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Perspectives

Europe After Fukushima

German Perspectives on the Future of Nuclear Power

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FRANK UEKOETTER
MARKUS VOGT

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Introduction

One year after the reactor meltdown at the Fukushima Daiichi Nuclear Power Station, this volume of *RCC Perspectives* takes stock of its impact and possible legacy in Europe. Triggered by the massive earthquake and tsunami that struck northeast Japan on the morning of 11 March 2011, the nuclear disaster radiated out from Fukushima to the surrounding countryside, cities, and the wider globe. While Europe may have been spared radioactive fallout, political and cultural fallout has been significant. A quarter of a century after Chernobyl, Europe is again faced with serious questions about the risks, ethics, and, ultimately, future of nuclear power.

In Germany, where both political will and popular support for nuclear power have been steadily shrinking over the past two decades, Fukushima appears to be "the nail in the coffin," as one contributor puts it. In June 2011, the German government declared a definitive phase-out of nuclear energy, setting shutdown dates for all reactors and calling for a radical shift in its energy policies. Yet, as the articles here suggest, nuclear matters are never clear-cut. Surrounded by foreign reactors that still supply a significant portion its energy, Germany's vow to abandon nuclear power is not without ambiguity. Moreover, it is not all clear whether other European nations—not to mention other regions in the world—will follow Germany's lead. Nuclear power has survived long odds before: it has been both unpopular and uneconomic, never accounting for more than 5 percent of the world's energy supply. Are we witnessing the beginning of the end of the nuclear era? Or the beginning of a new one, glimpsed in the shade of authoritarian regimes?

To explore this uncertain landscape of post-Fukushima Europe, *RCC Perspectives* presents the work of three German scholars from the fields of history, ethics, and law. Frank Uekoetter offers a historical portrait of nuclear power while reflecting on the methodological, as well as moral, demands Fukushima places on future research. Uekoetter frames the German response as part of a long farewell to nuclear power, fueled by local protest as well as slow-growing concerns within technological and political circles. At the same time, he sees Fukushima as an opportunity for both scholars and policy makers to rethink not just nuclear power but complex technological systems in general. The myth of technological progress—innovation uncoupled from culture, politics, and environment—continues to obscure the risks our technological systems produce. Uekoetter insists that we let go of the preconceptions and false assurances of energy utopias, whether atomic or alternative, and become more supple in both our thinking and policy if we are to devise truly sustainable energy systems. "If we can learn anything from the history of nuclear power," he concludes, "it is surely the need for constant learning."

Markus Vogt reprises the question of nuclear power after Fukushima by looking at it as an artifact of ethical, as well as technological, choices. For Vogt, Fukushima—like Chernobyl before it—has reminded us of the urgent need to rethink nuclear risk, not just as the product of a complex technological system but as an integral component of our ethical lives. Among the many ethical challenges nuclear power poses, the problem of responsibility stands out. To manage the "long-term and long-range" risks of our energy systems, nuclear and otherwise, we need broad, transparent, and informed dialogue about our patterns of consumption and the kinds of technological choices they often force upon us: "The maxim of 'faster, higher, further' is neither suitable for the future nor for the ongoing process of globalization. Temperance may not be the strongest virtue of modern society, but it represents one of our best chances to increase quality of life and promote development." The way we approach the problem of nuclear risk, Vogt argues, will be a "crucial test of whether our society is ready to accept its responsibility for creation and the shaping of the future."

Jens Kersten concludes the volume with a careful consideration of the legal and constitutional fate of nuclear risk after Fukushima. While he views the new phase-out of nuclear power as both reasonable and constitutional, he also notes the ambivalent position nuclear risk occupies in political discourse. After Fukushima, nuclear risk appears both "too risky for German risk society and yet socially acceptable for a further ten years." In this sense, Germany offers a preview of how debates over nuclear power might play out elsewhere, particularly in liberal democracies where "the demand for a risk-free society flies in the face of the necessary production of risks that are never completely predictable." While Fukushima has provoked immediate political action, substantive change in energy policy will require much more. In particular, Kersten argues that Germany—and other nuclear nations—must take a hard look at how the state endorses risky technologies, even as it seeks to regulate them. The problem of nuclear risk, he suggests, is too important to banish to the realms of expert knowledge and commissions that too often confuse vested interests for public interests.

Following hard on the heels of the Deepwater Horizon explosion and ensuing oil spill, Fukushima has alerted us all to the dangers of decoupling complex technological systems from their users and their environments. What we are witnessing, Uekoetter gently suggests, is a failure of imagination—an inability or unwillingness to imagine the kinds of risks produced by the unanticipated convergence of human error, technological design, and nature. New stories, new ways of seeing the problem of nuclear power are urgently needed if we are to move forward rather than just, as Joachim Radkau puts it, "muddle through." The three essays presented here remind us that disasters are also opportunities to learn new stories and new ways of seeing. Hopefully these contributions will succeed in extending the miserably short "political half-life," as Vogt terms it, of catastrophe and provide an antidote to the habitual amnesia that eventually overtakes even the worst disasters.

Given that this year marks the fiftieth anniversary of *Silent Spring*, Rachel Carson's roll call of the manufactured but invisible risks to bodies and environments, it seems fitting to recall her challenge to spit out the "tranquilizing pills of half truth." Carson, quoting the French writer and biologist Jean Rostand, declared that "[t]he obligation to endure gives us the right to know." As these authors suggest, the right to endure also gives us the obligation to know.

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Frank Uekoetter

Fukushima and the Lessons of History: Remarks on the Past and Future of Nuclear Power

> *Hegel remarks somewhere that all facts and personages of great importance in world history occur, as it were, twice. He forgot to add: the first time as tragedy, the second time as farce.*
>
> Karl Marx, *The 18th Brumaire of Louis Bonaparte*[1]

In this essay, I rush in where angels fear to tread, into the business of "history in the making." It has become common sport to underscore the importance of current events by labeling them "historic," and Japan's nuclear disaster was no exception. Within hours of the first explosion at the Fukushima Daiichi nuclear complex, the German weekly *Der Spiegel* proclaimed "the end of the nuclear age" on its front page.[2] As it happened, the magazine was on the mark for Germany, where Fukushima became the nail in the coffin of nuclear power: the governing center-right coalition abandoned a decades-old pro-nuclear stance, even rescinding a controversial law that was only a few months old. Other European countries are tilting in that direction. In a referendum, Italy reaffirmed a previous decision to abstain from nuclear power, while Belgium and Switzerland are considering exit plans. However, most countries in the world remain indecisive; one year after Fukushima, the meaning of Japan's nuclear disaster is still open and contested. Even in the German context, the importance of Fukushima is more complicated than one might think.

Nonetheless, this essay aims for more than an exercise in speculation. It consists of two parts. The first gives a brief summary of the development of nuclear power in Germany, arguing that the decision of 2011 was the final step in a long farewell. This part also offers some perspectives on other countries, as Germany's trajectory is in many respects typical of developments elsewhere in the West. The second part builds on this discus-

I wish to thank the Hiroshima Peace Institute for inviting me to its conference in November, 2011, where an earlier version of this paper was presented. That version is due to be published in Japanese. I also thank the Carson Center fellows who attended the work-in-progress session on 5 October 2011, and particularly Bao Maohong, who translated the article into Chinese.

1 Karl Marx, *The Eighteenth Brumaire of Louis Bonaparte*, Original (1852; repr., New York: International Publishers, 2008).
2 Cover, *Der Spiegel* 11 (2011).

sion, assessing the methodological arsenal of the historical profession in order to shed light on future developments. Approaches from the history of science and technology play a prominent role in this endeavor, making it something of an empirical response to Markus Vogt's ethical account, also appearing in this issue. After all, nuclear power is one of those large technological systems that scholars have long recognized as a crucial feature of modern history. What can we learn when we conceive nuclear energy as a piece of technology rather than an ethical challenge?

One should stress from the outset that a technological system as defined in this essay is more than an artifact. It is now common within the history of technology to see technological systems as characterized by a complex interaction of human beings and technological artifacts. In the case of nuclear energy, the technological system includes not only reactors and other complex machines but also the scientists and engineers who design and operate them, the managers who build them, and the politicians who support them. In fact, one could go even further to include consumers as well, since assumptions about future consumption played a key role in nuclear development. At any rate, technological systems are more than cold steel and wires, a fact that highlights the importance of merging ethical and historical perspectives. Reactors do not have morals. But technological systems do.

I. Towards a Mythology of Nuclear Power

On 30 June 2011, the German parliament voted to close the last reactor within the country by 2022. Of the 600 votes cast, 513 were in favor, with most of the negative votes coming from the Leftist Party (*Linkspartei*); the Green Party delivered 61 votes in favor with six abstentions.[3] With that, the law became the first nuclear policy statement in a generation to win support across the political spectrum. The preceding months had seen a dramatic conversion within the governing coalition, which had reaffirmed its stance in favor of nuclear power only a few months earlier. In spite of vigorous protests, the government had extended the operating life of existing reactors in the fall of 2010, thus revising the previous phaseout decision of 2000. As German chancellor Angela Merkel declared in a speech in parliament, "The dramatic events in

3 "Gesetzentwurf CDU/CSU, FDP auf Drucksache 17/6070," Deutsche Bundestag [German Federal Parliament] *www.bundestag.de* (Berlin: 30 June 2011), http://www.bundestag.de/bundestag/plenum/abstimmung/20110630_17_6070.pdf.

Japan are a watershed for the world, and a watershed for me personally."[4] For a generation used to seeing the political right as pro-nuclear and the left as anti-nuclear, it was as if the pope had turned Muslim.

Dramatic conversions have a tendency to turn into myths. Counting on the amnesia of the general public, some spin doctors suggested that Christian Democrats, despite their extension of reactor licenses the year before, were merely closing loopholes in the 2000 phaseout agreement. A more noteworthy reading stressed the role of Angela Merkel, who reacted with a firmness that she has frequently shunned on other issues. At any rate, the stories told after Fukushima were notably short on context, and that makes it all the more important to recount the history of nuclear power in Germany and beyond. Nuclear technology is arguably complicated and difficult to understand, but its history, if told in an adequate fashion, is anything but a dry topic. It is a history of unexpected results; one might even call it ironic if the outcome had not been so tragic. Most crucially in the present context, it is a history that dispels the notion that Fukushima put an end to nuclear energy in Germany. As we shall see, the nuclear complex had been in decline for more than three decades.

However, myth production is also underway in the anti-nuclear camp. Fukushima underscored the movement's contention about the inherent risks of nuclear power. For those who have read Charles Perrow's discussion of "normal accidents," Japan's nuclear disaster unfolded in an unsettlingly familiar fashion.[5] And yet it would be shortsighted to attribute the demise of nuclear power simply to its inherent risks and a persistent civic movement that highlighted them. For all the importance of civic protests, they might have been futile if they had not joined doubts within the nuclear community, where the case for nuclear power became weaker and weaker until it was essentially a problem in search of a solution. The key to success was a combination of external pressure and internal doubt that made abandoning nuclear power the path of least resistance.

What all this comes down to is that the German decision of 2011 was not simply due to a sudden shock. To be sure, the weeks after 11 March were terrifying indeed, and not only for those who were living in northern Japan. It is also quite clear that Merkel would not

4 "Die Atomkanzlerin erklärt ihren Ausstieg," *Süddeutsche.de*, 9 June 2011, http://www.sueddeutsche.de/politik/regierungserklaerung-zur-energiewende-merkel-erklaert-den-atomausstieg-zur-herkulesaufgabe-1.1106773.

5 Perrow's approach to technological accidents is discussed more extensively toward the end of this article.

have reversed her pro-nuclear stance without Fukushima. Yet the disaster was ultimately more of an accelerator: at its core, the phaseout decision of 2011 was due to a coming-together of long-range trends and the wisdom of the moment. Fukushima may be slowly disappearing from the news but its significance endures and may actually grow over time. After all, there has been talk about a "renaissance" of nuclear power for several years now, propelled by the threat of global warning. Finland is building the first new reactor in a generation, and some countries are drafting plans for new building programs.

To the historian, all this sounds quite familiar. After all, that is how the first atomic age got started: high hopes based on very limited construction programs. However, even before Fukushima, the second atomic age looked timid in comparison to the first—a farce on the heels of a tragedy. Now that the presumably improbable disaster has happened, the case for nuclear power looks more dismal than ever. With that, the German decision has by no means the hallmarks of a unique path. Quite the contrary, it may be merely the prelude to what historians may one day see as a crucial turning point.

II. A Tale About Energy Planning: Nuclear Power in Germany

Like most countries, Germany built its current reactors between the late 1960s and the early 1980s. After a number of experimental projects, construction of the first commercial reactors started in 1967. The construction of commercial-scale reactors was initially not a divisive political issue, as it seemed like common sense. Since the 1950s, the government had invested a lot of money into nuclear development, most notably into two new research centers in Karlsruhe and Jülich. Like many Western countries, Germany saw nuclear technology as a key area of science-based progress—a modern, world-class nation just had to master the peaceful atom. In the German context, embracing nuclear power seemed even more important as it provided an opportunity to regain world-class status in science after the terrible demise of academic prestige due to the reign of the Nazis. In any case, politicians from the left and the right were unanimous that West Germany needed nuclear reactors. When the oil crisis of 1973 made energy a hot topic all over the West, political and business leaders felt that they were on the right course.[6]

6 Even after more than three decades, the defining study on German nuclear development remains Joachim Radkau, *Aufstieg und Krise der deutschen Atomwirtschaft 1945-1975: Verdrängte Alternativen in der Kerntechnik und der Ursprung der nuklearen Kontroverse* (Reinbek bei Hamburg: Rowohlt, 1983).

It is important to recognize that when research began in the 1950s, it was by no means clear what type of technology would emerge. Nuclear energy was supposed to have many different uses: nuclear ships, locomotives, even airplanes were on the drawing board. The large power stations of today were essentially the result of a long process of narrowing down the range of technological options; even with nuclear power stations, the original idea was notably different from the ultimate outcome. In the 1950s and 1960s, nuclear experts conceived reactors for electric power generation as merely one component of a nuclear system that also included breeder reactors and reprocessing plants. Since breeder reactors were supposed to produce more fissile material than they use, experts were aiming for a technological system that could sustain itself indefinitely. It is hard to understand the allure of nuclear energy without the endless fuel cycle, as it promised a permanent solution to energy woes—a technological utopia tantamount to perpetual motion.

Nuclear technology was new, but that did not mean that there were no pre-existing traditions. In the field of nuclear technology, military use preceded civil use, and that framed the choice of reactor types to an extent that one might speak of predetermination. Since 1955, the submarine USS *Nautilus* was underway with nuclear power, giving a head start to light water reactors. Even France decided to abandon its own gas-graphite program in 1969 and bought American light water technology.[7] However, submarines had peculiar technological requirements, most prominently a preference for compact designs that led to the use of enriched fuels. That also met with another military interest, as fuel enrichment was an existing technology: it was needed for building bombs, and that meant that civil use of enriched fuels was a great way to write down the costs of the nuclear arms race. The drawback was that reactors contained far more fissile material than necessary. That was great for submarines, which were supposed to stay ashore for months, but it implied a dangerous concentration of hazardous material in large power stations.

