NATIONAL ACTION PLAN FOR UNITED STATES LEADERSHIP IN

Next-Generation Energy

SPECIAL COMPETITIVE STUDIES PROJECT 02.2024

The Special Competitive Studies Project (SCSP) is a bipartisan, non-profit project with a clear mission: to make recommendations to strengthen America's long-term competitiveness as artificial intelligence (AI) and other emerging technologies are reshaping our national security, economy, and society.

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A Letter from the Chairman & the CEO

SCSP is developing a series of National Action Plans to ensure U.S. leadership in key technology areas. This action plan – the fourth in the series – addresses the next generation of clean energy technologies that will shape individual lives and great power geopolitical tensions. Energy is the foundation of the modern world. Everywhere you look, some form of energy is being used to make our lives better. As we enter the Age of AI with an increasingly digitized and connected world, energy technologies will only grow in importance.

The national security imperative that the United States and its allies and partners lead the world in energy cannot be overstated. Since the dawn of the Industrial Age, energy has been at the center of geopolitics. Access to energy is so critical to society that reliance on rival or unreliable countries is a threat to national power. Energy security confers economic, diplomatic, and military advantages. Unsurprisingly, it will continue to play a central role in the global techno-economic competition between the United States and the People's Republic of China (PRC). The PRC has a significant lead in many aspects of the clean energy technology ecosystem and has used its massive domestic market and sprawling industrial manufacturing base to excel in areas such as electric vehicles, solar and wind power, and critical mineral mining and processing.

The race is now on to develop and deploy next-generation ways to generate, store, and move clean energy in the drive to reduce greenhouse gas emissions. The United States built a position of strength in a world powered by coal, oil, and gas, but the global community is shifting resources to clean energy sources and continued U.S. leadership is not assured. The energy sector is undergoing a massive transformation, and the United States must take bold actions to accelerate energy innovation and deployment.

Drawing on expertise from academia, the private sector, and government, this action plan combines bold technology "moonshots" with organizational changes and policies that would position the United States for durable advantage. Rather than address every aspect of the vast energy sector, our action plan focuses on solving for U.S. advantage from a national security perspective. We invite you to join us in this effort to ensure that the United States, along with its democratic allies and partners, is positioned and organized to win the techno-economic competition between now and 2030, the critical window for shaping the future.

Eric Schmidt
Chairman

Ylli Bajraktari
President & CEO

Introduction

The world's two largest economies, the United States and the People's Republic of China (PRC), are jockeying for competitive advantage across every element of national power. As the world's largest energy consumers and producers, energy leadership is central to the geopolitical competition. The ability to produce and use energy when and where it is needed confers a host of national security, economic, and diplomatic advantages.[1]

Meanwhile, the global energy system is undergoing a massive transformation. While fossil fuels continue to play a vital role in the global economy, the world is increasing its clean energy capacity to address the effects of climate change.[2] Global clean energy investments matched fossil fuel investment for the first time in 2016, and since then, has grown to surpass it by $700 billion as of 2023.[3] The growth of clean energy deployments is changing how we generate, store, and move energy for end-use applications.

The confluence of these techno-economic trends is bringing about new challenges, new supply chains, and new uncertainties about how to handle emerging energy technology and policy tradeoffs. An ideal energy system would be abundant, clean, secure, reliable, resilient, and low-cost. However, real-life decisions seldom allow for easy progress across all these variables, and maximizing for one will come at the expense of the others.

Policymakers are forced to choose among competing geopolitical and energy objectives and are grappling with a range of difficult questions: How can we secure supply chains without driving up costs and slowing new deployments? How can we accelerate clean energy at scale without compromising the redundancies and security of the fossil fuel networks we built over decades? How do we prioritize limited resources between catching up to competitors and looking for areas in which we can establish new leadership?

Technology will not always be the answer to these policy questions, but it can help better balance the political-economic trade-offs. For example, improved grid-scale energy storage reduces the impact of wind and solar power generation intermittency. Advances in materials science will lead to substitutes for scarce metals and minerals, thus improving supply chain costs and security. Commercial fusion energy could rewire the geopolitics of energy entirely.

