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Monitored this issue:

UK Plans for Small and Advanced Modular Reactors

By Pete Roche; Editor of no2nuclearpower.org.uk website

In January, the UK Government published its Civil Nuclear Roadmap,[1] which supposedly sets out how it will increase nuclear generation by up to four times to 24 gigawatts (GW) by 2050 – enough to provide a quarter of the UK's electricity needs.[2] The plans include next steps for exploring a large-scale power plant as big as Sizewell C and Hinkley Point C. (A final investment decision on Sizewell C is due to be made by the end of this year).

But the plan also includes a key role for Small Modular Reactors (SMRs).[3]

Great British Nuclear

In March last year, the Government announced the establishment of a new organisation that would be responsible for driving the delivery of new nuclear projects.[4] Called 'Great British Nuclear' (GBN) its first job was to launch a competition to select the best small modular reactor technologies for development. [5]

In October, GBN issued a shortlist of six companies – EDF, GE Hitachi, Holtec, NuScale, Rolls-Royce and Westinghouse who would be invited to tender for building SMRs. The six companies can now access tender documentation, allowing them to bid for potentially multi-billion-pound technology development contracts by June 2024. GBN will assess these to determine which bidders to negotiate with, before inviting those bidders to submit final tenders, with the aim of announcing successful bidders later in 2024.[6]

The chair of GBN, Simon Bowen, hopes to deliver two final investment decisions about 2028/9[7] along with the detailed design and all the regulatory approvals. He wants the first SMR online by about 2035, with more being rolled out pretty quickly after that. But they won't be ready in time to meet the Government's target of decarbonising electricity by 2035.

Nuclear Sites

There are currently 8 sites in the UK designated for new reactors under what is called a National Policy Statement. All 8 sites are also sites of existing reactors, some of which have already closed. So GBN is currently focussed on building on these sites and it has just bought back from Hitachi the Wylfa site on the Island of Anglesey, and Oldbury in Gloucestershire, for £160 million.[8] But GBN

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[1] Civil Nuclear: Roadmap to 2050, Department for Energy Security and Net Zero, January 2024 https://assets.publishing.service.gov.uk/media/659fb57ae8f5ec000f1f8b78/6.8610_DESNZ_Civil_Nuclear_Roadmap_report_print-version.pdf

[2] UK Government Press Release 11th January 2024 https://www.gov.uk/government/news/biggest-expansion-of-nuclear-power-for-70-years-to-create-jobs-reduce-bills-and-strengthen-britains-energy-security

[3] Edie 11th January 2024 https://www.edie.net/uk-government-sets-out-plans-to-quadruple-nuclear-generation-capacity-by-2050/

[4] UK Government Press Release 30th March 2023 https://www.gov.uk/government/news/shapps-sets-out-plans-to-drive-multi-billion-pound-investment-in-energy-revolution#full-publication-update-history

[5] Great British Nuclear: Overview https://www.gov.uk/government/publications/great-british-nuclear-overview/great-british-nuclear-overview

[6] GBN Blog 22nd March 2024 https://greatbritishnuclear.blog.gov.uk/2024/03/22/three-months-into-the-year-and-three-big-steps-forward/

[7] BBC Today Programme, Radio4 11th March 2024 https://www.bbc.co.uk/sounds/play/m001x4n5 (From 16:44)

[8] Spring Budget 2024, HM Treasury 6th March 2024 https://assets.publishing.service.gov.uk/media/65e

says to get to 24GW the 8 sites are simply not going to be enough.

So, the Government has consulted on a new draft Nuclear National Policy Statement,[9] which would open up far more areas as potential sites. Rather than specifying sites, developers will be asked to identify locations for reactors based on a new list of safety and environmental criteria. Only "population density" and "proximity to military activities" will rule out nuclear plants, meaning they cannot be built in areas with more than 5,000 people per square kilometre. All other criteria will be discretionary, including size, flood risk, proximity to civil airports, the natural beauty, ecological importance or cultural heritage of the site. Officials believe developers are likely to want to site plants near industrial estates needing power and heat, or in areas that have skilled workers and grid connections. If this is agreed SMRs could be built almost anywhere outside built-up areas.[10]

Advanced Reactors

The six successful SMR designs going forward to the next stage of the competition, are all Light Water Reactors – either Pressurised Water Reactors or Boiling Water Reactors – so similar to most current reactor-types around the world.

The Government's 'Ten Point Plan for a Green Industrial Revolution' published in November 2020[11] also announced plans to invest up to £170 million to support Advanced Modular Reactors (AMRs). These are generally Generation IV reactors, which use novel cooling systems or fuels to offer new functionality (such as industrial process heat) and potentially a step change reduction in costs. There are a large number of reactor technologies that would fall into this category, for instance lead-cooled fast reactors (LFRs), molten salt reactors (MSRs), and High Temperature Gas Reactors (HTGRs). However, the UK Government is focussed on HTGRs.[12]

The Government is providing funding for an AMR Research, Development and Demonstration (RD&D) programme, to enable an AMR demonstration project to be built in the early 2030s. The next step of the programme aims to provide funding to 2 vendors, alongside 50% matched funding, to advance designs to at least the level of maturity required to enter the regulatory review process by March 2025.[13]

Scotland

Fortunately, the Scottish Government does 'not support the building of new nuclear power plants under current technologies.' The policy recognises that the proposed Small Modular Reactors 'use the same nuclear fission technology as the power generating process found in larger traditional nuclear power plants and carry the same environmental concerns', but the Scottish Nuclear Free Local Authorities (SNFLAs) were concerned that an attempt might be made by the UK Government and the nuclear industry to hoodwink parliamentarians at Holyrood into accepting claims that AMRs are somehow different.

In February, SNFLA wrote to Scotland's Energy Minister Gillian Martin urging her not to fall for the rhetoric that so-called 'Advanced Modular Reactors' (AMRs) represent a step-

8578eb559930011ade2cb/E03057752_HMT_Spring_Budget_Mar_24_Web_Accessible__2_.pdf

[9] National Policy Statement for new nuclear power generation: new approach to siting beyond 2025 - consultation document, DESNZ 11th Jan 2024 https://www.gov.uk/government/consultations/approach-to-siting-new-nuclear-power-stations-beyond-2025

[10] Times 11th Jan 2024 https://www.thetimes.co.uk/article/nuclear-power-plants-built-uk-plans-2024-rv5qxhzg2

[11] UK Government 18th November 2020 https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

[12] Advanced Nuclear Technologies, UK Government Policy Paper, 15th Aug 2023, https://www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies

[13] Civil Nuclear: Roadmap to 2050, Department for Energy Security and Net Zero, January 2024 https://assets.publishing.service.gov.uk/media/659fb57ae8f5ec000f1f8b78/6.8610_DESNZ_Civil_Nuclear_Roadmap_report_print-version.pdf

change beyond the existing fission nuclear plants which have been plagued by failure.

