NICE Future
Nuclear Innovation: Clean Energy Future

Repowering 2TW of Phased Out Coal by 2050 with Clean Nuclear Energy

November 2023

The Challenge

In 2015 the world came together to sign the "Paris Agreement,"[1] which states that if we want to limit global warming to 1.5-2°C above pre-industrial levels in order to maintain the Earth as a livable planet, then we need to reach Net Zero emissions by 2050 — at the latest.

More than 2,000 gigawatts (GW) worth of coal-fired plants are operating in the world today, generating roughly 15 billion tons of CO_2 emissions per year. Should the coal fleet keep operating unabated, its emissions alone would exceed the 2°C commitment in the Paris Agreement. Mainstream climate thinking risks making an unrealistic assumption that countries will simply shut down their unabated coal plants. Most coal plants are young assets, and more than half are less than 15 years old.[2] These plants deliver around 37 percent of global electricity supply and provide jobs, tax revenue, reliability to the electric power grid, and an enormous amount of electricity and industrial heat to drive economic growth. It is unclear whether these same benefits can be supplied by renewables, energy storage, or clean hydrogen. Land availability, transmission, and investment requirements also represent serious constraints to the clean energy transition being achieved at the necessary scale, cost, and speed.

The Opportunity

Repowering coal fleets with clean generation offers a fast, low-risk, large scale contribution to decarbonizing the world's power generation. Installing advanced heat sources, such as small modular nuclear reactors (SMRs), to replace the coal fired boilers at existing coal plants enables the continued use of existing infrastructure for emissions-free electricity generation. By sustaining permanent high-quality jobs for communities, repowered coal plants reduce the negative impacts on communities to help enable public and political support for a just transition. It also reduces the overall global investment required to transition to clean energy. As shown in a recent study by Scott Madden,[3] aside from the difference in how steam is generated, a nuclear power plant is remarkably similar to a coal plant.

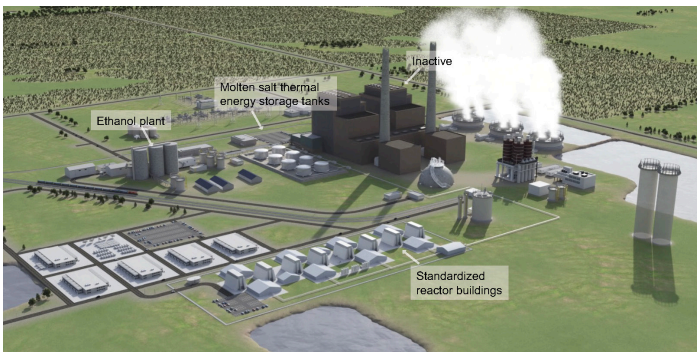
"The actual transferability of skills is amazing between a coal plant and a nuclear plant. At the heart of it, what a nuclear plant does is boil water differently."

– Maria Korsnick, President and CEO of the NEI[4]

The Clean Energy Ministerial's Nuclear Innovation: Clean Energy Future (NICE Future) initiative, under its campaign to Research the Impacts on Social Equity and Economic Empowerment (RISE[3]), is convening governmental, industry, and non-profit partners to examine practical solutions to decarbonization. The NICE Future partner organizations are looking into ways to accelerate coal plant repurposing.

Terra Praxis, for example, is working on a design tool to support a fast, low cost, and repeatable transition.[5] TerraPraxis has assembled a world-class design team including Microsoft, Schneider Electric, and the multinational architecture/engineering firm Bryden Wood. Together, the team is developing feasibility, design, and project development applications to reduce the cost, risk, and duration of repowering coal plants with new emissions-free advanced heat sources (while reusing most of the existing infrastructure and balance of plant). This digital platform will incorporate site independence for the heat island design and use standardized designs for the buildings, systems, and interfaces needed to integrate an advanced fission or fusion heat source. To ensure the repowering coal platform meets customer needs, user groups comprising coal plant owners, heat source vendors, safety regulators, and other critical stakeholders are closely involved in the design process.

The Gateway for Accelerated Innovation in Nuclear (GAIN)[6] and Idaho National Laboratory (INL) are conducting extensive research and providing support in feasibility analysis to repurpose coal plants in the U.S. For example, a case study for the Colstrip site in Montana concludes that it is a potential location to transition from coal to nuclear. Colstrip[7] presents several attractive factors—like the benefits to the local community in terms of jobs and tax base. This transition would provide a clean, firm, dispatchable form of electricity that can make use of the existing infrastructure, such as the grid connection and the cooling system (depending on which type of reactor design chosen).



