HEINRICH BÖLL STIFTUNG
ECOLOGY

E-PAPER

Nuclear Exnovation:

How the Nuclear Phaseout drives Ecological Modernization

BY ARNE JUNGJOHANN

Published by Heinrich Böll Foundation, April 2020

Nuclear Exnovation

By Arne Jungjohann

Contents

Introduction

With its 2050 vision for climate neutrality, the European Commission pursues a long-term strategy for a prosperous, modern, and competitive economy. The goal is to invest in technology, empower citizens, and align action in key areas such as industrial policy, finance, or research – while ensuring social fairness for a just transition.[1]

For the road forward, the strategy identifies seven strategic areas, among them energy efficiency, the deployment of renewables, and a competitive industry and circular economy. The approach stresses the importance to develop and deploy new technologies. It focuses heavily on innovation. Yet achieving the goal of climate neutrality cannot be reached «only» by new technologies. New technologies alone do not necessarily replace old ones quickly enough. A strategy of ecological modernization will also require the phasing out of aging technologies, which are carbon-intensive or unsustainable.[2] Thus, innovation must go hand in hand with «exnovation» – effective substitution – for the energy transition to be successful.

A key field in which exnovation will occur in Europe one way or the other is nuclear power. By 2050, all of Europe's 130 nuclear reactors currently in operation are likely to close as they reach a critical geriatric age. Ninety reactors in Europe are 31 years old or even older.[3] Europe thus faces a massive wave of reactor closures without properly harmonized policies in place for what experts refer to as decommissioning. In 2016, nuclear power provided around 25 percent of the net electricity generation in the EU.[4] The expected closure of this generation capacity and the aim for climate neutrality by 2050 underlines the motivation behind the EU's task to overhaul its energy system over the next decades completely.

This paper explores the interplay of exnovation and innovation within the strategy for ecological modernization. It will argue for a more holistic approach. Specifically, the paper

1 European Commission. 2018. A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. Brussels, 28.11.2018. COM(2018) 773 final. Assessed 12 December 2018. *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0773*

2 Hajer, M.A. 1995. The Politics of Environmental Discourse: Ecological Modernization and the Policy Process, Oxford, UK, Oxford University Press, ISBN 0-19-827969-8.

3 The World Nuclear Industry Status Report (WNISR). 2018. Mycle Schneider et al. Paris. September. p. 223.

4 Eurostat. 2018. «Energy production and imports» Data extracted in July. *https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports*. Retrieved 12 Dec 2018.

looks at the challenges ahead for decommissioning nuclear power in Europe as part of the EU's overall vision for a climate-neutral economy by 2050. Finally, the paper develops recommendations for policymakers, industry, and civil society to build up capacities for organized exnovation in the field of nuclear decommissioning.

Innovation without exnovation leads to unintended consequences

Europe currently imports more than half of its energy.[5] The continent owes its high standard of living today largely to innovations; what it lacks in natural resources, it attempts make up for in brainpower. Support for innovation such as incentives for new technologies is highly important (though some researchers warn of unintended lock-in effects).[6] However, it is missing a key part of the picture: getting old technologies and business models out of the market. Thus, while pursuing innovation-only strategies will lead to some success, this approach will take more time at higher costs.

New technologies alone do not necessarily replace old ones quickly enough unless an attempt is made to phase out the old tech. To that end, innovation must go hand in hand with «exnovation» – effective substitution – for the energy transition to be successful. If governments match innovation with exnovation, they can reach their goals of change faster and more cost-effectively.

«Exnovation» is defined as the successful substitution of the old with the new. At present, for instance, renewable energy additions have only slowed down carbon emissions globally, not reduced them, in the past few years primarily because new renewables have only kept up with growing energy demand without offsetting fossil fuel use. Governmental policies promote renewables without sufficiently discouraging fossil fuel consumption and encouraging efficiency and behavioral change.