SNFLA sent her a briefing on AMRs which can be found here: https://www.nuclearpolicy.info/briefings/nfla-policy-briefing-292-prospects-for-advanced-modular-reactors-in-the-uk/

The briefing concludes that: "*the UK Government's plans for AMRs will be expensive, unlikely to be able to contribute anything to our net zero goals by 2050, will still present safety and environmental concerns and will still generate nuclear waste. So, in all important aspects AMRs will not be any different from current designs*".

The Minister replied with a reassurance that the Scottish Government remains opposed to building any new nuclear power plants in Scotland 'using current technologies' and that this includes Small or Advanced Modular Reactors which also employ 'traditional fission nuclear power'. The Minister agreed with the SNFLA analysis that AMRs: "*will be expensive and are unlikely to be ready in time to contribute towards Scotland's ambition of being Net Zero by 2045*" and makes plain that the Scottish Government holds a similar view to the SNFLAs that '*significant growth'* in renewables and storage provides '*the best pathway to net zero by 2045*'.[14]

HALEU

AMRs will require fuel with a higher enrichment level than existing reactors**.** Natural uranium contains about 0.7% of the 'fissile'[15] isotope of uranium, U-235. This must be 'enriched' (for example, by use of a centrifuge) to 3.5-5% for a chain reaction to be sustained in a PWR or BWR. AMRs require High Assay Low Enriched Uranium (HALEU) is uranium enriched to 5-20%.

Currently, Russia is the only country that can supply commercially viable HALEU. So, the UK Government is planning to spend £300m on supporting domestic production of HALEU fuel.[16] The UK Secretary of State for Energy Security and Net Zero, Claire Coutinho, said this will weaken the Kremlin's grip. But this is somewhat misleading. HALEU is only currently used in the small number of reactors that produce medical isotopes and for a very small number of prototype advanced reactors. So, any dependence on Russia is trivial compared to the dependence on Russia for material for fuel for PWRs and BWRs. Given that, worldwide, AMRs are unlikely to be built in significant numbers till after 2040 at the earliest by which time the agenda to reduce dependence on Russia may well be very different, this seems a strange and speculative commitment of a significant amount of public money.[17] The Capenhurst site in Cheshire, in North West England, will most likely enrich the uranium. [18] and the Westinghouse Springfields site near Preston, also in North West England, is likely to fabricate the fuel.[19]

Nuclear Waste, SMRs and AMRs

A new report from the UK Government's Committee on Radioactive Waste Management (CoRWM) has called for the management of spent fuel and radioactive waste from small and advanced modular reactors to be considered when selecting technologies for investment, further development, construction and operation.[20]

[14] NFLA 20th Feb 2024 https://www.nuclearpolicy.info/news/holyrood-minister-says-there-will-be-no-advanced-modular-reactors-in-scotland/

[15] Reactors need fissile material top sustain a chain reaction, i.e., material that can undergo nuclear fission when struck by a neutron of low energy

[16] UK Government Press Release 14th January 2024 https://www.gov.uk/government/news/uk-invests-in-high-tech-nuclear-fuel-to-push-putin-out-of-global-energy-market

[17] DESNZ 7th Jan 2024 https://www.gov.uk/government/news/uk-invests-in-high-tech-nuclear-fuel-to-push-putin-out-of-global-energy-market

[18] Chemical Engineer 11th Jan 2024 https://www.thechemicalengineer.com/news/uk-declares-biggest-nuclear-revival-in-70-years-with-plans-for-new-reactors-and-fuel-production/

[19] Lancashire Post 12th Jan 2024 https://www.lep.co.uk/news/environment/preston-nuclear-site-poised-to-produce-new-fuel-technology-that-will-help-power-uk-4476332

[20] Development of Small Modular Reactors and Advanced Modular Reactors – implications for the management of higher activity wastes and spent

This must involve addressing the uncertainties about such management at an early stage, to avoid costly mistakes which have been made in the past, by designing reactors without sufficient consideration of how spent fuel and wastes would be managed, and also to provide financial certainty for investors regarding lifetime costs of operation and decommissioning.

CoRWM says there is little published material from the promoters and developers of new reactor types to demonstrate that they are devoting the necessary level of attention to the waste arisings. It is clear that different types of reactor, ranging from those which are very similar to current light water reactors (LWR), through to those using exotic fuels about which little is known, will present highly variable levels of confidence as to how the spent fuel and waste will be managed and ultimately disposed of. The Committee adds "*it is not necessarily the case that all types of spent fuel and radioactive waste will be suitable for disposal in a geological disposal facility (GDF), at least without potentially difficult prior treatment processes*.".[21]

Generic Design Assessment process

In the UK, the nuclear regulators – the Office for Nuclear Regulation (ONR), the Environment Agency and Natural Resources Wales (NRW) – undertake a process called the 'Generic Design Assessment' (GDA), to look at the safety, security and environmental implications of new reactor designs before an application is made to build that design at a particular site. The GDA process has 3 steps: 1. Initiation; 2. Fundamental assessment and 3. Detailed assessment.[22]

Rolls Royce SMR

The Rolls-Royce SMR was the first SMR (although it is not particularly small at 470MW) to enter the GDA process. It entered Step 1 of the GDA Process on 1 April 2022. Step 1 is the project initiation stage of the design assessment process. It involved discussions to ensure a full understanding of the requirements and processes that will be applied, readiness of the Requesting Party (RP) to begin Step 2 and a review of the RP's security and Quality Assurance (QA) arrangements. In April 2023, the regulators started Step 2 - a 16-month assessment of the fundamental acceptability of the Rolls-Royce SMR design for deployment in Great Britain. Step 2 is expected to take until July 2024. After that Step 3 – the detailed assessment - could take around another 2 years.[23]

In November 2021, the UK government provided funding of £210 million to help Rolls Royce further develop its design.[24]

Holtec SMR-300

In December 2023, the UK Government awarded Holtec Britain £30 million of grant funding to help the Company complete the first two steps of the GDA for their SMR-300 reactor.[25]The Regulators have now been asked by the Department for Energy Security and Net Zero to begin the GDA.[26] Presumably Holtec and ONR have decided not to commit to the third step of the GDA until the winners of GBN competition are known.

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fuel, CoRWM, Feb 2024, https://assets.publishing.service.gov.uk/media/65c26c9ca6838e000d49d589/corwm-smr-and-amr-position-paper.pdf

[21] A useful summary of the CoRWM report: World Nuclear News 14th Feb 2024 https://www.world-nuclear-news.org/Articles/Waste-issues-need-consideration-in-SMR-deployment,

[22] See https://www.onr.org.uk/generic-design-assessment/

[23] See https://www.onr.org.uk/generic-design-assessment/assessment-of-reactors/rolls-royce-smr/

[24] BBC 9th November 2021 https://www.bbc.co.uk/news/business-59212983

[25] Holtec 7th Dec 2023 https://holtecinternational.com/2023/12/07/holtec-britain-awarded-uk-government-grant-funding-for-generic-design-assessment-of-us-origin-smr-300-nuclear-reactor-in-the-united-kingdom/

[26] ONR 7th Dec 2023 https://news.onr.org.uk/2023/12/onr-begins-new-smr-reactor-assessment/

South Korea's Hyundai Engineering & Construction (Hyundai E&C), Balfour Beatty and engineering company Mott MacDonald, have teamed up with Holtec.[27] Now the British arm of Holtec International is launching a competition to find a site for a £600 million factory in Britain to build SMRs.[28] Local authorities and businesses will be invited to submit expressions of interest to host the factory.

