WORLD NUCLEAR ASSOCIATION

Building a stronger tomorrow

Nuclear power in the post-pandemic world

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Executive Summary

The global coronavirus pandemic has had profound impacts on societies around the world. In many countries it has prompted reviews by governments of how best to build stronger, cleaner and more resilient societies. Whilst the pandemic has done great damage, with appropriate policy responses it may well provide a unique opportunity to build a genuinely sustainable world.

Nuclear energy can play a central role in post-COVID recovery efforts by boosting economic growth in the short-term, whilst also supporting, in a cost-effective manner, the development of a low-carbon, resilient and affordable electricity infrastructure. Investments into nuclear energy will also strengthen energy security, and can contribute to the production of heat and hydrogen to decarbonize other sectors of the economy.

Nuclear projects attract valuable inward investment, driving sustained long-term local and national economic growth with, for instance, every euro spent on nuclear generating a further four euros in the broader economy. There are "shovel-ready" nuclear projects around the world – some 108 planned reactors with approval, funding or commitment in place – which, with the right support, can provide immediate employment and create long-term high-value jobs.

These reactors can all 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 we must put mechanisms in place to value nuclear's unique attributes. Further "shovel-ready" projects exist in the form of ensuring the long-term operation of existing nuclear reactors. Securing continued generation from the about 290 reactors which have been operating for more than 30 years is the cheapest way to generate low-carbon electricity.

There is a window of opportunity for governments to invest in nuclear energy to address the immediate crisis caused by coronavirus, and to prevent future crises by dealing with bigger, chronic problems, such as climate change, air pollution and energy poverty. Investment in nuclear energy would therefore not only be socially responsible, but would also help to future-proof economies and societies by building towards a cleaner and more equitable future. Against this backdrop, World Nuclear Association calls upon policymakers to:

1. Consider nuclear and its socio-economic, environmental and public health benefits in any energy transition plan, and enact policies to ensure the realisation of the many benefits of nuclear energy;
2. Accelerate the implementation of the 108 reactors which are already planned by governments, and ensure the long-time operation of the 290 reactors which have been operational for 30+ years;
3. Unlock finance by providing the appropriate frameworks that will drive investment and provide better value for consumers.

Strengthening society with nuclear energy

The global coronavirus pandemic has caused considerable human suffering and has had significant impacts, both socially and economically. It has also offered an opportunity to pause and reflect on what we value the most. Over the past few months, many communities around the world have been enjoying the benefits of significantly cleaner air, with some cities seeing blue skies for the first time in decades.

Despite the very considerable efforts to decarbonize the economy and the countless billions spent, our world remains heavily addicted to fossil fuels. The trend is clear – instead of reducing our dependence on fossil fuels, we are increasing it. As a direct result, greenhouse gas emissions continue to rise when they need to drastically fall.

With nearly a billion people around the world still living without access to electricity, humanity has a responsibility to learn from the past – everyone has the right to enjoy a modern lifestyle in a way that does not cause harm to people or the planet.

We need to deliver a worldwide transformation that is socially, economically and environmentally sustainable. We need electricity that is clean, sustainable and affordable, as no one should have to choose between essentials like heating or eating. We need a power source that can not only help us mitigate the effects of climate change and environmental degradation, but that can also help bring the enormous socio-economic benefits of a reliable electricity supply to the corners of the world that do not have access to it. Nuclear power has a proven track record of delivering such transformations.

With nuclear, we achieve stronger long-term energy security

Energy security is essential to ensure a modern quality of life and to help unlock human potential around the world. The International Energy Agency defines energy security as *"the uninterrupted availability of energy sources at an affordable price"*. There are numerous aspects of energy security such as ensuring timely investments to supply energy to support economic growth and environmental needs, as well as ensuring that the energy system is able to react to sudden changes.

Whilst the importance of energy security is well understood, an increasing trend towards short-term thinking has resulted in significant investment in variable renewables – wind and solar – whilst neglecting reliable low-carbon "backbone" capacity – nuclear reactors – which ensure safe electricity supplies round-the-clock. This has made our electricity systems much more vulnerable to the whims of the weather.