The nuclear sector serves as a good example of innovation with exnovation. Critics of nuclear power called for an end to the technology starting in the 1970s, but they also realized that it would need to be replaced with something.[7] The exnovation of the nuclear phaseout thus drove the innovations in renewable energy.

We generally conceive of innovation as the driver of change through «creative destruction».[8] Historically, however, exnovation – the need for replacement – has often driven

5 Ibd.

6 Rave, Tilmann; Triebswetter, Ursula; Wackerbauer, Johann. 2013. Koordination von Innovations-, Energie- und Umweltpolitik, ifo Forschungsberichte, No. 61, ISBN 978-3-88512-540-2. Assessed on December 11, 2018 under *https://www.ifo.de/publikationen/2013/monographie-autorenschaft/koordination-von-innovations-energie-und-umweltpolitik*

7 Morris, Craig and Jungjohann, Arne. 2017. Energy democracy, Palgrave. Pp. 15-36.

8 Schumpeter, Joseph. 1942. Capitalism, Socialism, and Democracy.

innovation to be applied. For instance, chlorofluorocarbons (CFCs) had been widely used as refrigerants, though because CFCs contribute to ozone depletion in the upper atmosphere, the Montreal Protocol eventually phased out their use. Once researchers had demonstrated that technological alternatives were available and feasible, policymakers could simply ban CFCs. The ban itself led to the use of better alternatives.

When innovation takes place without exnovation, there can be unintended consequences. The discontinuation of the Chevy Volt plug-in hybrid provides a learning example.[9] The car was General Motor's successful attempt to catch up with the Toyota Prius technologically, but policymakers failed to provide enough incentives for US drivers to give up fossil-fueled cars. As a result, sales of pick-up trucks and SUVs have shrunk the market share of smaller passenger vehicles, like the Volt.

A survey of technology manufacturers based in Germany shows that the credibility of the policy mix has a decisive impact on their green innovation expenditures.[10] As one might expect, robust policies that support investments in renewable energy technologies – such as the Renewable Energy Sources Act (EEG) – play a crucial role for many manufacturers. Surprisingly, however, interviewees rank the phase-out of nuclear power by 2022 first as the most important policy to support the expansion of renewables; even more important than the actual law to promote renewables. The German nuclear phase-out serves as a prime template of how exnovation can complement and accelerate innovation. It is safe to assume that the deployment of renewables would have been slower, had it not been accompanied by the nuclear phase-out, which provided stakeholders (such as investors, manufacturers, banks, insurance firms) with a high degree of certainty.

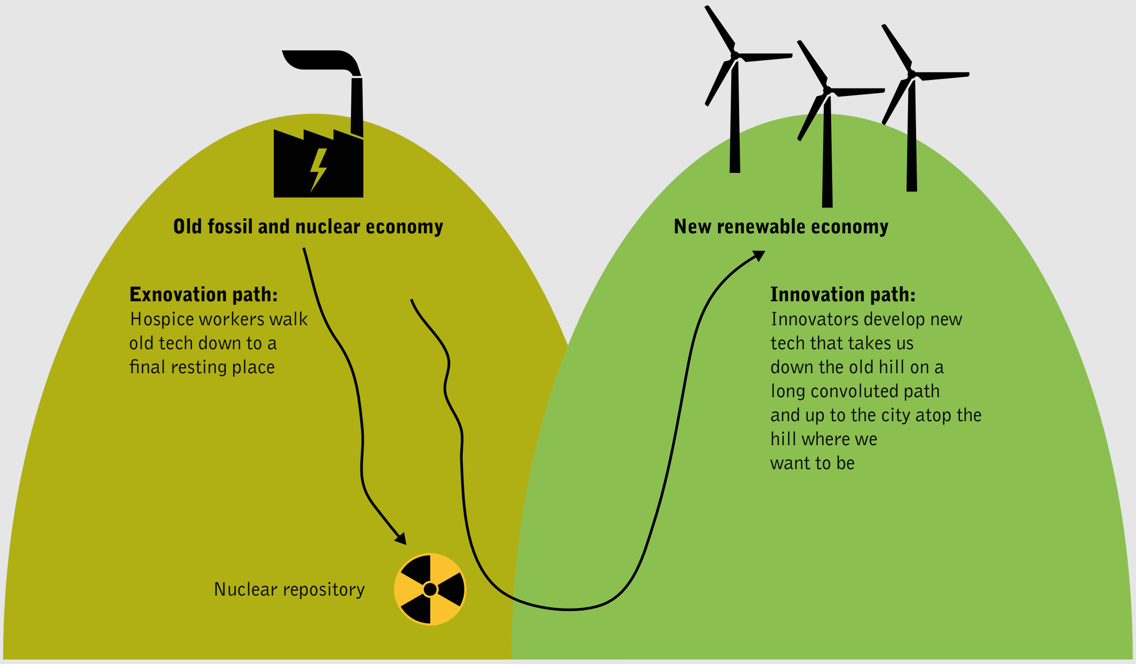
The interplay of exnovation and innovation can be illustrated based on the Berkana Institute's Two Loops model of change. It has frequently been used to describe the current shift from old fossil fuels to new renewables, but the model explains the process equally well for the switch from nuclear to renewables.[11] The figure below shows this loops model as two paths, one for exnovation and one for innovation.

