Highlights of the World Nuclear Performance Report 2020

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The 2020 edition of the World Nuclear Performance Report, published by World Nuclear Association, combines the Association's own data and analysis with data from the International Atomic Energy Agency's PRIS database. The report looks at long term trends in nuclear performance as well as progress in new nuclear build.

The full report, available from the Association's website[1] also includes five case studies and interviews, looking at individual examples of excellent performance in the nuclear industry.

While this year's report details the performance of nuclear reactors globally in 2019, over much of 2020 our focus has been on the impacts of the COVID-19 pandemic.

Throughout the pandemic, operators have worked with great commitment to ensure that their reactors have continued to provide electricity and support grid stability. Staff working at reactors have had to adapt to working in COVID-safe conditions whilst ensuring continuity.

With the dramatic drop in electricity demand seen in some regions, reactors have had to demonstrate greater flexibility in operation. While many renewable generators have been cushioned from the impacts of the pandemic by obligations to purchase their electricity, nuclear operators have had to vary the output of their plants to support both intermittent generation and changes in demand.

In 2020 the nuclear industry has been an essential part of the response to the coronavirus pandemic. Prior to this, 2019 proved to be one of the most significant for nuclear generation, with near-record levels of generation.

Nuclear reactors generated a total 2657 TWh of electricity in 2019, up 95 TWh from 2563 TWh in 2018, and second only to the 2661 TWh generated in 2006. This is the seventh successive year that nuclear generation has risen, with output 311 TWh higher than in 2012.

In 2019 reactors totalling 402.3 GWe were classed as operable, including those that either started up or shut down. This is fractionally higher than the 2018 figure of 402.0 GWe. The end of year capacity on 31 December 2019 was 392 GWe, down from 397 GWe in 2019.

Six reactors started up in 2019. Four large PWRs commenced operation, one in South Korea, one in Russia and two in China. In addition, two small reactors on the first purpose-built floating nuclear power plant, harboured at the town of Pevek in northeast Russia, started supplying electricity. New construction began on five reactors, two in China and one each in Iran, Russia and the UK.

In 2019, nuclear generation rose in Africa, Asia, South America and East Europe & Russia. It was fractionally down in North America, and 3 TWh lower in West & Central Europe. Recent trends continue, with particularly

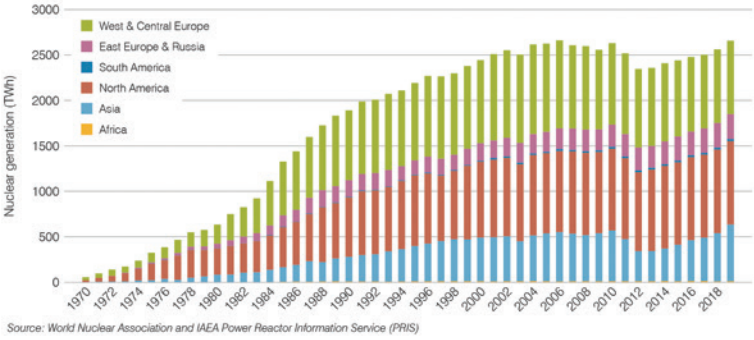

Fig. 1.
Nuclear electricity production.

Fig. 2.
Nuclear generation capacity operable (net).

	Africa	Asia	East Europe & Russia	North America	South America	West & Central Europe	Total
BWR		21 (-5)		34 (-1)		10 (-1)	**65 (-7)**
FNR			2				**2**
GCR						14	**14**
LWGR			13 (-1)				**13 (-1)**
PHWR		24 (-1)		19	3	2	**48 (-1)**
PWR	2	92 (+2)	38 (+3)	64 (-1)	2	102 (-2)	**300 (+2)**
Total	**2**	**137 (-4)**	**53 (+2)**	**117 (-2)**	**5**	**128 (-3)**	**442 (-7)**

Tab. 1.
Operable nuclear power reactors at year-end 2019.

