THIRD WAY

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Clean Firm: Decarbonizing Our Economy with 24/7 Clean Energy

Ryan Norman, *Senior Policy Advisor, Climate and Energy Program,* ***Shane Londagin,*** *Senior Policy Advisor for Innovation*

Takeaways

- The United States is mobilizing unprecedented levels of clean energy investment to meet substantial new growth in energy demand. However, clean energy capacity remains likely to fall short due to challenges with energy permitting and inability to compete with fossil fuels.
- To decarbonize economy-wide, the US must promote deployment of 24/7 clean energy capacity, or “clean firm”, that can fill in the energy segments captured by unabated coal and gas.
- Clean firm energy can be produced by versatile advanced clean technologies that can deliver electricity and/or heat, thereby enabling decarbonization for the industrial sector.
- Policy challenges at the federal and state level must be addressed to advance emerging technologies. This includes market and grid regulatory reforms to ensure new technology is economically viable across national power markets and align the IRA’s decarbonization incentives with local energy planning efforts.

The transition to a low-carbon energy system is the central component of reducing emissions and addressing climate change. In this context, "clean-firm" power—sources that can provide consistent, low-carbon power on demand—plays a pivotal role. This technology class is essential to complement variable renewable energy (VRE) such as wind and solar by ensuring system reliability and reducing dependence on carbon-emitting fossil fuels. In the US, emerging clean energy such as advanced nuclear, geothermal, and LDES are increasingly recognized as vital to achieving decarbonization targets while ensuring stable and reliable energy. Despite these positive trends, stakeholders still have work ahead to eliminate barriers and operationalize opportunities provided through the Bipartisan Infrastructure Law (BIL), the CHIPS and Science Act (CHIPS), and the Inflation Reduction Act (IRA).

This blog synthesizes key themes presented during a Third Way event on clean firm power held during NYC Climate Week 2024. Our analyses on this topic show that developing and commercializing clean firm energy technologies will help meet growing power demand, curtail

unabated fossil fuel electricity production, enable widespread economic opportunities across the economy, and position the US energy, technology, and industrial sectors to compete globally.

What is “Clean Firm” Power?

The term "clean-firm" power describes energy sources that can deliver consistent electricity reliably, and without producing greenhouse gas emissions. Clean-firm power is distinct from VREs, which deliver fluctuating power dependent on environmental conditions. Clean-firm sources typically include:

- **Nuclear energy**: A long-standing, zero-carbon electricity source capable of operating continuously to meet firm demand. Small modular reactors (SMRs) and next-generation nuclear technologies promise enhanced safety, lower costs, and flexible deployment options.

- **Geothermal energy**: Enhanced geothermal systems (EGS) have the potential to provide reliable and consistent power by tapping into the earth’s heat. Technology improvements and improved surveying hold the potential to make geothermal deployable almost anywhere in the US.

- **Fusion energy:** Fusion energy technology aims to provide a powerful and sustainable energy source with minimal environmental impact by harnessing controlled atomic fusion reactions. Fusion could offer a nearly limitless supply of carbon-free power that is safe, flexibly deployable, and affordable at scale.

- **Hydropower:** Hydroelectric plants generate electricity by harnessing the energy of flowing or falling water. Hydropower is one of the oldest and most widely used sources of renewable energy, however its deployment is highly constrained due to geographic and environmental requirements.

- **Existing fuels with Carbon Capture and Storage (CCS)**: Combining fossil fuel or biomass generation with technology to capture and store carbon emissions, allowing for reliable power generation with reduced environmental impact.

- **Long-Duration Energy Storage (LDES)**: Technologies such as flow batteries, compressed air energy storage, and hydrogen storage can provide firm power by storing excess renewable energy for use during periods of low generation.

The Role of Clean-Firm Energy in Decarbonization

In 2023, 84% of the US total net electricity generation was produced by 24/7 energy sources. This robust foundation of firm capacity is critical to maintain the stability of the grid by helping to reliably balance electricity production and load. Historically, this firm capacity has been primarily served by fossil fuels, with clean firm sources contributing 24% of that total segment. A definitive tipping point is approaching as aging coal and gas plants phase out by the mid-2030s and this existing capacity will need to be replaced. To maintain reliability and decarbonize, the share of clean firm sources must grow dramatically.

Numerous studies highlight the necessity of clean firm resources to achieve net-zero emissions in the US electricity sector. The National Renewable Energy Laboratory's (NREL) modeling has shown that while wind and solar can provide 60-80% of electricity generation, a fully decarbonized grid will require clean-firm resources to ensure reliability for the remaining 10-20%; and the Department of Energy has identified a need for at least 700-900 GW of new clean firm capacity on the grid by 2050 to reach net-zero.

Further, America's energy challenges are becoming increasingly pressing. Until recent years, US electricity demand remained relatively flat. Now, the increasing prevalence of energy-intensive data centers (for uses such as artificial intelligence and cryptocurrency) and an IRA-driven surge in domestic manufacturing have caused demand to spike. Our previous analysis finds that existing capacity projections are mostly sufficient to meet new demand in the near-to-medium term. However, without a significant expansion of transmission and clean firm generation, this new demand growth has the potential to 'lock-in' existing fossil fuel infrastructure in the long-term. Even worse, we're likely to see delayed retirements of coal-fired plants and expansion of unabated fossil generation.

