

# World Energy Scenarios | 2019

## EXECUTIVE SUMMARY

### THE FUTURE OF NUCLEAR: DIVERSE HARMONIES IN THE ENERGY TRANSITION

With contributions from the World Nuclear Association and the Paul Scherrer Institute

**There is increasing and widespread recognition that nuclear energy will feature in the future global energy mix and make its contribution to sustainable development. The growth of nuclear energy and its role in the global energy transition will be influenced by a number of factors.**

The pace and direction of the global energy transition is part of a much wider set of global developments. The Grand Transition is under way and implies a fundamental socio-economic transition in response to the promise of a coming era of digital and ecological productivity. Within this broader context, the outlook for nuclear and other forms of energy is being shaped by a complex and unpredictable interplay of global drivers of change – including decentralisation, decarbonisation, digitalisation and evolving geopolitics. Multiple possible pathways are emerging for managing a successful global energy transition from hydrocarbon molecules to low-carbon energy.

Innovation will play a key role but not only through new and improved energy technologies. A broader and disruptive landscape of innovation has led to many new ways of producing, trading and using energy and electricity - such as in transport, buildings and industry.

Recognising the diversity of perspectives on nuclear energy, the World Energy Council (the Council), with contributions from the World Nuclear Association (the Association), has gathered insights from senior energy leaders on the future of the industry. This work has contributed to the Council's new global nuclear perspectives, which have been fed into an update of the Council's World Energy Scenarios.

In this report, the future of nuclear is described through the lens of the Council's World Energy Scenarios archetype framework – Modern Jazz, Unfinished Symphony and Hard Rock – in three plausible, alternative pathways for the future development of the sector. This report also describes implications for the role of nuclear energy in the global energy transition.

The Harmony programme, coordinated by the World Nuclear Association, sets out a vision for the future of electricity with the goal for nuclear to provide at least 25% of global electricity before 2050 as part of a clean and reliable low-carbon mix. The Harmony programme works with the whole energy community to get support from key stakeholders to ultimately deliver a low-carbon future in which nuclear fully contributes.

## NUCLEAR ENERGY GROWTH IN ALL THREE SCENARIOS WITH DIFFERENT IMPLICATIONS

Nuclear energy will grow in all three scenarios but could take three very different pathways:



**Modern Jazz** is a digitally disrupted, innovative, and globally market-driven world. In the Modern Jazz scenario, the nuclear industry has the potential to reinvent itself, from selling units to providing services, and to remain an energy source of choice as some of the major existing nuclear countries and emerging economies expand their nuclear fleets. In this scenario, nuclear accounts for 8.5% of electricity generation by 2060 compared with 11% in 2015. Installed nuclear generating capacity increases by 52% from 407 GW in 2015 to 620 GW in 2060.



**Unfinished Symphony** is a world in which more coordinated and sustainable economic growth models emerge with a global aspiration to a low-carbon future. This scenario sees nuclear energy widely accepted as part of a reliable and affordable response to the climate change emergency. In this scenario, the share of nuclear reaches 13.5% of total electricity generation by 2060 while its installed capacity almost triples to 1003 GW. In addition to new build and lifetime extension initiatives, new nuclear technologies – small modular reactors, floating units and Gen IV reactors – make a significant contribution to the global nuclear fleet.



**Hard Rock** explores the consequences of weaker and unsustainable global economic growth and inward-looking governments. In this scenario, nuclear power's share of global electricity generation reaches 12.5% by 2060, with installed capacity increasing by 70% to 696 GW in 2060. The main focus areas are new construction in emerging markets and lifetime extension initiatives in developed economies.

## REFLECTIONS FOR INDUSTRY LEADERS

### 1 INNOVATION IS IMPACTING THE ENTIRE VALUE CHAIN – HOW TO ACCELERATE THE RATE OF NUCLEAR LEARNING?

The accelerating pace of innovation, particularly in digitalisation, is blurring sector boundaries and enabling new, non-traditional players to enter the market. Looking to the future, digitalisation has the potential to improve the nuclear industry's performance and supporting it to allow better informed decisions on new build and lifetime extension. However, learning curves in other sectors will accelerate too – including renewable power, energy storage, and carbon capture and storage. The relative pace of learning across the nuclear sector can be increased through international cooperation on harmonisation of regulatory processes, allowing reactor designs to be deployed globally with minimal design alterations. This would significantly reduce costs and project uncertainties.

