Highlights of the World Nuclear Performance Report 2019

Jonathan Cobb

The world’s nuclear plants continue to perform excellently. Growth is strong; but for the industry to reach the Harmony goal of supplying at least 25 % of the world’s electricity before 2050, much greater commitment from policymakers will be required.

The need for the reliable, predictable and clean electricity generated by nuclear has never been greater and, worldwide, that is reflected in the growing number of new build programmes underway.

However, a number of factors – both internal and external – are creating profound challenges for nuclear power in some of its most mature markets.

Nuclear reactors generated a total of 2563 TWh of electricity in 2018, up from 2503 TWh in 2017. This was the sixth successive year that nuclear generation has risen, with output 217 TWh higher than in 2012 (Figure 1).

Nuclear generation increased in Asia, East Europe & Russia, North America, South America and West & Central Europe. Generation fell in Africa, which has only two reactors operating, both in South Africa.

In 2018 the peak total net capacity of nuclear power in operation reached 402 GWe, up from 394 GWe in 2017. The end of year capacity for 2018 was 397 GWe, up from 393 GWe in 2017 (Figure 2).

Over 2019 six reactors with a combined generating capacity of 5178 MWe were added to the grid, while nine units were permanently shut down. Based on provisional figures global nuclear generating capacity stood at 391 GWe at the end of 2019.

Construction was started in 2019 on three new power reactors: unit 2 of the Kursk II plant in Russia; unit 1 of China’s Zhangzhou plant; and unit 2 of Iran’s Bushehr plant.

Of the 442 reactors that were operable at the end of 2019, over half were in the USA and Europe where, despite the vital importance of nuclear to achieving sustainable energy goals, reactor retirements continue to outpace capacity additions.

In 2018 the global average capacity factor was 79.8 %, down from 81.1 % in 2017 (Figure 3). Despite the small reduction, this maintains the high level of performance seen since 2000 following the substantial improvement over the preceding years. In general, a high capacity factor is a reflection of good operational performance. However, there is an increasing trend in some countries for nuclear reactors to operate in a load-following mode to accommodate variable wind and solar generation, which reduces the overall capacity factor.

There was a substantial improvement in capacity factors from the mid 1970s through to the end of the 1990s, which since has been maintained. Whereas nearly half of all reactors had capacity factors under 70 %, the share is now less than one-quarter. In 1978 only 5 % of reactors achieved a capacity factor higher than 90 %, compared to 33 % of reactors in 2018 (Figure 4). Capacity factors in 2018 are broadly similar to the previous five years, and reflect the consistently high capacity factors seen over the past 20 years.

There is no significant age-related trend in nuclear reactor performance. The mean capacity factor for reactors over the last five years shows little variation with age (Figure 5). In 2019 five reactors reached the milestone of 50 years of operation: Tarapur 1 and 2 in India, Nine Mile Point 1 and R.E. Ginna in the US and Beznau 1 in Switzerland.

The continued good operation of reactors is an indication of the potential for longer operations. In the US
Turkey Point units 3 and 4 became the first reactors to be issued with licences authorizing them to operate for up to 80 years.

Most reactors under construction today started construction in the last nine years (Figure 6). A small number of reactors have been formally under construction for a longer period, but may have had their construction suspended. For Mochovce 3&4 in Slovakia, where first concrete was poured in 1987, construction was suspended between 1991 and 2008. Start-up of the first unit is now expected in 2020.

Over the course of nuclear energy’s 66 years of commercial operation reactor designs have evolved. One characteristic of that evolution has been an overall increase in reactor capacity, particularly over the first thirty years of reactor development.

Reactor start-ups are predominantly taking place in non-OECD countries, demonstrating the importance of nuclear energy in growing economies.

The evolution of reactor start-ups in different regions is shown in Figure 7. The majority of reactor capacity built between 1970 and 1990 was in West and Central Europe and in North America. Since that period the majority of reactor start-ups have been in Asia, with grid connections in East Europe and Russia also contributing to new global capacity.

There is growing demand for electricity, and that electricity must be cleanly generated. The world’s population continues to grow, the economic and societal aspirations of developing countries are undimmed and demand grows as modern society produces ever-more uses of electricity.

Nuclear energy can meet this growing demand, providing clean and reliable supplies of electricity.

In May 2019, the International Energy Agency (IEA) published its report, “Nuclear Power in a Clean Energy System”. The vital role for nuclear energy was set out by IEA Director General Fatih Birol, who said; “Without an important contribution from nuclear power, the global energy transition will be that much harder.”