This document provides forward-looking moves for how the United States, together with allies and partners, can establish global leadership in next-generation energy through 2030 and beyond. Meeting the need for more energy, and increasingly more sustainable energy, will require innovations in how we generate, store, and move energy. We must reconsider what talent, structures, and policies we need to create to demonstrate and deploy new breakthroughs at speed and scale. Bold national energy technology goals can propel the entire American innovation ecosystem into a position of global advantage.

Desired Endstate

The United States leads the world in energy technology innovation and deployment, resulting in an abundant, clean, secure, reliable, resilient, and low-cost energy system at home and shared abroad.

We envision a world where:

- Clean energy is **"too cheap to meter,"** meeting future demand while unleashing prosperity and innovation across society.[4]
- Secure critical **energy supply chains** run through the United States and its allies and partners, ensuring the ability to realize our collective economic potential and protect national security interests.
- A **diversified energy portfolio** and hardened infrastructure strengthen resiliency and broaden accessibility, protecting against geopolitical and environmental disruptions.
- The U.S. government and industry together lead the world in **expanding energy innovation and deployment** globally to empower emerging and middle-income economies.

Central Policy

Chart a path toward next-generation energy technologies by catalyzing disruptive innovation via energy moonshots to offset strategic dependencies. In parallel, pursue key supporting moves to strengthen ecosystem enablers for sustainable innovation, demonstration, and the scaled deployment of next-generation energy technologies.

Background

The geopolitics of energy security is set to undergo a major transformation as the world scales up clean energy deployments to supplement and eventually supplant fossil fuels. Positional advantage in next-generation energy technologies will cut across multiple domains, from research and development (R&D) to critical supply chains to manufacturing to the deployment of energy technologies at scale.

Confronting China's Outsized Dominance in the Clean Energy Supply Chain

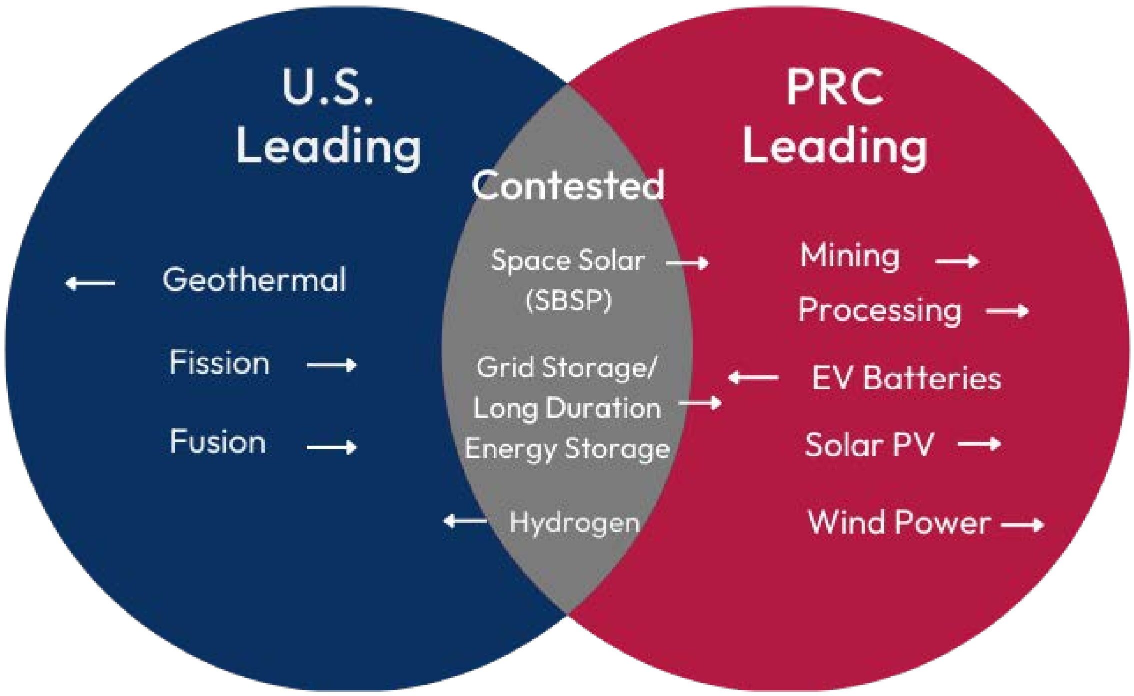
The United States continues to excel in innovating clean energy technologies, but faces hurdles in supply chains and commercialization, challenged by high costs, financial risks, talent gaps, and regulatory barriers. Indeed, many of the core clean energy technologies today, such as the lithium-ion battery and photovoltaic solar panels, were invented in the United States but were ultimately outsourced abroad, namely to China. At the same time, the PRC holds commanding leads in access to critical inputs for clean energy technologies, minerals processing, manufacturing, and deployment. China controls 60% of worldwide critical mineral extraction and 85% of processing capacity.[5] It also has 80% of the world's solar manufacturing capacity and nearly 60% of global wind power manufacturing.[6] It is the same story for batteries. Six out of the top ten battery manufacturers are in China, which produces 77% of the world's batteries.[7] China's success in scaling green energy production has lowered global costs, but has left the world increasingly dependent on a single source of exports, undermining innovation in alternative clean energy technology pathways.[8]