Nuclear energy is one of the most cost-effective sources of electricity in many countries and the industry is actively improving project management. The industry must continue to ensure projects are delivered successfully, as shown by current programmes in Asia and elsewhere. These projects highlight the opportunity to accelerate innovation and take advantage of digitalisation and standardisation to ensure the nuclear industry remains competitive.

## **2 MANAGING NEW TENSIONS BETWEEN STABILITY AND FLEXIBILITY – HOW CAN NUCLEAR ENABLE INTEGRATED, AGILE AND RESILIENT SYSTEMS?**

Decarbonisation continues to be driven by electrification in all three scenarios. The scale up of intermittent renewable energy, however, is associated with system costs. In addition to providing clean and low-carbon energy, nuclear energy contributes to system stability and resilience attributes, which are not currently included in comparison of generation only costs. Small and medium reactor designs, which are being developed and some are under construction in some countries and are expected to be fully commercialized in the next 10-15 years, could provide new and significant opportunities for synergies in the development of nuclear-renewable hybrid energy systems. Reductions in the costs of nuclear-based electrolysis also present opportunities to help accelerate global trade in clean liquids, which depends in large part on global cooperation on new hydrogen pathways that might become economically feasible.

## **3 HOW CAN THE CO-BENEFITS AND SYNERGIES OFFERED BY NUCLEAR BE BETTER UNDERSTOOD AND RECOGNISED?**

Despite increasing global awareness of climate change and of nuclear energy's status as a low-carbon energy source, greater support is needed from policymakers to establish a level playing field that compares the full costs offered by different technology pathways. In the public realm, improving awareness of the benefits of nuclear energy are starting points for clarifying the basis for inclusion of nuclear in green labelling initiatives.

Spent nuclear fuel and high-level radioactive waste remains an issue in all three scenarios. Both public and the industry work together on a final solution. Repositories for this purpose are currently in development and under construction in several countries and are expected to provide safe final disposal of the small volumes these materials represent.

Technology-neutral policies that enable all types of low carbon solutions to be considered, including nuclear power, will play a fundamental role in providing signal for investment and reducing the financing costs to deliver the best value to consumers.

**Looking across the scenarios, four critical challenges and opportunities faced by the global nuclear industry and energy leaders – faster learning, linking renewables and nuclear, leveraging benefits and leadership for the long-term – become clear and will define how nuclear energy fits in the future energy system. Implications are detailed in the main report.**

## ABOUT THIS REPORT

The “The Future of Nuclear: Diverse Harmonies in the Energy Transition” report provides a set of global scenarios describing alternative pathways for the nuclear energy industry to 2060. It is developed using the World Energy Scenarios archetypes framework – Modern Jazz, Unfinished Symphony and Hard Rock – and informed by insights from energy leaders.

This report aims at facilitating strategic sharing of knowledge between experts and promoting a better quality of strategic conversation among the Council’s members, energy stakeholders and policy shapers.

This report includes contributions from the World Nuclear Association.

The Council’s global scenarios framework used in this report is developed in 2016 in collaboration with Accenture Strategy and the Paul Scherrer Institute.

## ABOUT THE WORLD ENERGY COUNCIL

The World Energy Council is the principal impartial network of energy leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all.

Formed in 1923, the Council is the UN-accredited global energy body, representing the entire energy spectrum, with over 3,000 member organisations in over 90 countries, drawn from governments, private and state corporations, academia, NGOs and energy stakeholders.

We inform global, regional and national energy strategies by hosting high-level events including the World Energy Congress and publishing authoritative studies, and work through our extensive member network to facilitate the world’s energy policy dialogue.

Further details at [www.worldenergy.org](http://www.worldenergy.org) and [@WECouncil](https://twitter.com/WECouncil)

The full report can be found at [www.worldenergy.org/publications](http://www.worldenergy.org/publications)

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