9 Pyper, Julia. «Why General Motors is ditching the Chevy» Volt. 10 December 2018. *https://www.greentechmedia.com/articles/read/why-general-motors-is-ditching-the-chevy-volt*

10 Rogge, K.S., Breitschopf, B., Mattes, K., Cantner, U., Graf, H., Herrmann, J., Kalthaus, M., Lutz, C. and Wiebe, K. 2015. Green change: renewable energies, policy mix and innovation. Karlsruhe: Fraunhofer ISI. *https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/gretchen/GRETCHEN_report.pdf*. Retrieved 5 Sep 2019.

11 Bond, Brittnee. 2017. «Two Loops Model Exploring how systems change.» Medium. Sep 11. Assessed on December 12, 2018 *https://medium.com/@brittneebond/two-loops-model-9a3d52c7da4e*

Figure 1: The exnovation and innovation paths to ecological modernization
Own illustration based on the Berkana Institute's Two Loops model of change



The top of the first loop describes the pinnacle of our old fossil-based economy. A lot of attention is paid to the «innovators» here: those developing new carbon-free technologies – wind turbines, solar panels, power storage, etc. – are needed to transition our economies from the old world to the new «illuminated» one. Importantly, the model stresses that «hospice workers» are needed to help phase out the old world. For fossil fuels, for instance, coal communities receive special help because job losses will largely be regional. Germany's coal commission is one example. It provided the federal government with recommendations for future economic development in the country's three coal regions.[12] Another example is Hillary Clinton's $30 billion plan for coal miners during her bid for the US presidency.[13]

This «hospice» work is crucial in two ways. First, it undertakes that entire regions should not be allowed to fall behind, lest a country lose its social cohesion. Second, efforts to help big incumbent firms navigate the transition reduces pushback by encouraging them to

12 Wehrmann, Benjamin. 2018. Germany's coal exit commission. December 13. *https://www.cleanenergywire.org/factsheets/germanys-coal-exit-commission*. Retrieved 5 Sep 2019.

13 Roberts, David. «Clinton has a $30 billion plan to help coal miners, but it got buried by a silly 'gaffe'.» Vox, 21 May 2016. *https://www.vox.com/2016/3/21/11278138/clinton-coal-gaffe*. Retrieved 5 Sep 2019.

participate in the transition, thus mitigating resistance which otherwise would slow down the process.