With that, nuclear reactors became a showcase for the difference between military and civilian technology. As a military technology, light water reactors were not built according to a "safety first" principle, and it is not at all certain that this reactor type would have been chosen if safety had been the overriding concern. Unlike other reactor types,

7 Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity after World War II* (Cambridge, MA: MIT Press, 1998), 297.

water-moderated reactors need emergency cooling systems to forestall a meltdown. At Fukushima, it was the failure of cooling systems in the wake of the 11 March earthquake that was the decisive reason for the disaster. Other reactor types would have shut down automatically.

However, the inherent risks of light water reactors were not plain from the outset. David Okrent, a member of the US Advisory Committee on Reactor Safeguards, noted that "a revolution in LWR [light water reactor] safety occurred in 1966," when the threat of nuclear meltdown with subsequent damage to containment, later known as the "China Syndrome," became recognized.[8] However, the timing could not have been worse: as building programs were gathering momentum, there was no opportunity to pause for a moment and consider alternatives to light water reactors. The best option was to add safety measures, but multiple emergency cooling systems did not assuage the fears of more conservative experts. After all, emergency cooling systems were tricky devices: they were on stand-by most of the time, but they had to operate perfectly in case of an incident. In short, the risks of light water reactors were a contested topic within expert circles long before they were making headlines in the mass media.

Nuclear reactors were also controversial for other reasons. Initially, the greatest resistance came from electric power companies who were supposed to build and operate them. From their point of view, it was good business to proceed cautiously: reactors were expensive, the technology was complicated, and the overall economics was by no means certain. Furthermore, utilities had other sources of electricity that had their own lobbies. Within the utility giant RWE, for example, a powerful lobby was plotting against nuclear power because it competed with the company's brown coal branch.[9] It took massive pressure from the government to strong-arm utilities into the new technology.

Opposition also came from the communities where reactors were supposed to be built. Wherever plans were drafted, planners had to cope with skepticism and open protest. Protest was first and foremost local: people were skeptical of the changes that a nuclear power plant would bring to their hometowns. Most reactors were planned for sparsely populated rural areas, where they appeared as harbingers of industrial transformation.

8 David Okrent, *Nuclear Reactor Safety: On the History of the Regulatory Process* (Madison: University of Wisconsin Press, 1981), 296.

9 Joachim Radkau, "Das RWE zwischen Braunkohle und Atomeuphorie 1945–1968", in *RWE—ein Konzern wird transparent "der gläserne Riese"*, ed. Dieter Schweer (Wiesbaden: Gabler, 1998), 173–96.

In other words, people were skeptical even before they learned about the dangers of nuclear power: they realized without knowing too much about nuclear technology that these power plants would change their way of life. In the southwest German town of Wyhl, winegrowers feared that the steam from the large cooling towers would change the local climate.

Of course, nuclear power plants also implied the promise of jobs. However, local people were realistic: they realized that most of these jobs would go to people from outside—locals simply did not have the necessary skills. The one important attraction was money, as German companies pay a hefty tax to the municipality where they are situated. As a result, towns and villages with a nuclear power plant were usually flush with money, but even that attraction has lost much of its charm nowadays. The tax shrinks dramatically when a reactor goes out of service. Therefore, nuclear municipalities have learned, at times painfully, that the expansion of the tax base is temporary.

Thus, the movement against nuclear power was initially a local movement, borne out of a wide array of concerns. Nuclear hazards emerged as the key issue as locals became educated about the risks of nuclear technology. The anti-nuclear movement developed a tremendous expertise of its own, with numerous people willing to understand the complex technology and its inherent dangers. As the movement grew, protesters learned more and more about technological hazards, licensing systems, political connections, and effective modes of protest. But important as knowledge was and is for effective protest, it was crucial that this knowledge did not remain aloof. The movement remained rooted in regional campaigns, each of which would deserve a discussion of its own: Wyhl, Brokdorf, Gorleben, Kalkar, Wackersdorf.[10]

Over time, local protests won powerful allies within the political system, bringing permanence to a movement that was, like all social movements, inherently unstable. After all, nuclear power is not a very interesting topic by itself: it is complicated and brings dissenters up against powerful and well-funded opponents. Therefore, it was very important that the German anti-nuclear movement found friends in politics. Most crucially, nuclear energy has been a defining issue of the Green Party since its foundation in 1980.

10 Scholarly treatment of these regional campaigns is notoriously uneven. The lion's share of attention went to one of them, Wyhl, which even became an entry in the popular anthology of German *lieux de mémoire*. See Bernd-A. Rusinek, "Wyhl", in *Deutsche Erinnerungsorte*: II, ed. Étienne François and Hagen Schulze (Munich: C.H. Beck, 2001), 652–66. See also chapter II.1 of this essay.

The issue also received support within the Social Democratic Party (SPD), one of the two large parties in the Federal Republic of Germany. After the Chernobyl disaster of 1986, the Social Democrats voted to abandon nuclear power. On the other side of the political spectrum, the conservative Christian Democratic Party (CDU/CSU) and the Liberal Party (FDP) maintained their pro-nuclear stance.

As a result, the nuclear issue became entrenched in the political system: the political left was against nuclear power, and the right was in favor. That kept the issue alive politically, as nuclear power often featured prominently in election campaigns. It also meant that government policy remained staunchly pro-nuclear, as the Christian Democrats and the Liberal Party ruled the Federal Republic in a coalition government from 1982 to 1998. The protest movement nonetheless achieved some remarkable successes. Vigorous and well-informed opposition prevented the construction of a large reactor complex in Wyhl and a reprocessing plant in Gorleben. Furthermore, protest made construction of new power plants much more difficult: new reactors had to undergo complicated licensing procedures, where protesters monitored and contested each and every step. As a result, the nuclear construction program slowed down notably.

Interestingly, this was not only a victory for the protesters. The utilities also profited in an indirect way. In the 1980s, it gradually dawned on energy managers that their earlier plans had been overblown. In the early 1970s, blueprints had called for a massive expansion of generating capacity, mostly through nuclear power. A decade later, it turned out that there would not have been any need for so many reactors. The Federal Republic of Germany could easily provide enough electricity with existing power plants and did not need more of them. In short, the nuclear protesters had saved the German utilities a huge amount of money.

This was more than an irony of history. It was an important lesson in the economics of nuclear energy. Nuclear reactors are expensive to build and cheap to run. For power plants running on gas or coal, it is the other way round. In other words, building a reactor means hedging a bet on energy demands several decades into the future—a gamble with all sorts of unknowns. Energy managers thus learned that reactors could land you in economic trouble even when they operated perfectly, and the current stance of Germany's utilities looks notably cautious as a result. While they are presently grumbling about the government's change of mind, utilities have shown little interest in new reactor programs. After having the luck to come out of the first nuclear age with a profit, another gamble simply looks like bad business.

The German nuclear community had also learned something else by the 1980s: nuclear energy would not supersede conventional utilities but rather co-exist with them. That is important because the original assumption of the atomic age was that nuclear energy would make coal and other fossil fuels for electricity production obsolete. In reality, nuclear power never supplied more than 30 percent of electricity in Germany, which means that coal was always more important for German utilities than nuclear power. While power companies looked like staunch believers in nuclear energy from the viewpoint of the anti-nuclear movement, they never committed themselves unconditionally. One can only hope for the day when company archives are open to reveal internal debates.

Nuclear dreams took another blow in the late 1980s when the Kalkar breeder project and the Wackersdorf reprocessing plant project were abandoned. Despite consuming enormous amounts of money, both financially and politically, they did not become unstoppable, unlike the power plants in Brokdorf and Grohnde, which became operational in spite of heavy protest. However, nuclear planners had envisioned Kalkar and Wackersdorf as indispensable pillars for the endless fuel cycle, which meant that the decisions of the late 1980s changed the general character of the nuclear project. In short, nuclear power became simply another method of heating water.

The German decision was typical of nuclear development worldwide. Breeder projects failed miserably wherever they were started; most recently, the Japanese government slashed the budget for the Monju fast breeder reactor, which had been under repair since a major accident in 1995.[11] No country came close to maintaining an endless fuel cycle, and with that defeat went the aura that had once sustained nuclear euphoria. Gone are the dreams of atomic energy as the technology of the future, or the belief that every self-respecting modern nation should use this super-modern technology. Compared with computer technology and the life sciences, nuclear power emerged as a technology with an exceedingly narrow range of uses: it was about electricity, pure and simple. From a historical perspective, the reality of nuclear power appears a far cry from the original fantasies. By the late 1980s, West Germany had essentially

11 David Cyranoski, "Japan Freezes Fast Breeders Plan," *newsblog, nature*, 28 September 2011, http://blogs.nature.com/news/2011/09/japan_fast_breeder_freeze.html.

abandoned nuclear utopias. It was now clear that German nuclear energy would mean water-moderated reactors and nothing more.

The next step came with German reunification. The German Democratic Republic (GDR) had its own nuclear program. It maintained a large nuclear complex on the Baltic Sea near Greifswald and was building another one near Stendal. Therefore, the West German nuclear lobby saw reunification initially as an opportunity: faced with stiff local opposition in the West, it dreamed about new reactor projects in the former GDR. However, the GDR reactors were shut down during reunification, and no new reactor project ever got anywhere.[12] This outcome begged an important question: if you could not build a new nuclear reactor in East Germany, where state governments were otherwise eager to promote industrial enterprises, was there any place in Germany where one could build another reactor? Revealingly, there has been no serious proposal for a new reactor anywhere in Germany since reunification, which implies a tacit admission that the nuclear age would end in Germany. Few people dared to spell it out, as neither pro- nor anti-nuclear activists had an interest in doing so, but since the 1990s, the consensus has been that, unless something dramatic happened, Germany would become nuclear-free once the last of the existing reactors shut down.

Reunification was also important in a second respect. In September 1990, Germany signed the Two Plus Four Treaty with the United States, Great Britain, France, and the Soviet Union to clear the path for the merger of the two German states. In this treaty, Germany pledged to refrain from the manufacture of nuclear, biological, and chemical weapons. That was the endpoint of a long flirtation with the nuclear option. Of course, West Germany had never actually built a nuclear bomb, and never maintained an active weapons program. Still, there were a number of politicians who had considered nuclear bombs an option. All that ended in 1990, due both to the Two Plus Four agreement and the end of the Cold War in Europe, which rendered all ideas about a German bomb pointless. It is one of the mysteries of nuclear policy that it took until 2005 to empty the federal plutonium storage in Hanau—a leftover from the breeder project that could have provided the raw material for a bomb.[13]

12 On the GDR's nuclear history, see Mike Reichert, *Kernenergiewirtschaft in der DDR*: *Entwicklungsbedingungen, konzeptioneller Anspruch und Realisierungsgrad*, 1955–1990 (St. Katharinen: Scripta Mercaturae, 1999), and Wolfgang D. Müller, *Geschichte der Kernenergie in der DDR: Kernforschung und Kerntechnik im Schatten des Sozialismus* (Stuttgart: Schäffer-Poeschel, 2001).

13 Bundesumweltministerium [Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety], "Hanau vor dem Ende seiner Atomgeschicte," *BMU-Pressedienst* 173/04 (2004).

After 1990, protest movements shifted attention to the issue of nuclear waste. In 1995, the nuclear industry started to use a storage facility in the northern German community of Gorleben. Every single shipment of waste became subject to a huge demonstration of several thousand protesters, kept at bay by an equally large army of policemen. In contrast, demonstrations against nuclear reactors became rare, not least because many of them were operating smoothly. Concern about reactors shifted eastwards, as anti-nuclear protest focused on reactors that were remnants from Soviet times, such as Temelín in the Czech Republic, Kozloduy in Bulgaria, or Chernobyl in the Ukraine, where the last reactor was only shut down in December 2000. The disaster at Fukushima Daiichi came as a surprise to anti-nuclear protesters, too.

In 1998, a general election brought a coalition of SPD and Green Party members to power. Both parties once more made election-campaign pledges to abandon nuclear power and, after long and tense negotiations, they sealed an agreement with the nuclear lobby in 2000. The deal limited the lifespan of existing reactors to 32 years, thus fixing a date for shutdown. It attests to the vigor of anti-nuclear sentiments in Germany that this deal met with protest from anti-nuclear activists who pushed for more drastic timetables. On the other side, the nuclear lobby tried to profit from the growing debate over global warming by praising nuclear power as carbon-neutral. Before the federal election of 2009, the German Atomic Forum (*Deutsches Atomforum*) launched a media offensive to suggest that the nuclear question was still open.[14] In any case, the issue remained a political hotbed, and nuclear power played a prominent role in the federal election of 2009.

This election brought into power a new center-right government under chancellor Angela Merkel. In the fall of 2010, her coalition government enacted a new law that extended the lifespan of existing reactors by twelve years on average. Inevitably, this law met with vigorous protest. However, it was remarkable how the government sold the revision. It neither made a case for new reactors nor praised nuclear power unduly. Instead, it argued that nuclear energy was a “bridging technology”—a technology needed to bridge the time until renewable energy sources were available. That was a far cry from the utopias of the 1950s; enthusiasm for nuclear power had truly come a long way. In fact, it was hard to imagine a less enthusiastic stance from a proponent of nuclear energy. This is important for a proper understanding of the shift in government policy after Fukushima.

14 S. Heiser and M Kaul, “Die Geheimpapiere der Atomlobby,” taz.de, 28 October 2011, http://www.taz.de/taz-enthuellt/!80743/.

Needless to say, the nuclear lobby was jubilant after the decision of 2010, but their victory proved to be a Pyrrhic one when this law was quashed after Fukushima. The outcome matched the long-term trajectory of the nuclear lobby; since the late 1970s, it had suffered many defeats and few gains, and the latter had a tendency to turn into strategic blunders. The Gorleben shipments provide a case in point: from a technical standpoint, the costly transfers of spent fuel into the storage facility were successful, but they ultimately did more for anti-nuclear protests than for the proper disposal of nuclear wastes. Even the debate over climate change did not bring a significant shift in public opinion. Whatever it tried, the nuclear lobby remained on the defensive. Nuclear power was a solution in search of a problem.

In sum, the decision to abandon nuclear power in Germany was not as sudden as it might appear at first glance. For several decades, the pro-nuclear camp had failed to find a convincing rationale for its cause and momentum was clearly with the opposition. Recent nuclear accidents in Forsmark (2006) and Krümel (2007) received widespread media coverage, though the most frightening incident—the 2002 reactor head hole at Davis-Besse—somehow escaped public scrutiny. Characteristically, the *Spiegel* cover of March 2011 was not the journal's first farewell to nuclear power; in 1995, an issue had announced "the atomic age is ending."[15] While Merkel's recent decision was obviously tied to an unforeseeable event in Japan, the end of nuclear power really came about gradually over many years—the final step in a long decline. In a way, Merkel chose the path of least resistance after Fukushima. Why spend much political capital to defend a technology that was bound to expire anyway?

