Driving deeper decarbonization with nuclear energy

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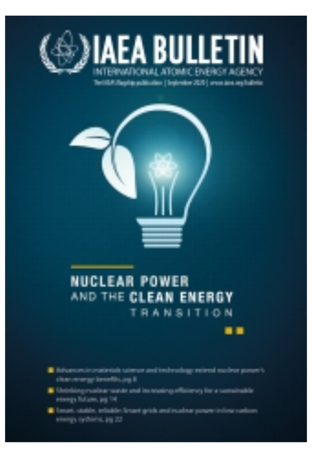

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The world is far off track when it comes to meeting the Paris Agreement climate goals of limiting the global temperature increase by 1.5°C to 2°C by 2050. Current projections show that fossil fuels will still make up the majority of world energy use by 2050.

If we miss the 1.5°C target, this could mean accepting climate impacts, such as millions of people being displaced by sea level rise and millions more being exposed to extreme heatwaves, as well as major biodiversity-related impacts, including species loss, the elimination of sea ice in the Arctic Ocean, and the loss of virtually all coral reefs.

If we miss the 2°C target, half the world's population could be exposed to summertime 'deadly heat,' Antarctic ice sheets could collapse, droughts could increase massively, and the Sahara Desert could begin to expand into southern Europe. World food supplies could be imperilled, driving mass human migration and leading to a growing risk of civilizational collapse.


Eric Ingersoll is Chief Technology Officer at Energy for Humanity and a strategic advisor and entrepreneur with deep experience in the commercialization of new energy technologies.

Current energy pathways, even those that include a vast expansion of renewables generation, are pushing the world towards catastrophic climate outcomes, with a high risk of a 4°C outcome. This could mean substantial areas of the planet becoming uninhabitable.

The Clean Energy Ministerial Flexible Nuclear Campaign we co-founded explores the expanded role that nuclear energy can play in de-risking the energy transition. Here, we describe two opportunities to drive deeper decarbonization with nuclear energy.

The first is to expand the role of nuclear energy in electricity production through a combination of advanced reactors and thermal energy storage. This is intended to complement renewables in future energy grids.

The second is to address the use of oil and gas, which currently accounts for three quarters of energy consumption, by providing large-scale, low-cost hydrogen produced with nuclear power.

To achieve the necessary cost, scale and rates of nuclear energy deployment, a new paradigm is needed. The nuclear industry must apply commitment and creativity, combined with technical and business innovation, just as the renewables industries learned to do.

How could a high-volume, low-cost, rapidly deployable and commercially attractive manufacturing model enable nuclear technologies to contribute to zero emissions and sustainable energy for all by 2050?

Flexible nuclear in future electricity grids

Our recent study on cost and performance requirements for advanced nuclear plants, as part of ARPA-E's MEITNER Program in the United States, defines market requirements for advanced reactor developers seeking to design useful and cost-competitive products for commercialization in the early 2030s.

Our study identifies price and performance characteristics that will be required for nuclear plant owners and investors, as well as for society at large, to achieve affordable, reliable, resilient, flexible and — above all — clean future electricity systems. Our findings show that there will be large markets for advanced reactors that cost less than US $3,000/kW. Combining nuclear plants with thermal energy storage enables nuclear to be a peaking resource — creating additional valuable energy storage — and added value for the energy system. For grid operators, energy system modellers and policymakers this shows the value of flexible nuclear technologies, not only in lowering emissions, but also in lowering total costs across the whole energy system.

Hydrogen-enabled synthetic fuels

To achieve the scale and pace of emissions reduction required, alongside increased global energy access and economic growth, zero- and carbon-neutral fuel substitutes need to achieve price and performance parity with fossil fuels.

Emissions-free nuclear hydrogen production can be cost-competitive with other zero-carbon dioxide (CO2) production methods and has the potential to be cost competitive with steam methane reforming of low-cost natural gas (Allen et al. 1986; BloombergNEF 2020; Boardman et al. 2019; Gogan and Ingersoll 2018; Hydrogen Council 2020; IEA 2019b; NREL 2019b; M. Ruth et al. 2017; Yan 2017). Even expensive first-of-a-kind conventional nuclear plants in the European Union and the United States can produce clean hydrogen at costs comparable to today's wind and solar resources, with good capacity factors.

Large-scale, low-cost clean hydrogen could enable decarbonization of aviation, shipping, cement production and industry, if it's competitive with cheap oil. We estimate this target price to be US $0.90/kg.

Current projections for renewables-generated hydrogen are estimated to be as low as US $2 by 2030, and even less by 2050. Price reductions are constrained by low capacity factors even though we expect capital costs for renewables to continue to fall.

Nuclear plants today could deliver clean hydrogen for below US $2/kg and a new generation of advanced modular reactors could achieve US $0.90/kg, potentially by 2030.

To drive a massive increase in clean hydrogen production, the nuclear industry will need to transform project delivery and deployment models in order to scale up and deliver clean heat, fuels and power. This will require the same intensity of focus on cost reduction, performance improvements and deployment rates that have enabled renewables to begin transforming the global energy system.

Steep, near-term cost reduction is achievable by shifting from traditional construction projects to high-productivity manufacturing environments, such as shipyards, or 'hydrogen gigafactories', which are next generation refineries located on brownfield sites, such as large coastal oil and gas refineries.

Moving from traditional construction to high-productivity manufacturing of advanced reactors will dramatically lower the cost of clean hydrogen and synthetic fuel production. Leading shipyards already have extensive manufacturing capacity, which can produce designed-for-purpose hydrogen production facilities.

Gigafactories and shipyard-manufactured offshore nuclear power plants could put the world back on track to meet 1.5/2°C Paris Agreement goals. This massive decarbonization effort can be achieved with very little land take, allowing large areas of land to be spared for rewilding and regeneration of natural ecosystems, unlike the 'energy sprawl' associated with country-sized renewables industrial developments.

Using these delivery models, the three-decade transition from 100million barrels of oil consumed per day today to an equivalent flow of clean substitute fuels can be achieved at a much lower cost: instead of US $25 trillion required to maintain oil flows until 2050, the clean energy substitute fuels would cost US $17 trillion. This contrasts further with the US $70 trillion for a renewables-only strategy.

Nuclear energy, through these transformed delivery models, can decarbonize the economy at a cost lower than that required to maintain fossil fuels. However, this transition will not begin without urgent action by governments and other actors to bring down costs and accelerate innovation and deployment. Nuclear energy needs to be brought fully into the world's decarbonization efforts.

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