Exnovation highlights another reason for the need for «hospice workers» in the Two Loops model: avoiding unintended consequences. As one researcher put it, «Paradoxically, the consequences of innovation into 'the unknown' cannot themselves be known.»[14]

In the nuclear sector, numerous manufacturers have already embarked on this transition. Germany's Siemens, for instance, stepped away from its nuclear division in 2011 altogether and is now a major manufacturer of the offshore wind turbines that recently drew attention in projects that need no subsidies.[15] In contrast, France's Orano (previously Areva), which also makes wind turbines, did not spin off its nuclear division until 2017, when a lack of international sales had made the firm a financial liability for the French state, which owns some 90% of the firm.[16] The German nuclear phase-out had sent a clear signal to German firms, whereas France remains committed to nuclear alongside somewhat lukewarm support for solar and wind. No reactor has ever been built under free market conditions, so governmental support for nuclear remains crucial. In France, this results in mixed signals for businesses, as it remains unclear what role nuclear power should play in the future.

Finally, business generally focus on incremental, not disruptive changes: improving their own products, not substituting them with completely different ones. Two Loops is thus best thought of not as a model merely of change, but of fundamental change – of substitution. Governments often need to facilitate fundamental change because market players want incremental change that does not challenge their business models.

14 Kropp, Cordula. 2015. «Exnovation – Nachhaltige Innovation als Prozesse der Abschaffung.« Arnold, A., David, M., Hanke, G. & M. Sonnberger (ed.) Innovation –Exnovation. Über Prozesse des Abschaffens und Erneuerns in der Nachhaltigkeitstransformation. Marburg: Metropolis. p. 13-34. („Das Innovationsparadox liegt nun darin, dass diese Innovationsfolgen beim ‚Vorwärts in die Gefilde des nie da Gewesenen' (Paech 2005, 255) nicht gekannt werden können.«)

15 Reed, Stanley. «Germany strikes offshore wind deals, subsidy not included.» New York Times, 14 April 2017. *https://www.nytimes.com/2017/04/14/business/energy-environment/offshore-wind-subsidy-dong-energy.html* Retrieved 5 Sep 2019.

16 Koahane, David. «EDF board gives green light to Areva stake purchase,» 15 December 2017. *https://www.ft.com/content/e9ff5626-e19f-3b4b-93ad-2de680c0e3c0* Retrieved 5 Sep 2019.

Comparing nuclear power in Germany and the United States

A comparison of the nuclear sectors in the United States and Germany helps illustrate how the Two Loops relate to exnovation. The main difference is between planned exnovation in Germany and unplanned in the US:

In the US, market forces currently drive the closure of nuclear reactors – in many regional markets, reactors are no longer competitive on price.[17] Analysis suggests that it is inevitable for the US nuclear sector to continue to decline for the near future, though the decline could decelerate through subsidies.[18] As of 2019, at least eight nuclear plants in the US receive subsidies in form of so-called Zero Emission Credits. There is concern that this power could be replaced by natural gas instead and thus lead to rising carbon emissions. At least nine nuclear power plants have announced plans to retire operations by 2025 with more closures anticipated thereafter.[19] The industry itself had warned that up to 20 nuclear power plants could shut down by 2025.[20] Overall, there is a lack of planning and no unified approach to this issue, leaving the market in a state of uncertainty. In a way, exnovation is underway in the US, but slowed down by regulatory efforts to prevent the closure of nuclear power plants. It is a stark contrast to Germany.

As part of the Energiewende, Germany originally adopted its nuclear phase-out in 2002 in a consensus with the utilities sector. Initially, opposition parties contested the policy, but the transition received cross-party support following the nuclear accident in Fukushima in 2011.[21] Today, Germany has more than offset the reduction in nuclear power with new renewables. The record year for nuclear was 2001, when 171 TWh of nuclear power was generated. By 2017, that number had fallen to 94 TWh, a reduction of 77 TWh. Yet, non-hydro renewable power made up 190 TWh of power supply that year, more than twice

17 Morris, Craig. 2018. «Can reactors react?» IASS Discussion Paper. DOI: 10.2312/iass.2018.002. *https://www.iass-potsdam.de/en/output/publications/2018/can-reactors-react-decarbonized-electricity-system-mix-fluctuating* Retrieved 5 Sep 2019.