China's recent export controls on critical minerals such as graphite and gallium, as well as mineral processing equipment, underscore not only Beijing's willingness to use its dominance in the mineral supply chain as a tool for coercive leverage in the tech competition, but also demonstrates the need for the United States and other allied/partner nations to diversify its energy storage options beyond lithium-ion batteries.[9] China's central role in the critical mineral supply chain is not a result of natural endowment, but rather a product of industrial strategy.[10]

Due to China's dominant position in many aspects of the energy technology ecosystem, the United States must carefully evaluate ways to strategically offset Beijing's capabilities while finding ways to reduce dependence on the PRC. Indeed, in areas such as advanced battery technology, U.S. firms are also forming voluntary joint ventures with their PRC counterparts in order to gain access to PRC battery technologies, after decades of the PRC seeking to gain access to superior U.S. technology.[11] In some cases, PRC battery firms like CATL have collaborated with U.S. firms to gain access to the lucrative U.S. market, risking deepening U.S. dependence on PRC technology.[12]

Energy Sector Comparative Analysis

This graphic summarizes the SCSP staff's current assessment, as of February 2024, of the energy landscape between the U.S. and PRC in several key energy technologies from now until 2030.



Graphic Source[13]

Accelerating American Innovation and Industrial Capacity to Meet the Energy Challenge

The United States has been a net exporter of energy since 2019, largely thanks to the shale revolution, which strengthened U.S. energy security and reduced the leverage of geopolitical rivals like Russia.[14] However, shifting away from our advantages in natural gas to maximize clean energy could come at the expense of U.S. and allied energy security, especially if the PRC continues to dominate clean energy supply chains.[15] We cannot yet responsibly account for all the variables of an ideal energy system (abundant, clean, secure, reliable, resilient, and low-cost) with clean energy alone; we need to accelerate innovation and industrial capacity.

The good news is that the United States is aggressively taking action to establish leadership in clean energy technologies. Significant investments by the U.S. government and private sector are spurring technological innovation as policymakers, regulators, and utilities work through barriers to deployment. A great deal of work remains to be done, but there is momentum in the right direction. In 2021 and 2022, Congress passed monumental pieces of legislation, including the

Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA), signaling a renewed American commitment to clean energy manufacturing and deployment.[16] The Department of Energy (DOE) has sought to keep pace with the changing nature of technology by restructuring its bureaucracy, adding new tech-focused offices, streamlining processes, and making a major hiring push to advance ambitious energy goals.[17] The private sector is also actively involved. Maturing "capital stack" and a developing capital structure that is increasingly open to experimentation with financing, risk, and business models aim to effectively transition technology from the laboratory to capital-intensive deployments.[18]