1 https://world-nuclear.org/our-association/publications/global-trends-reports/world-nuclear-performance-report.aspx

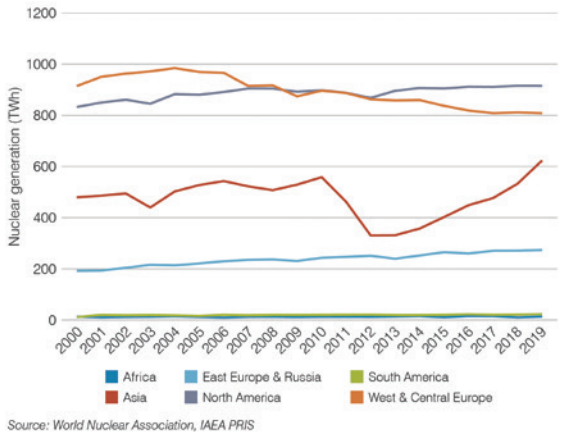

Fig. 3.
Regional generation.

strong growth in Asia, which saw nuclear generation rise by 17 %.

At the end of 2019 the capacity of the world's 442 operable reactors was 392 GWe, down from 397 GWe at the end of the previous year. Thirteen reactors shut down, of which four were in Japan and had not generated electricity since 2011; and three, in South Korea, Germany and Taiwan, were shut prematurely due to political phase-out policies.

Given the reduction in overall nuclear capacity, the increase in generation in 2019 is all the more remarkable. However, there is an urgent need for the pace of grid connections and new construction starts to increase in order to expand the essential contribution nuclear energy makes to global clean energy provision and reach the nuclear industry's Harmony goal.

Operational Performance

Capacity factors are based on the performance of those reactors that generated electricity during each calendar year. For reactors that were grid connected or permanently shut down during a calendar year their capacity factor is calculated on the basis of their performance when operable.

In 2019 the global average capacity factor was 82.5 %, up from 79.8 % in 2018, maintaining the consistently high capacity factors seen over the last 20 years. In general, a high capacity factor is a good indication of excellent operational performance. However, there is an increasing trend in some countries for nuclear reactors to operate in a load-following mode, which will reduce the overall capacity factor. The ability of nuclear reactors in France to adjust output to match varying demand and balance the output of intermittent renewables is covered in one of the case studies of the full World Nuclear Performance Report 2020.

Capacity factors in the different geographical regions are also broadly consistent with those achieved over the preceding five years. Capacity factors in North America continue to exceed 90 %.

With 2019 seeing the first five reactors to reach 50 years of operation and the first licences granted for 80 years of operation, it is welcome to note that there is no significant age-related decline in nuclear reactor performance. The mean capacity factor for reactors over the last five years shows little variation with age after the initial start-up of the reactor. For reactors beyond 40 years of operation there is a slight increase in average capacity factor. There may be a selection effect, with those reactors performing best more likely to be selected for long-term operation.

The spread of capacity factors in 2019 is broadly similar to the average of the previous five years, with more than two-thirds of reactors having a capacity factor greater than 80 %. With load-following increasing in some countries, a greater spread of capacity factors may be seen in the future.

There was a substantial improvement in capacity factors achieved from the 1970s through to the 2000s.

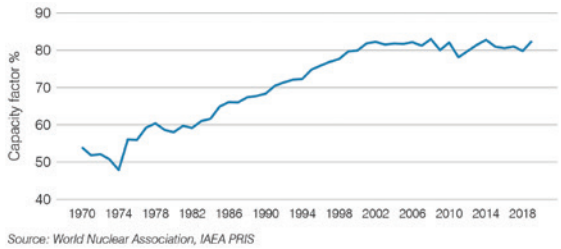

Fig. 4.
Global average capacity factor.

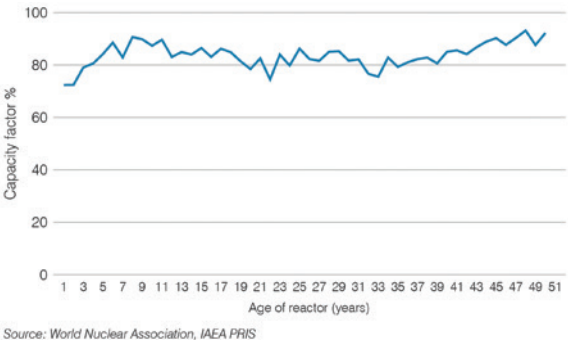

Fig. 6.
Mean capacity factor 2015-2019 by age of reactor.