Repowering Coal case study of Coal Creek Station, conceptual repowering of a two-steam-unit, 1,200 MW-electric plant with eight advanced reactors and thermal storage (turbine halls and storage units in the foreground). Image credit: Terra Praxis

The Benefits

- Opportunity to accelerate and de-risk the clean energy transition while reducing the overall scale of investment required.
- Large public health benefits associated with eliminating coal-fired boilers and the associated pollution from toxic coal ash.
- Continued affordable, reliable, grid-scale electricity generation to support regional and national economic well-being and prosperity, without emissions.
- Advanced nuclear plants are expected to hire more professionals, at a higher wage than the coal plants, and with the potential to be long lasting jobs.[8] A case study from the U.S. Department of Energy has found that replacing 1,200 MWe of coal capacity with 924 MWe of nuclear capacity would create 650 additional and permanent jobs to the region.[9]
- The increase in job opportunities, in turn, fosters economic growth in the local community around the power plant maintaining or even enhancing tax revenues.[10]
- Potential for new energy services such as clean hydrogen production, heat supply, and direct air capture of CO_2.

New Digital Platform

Coal-fired power stations could, depending on the case, be replaced by nuclear reactors (both large and SMRs) ensuring the equivalent production of electricity into the grid. Various initiatives can facilitate the fast, low cost and repeatable replacement of coal-fired plants with SMRs,[12] such as standardized and pre-licensed designs supported by automated project development and design tools with a set of purpose-driven digital applications and data exchange infrastructure for the building system to standardize and optimize:

- Site assessment and repowering feasibility
- Procurement, investment, and regulatory approval
- Construction and engineering systems
- Design, manufacture, assembly, and operation
- Increased collaborative interactions between supply chain organizations.

These applications are being developed to compress plant design and engineering from years to months or weeks and to leverage proven and demonstrated innovations in other sectors.[13]

This large-scale solution to the world's largest single source of carbon emissions could repurpose trillions of dollars of existing infrastructure to continue supplying reliable energy, without emissions, and could advance ground-breaking progress toward Net Zero by 2050.

"With these [advanced nuclear] technologies now maturing, the next horizon is about their deployment, which is really a bridge to bankability for nuclear. And that's to me what we're really talking about here today, which is that we need a phased approach to the deployment of new nuclear that prioritizes speed to market."

– Jigar Shah, Director of the Loan Programs Office at United States Department of Energy (US DOE)[11]

Repowering coal plants with clean nuclear energy is a way to accelerate and de-risk global decarbonization, while also supporting an affordable clean energy provision on existing sites utilizing existing transmission.

Once repowered with clean nuclear energy, coal-fired power plants could become jewels of the new clean energy transition by producing clean electricity, acting as flexible generators, complementing renewables in support of delivering reliable, affordable, and resilient electricity grids.

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[1] *Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement*

[2] *Drawing on public sources, Terra Praxis aggregated a global data set that allows you to explore information about coal plants across the globe. https://www.terrapraxisrepower.com/The-Platform/Global-Plant-Data/*

[3] *Gone with the Steam. 2021. Scott Madden.*

[4] *Maria Korsnick at TerraPraxis' Energy Day at COP26, 2021.*

[5] *Repowering Coal Platform. https://www.terrapraxis.org/projects/repower*

[6] *Gateway for Accelerated Innovation in Nuclear*

[7] *George Griffith, Transitioning Coal Power Plants to Nuclear Power, Idaho National Laboratory. December 2021.*

[8] *SMR Start To a Clean Energy Future, The Economics of Small Modular Reactors, 2021.*

[9] *U.S. Department of Energy, Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants, 2022.*

[10] *SMR Start To a Clean Energy Future, The Economics of Small Modular Reactors, 2021.*

[11] *IEA, Nuclear Power and Secure Energy Transitions From today's challenges to tomorrow's clean energy systems, 2022.*

[12] *Terra Praxis, Repowering Coal System.*

[13] *Jigar Shah speaking at Terra Praxis' Energy Day at COP26, 2021.*

For more information: Shannon Bragg-Sitton, Ph.D. • 208-526-2367 · shannon.bragg-sitton@inl.gov