History teaches us that in the midst of every crisis, lies great opportunity. From the 1973 oil crisis, we find how nuclear can fundamentally transform an electricity sector within less than two decades, building energy security, whilst delivering economic growth and prosperity. Sweden is a key example of how complete electricity decarbonisation, building energy security and delivering economic growth can be delivered concurrently. After the oil crisis of 1973, nuclear power was significantly expanded, when energy independence was thrust to the top of the political agenda, with 12 reactors constructed. Today, up to 40% of Sweden's electricity is from nuclear.

Since 1972, when the country's first large reactor – Oskarshamn 1 – became operational, the amount of energy Sweden imports plummeted, from over 82% in 1970 to less than 25% in 2015.[i] At the same time, carbon emissions decreased from 11.49t of CO_2 per capita/year in 1970 to 3.6t in 2018[ii], whilst GDP grew from 38 billion USD in 1970 to 531 billion USD in 2019.[iii] This clearly demonstrates that it is possible to increase living standards, whilst achieving virtually complete decarbonisation of the electricity system at a manageable cost.

The Japanese experience serves equally to highlight how nuclear energy can significantly reduce a country's reliance of energy imports, providing stability and resilience to the national economy and society at large. Japan has very few domestic natural resources, and is heavily dependent on energy imports, be it oil or fossil gas from the Middle East or coal from Australia. Before the oil crisis of 1973, imported fossil fuels accounted for 91%[iv] of Japan's energy mix, and the crisis highlighted just how vulnerable the Japanese economy was to external geopolitical circumstances. This led to the fast-tracking of nuclear reactors to reduce Japan's dependency on foreign oil. When comparing the cost of nuclear energy to other energy sources, including fossil gas and coal, nuclear energy is the lowest-cost option in both Japan and South Korea, both significant energy importers.[v,vi]

However, due to the post-Fukushima suspension of Japan's 54 nuclear reactors, Japan's progress towards energy independence has been reversed, with nuclear energy being replaced by imports of oil, coal and fossil gas for electricity production. In 2017, some 11 billion cubic feet of natural gas was imported – every day – making Japan the world's largest consumer of liquified natural gas. Japan is also the world's third-largest importer of coal and fourth-largest importer of oil. Inevitably, this has significantly undermined Japan's energy security, and caused socio-economic and environmental impacts.

Since its very inception, nuclear energy has been a pillar of stability to not only its local communities, but also to the countries it serves, providing clean electricity round-the-clock, irrespective of weather and seasons. Nuclear energy remains the only low-carbon and clean energy source that can provide uninterrupted and affordable electricity, which should make it a cornerstone in any energy security plan.

With nuclear, we ensure the stability of electricity for uncertain times

Virtually all aspects of modern life are completely dependent on a reliable and uninterrupted electricity supply. Simplicity is a desirable feature of any resilient infrastructure system, as it reduces risk of cascading failures which could be caused by a system composed of an ever-increasing number of parts.[vii]

However, with variable renewable electricity generation forming a larger part of the electricity mix, complexity has increased significantly. This complexity, and the increasing decentralization of generation, could, in turn, lead to the system becoming increasingly destabilised, increasing the risk of blackouts. Additionally, any electricity system with a high proportion of variable renewables will require technologies that are not yet proven on an economy-wide scale, both technically and in terms of cost-competitiveness. Excluding nuclear and betting our common future on technologies with such uncertainties would not only result in new risks, but also likely undermine economic competitiveness.

Achieving stability requires long-term strategic planning at regional and national level, which runs counter to the inherent weather dependency of an electricity system built on a high share of variable renewables. This becomes especially evident when the characteristics of variable renewables are compared with the characteristics of a secure source, which the OECD-NEA defines as[viii]:

- The physical availability of generating capacity at all times;
- The contribution of capacity to the smooth operation of the electricity system, even in the presence of sudden shifts in demand or changing weather;
- The contribution of capacity to the stable economic behaviour of the electricity system.