18 WNSIR 2018, p. 100.

19 Energy Information Agency (EIA). 2018. Future of U.S. nuclear power fleet depends mostly on natural gas prices, carbon policies. May 8. *https://www.eia.gov/todayinenergy/detail.php?id=36112* Retrieved 5 Sep 2019.

20 Barber, Wayne. 2016. NEI warns more nuclear power plant retirements on the way. Electric Light & Power. May 23. *https://www.elp.com/articles/2016/05/nei-warns-more-nuclear-power-plant-retirements-on-the-way.html* Retrieved 5 Sep 2019.

21 Kern, Florian; Rogge, Karoline; Kivimaa, Paula. 2017. Accelerating low-carbon innovation: the role for phase-out policies. Policy Briefing 05. Centre on Innovation and Energy Demand CIED. March.

the reduction in nuclear.[22] However, because coal power was not specifically targeted for exnovation, it has shrunk only modestly. Germany is now working on exnovation in its coal sector. It will do so in planned fashion, with a coal commission.

This planning is important because exnovation must include all stakeholders, allowing them to express their concerns. Then, there can be the broadest possible acceptance of the outcome with fewer unintended consequences.[23] In the absence of such a planned process, the transition is left to the market, which, though likely producing more open outcomes, some stakeholder groups may also find unacceptable. The distinction between planned and unplanned outcomes is typical of US and German policymaking in general: in the US, Americans perceive state planning often as an intrusion in the otherwise free market, while German economic policy sees a role for the state in preventing unwanted market outcomes.[24]

Focusing merely on decarbonization – as important as climate change is – could lead to results that many parts of society reject. Reducing greenhouse emissions alone will not solve all of the problems our current energy system produces. The risk of nuclear power is one such consequence. Broader input in the debate would ensure that water and land use, local decision-making, soils, market concentration, and many other factors be taken into consideration. Likewise, merely focusing on producing new technology through innovation assumes that new technology will make the old obsolete – as though no political regulation were needed.

22 AGEB, Energiebilanzen. Retrieved 10 December 2018, *https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20181019_brd_stromerzeugung1990-2017.pdf*. Retrieved 5 Sep 2019.

23 Wernert, Timo. 2017. Anforderungen an eine Forschung für den Kohleausstieg. Zwischen Innovation und Exnovation. In: politische ökologie. Nr. 149. p. 30-36. Oekom-Verlag. München. *https://epub.wupperinst.org/frontdoor/index/index/docId/6713*

24 Morris et al. 2017, pp. 161-196.

The specific innovation needs of nuclear decommissioning

Worldwide, some 173 reactors had permanently shut down as of mid-2018, with over half of them in the EU. However, only 19 of these had been fully decommissioned. The discrepancy in these numbers show that there is a clear lack of experience in nuclear decommissioning. The market, on the other hand, is huge and growing. Assuming that a nuclear reactor has an average lifetime of 40 years, we can expect more than 200 further reactors around the world to close by 2030.[25]

New «nuclear builds,» in contrast, are few and far between; indeed, the future market for reactors seems quite limited. In December 2018, France's environmental agency Ademe announced its finding that nuclear is not an economically competitive way for France to meet its climate targets.[26] The decommissioning market for nuclear will dwarf the market for new reactors in coming decades.