If we look at the path of nuclear power in Germany since the 1950s, one big lesson emerges: prepare for the unexpected. No group succeeded in realizing its original intention. Engineers and physicists thought they were engineering a new human era—and they ended up building power plants with dubious profit margins. The social democrats were initially enthusiastic—and ended up as an anti-nuclear party. The center-right coalition supported nuclear power, but they drew no benefits from that stance, and actually had to revise it after Fukushima in a way that conservatives found humiliating. Plans for an energy future are obviously tricky, and the best advice that history has to offer is to allow for as much flexibility as possible.

15 Cover, *Der Spiegel* 7 (1995).

However, Germany remains in the center of Europe. In a dozen years, Germany may be nuclear-free, but it will most likely be surrounded by reactors in Great Britain, France, Belgium, Switzerland, Sweden, and the Czech Republic. The German anti-nuclear movement has been very hesitant to grapple with this fact, to a point that borders on willful denial. After the events of last year, that stance looks more dubious than ever. If things turn out badly, Germany will become a major importer of nuclear electricity from abroad. After all, nuclear power supplied 22 percent of all electricity in Germany in 2010—a significant share that will not be easy to replace.

Of course, Germany may emerge as a pioneer of renewable energy, and international attention on German energy policy is virtually guaranteed for the next few years. We already see an emerging discussion over the price of renewable energy—for instance, in conflicts over new power lines and hydroelectric projects, where the lack of proper standards for balanced decisions is painfully clear. However, one of the less obvious challenges is whether Germany can stay within the nuclear community after the decisions of last year, as the nuclear expert system is dearly in need of critical input. After all, the lifespan of existing reactors is the key issue when it comes to nuclear safety in upcoming years. Old reactors are much more prone to problems and accidents, and it is a pity that the German path now carries the air of a political decision. The technological case for a time limit on nuclear reactors was and remains strong.

What all this comes down to is that a lot hinges on how the German path will be received internationally in upcoming years. Will it come across as a political ploy or a hallmark of nuclear safety that may serve as a yardstick for other nations? The latter is more likely than one might think. After all, when we look across Europe, the prospects of nuclear power seem dim. Compared with the frenzy of the 1960s and 1970s, existing construction programs are lukewarm and timid; even the World Nuclear Association concedes that Europe is becoming a backwater for nuclear power, as "most reactors currently planned are in the Asian region."[16] Despite several decades of experience, construction projects are beset by problems, as the delays with Finland's new reactor at Olkiluoto serve to attest. Even before Fukushima, the second atomic age looked like a lukewarm follow-up, devoid of the hopes and utopias of the first. So German developments may not be so unique after all. In most European countries, the history of nuclear power is

16 "Plans for New Reactors World-Wide," World Nuclear Association, last modified February 2012, http://www.world-nuclear.org/info/inf17.html.

a history of disappointments and diminished expectations. The difference is that other countries have not yet drawn the drastic conclusion that Germany has.

After Fukushima, the prospects for nuclear power look more dismal than ever. It is likely that the disaster will spur a new interest in safety. Engineers and operators will be more cautious. They will spend even more money on safety, further reducing profits. Local authorities will be more skeptical than ever, making it more expensive to buy local support. Meanwhile, public debt is high all over the West, making it unlikely that countries will invest billions into nuclear technology. In short, the German policy differs from the rest of Europe merely in its speed and its vigor. Elsewhere in Europe, the general situation is one of indecision: nuclear energy is sputtering on, too strong to die but too weak to flourish. After Fukushima, signs are strong that, when it comes to Europe, nuclear power is heading for a long, slow, and probably painful death.

III. Writing Nuclear History after Fukushima

The history of nuclear power bears the marks of a tragedy, and yet the label leaves the historian with a sense of unease. It only takes a reference to the controversy over Hayden White's metahistory to understand the delicate nature of this kind of emplotment.[17] The second part of this essay thus seeks to highlight the methodological pillars that the first part rests upon. It does so for a double purpose: to show how these concepts can enlighten policy decisions and to rethink scholarly debates in the light of recent events. It would certainly go too far to say that we need to rewrite history after Fukushima; after all, past debates over large technological systems and their inherent risks provide much of the foundation for this article. But these debates have arguably languished in recent years, and Fukushima may be a good occasion to dust them off and reflect on opportunities and needs.

Local Roots

As the previous discussion stressed, it is important to recognize the local roots of antinuclear protests. However, it is far more difficult to discuss them in depth, as we are still lacking case studies for many sites of conflict. As it stands, Bavaria is now the only

17 Hayden V. White, *Metahistory: The Historical Imagination in Nineteenth-Century Europe* (Baltimore: Johns Hopkins University Press, 1973).

German state where we have a comprehensive overview of nuclear conflicts up to 1980;[18] elsewhere, research has been patchy. That has as much to do with the small cadre of environmental historians as with the exceeding emphasis on a single site for numerous case studies: Wyhl, in the Black Forest. Not only has the plethora of Wyhl studies provided few new insights, they have also produced a rather benign picture of the nuclear opposition. Protests in Wyhl remained peaceful, whereas places like Brokdorf and Grohnde became synonymous with violent clashes between activists and the police. The experience of violence touches people deeply, and yet we know very little about the views and debates on either side.

Case studies could also shed light on the networking of activists, particularly across national borders. As it stands, we have little more than anecdotal evidence. For instance, Joachim Radkau noted that Holger Strohm, who published the first critical compilation of nuclear facts in 1973, was heading the German branch of Friends of the Earth at that time, which provided him with access to information from the United States.[19] In a way, the anti-nuclear movement was at its most international during the early stages, as debates became entangled in national contexts from the mid-1970s. The widely divergent reactions to the Fukushima disaster mirror the extent to which our thinking about nuclear issues is framed by national traditions and customs.

Momentum and Path Dependency

It is difficult to understand the trajectory of nuclear power without an understanding of the inner dynamics that a huge network of researchers and artifacts develops over time. There was little chance to pause and reflect while atomic-age fantasies shrank to mundane reactor programs. Nuclear technology today bears the marks of these early decisions—for instance, in its penchant for light water reactors with their precarious emergency cooling systems. When it comes to the development of large technological systems, momentum and path dependencies are clearly important concepts.

Within the history of technology, the debate over technological momentum was strongly influenced by Thomas Hughes, who defined momentum as analogous to physics: "The

18 Ute Hasenöhrl, *Zivilgesellschaft und Protest: Eine Geschichte der Naturschutz- und Umweltbewegung in Bayern 1945-1980* (Göttingen: Vandenhoeck & Ruprecht, 2011).

19 Joachim Radkau, *Die Ära der Ökologie: Eine Weltgeschichte* (Bonn: Bundeszentrale für Politische Bildung, 2011), 144.

systematic interaction of men, ideas, and institutions, both technical and nontechnical, led to the development of a [sociotechnical] supersystem . . . with mass movement and direction."[20] While later studies focused on human agency, from expert mentalities to consumer habits, the concepts of momentum and path dependency remained theoretically unrefined. Even more, both concepts easily lead to tautologies: momentum fosters growth, and growth creates momentum.

In this context, we might take the Fukushima disaster as a cue that momentum depends on a wide array of supportive factors, most of which are inconspicuous in normal times. Japan's nuclear complex would still be going strong if only TEPCO had built a higher seawall. Likewise, the concentration of six reactors in one place made for synergies before 11 March and for trouble thereafter. And Fukushima is not alone here: one year earlier, we witnessed how one of the largest companies in the world, British Petroleum, almost went bankrupt because of a valve malfunction. Path dependencies hinge on countless small details, and failure in marginal components have the potential to break the momentum. Seen from the ground, momentum looks more like a series of makeshift solutions that stabilize an inherently unstable technological system. Thus, the famed "momentum" is the result of many delicate improvisations that somehow perpetuate a technological system—until someone drops the ball.

Utopias

It is hard to recount the trajectory of nuclear visions without an air of degeneration. In the beginning, the "peaceful atom" was the key to the future; in the twenty-first century, the talk is about "bridging technologies"—a temporary solution until we have found something better. That makes it all the more important to take a critical look at the nuclear utopias of the 1950s: Who created them? How did they separate the bomb from the peaceful atom? And were they truly popular, or did people simply not care enough to make their dissent heard?

Indications are strong that the nuclear euphoria was first and foremost an elite phenomenon. For the broad public, energy was not something to worry about—it was simply

20 Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore: Johns Hopkins Press, 1983), 140. See also Thomas P. Hughes, "Technological Momentum," in *Does Technology Drive History? The Dilemma of Technological Determinism*, eds. Merritt Roe Smith and Leo Marx, 101–13 (Cambridge, MA.: MIT Press, 1994).

there. Energy scarcity, and even nuclear power itself, was a distant projection. Indeed, it is strange that enthusiasm for all things atomic emerged prior to the establishment of commercial reactors. The more one reflects on the psychology of the first atomic age, the more mysterious it appears.[21]

When talking about nuclear elites, it is important to recall that military and civilian uses of nuclear power were closely intertwined. Even Germany, officially a happy protégé of the US nuclear umbrella, maintained a stockpile of plutonium for many years, just in case international relations changed dramatically. In the history of nuclear power, military interests are the elephant in the room, lurking behind the public celebrations of the atomic age—a fact that should remind scholars not to take public enthusiasm at face value.

A critical reassessment of energy utopias has political as well as academic relevance. While nuclear utopias are a fading memory (the atomic airplane is nowadays a sure laugh at conferences) the enthusiasm for renewable energy evokes unpleasant memories, recalling earlier quests for the ultimate energy fix. However, there is no panacea when it comes to energy troubles. In fact, there is good reason to doubt that renewable energy is really profiting from its new aura. In his discussion of the history of solar energy, Gerhard Mener has argued that solar utopias decoupled research from market pressures and thus deprived companies of practical "learning by using" experience.[22] Utopias can have multiple roles: nuclear utopias were short-lived but left a lasting imprint on the technology; solar utopias endured longer but did little to guide research and development.

Totalitarian Technology

If the first atomic age proved anything, it is that nuclear power does not sell itself. Everywhere we looked, we found government interventions on a grand scale that coaxed reluctant utilities into going nuclear. Without subsidies, state guarantees, and generous endowments for research institutions, nuclear dreams would never have become reality. The second atomic age will need equally generous governments, now that Fukushima has pushed the price of nuclear energy upwards. More money will

21 Cf. Allan M. Winkler, *Life Under a Cloud: American Anxiety About the Atom* (Urbana: University of Illinois Press, 1999).

22 Gerhard Mener, *Zwischen Labor und Markt: Geschichte der Sonnenenergienutzung in Deutschland und den USA 1860–1986* (Baldham: LK-Verlag, 2001).

be needed for additional security, for buying local support, and for the utilities. After Fukushima, the economic case against nuclear power looks stronger than ever. Why should a manager risk the collapse of his or her company, TEPCO-style, if there are plenty of alternatives to expensive reactors that will not pay off until far into the twenty-first century?

What all this comes down to is that nuclear reactors may emerge as a technology for authoritarian regimes, for only they can meet the necessary requirements. They can allocate money more easily than debt-stricken Western democracies. They can suppress criticism and calls for accountability. While Western democracies will have a hard time sponsoring nuclear projects after Fukushima, authoritarian regimes may follow a different rationale. In the twenty-first century, nuclear energy may turn into a totalitarian technology.

All of this may force us to rethink the status of nuclear technology in Western societies. If we recognize nuclear power as a totalitarian technology, what does that say about countries that have dabbled in it over several decades? After Fukushima, we can see clearer than ever how expert systems, like those of the nuclear complex, challenge our democracy. At the very least, we have learned enough about TEPCO shenanigans to conclude that Japan's nuclear complex was not democratically controlled.

In Search of Heroes

Historians of large technological systems have long noted that narratives of their development are often short on the human element. The individual is dwarfed in the presence of complex technology, and the present text is no exception. The nuclear complex has turned men and women into functionaries. Many became tragic heroes as they strived to create the atomic age only to realize (if they could stomach the awful truth) that they themselves had become puppets of anonymous technological transitions. At the risk of sounding sentimental, it is painful to see how much idealism went to waste in the first atomic age.

In retrospect, it seems that nuclear energy had a peculiar ability to make people of all camps look stupid: scientists, engineers, operators, and even protesters, who attacked a monolithic nuclear complex that never was. To be sure, the "liquidators" (clean-up workers) of Chernobyl may qualify as heroes, but most people do not like to think of them that way (quite apart from the fact that they had little choice when commanders sent them to their clean-up jobs). In the ruins of Fukushima, another group of faceless laborers is currently doing its job outside the purview of the public. Another tragic turn of events: while the atomic age turned scientists into the priests of a new epoch, it depended on a supply of reserve labor to do the dirty work as long as radiation dosimeters allowed.

Nuclear energy made a lot of people look dumb, even those who sought a middle ground between the extremes. Take, for instance, the advisory Enquete Commission "Nuclear Energy Policy of the Future," which the West German parliament set up in November 1978. During several months of talks and negotiations, the issue of nuclear power proved more complex than both sides thought. In the end, the Enquete Commission successfully outlined a path towards a nuclear consensus, arguing for the development of different scenarios for the future that both camps could agree to. The commission's report outlined four possible energy paths, two with nuclear power and two without. The report noted that a decision for one of these paths was not imminent: not until 1990 was there a need to opt for one of the four paths. From an intellectual viewpoint, it was a brilliant idea, but also one that quickly got lost in the trenches of politics. For all its wisdom, the middle ground was an uncomfortable place to be.[23]

Fukushima has once more underscored the dilemma of individuality in the age of nuclear power: many people have lost face as a result of the disaster, and those who would deserve credit remain faceless. So the lack of human agency in nuclear history is probably not really a deficit. It may be how things are.

The Next Catastrophe

Some three decades ago, Charles Perrow changed our view on the risks of technological systems. Perrow had worked for the President's Commission on the Three Mile Island accident near Harrisburg, Pennsylvania. In his published conclusion, Perrow argued that Three Mile Island was an example of what he called "normal accidents:" due to the complexity of large technological systems, there was a technological rationale for little incidents to turn into disasters. Furthermore, Perrow suggested two pa-

23 Cornelia Altenburg, *Kernenergie und Politikberatung: Die Vermessung einer Kontroverse* (Wiesbaden: VS Verlag für Sozialwissenschaften, 2010).

rameters that determined the likelihood of such escalations: complex versus linear interaction between the individual components of technological systems and their tight versus loose coupling. The risk was particularly grave when interaction was complex and coupling close. In fact, Perrow provided a graph to rank technological systems according to these two parameters. The technology that came out as the most dangerous in this graph was nuclear power.[24]

Perrow's approach is helpful for a fuller understanding of the disaster at Fukushima Daiichi. From such a perspective, the earthquake and the ensuing tsunami were not simply an unfortunate coincidence; these natural events met with a technological system that tended to react unpredictably to these disturbances. The existence of no less than six reactor units in close proximity to each other—one of the key factors for the hazardous escalation after 11 March—was exactly the kind of close coupling that Perrow was talking about. In fact, Perrow's systemic approach suggests Japan was fortunate that engineers succeeded in stopping the escalation. The chain reactions, both nuclear and technological, eventually slowed down, the result of heroic and improvised actions that are still awaiting a scholarly investigation. Containment never collapsed completely and the reactors, though leaking, never turned into nuclear volcanoes spewing radioactivity into the water, ground, and atmosphere without inhibition.