Forging New Partnerships for New Energy

Numerous allies and partners are joining the United States in driving the innovation necessary for expanding clean energy capacity, each pursuing their own ambitious policies. In October 2023, the European Commission updated its long-term Strategic Energy Technology Plan to harmonize efforts among EU members, support clean energy technology, create resilient networks, and secure industrial competitiveness under the Net-Zero Industry Act, reaffirming goals outlined in the European Green Deal.[19] Australia, having finalized the bilateral Climate, Critical Minerals, and Clean Energy Transformation Compact in 2023 and establishing an Australia-United States Task Force on Critical Minerals, has become a prominent advocate and partner in the worldwide shift towards clean energy.[20] South Korea, too, has outlined ambitious clean energy objectives in its own New Green Deal of 2020, with $61 billion earmarked for supporting green economic endeavors and more than tripling renewable energy sources between 2019 and 2025.[21] And Japan is putting approximately $1 trillion USD towards clean energy technologies as part of its Green Transformation (GX) program.[22]

Capitals around the world are adopting policies and initiatives to fully harness the potential of next-generation energy technologies. To maximize our collective competitiveness against outsized PRC advantages throughout the clean energy supply chain, however, the United States should work closely with allies and partners to not only foster closer collaboration on energy R&D, but also ensure that there is a sensible degree of policy coordination. The nature of the tax incentive provisions in the IRA created tensions with important allies, but also opened the way to new framework negotiations for better integration. The United States came to an agreement with Japan and is in negotiations with the European Union.[23] Broad alignment and cooperation will accelerate global clean energy advancement.[24]

Those who lead in developing and deploying abundant, low-cost, and resilient clean energy technologies will be poised to rewrite the geopolitical dependencies of the 21st century. U.S. and allied success is not assured. No single technology or policy shift will solve our challenges. We need a whole-of-nation effort to advance a diverse portfolio of technologies. We must embrace innovation, foster collaboration, and navigate the challenges with strategic foresight.

Fueling the Next Wave of Technology Innovation

The connection between emerging technologies and energy is multi-faceted. On one hand, certain advanced technologies are consuming increasingly higher levels of energy.[25] However, it is essential to recognize that these technologies hold the potential to catalyze innovation in the energy sector, leading to increased efficiencies that could enhance energy production and supply.

On the demand side, AI is trained and run via massive data centers, which require tremendous and an increasing amount of electricity.[26] The ever-growing demand for computation has led to data centers currently accounting for 1 to 1.5 percent of global electricity consumption.[27] According to analysts, by 2027, AI servers could use up to 134 terawatt hours of electricity annually, the equivalent usage of a small country.[28] At the same time, AI has the potential to streamline energy production capabilities and increase efficiencies, resulting in an expanded energy supply. AI can be used to forecast supply and demand, identify predictive maintenance priorities on the grid, site new solar and wind projects for maximum generation, improve discovery of critical mineral deposits, and spur energy technology innovation.[29]

Addressing challenges around the increasing energy demands of new technologies like AI is no different than those related to other energy demands. The world needs more energy to advance our collective prosperity. Energy abundance must be the goal. The way forward is improving technological efficiency while accelerating the efforts covered in this Action Plan to increase clean energy availability at low cost.[30]

First Principles

- **Leadership in the Energy Transition Will Convey Strategic Advantage.** The ability to create, deliver, and use energy is intrinsically tied to military, economic, diplomatic, and societal power. Early adopters in new emerging energy technologies will have tremendous leverage in nearly every aspect of geopolitical competition.
- **Success Will Require a Silver Buckshot Rather than a Silver Bullet.** Diverse geographical and environmental conditions require diverse clean energy solutions and every solution has its tradeoffs. The United States must support multiple simultaneous energy investments and adopt a diverse portfolio of energy technologies.