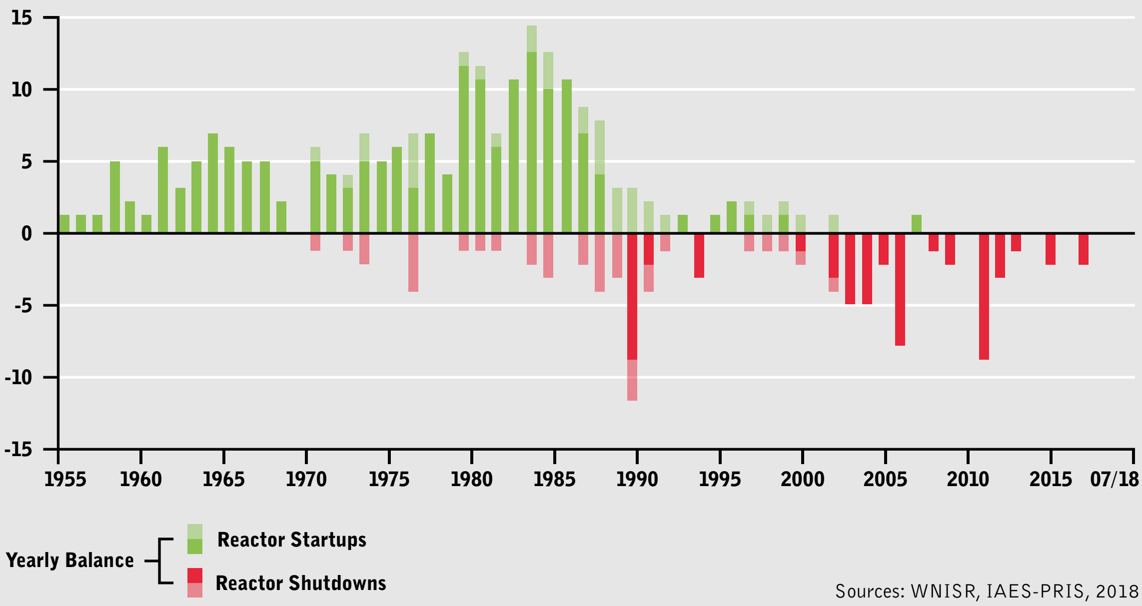
The decommissioning process will stretch over decades, providing jobs to a generation or more of highly skilled workers. In addition, much research will be in high demand. The EU already provides funding for projects related to nuclear decommissioning, such as in Horizon 2020. The 2011/70/Euratom Directive is a starting point for nuclear waste disposal in the EU. To date though, no EU member state has a final repository. Furthermore, the costs are highly uncertain. Germany is the only European country to have decommissioned a commercial reactor back to a greenfield. This expertise could prove to be a hot export item. Japan's Atomic Energy Commission, for instance, urges Japanese utilities in its White Paper on decommissioning to learn from European examples, «especially those of Germany, France and Britain».[27]

25 WNISR 2018, p. 134.

26 Ademe. 2018. Press release, «Trajectoires d'évolution du mix électrique 2020-2060». 10 Dec 2018. *https://presse.ademe.fr/2018/12/etude-quelle-trajectoire-devolution-du-mix-electrique-francais-di-ci-2060.html*. Retrieved 5 Sep 2019.

27 Yamaguchi, Mari. 2019. Japan urges nuke plants to prepare for decommissioning era. Sept 2, 2019. Associated Press. *https://www.dailymail.co.uk/wires/ap/article-7418227/Japan-urges-nuke-plants-prepare-decommissioning-era.html* Retrieved 5 Sep 2019.

Figure 2: Reactor Startups and Shutdowns in the EU28
In Units, from 1956 to 1July 2018



Sources: WNISR, IAES-PRIS, 2018

Decommissioning itself differs from one reactor type to another. Some of the internal machinery in nuclear reactors become radioactively contaminated, but there is a difference between the two main types used in Europe: pressurized water reactors (PWRs) use a secondary circuit to bring steam to the turbines; the radioactive hot water in contact with the nuclear fuel rods thus never reaches the power generation equipment.[28] In contrast, boiled water reactors (BWRs) have only one steam circuit, so the radioactive steam contaminates the steam turbine, which then also has to be disposed of as radioactive waste.

It remains yet unclear what lessons from one reactor type will apply to another. The gas-cooled reactors once widely used in the UK and France, for instance, may require different expertise than BWRs and PWRs. Neither country has completed the decommissioning of any reactor type. In any case, the expertise of staff at each reactor is likely to prove useful during decommissioning.