When comparing available low-carbon electricity sources against these characteristics, it is evident that nuclear energy is the only generator which exhibits all three. Nuclear power provides services required to keep a transmission system stable – services that are vital for any low-carbon system, but particularly those with a share of variable renewables.

The International Energy Agency recently concluded in its Special Report on Sustainable Recovery that extending the operation of existing nuclear reactors *"would improve electricity security by lowering the risk of*

outages, boosting flexibility, reducing losses and helping integrate larger shares of variable renewables such as wind and solar PV." [ix] In June this year, Sweden's electricity transmission operator, Svenska Kraftnät, moved to secure an earlier than scheduled return to service of Ringhals 1 from its current maintenance outage. According to the transmission operator, the agreement reached with Ringhals 1 was needed to *"ensure voltage stability and short-circuit power, capacities that are important for power system operation and which cannot be secured through existing market solutions."* [x]

Beyond this, nuclear energy is capable of operating for very long periods of time without refuelling – about 12-24 months in most cases – which means that reliable and low-carbon electricity is being generated on a continuous basis, regardless of time of day, weather, or season, contributing an extra layer of security to the energy system. This is further strengthened by the fact that uranium fuel is incredibly energy dense, with a single fuel pellet containing the equivalent energy as one tonne of coal. It is therefore easy to store several years' worth of uranium fuel at reactor sites as a strategic stockpile.

The atom leading the recovery

Ensuring that investments are made in essential infrastructure is doubly important at present. In the short-term, making investments will help governments deal with pressing issues such as unemployment, helping to secure economic recovery. In the long-term, these investments can help countries to succeed in dealing with bigger, chronic problems, be it climate change, air pollution, or energy poverty by ensuring reliable, affordable and resilient electricity supplies.

With nuclear, we get value-for-money decarbonisation

In looking to stimulate the economy in the wake of the pandemic, there should be considerable focus on delivering the best value for money in regard to public spending. It is crucial that this also applies to our energy system, and that investments made today are genuinely sustainable and represent value in the short- and long-term. A higher share of nuclear energy means lower generation costs, lower system costs, and lower electricity prices for the consumer – ensuring a socially and environmentally just transition to a cleaner future.

It is clear that in order for governments to deliver truly cost-effective decarbonisation, the total cost of electricity provision, including system costs, needs to be at the core of their decision making. However, this has not been the case to date as electricity markets do not recognize the costs of different forms of electricity generation and simple levelized cost of energy metrics fail to capture all costs. Whilst the nuclear industry takes responsibility for its full lifecycle costs, other electricity generators do not. Fossil fuel generators are rarely required to pay a price in line with the environmental and health damage that their emissions cause, whilst the quoted cost of wind and solar projects does not include hidden costs brought on by their intermittency. In the case of wind and solar, associated hidden costs such as backup provisions and refits of electricity grids are always ultimately paid for by consumers or taxpayers.

A recent study from the Massachusetts Institute of Technology[xi] analysed a range of decarbonisation scenarios in the US. The study found that when nuclear is part of the mix, the overall cost of the electricity system decreases. Conversely, when nuclear power is excluded from the list of available low-carbon technology solutions, the average cost of electricity increases. This is due to the need to rapidly increase the deployment of new – and currently unavailable – storage technologies, as a decarbonised electricity system cannot rely on fossil gas or coal to support the intermittency brought on by renewables.

Whilst nuclear reactors require a substantial upfront investment, it is important to remember that reactors will operate for at least 60 years, generating immense amounts of electricity for generations to come. This kind of perspective is crucial when making decisions for the future, ensuring that investments made now create sustainable benefits for many decades. As a matter of fact, the electricity generated by reactors which

operate today is amongst the cheapest available as once the construction costs have been paid, ongoing costs, such as fuel, are very low. This has been highlighted by the International Energy Agency, which finds that *"lifetime extensions are one of the most cost-effective ways of providing low-carbon sources of electricity through to 2040"*.[xii]

Ensuring that existing reactors can operate for longer periods of time is also an easy 'win' for both jobs and the environment. As of June 2020, there are some 440 operable nuclear reactors worldwide, of which 290 have been operating for more than 30 years. Ensuring long-term operation of reactors protects much-needed clean electricity supply, and jobs and broader economic benefits often follow as a result of uprates, modernisations and refurbishments.