One drawback of Perrow's scheme is that it focuses on the technological layout, thus downplaying the human element in the design, management, and collapse of technological systems. Perrow sensed that himself and his more recent publications highlight human agency, most notably with regard to deliberate manipulation of technological systems by terrorists—an obvious choice given the debates in post-9/11 America.[25] However, human agency in design decisions still appears notably undertheorized in the history of technological disasters, remaining an erratic element that seems to defy comprehensive analytical schemes.

With that, the call is to bring humans back in to the debate over technological hazards. The two defining technological disasters of 2010 and 2011, Deepwater Horizon and Fukushima, demonstrate what might emerge as a key theme for the sociology of technological disasters: how technological fixes become endpoints for disaster prep-

24 Charles Perrow, *Normal Accidents. Living with High-Risk Technologies* (New York: Basic Books, 1984).
25 Charles Perrow, *The Next Catastrophe. Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters* (Princeton: Princeton University Press, 2007).

aration. The failure of certain devices turns into a taboo even in the wake of abundant evidence that failures do occur. The blowout preventer, whose failure turned the Deepwater Horizon explosion into a massive oil spill, provides a case in point: emergency crews were clueless once the device had failed. In the absence of ideas and concepts, engineers started using a number of improvised devices that looked all the more embarrassing as they were put together under the watchful eye of impatient media crews. The blowout preventer was the last line of defense and thinking beyond it had obviously been discouraged, even though blowout preventers are inherently delicate pieces of technology. Like emergency cooling systems in light water reactors, they are lying dormant most of the time until called to duty, at which point they are supposed to function perfectly. Unsurprisingly, they have not done so in the past: according to a report for the U.S. Minerals Management Service of 1999, there have been 1,031 events where blowout preventers had failed between 1978 and 1999.[26]

Fukushima also highlighted similar taboos in nuclear disaster preparedness thinking: the failure of electric power supply. The loss of control occurred after the tsunami had destroyed the connection to the power grid and put the diesel-powered emergency units under water. The result was a frantic search for electric power that reportedly had engineers heading for their cars in order to rip out the battery. Once supplies were exhausted, it was carte blanche.

What all this comes down to is that we need a sociology of technological taboos. Why is it that planners and operators treat some emergency procedures as infallible, thus ignoring common-sense notions that everything is prone to failure? How did they impose these taboos, and what happened to people who disregarded them? The answers may relate to psychological and social aspects as well as to economic ones. Is it possible that large technological systems need these kinds of taboos in order to keep expenses for research and development within certain boundaries?

The Strange Renaissance of Energy Planning

In the wake of the Fukushima disaster, it became a matter of common sense that Germany needs to invest into renewable energy. The result was a plethora of blueprints

26 Per Holand, *Reliability of Subsea BOP Systems for Deepwater Application, Phase II DW,* SINTEF Industrial Management (7 November 1999), 38; available online at http://www.boemre.gov/tarprojects/319/319aa.pdf.

for what came to be called the "energy transition" (*Energiewende*). Authorities of all stripes came up with plans for sustainable energy production by 2030, 2040, or 2050, leaving this author to wonder whether they had really come to terms with what had happened. How were we to trust blueprints that ran decades into the future, now that the federal government had shown unable to sustain its nuclear policy of 2010 for just twelve months?

Fukushima and its aftermath has undermined the idea of long-range energy planning. To be sure, it was not the first such verdict. In a way, the entire path of nuclear energy is poised to cast doubts on the concept of energy policies that look decades into the future—especially when one recalls that nuclear energy once figured as the epitome of wise, science-based long-range planning. It seems that decision makers have yet to understand the full tragedy of the nuclear age: nothing happened as expected.

It would be bad enough if that merely showed an unwillingness to learn from history. However, the current penchant for long-range energy plans may also be a result of the merger of civic and state interests that lay at the root of the success story of German environmentalism. As I have shown elsewhere, politicians and administrators have embraced environmental issues because they have provided one of the last realms for massive budgetary expansion in the late twentieth century.[27] In the light of this finding, current energy planning looks like an act of wishful thinking, if not autosuggestion: governments can act as if their powers had not been eroded in the age of globalization, and states behave as if they still have the ability and wisdom to plan decades ahead. In all likelihood, future historians will talk about these plans with the same mixture of bemusement and contempt that we now bestow upon the nuclear plans of the post-war years.

To be sure, energy remains an important field of government policy, all the more so since replacing the 22 percent share of electricity that nuclear reactors provided in 2010 with sustainable alternatives is no mean feat. However, it would seem that clever energy policies would refrain from getting lost in distant decades and emphasize the challenges of the next few years. What can we do to encourage construction of new facilities and encourage diversity in ownership structures? How can we produce a steady and reliable

27 Frank Uekötter, *Am Ende der Gewissheiten: Die ökologische Frage im 21. Jahrhundert* (Frankfurt am Main: Campus, 2011), 109n.

stream of energy from sources like wind and sunlight that are subject to the moods of nature? And how can we react flexibly to the vagaries of future energy demands and avoid decisions that eventually turn into fateful path dependencies? All this calls for a new style of policy that sees energy paths as a work-in-progress, where the ability to respond to unforeseen events and unexpected side effects makes for the sophistication of policy. Self-reflection will be an important part of sustainable energy paths. If we can learn anything from the history of nuclear power, it is surely the need for constant learning.

It would not be surprising if we hear a sigh of relief from energy managers once they have shut down the last German reactor. If they have a sense for the ironies of history (unlikely, but nonetheless possible), they will thank the anti-nuclear movement, for it was their staunch opposition that allowed the utilities to come out of the first atomic age with a profit. More realistically, these managers might remember the trajectory of nuclear power as a cautionary tale. If one agrees with Markus Vogt, abandoning nuclear power was a moral imperative. As this essay has tried to show, it was also the end of a botched path of technological development. However, the full truth may only emerge decades from now; maybe abandoning nuclear power was good business, too.

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Markus Vogt

The Lessons of Chernobyl and Fukushima: An Ethical Evaluation

Energy is power—both technical and social. The way we manage our energy resources determines the development of both our economy and our society. A secure energy supply is thus not solely a technological or economic matter but a political and ethical question. This is especially true for nuclear energy, which opens up a Pandora's box of questions related to long-term investments, path dependencies, and different kinds of risks. Thus, the problem of energy supply cannot be solved by the free market alone; it requires ethical reflection and public dialogue. After Chernobyl and Fukushima, there is a pressing need for a reassessment of the potentials and risks of our energy supplies. The aim of this article is to provide an ethical assessment of current events and trends by introducing some thoughts from a Christian, socio-ethical point of view.

I. Diverse Reactions to the Catastrophes

Nuclear Energy as a Particularly Sensitive Issue in Germany

The accidents at Chernobyl on 26 April 1986 and at Fukushima on 11 March 2011 are the only nuclear catastrophes that have been rated the highest level (7) on the International Nuclear and Radiological Events Scale (INES). In Germany, the tragic accidents entailed serious political consequences. Only a few weeks after the incident at Chernobyl, the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety was founded. Partly as a response to the Fukushima disaster, the Green Party became the strongest party in a German state for the first time in history (Baden-Württemberg in 2011). Furthermore, the federal government in Berlin created the Ethics Commission on Energy Policy to work towards a quick phaseout of nuclear energy and to draft a strategy for a radical turn in energy policies, proclaimed one of the most important projects of the current coalition government.

Reactions in Germany have so far been quite isolated. Whether other nations will follow this ambitious path remains to be seen. The global demand for energy is so strong that it is unlikely that other countries relying on nuclear power will be able to abandon this technology any time soon.[1] Even in Germany, many doubt whether a nuclear phase-out is ethically appropriate or economically feasible.

The Power of Symbolic Interpretations and Contexts

The symbolic associations of nuclear power have shaped perceptions of Chernobyl and Fukushima and the political decisions they informed. During the 1950s, nuclear power became a symbol of economic progress and Great Power status in the Soviet Union, the United States, France, and other industrialized countries.[2] Consequently, political and economic elites have refused to consider phasing out nuclear power. The persistence of symbolic associations is particularly evident in the Ukraine, where support for nuclear energy remains strong. Despite suffering greatly from the Chernobyl disaster, the political establishment continues to believe in the safety and necessity of nuclear power and envisions the construction of about twenty new power plants.

Within the German environmental movement, by contrast, nuclear power has come to symbolize the ambivalence of technology. Here, nuclear power has been, and remains, an important catalyst of civic mobilization.[3] In this context, Chernobyl and Fukushima have become powerful political reference points in the German debate on ecology and environmental protection.

Hence, the debate on nuclear energy is not only based on a conflict of interests but also on a conflict of beliefs, posing a great challenge to common mechanisms of conflict resolution based on tolerance and reconciliation of interests.[4] The current challenge for scientific environmental ethics is to understand the reasons behind these contrasting perceptions of nuclear risk. In exposing deep-rooted problems in conventional risk assessment, the disasters at Chernobyl and Fukushima have highlighted the need

1 For further insight into the discussion in the EU, see Christian Hübner ed., *Atomunglück in Japan—Internationale Stimmungsbilder* (Sankt Augustin: Konrad Adenauer Stiftung, 2011).
2 Even though Soviet businesses revealed high levels of inefficiency, many—including high-ranking politicians such as Gorbachev—did not question the maxim of liberating progress through technology. See Joachim Radkau, *Die Ära der Ökologie: Eine Weltgeschichte* (Munich: C.H. Beck, 2011), 512.
3 The German environmental movement was strongly influenced by the anti-nuclear power demonstrations against Wyhl. See Markus Vogt and Jochen Ostheimer, "Politische Ökologie: Die Suche nach der guten Gesellschaft," *Politische Ökologie* 7 (2006): 13–7.
4 For a differentiation between conflicts of interests and conflicts of belief, see Wilhelm Korff, *Die Energiefrage: Entdeckung ihrer ethischen Dimension* (Trier: Paulinus, 1992), 232–35.

for a new concept of risk maturity that can assess complex, rather than calculable, dilemmas.[5]

Nuclear Energy from an Ecclesiastical Point of View

The introduction of nuclear power as a means of energy production has sparked significant religious debate. Original contributions of the Catholic Church include the rational approach of weighing the costs and benefits, as suggested by Wilhelm Korff in 1979;[6] Cardinal Höffner's more radical criticism of nuclear energy as unjustifiable; and, most recently, the commissariat of German Bishops coinage of the term "bridge technology" that characterizes nuclear power as a mere transition towards renewable energies rather than a progressive end in itself.[7]

A report from the German Bishops' Conference dating back to 2006 voiced its clear ethical opposition to nuclear energy:

> Whether nuclear power is a sustainable solution (regarding climate change) has to be doubted, since our reserves of uranium have to be imported and are limited. More importantly, the technology is associated with grave risks and challenges that have yet to be resolved (especially in terms of temporary and permanent storage), which may not be imposed on future generations. Nuclear technology is a clear violation of the principle of precaution and proportionality.[8]

5 "Risk maturity" refers to the fact that, given the many risks posed by modern technology and society, there is no such thing as "zero risk." At the same time, it suggests we must learn to avoid "systemic risks" through new strategies of risk analysis and risk management, as well as a greater awareness of the social conditions of risk acceptance. See Ortwin Renn, *Risk Governance: Coping with Uncertainty in a Complex World* (London: Earthscan, 2008); Jochen Ostheimer and Markus Vogt, "Risikomündigkeit—Rationale Strategien im Umgang mit Komplexität," in *Praxis in der Ethik: Zur Methodenreflexion der anwendungsorientierten Moralphilosophie*, eds. Michael Zichy and Herwig Grimm (Berlin: De Gruyter, 2008), 185–219.

6 Wilhelm Korff, *Kernenergie und Moraltheologie: Der Beitrag der theologischen Ethik zur Frage allgemeiner Kriterien ethischer Entscheidungsprozesse* (Frankfurt am Main: Suhrkamp, 1979); also see Korff, *Die Energiefrage*. On the Protestant side, most publications reject nuclear energy. Concerning the strong impact of confessional background, see Stephan Feldhaus, "Der Fall Kernenergie—ein Glaubensstreit? Kirche und Energieversorgung," in W. Korff, *Die Energiefrage*, 287–347.

7 See *Arbeitskreis Umwelt im Kommissariat der Deutschen Bischöfe: Zur Bewertung der Kernenergienutzung* (Bonn, 1996).

8 The German Bishops' Commission for Society and Social Affairs Commission for International Church Affairs, *Climate Change: A Focal Point of Global, Intergenerational and Ecological Justice*, 2nd ed. (Bonn: 2007).

After Fukushima, the bishops of Bavaria issued an even sharper critique of nuclear power:

> The catastrophe in the Japanese nuclear power plant Fukushima has again illustrated the limits of the power of humans. The residual risk of nuclear power is unforeseeable; the question of permanent storage has yet to be answered and cannot be imposed on future generations. The Bavarian Bishops do not consider nuclear power as a sustainable means of energy production. The phaseout of this technology is to be implemented as soon as possible and the period of the utilization of nuclear technology as a bridge technology is to remain as short and limited as possible.[9]

Protestant churches in Germany have also taken strong positions on the ethics of nuclear power, particularly on issues of permanent storage, risk assessment, and climate change.[10] For instance, after Chernobyl the Evangelical Church in Germany (EKD) issued a categorical renunciation of nuclear power, declaring that "the utilization of nuclear energy is incompatible with our responsibility for creation."[11]

At the same time, there have been, and still are, many supporters of nuclear power in the churches in Germany and abroad. On an international level, the ethical statements of Catholic representatives are mostly limited to an assessment of the preconditions for a responsible use of nuclear power, reminding us to not abandon the challenge to "shape" creation for the responsibility to protect creation.

Churches are in a unique position to foster an open dialogue with people from different backgrounds on the advantages and disadvantages of nuclear power. Given the different ways risks are perceived and evaluated, an interdisciplinary and international dialogue is vital if we are to craft a common and responsible strategy for managing the long-term and long-range risks of nuclear, fossil, and renewable energies.[12]

9 "Erklärung der Freisinger Bischofskonferenz," *Erzbistum München und Freising*, (March 2011) http://www.erzbistum-muenchen.de/page007538.aspx?newsid=21484. While the Bavarian bishops issued the most concise formulation, several other Catholic bishops argued along the same line. The Pontifical Academy, on the other hand, supports the peaceful utilization of nuclear energy.

10 Statements made by the EKD spokesperson for environmental issues, Hans Diefenbacher, on nuclear energy and climate protection are especially relevant. Since 2007 the EKD actively supports projects for CO2 compensation.

11 The Evangelical Church in Germany (EKD) reemphasized their categorical rejection of nuclear power in 1998 and 2006.

12 Wilhelm Korff, "Schöpfungsgerechter Fortschritt: Grundlagen und Perspektiven der Umweltethik," *Herder Korrespondenz* 51(1997): 78–84.

