American Security Project

Innovating Out of The Climate Crisis: Electrification

Briefing Note

Quick Facts

- The U.S. currently gets approximately 60 percent of its electricity from fossil fuels, mostly from coal and natural gas.
- The U.S. has committed to producing all of its electricity from zero-carbon sources by 2035 and achieving net-zero carbon emissions by 2050. This clean energy transition away from fossil fuels requires unprecedented speed, implementation of innovative technologies, and anywhere from $330—$740 billion in investment over the next decade.
- There are many benefits to a clean energy transition, including a significant reduction in air pollution, human and environmental health benefits, jobs, and economic and social benefits. The net economic benefits in 2035 of reducing air pollution alone are estimated to be nearly $400 billion, while the benefits from reducing climate impacts could top $1 trillion.
- Fossil fuel-dependent sectors like transportation, electricity generation and heavy industry account for more than three-quarters of U.S. CO2 emissions. Substantial investments in both innovation and infrastructure will be needed to transition to clean energy in these sectors.
- According to the National Academies of Sciences, investments needed to achieve a clean energy transition are roughly in line with estimates of historical and business-as-usual energy spending.

Key Challenges and Opportunities

Scale

- Electricity generation will need to grow up to four times the current levels to meet the energy demands from electric vehicles, homes, and industries as part of the clean energy transition.

Integrated Grids

- Transforming America's current landscape of fragmented, regional grids into a single, integrated system could allow the U.S. to decrease carbon emissions by up to 42 percent.

Regulatory and Permitting Speed

- Transmission siting processes can average anywhere between ten to fifteen years or more for inter-state/regional transmission lines. An estimated 750 GW of proposed renewable energy is currently waiting to connect to the grid—enough to more than double U.S. renewable energy capacity.

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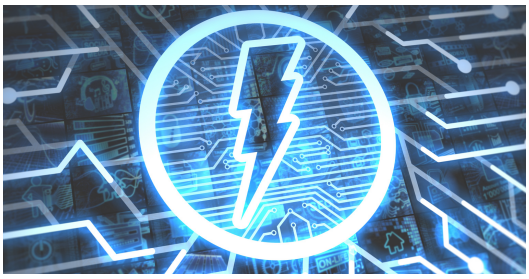
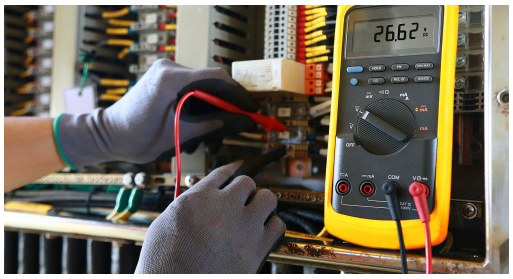
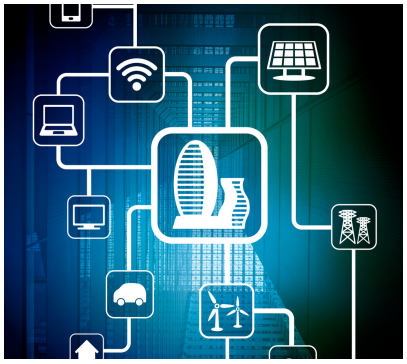



Transmission

- Virtually all zero-carbon energy sources must be converted to electricity where they are found—most often in large open areas far away from major urban areas—then transported via the grid to where it is needed. Renewables like solar and wind are often located far from existing infrastructure, which is near coal and natural gas facilities.
- By 2035, total grid capacity is estimated to need to be as much as three times what it is today and require up to 10,000 miles of new high-capacity lines annually from 2026-2035.
- Transmission lines have an average 50 year service life. More than 70 percent of existing transmission lines are more than 25 years old.
- The transmission siting process determines who can build what, where, when, and who pays for it. These challenging negotiations, which can involve local, state, and federal agencies, often drag on for years; event short lines can take an average of 10 years to secure the necessary permissions.
- Microgrids are a relatively low-cost way to power remote locations that are difficult to connect to standard grids. Deployment of microgrids has tripled over the past five years and the price per KwH has dropped by nearly a third.

Storage

- Long-duration grid-scale storage will become increasingly important with higher levels of renewable energy adoption. The U.S. is estimated to need to install up to 360 GW of diurnal (2-12 hours) storage by 2035 to meet its net-zero emissions goals.
- Today, over 90 percent of functional, grid-scale storage worldwide comes in the form of pumped hydropower. Pumped hydro and pumped air energy storage projects are typically large, costly to build, and rely on favorable topography to build a reservoir.
- The scale of deployed battery systems remains modest—less than 1GW of rated power in the United States in 2021—but they account for the majority of deployed and announced projects.
- Deployed, grid-scale battery storage is dominated by lithium-ion batteries—the same chemistry as the battery in your phone or laptop. Technical innovations and manufacturing scale have driven prices of these batteries down by more than 70 percent during the last decade.
- The critical minerals required to make batteries present both geopolitical and supply chain challenges. China controls approximately two thirds of global lithium processing capacity, and a vast majority of the world's cobalt is mined in the Democratic Republic of the Congo.