GE Hitachi BWRX-300

In January 2024, GE Hitachi Nuclear Energy (GEH) was awarded £33.6 million - to support it in developing its BWRX-300 SMR in the UK. [29] The design has now entered the GDA process.[30] Again it will only be the first two steps of the process for now. ONR says it is up to investors, developers and vendors to decide whether the shorter two-step GDA gives them enough confidence to proceed with procuring a site, setting up a licensee organisation, and start to place contracts for components and construction activities.

Westinghouse AP300s

In February 2024, Westinghouse formally submitted an application to the UK Government for approval to enter its AP300 into the GDA process.[31]

The Westinghouse Electric Company signed an agreement with Community Nuclear Power, Ltd. (CNP) to deploy its AP300 reactors on Teesside in North-east England.[32] The proposal is to build 4 SMRs on the north bank of the River Tees, not far from the Hartlepool Nuclear Power Station, producing 1.5GW of power. Lord Houchen, the Tory mayor of Tees Valley, says of the project: "*For the first time in British history, the taxpayer is not involved*."[33]

In terms of the practicalities, Westinghouse only announced the design last May so the likelihood is that it's at an early stage. Prof Steve Thomas says the AP300 only has the slightest chance of being cheaper per KW than the AP1000 if significant features are left off. The AP1000 was a scaled up version of AP600 which got NRC safety approval in 1998. Westinghouse applied to NRC in 2002 for approval of the AP1000 saying it would be easy (a year or two) because it was just a scaled-up version of an approved design. But the NRC didn't give final approval until 2011. According to NS Energy the project is in accordance with the recently published UK Government Alternative Routes to Market for New Nuclear Projects and complementary to Westinghouse's participation in the GBN competition.[34]

Chris Goodall, in his Carbon Commentary Blog said: "*The Tees Valley SMR plan is said to have a budget of £10bn, which makes it almost as expensive per unit of electricity output as the*

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[27] Power Technology 7th March 2024 https://www.power-technology.com/news/holtec-and-hyundai-to-partner-with-british-firms-on-smr-bid/

[28] Reuters 7th March 2024 https://www.reuters.com/business/energy/holtec-seeks-uk-site-600-mln-pound-small-nuclear-reactor-factory-2024-03-07/

[29] World Nuclear News 24th January 2024 https://www.world-nuclear-news.org/Articles/Funding-to-support-UK-deployment-of-BWRX-300

[30] ONR 25th Jan 2024 https://onr.org.uk/news/all-news/2024/01/onr-begins-new-small-modular-reactor-assessment/

[31] World Nuclear News 13th Feb 2024 https://www.world-nuclear-news.org/Articles/Westinghouse-begins-UK-licensing-process-for-AP300

[32] Westinghouse 8th February 2024 https://info.westinghousenuclear.com/news/westinghouse-and-uks-community-nuclear-power-collaborate-to-deploy-fleet-of-ap300-small-modular-reactors

[33] Telegraph 8th February 2024 https://www.telegraph.co.uk/business/2024/02/08/britains-first-private-nuclear-power-station-teesside-2030s/

[34] NS Energy 9th February 2024 https://www.nsenergybusiness.com/news/westinghouse-and-uks-community-nuclear-power-collaborate-to-deploy-fleet-of-ap300-small-modular-reactors

full size reactors in construction in France and the UK."[35]
There have been no further mentions in the UK media of the other two reactors shortlisted by GBN – EDF's NUWARD reactor and NuScale's VOYGR reactor.

AMRs - X-Energy

Following the release of the UK Government's Civil Nuclear Roadmap, Carol Tansley, vice president of UK new build projects at X-energy, expressed her delight in a quote in the Government Press Release.[36]

X-Energy is keen to build some of its Xe-100 HTGRs at the Hartlepool site in North East England where there is currently an AGR station due to close in 2026. X Energy says they can be up and running by 2030 or soon after.[37] The UK Nuclear Industry Association says Hartlepool is the ideal place to support new advanced nuclear reactors and "*usher in a revolution in industrial production*". Nuclear can replace the burning of fossil fuels by heavy industry to generate home-produced electricity, and hydrogen or high-grade steam for industry. "*New advanced nuclear reactors designed to generate very high temperatures are here and ready for the challenge. Hartlepool is the place to prove it can be done. It has a site designated for new nuclear development. It has the heavy industries that would be customers for heat, power and hydrogen. Lastly, it has a skilled workforce ready, willing and able to deliver the next generation of nuclear power*."[38]

X-Energy makes some very powerful claims about the safety of its HTGR saying its design is "*meltdown-proof 'walk-away' safety, and the most robust encapsulated fuel, our approach is the safest and most secure of the Gen-IV approaches*." This gives a misleading impression of the safety of HTGRs.[39] They do not raise the same safety issues as PWRs and BWRs but raise a different set of issues.[40]

X-energy UK Holdings, a subsidiary of US-based X-energy Reactor Company, is working with Cavendish Nuclear (part of Babcock).[41] In April 2024 it was announced that the two companies would receive £3.34m in government funding to advance their plans. X-energy said it would also match the government's funding, which has been awarded through the Future Nuclear Enabling Fund (FENF), to bring the total investment pot to £6.68m overall. The companies said they would use the funds to develop UK-specific deployment plans for AMRs, including an assessment of domestic manufacturing and supply chain opportunities, constructability, modularisation studies, and fuel management. The Companies' long-term plans include the development of a multi-billion-pound, 12-reactor plant at Hartlepool, which they hope to have operational by the early 2030s. They envisage the project as the first in a future fleet of up to 40 advanced small modular Xe-100 reactors.[42]

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[35] Carbon Commentary 3rd Dec 2024 https://mailchi.mp/1b61a44076ea/carbon-commentary-newsletter-december-3rd-2023

[36] UK Government Press Release 11th January 2024 https://www.gov.uk/government/news/biggest-expansion-of-nuclear-power-for-70-years-to-create-jobs-reduce-bills-and-strengthen-britains-energy-security

[37] ITV News 1st Aug 2023 https://www.itv.com/news/tyne-tees/2023-08-01/hartlepool-nuclear-power-station-at-40-what-does-the-future-hold

[38] Hartlepool Mail 1st Aug 2023 https://www.hartlepoolmail.co.uk/business/nuclear-industry-association-praises-legacy-of-hartlepool-power-station-and-looks-to-future-potential-4239946

[39] See https://x-energy.com/reactors/xe-100

[40] For an account of the safety issues HTGRs raise, see Matthias Englert, Friederike Frieß & M. V. Ramana (2017) Accident Scenarios Involving Pebble Bed High Temperature Reactors, Science & Global Security, 25:1, 42-55, DOI: 10.1080/08929882.2017.1275320 http://dx.doi.org/10.1080/08929882.2017.1275320