II. Will there be a "Renaissance" of Nuclear Power?

Chernobyl as an Interruption of the Global Development of Nuclear Energy

As of March 2012, there were 435 nuclear power plants operating in thirty nations around the globe. Another sixty plants were under construction.[13] The six major producers of nuclear power (USA, France, Japan, Germany, Russia, and South Korea) provide about two-thirds of the total amount of nuclear energy. However, the so-called "renaissance" of nuclear power proclaimed by the media is a chimera: on a global scale, the share of nuclear energy has been steadily declining since 2002. In 2008 no new reactors became operational, a first in the history of commercial production of nuclear power; in 2009, there was only one.[14] Nuclear energy is losing ground in both absolute and relative terms.

Chernobyl had an important but uneven impact on attitudes towards nuclear power. As the graph below illustrates, there has been a decline in new reactors and a rise in reactor shutdowns since the 1980s. This trend, it should be noted, does not apply to the countries of the former Soviet Union, where the social forces needed to channel the momentum stirred by the catastrophe towards support for alternative energy have not materialized.[15]

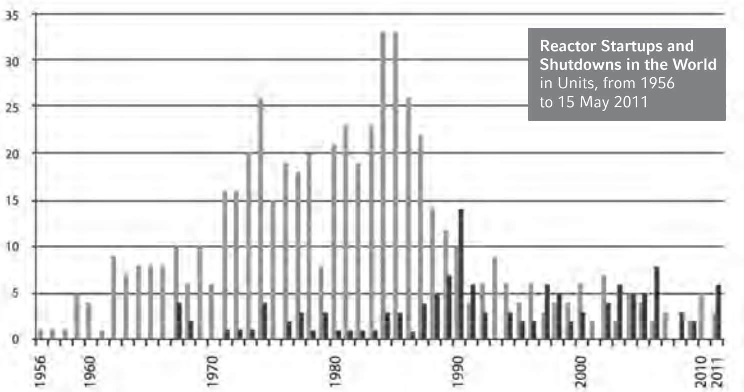

Figure 1
IAEA-PRIS (Power Reactor Information System), modified by Mycle Schneider

13 Current statistics can be found at www.world-nuclear.com. For a fuller analysis, see Mycle Schneider, Antony Froggatt, and Steve Thomas, *Nuclear Power in a Post-Fukushima World: 25 Years After the Chernobyl Accident*, The World Nuclear Status Report 2010-2011 (Washington, DC: Worldwatch Institute, 2011).

14 Mycle Schneider, "Renaissance oder Technologie-Geriatrie? Stand und Perspektiven der Atomindustrie weltweit," *Amos International* 1 (2010): 3–11.

15 Radkau, *Die Ära der Ökologie*, 513.

The data on the development of atomic energy has to be seen in the context of the general development of global energy markets. In 2007, nuclear power contributed about 14 percent to the total amount of electrical power, amounting to a mere 5.5 percent of the global commercial use of "primary energy." Looking at the share of nuclear power in total "final energy," the percentage shrinks to 2 percent.[16] Despite the plans of several countries to join the nuclear club or expand their production capacity, a comprehensive study carried out by the OECD suggests that the number of reactors will decrease even further, citing a lack of funds, expertise and planning reliability.[17]

Contrary to some accounts, a "renaissance" of nuclear energy is not currently taking place. On the other hand, the controversies concerning nuclear power have both influenced and complicated debates on ecology and the environment. As the energy sector is characterized by long-term decisions and considerations, and reactions to the accident in Japan are slow, we must wait to see what impact, if any, Fukushima will have on the development of nuclear power.

The "Fast" Breeder: Disappointed Hopes

Another controversy regarding nuclear power is the extent of uranium reserves. In 2009, Prognos calculated that reserves are likely to last for another fifty years.[18] Skeptics, on the other hand, argue that this number has remained unchanged for years and thus should not be taken as a reliable indicator, especially since rising demand, changing prices, and the resulting increase in exploitation have not been taken into account. Prices for uranium are likely to rise in the future, given the declining production of uranium mines and the end of supplies from nuclear disarmament in 2013.

The technology of breeder reactors, which depends on plutonium and recycled atomic waste, would potentially decrease the pressure on uranium reserves by allowing for more efficient use. Moreover, breeder technology has the advantage of decreasing the radiation of the atomic waste (to "only" three or four hundred years). The fact that

16 Schneider, "Renaissance oder Technologie-Geriatrie?" 5. The term "primary energy" refers to energy as we find it in nature. It is contained in raw fuels and other forms of energy received as input to a system. "Final energy" (also known as "end energy") is that part of energy destined for or used by the consumer. The exact definition of "end energy" is controversial in the scientific literature.

17 Matthias Deutsch et al., *Renaissance der Kernenergie? Analyse der Bedingungen für den weltweiten Ausbau der Kernenergie gemäß den Plänen der Nuklearindustrie und den verschiedenen Szenarien der Nuklearagentur der OECD* (Berlin: Prognos, 2009), 42–59.

18 Ibid., 47–9.

these reactors can also be fuelled by thorium—abundant in India and elsewhere—would further ease the pressure on global uranium reserves. However, more research into this technology is necessary before building up hopes for a solution to our climate and energy worries, especially given the disastrous track record of breeder reactors. The British breeder reactor never reached more than 15 percent of its total capacity before it was shut down in 1992. Likewise, the French *Superphénix* reactor was only operational for 11 years before it was closed down in 1997. The fate of breeder reactors suggests that nuclear power has already passed its peak. It is no longer a symbol of technological progress, but rather a leftover liability from yesterday's utopia.

III. The Ethics of Risk after Chernobyl and Fukushima: Making Space for Discussion

Nuclear Energy Does Not Contribute Significantly to Climate Protection

An important ethical argument supporting nuclear energy is its contribution to climate protection. Though this position has some merit, its scope is limited. As stated above, nuclear power accounts for about 14 percent of our global electricity supply and 5.5 percent of the global commercial use of primary energy. These numbers prove that nuclear energy cannot contribute significantly to the reduction of CO2 on a global scale. The persistent belief in the promise of nuclear power distracts from the more complicated challenge of transforming our model of economic wellbeing.[19]

It makes little sense to play one catastrophic risk off another. Given their global nature, the risks related to climate change are no less dramatic than the risks related to nuclear technology. Hundreds of millions of people are already suffering from the consequences of climate change, which often aggravates situations of extreme poverty.[20] Given the urgency to limit climate change, a phaseout of nuclear energy cannot be facilitated by a renewed over-reliance on fossil fuels.

19 Markus Vogt, "Wohlstand neu denken: Ethische Bewertung der Kernenergie und der Ausstiegsoption," *Herderkorrespondenz* 1 (2010): 48–53.
20 Cf. Markus Vogt, "Climate Justice," *Rachel Carson Center Perspectives* 3, 30–46 (2010).

Nuclear Energy is a Violation of the Principle of Intergenerational Justice

The question of temporary and permanent storage of the nuclear waste has yet to be answered. Nobody can guarantee a stable society for 10,000 years, the precondition for the secure storage of the fuel rods. According to Robert Spaeman, the exceptional fragility of our technological civilization lies in its inability to guarantee the management of high-risk technology in the future.[21]

Nuclear waste, in particular, requires long-term risk management. In Germany, leaked reports about the contamination of groundwater and the possible collapse of the temporary storage facility *Asse* II in Lower Saxony have eroded public confidence in the assurances of scientists, politicians, and the operators of the nuclear factories. The issue of the disposal of nuclear waste has also triggered conflicts on the international level: reports about China dumping its nuclear waste in Tibet sparked intense public outrage, while Sweden has filed complaints about Russian nuclear waste in the Baltic Sea that threatens the ecological balance of the semi-enclosed marine environment.[22]

The use of nuclear energy, therefore, appears reckless. We don't have the right to risk turning whole regions into "no-go areas" for thousands of years to come. According to Spaeman, we are not responsible for the wellbeing and the prosperity of future generations—this they have to accomplish on their own. But it *is* our responsibility to pass on the basic conditions of wellbeing undiminished. We are not entitled to deprive them of the natural resources that we ourselves have inherited.[23]

As long as the problem of permanent storage remains unsolved, the use of nuclear energy constitutes a violation of the principle of precaution and the principle of intergenerational justice as guaranteed in many national constitutions, including the German Basic Law (Grundgesetz Art. 20a). These principles should be backed by an assessment of the basic resources necessary for future generations.

21 Robert Spaemann, "Nach uns die Kernschmelze," *Frankfurter Allgemeine Zeitung*, 6 October 2008, 33.
22 Christina Heischmidt, "China's Dumping Ground: Genocide Through Nuclear Ecocide in Tibet," *Penn State. Environmental Law Review* 213 (Winter 2010); "Sweden wants explanation for Baltic nuclear 'dumping'," *BBC News*, 5 February 2010, http://news.bbc.co.uk/2/hi/europe/8499762.stm.
23 Robert Spaemann, *Nach uns die Kernschmelze: Hybris im atomaren Zeitalter* (Stuttgart: Klett-Cotta, 2011), 7 and 11.

An Underestimation of the Risk of Human Errors

The long-term risks of nuclear power—projected over millennia—also create new structural problems of responsibility.[24] In our technologically-driven civilization, the concept of responsibility needs to encompass increasingly complex scenarios. Decision-making has become more complex as a result of the high level of insecurity and unpredictability surrounding extremely unlikely risks—risks that might cause extreme unanticipated damages. Current models and prognoses have generally failed to take into account the contextual interdependence between technology and its social environment. As Chernobyl and Fukushima painfully illustrate, human error as a risk factor has been systematically underestimated. It was human, not technical, failure that ultimately led to the catastrophe at Chernobyl.[25] Human errors also exacerbated the problems at Fukushima, including the insufficient maintenance of the cooling system and the reluctance to accept professional support in managing the catastrophe. Under these circumstances, the ethics of responsibility must become an ethics of risk, with a logic not based on linear models, but on a kind of rationality grounded in complex and systemic thinking.[26]

The Dangers of Military Misuse

Nuclear plants, especially those situated in densely populated areas, represent attractive potential targets for terrorists since they can exponentially increase the damage caused by their weapons. At the same time, uranium—that precious provider of energy—can become weaponized. In June 1995, a commission of enquiry forced the federal government of Germany to admit the disappearance of 2,200 tons of uranium. In the case of plutonium, the fuel cycle is very difficult to control, thereby increasing the risk of nuclear material being “lost” in the process, with potentially grave consequences.

Nor should we neglect the risk that states might use the peaceful technology of nuclear energy for non-peaceful ends. The current discussion about Iran’s nuclear ambi-

24 Hans Jonas, *Das Prinzip Verantwortung: Versuch einer Ethik für die technologische Zivilisation* (Frankfurt am Main: Suhrkamp, 1984), 20.

25 Christine Frenzel and Edmund Lengfelder, “25 Jahre nach der Tschernobyl-Katastrophe—ernste Gesundheitsschäden auch im Westen,” *umwelt-medizin-gesellschaft* 1 (2011): 9–14. This publication suggests that the human errors at Chernobyl can be traced back to a lack of transparency and the inability of the system to react quickly. Concerning the failure of the security system, see Dietrich Dörner, *Die Logik des Mißlingens: Strategisches Denken in komplexen Situationen* (Reinbek bei Hamburg: Rowohlt, 1992).

26 Ostheimer and Vogt, “Risikomündigkeit,” 185–219; Markus Vogt, *Prinzip Nachhaltigkeit: Ein Entwurf aus theologisch-ethischer Perspektive* (Munich: Oekom, 2009), 305–85.

tions is an exemplary case. The greater their international insecurity, the more some governments will be inclined to increase their military and political standing by acquiring nuclear arms.[27]

These facts have to be seen in the light of the changing nature of war in the twenty-first century. The events of 9/11 have dramatically altered the global political landscape. Nevertheless, the attacks on the World Trade Center should not be considered a single military event but rather the result of a changing security situation. The vulnerability of Western societies, especially at strategic energy and nuclear facilities, has been recognized as an important challenge for national security policy.

In sum, the arguments supporting the use of nuclear power are not ethically justifiable. Today, the pressing question is not whether nuclear energy in itself is good or bad—it just is—but rather how to responsibly manage its phaseout. It is for this reason that an ethical approach of weighing different interests and public goods against one another, including economic ones, is absolutely essential.

IV. Nuclear Technology in the Context of Business Ethics

The affordable and secure supply of energy is a very important social good and nuclear power contributes to this end. However, the low prices for nuclear energy are only possible because the risks and the high costs of scientific research and construction are not taken into account. Given the increasing global demand for and dependency on energy, we are clearly heading towards a crisis. Against this backdrop, nuclear energy and its side effects might appear to be the lesser evil. In order to adequately assess its true costs and benefits, we must take economics into account.

The Hidden Costs of Nuclear Energy

How much does electricity derived from nuclear power actually cost? The calculations range from a few cents to more than two Euros per kilowatt-hour.[28] These strongly differing perceptions are based on diverging views on how to account for the value

27 Special issue, "Ambition and Peril: Nuclear Energy and the Arab World," *Perspectives: Political Analysis and Commentary from the Middle East* 1 (April 2011), www.boell-meo.org/web/114-574.html.
28 Deutsch et al., "Renaissance der Kernenergie?"

of investments, the provision of security and the costs for storage. Until now, these costs—both in Germany and worldwide—have usually been covered by the state, the provision of energy being deemed an important public good.

In this discussion, I will focus on the amount of money covered by liability insurances for nuclear power plants. In Germany, the amount covered is capped at 2.5 billion Euros. The catastrophe in Fukushima has shown that this amount is absolutely insufficient. In 1992, *Prognos* calculated for the German Ministry of Economics that an additional 3.60 DM (approximately 2.15 Euros) would have to be added to the price per kWh if all insurance costs were to be covered.[29] This number still excludes the risks deriving from terrorist threats or human error. Consequently, it is an ethical as well as an economic imperative to raise the compulsory coverage in order to allow for a fair competition between different means of energy production.

Insurance policies should be also be standardized internationally, as the damages of a potential catastrophe are unlikely to be contained within national boundaries. Indeed, throughout Europe nuclear power stations are predominantly built close to international borders in order to displace risk across national boundaries. For instance, about 70 percent of the damage caused by the accident at Chernobyl was inflicted on Belarus.[30] An all-embracing compulsory insurance for nuclear power plants would require a market-based mechanism to internalize the costs of nuclear power, leaving the choice to consumers and producers.

