italy voted against expansion of nuclear energy in referenda. Not surprisingly, the biggest influence was visible in Japan, where the entire nuclear fleet (fifty-four reactors) was eventually shut down. This made many believe that nuclear energy is dying a slow death.

The appearances are, however, deceptive. In addition to the six damaged reactors in Fukushima Daiichi, worldwide only eight other reactors have been *permanently* shut down as a result of the Fukushima Daiichi accident, and those are in Germany. The remaining forty-eight undamaged Japanese reactors are shut down *temporarily*; their future is still uncertain. It is commonly expected that Japan will reopen at least some of those reactors (e.g. Orcutt 2014; Tabuchi 2014). Japan's nuclear safety watchdog, the Nuclear Regulation Authority

(NRA), has already approved the first two reactors to go back online (Hamada and Tsukimori 2014). It seems that the NRA only pushes to shut down reactors older than 40 years; this could mean that only another handful of Japanese reactors will be permanently shut down.[1]

More importantly, projections of nuclear energy before and after the Fukushima Daiichi accidents have not changed at all. At the time that this book goes to press, 72 reactors are under construction worldwide, 174 are on order or planned, and another 299 reactors are proposed.[2] If these projections are realized, the currently operable 387 reactors in the world[3] will be joined by another 545. This represents a slight increase compared to the 540 future nuclear reactors forecast just before the Fukushima accident.[4] It is at least equally important that the number of countries with nuclear energy ambitions is vastly growing. Thirty countries currently produce nuclear energy, with the last entrant being Iran. Forty-five countries seem now to be interested in embarking on nuclear energy programs in the next decades.[5]

Hence, contrary to what one might have expected, Fukushima did not herald the end of the nuclear era. Nuclear energy is likely to play a role in the world's future supply of electricity. These observations and developments give rise to a pressing ethical question that society needs to face, namely, whether or under which circumstances nuclear energy is a desirable form of energy. It is now time to revive the field of nuclear ethics which has been dormant for some time. The challenge that this book takes up is to contribute to the academic and ultimately public debate on nuclear energy. The volume

[1] According to the International Atomic Energy Agency databases, Japan has only seven reactors that were built in 1975 or before. See www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=JP (accessed September 22, 2014). It is also important to mention that some other reactors that are on "active" earthquake faults and reactors that for other reasons are unable to meet the safety standards will probably shut down too (Kyodo 2014).

[2] These figures are according to the public information of the World Nuclear Association website, which keeps track of the operational nuclear energy reactors all around the world. See www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements/ (updated August 1, 2014; accessed September 17, 2014)

[3] The figure that WNA shows on its website is 435; see the last footnote. While WNA calls this "currently operable reactors" a closer look shows that the forty-eight Japanese reactors that are temporarily shut down are listed there too. WNA lists those reactors because they are still connected to the electricity grid, but they are not generating electricity. A more accurate figure of *currently operable reactors* would therefore be 435 minus the 48 Japanese reactors, which results in the 387 reactors, as mentioned in the text.

[4] On February 1, 2011, and just before the Fukushima accidents, there were 443 reactors operational, 62 under construction, 156 on order or planned, while another 322 proposed. See the WNA website: www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-Archive/Reactor-Archive-February-2011/ (updated February 1, 2011; accessed September 17, 2014)

[5] See the WNA website: www.world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/ (updated September 2014; accessed September 17, 2014). It is worth mentioning that the WNA are lobbyists for the world nuclear industry, which means that their opinion might be biased. Yet, there seems to be a serious interest in some new countries to start a nuclear energy programs.

addresses a wide range of ethical issues related to nuclear energy production and nuclear waste disposal. In this introduction, we first sketch a history of the field of nuclear ethics. We then provide an overview of the chapters and how they are interconnected. We conclude with some general observations and recommendations.

1.2 Nuclear ethics: a field in evolution

At the outset of this volume, Sven Ove Hansson poses the question of whether there is something to be called "the ethics of nuclear energy." It is fair to say that this field does not yet exist; as yet there is no established and well-developed field of research focusing on the full spectrum of ethical issues that nuclear energy engenders. Furthermore, the question arises as to whether we need to develop yet another field of applied ethics – or area-specific ethics as Hansson prefers to call it – that focuses solely on ethical questions of nuclear energy. Yet, we believe that this special attention to nuclear energy is more than justified. There are at least three reasons for this.