[41] Professional Engineering 6th Jan 2023 https://www.imeche.org/news/news-article/smr-developers-submit-6-designs-for-uk-approval

[42] Business Green 4th April 2024 https://www.businessgreen.com/news/4192414/energy-cavendish-nuclear-win-gbp-3m-grant-develop-advanced-modular-reactor-vision

Newcleo

Newcleo has proposed building small modular lead-cooled fast reactors in the UK which would use MOX fuel.[43] But the Civil Nuclear Roadmap says the Government does not support the use of plutonium stored at Sellafield by AMRs whilst high hazard reduction activities are being prioritised. Now Newcleo has dropped plans to build one of its reactors in Cumbria (near Sellafield) but will build in France instead.[44] But it is still talking about building 20 lead-cooled fast reactors in the UK in the future.[45]

In April 2024 the Nuclear Industry Association announced that it had applied for a justification decision for Newcleo's lead-cooled fast reactor, the LFR-AS-200. Evaluation of potential benefits and detriments is required for in-principle justification of any new nuclear practice. Justification is a regulatory process which requires a Government decision before any new class or type of practice involving ionising radiation can be introduced in the UK. This is the first ever application for justification of an advanced nuclear technology in the UK. The UK Government has confirmed that the application has been accepted for consideration, and the Department for Environment, Food and Rural Affairs will support the Secretary of State in their role as the justifying authority responsible for the justification decision. Stefano Buono, Newcleo Chairman and CEO, says he is aiming to deliver our first of a kind commercial reactor in the UK by 2033.[46]

Newcleo has commissioned Nuclear Transport Solutions (NTS) (part of the UK Government's Nuclear Decommissioning Authority) to carry out feasibility studies on the transport of mixed plutonium-uranium oxide (MOX) fuel.[47]

Conclusions

The UK has been trying to push for a so-called nuclear renaissance since November 2005 when Tony Blair said he was putting nuclear power at the centre of a new government energy review. Today, 19 years later, only one new nuclear station is under construction at Hinkley Point C in Somerset, and the first reactor is now not expected to start operating until at least 2029 – more likely 2031. It remains to be seen whether Small or Advanced Modular Reactors can make any progress.

In 2005 Professor Gordon Mackerron, writing in the *Observer*, said that a worst-case scenario following a commitment to nuclear new-build would be a sterilisation of non-nuclear investment while the nuclear programme itself stalled.[48] Things over the past 20 years may not have been quite that bad - the UK has at least been building some renewables - but not nearly enough. The danger from a climate change point of view is that we are now going to perpetuate this problem – fail to revive nuclear power but also fail to give our full attention to developing renewables and energy efficiency.

Pete Roche;
Editor of no2nuclearpower.org.uk website

[43] World Nuclear News 18th January 2024
https://www.world-nuclear-news.org/Articles/Newcleo-consults-NTS-on-transport-of-MOX

[44] Telegraph 20th January 2024
https://www.telegraph.co.uk/business/2024/01/20/newcleo-nuclear-start-up-drops-british-factory-plans-france/

[45] World Nuclear News 1st February 2024
https://www.world-nuclear-news.org/Articles/Podcast-Newcleo-s-Andrew-Murdoch-on-its-lead-coole

[46] Newcleo 5th April 2024
https://www.newcleo.com/press-releases/first-ever-advanced-reactor-submitted-for-justification-in-uk/

[47] World Nuclear News 18th January 2024
https://www.world-nuclear-news.org/Articles/Newcleo-consults-NTS-on-transport-of-MOX

[48] Observer 4th Dec 2005
https://www.theguardian.com/business/2005/dec/04/nuclearindustry.environment3

Phasing out nuclear power in Europe is possible

By Jan van Evert, editor Nuclear Monitor

Politicians from Europe and many other countries recently promoted nuclear power at a conference in Brussels held by the International Atomic Energy Agency (IAEA). According to IAEA head Rafael Grossi, nuclear power is a solution to climate change. However, building new nuclear power plants to decarbonise Europe in time is unrealistic. The European Environmental Bureau (EEB) has published the report 'Nuclear Phase-out' demonstrating that phasing out nuclear power alongside fossil fuels is feasible. It is even compatible with climate targets as the EU accelerates the deployment of renewables and energy savings.

Several factors contribute to this assessment. First, given the need to rapidly reduce emissions from the EU's power sector in line with climate targets, the long lead times and construction delays of nuclear power plants significantly increase the risk of overshooting remaining the EU's carbon budget. Second, high investment and maintenance costs render nuclear power plants uncompetitive with renewables. This leads to a very heavy reliance on public funding and associated political lags - likely to reduce resources for phasing out fossil fuels rapidly. Third, uncertainties about the safety of nuclear power plants and climate vulnerability of nuclear reactors that rely on river water cooling add further financial burdens and delays.

The report is based on the Paris Agreement Compatible (PAC) energy scenario. There are two main decarbonisation drivers displacing nuclear power from the energy mix over time. First, a sharp energy demand reduction, driven by efficiency and sufficiency measures, improved circularity and recycling, and the electrification of processes that currently rely on fossil fuels. Secondly, faster renewable energy deployment, replacing fossil fuels and nuclear power. Grids, storage, and demand-side management will maximize the use of renewable energy for electricity generation. It is important to realize that the role of nuclear power in the energy transition is limited. Nuclear power currently makes a small contribution to the EU's energy needs. Only 12 of the 27 EU countries generate nuclear power, which accounts for less than five percent of the bloc's final energy consumption. The PAC nuclear phase-out trajectory is in line with the planned retirement of the ageing European nuclear reactors. Without further extensions, most of the capacity in operation in 2022 will reach retirement age by 2040.

The combination of renewable energy, energy savings and flexibility tools can ensure stable energy security and fully replace fossil fuels. It can even replace the remaining nuclear power plants.

Jan van Evert, editor Nuclear Monitor

The full report can be downloaded here; https://eeb.org/library/nuclear-phase-out-how-renewables-energy-savings-and-flexibility-can-replace-nuclear-in-europe/

Q&A - Germany’s nuclear exit: One year after

Benjamin Wehrmann, CLEAN ENERGY WIRE

Decades of debates came to an end in April 2023, when Germany finally shuttered its last nuclear power plants after the energy crisis. One year on, predictions of supply risks, price hikes and dirty coal replacing carbon-free nuclear power have not materialised.

Instead, Germany saw a record output of renewable power, the lowest use of coal in 60 years, falling energy prices across the board and a major drop in emissions. Industry representatives warn that an effect on power costs may still become visible once Germany's economy moves out of recession.

At the same time, many countries plan to expand nuclear power, suggesting the country's phase-out has not found many followers. Yet, global nuclear power market numbers indicate that a nuclear revival is not imminent either.