The current utilization of nuclear power is not only contrary to ethical sanity and reason but also to economic rationality. The differing calculations of the costs of a phaseout and the costs for alternative energy systems are based on shaky methodological ground, the underlying presumptions of which need to be urgently reassessed.[31]

Economic Prospects of Alternative Energy Scenarios

To truly gauge the economic efficiency and feasibility of different kinds of power, one must move beyond an exclusively demand-side analysis. Though revenues and benefits

29 "Externalisierte Kosten der Atomkraftnutzung," *Zukunftslobby* (2008), http://www.zukunftslobby.de/Tacheles/prognstu.html.
30 Frenzel and Lengfelder, "25 Jahre nach der Tschernobyl-Katastrophe," 10.
31 Hans-Jochen Luhmann, "Politik als Rechenaufgabe: Jeder kalkuliert die Kosten des Atomausstiegs nach Interesse, niemand kalkuliert die Gewinne," *Süddeutsche Zeitung,* 30 April 2011, 2.

are important, we must also take into account the prosperity of users and the interdependence of technical and sociocultural factors. It is a common mistake to think we can change our energy use by merely replacing fossil fuels with renewable energy, rather than by reforming the entire system of production. The true potential of renewable energies lies in the efficiency created by the synergistic effects of decentralized production. When one takes into account such factors as cogeneration (combined heat and power, or CHP), the declining need for infrastructure and "ecological mending," incentives for high-level employment and new export markets, the many advantages of renewable energies become evident.[32]

Simply put, the most economical, least risky, and quickest way to increase the amount of energy available is cutting down on what is currently consumed. For this, fundamental changes in both consciousness and technology are necessary. As structural changes take time, a prompt initiation of this process is ethically necessary, economically sensible, and politically imperative.

While the costs for renewable energies are predicted to drop in the future, the prices for nuclear and fossil energy are expected to rise. Predicted to remain the cheapest source of energy through the middle of this century, nuclear power will become progressively more expensive as costs (for uranium, construction of new plants, etc.) rise. In Germany, investments in research for renewable energy and for more systemic efficiency, while laudable, are still dwarfed by the funds allocated to the development of nuclear technologies—an imbalance that can be found in most countries around the world.

Reconceptualising Economic Prosperity

Cleary, the phaseout of nuclear energy is imperative. However, given the urgency of the problem of climate change, this phaseout must not result in an increasing reliance on fossil fuels; rather, it should be the starting point for a sustainable system of energy provision. This requires nothing short of a "green" industrial revolution, based on a radical change in economic models, technological innovations, and individual lifestyles.

32 Hermann Scheer, *Energieautonomie: Eine neue Politik für erneuerbare Energien* (Munich: Kunstmann, 2005).

A phaseout of nuclear energy that is compatible with climate protection is only possible if we reconceptualize economic wellbeing and adapt our economic and social development accordingly. Energy and financial funds are prerequisites for a path of development that aims to improve the quality of life of everyone. A transformation of our model of economic wellbeing is thus a precondition for a sustainable solution to our energy problems.

Cheap energy, like "cheap money," is a tool to generate growth over the short term.[33] The financial crisis has clearly revealed that these policies do not lead to sustainable development. Cheap energy is shortsighted and brings many unwanted consequences, pollution being only one. The maxim of "faster, higher, further" is neither suitable for the future nor for the ongoing process of globalization. Temperance may not be the strongest virtue of modern society, but it represents one of our best chances to increase quality of life and promote development.[34]

A decentralized energy supply, strengthened by the utilization of renewable sources of energy, is closely tied to the decentralization of democratic structures in our society. This offers many opportunities to reduce risks and to encourage democratic participation in our complex world.[35]

V. A Reorientation after Chernobyl and Fukushima

Chernobyl as a Catalyst for the Collapse of the Soviet Union

The most decisive consequence of the catastrophe in Chernobyl was not a wave of fundamental criticism of nuclear energy, but rather a further erosion of the already strained power of the Soviet Union. According to Joachim Radkau,

> Gorbachev assumed that the accident in the reactor in Chernobyl … might have been more central to the breakdown of the Soviet Union than the process of *perestroika* that [he] had initiated. Chernobyl marks a historic turning point: there was the time before the catastrophe, and then there was the time after the catastrophe,

33 Markus Vogt, "Das gerechte Geld," *Christ in der Gegenwart* 7 (2011): 77–8.
34 Tim Jackson, *Prosperity Without Growth: Economics for a Finite Planet* (London: Routledge, 2009).
35 Renn, *Risk Governance*, 273–83.

> which was completely different. More than anything, Chernobyl has helped to bring about freedom of speech. The system as we knew it could no longer exist, and it became clear how important the continuation of the Glasnost policy actually was.[36]

For Radkau the accident undermined national and international confidence in technological progress, as well as in Soviet crisis management, an important facet of political legitimacy. Especially with the waning of Marxist ideology since the 1980s, this blow to Soviet technical self-confidence has had highly destabilizing effects throughout the former Soviet states.[37]

The Need for Further Research

To this day, estimates concerning the number of victims of Chernobyl vary greatly, from several thousand to one million.[38] And we still know very little about the approximately 5.7 million people "affected" by the catastrophe.[39] Remarkably, the memory and the perception of the consequences vary significantly within Ukraine and internationally, depending on different cultural and political conditions.

Overall, the causes and effects of the accident in Chernobyl have not been sufficiently analyzed. In order to learn from history and to move towards a more responsible attitude concerning energy production, this shortcoming should be addressed by both civil society and academia. But mere analysis will not suffice. We also need concrete and

36 See Radkau, *Die Ära der Ökologie*, 506.

37 Ibid., 498–519, especially 512.

38 In 1991, the IAEA, WHA, and FAO published a joint report that denied there were any deaths traceable to the events in Chernobyl. In 2000, IAEA confirmed these results. See Frenzel and Lengfelder, "25 Jahre nach der Tschernobyl-Katastrophe," 9–14, especially 10f. In contrast, even the Russian Ministry of Emergency Situations estimates that the disaster in Chernobyl has claimed approximately 300,000 deaths. See Radkau, *Die Ära der Ökologie*, 501. Data on the physical consequences of the accident have not been fully disclosed. At the same time, numbers have been exaggerated with the goal of securing subsidies or winning public attention. The collection and analysis of the data is unlikely to yield concrete results because of methodological difficulties: the physical effects of the radiation can only be assessed over a long term, they are not monocausal, and they are highly dependent on individual sensitivities. More research is needed in this field. One of the most sound and widespread studies about the Chernobyl incident, carried out by a group of Russian experts, estimates that about one million people fell victim to the catastrophe. See Aleksej V. Jablokov, Vassily B. Nesterenko, and Aleksey V. Nesterenko, "Chernobyl: Consequences of the Catastrophe for People and the Environment," *Annals of the New York Academy of Sciences*, vol. 1181 (2009).

39 Frenzel and Lengfelder, "25 Jahre nach der Tschernobyl-Katastrophe," 9. By "affected" I mean those people exposed to levels of radioactivity considered dangerous. Since a large proportion of "affected" live without any apparent problems (so far), the number of "victims" is much smaller. For sophisticated scientific research in the field of medical health, see Sebastian Pflugbeil et al, *Gesundheitliche Folgen von Tschernobyl* (Berlin: International Physicians for the Prevention of Nuclear War, 2006), 1–76.

tangible solidarity, as displayed in the invitations to hundreds of thousands of children suffering from the effects of radiation to spend vacations in European countries.[40] The involvement and engagement of the Ukrainian people is crucial in this endeavour. To remember the suffering of the past is the first step towards change. It is a central task for Christians to give voice to those whose experience has been forgotten and neglected because they do not fit acceptable social or political models.

The Unpredictable Nature of Cultural Memory

The political half-life of the memory of catastrophe is usually short. Many people are torn regarding their perception of the nuclear accidents in Chernobyl and Fukushima: the fears and insecurities generated by the events are pushed aside by their habitual patterns of thinking and acting. While the mood has changed, actions and policies have not. In a way, this is a typical post-modern phenomenon: the reluctance and even inability to let go of certain symbols of modernity, even though they have lost their persuasive power.

There are no reliable assessments of the consequences and the future developments triggered by the accident in Fukushima. The interplay between earthquake, tsunami, and nuclear accident render causal assessment difficult, if not impossible. What is apparent is that the perception of the events is strongly shaped by cultural backgrounds. A comparison of the disasters in Fukushima and in Chernobyl demonstrates crucial differences in causes, management, and interpretations of risks. From this we can conclude that a sound analysis of nuclear risks requires an appreciation of cultural context. The different reactions around the world have demonstrated that social and political conditions have an overwhelming impact on the assessment of nuclear technology.[41]

40 See "Tschernobyl Kinderhilfe" www.tschernobyl-kinderhilfe-online.de/presse.html as well as the "Renovabis Exposition 2011," www.renovabis.de/aktuell/pfingstaktion/pfingstaktion-2011.

41 As of May 2011, it seems unlikely that Fukushima will inspire a change in our perception of nuclear energy. Italy and Japan have frozen all plans for the construction of additional nuclear power plants as a reaction to the Fukushima incident. China, the United States, India, Brazil, and Russia are sending varied and unsteady signals, but a continuation of the current policies, albeit under improved security standards, and a delay of the construction of further factories seems like the most probable scenario at present. See Schneider, Froggatt, and Thomas, *Nuclear Power in a Post-Fukushima World*, 11–9.

The Lessons of Chernobyl and Fukushima

The great hope that nuclear power would solve our energy issues has dissipated over the last several decades. At best, it has become a "bridge technology," a transition stage in technological evolution. In the long run, there is no alternative to renewable energies. Fossil and nuclear energy should only be considered as steps along this route.

These, then, are the ethical lessons of Chernobyl and Fukushima:

1. A technology that is based on the presumption of perfect human agency is irresponsible. We need a technology that is able to *tolerate mistakes* and is manageable in various political and cultural contexts.

2. Even hypothetical risks need to be taken seriously and dealt with according to the *principle of precaution*. This principle demands coherent stress tests for all nuclear power plants, not just in Germany, but within the EU and, in the long run, the world.[42]

3. There are no technologies without risks. In order to deal with them adequately a *sense of proportion*, as well as systemic thinking, are essential for an ethics of responsibility and for modern risk government.[43]

4. Risk is always a dependent variable of social perceptions and priorities. Since there is no scientifically unambiguous assessment of the risks posed by nuclear radiation, *discursive strategies* are extremely important.[44]

5. Remembering and showing *solidarity with the victims* of Chernobyl and Fukushima is an integral part of this task.

6. In the face of irreconcilable differences, politics must strive for a *fair and transparent system of conflict management* and allocate costs and benefits in a just way.

42 The principle of precaution is not an element of US environmental law. See Radkau, *Die Ära der Ökologie*, 518f.
43 This is a proposal to advance the method of "ethics of responsibility," as Max Weber suggested. Max Weber, *Politik als Beruf* (Stuttgart: Reclam, 1993; first published in 1919). Cf. Markus Vogt, "Grenzen und Methoden der Verantwortung in der Risikogesellschaft," in *Fortschritt und Risiko: Zur Dialektik der Verantwortung in (post-)moderner Gesellschaft,* ed. Jan Beaufort, Edmund Gumpert, and Markus Vogt (Dettelbach: J.H. Röll, 2003), 85–108.
44 Renn, *Risk Governance*, 93–7 and 201–351.

7. In order to comply with fair and just market-based mechanisms, the *limited coverage for compulsory insurances* needs to be raised.

8. A phaseout of nuclear energy cannot be achieved in isolation; instead, it requires a revision of our energy and economic policy. We need a *new model of economic prosperity.*

9. A necessary starting point of this change is investment in renewable energy and technology to reduce our consumption. It's a *political duty to act now*, because the self-regulation of markets will come too late.

10. The way we approach this historical project is a crucial test of whether our society is ready to accept its *responsibility for creation* and the shaping of the future.

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A Farewell to Residual Risk? A Legal Perspective on the Risks of Nuclear Power after Fukushima.

Following the "slow-motion catastrophe"[1] that unfolded at Fukushima in March 2011, the German political establishment reacted by accelerating its controversial phaseout from domestic nuclear energy production the following June. Proponents of nuclear power regard this to be a premature end of the non-military use of nuclear energy;[2] as far as they are concerned, Germany's nuclear safety record has not been compromised by the Japanese reactor disaster. On the contrary, they argue that a rash jettisoning of nuclear technologies will weaken energy safety in Germany. For many pro-nuclear advocates, it is ultimately hypocritical for Germany to halt the domestic production of nuclear power while continuing to import it from neighbouring countries. Critics of nuclear power, on the other hand, consider the accelerated exit strategy long overdue.[3] Coming after Three Mile Island and Chernobyl, Fukushima was hardly just another isolated accident; the Japanese reactor debacle—with its catastrophic human, social, ecological, and economic consequences—proved once again the latent dangers of nuclear power plants. For opponents of nuclear power, no measures to minimize the risks, however drastic, can give humans the right to subject successive regions of the earth to atomic meltdown. They reject the pro-nuclear argument that Germany cannot afford to forego nuclear solutions to its energy economy; on the contrary, they maintain that as long as nuclear energy continues to be a viable option, there will be no concerted effort to develop alternative energy sources.

In the spring and early summer of 2011, the two sides fell back on these well-rehearsed arguments: the charge of hysteria was levelled at those in favour of the exit strategy, while those against it were accused of marching blindly towards the apocalypse.[4] But in the elections on 27 March 2011 the citizens of the federal state of Baden-Württ-

1 Frank Rieger, "Wir haben Dämonen geschaffen," *Frankfurter Allgemeine Zeitung*, 12 April 2011, 29. "Zeitlupen-Katastrophe" in German.
2 Konrad Kleinknecht, "Abkehr vom Klimaschutz?" *Aus Politik und Zeitgeschichte* 61, no. 46–47 (2011): 29.
3 Robert Spaemann, *Nach uns die Kernschmelze: Hybris im atomaren Zeitalter* (Stuttgart: Klett-Cotta, 2011), 7ff.
4 Frank Schirrmacher, "Sie nennen es Hysterie," *Frankfurter Allgemeine Sonntagszeitung*, 3 April 2011, 23; Martina Heßler, "Unsere Scham vor der Maschine," *Frankfurter Allgemeine Zeitung*, 2 April 2011, 33. For a historical perspective, see Philipp Gassert, "Popularität der Apokalypse: Zur Nuklearangst seit 1945," *Aus Politik und Zeitgeschichte* 61, no. 46–47 (2011): 48; and Frank Uekötter, *Am Ende der Gewissheiten: Die ökologische Frage im 21. Jahrhundert* (Frankfurt am Main: Campus, 2011), 155ff.

temberg ousted their government, a strong supporter of nuclear energy. The federal government got the message. Although Chancellor Merkel had announced at the end of 2010 that the phaseout of nuclear energy—negotiated by the Schröder government in 2002—would be delayed, after Fukushima it was re-started. The government did not, however, announce an immediate shutdown of nuclear energy. Instead, it proposed a "delayed acceleration" of nuclear phaseout: the final shutdown of the last nuclear reactor in the Federal Republic is not scheduled until 31 December 2022. Therefore, some questions need answering: Can we really talk about a "reaction" to the Japanese reactor meltdown if the final exit won't happen for a whole decade? Furthermore, shouldn't the exit be immediate if people, environment, and economy are all out on a limb? Is this really the farewell to residual nuclear risk?