Firstly, the magnitude and the nature of harm that can occur after a possible accident with a nuclear facility are different from other technology. The catastrophic events of major accidents in the past – most notably the Chernobyl accident – bear witness to this fact. Secondly, the longevity of nuclear waste poses questions with regard to future generations. One might argue that climate change poses similar questions. This is, however, only partly true. Nuclear waste with radiotoxicity of 200,000–1,000,000 years brings new and sometimes unprecedented intricacies to the table; our species (*Homo sapiens*) is *only* 200,000 years old. Thirdly, within nuclear technology there are specific technologies – also referred to as "dual use" technologies – that are needed for the civil production of nuclear energy, while they can also be used for the purpose of nuclear weapons production. This, again, is a unique aspect of nuclear energy as compared to other energy producing technologies that do not often have such evident and potentially high impact "dual use" aspects. Furthermore, and on a related note, nuclear weapons have a unique status as compared to other kinds of weapons technology, given their major potential for destruction. Considering the nature and the magnitude of nuclear risks, a broad focus on the ethics of nuclear energy is urgently needed.

In previous decades, nuclear security and proliferation[6] risks have received serious attention in the social-scientific and philosophy literatures. To the

[6] In nuclear technology studies, one distinguishes between nuclear safety and nuclear security. Safety usually refers to unintentional harm or harm as a result of a nuclear accident, while security refers to intentional harm. The latter refers to both risks of theft of nuclear material for the purpose of nuclear sabotage or manufacturing a so-called nuclear dirty bomb and any other way to expose a large number of people to harmful radiation. Proliferation means both the

extent that there has been any attention to *the ethics of nuclear energy* in the past, the main focus has been on discussions of nuclear security and arms control. The literature about "nuclear ethics" emerged in the 1950s and 1960s in light of the nuclear arms race. A collection edited by Allers and O'Brien (1961), for instance, explicitly questioned the moral legitimacy of nuclear warfare. Their collection took the position of "Christian ethics," which was "an attempt to bring together some eminent thinkers from the Christian faith to discuss . . . the moral problems of nuclear war" (Allers and O'Brien 1961: iii). A number of other collections focused on the development, possession, and use of nuclear arms, usually from the perspective of religious studies (e.g. Ford and Winters 1977; Goodwin 1982; English 1985; Walters 1989; Whitmore 1989). In the literature on ethics and international security, there has been a particular focus on nuclear deterrence, which is perhaps one of the most dominating features in international relations in the post-World War II era (e.g. Goodwin 1982; Nye 1986; Ardagh 1990; Barkenbus 1992). The main idea is rather counterintuitive, namely that it is by virtue of the destructive power of nuclear weapons that nuclear weapon possessing countries never attacked each other. The climax of nuclear deterrence was the confrontation between the Soviet Union and the United States in October 1962 concerning the Soviet Union's ballistic nuclear missiles in Cuba. It was – as the argument goes – the mutually assured destruction by the enormous power of both parties that prevented them from attacking one another.[7]

Despite powerful international agreements such as the Non-Proliferation Treaty (NPT), at least four new proliferators have been added to the list of nuclear weapons possessing countries, namely, India, Pakistan, Israel, and North Korea.[8] Moreover, a number of countries have openly or clandestinely pursued nuclear ambitions, either through a program dedicated to the development of nuclear weapons or as a civil program that opens the door toward a military program. As previously stated, there are a number of *dual use* nuclear technologies that are particularly troublesome. The controversies surrounding the Iranian nuclear programs vividly illustrate the complexities of this dual use of nuclear technology. While Iran keeps emphasizing its

dispersal of the knowledge that could lead to manufacturing of nuclear weapons and the dispersal of those weapons themselves.

[7] This is of course a very short summary of an extensive line of literature, which includes, among other things, debates on the moral legitimacy of deterrence, just war theory, as well as just defense doctrine in the nuclear age. Furthermore, there are discussions whether small yield weapons that kill fewer people might lower the threshold to nuclear war, as well as discussions on the moral imperatives of moving toward complete nuclear disarmament (e.g. Walzer 1977; Nye 1986; Hashmi and Lee 2004).

[8] It should be noted that the first three never signed the NPT, while Israel had nuclear weapons before the NPT was even completed. When the NPT was signed and ratified it was projected that there would be a far larger number of nuclear weapon states by now; however, there has actually been no net increase in the number of nuclear weapon states for a quarter century (North Korea joined the group and South Africa left it).

inalienable right to nuclear technology for civil purposes (NPT, Article 4), many countries dispute whether Iran should also develop dual use nuclear technologies. The case of Iran could gain relevance in the next couple of years because it establishes a precedent for the new countries that are planning to join the nuclear energy producing countries in the coming decades.