- **Energy Leadership Will Require Integrated Energy Policies.** Energy policy cannot be stove-piped by sector. When new energy generation technologies come online, they need to be supported by the proper infrastructure to be transmitted, distributed, and stored. Energy technologies are interconnected and policies governing them need to be formulated and executed holistically.
- **Energy Invention Needs to be Deployed.** Breakthroughs in energy technologies will not translate into competitive advantage until they are more broadly scaled and adopted. Invention and limited deployment are not sufficient. Energy abundance, and all the benefits that it will confer, will come from mass deployment and adoption.
- **Many Obstacles to Scale Are Not Technical.** Transforming the infrastructure-heavy energy system is as much about people, places, and processes, as it is about technology innovation. This will require business incentive alignment, regulation and permitting reform, and shifts in traditional ways of thinking.
- **Economics Will Ultimately Drive Technological Sustainability.** Mass adoption of clean energy technologies cannot be achieved through indefinite subsidies and mandates. Government investments should be accepting of risk, but also pragmatic in how they support technologies in later stages of development – support should only go towards those technologies with clear paths to price-performance parity.[31]

Action Plan Overview

1. Launch: National Moonshot Programs for Next-Gen Energy

1.1 Catalyze a Commercial Space-Based Solar Power (SBSP) Industry
1.2 Push Fusion From Lab to Grid
1.3 Scale Long Duration Energy Storage (LDES) Solutions

2. Train: Human Capital for the Clean Energy Future

2.1 Empower U.S. Department of Energy Workforce Recruitment
2.2 Build a More Agile Green Collar Workforce
2.3 Bolster Domestic Critical Mineral Expertise

3. Organize: National Capacity for Energy Innovation

3.1 Fund the Future
3.2 Establish a "Help Desk" for the Department of Energy
3.3 Increase Coordination Between Innovation Hub Programs
3.4 Supercharge Energy Research Using AI
3.5 Harness Innovation Synergies with Allies and Partners

4. Assure: Supply Chains for Energy Technologies

4.1 Stockpile Critical Minerals for National Security and to Boost Domestic Production
4.2 Advance Improved Mining Technologies
4.3 Use Public-Private Partnerships to Increase Domestic Processing Capacity and Technology
4.4 Expand the Critical Mineral Supply to Include Alternative Sources
4.5 Build a Global Network for Critical Mineral Supply Chain
4.6 Increase Manufacturing Capacity of Production Components

5. Scale: Commercial Deployments of Clean Energy Technologies

5.1 Speed Up Regulatory Approvals and Permitting
5.2 Make More Deployment Finance Available

6. Build: The Foundation for the Energy Transition: The Grid of the Future

6.1 Modernize the Grid
6.2 Build a More Connected and Expansive Grid
6.3 Secure the Grid

Appendix: Additional Elements of Success

Nuclear Fission
Hydrogen
Geothermal Energy

The energy sector is vast and complex, involving diverse stakeholders. Building and sustaining leadership in clean energy is a long-term effort. This Energy Action Plan does not offer an exhaustive list of actions; rather, it presents a minimal set of key moves to lay the foundation for U.S. energy leadership. The following recommendations build off of the efforts already underway in the United States in collaboration with allies and partners.[32] The first section offers three ambitious strategic offsets that would create significant new advantages. The next section addresses a range of critical enabling areas that together, serve as a minimum viable solution set for U.S. leadership.

ACTION PLAN RECOMMENDATION — 1 / 6

Launch: National Moonshot Programs for Next-Gen Energy

1.1 Catalyze a Commercial Space-Based Solar Power (SBSP) Industry
1.2 Push Fusion from Lab to Grid
1.3 Scale Long Duration Energy Storage (LDES) Solutions

Moonshots are audacious goals that can move the entire U.S. innovation ecosystem toward a position of competitive advantage. These proposed goals are beyond "hard," but like the Apollo Program, they are attainable through a whole-of-ecosystem effort. The United States needs to build off its history of innovation to develop whole new energy capabilities to offset competitor advantages in critical segments of the transitioning energy system.