[UPDATES Government advisor says power prices higher due to exit; majority in survey says nuclear exit was a mistake]

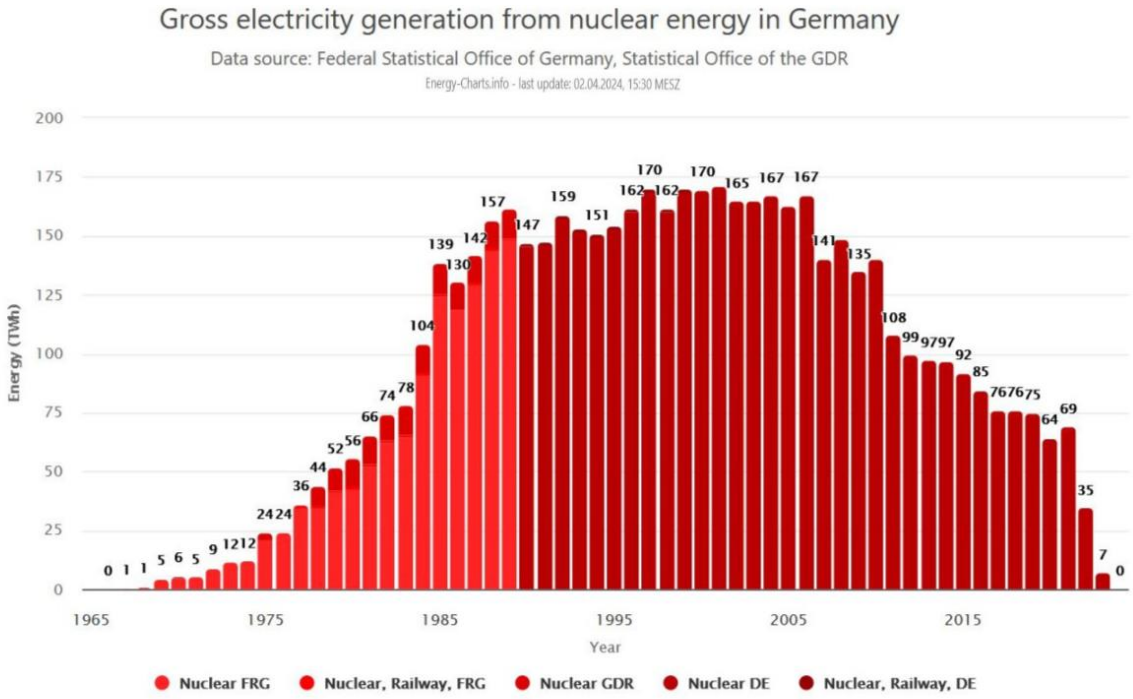
Content

Demolition works at the Stade nuclear plant in northern Germany. Photo: Hiroyasu Sakuma

1) How has the phase-out been conducted?

The three last remaining nuclear power plants in Germany were taken offline on 15 April 2023. The *Atomausstieg's* finalstep marked the end of a process that had been prepared for over two decades and involved almost all of Germany's main political parties. It followed on a three-month delay caused by the energy crisis, during which the Emsland, Isar 2 and Neckarwestheim 2 plants were kept online as backup capacity for electricity generation.

By the phase-out's first anniversary, Germany had achieved a substantial expansion of its renewable power capacity. However, the country still faces challenges regarding the required grid modernisation as well as back-up and storage capacity, including batteries and green hydrogen infrastructure, to complement renewable power output.



Nuclear power's life cycle in Germany: output fell gradually throughout the past years and stood at about 35 TWh before the phase-out. Source: Energy Charts

The last stage of the nuclear phase-out was implemented without any technical challenges or electricity price shocks. Shortly before the deadline, citizens were worried about the possible impact of taking the final step. However, none of the most dire predictions by opposition parties and industry lobby groups materialised. "We see today that our power supply is secure, that power price dropped also after the nuclear phase-out and that CO2 emissions are going down as well," Germany's economy and climate action minister Robert Habeck said.

The German Chamber of Commerce and Industry (DIHK) had been a vocal critic of the final phase-out step. One year after the phase-out, there was no indication that companies experienced supply challenges related to the nuclear exit, DIHK energy expert Sebastian Bolay told Clean Energy Wire.

2) Was there any supply security risk in the aftermath?

The importance of nuclear power for Germany's electricity generation already declined significantly in the years before the phase-out was completed. In 1995, nuclear plants contributed almost 30 percent to the mix. By 2022, their share had dropped to roughly 6 percent. The share of renewable energy sources grew from about 5 percent to more than 46 percent during the same period and reached more than 50 percent in 2023.

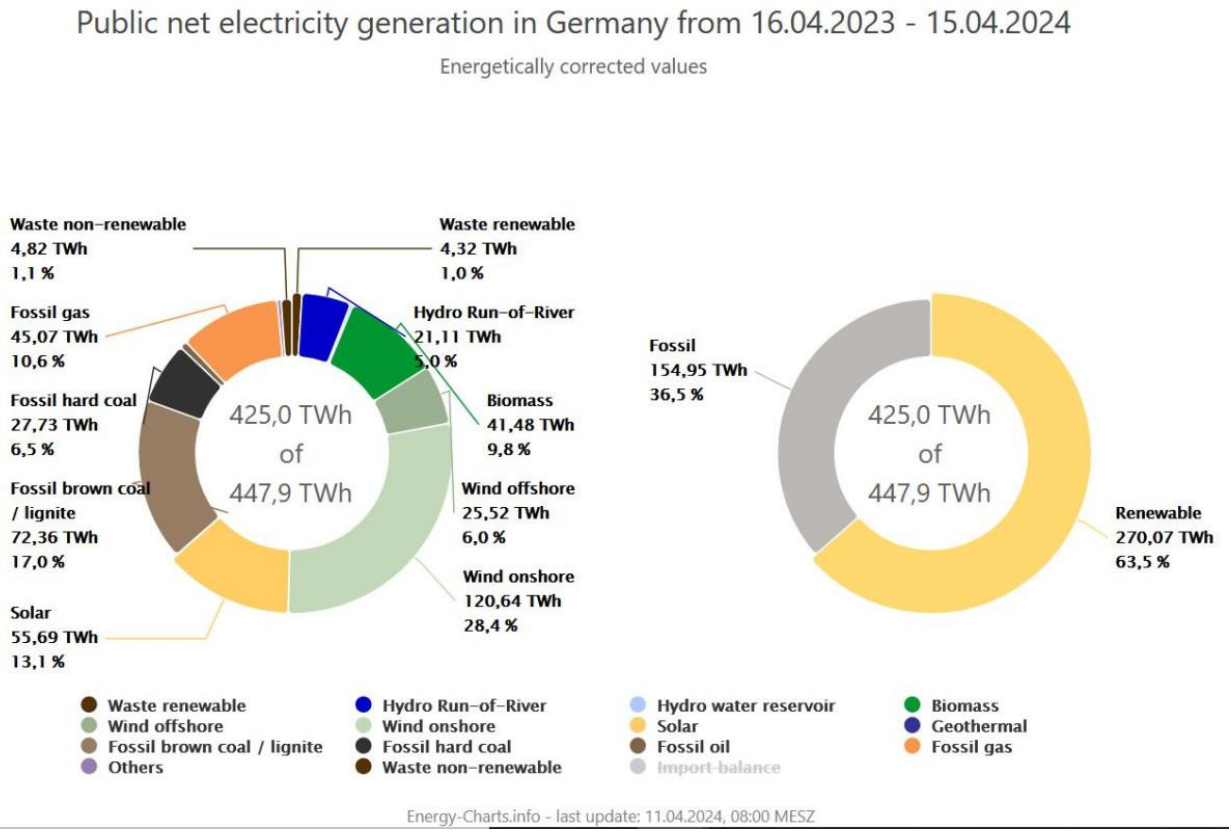
In the winter season following the phase-out, supply security "significantly improved" compared to the previous year, the Federal Network Agency (BNetzA) said, adding that greater reliability of the French nuclear fleet after its partial shutdown in the 2022/2023 period played a great role in improving stability. The risk of a larger blackout in

Germany remained “very low,” the BNetzA said.