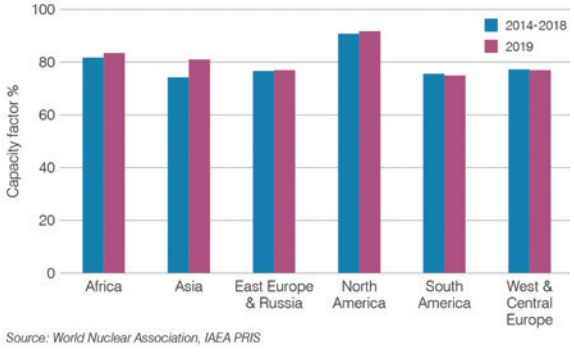

Fig. 5.
Capacity factor by region.

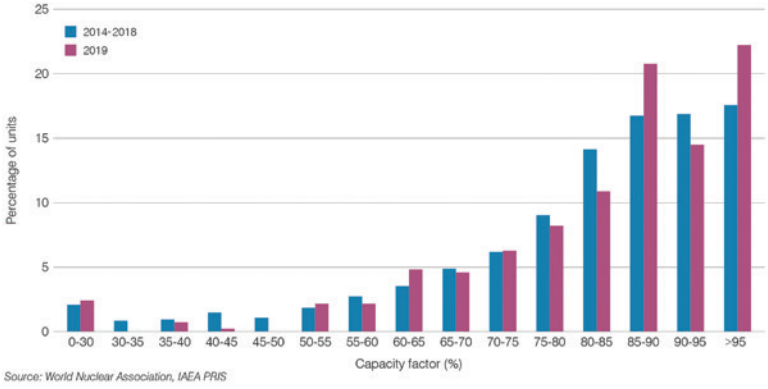

Fig. 7.
Percentage of units by capacity factor.

Since then, this high performance has been maintained. In the 1970s less than half of all reactors achieved a capacity factor greater than 70 %, compared to 83 % of reactors in 2019.

Thirteen reactors shut down in 2019. Of these, four units at Fukushima Daini in Japan had not generated electricity since 2011, and three reactors (Wolsong 1 in South Korea, Philippsburg 2 in Germany and Chinshan 2, Taiwan) were shut prematurely due to phase-out policies.

Six reactors were connected to the grid in 2019. Four of these reactors were large-scale PWRs, two of which were in China (Yangjiang 6 and Taishan 2), Shin Kori 4 in South Korea and Novovoronezh II-2 in Russia.

In addition, the two reactors on the first purpose-built floating nuclear power plant, the Akademik Lomonosov, began supplying electricity in the town of Pevek, on the north east coast of Russia. Those reactors also supply district heating to the community.

The median construction time for reactors in 2019 was 117 months. As was the case in 2018, several of the reactors starting up in 2019 featured designs that were first-of-a-kind (FOAK).

The Akademik Lomonosov's start date represents its first keel-laying ceremony. The project restarted with a second keel-laying ceremony in 2009, when construction moved from Severodvinsk to Baltiysky Zavod.

Consequentially, the median construction time for reactors in 2019 is significantly above the average achieved over the last 20 years.

Not all new reactor designs have entailed such long construction times. Yangjiang 6, which was completed in 66 months, is the second ACPR-1000 unit to be built, after completion of its sister unit, Yanjiang 5, in 2018.

Construction times since 2015 have more typically been between five to six years. In August 2020 we saw the startup of Tianwan 5, after a construction period of 56 months, less than half the 2019 average; this is in part due to the benefits of experience gained through series construction. Even though the reactor is only the third of this specific design, it is a development of a design that was used for more than 20 different reactors. It is also partly the result of having an ongoing construction programme that helps build and retain skills among the workforce.

Where new reactors have been successfully deployed there needs to be a commitment to repeating that deployment through series build, to take advantage of the learning gained.

Barakah 1, which started up in August 2020, will be followed by three more reactors that will benefit from the experience gained in starting the first unit.

Construction started on reactors, Kursk II-2 in Russia, Bushehr 2 in Iran, Hinkley Point C2 in the United Kingdom and two units in China, Zhangzhou 1 and Taipingling 1.

