

Part IV

Collected Insights on Novel Nuclear Technologies

only English

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Categorizing Perceptions of Dangers and Risks

A Philosophical Perspective

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Affiliation

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Et reptatem re voluptenit plaborem eaque pro

1. Introduction

The philosophical examination of danger and risk transcends practical statistical analysis and economic consequence, reflecting cultural values, emotions and cognitive processes. In essence, risk reflects not only material conditions but the values, fears, and aspirations of societies ①. This paper explores the multilayered nature of risk perception, emphasizing openness' importance in nuclear energy's controversial field.

Human responses to danger are influenced not only by immediate experience but also by collective memory and cultural heritage. This intersection of historical awareness and present realities creates a nuanced landscape, where nuclear science represents both a symbol of progress and a source of existential anxiety. Philosophical reflection thus becomes indispensable in disentangling these paradoxes and illuminating pathways through uncertainty. Risk is not merely an obstacle to progress; it is the very terrain where progress is negotiated. Risk embodies tensions between preservation and transformation, between the instinct to safeguard the present and the drive to innovate for the future. Nuclear technologies exemplify this dual nature, representing both the dangers of hubris and the promise of sustainable advancement ②.

①

U. Beck, »Risikogesellschaft. Auf dem Weg in eine andere Moderne«, Suhrkamp, 1986. English translation: »Risk society: towards a new modernity«, Sage Publications, 1992.

②

K. Mainzer, »Complexity, Risk, and Technoscience«, in P. A. Wilderer, O. Renn, M. Grambow, M. Molls, K. Mainzer (eds.), Sustainable Risk Management, pp. 209–222, Springer, 2024.

2. The Temporal and Ethical Dimensions of Risk

Risk perception situates individuals and societies within webs of temporal and ethical considerations. Immediate threats, whether industrial or environmental, elicit instinctual, survival-driven responses. In contrast, long-term risks—such as climate change or the persistent impact of nuclear waste—demand reflection, ethical foresight, and a shared sense of responsibility across generations. The philosopher's role, far from being abstract, involves articulating the deeper connections between these temporal layers, framing risk as an inextricable human aspect alongside growth, resilience, and moral responsibility.

The accumulating nuclear waste exemplifies the urgency of addressing long-term risks. According to the International Atomic Agency Energy about 400,000 tonnes of spent fuel has been discharged from reactors

③

»Status and Trends in Spent Fuel and Radioactive Waste Management«, IAEA Nuclear Energy Series No. NW-T-1.14 (Rev. 1), International Atomic Energy Agency (January 2022).

④

Postponed to April 15, 2023, due to the risk of electricity shortages in Germany following the phase-out of Russian gas deliveries. In 2024, Germany imported approximately the same amount of nuclear-generated electricity from France as its own nuclear power plants had produced in the year before their shut-down.

⑤

P. A. Wilderer, »General Recommendations,« in Sustainable Risk Management, in P. A. Wilderer, O. Renn, M. Grambow, M. Molls, K. Mainzer (eds.), Sustainable Risk Management, pp. 273–278, Springer, 2024.

worldwide, with about one-third having been reprocessed ③. This mounting burden surpasses technical management, raising deep questions of intergenerational justice and environmental stewardship ①. The challenge lies not merely in containment but in fostering a moral perspective that recognises our duties to future generations.

At the same time, the Fukushima disaster of 2011 stands as a stark reminder of how perceived risks shape policy far more decisively than empirical and scientific data. Despite relatively limited direct casualties (See Chapter IV.5), the ensuing fear and political pressure led to Germany’s abrupt shift away from nuclear power, accelerating its plans to decommission reactors by 2022 ④. This decision reverberated beyond Germany, influencing Belgium and Switzerland to phase out nuclear energy entirely. Italy’s national referendum further echoed this shift, with 94% voting against continuing government nuclear plant plans. In light of the evident challenges in achieving the goals of the national energy transition, there is an active political debate in these three countries regarding the reconsideration of nuclear power as a component of a greenhouse gas-free energy strategy.

These developments raise critical questions: How can societies recalibrate their perception of nuclear energy, recognizing both its potential and its pitfalls? How can societies ensure that their actions do not impose undue harm on those who come after them?

Furthermore, transparency emerges as a cornerstone of ethical risk management. Historical secrecy in fields like nuclear research has often exacerbated public fears, undermining trust and stalling progress. An ethical approach demands open dialogue, where the benefits, limitations, and uncertainties of scientific advancements are communicated honestly. This fosters informed decision-making and reduces the likelihood of mistrust or opposition ⑤.

Another critical ethical dimension is the balance between individual and collective interests. The deployment of nuclear technology, for instance, may benefit society as a whole through clean energy production, yet it also entails risks that affect specific communities, such as those living near storage sites or reactors. Addressing this inequity requires a commitment to fairness and inclusivity, ensuring that all stakeholders have a voice in the decision-making process.

Finally, the ethical implications of inaction must also be considered. While it is right and proper to focus on the risks of pursuing certain technologies, failing to act can carry its own set of consequences. For instance, abandoning nuclear research out of fear may hinder progress in waste reduction technologies or delay the transition to sustainable energy systems. It is therefore necessary to develop a nuanced and non-ideological approach that recognises both the risks of action and the dangers of inaction.