DIHK expert Bolay said some companies had reported an increase in short-term energy supply challenges throughout 2023. “Whether this was related to the decommissioning cannot be answered." However, the growing share of renewable power in the system can hardly be an explanation either. “Hourly electricity trading has a greater effect on grid stability than renewable power feed-in,” energy researcher Bruno Burger from the Fraunhofer ISE institute told Clean Energy Wire.

alone thus more than compensated for the loss of nuclear capacity in net public electricity generation.

Fossil power sources contributed 210 TWh to electricity production in the final year of nuclear power use, when Germany had deployed additional coal power capacity as a safety measure in the energy crisis. However, the fossil fuel-fired power plants’ output dropped markedly in the following year and stood at about 160 TWh by 15 April 2024. In fact, the use of coal power dropped to its lowest level in more than half a century in the same year Germany went

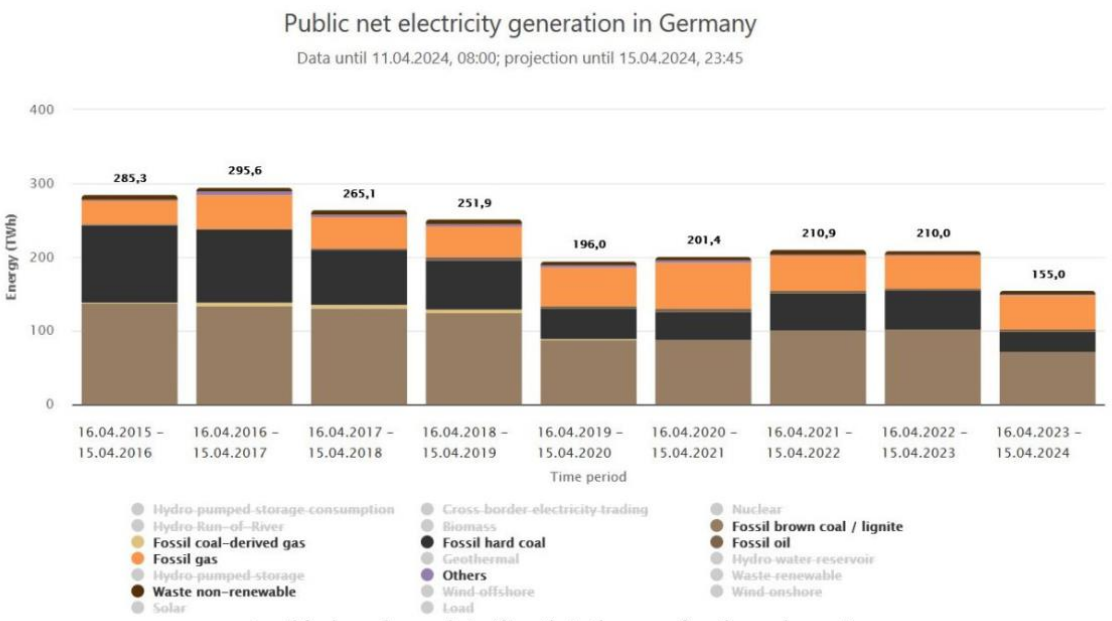


3) What was the gap left by nuclear power filled with?

Nuclear power had a total output of just under 30 terawatt hours (TWh) in the year before the last three plants went offline and output dropped to zero. On the other hand, the output of renewables was 237 TWh in the period between April 2022 and the final phase-out step. In the year after 15 April 2023, renewables had surpassed the previous year’s output, reaching nearly 270 TWh by early April, according to Fraunhofer ISE researcher Burger. With a net increase of more than 30 TWh, the additional output of renewables

nuclear-free, meaning fossil fuel did not see a revival to fill the gap. According to an analysis by the anti-nuclear NGO Greenpeace, energy sector emissions in Germany dropped by 24 percent.

The total load in the electricity system decreased compared to the year before the phase-out, from 468 TWh to about 460 TWh, a trend that has partly been due to sluggish growth and lower energy demand from industry. However, as a result of renewables expansion, lower coal power use and reduced energy demand, Germany’s total emissions



Fossil fuel use dropped significantly in the year after the nuclear exit.
Source: Energy Charts

dropped by about 10 percent in the final year of the nuclear exit.

4) What changed in electricity imports and why?

For the first time in many years, Germany became a net electricity importer in 2023. The trade balance for electricity switched from 21 TWh of exports to 22 TWh of imports in the same period. Imports have risen despite sufficient plant capacity in Germany to cover domestic demand entirely. In March 2024, the country announced the shutdown of seven more coal-fired power plant units after the winter, as they are no longer needed to guarantee supply security.

A Greenpeace analysis found that natural gas reserves alone would have sufficed to cover the demand for additional electricity in Germany. The fast growth of renewables meant that the country will likely become a net-exporter again roughly by 2030, the NGO said.

Economy minister Habeck stressed on the phase-out's anniversary that Germany has enough power production capacity to fully cover its demand domestically, not least thanks to a resolute expansion of renewables. "At the same time, we participate in the European power market," he added. According to energy industry association BDEW, Germany's import balance is a sign of a functioning internal EU electricity market: it has been cheaper to generate electricity abroad in recent months and thus replace domestic fossil power generation. Lower power prices on European wholesale markets, driven by a high output of renewables from the Alps to Scandinavia especially during the summer of 2023, meant Germany's coal power plants could not compete. Electricity retailers therefore opted for imports instead of more expensive domestic production. At the same time, the return of French nuclear plants to the grid, whose shutdown had pushed Germany's electricity exports in the year before, meant demand abroad was also lower and the scope for power exports reduced.

While Germany's electricity trade balance turned negative in 2023, imports accounted for only 2 percent of total electricity generation. One quarter of this share came from nuclear power frontrunner France, economy minister Habeck pointed out in early 2024. With the majority of imports coming from renewables-rich Scandinavia, French nuclear energy did not become more important for Germany's power imports.

5) Did power prices go up due to the phase-out?

Day-ahead prices on the European power exchange in April 2024 stood at roughly 53 euros per megawatt hour (MWh), lower than

in June 2021 (72€/MWh), at the onset of the energy crisis and before Russia's invasion of Ukraine. In January 2021 was also 53€/MWh. Price decreases on wholesale markets also translated into lower power bills for households: New customers in March 2024 paid about as much as those entering contracts in June 2021 (roughly 25 cents per kilowatt hour), according to data by price comparison website Verivox.