What sets moonshots apart from more incremental approaches to technological progress? First, by aiming to achieve a step-change or paradigm shift, such programs drive the rest of the innovation ecosystem along with them. Second, properly designed moonshots promote accountability by assigning a National Mission Manager to own the program full-time. And third, moonshots aim to create a tangible platform – *a capability* – that solves an especially hard problem and creates many second-order benefits for the economy.[33]

For this National Action Plan, we are proposing one moonshot in each of the three core segments of the energy ecosystem: power transmission/distribution, generation, and storage. Hundreds of technological breakthroughs are needed throughout the energy ecosystem, but the three ideas presented here stand out for their boldness and impact.

1.1 Catalyze a Commercial Space-Based Solar Power (SBSP) Industry

One of the fundamental obstacles to achieving energy resiliency is guaranteeing the delivery of power supply to meet the demands of end-users. In the United States, building the infrastructure necessary for ubiquitous energy transmission has remained a systemic challenge.[34] Space-based solar power (SBSP) offers a new paradigm for energy distribution by combining 24/7 renewable energy generation with continuous power transmission to ground points anywhere on Earth. As a type of wireless power transmission, SBSP holds tremendous geopolitical implications for economic, diplomatic, and military influence on par with space-based communications and global navigation satellite systems.[35] The first nation to successfully deploy and scale SBSP will hold a number of downstream advantages in energy, space access mobility and logistics (SAML), and in-space servicing, assembly, and manufacturing (ISAM), opening the door to new technological capabilities beyond energy transmission.[36]

Technical advancements in reusable launch, power beaming, solar power systems, electronics miniaturization, and robotics systems have transformed a decades-long idea into an achievable, ambitious goal that would enable the United States to lead in both a critical sector – energy – and a critical domain – space.[37] SBSP today is more of an engineering challenge than a science challenge, though continued innovation is necessary to take technology from the lab to scaled, cost-competitive deployment. Challenges include high up-front costs, orbital slots, spectrum allocation, lack of assembly techniques, and maintenance.[38]

China has put forth an ambitious national SBSP program to achieve gigawatt (GW) capacity by 2050.[39] U.S. allies and partners, in particular Japan, the United Kingdom, and the European Union, also have coordinated research programs with SBSP deployment goals.[40] The United States has loosely connected efforts, but not the type of whole-of-nation effort needed to take leadership in this technology and compete with the PRC.[41]

Objective: Catalyze a commercially viable SBSP energy system ahead of competitors. Set aggressive goals to demonstrate at least 50-kilowatt (kW) capacity by 2030 and 35GW by 2050.

Method: The goal must be to set the conditions for commercial success as quickly as possible. Several public-private partnership (PPP) constructs could effectively advance U.S.-led SBSP technology by harnessing the whole innovation ecosystem, including our international partners, to overcome technical, engineering, financial, and regulatory risks. Potential options include a

DoD-led effort (similar to the Global Positioning System), a broad-based international coalition (similar to the International Space Station), a federally funded public corporation (similar to the Communications Satellite Corporation (COMSTAT) for commercial communications satellite systems), or a secure government market supporting a portfolio of commercial companies (like NASA's Commercial Orbital Transportation Services (COTS) program or DOE's commercial fusion model).[42]

SBSP has economic and national security implications in both the space and energy sectors, so the group of government stakeholders that must be involved is diverse: the Department of Energy, Department of Defense, NASA, and Department of Commerce. Regardless of the PPP construct, the Defense Advanced Research Projects Agency (DARPA) should lead the effort to buy down risk in the most important technology areas, such as power beaming, in-space assembly, and deployable lightweight structures.