Technologies and Innovations

Smart Grids

- Widespread adoption and incorporation of renewable energy and increased electrification requires a more technologically advanced, smarter, and faster grid. Smart grids can use digital tools to balance load across the system down to the microsecond, enabling finer control over the integration of variable renewable energy sources like wind and solar.
- Advanced metering infrastructure (AMI), or smart metering, gives consumers detailed information about when they're using power. Smart meters and thermostats are already in 8.3 million U.S. homes, and enable customers to shift their usage to save money and smooth demand.
- New, high-temperature conductors made of stronger materials can increase the transmission capacity of existing lines by as much as 2.5x and are more resistant to extreme weather.

Energy Storage

- Energy storage is critical to maximize the benefits of wind and solar generation, so excess energy can be released when it is needed. Technologies like lithium-ion batteries and pumped hydro storage are already being deployed, but there are several other technologies in development, including: compressed air energy storage, mechanical gravity energy storage, and flow batteries.
- Batteries are a critical tool for energy storage. DOE, the Joint Center for Energy Storage Research (JCESR) at Argonne National Laboratory, and several other national labs are developing new chemistries and technologies to improve battery power, capacity, and cost.

Critical Mineral Supply

- Critical minerals such as lithium, nickel, cobalt, and manganese are essential components needed to make batteries and clean energy technologies. Global demand for critical minerals is expected to increase dramatically as more countries transition away from fossil fuels. In October 2022, DOE announced $39 million in funding for domestic development of market-ready technologies to increase domestic supplies of critical minerals.
- In March 2022, President Biden invoked the Defense Production Act (DPA) to provide tax credits for manufacturers to increase critical mineral mining and production.
- The Critical Minerals Institute (CMI) is a DOE Energy Innovation Hub and public-private partnership developing critical mineral technologies and a domestic industry ecosystem.

Policy & Regulatory Frameworks

- The grants and loan guarantees, tax credits, and emissions fees in the Inflation Reduction Act (IRA) will drive 439-660 million metric tons of additional CO2 emissions reductions by 2030, compared to current policy. The top of that range is equivalent to eliminating the emissions of California and Florida combined.
- Provisions in the Bipartisan Infrastructure Law (BIL) and the IRA can reduce U.S. power sector emissions by an estimated 68-78 percent (relative to 2005 levels) by 2030.
- The IRA offers a manufacturing production credit for certain components, including battery cells, solar photovoltaic cells, wind turbine components. Over 10 years, it is estimated that the bill will offer nearly $400 billion in support for U.S. climate policies.
- In early 2022, the BIL authorized the Department of Energy (DOE) to launch the Building a Better Grid Initiative, which will help centralize long-term transmission planning, coordinate permitting processes, and support research and development for transformers, high-voltage converter stations, storage, and analytical tools. It provides approximately $20 billion in financing tools to build out the grid for the deployment of innovative technologies like dynamic electricity flow control, advanced conductors, and network organization optimization.
- Congress is working to reduce new transmission line building time. The BIL clarifies the Federal Energy Regulatory Commission's (FERC) authority to site power lines where DOE judges it would be in the national interest. Though the federal government has not yet acted on this authority, this power could speed and streamline siting decisions that have previously been handled primarily by states.

National Security Considerations

The clean energy transition has numerous economic and environmental benefits, but it also has important benefits for U.S. energy security and national security.

- The Department of Defense, and the Departments of the Air Force, Army, and Navy have all released climate adaptation plans/strategies which detail the importance of the clean energy transition for military readiness, operational effectiveness, and installation resilience.
- The Department of the Army has scoped and planned 25 microgrid projects through 2024 and intends to install a microgrid on every installation by 2035. By 2040, the Army also aims to have enough renewable energy generation and battery storage capacity to sustain the critical missions of every installation.
- In accordance with federal guidance, the U.S. military has made widespread electric vehicle (EV) adoption across the vehicle fleet a priority. Adopting EVs will help reduce fuel consumption, emissions, and logistics requirements, which can give troops an edge on the battlefield.

This briefing note is part of ASP's *Innovating out of the Climate Crisis* programming which seeks to explore innovations in technology and policies in key clean energy areas. These innovations will help facilitate our collective ability to adapt to climate change, ultimately leading to a more resilient nation.

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