Leaving the nuclear reactors online could have made wholesale power prices 0.3 ct/kWh cheaper in 2024, consultancy Prognos AG had estimated, which is equal to about one percent of the average household's power bill. "That's a magnitude which practically no one would ecognize," commented Prognos analyst Marco Wünsch.

the nuclear exit could lead to a significantly higher price level for households have thus not come true," he said.

However, energy expert Bolay from business association DIHK insisted that the decommissioning must have had an inevitable effect on power prices. "It's clear that more supply to the market means lower prices for buyers," he argued. German economy's weakened output so far might have obscured the real impact: "Larger ramifications can be expected once the economy is back on track and power demand increases," Bolay said. The DIHK pointed out that wholesale power prices in spring 2024 were still twice as high as they used to be in 2019, which was compounded by taxes, grid fees and other levies.

Average power prices for new customers in Germany

Household prices for average demand of 4,000 kWh in ct/kWh

Prices for new power customers in March 2024 were similar to those paid in June 2021, before the onset of the energy crisis.
Source: Verivox 2024

The massive fluctuations on energy markets caused by fossil fuel prices at the height of the energy crisis made a clear attribution of the nuclear exit's price effect difficult, according to an analysis by think tank Agora Energiewende. However, Agora said "the price-increasing factor of the nuclear exit has been overcompensated by the strong price reduction on the power exchange."

Energy expert Thorsten Storck from Verivox likewise said falling wholesale power prices were the main reason customers had to pay less one year after the phase-out. "Fears that

Efforts to further develop the power system and guarantee companies an electricity supply at competitive prices after phase-out have been inadequate, Bolay added. "Despite lower purchase prices, many companies pay more than in 2023" due to taxation and grid-related costs. Purchase prices could rise once economic activity picks up again, while further rises in grid fees are expected for the next years, Bolay warned. "Some relief regarding levies and fees is decisive for preventing competitive disadvantages from deepening."

Government advisor Veronika Grimm, who sits on the national council of economic experts, also said that power prices "of course" would be lower if nuclear plants were kept running. In an interview with newspaper WirtschaftsWoche, Grimm argued that a "significant effect on the wholesale price" could be expected if the reactors still fed power into the grid, without specifying how much cheaper she thinks electricity would be. She singled out the Green Party for being "inflexible" with respect to the nuclear exit's timing amid the energy crisis, criticising that the government went forward with the shutdown while simultaneously paying out huge subsidies to keep power prices affordable. Grimm recently released a study in which she argued that renewables will not make power prices more affordable in the next decade.

6) What happens with the retired nuclear plants and waste materials?

According to the World Nuclear Industry Status Report, 213 nuclear reactors had officially been decommissioned around the world by the beginning of 2024. However, dismantling had only been completed for 22 of these. In Germany, three nuclear reactors have been fully dismantled and 29 are currently in the decommissioning's final stage, according to the Federal Office for the Safety of Nuclear Waste Management (BASE). Six research reactors and other three other nuclear energy-related installations continue to operate in the country.

Nuclear waste is currently kept in 16 temporary storage facilities that are needed as long as the search for a final repository is completed. This process was initially planned to be completed by 2031, but the deadline meanwhile has been postponed without setting a new date. "Only a deep geological storage offers permanent protection," BASE said. BGE, the federal company for radioactive waste disposal, has announced it will publish proposals for a possible location by 2027. "For all further steps, a realistic and ambitious schedule is needed that says until when a final repository is to be found," a spokesperson for BASE told Clean Energy Wire.

The nuclear plant sites could also play a role in solving Germany's power storage problems: PreussenElektra, operator of the decommissioned Brokdorf nuclear power plant in northern Germany that was taken offline at the end of 2021, wants to transform the site into a 800-megawatt (MW) battery plant. Coming with a price tag of about 500 million euros, the plant would be the biggest of its kind in Europe.

7) How did the national debate about nuclear power develop?

The nuclear exit's completion in spring 2023 was accompanied by a reignited controversy about the phase-out's timing during the crisis. Especially representatives from centre-right parties, the conservative CDU/CSU alliance and the pro-business Free Democrats (FDP), which under then-chancellor Angela Merkel decided to accelerate the original phase-out plan in the wake of the Fukushima nuclear disaster, moved on to question the phase-out or even called for re-entering the technology.

Partly fuelled by critical remarks from the International Energy Agency (IEA) about the step's timeliness, nuclear energy has not disappeared from policy debates after the last reactors went offline. In a nod to the potential of nuclear technology beyond existing procedures, the research minister from the government coalition member FDP party promised a deepened commitment to develop nuclear fusion in Germany. Despite scepticism among former plant operators, the opposition party alliance CDU/CSU is pushing to include nuclear energy in long-term energy system planning again. In a motion in parliament, the conservative alliance in April 2024 called for a halt of dismantling works at the three decommissioned plants until a new government can make a final decision at a later stage. Environment minister Steffi Lemke commented that the idea to stop the decommissioning process for the last plants would be "detached from reality" and has little to do with the facts on nuclear power's usefulness in Germany's future energy system.

The CDU's secretary general, Carsten Linnemann, ahead of the nuclear exit's

anniversary called the step an “historic mistake” that had led to all the negative consequences some had expected, such as higher imports, economic challenges and no countries following Germany’s example (In late 2023, the Spanish government confirmed its intention to end nuclear power use in the country by 2035 and to plan towards an energy system based on renewable power). However, Linnemann said the conservatives would aim to “correct” the phase-out. Meanwhile, local CSU politicians in the southern state of Bavaria have expressed concerns about the security of nuclear power stations planned in neighbouring Czechia.

Green Party minister Habeck pointed out that the government coalition merely implemented what a coalition of the FDP and CDU/CSU had decided in 2011. “It would therefore be better not to permanently put things into question that the whole country had agreed on but to focus on solving current problems.”

According to the nuclear safety agency BASE, a debate about re-entering nuclear power in the country lacks a technical foundation. Modern nuclear power plant concepts do not resolve the technology’s fundamental challenge of producing hazardous nuclear waste materials, a report commissioned by BASE found. “None of the alternative reactor types would make a final repository redundant,” the report led by the Institute for Applied Ecology (Öko-Institut) concluded.
Meanwhile, a plan agreed by France and Russia to produce nuclear fuel rods in Germany provoked an outcry among anti-nuclear groups in the country earlier in the year. Greenlighting modifications of the plant to construct the rods would amount to the "co-financing of the Russian war machine" and undermine Germany's nuclear phase-out, the NGOs argued.

Olaf Bandt, head of NGO Friends of the Earth Germany (BUND), commented that the debate about nuclear power posed a siginificant hurdle to climate action by directing investments away from renewable power and storage technologies. "No company would invest its own money into nuclear power plants, as this requires a lot of money and blindness to risks," Bandt argued. "Money for nuclear plants always came and will always will come from taxpayers."