1.2 Push Fusion from the Lab to the Grid

Fusion — the same process that powers the Sun — is perhaps the ideal source of clean, limitless energy. While fusion has been studied in laboratories for over 75 years, scalable fusion power appears closer than ever.[43] The National Ignition Facility (NIF) at Lawrence Livermore National Laboratory achieved ignition or "scientific energy breakeven" in an inertial fusion reaction — producing more energy than used for the reaction — in December 2022, and has replicated the breakthrough multiple times since.[44] Private sector companies, taking a variety of technical approaches, have raised over $6 billion to achieve scientific net energy in the near future and plan to deliver the first commercial fusion power plants within a decade.[45] Much work remains to translate fusion from a scientific to a commercial endeavor, but with commitment and sustained focus to close known R&D gaps and by leveraging the public-private partnerships with the fusion industry and stakeholder strengths, fusion energy could reach the grid by the early 2030s.[46]

Successfully deploying fusion power at scale is a national security imperative, and fusion leadership would be a boon for national competitiveness. Both allies and rivals are quickly scaling their own programs and ambitions, competing for global fusion leadership.[47] The United States should seize this moment and set a fusion moonshot as a proof of concept that will organize our innovation ecosystem for a scaled fusion future.[48]

Objective: The United States should have multiple fusion pilot plants successfully delivering energy to the grid by 2030.

Method: A National Mission Manager (NMM) with appropriate legal and budgetary authorities should be established and tasked with delivering fusion to the grid and encouraging multiple technical pathways for fusion. As part of an effort to attract private capital and effectively use public monies, Congress authorized the DOE Milestone-based Fusion Development Program in 2020 and then allocated the program $415 million over five years in the CHIPS and Science Act.[49] It is important for DOE to continue to focus the necessary resources on this program and the Federal Government to support this program with proper funding. Additionally, the Federal Government should consider options to make fusion-related technologies eligible for the 45X Advanced Manufacturing Production tax credits under the Inflation Reduction Act.[50] To enable regulatory streamlining, Nuclear Regulatory Commission (NRC) should continue down the path of 'by-product-material' regulation of fusion plants. Funding for basic and applied plasma science should continue increasing aggressively, with the growth path envisioned by the Department of Energy FY24 budget request as a lower bound.[51] The Federal Government should establish an Office of Fusion Energy at the Department of Energy to meet the growing needs of a commercial fusion industry and fulfill the Bold Decadal Vision. The office's initial mission should be to get fusion power on the grid by 2030 and ultimately serve as the policy apparatus for a thriving U.S. fusion ecosystem.

1.3 Scale Long-Duration Energy Storage (LDES) Solutions

Long-duration energy storage will be a critical enabler of the future energy grid by offering greater flexibility and reliability. Global solar and wind power generation is projected to grow 3-4 times by 2030.[52] One challenge this presents is that solar and wind power are intermittent sources, so their production cannot always match demand in real-time. To meet periods of high demand during low production, energy from peak production periods must be stored for hours, weeks, or even months.[53]

Unlike mobility applications, LDES solutions for the grid are less constrained by the need for small size and low weight, therefore a much greater range of approaches may prove viable for diverse use cases. The LDES commercial sector is rapidly evolving; in an LDES market roundup, Sightline Climate captured 51 companies across 10 different technology approaches, from pumped hydropower to flow batteries to sensible heat.[54] To meet demand, LDES will have to scale 400x by 2040, suggesting that the overall market could be valued at over $3 trillion between now and 2050.[55]

Objective: As called for in DOE's Long Duration Storage Earthshot, reduce storage costs by 90% in relation to a 2020 baseline in storage systems that deliver 10+ hours of duration by 2030.[56]

Method: DOE's Pathway to Commercial Liftoff report for Long Duration Energy Storage outlines the key improvements needed in technology, regulation, and supply chains.[57] The Long Duration Storage Earthshot sets ambitious targets for performance and cost, and organizes cross-cutting programs to advance promising technologies at various levels of maturity - either through continued R&D or support for demonstration projects. This program deserves continued prioritization by the DOE Office for Science and Energy Crosscuts. Regular updates to the Liftoff report are needed to assess progress and address barriers to full commercial viability by 2030.