Of further importance is the Obama Administration's decision to revitalize its nuclear weapon program,[9] despite Obama's efforts during his first term of presidency to make nuclear disarmament a main goal of American defense policy and to substantially reduce nuclear weapons worldwide (Broad and Sanger 2014). These developments make nuclear proliferation and arms control especially relevant for academic and public inquiries. This is indeed the focus of various studies in international relations and more specifically international security. Indeed, there is an area of overlap between international relations and philosophy. This volume includes a chapter by Thomas Doyle entitled "Global nuclear energy and international security" (Chapter 11), which addresses a number of pressing moral questions, such as the legitimacy of the pressure exerted by the United States and Europe (as nuclear weapon possessing countries) on countries like Iran to abandon their dual use technologies such as uranium enrichment facilities.

However, the bulk of this volume focuses on questions of nuclear safety and risk as well as on the more fundamental issues of justice and democracy. As previously stated, most literature reflecting on the ethical and societal aspects of nuclear technology in the past decades was concerned with the military use of this technology. Some research has, however, been done to focus more on ethical issues associated with nuclear energy, mostly from the perspective of whether it is morally justified to produce nuclear energy. This is a question to which Kneese (1973) unequivocally responds in the title of his essay "The Faustian Bargain." Routley and Routley (1981) argue that considering the longevity and the toxicity of nuclear waste, nuclear energy production is morally unacceptable. A number of other authors reflected on the desirability of nuclear energy and unanimously reached the conclusion that it is ethically unacceptable to produce nuclear energy because of the inability of victims to control their fate (Hollyday 1991) and the unacceptable radiation risk that arises from nuclear energy for both the public and radiation workers (Bertell 1991). Kristin Shrader-Frechette did pioneering work in the 1990s. In addition to editing the first collection that addressed the ethical issues of nuclear energy (Shrader-Frechette 1991a), she wrote several influential

[9] While the recent decision of the Obama administration to revitalize nuclear weapons was portrayed as an important new development, it is, in essence, a continuation of earlier policy by both the Bush and the Obama Administration. As President Obama put it in his Prague Speech on Nuclear Weapons: "Make no mistake: As long as these weapons exist, the United States will maintain a safe, secure and effective arsenal to deter any adversary" (Obama 2009).

articles and books that addressed various ethical aspects of nuclear energy and nuclear risk (Shrader-Frechette 1980, 1991b, 1993, 1994, 2000). Among other things, she questioned the ethical acceptability of nuclear energy because of its inequitable distribution of risk (Shrader-Frechette 1991a) and for environmental justice issues associated with different steps of nuclear energy production (e.g. Wigley and Shrader-Frechette 1996). In a recent book, she argues that rather than nuclear energy, renewable energy resources are the answer to addressing the challenges posed by climate change (Shrader-Frechette 2011a). In Chapter 4 of this volume, she addresses the issues of autonomy and rights to know in the context of nuclear risk.

A number of recent works address ethical issues associated with nuclear energy production and nuclear waste disposal (Gosseries 2008; Löfquist 2008; Doyle 2010; Taebi 2011, 2012b; Roeser 2011; Taebi et al. 2012; Oughton and Hansson 2013).[10] This volume aims to make a major contribution to further establish the field of the ethics of nuclear energy by bringing together contributions on three key ethical aspects related to nuclear energy, namely, risk, justice, and democracy. The latter questions are less prominently discussed in the literature, but given their complexity and potentially far-reaching societal impact, require thorough ethical investigation. This book aims to set the scene for a comprehensive expansion of the field of nuclear ethics in light of nuclear energy's continued presence and its expected expansion.[11]

1.3 Overview of the book

The book consists of three main parts. Part I discusses normative aspects of nuclear risk. It consists of chapters that examine ethical aspects of the reliability of the available data on accidents as well as on the soundness of nuclear risk assessment methods. Furthermore, ethical issues of radiological protection principles and the influence of cultural values and gender in the acceptability of nuclear risk will be addressed. In Part II, various notions of justice will be discussed in the context of nuclear energy. This includes environmental, international, and intergenerational aspects of justice. Furthermore, the

[10] In addition, substantial work has been done by various national and international organizations in establishing ethical principles for governing the risk of nuclear energy and nuclear waste disposal. In particular, the work done by the following organizations should be acknowledged: i.e. the International Commission on Radiological Protection (ICRP 1977; 2007), the International Atomic Energy Agency (IAEA 1997; IAEA et al. 2006), the Nuclear Energy Agency (NEA-OECD 1995), the National Council for Nuclear Waste in Sweden (KASAM 1988, 2005, 2007) and the Canadian Nuclear Waste Management Organization (NWMO 2005); see also (Wilson 2000).