The IEA report made it clear that nuclear can make a significant contribution to achieving sustainable energy goals and enhancing energy security. However, urgent action is needed to ensure that this significant contribution can be made.

Fatih Birol said; “Policy makers hold the key to nuclear power’s future. Electricity market design must value the environmental and energy security attributes of nuclear power and other clean energy sources.”

These conclusions were echoed by the OECD Nuclear Energy Agency’s (NEA) report, “The Costs of Decarbonisation”, which observed that; “Decarbonizing the electricity sector in a cost-effective manner while maintaining security of supply requires the rapid deployment of all available low-carbon technologies.”

To achieve this would require policymakers to recognize and allocate the system costs to the technologies that cause them and to encourage new investment in all low-carbon technologies by providing stability for investors. The overall conclusion of the NEA analysis was that the most effective way to achieve deep decarbonization of the electricity generation mix was to have a high proportion of electricity supplied by nuclear power.

This conclusion echoes that reached in the Intergovernmental Panel on Climate Change (IPCC) report on Global Warming of 1.5 °C, published in 2018. This report evaluated 85 scenarios that would achieve the goal of limiting global warming to 1.5 °C.

On average, these scenarios would see nuclear generation increasing by around two and a half times by 2050. In a representative scenario, where societal and
technological developments follow current patterns, nuclear generation increases over five-fold.

It is evident that unless nuclear energy is a significant part of the global response to climate change it is highly unlikely we will be able to achieve a full decarbonization of our generation mix, and even if it were possible the costs would be exorbitant.

Over the last two years the call for action on climate change has become louder and more urgent. Some have questioned whether nuclear energy can be deployed quickly enough to tackle climate change in time. The fact is that nuclear energy is making a major contribution to avoiding climate change today, with more than 10% of the world’s electricity supplied by nuclear generation.

One of the most effective actions to be taken to avoid greenhouse gas emissions is to ensure those reactors continue to operate to their full potential. The average age of the nuclear fleet is around 30 years. This year, five reactors have achieved fifty years of operation and reactors today are seeking approval for 60 or even 80 years of operation. Many of our current reactors have the potential to still be part of a fully decarbonized generation mix in 2050.

More than 50 reactors are under construction, and half of those are expected to start generating electricity over the next two years.

Using nuclear avoids carbon dioxide emissions, as it reduces our dependence on coal. By 2025, the reactors under construction today will avoid the emission of 450 million tonnes of carbon dioxide each year – adding to the already two billion tonnes of CO₂ avoided by the existing fleet. This is equivalent to the combined annual CO₂ emissions of Japan, Germany and Australia.

Where reactors are decommissioned over the next 30 years, new reactors should be constructed to replace them. As well as ensuring the continuation of the benefits of nuclear generation, construction and commissioning of replacement reactors will ensure that key skills are retained and local communities continue to have employment opportunities.

But can nuclear generation be expanded fast enough to combat climate change? During the rapid expansion of nuclear generation in France in the 1980s and 1990s, most reactors were built in six to seven years. In recent years in China, nuclear reactors have been frequently constructed in around five years. In 2018, the global median construction time was longer, eight-and-a-half years, primarily because of the high proportion of first of a kind reactors starting in 2018.

A commitment to a substantial expansion of nuclear generation would deliver the benefits of series construction, including faster and lower cost construction.

The IPCC’s 1.5 °C report states that global greenhouse gas emissions need to start to decline almost immediately. Reactors under construction and the continued operation of existing reactors can contribute to this goal. But to achieve the further reductions that will be necessary from 2025, and net zero emissions by 2050, decisions to invest in new nuclear build will need to accelerate urgently.

The nuclear industry’s Harmony goal is for nuclear generation to supply 25% of the world’s electricity before 2050. This would require at least 1000 GWe of new nuclear build. To achieve this, new nuclear capacity added each year would need to accelerate from the current 10 GWe to around 35 GWe for the period 2030-2050. Those countries operating nuclear power plants should commit to continue to do so and those countries with recent experience of new nuclear build should commit to a rapid expansion of their construction programmes to deliver significant new nuclear construction from 2025.

Beyond 2025 more countries will be able to contribute to achieving our Harmony goal. More new nuclear generation will be needed to bring economic growth, as developed countries continue their efforts to decarbonize their generation mixes and developing countries endeavour to meet demand for electricity driven by growing populations and industrial expansion essential to modern life.

If we are to be serious about climate change we should also be serious about the solutions. Transitioning to a low-carbon economy that meets the energy needs of the global community presents a daunting task. But it is a challenge that must be met, and one that can only be met by using the full potential of nuclear energy.

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