⑥

J. Höffken, M. V. Raman, »Nuclear power and environmental injustice«, Wires Energy and Environment, 2024.

3. Novel Nuclear Technologies A Philosophical Reconciliation of Public Concerns with Innovation

The development of novel nuclear technologies (NNTs)—including small modular reactors (SMRs), thorium-based systems, and fusion energy—offers an opportunity to address public concerns. These technologies, by design, enhance safety, reduce waste, and hold the potential to transform hazardous materials into more benign forms ⑥. SMRs, for example, provide a scalable and flexible approach to nuclear energy production, with enhanced passive safety systems that significantly reduce the risk of core meltdowns. Similarly, thorium reactors offer the advantage of producing less long-lived radioactive waste, mitigating the most pressing concern of traditional nuclear fission. Fusion energy, though still in the experimental phase, holds the promise of virtually limitless clean energy with minimal environmental impact.

Moreover, NNTs play a significant role in decarbonizing industrial sectors that are difficult to electrify, such as steel, cement, and chemical production. Bavaria, with its advanced research infrastructure and strong industrial base, exemplifies the potential for regional leadership in this area. To this regard, the Technical University of Munich (TUM), plays a pivotal role in driving forward innovations in NNTs.

A vital aspect of NNTs lies in their potential to address the intermittency challenges faced by renewable energy sources. As highlighted by Working Group III and in the contribution »Renewables, Energy Storage and the Need of a GHG-free Base Supply«, a balanced energy portfolio integrating both renewable and dispatchable technologies, such as advanced nuclear reactors, creates a more resilient and cost-effective energy system. The inclusion of NNTs can reduce the need for extensive energy storage solutions and minimise the overproduction of renewable energy during periods of low demand.

In a philosophical tone of voice, NNTs represent a reimagining of humanity’s relationship with nature and technology. They compel us to confront the dual nature of scientific progress—balancing hopes for boundless advancement with the risks and fears of potential catastrophe. This duality reflects a broader narrative of human development, in which every stride forward bears the weight of new ethical responsibilities engagement with it.

The deployment of NNTs requires transparent communication and public involvement, ensuring that societal apprehensions are met with informed dialogue and shared decision-making. NNTs, by addressing vulnerabilities associated with older nuclear technologies, embody a vision where scientific advancement is guided by ethical foresight and societal engagement. In other terms, a vision where innovation emerges not as an escape from risk but as a conscious engagement with it. This proactive approach ensures that technological advancement aligns not only with innovation per se but also with broader commitments to sustainability, equity, and long-term resilience.

By fostering interdisciplinary collaboration and promoting public discourse, NNTs exemplify how humanity can navigate the complexities of energy transitions while respecting the boundaries of ecological stewardship and community values.

NNTs are not isolated solutions but integral components of a broader energy ecosystem. By complementing renewable sources, they contribute to a diversified, resilient energy mix. This symbiotic relationship underscores a key philosophical point: progress need not be linear or singular but can emerge from the dynamic interplay of multiple technologies.

4. Openness as an Ethical Imperative in Technological Advancement

Central to overcoming public resistance is the principle of openness—an essential cornerstone for fostering trust and accelerating scientific progress. This is especially relevant in the field of novel nuclear technologies, where innovation frequently meets public skepticism, often stemming from a lack of transparency. Open science, free from fear and political constraints, not only ensures the dissemination of knowledge but strengthens public confidence in the safety and potential of emerging nuclear systems. By demystifying the research process and involving communities in a meaningful dialogue, open science dismantles barriers of fear and misinformation. This inclusive approach can reduce opposition to NNT projects and enhance public understanding of their long-term benefits.

In addition, embracing open science encourages innovation by providing a platform for diverse scientific contributions and minimizing the monopolization of knowledge. It ensures that breakthroughs in NNTs are accessible, fostering cross-sector collaborations that span academia, industry, and government. This shared ecosystem accelerates technological advancements while aligning with the broader goals of sustainability and energy equity. International collaboration on fusion energy projects, for instance, underscores the value of shared knowledge in accelerating breakthroughs that might otherwise take decades to achieve. Philosophically, the pursuit of open science aligns with the ethical imperative of democratizing access to technological progress, ensuring that advancements benefit humanity as a whole rather than remaining confined to isolated centres of powers and privilege ⑦.

⑦

K. Shrader-Frechette, »Ethics of scientific research«, Rowman & Littlefield Publishers, 1994.

5. Conclusion

The philosophical categorization of dangers and risks is not a mere academic exercise. It is a practical and moral imperative that touches on the very fabric of societal progress and survival. By unraveling the nuances of risk perception, philosophers can articulate frameworks that balance prudence with pioneering spirit, confirming that society does not retreat into fright but moves forward with courage and foresight.

The interplay between risk and scientific progress reveals a profound ethical duty: to embrace the uncertainties of exploration while steadfastly safeguarding human and environmental well-being. Ethical considerations must remain at the forefront, addressing questions of justice, equity, and accountability. Scientists, philosophers of science and policymakers, must strive to build trust through transparency and inclusivity, ensuring that decisions reflect a collective commitment to the »greater good«.

Scientific freedom, framed by philosophical and logical rigor, has the power to transform perceived dangers into opportunities for growth and resilience. Through interdisciplinary dialogue and ethical accountability, societies can foster trust in innovation and ensure that the pursuit of knowledge contributes to a shared vision of prosperity and sustainability. In this way, the study of risks becomes not merely an analysis of threats but a testament to human ingenuity and the enduring quest for a better future.