[11] This book is part of a bigger project at Delft University of Technology to reinvigorate the debate on sociotechnical and ethical aspects of nuclear energy production and nuclear waste disposal. Another part of this project is the publication of a special issue in the *Journal of Risk Research* (Taebi and van de Poel 2015).

question of how procedural justice relates to distributive justice will be addressed with a case study of nuclear waste management. Part III focuses on aspects of nuclear energy related to democracy. It discusses the justifiability of nuclear risks, both in general and in the specific context of developing countries and from a capability approach. Part III will also present a proposal to approach the introduction of nuclear technology as an ongoing social experiment whose acceptability should be continuously assessed.

Part I: Risk

Chapter 2 In "Nuclear energy and the ethics of radiation protection," *Sven Ove Hansson* focuses on one of the key areas in the ethics of nuclear energy, namely the ethics of radiological protection. Hansson argues that there is often a mismatch between *fundamental* ethics (which dominates traditional philosophy literature) and area-specific ethics. This is because of a lack of empirical links between the fundamental theories and the areas of application. Ethics of radiological protection is, however, a remarkable exception. Radiological risk can be measured and calculated rather precisely. This makes it similar to utilitarianism that works with numerical values for the measurement of moral values. Hansson uses radiation protection as a potential bridge-builder between fundamental and area-specific ethics.

This chapter covers some major issues in the ethics of radiological protection, while paying particular attention to its applications in the nuclear energy industry. Among other things, the chapter discusses the following topics: the relationship between collective and individual doses of radiation exposure, a topic that brings out the parallels between dose minimization (radiation protection) and maximization of the good; scrutinizing the legitimacy of the current practice, which applies much higher exposure limits on workplaces than in non-occupational settings; the ethical implication of the differences in radiation sensitivity between different subpopulations; the use of probability weighing in relation to the importance of low-probability disasters in nuclear risk assessment; the ALARA principle (as low as reasonably achievable) as a leading principle in radiological protection and its relation to cost–benefit analysis; the ethical implications of background (natural) radiation and risks to future generations. Hansson concludes with a list of recommendations to better understand and address the ethical issues of radiological protection.

Chapter 3 In his chapter "The unknowable ceilings of safety," *John Downer* discusses three ways in which nuclear accidents escape the formal calculus of risk assessments. He outlines the history of modern nuclear risk assessment, dating back to the US Nuclear Regulatory Commission's (NRC's) famous 1975

report: "WASH-1400." This report, for the first time, excluded meltdowns by deeming them too improbable to merit consideration – a practice that remains essential to nuclear regulation. Downer argues that there are three limitations to this approach. The first are "framing limitations," arising from the inability of reliability calculations to model all the variables that can potentially contribute to failures (including, for instance, human error). The second are "systemic limitations," arising from the emergent effects of complex, tightly coupled technical systems (due to their propensity to fateful coincidences). The third are "epistemic limitations," arising from the inherent uncertainty of the tests, theories, and models implicit in reliability calculations (which are always projections with minimal empirical data). He concludes that nuclear reliability calculations should be understood as "imperfect judgments" rather than as "objective facts," and that this has far-reaching implications for nuclear governance.

Chapter 4 *Kristin Shrader-Frechette* argues in her chapter "Rights to know and the Fukushima, Chernobyl, and Three Mile Island accidents" that governments and industry violate citizens' rights to be fully informed about nuclear risks. Shrader-Frechette argues that rights to know are necessary for autonomy and autonomy is necessary for human dignity. She draws on the Rossian idea that rights and duties are *prima facie* and can be overridden by other *prima facie* rights and duties. Shrader-Frechette argues that in such a case, the burden of proof is on the violator. If a *prima facie* right is not overridden, it is an *ultima facie* right. She argues that in the case of harms imposed on citizens, there is a general consensus that no explicit justification needs to be given that people have an *ultima facie* right to know about these harms (except in cases of potential mass panics). However, she argues that despite this consensus, this *ultima facie* right is continuously violated in the case of potential harms resulting from nuclear energy production. She presents and discusses data that indicate that nuclear risks and impacts from nuclear disasters at Three Mile Island, Chernobyl, and Fukushima Daiichi nuclear energy plants are more severe than is officially acknowledged. Shrader-Frechette argues that authorities intentionally misinform the public, thereby violating people's right to know and ultimately, their autonomy.

