Foreword From Lead Nongovernmental Organizations (NGOs): ClearPath and Energy for Humanity

We applaud the commitment and vision shown by governments in the creation of the Clean Energy Ministerial's (CEM) Nuclear Innovation: Clean Energy Future (NICE Future) initiative and the Flexible Nuclear Campaign for Nuclear-Renewables Integration (Flexible Nuclear Campaign) launched under the initiative, which seeks to provide evidence of the combined multiple roles that nuclear and renewables together can play in delivering affordable, reliable, and clean energy systems.

Based on the evidence provided in this report, our organizations urge all members of the CEM to continue to lead the reinvention of global energy supply, especially in the wake of the COVID-19 pandemic, as protecting human health through cleaner air and economic recovery come into view as leading challenges.

The scale of our ambition must be commensurate with the scale and urgency required by our combined economic, environmental, and energy challenges.

The last decade has seen the development of wind and solar generation into affordable technologies that can help significantly reduce emissions from the electricity sector. Flexible advanced nuclear reactors can complement and enable higher penetrations of variable renewables in future energy systems. However, the combined commitment, creativity, and technical and business innovations that have helped to commercialize renewables affordably and at scale have not been applied extensively to other technologies.

The time has come to realize the expanded role that a wider range of technologies will need to play in de-risking pathways to significantly lower emissions. Specifically, this means applying lessons learned from renewables' successes as templates for broader and deeper emissions reductions. This also means looking to other large-scale, high-productivity industries, such as shipping and

What is the NICE Future initiative?

- Launched at the 9th Clean Energy Ministerial (May 2018, Copenhagen), the Nuclear Innovation: Clean Energy Future (NICE Future) initiative is an international collaboration that envisions a world in which nuclear energy innovation and applications advance clean energy goals.
- Initiative participants are exploring innovative technologies and diverse uses of nuclear energy, including nuclear-renewables integration, flexible electricity grids, rural electrification, industrial processes, water purification, clean transportation fuels, and alternative energy carriers such as hydrogen.
- At the 10th Clean Energy Ministerial (May 2019, Vancouver), several participants in the initiative launched the Flexible Nuclear Campaign for Nuclear-Renewables Integration, a joint effort between civil society and governments to enlist global experts in the valuation of flexible nuclear systems working in concert with renewables. This report is part of that work stream.

This document encompasses one section of a larger report, titled Flexible Nuclear Energy for Clean Energy Systems. The full report can be found at https://www.nrel.gov/docs/fy20osti/77088.pdf. The author(s) of each section is/are solely responsible for its content; the publication of these perspectives shall not constitute or be deemed to constitute any representation of the views or policies of any Governments, research institutions, or organizations within or outside the NICE Future initiative.

aviation. Innovative delivery and deployment models in "designed-for-purpose" facilities can quickly achieve very low costs and large-scale deployment of a range of clean technologies for rapid, near-term emissions reductions.

In this critical decade, we aim to expand the suite of clean energy options to include flexible nuclear technologies and products that are cost competitive, present lower risk to investors, and can meet a broad range of market applications.

These advanced nuclear products must be designed to address the clean energy transitions being pursued by countries and to meet market requirements for flexibility, affordability, security, and availability in future energy systems with high penetrations of renewables. Rapid commercialization of these valuable technologies is needed to transform a significant percentage of the world's total energy consumption over the coming decades.

In addition to nuclear energy's traditional supply of electricity, the existing fleet and advanced nuclear reactors have the potential to supply heat to homes, businesses and industrial processes; produce hydrogen and synthetic fuels to support cleaner transport, including the hard-to-abate sectors of aviation and shipping; desalinate and purify seawater in regions suffering water scarcity; support access to modern energy services in remote and developing communities; and offer industry an emissions-free source of high-temperature heat, all as part of energy transitions that can benefit society and lift up living standards around the world.

Forthcoming advanced nuclear and other small modular reactor (SMR) technologies could enable sustainable development and cleaner energy transitions simultaneously. We applaud the efforts of the CEM to realize the potential of these technologies and call on all capable and desiring countries to collaborate to accelerate their development and commercialization over the next decade for rapid global deployment.

As NGOs focused on increasing the range of clean energy options, there are several immediate actions we recommend for consideration by countries and stakeholders:

- **Governments:** Promote clean energy and encourage more collaboration between nuclear energy and renewable energy experts and stakeholders that go beyond energy ministries to reach across all relevant agencies that address clean energy technologies and opportunities, with the assignment to work together to create clean energy systems.

- **Policymakers**: Develop ambitious and achievable strategies for energy transitions and innovation, climate change, power, heat, industry, and transport. Invest effort and resources, including in improved market designs and incentives that can foster healthy competition, encourage efficiencies, and better realize the untapped potential of the full range of options available.

  As countries look to design economic recovery measures that can reduce emissions while creating jobs and bolstering our economies, they should seek to recognize and evaluate the various opportunities of flexible nuclear technologies to form part of the solution.

- **Climate and energy modelers**: Broaden the range of emissions reduction pathways through the inclusion of a broader set of technology options. Having more options both alleviates pressure elsewhere in the system and creates new opportunities. Mapping realistic, achievable pathways to significantly reduce emissions while ensuring economic growth is a crucial part of mobilizing investors, supply chains, policymakers, and the public for success.

- **Analysts and technologists**: Focus on emissions reductions to address and act upon the gaps in the literature, where alternative pathways are either drastically under-represented or entirely omitted from the range of clean energy options, including the roles flexible nuclear energy can play alongside renewables to drive down costs and emissions across the whole energy system.

- **Investors:** Consider a portfolio approach to clean energy investments spread across a range of technology options in order to reduce exposure to risk. Consistent, technology-inclusive access to finance is vital to realizing this objective.

- **Business leaders**: Help create markets for the cleaner energy technologies currently under development and invest in demonstrating these technologies so that those markets might be fully realized, resulting in economies of scale and market-driven emissions reductions.

Our view is that to achieve these clean energy transitions, within meaningful timescales, a new form of dialogue is needed. Accordingly, we welcome the CEM's efforts to frame the discussion in terms of whole systems thinking—across power, heat, industry, and transport.

How can we design the highest possible performance system (flexible, clean, reliable, affordable, resilient) with a diverse portfolio of technologies?

We need a discussion that enables evidence-based decision-making focused on shared goals and outcomes. Our future energy systems will need to be low-emissions, reliable, affordable, and flexible. They should provide social, economic, and environmental benefits, including reducing air pollution, protecting habitats and biodiversity on land and in the oceans, driving jobs and general economic prosperity, and improving quality of life and access to opportunities, including for women and children throughout the world—all while providing increased energy supply, both electricity and fuels, without emissions and radically reducing the impact on the environment.

We believe that a determined focus on evidence-based, outcomes-focused, decision-making will deliver the progress that we need at the speed and scale of action needed to address our shared global challenges.