To sustainably power the economy of the future, we have to commercialize the next generation of 24/7 clean energy technologies. Doing so will:

- **Provide Complementarity**: Clean-firm sources (including nuclear, geothermal, fusion, LDES, and CCS-enabled generation) can provide a steady, reliable source of power that can operate independently of weather conditions. In high-renewable areas, clean-firm power serves as a complement to VREs by filling in the gaps when renewable generation is low. This capacity helps maintain system stability by allowing grid dispatchers to more accurately forecast day-ahead availability and providing resilience during severe weather events.

- **Meet Growing Demand:** According to industry analysts Grid Strategies, grid planners have nearly doubled their peak demand forecasts from last year. Meanwhile, estimates from the North American Electric Reliability Corporation (NERC) and the International Energy Agency (IEA) similarly forecast significant increases in both summer and winter peak demand. New heavy-load centers are popping up across the country, often in places far removed from new capacity additions..

- **Serve Hard-to-Abate Sectors**: Clean firm sources like nuclear, geothermal, and fusion offer the capability to produce combined heat and power, enabling additional uses of our energy infrastructure. This thermal capacity can be used to decarbonize manufacturing and production processes for concrete, steel, and chemicals by replacing coal and gas heat sources (boilers, furnaces, etc) further aiding direct industrial sector decarbonization.

Why Haven't We Built More Clean Firm Capacity?

Despite their potential, the deployment of clean-firm power in the US faces several challenges:

- **Technological readiness**: While nuclear and hydropower are mature technologies, newer clean-firm options like advanced nuclear reactors, geothermal, and fusion remain at varying stages of development. The deployment of these technologies at scale will require significant innovation and successful demonstration projects to prove their commercial viability.

- **Economic barriers**: The high capital costs associated with nuclear power, geothermal development, and CCS infrastructure present significant barriers. First-of-a-kind, or "FOAK", projects in the US, such as the new nuclear Vogtle Electric Generating Plant, have experienced cost overruns and delays with earlier deployments. This increases concerns about the economic viability of new projects and presents one of the most significant risks for early stage technology.

- **Regulatory and permitting**: Siting and permitting for new clean-firm projects can be a major risk as initial deployments are largely untested and may be novel. Some technologies, such as nuclear and fusion energy, require the navigation of additional regulatory entities (ex. the US Nuclear Regulatory Commission). Lack of clarity in these processes can act as another barrier to entry for innovators and investors by driving up the cost of capital or adding delays to project development.

- **Public perception and political challenges**: Public acceptance of a new technology is an essential component of the value offer for a new energy plant. Technology like advanced nuclear energy can require renewed public education to reach community adoption in the US. In other regions, concerns over siting, drilling, and the impacts of large infrastructure projects generally, have contributed to deployment challenges for new clean technology.

The Path Forward

A surge in new investment in VREs since the passage of BIL and IRA highlights that renewables will continue to lead the clean energy transition with the bulk of new capacity additions. But, with nearly 1.2 TW of VREs stuck in the interconnection queue and electric load growing rapidly, there is an urgent need to promote a class of energy solutions that can compete with unabated fossil fuels and serve hard-to-abate market segments. Clean firm sources including nuclear, geothermal, fusion, carbon capture, and LDES are emerging and have the potential to address new and existing demand–but challenges remain to commercialization, including economic, regulatory, and public adoption barriers.

To fully realize the potential of clean-firm, state and federal policy interventions are essential. The IRA included numerous policies that incentivize investment in clean-firm resources, including tax credits, grant funding for clean energy supply chains, and loan-assistance. These incentives work to complement and draw in private sector investments in emerging technology and, ultimately, state efforts toward decarbonization and economic growth. The US now needs additional policies to maximize the impact of the IRA's provisions, unlock the growth of the grid, and enable major opportunities in the American economy.

Policy and Market Mechanisms

- **Enabling Investment in RDD&D**: Increased funding for research, development, demonstration, and deployment of advanced nuclear, EGS, fusion, CCS, and other emerging technologies is crucial for their commercialization.

- **Reforms for Energy Permitting Regulation**: Clean energy technologies and transmission infrastructure often face significant siting, permitting, and interconnection challenges. Policies, such as those included in the Energy Permitting Reform Act of 2024 (EPRA), are focused on reducing those roadblocks and providing clean energy and transmission projects with the regulatory parity and certainty fossil projects have long enjoyed. Beyond EPRA, updating the regulatory landscape to encourage the integration of clean firm power sources through efficient land leasing and streamlined environmental processes can support new deployments.

- **Delivering on Public-Private Partnerships:** Collaborations between federal and state governments and the private sector can accelerate the demonstration and deployment of clean-firm power technologies through de-risking private sector investment and FOAK deployment. New federal and state energy deployment policies that support private stakeholder (offtakers, developers, and power providers) risk-sharing mechanisms by mitigating construction and commercialization costs will also incentivize new investment and order book development.

- **State Policies for Energy Deployment**: Implementing robust state energy financing including tax incentives for 24/7 clean electricity, clean energy standards that set minimum capacity limits for clean firm, and zero-emissions credit multipliers for clean firm technologies can drive investment towards new 24/7 clean energy capacity rather than new fossil fuels.

- **Grid Management and Development:** Regional grid management involves multiple agencies of jurisdiction, varying from independent system operators to public utilities commissions, each with their own standards and processes for deploying new energy infrastructure. Adopting behaviors that place higher value on clean firm, and prioritizing new clean firm projects in high-risk regions, would enable existing power producers and new market entrants to serve growing demand and invest in carbon-free firm energy sources.

Want to dive deeper? Check out our full CWNYC session here.