The answers to these questions must take into account the complex relationship between humans and their energy sources. As environmental historians have shown, this relationship has never been entirely "rational," at least not since industrialization fed the energy appetites of Western, and now global, modernity. This is particularly true of atomic energy. For John McNeill, the "strange career of nuclear power" has proven to be both unpopular and uneconomical.[5] The promise of the 1950s—that nuclear power would make energy "too cheap to meter"—ignored the costs of both investment and production. Reactor disasters and the political "metaphysics of radioactive waste storage" have already yielded very real social and environmental consequences.[6] As McNeil points out, "[s]ome nuclear wastes and part of Chernobyl's fallout will be lethal for 24,000 years—easily the most lasting insignia of the twentieth century and the longest lien on the future that any generation of humanity has yet imposed."[7] In this sense, environmental history offers a valuable "critique of prophetic sense," which Peter Sloterdijk warned us of with regard to climate change and that applies equally to the non-military use of nuclear energy as well.[8]

5 John R. McNeill, *Something New Under the Sun: An Environmental History of the Twentieth-Century World* (New York: W.W. Norton & Co., 2000), 312.
6 Peter Sloterdijk, *Zorn und Zeit: politisch-psychologischer Versuch* (Frankfurt am Main: Suhrkamp, 2006), 146.
7 McNeill, *Something New*, 313. For a perspective on inter-generational justice, see Cass R. Sunstein, *Worst-case Scenarios* (Cambridge, MA: Harvard University Press, 2007), 266.
8 Peter Sloterdijk, "Wie groß ist 'groß'?" in *Das Raumschiff Erde hat keinen Notausgang,* eds. Paul J. Crutzen et al. (Berlin: Suhrkamp, 2011), 96; for a historical perspective, see Frank Uekötter, "Fukushima and the Lessons of History: Remarks on the Past and Future of Nuclear Power," in this issue.

The work of Ulrich Beck has been crucial in re-shaping our ideas of energy and risk. In his book *Risk Society*, Beck analyzes social reactions to risks that have the potential to visit large-scale destruction on our civilizations.[9] He describes the 1986 Chernobyl reactor disaster in terms of the conceptual triad of "residual risk, residual hope, and residual activity" (*Restrisiko, Resthoffnung und Restaktivität*) and shows how nuclear risks are actively ignored by society.[10] Since Chernobyl, the communicative parameters of nuclear accidents have changed. In the reactor catastrophe at Fukushima we have seen how the tense relationship between the triad of residual risk, residual hope, and residual activity has been further intensified by strategic disinformation policies of energy corporations and national governments.[11] In addition, Fukushima quickly became old news in the media circus of our information-powered society. While Fukushima no longer dominates the headlines, the nuclear disaster in Japan is by no means over. These are some of the ambivalent ways that the global risk society and the global information society are inseparably linked.

In Beck's triad, "residual risk" is the key term for a political understanding of "risk society." Risk societies constitute themselves when risk-taking becomes socially risky.[12] Historically, people have always taken risks. They must act in the face of potentially negative outcomes, whether in agriculture, trade, or war. People have always been—and still are—presented with the choice of acting (or not) to prevent negative consequences. Yet, over the course of industrialization, public and private law have increasingly regulated the framework for risk acceptance and prevention, constituting a legal safety net for social risk-taking. For Beck, these legal provisions constitute the social "risk contract."[13] This contract is based on the principle that risks can be controlled and/or compensated. That is to say, risks can be taken provided that technical preventative measures are in place and that, in the case of damages, there is some form of compensation or insurance. In contrast to this social normalization and

9 Ulrich Beck, *Risikogesellschaft* (Frankfurt am Main: Suhrkamp, 1986). Published in English as *Risk Society: Towards a New Modernity*, trans. Mark Ritter (London: Sage Publications, 1992). The discussion of the Chernobyl disaster (which took place shortly before the book was published) is in an introduction to the German edition that was omitted in the English translation. Citations thus refer to the German text.

10 Ibid., 7ff.

11 Albert Ingold, *Desinformationsrecht: Verfassungsrechtliche Vorgaben für staatliche Desinformationstätigkeit* (Berlin: Duncker & Humblot, 2011).

12 Ulrich Beck, *Weltrisikogesellschaft. Auf der Suche nach der verlorenen Sicherheit* (Frankfurt am Main: Suhrkamp, 2007), 19ff., 24ff. Published in English as *World at Risk*, trans. Ciaran Cronin (Cambridge: Polity Press, 2009).

13 Ibid., 25.

legal containment of risks, a "risk society" emerges when risks surpass regulatory measures. A society develops into a risk society when, as with nuclear energy, there is residual risk of an uncontrollable and uncompensatable damage, despite technical measures of prevention.[14]

The legal significance of residual risk for the analysis of risk society becomes clear if we take a constitutional perspective. According to the German Federal Constitutional Court (*Bundesverfassungsgericht*), any event that causes "damages of apocalyptic proportions [must] be *effectively* eliminated according to the current state-of-the-art of science and technology."[15] Risk society, then, only admits to residual risk in theory. Even if a nuclear residual risk theoretically exists, the chance of it actually occurring must be effectively eliminated in order to be constitutional. Sloterdijk underlines this marginalization of residual risk: "risk 'society' is *de facto* one in which true risk-taking is prohibited."[16] In other words, risk societies tend to ignore or to banish residual risk from political discourse. Thus, the bickering about the existence of nuclear residual risk as a "worst-case scenario,"[17] in fact, cuts to the heart of the political legitimacy of risk societies.

According to Christof Mauch, however, this sociological, political and legal approach to risk society "does not explain how such decisions came about historically and how communities have adapted to 'risks' and the 'challenges of nature' over time."[18] Thus, the abstract reflection on risk society has to prove its theoretical validity in historical case studies. Germany's adoption of the concept of "delayed acceleration," as set out in June 2011 in the Thirteenth Amendment to the Atomic Energy Act, allows such a case study. It exemplifies the paradoxical managing of nuclear risk, considered at once too risky for German risk society and yet socially acceptable for a further ten years. It is this antinomy of residual risk within German energy policy after Fukushima that will be the subject of the analysis below.

14 Ibid., 26.
15 Bundesverfassungsgericht [German Federal Constitutional Court], "Decision 2 BvR 2502/08, 18 February 2010" (CERN), *Neue Zeitschrift für Verwaltungsrecht* 29 (2010): 703f; italics added.
16 Peter Sloterdijk, *Im Weltinnenraum des Kapitals. Für eine philosophische Theorie der Globalisierung* (Frankfurt am Main: Suhrkamp, 2005), 150; italics in the original.
17 Sunstein, *Worst-case Scenarios*.
18 Christof Mauch, "Introduction," in *Natural Disasters, Cultural Responses: Case Studies Toward a Global Environmental History*, ed. Christof Mauch and Christian Pfeiffer (Lanham, MD: Lexington Books, 2009), 5.

I. The "Delayed Acceleration" of Nuclear Phaseout

In reaction to the nuclear disaster unleashed by the earthquake and tsunami in Japan, the German government agreed on 6 June 2011 to accelerate the end of domestic nuclear energy production.[19] The *Bundestag*—Germany's national parliament—quickly passed the Thirteenth Amendment to the Atomic Energy Act (513 votes for and only 79 against) and it became law on 6 August 2011.[20] The phrase "accelerated exit from nuclear energy" indicates that this amendment should not be seen in isolation, but rather in its legislative context.[21] Originally, the Federal Republic of Germany authorized the construction of nuclear power plants without imposing any constraints on the operational life of the facilities. In 2002 the Schröder Government and energy providers negotiated a nuclear phaseout that capped the total amount of energy able to be produced by nuclear power. In 2010, in the Eleventh Amendment to the Atomic Energy Act, Chancellor Merkel expanded the scope of this "residual current" model so that energy companies were permitted to produce additional amounts of atomic electricity.[22] And now, after Fukushima, the Thirteenth Amendment to the Atomic Energy Act introduces the concept of a "delayed acceleration" of the nuclear phaseout.

The Thirteenth Amendment includes three major provisions: *First*, it sets a shutdown date for every nuclear power plant. For eight nuclear power plants, production ended with the enactment of the amendment on 6 August 2011. The remaining nuclear power plants will be shut down at staggered intervals in 2015, 2017, 2019, 2021, and 2022. On 31 December 2022, the last three German nuclear reactors—I*sar 2, Emsland,* and *Neckarwestheim 2*—will be closed down. *Second*, it puts an end to the current contingents of atomic energy production permitted under the Eleventh Amendment to the Atomic Energy Act. *Third*, the amendment contains the caveat that a closed reactor may be designated as a reserve energy provider by the government, and kept on standby until 31 March 2013, to ensure the security of energy supply.[23] These three

19 Bundestagsdrucksache [Printed Matter of the German Bundestag], no. 17/6070; 17/6246.

20 Bundesgetzblatt I [Federal Law Gazette I] (2011): 1704.

21 Dieter Sellner and Frank Fellenberg, "Atomausstieg und Energiewende 2011—das Gesetzespaket im Überblick," *Neue Zeitschrift für Verwaltungsrecht* 30 (2011): 1025ff.; Michael Kloepfer and David Bruch, "Die Laufzeitverlängerung im Atomrecht zwischen Gesetz und Vertrag," *JuristenZeitung* 66 (2011): 377 ff.; Jens Kersten and Albert Ingold, "Die Beschleunigung des Atomausstiegs. Verfassungsrechtliche Anforderungen," *Zeitschrift für Gesetzgebung* 26 (2011): 350 ff.

22 Bundesgesetzblatt I (2010): 1814; Bundestagsdrucksache, no. 17/3051; Kloepfer and Bruch, "Die Laufzeitverlängerung," 378f.

23 However, this third measure has already been made obsolete by the decision of the Federal Network Agency (*Bundesnetzagentur*) that such "nuclear reserves" are not necessary for supply security (http://www.bundesnetzagentur.de/cln_1912/DE/Presse/Berichte/berichte_node.html).

provisions of the amendment do not foresee any compensation for the energy companies. Parliament justifies this with the economic amortization of the reactors.[24]

The constitutional evaluation of the Thirteenth Amendment is highly controversial, particularly regarding the question of whether, and to what extent, energy companies should be compensated for the "delayed acceleration" of the nuclear phaseout.[25] The constitutional justification for the three measures that comprise the amendment is dependent on one decisive question: whether the Japanese reactor disaster should result in a re-evaluation of the risks of nuclear energy to protect the life, livelihood, and health of German citizens.[26]

II. Constitutional Requirements for Risk Assessment

The Federal Constitutional Court developed the framework for the constitutional law on risk in its decision of 8 August 1978 regarding the Kalkar nuclear power plant.[27] It still adheres to these guidelines today, particularly with respect to its judgement of 18 February 2010 concerning a series of scientific tests carried out by the European Organization for Nuclear Research (CERN).[28]

The government has to live up to its constitutional obligation to defend its citizens from any threat to life or health caused by scientific and technological progress.[29] This is particularly relevant for the non-military use of nuclear energy that, in the event of malfunction or accident, can transform whole regions into "No-Go areas" or "dead zones."[30] In the opinion of the Constitutional Court, nuclear energy therefore constitutes a "hazard to human rights."[31] That is the reason why nuclear power plants are only

24 Bundestagsdrucksache, no. 17/6070, 6.
25 See Wolfgang Ewer, "Der neuerliche Ausstieg aus der Kernenergie—verfassungskonform und entschädigungsfrei," *Neue Zeitschrift für Verwaltungsrecht* 30 (2011): 1935ff.; David Bruch and Holger Grewe, "Atomausstieg 2011 als Verletzung der Grundrechte der Kernkraftwerksbetreiber?—Zur Verfassungsmäßigkeit der 13. Atomgesetznovelle," *Die Öffentliche Verwaltung* 64 (2011): 794ff.; Michael Kloepfer, "13. Atomgesetznovelle und Grundrechte," *Deutsches Verwaltungsblatt* 126 (2011): 1437ff.; Sellner and Fellenberg, "Atomausstieg und Energiewende," 1025ff.; Kersten and Ingold, "Die Beschleunigung des Atomausstiegs," 350ff.
26 Grundgesetz für die Bundesrepublik Deutschland [The Basic Law for the Federal Republic of Germany], art. II, par. 2; art. XXa.
27 Bundesverfassungsgericht, "Decision 2 BvL 8/77, 8 August 1978" (Kalkar), *Entscheidungen des Bundesverfassungsgericht* (Decisions of the Constitutional Court) vol. 49 (Tübingen: Mohr Siebeck, 1978), 124ff.
28 Bundesverfassungsgericht, "CERN," 702ff.
29 Bundesverfassungsgericht, "Kalkar," 132, 141f.; "CERN," 703.
30 Spaemann, *Nach uns die Kernschmelze*, 7.
31 Bundesverfassungsgericht, "Kalkar," 141.

constitutionally acceptable if they conform to the "basic principle of the best possible defence against hazards and prevention of risks."[32]

In the context of risk assessment necessary for nuclear hazards, the Constitutional Court further differentiates between two types of risks: unacceptable risks, which must be prevented, and acceptable risks, which must be tolerated as "inescapable residual risks."[33] This distinction between unacceptable and acceptable risks reflects the intertwining of risk and rights in liberal society: the risky activities that drive scientific and technological development are protected by the freedom of research, of profession, and of property.[34] Hence, the demand for a risk-free society flies in the face of the necessary production of risks that are never completely predictable.

In differentiating between risk prevention and risk acceptance, the Constitutional Court adheres to the concept of a "dynamic protection of human rights" that requires the administrative regulation of nuclear power plants using state-of-the-art science and technology.[35] According to the court, "a disaster of apocalyptic magnitude as the potential consequence of scientific progress must, by the standards of current scientific and technological knowledge, be completely ruled out."[36]

With this ambivalent standard, the Constitutional Court reflects the "breakdown of the horizon of objective knowledge" in risk assessment.[37] In other words, risk assessment is no longer just a problem of scientific and technological knowledge but a question of political responsibility.[38] The political discretion of parliament in its assessment of risk is, in the words of the Constitutional Court, "largely dependent on the observations of actual events when calculating the relative frequency of the occurrence and the similar consequences of similar events in the future."[39] Revising risk decisions due to new knowledge and experience is part and parcel of dynamic risk assessment: "Knowledge generated by experience, even if this experience is closely entwined with the laws of

32 Ibid., 139.
33 Bundesverfassungsgericht, "CERN," 704; Bundesverfassunggericht, "Kalkar," 137.
34 Bundesverfassungsgericht, "Kalkar," 143; Bundesverfassungsgericht, "CERN," 704.
35 Bundesverfassungsgericht, "Kalkar," 137; Helmuth Schulze-Fielitz, "Risikosteuerung von Hochrisikolagen als Verfassungsproblem—Notfallschutz bei Kernkraftanlagen," *Die Öffentliche Verwaltung* 64 (2011): 788ff.
36 Bundesverfassungsgericht, "CERN," 703f.
37 Liv Jaeckel, "Risiko-Signaturen im Recht. Zur Unterscheidbarkeit von Gefahr und Risiko," *JuristenZeitung* 66 (2011): 120; on the change to "subjective" risk-perception, see Liv Jaeckel, *Gefahrenabwehrrecht und Risikodogmatik. Moderne Technologien im Spiegel des Verwaltungsrechts* (Tübingen: Mohr Siebeck, 2010): 317ff.
38 Bundesverfassungsgericht, "Kalkar," 131f.
39 Ibid., 142.

science, is only approximate, at least as long as it includes human experience. This kind of knowledge cannot give certainty, but stands to be corrected by every subsequent new experience, and so is always at the cutting edge of what are potentially only as-yet unproved misunderstandings."[40]

III. New Risk Assessment

The German Parliament met these constitutional requirements for redefining risk assessment of nuclear energy after Fukushima in the Thirteenth Amendment to the Atomic Energy Act.[41] It combines a fundamental re-assessment of the risks specific to nuclear technology with an estimate of consequences of the nuclear exit strategy for German energy policy.