Only two countries in the world have completely decommissioned nuclear reactors: the United States and Germany.[29] Germany has finished 5 such projects; the United States, 13. However, the US allows some practices that Europe prohibits, such as using explosives

28 DIW. 2015. Stand und Perspektiven des Rückbaus von Kernkraftwerken in Deutschland (»Rückbau-Monitoring 2015«). Ben Wealer, Clemens Gerbaulet, Jan Paul Seidel and Christian von Hirschhausen, 2015. Data documentation 81. P. 7.
29 WNISR 2018, p. 135.

on concrete structures to be decommissioned. The least expensive decommissioning project by far was the US Trojan unit, whose reactor vessel was moved in one piece on a barge and buried under gravel. Whenever the US selects a final repository site, it will need to be dug up again and possibly cut into pieces small enough for permanent storage. This procedure is not allowed in Germany.[30]

Data on actual decommissioning costs are correspondingly scarce, but thus far indicate a wide range when looking at the installed capacity. In the US, decommissioning costs vary between projects from US$ 280/kW to US$ 1,500/kW. In Germany, the cost to decommission one reactor reached a sum of € 9,300/kW (US$ 10,500/kW, while another one totaled only € 1,700/kW (US$ 1,900/kW).[31]

There are two basic approaches to decommissioning: long-term enclosure (LTE) and immediate dismantling (ID).[32] Enclosing a reactor is assumed to work for some decades, it may vary from 60 years in the United States to 85 years in the UK. The hope, apparently, is that future generations will have solved the problem of nuclear waste disposal. LTE thus kicks the can down the road – instead of picking up the can and disposing of it properly. Should the disposal solution take so long, two or three generations hence, few of the people who worked at these units will still be alive. Their expertise – so crucial in a sector of complicated, differing technologies – will no longer be available. Those working on these projects will only be able to rely on whatever documentation has survived. Furthermore, LTE increases the cost of decommissioning by adding the initial storage to the unavoidable cost of the ultimate dismantling of these units. Finally, the timeframe is too short for significant amounts of this material to be considered low-level waste when actual dismantling occurs.[33]

In comparison, the immediate dismantling of reactors is far more preferable. The process can be broken down into four stages:

- Logistics is set up, and systems no longer needed for decommissioning are disassembled.
- Highly radioactive interior components are removed.
- Removal of exterior parts (biological shield).
- Dismantling of remaining parts and removal of systems used (cranes, filters, etc.); decontamination of building surfaces.

30 DIW 2015, p. 4.
31 World Nuclear Waste Report (WNWR). Focus Europe. 2019. Berlin & Brussels. Chapter on finances.
32 WNISR 2018, p. 136.
33 WNISR 2018, p. 142.

The first phase can often be done by general construction firms without special experience with radioactivity. The other phases, however, require skills that are more sophisticated, as well as highly specialized equipment and a well-trained workforce.[34] The third phase is the one requiring the most expertise. The companies must be able, for instance, to produce and handle specific nuclear waste containers and use robots for remote dismantling. They must be able to apply cutting technologies, such as plasma cutting and water-abrasive suspension cutting. The workforce will require training in the decontamination of surfaces for reuse, in the recycling of radioactive metals, and in the production of special tools for dismantling. Not many companies have this capacity. In Germany alone, there are only seven companies with these resources.[35] Overall, economists assume that demand for such expertise may soon exceed supply from a small group of companies, possibly leading to a market concentration, higher prices, and delays.

This expertise and experience could help accelerate decommissioning projects and reduce costs – but it could also provide business opportunities for the companies with a head-start.

34 DIW 2015.

35 Energiewerke Nord GmbH (EWN GmbH), GNS Gesellschaft für Nuklear-Service mbH (GNS), NUKEM Technologies GmbH, Areva GmbH, Siempelkamp Ingenieur und Service GmbH, NIS Ingenieurgesellschaft mbH (NIS), Babcock Noell GmbH (BNG), now Bilfinger Noell (DIW 2015).