Most reactors under construction today started construction in the last nine years. The small number that have taken longer are either pilot plants, FOAK reactors, or projects, where construction was suspended before being restarted more recently (such as Mochovce 3&4 in Slovakia)

Nuclear's place in the post-pandemic recovery

At the time of writing, the pandemic is still affecting many parts of the world. Its impact has not been limited to its tragic health effects. Around the world, economies have contracted sharply and many people have lost their jobs. A key question for governments now is how to restart their economies safely to generate new employment opportunities.

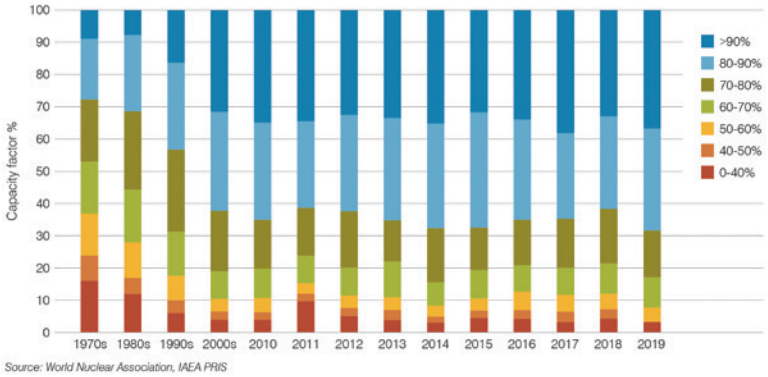

Fig. 8.
Long-term trends in capacity factors.

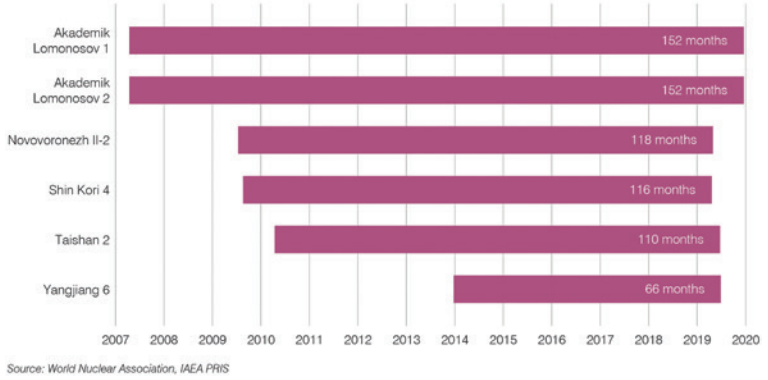

Fig. 9.
Construction times of new unit's grid connected in 2019.

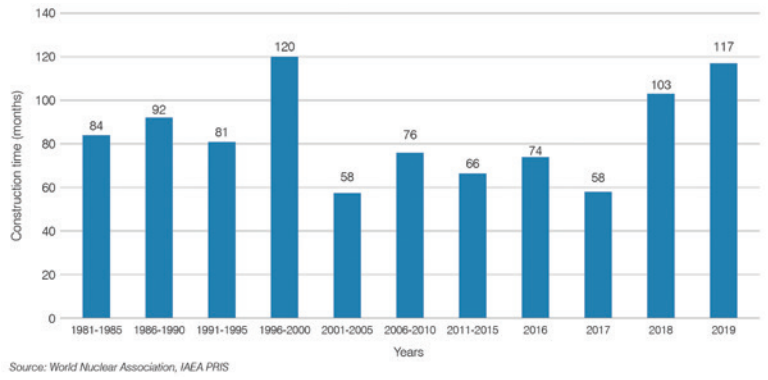

Fig. 10.
Median construction times for reactors since 1981.

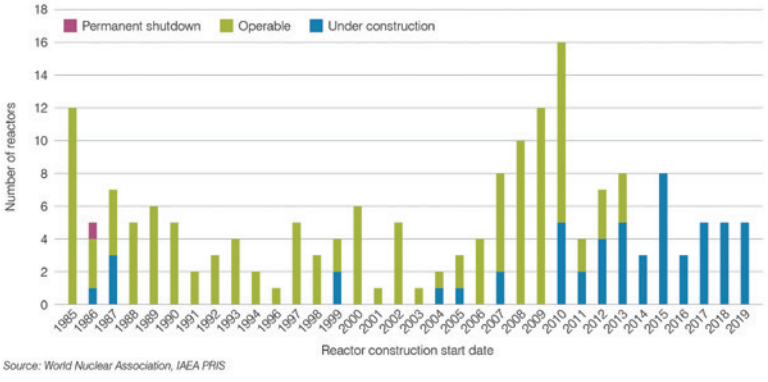

Fig. 11.
Operational status of reactors with construction starts since 1985.