Government commitments to invest in nuclear – be it in new reactors or long-term operations of existing reactors – provide a very strong signal for broader investments to be made. Specific projects in the pipeline may benefit directly, but the certainty also supports the wider supply chain, allowing for the building of domestic construction and manufacturing capability, and skills development. Government support for financing arrangements for immediate new build is likely to significantly increase investor confidence and pave the way for additional capacity deployment in the early 2020s and beyond.

There are a number of financing models available to governments that are well-suited to support near term nuclear new build projects and which could help deliver significant reduction in the expected cost of capital. This would, in turn, significantly reduce the ultimate levelized cost of nuclear energy, benefitting consumers.

Recent analyses suggest that public-private partnerships (*e.g.* the Regulated Asset Base or RAB model) – which have been used in other sectors to finance large scale infrastructure projects – can be applied to future nuclear projects to achieve a significantly lower levelized cost relative to other approaches. Such a scheme is under consideration in the UK for the proposed twin reactors at Sizewell C.

With nuclear, we create high-value jobs and deliver economic growth

Investing in nuclear energy is a very good way to create a large amount of jobs. For instance, every direct job created in the nuclear industry creates an additional 3.2 jobs in the European economy.[xiii] Equally, nuclear new build projects uniquely provide a significant number of jobs to local and regional economies, as well as creating or strengthening national construction and technology capabilities.

There are currently 55 reactors under construction and some 108 planned reactors around the world with approval, funding or commitment in place[xiv] – projects which could play a crucial role in the post-pandemic recovery. For example, the Hinkley Point C project in the UK will result in some 25,000 employment opportunities, including over 1,000 apprenticeships during the construction phase, and 900 permanent jobs onsite during the 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, and £40 million a year during operation.[xv]

Upgrading existing reactors provides major employment benefits as well. A good example of the benefits of future-proofing existing reactors can be found at the Bruce Nuclear Power Plant in Canada, where the refurbishment of its six reactors will sustain 22,000 jobs, as well as ensuring low-cost, reliable, carbon-free electricity until 2064.

Investments into nuclear stimulate the economy beyond the nuclear industry and deliver widespread economic growth. Every euro spent in the European nuclear industry generates an additional 4 euros in the European economy and creates benefits for every European household.[xiii] In the USA, each dollar spent by an average nuclear power plant during one year of operation is estimated to generate an additional $4 in the country's economy.[xvi]

Building a stronger - and cleaner - tomorrow

In order to be able to build a more sustainable and equitable future for everyone around the world, we need greater ambition. We must go beyond the announced national plans and commitments. Electricity is central to modern life – it powers our daily lives, as well as our dreams and ambitions. Ensuring that no one is forced to live without reliable and affordable energy, whilst also protecting the planet for future generations, is the essential challenge of our time.

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 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.

The pandemic recovery has presented a window of opportunity for governments to not only boost economic growth and create many highly valued and largely local jobs, but also to fulfil climate change commitments and build a clean and resilient system. With timely investments in existing and new nuclear reactors, we can deliver a cleaner, fairer, more ambitious and truly sustainable tomorrow.

World Nuclear Association therefore calls on policymakers to:

1. Consider nuclear and its socio-economic, environmental and public health benefits in any energy transition plan, and enact policies which ensure the realisation of the many benefits of nuclear energy;
2. Accelerate the implementation of the 108 reactors which are already planned by governments, and ensure the long-time operation of the 290 reactors which have been operational for 30+ years;
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World Nuclear Association is the international organization that represents the global nuclear industry. Its mission is to promote a wider understanding of nuclear energy among key international influencers by producing authoritative information, developing common industry positions, and contributing to the energy debate.

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