Chapter 5 *Karen Henwood* and *Nick Pidgeon* contribute a chapter titled "Gender, ethical voices, and UK nuclear energy policy in the post-Fukushima era." Of all socio-demographic variables, gender is the one with the most pronounced effects on risk perception, with some men in surveys tending to express less concern about risks than women. This especially holds in the case of nuclear energy and nuclear waste. In their chapter, Henwood and Pidgeon

examine the ethical implications of this gendered nature of nuclear risk perception, based on a qualitative empirical study they have conducted in the UK. In focus groups where they let people discuss nuclear energy, they observed masculine marked discourses of "technocentrism," which they contrast with those stressing more caring concerns. Henwood and Pidgeon argue that presentation of knowledge claims and values as traditionally framed within the gender and risk effect literature might not always be capable of catering to epistemic diversity and the collective good. Forms of knowledge and values that are uncontested in some contexts can become controversial in others, as in the context of nuclear risk. Based on their empirical work, Henwood and Pidgeon argue that public energy discourse risks gender insensitivity, when it adopts an essentialist association between masculinity and technology on the one hand and between femininity and care on the other hand. They argue that this gender insensitivity can best be overcome by combining a technocratic approach and more "soft" approaches to risk, such as care ethics, in debates about nuclear energy.

Part II: Justice

Chapter 6 In his chapter, "The need for a public 'explosion' in the ethics of radiological protection, especially for nuclear power," *Stephen Gardiner* scrutinizes the existing principles of radiological protection. The nuclear community already acknowledges the ethical dimension of radiological protection and various standards are being proposed that are derived from explicit ethical principles. The nuclear community seems further to be satisfied about the level of maturity of these principles. Gardiner argues, however, that there are major gaps in the present system, at least when it comes to the application of these principles to nuclear energy. Following a pluralist "bottom up" approach, he introduces a number of new principles and fresh interpretations of existing ones. These new principles include three new procedural principles (Inclusiveness, Accountability, Publicity), a collective welfare principle (Presumptive Net Benefit), two minimization principles (Necessity and Comparative Minimization), and four principles of respect (Excessive Harm, Proportionality, Special Representation, Vulnerability). In particular, Gardiner's principle of publicity – which presents a duty for all people involved in nuclear energy policy to make clear to the wider public the scientific and ethical reasoning involved in justifying these policies – is of great importance for establishing public trust. With the increasing controversies in the worldwide nuclear energy debate, public trust is a vital matter. Gardiner concludes that the confidence of the nuclear community about the maturity of the currently existing radiological protection principles is premature and that there is substantial work to be done. He

presents a number of alternative principles in this chapter that could be considered as a substantial first step toward a robust new ethical framework for nuclear protection.

Chapter 7 In their chapter, "Distributive versus procedural justice in nuclear waste repository siting," *Pius Krütli, Kjell Törnblom, Ivo Wallimann-Helmer, and Michael Stauffacher* focus on two key notions of justice in nuclear waste disposal, namely distributive and procedural justice, and their relative importance with respect to each other. Attitudes toward repository projects cannot be explained merely on the basis of perceived risks, trust, or technical information. Issues of justice and fairness frequently arise when burdens and benefits are to be allocated, also in case of nuclear waste disposal. A fair distribution across the various parts of a given territory for waste disposal is contingent on a number of factors such as appropriateness of the geological host formations. The process by which the specific distribution is determined and accomplished needs to be taken into account as well. Thus, justice evaluations of both the distributive outcome and the process itself, by which the outcome is accomplished, are likely to affect people's attitudes toward and acceptance of siting decisions.

They present data from a number of different studies conducted over the last eight years on site selection in Switzerland. These data suggest that a fair procedure is more essential than a fair distribution of burdens resulting from siting to a consensus about the decisions made. As a consequence, even normative assessments of the fairness of a distribution of nuclear waste must consider procedural justice as a valuable indicator of the fairness of distribution, independently of the particular shape of the distribution. In addition, contextual factors, such as the wider nuclear energy strategy of a country, may compete with procedural fairness in terms of importance. While fairness is a requirement in siting, properly addressing this issue might positively affect the acceptability of a site from a moral standpoint.

Chapter 8 In "Nuclear energy, justice, and power: The case of the Pilgrim Nuclear Power Station license renewal," *Bindu Panikkar* and *Ronald Sandler* present an ethical analysis of life extension of nuclear energy reactors. While nuclear energy is expanding worldwide and many new plants are being built, many old plants are reaching the end of their license period; on some occasions utilities choose to extend the lifetime of the reactor and, subsequently, apply for a license renewal. Panikkar and Sandler review the case of license renewal for the Pilgrim Nuclear Power Station (Pilgrim) in Plymouth, Massachusetts. Central ethical issues in decision-making on license renewals concern proper assessment of nuclear risks as well as questions regarding the distribution of risks. These need to be conducted in accordance with best