In its preamble, the amendment makes it clear that Fukushima represents the end of nuclear energy in Germany.[42] Its production and use should be stopped as early as possible. The preamble justifies this new assessment of nuclear power by summarizing the opinion of the independent Ethics Commission on Safe Energy Provision *(Sichere Energieversorgung)*, published in its 30 May 2011 report, *Germany's New Direction in Energy—A Community Decision for the Future.*[43] The Ethics Commission's report observed that, while the risks of nuclear energy have not changed as a result of Fukushima, the perceptions of those risks certainly have: more people are now aware of the real, not just hypothetical, risks of large-scale accidents.

In the view of the Ethics Commission, there are three relevant aspects of this new evaluation of nuclear risks. *First*, the fact that the reactor disaster happened in high-tech Japan dispels the conviction that such an accident—as well as the botched responses to it—could never happen in Germany. *Second*, it is now clear that it was impossible, even weeks after the disaster, to foresee an end to the catastrophe, to take stock of the extent of the damage, or to give definitive borders to the geographical area affected. *Third*, the disaster in Japan was initiated by events that the reactor had not been

40 Ibid., 143; cf. Bundesverfassungsgericht, "CERN," 705.
41 Bundestagsdrucksache, no. 17/6070.
42 Ibid., 1, 5.
43 Ethikkommission für Sichere Energieversorgung [Ethics Commission on Safe Energy Provision], *Deutschlands Energiewende—Ein Gemeinschaftswerk für die Zukunft* (Berlin, 2011), 11f.

designed to withstand. In short, Fukushima revealed the limitations of technical risk assessments that are often drafted on the basis of inaccurate or flawed assumptions—for example, about earthquake safety or the maximum height of a tsunami. The preamble of the Thirteenth Amendment, by adopting the Ethics Commission's evaluation of nuclear risks, reflected the reluctance of legislators since 2002 to support nuclear energy given the problems associated with nuclear power plants, the disposal and reprocessing of nuclear waste, and the potential for abuse.[44]

This re-evaluation of nuclear risks in the Thirteenth Amendment extends to the nuclear phaseout in German energy policy. The amendment set the year 2022 as the earliest possible deadline for the end of nuclear energy programs. Among its reasons, the preamble cites the "the guarantee of nuclear safety, the adherence to national and international climate protection goals, and the guarantee of fair and socially acceptable energy prices."[45] These considerations lead to the designation of nuclear energy as a *Brückentechnologie* or "bridging technology."[46] The concept of *Brückentechnologie* focuses on the efficient expansion of alternative energy technologies and infrastructure to allow a speedy transition to an age of renewable energies. The preamble justifies the conditional acceptance of risky nuclear power through its guarantee of the "absolute priority afforded to nuclear safety."[47] To support this decision, the preamble draws on the report by the Reactor Safety Commission (*Reaktor-Sicherheitskommission*), which had testified in May 2011 that, in light of the immediate causes of the Japanese disaster (tsunami, earthquake, flooding) and of potential human-triggered causes (airplane crashes, gas leaks, accidents in neighboring reactors, terrorism, technical malfunctions, computer-managed attacks), German nuclear power plants still displayed "a high degree of robustness."[48]

IV. Legal Conformity of the New Risk Assessment

From a legal perspective, both the re-evaluation of nuclear risks and the risk assessment of the phaseout are in line with the federal constitution, with regard to German energy

44 Bundestagsdrucksache, no. 17/6070, 5f.
45 Ibid., 1.
46 Ibid., 5.
47 Ibid., 1.
48 Reaktor-Sicherheitskommission [Reactor Safety Commission], *Bericht zur anlagenspezifischen Sicherheitsüberprüfungen deutscher Kernkraftwerke*, (16 May 2011), 6ff., 23ff., 13ff., 83ff.; Bundestagsdrucksache, no. 17/6070, 5.

policy.[49] Legislators are constitutionally required to adhere to the principles of a dynamic risk assessment to protect citizens' health, lives, and livelihoods. In other words, new practical experience and knowledge have to be integrated quickly into risk assessment when it concerns the functioning—and malfunctioning—of hazardous nuclear reactors.[50] Thus, the constitution does not, in Beck's words, follow "a concept of risk that is immune to experience."[51] It could not allow Three Mile Island, Chernobyl, and Fukushima to be summarized as "unfortunate accidents, from which there is nothing to be learnt."[52] Instead, from a constitutional perspective, every decision about risk has to be re-examined in the light of new experiential knowledge and, if necessary, adjusted. In assessing nuclear risk, parliament has broad political discretion, subject only to legal examination under the terms of accuracy and rationality. Following the Ethics Commission's report *Germany's New Direction in Energy*, it accepted the reality of residual nuclear risk in a high-tech country, underlining the limits of effective provisions for disaster scenarios and the inability to manage the consequences of a nuclear catastrophe.

The reasons for the re-evaluation of nuclear risk are rational and supported by evidence. They cannot be dismissed by the argument that those risks were already influencing the controversial debate about nuclear power prior to Fukushima. Constitutionally speaking, "new" risks from nuclear energy are not needed for a new risk assessment; rather, it lies within legislative discretion to re-examine and re-evaluate known risks in the light of current and, in this case, catastrophic experiences. On these grounds, parliament could come to the conclusion that the non-military use of nuclear energy in the Federal Republic of Germany should be prohibited in the future because of the residual risk to civilization.

After weighing this new evaluation of risks against the security of energy supply, climate protection, and socially acceptable energy prices, parliament concluded that a complete phaseout of nuclear energy could only be realized in 2022.[53] In principle, this decision has its basis in the constitution. Parliament justifiably extended its perspective beyond purely

49 Kersten and Ingold, "Die Beschleunigung des Atomausstiegs," 363ff.
50 Bundesverfassungsgericht "CERN," 703f.
51 Ulrich Beck, "Atomausstieg: Der Irrtum der Raupe," *Frankfurter Allgemeine Zeitung*, 14 June 2011, 31.
52 Spaemann, *Nach uns die Kernschmelze*, 7.
53 On the necessity of balancing nuclear risk and alternative resources of energy, see Anthony Giddens, *The Politics of Climate Change* (Cambridge: John Wiley & Sons, 2009), 131ff.; Manfred Bürger, Michael Buck, Georg Pohlner, and Jörg Starflinger, "Fukushima—Gefahr gebannt? Lernen aus der Katastrophe," *Aus Politik und Zeitgeschichte* 61, no. 46–47 (2011): 40.

nuclear hazards to encompass risks relating to energy supply, energy pricing and climate change—since all three are integral to the political evaluation of the nuclear phaseout.

The ambivalent relationship between nuclear power and climate protection, discussed by Markus Vogt elsewhere in this issue, is particularly noteworthy.[54] On the one hand, the proportion of global energy produced by nuclear means is too low—just 2 percent—to justify nuclear energy as a contribution to climate protection. On the other hand, the consequences of climate change (widespread desertification, flooding, and famines) are no less dramatic for the environment and society than the risks associated with nuclear energy. In light of Fukushima, increasing the proportion of nuclear energy in the grid is out of the question. At the same time, legislators must also consider how the loss of energy provision caused by a nuclear phaseout might be "compensated" by fossil energy harmful to the climate.

As a benchmark for these considerations of nuclear, climatic, and social risks, parliament has proclaimed the "absolute priority of nuclear safety."[55] Yet, we should not overlook parliament's fundamental acceptance of the residual risk of nuclear energy: an "absolute priority of nuclear safety" only makes sense as a benchmark if one assumes the continuation of nuclear energy production and, therefore, the persistence of residual nuclear risk. In this phrase, parliament is not promising nuclear safety per se, but rather merely the "absolute priority" of nuclear safety in their considerations of the climatic, social, and political risks of a nuclear phaseout.. Hence, the suggestive force of the "absolute priority of nuclear safety" is very much in line with the risk society: it allows the residual nuclear risk to "disappear," semantically and, thus, politically.

These political criticisms, however, must not be confused with the legal question of whether the Thirteenth Amendment to the Atomic Energy Act is constitutional or not. Parliament has not over-stepped its authority by establishing the benchmark of the "absolute priority of nuclear safety," which reflects its fundamentally negative evaluation of nuclear risks. Here, the government's political strategy of bringing in two bodies of experts to legally evaluate the consequences of the Fukushima accident is revealed. The Ethics Commission, in its report *Germany's New Direction in Energy*, used the new evaluation of nuclear risks to justify the government's accelerated nuclear phaseout. At

54 Markus Vogt, "Lessons learned from Chernobyl and Fukushima: An ethical evaluation," in this issue; Giddens, *The Politics of Climate Change*, 131ff.
55 Bundestagsdrucksache, no 17/6070, 1.

the same time, the Reactor Safety Commission justified the "absolute priority of nuclear safety" in the context of the extension of nuclear energy production through December 2022 by assessing the "robustness" of German nuclear power plants. It legitimized the conditional continuation of nuclear energy production by casting it as a "bridging technology" in a nuclear phaseout.

Despite this strategic use of expert knowledge and expert commissions, the constitutionality of risk assessment is not in question. It is neither irrational nor contradictory. Because risk assessment, however delayed, remains orientated towards an exit, there is no contradiction in the fundamentally negative re-evaluation of nuclear risks. In the context of their discretionary prerogative, parliament can thus come to the conclusion that the continued use of nuclear power for a ten-year transition period up to 2022 is acceptable. In short, the model of the "delayed acceleration" of the nuclear phaseout is constitutional.

V. Summary

Germany responded to the reactor disaster in Fukushima by reassessing the risks posed by the domestic production and use of nuclear energy. Parliament decided to accelerate the phaseout of nuclear energy production. But this political change does not mark a move away from nuclear residual risk. The reasons for this go beyond the 143 nuclear power plants throughout Europe that ensure a measure of residual risk for all EU countries, including Germany.[56] Even without these shared European risks, the German model of "delayed acceleration" accepts the residual nuclear risk for a further decade. Though this slow-motion reaction to the Japanese slow-motion catastrophe can be criticized politically, it is nonetheless constitutional.

This long farewell to nuclear power is mainly due to the fact that the Federal Republic of Germany has identified itself politically with nuclear energy for almost fifty years. The dangers of such a close alliance between state and technology were first addressed in the 1960s and 1970s by Ernst Forsthoff.[57] Only if the state does not identify itself with

56 On European "risk integration," see Severin Fischer, "Das 'Modell Deutschland' und die europäische Energiepolitik," *Aus Politik und Zeitgeschichte* 61, no. 46–47 (2011): 19, 22.

57 Ernst Fortstoff, *Der Staat der Industriegesellschaft* (Munich: C. H. Beck, 1971), 42ff.; Jens Kersten, "Die Entwicklung des Konzepts der Daseinsvorsorge im Werk von Ernst Forsthoff," *Der Staat* 44 (2005): 560ff.

technology can government and legislature be successful in regulating the competing interests of technical development. Yet, as the drafting of the Thirteenth Amendment to the Atomic Energy Act attests, the alliance between state and technology remains strong, reflected in the strategic political management of the evaluation of nuclear risk by expert commissions.

Forsthoff's demand for the separation between the state and technological development applies not just to Germany but to the European Union as well.[58] A distanced relationship between politics and technology is the precondition for a new form of energy policy, the contours of which have been sketched by Frank Uekoetter elsewhere in this issue. For Uekoetter, sustainable energy solutions will require a more supple style of policy-making that treats energy paths as works in progress, amenable to unforeseen events and unexpected side effects.[59] However, such a self-reflective energy policy is only possible if political actors keep their distance from energy producers and resist identifying themselves with any particular form of energy provision. The Thirteenth Amendment to the Atomic Energy Act of 2011 only partially succeeds in enforcing this distance; in its principle of the "absolute priority of nuclear safety," German risk society has tried once again—one final time?—to semantically gloss over the residual nuclear risk. Thus, the Japanese worst-case reality will remain a German worst-case scenario for at least another decade.

58 On the development of European energy policy, cf. Fischer "Das 'Modell Deutschland,'" 15ff.; Severin Fischer, *Auf dem Weg zur gemeinsamen Energiepolitik. Strategien, Instrumente und Politikgestaltung in der Europäischen Union* (Baden-Baden: Nomos, 2011).

59 Uekötter, *Am Ende der Gewissheiten*, ch. 7.

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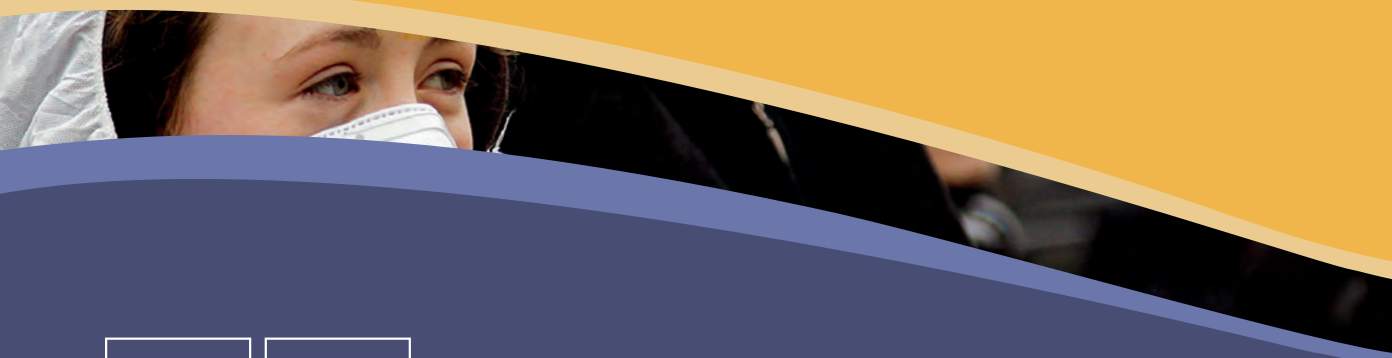
One year after the reactor meltdown at the Fukushima Daiichi Nuclear Power Station, this volume of *RCC Perspectives* takes stock of its impact and possible legacy in Europe as part of the Rachel Carson Center's research focus on natural disasters and cultures of risk. While Europe may have been spared radioactive fallout, political and cultural fallout has been significant. Are we witnessing the beginning of the end of the nuclear era? Or beginning of a new one, glimpsed in the shade of authoritarian regimes?



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