However, many citizens in Germany so far do not seem to be convinced that nuclear power should no longer play a role: In a survey commissioned by Verivox ahead of the nuclear exit’s anniversary, more than 51 percent of respondents agreed with the statement that “the phase-out of nuclear power was a mistake.” Only about 28 percent fully backed the decision while 20 percent said they have no clear opinion. At the same time, just under 45 percent agreed with the statement that Germany should switch to a climate-neutral electricity supply as quickly as possible, while nearly 25 percent disagreed.

8) How did the nuclear debate move on in the rest of the world?

Many other countries continue to rely on nuclear technology or even plan to considerably expand it in a bid to bring down their energy-related greenhouse gas emissions. At the International Atomic Energy Agency’s (IAEA) first ever nuclear energy summit in Brussels in March 2024, more than two dozen states called for a revival of the technology, including close allies of Germany such as France, the Netherlands, the U.S. and Japan. "Without the support of nuclear power, we have no chance to reach our climate targets on time," IEA chief Fatih Birol said at the nuclear summit.

The role of nuclear power in Europe’s emissions reduction plans has been a contentious issue for years, with Germany and France emerging as the main opposing forces between two groups of countries aiming to rely entirely on renewable power or to also use nuclear power in a future climate neutral energy system. France has the largest share of nuclear power production of any country but struggles to secure funding for new projects and to comply with cost and construction time plans for existing ones. The planned new Hinkley Point nuclear plant in the UK has faced years of delay and massive cost overruns. At an estimated 50 billion euros, the plant built by French energy company EDF looks set to become one of the most expensive buildings in history. Similar

cost overruns could also occur with the planned new reactors in France.

While building new nuclear power plants remained an “unrealistic strategy for decarbonisation” due to the high cost overruns and long construction times, the current reactor fleet would also not be needed to achieve climate neutrality in Europe, according to an analysis by the NGO alliance European Environmental Bureau (EEB). “The existing nuclear fleet can be phased out alongside fossil fuels as EU countries transition to a drastically more efficient energy system,” the EEB argued. More renewable power in the system, lower energy use, and better flexibility through storage and demand-side management could compensate for the EU’s nuclear energy capacity, the NGO alliance said.

In early 2024, surging renewables and a slump in power prices were undermining operations of atomic plants, leading news agency Bloomberg to conclude that the industry is "facing some tough times ahead." The trend would be a "warning sign" that nuclear power could be pushed out of the market even if individual countries plan to huge investments.

Nuclear plants accounted for roughly 10 percent of Europe’s energy consumption in 2023, with France being the biggest user by far. Most reactors in the EU are approaching their 40-year runtime limit and will likely have to be shut down around 2030 unless they are granted runtime extensions. Globally, nuclear power accounted for about 9 percent of electricity production, down from more than 17 percent in 1996, the World Nuclear Industry Status Report found. In 2023, five new nuclear plants were connected to the grid, but total installed generation capacity still fell by 1 gigawatt (GW) due to parallel decommissioning. The increase in installed renewable power capacity was 107 GW in the same year.

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This article was first published on
https://www.cleanenergywire.org/factsheets/qa-germanys-nuclear-exit-one-year-after

Earthquakes appear a bigger threat to nuclear power plants

By Jan van Evert, editor Nuclear Monitor

A recent earthquake in Japan revealed that earthquakes are even more dangerous to nuclear power plants than previously thought. On January 1, a severe earthquake occurred on the Noto Peninsula on the northern side of central Honshu, Japan. In Wajima City and two other cities close to the epicenter of the earthquake, more than 13,000 houses were completely or partially destroyed. More than 230 people lost their lives. In Wajima City, the ground rose up to four meters.
Things could have been much worse: until 2003, the Suzu nuclear power plant was scheduled to be built near what has now become the epicenter of the earthquake. If this nuclear power plant had been built, it is highly likely that it would have been destroyed by the earthquake, leading to a catastrophic nuclear disaster. Strong opposition by local residents forced Kansai Electric Power and Chubu Electric Power Co. to freeze the planned construction.

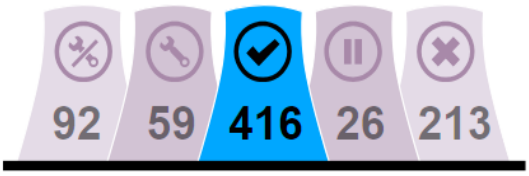
A large tremor struck the Shika nuclear power plant, located about 70 kilometers from the epicenter of the main shock. The intensity of the tremor was such that if the plant had been in operation, it would have greatly exceeded the set value for an emergency shutdown of the reactor. That’s where the trouble starts. Even if the reactor would have shut down without any problems, the reactor core would then have to be cooled. But if power and cooling water were lost as a result of the

earthquake, the result would have been a severe accident such as the one at Fukushima in 2011. Fortunately both reactors had been shut down since March 2011, preventing an emergency shutdown.
But the quake did cause some damage to the Shika plant. The spent fuel pool cooling pump stopped automatically and it took 40 minutes to restart it. The situation could have been more serious if the pump stoppage time had been much longer. Moreover, piping was damaged in two transformers, causing a leak of about 24,000 liters of insulating oil, some of which spilled into the sea.

If that's not enough trouble, a tsunami of about three meters in height arrived about 90 minutes after the earthquake, causing fissures and deformations in several locations in onsite roads. All together, this incident shows clearly that we are unable to prevent a major disaster if a nuclear power plant is struck by a major earthquake.

Jan van Evert; editor Nuclear Monitor
Source: https://cnic.jp/english/?p=7098

NUCLEAR NEWS



Number of Reactors
(as of April 2024)

Source: https://www.worldnuclearreport.org

Compared to the last edition of the Nuclear Monitor (914) , one more reactor is operating.

In China the FANGCHENGGANG-4 was connected to the grid on April 11, 2024.

EU and US doubled purchases of nuclear fuel & uranium from Russia in 2023

An analysis by the Norwegian NGO Bellona of transborder trade operations with the customs code 840130 (irradiated fuel assemblies or fuel elements) show a more than twofold increase of import to EU countries of fresh nuclear fuel in cash terms – from 280 million Euros in 2022 to 686 million Euros in 2023. In physical terms this means an increase of deliveries from 314 tons of nuclear fuel to 573 tons.

Bellona also reported that the import of enriched uranium from Russia to the USA grew in 2023 to a record level of $1.2 billion, 40% more than the import volume for 2022. With rising prices, import also increased in physical volumes by around 20%, from 588 tons in 2022 to 702 tons in 2023.

Source: https://www.laka.org/button/162618?mtm_campaign=zoeken&mtm_kwd=bellona

BASE study: Alternative reactor concepts do not solve the repository problem

A new scientific study commissioned by the Federal Office for the Safety of Nuclear Waste Management (BASE) indicates that the market launch of alternative reactor concepts (also known as "Generation IV") is currently not on the horizon.
Read the press release or the full report (in German only) at;
https://www.base.bund.de/SharedDocs/Pressemitteilungen/BASE/EN/2024/alternative-reactor-concepts.html