Recommendations

A European energy shift towards renewable energy can only succeed if Europe also exits from fossil energy and nuclear power. However, after a half century of commercial nuclear power, no country in Europe has yet adopted a binding disposal strategy, let alone a fully operational repository for highly radioactive waste. There is no certainty about the actual costs and no secure financial means for plant decommissioning and waste disposal. The continued losses of large European energy suppliers and their restructuring projects underscore the need for political action.

Decommissioning is a complex, expensive task requiring highly specialized expertise. For at least one generation of engineers, the job opportunities are significant, and this market will be quite large indeed. Nuclear decommissioning is a new sector for innovative companies in countries benefiting from their pioneering role in ecological modernization. As the global situation is similar, European companies could position themselves for a new worldwide market of decommissioning expertise.

The EU Commission should support member states to provide certainty for phasing-out aging nuclear reactors. This would include an update of the 2011/70/Euratom Waste Management Directive. The aim should be to provide transparency, require securing the financial resources for decommissioning and set minimum safety standards. The European Commission, for its part, wants to help ensure that the first repositories for highly active and long-lived waste in Europe are put into operation. With research programs (Horizon 2020), it supports the transfer of knowledge and exchange of experience between national programs.

The EU should develop more concrete mandatory standards for final nuclear waste disposal, including reactor decommissioning. Financing in line with the polluter-pays-principle and safety procedures should be covered. A broad range of stakeholders should be involved, such as in German's Ethics Commission for the nuclear phaseout and the coal commission. Only then can policies be adopted that are not likely to be overturned in the next election.

Many EU member states currently pursue plans to phase out coal in electricity generation. They should expand this approach to nuclear power to build investor confidence for renewable, flexible energy sources. By removing the inflexible nuclear baseload in favor of more flexible load-following plants, consumers realize the full benefit of the lowest-cost resources while receiving the same quality of service. As research shows, continuing to rely on inflexible baseload would require curtailment of less costly energy.[36] The alternative is an economic mix of VREs and load-following plants that displaces baseload operations. Thus, the EU could support member states in achieving decarbonization in a more cost-effective way and strengthen its overall economic competiveness.

Finally, exnovation should always be a part of innovation towards ecological modernization. Including exnovation as part of a strategy of ecological modernization will boost further innovation. Unwinding old technologies in an informed, planned, and organized way provides certainty for stakeholders and reduces risks for long-term investment decisions. For political, social, and economic reasons, it is prudent to allow for transition periods, but also to begin the transition process early and to be transparent concerning intentions and time horizons. This allows certainty in the planning and investment stages, which is especially valuable for sectors with long investment cycles. It also means action should be taken now.

Too often, new technologies have failed to replace the old ones in a timely fashion; rather, the outdated and modern continue instead to coexist side by side. As researchers from the University of Sussex point out, governments can ensure that industry has sufficient incentives and time to invest in (re-)training staff, building expertise in order to become part of the change process.[37] To do so, however, they need to signal the direction of travel and set clear long-term goals and milestones. Policymakers should start mapping the existing policy landscape to identify hurdles that are in the way of a rapid transition on the path towards decarbonization.

36 Hogan, Michael; Camille Kadoch, Carl Linvill & Megan O'Reilly. 2018. How German Energiewende's renewables integration points the way. Energypost.eu. March 12. Assessed on December 11, 2018 under *https://energypost.eu/how-german-energiewendes-renewables-integration-points-the-way/* Retrieved 5 Sep 2019.

37 Kern et al. 2017

About the author

Arne Jungjohann is a senior energy analyst. He works on political parties, federalism, and coalition governments. Arne Jungjohann is a member of the Green Academy, a project of the Heinrich-Böll-Stiftung.

Imprint

Editor: Heinrich-Böll-Stiftung e.V., Schumannstraße 8, 10117 Berlin
Contact: Marc Berthold, Referat Europäische Union/Nordamerika **E** *berthold@boell.de*

Place of publication: *www.boell.de*
Release date: April 2020