Major public infrastructure investment is the cornerstone of many governments' strategies for recovery. The scale of planned stimulus packages provides a unique opportunity to build a more sustainable world, with societies emerging stronger, cleaner and more resilient.

Nuclear energy should play a central role in these recovery efforts. Supporting existing nuclear generation and promoting new nuclear build will boost economic growth in the short-term and underpin the development of a low-carbon, resilient and cost-effective electricity infrastructure. Nuclear projects attract valuable inward investment, driving sustained long-term local and national economic growth.

Investments into nuclear projects stimulate the economy well beyond the nuclear industry and deliver widespread economic growth.

Studies in the USA and Europe have shown that every euro or dollar spent on the nuclear industry results in four times that investment in the broader economy. And, when evaluated on an equitable basis, nuclear energy remains a very competitive option for new generation.

Investment in nuclear energy research, development and deployment will stimulate job creation in new sectors and broaden the application of nuclear technologies. Small modular reactors and advanced reactor technologies have the potential to decarbonize other sectors through, for example, the provision of carbon-free heat for use in both residential and industrial applications.

Around the world there are more than 100 planned reactors with approval, funding or commitment in place. With the right support, these reactors would play a crucial role in the post-pandemic recovery, and each and every one will create considerable societal benefits – but to ensure these are realised governments must put mechanisms in place to value nuclear energy's unique attributes.

Further opportunities exist in the form of ensuring the long-term operation of existing nuclear reactors. Securing continued generation from the approximately 290 reactors which have been operating for more than 30 years, and which have the potential to generate for decades to come, is the cheapest way to generate low-carbon electricity.

Creating jobs and boosting local economies

Investing in nuclear energy is a very good way to create many jobs for local and regional economies, as well as strengthening national construction and technology capabilities.

For example, 25,000 employment opportunities will be created by the Hinkley Point C project in the UK, including over 1,000 apprenticeships during the construction phase, and 900 permanent jobs onsite during more than 60 years of operation. About 64 % of the construction contracts are being delivered by UK companies, and the project is contributing some £1.5 billion to the local economy during construction, when operating it is expected to contribute £40 million every year.

Looking forward, governments are considering at how to restart their economies and generate jobs, as well as how to meet their energy and environmental goals. Each new nuclear build project generates thousands of jobs and boosts the local economy, as well as contributes to our Harmony goal of a clean and reliable electricity mix.

Upgrading existing reactors also provides major employment benefits. The Bruce nuclear power plant in Canada is undergoing refurbishment of its six reactors. This will sustain 22,000 jobs, as well as providing low-cost, reliable, carbon-free electricity until 2064.

A time for action and ambition

The global nuclear industry is ready to work with policymakers to set a greater ambition for meeting climate goals and to create the jobs needed for sustainable economic growth.

We cannot afford to allow a minority of countries promoting their ill-judged anti-nuclear dogma to dictate and restrict multilateral action on energy and the environment. The failure to include nuclear energy in the European Commission's sustainable finance taxonomy from the very start, thereby potentially hampering the financing of new nuclear projects, runs counter to its "do no significant harm" principle – constraining nuclear energy will mean more pollution and higher carbon emissions, as well as less reliable supply and higher prices for consumers.

We need to have greater ambition to build a more sustainable and equitable future for everyone around the world. While the pandemic has been the focus for governments in 2020, the essential challenge of our time remains to ensure that no one is forced to live without reliable and affordable energy, whilst also protecting the planet for future generations.

We are ready to meet the Harmony goal of 1000 GWe of new nuclear capacity before 2050, which would ensure that at least 25 % of global electricity would be generated by nuclear reactors, as part of a low-carbon energy mix.

World Nuclear Association therefore calls on policymakers to consider nuclear in energy transition plans, and enact policies to ensure that the socio-economic, environmental and public health benefits of nuclear technology are extended to as many people as possible.

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