Key Enablers for U.S. Energy Leadership

The following sections outline essential, technology-neutral policy measures designed to position the United States to create and implement a spectrum of energy innovations. These innovations are instrumental in realizing our desired end state of establishing an energy system that is abundant, clean, secure, dependable, resilient, and cost-effective.

ACTION PLAN RECOMMENDATION	2 / 6

Train: Human Capital for the Clean Energy Future

2.1 Empower U.S. Department of Energy Workforce Recruitment
2.2 Build a More Agile Green Collar Workforce
2.3 Bolster Domestic Critical Mineral Expertise

The energy sector includes an incredibly diverse set of workforce needs, from inventors to technicians to construction workers. New systems, technologies, and business models will require a range of skill sets to meet our national goals. Finding enough workers to meet current energy sector demand is already a challenge, while projected future needs will be many times higher.[58] Smart government policies are needed to support existing market forces to more rapidly address critical skill gaps.

2.1 Empower U.S. Department of Energy Workforce Development

DOE is the center of the U.S. federal government's efforts to advance U.S. leadership in energy and it needs the best talent resources to achieve its mission. The Department needs the bureaucratic agility to recruit, hire, train, and retain talent to keep pace with the evolving energy landscape.

Objective: Expand DOE's toolkit to attract top energy talent.

Method: DOE's Clean Energy Corps initiative, which aims to hire 1,000 additional workers focused on clean energy, is taking advantage of expanded Direct Hire Authority (DHA) to accelerate onboarding of qualified staff.[59] In order to ensure DOE is able to continue hiring clean energy-focused staff, DOE should request OPM (1) extend its authority beyond 2025, and (2) increase its cap beyond 300 positions as the Federation of American Scientists recommended in its clean energy workforce report.[60] DOE should also expand and make it easier for its hiring teams to use the Intergovernmental Personnel Act (IPA) program that allows outside experts from eligible institutions to temporarily serve in government roles requiring specialized expertise. To do so, DOE should automatically grant IPA eligibility to organizations already certified by other agencies.[61]

2.2 Build a More Agile Green Collar Workforce

Scaling clean energy deployments will require expansive new infrastructure across the country. Stakeholders will have to build or retrofit manufacturing facilities and construct new energy installations. Workers will need to be trained to operate new systems and maintain equipment. An inability to fill the range of labor positions will slow the deployment of clean energy technologies.

Objective: Meet the growing demand for energy jobs, from operations and maintenance to construction and finance.

Method: There are many new and established government workforce initiatives. The 2023 Biden-Harris Administration Roadmap to Support Good Jobs seeks to align these many programs into a whole-of-government effort.[62] Given the scale and diverse nature of the energy sector's workforce needs, additional bureaucratic leadership is warranted. A single coordinator, based either at the National Economic Council (NEC) or the Department of Commerce (DOC), focused on energy workforce development and training would coordinate across multiple government agencies to identify skill gaps, establish standards, assess effectiveness, and share best practices.[63]

2.3 Bolster Domestic Critical Mineral Expertise

The United States needs more specialized operators and engineers to increase access to critical minerals through mining and processing operations at home and U.S. ventures abroad.[64] In particular, there are not enough qualified workers to fill highly technical positions.[65] The Critical Minerals Mining Research and Development program created in the CHIPS and Science Act allows grants to be used for undergraduate and graduate training and research opportunities, which is a good start, but more needs to be done.[66]

Objective: Grow and retain a domestic mining and processing workforce for critical minerals. This includes both mining operators as well as highly qualified metallurgy engineers proficient in emerging mining and processing technologies.

Method: The United States should establish a grant program for existing mining schools to expand student recruitment and research, and to support schools seeking to establish new mining programs.[67]

ACTION PLAN RECOMMENDATION 3 / 6

Organize: National Capacity for Energy Innovation

- **3.1 Fund the Future**
- **3.2 Establish a "Help Desk" for the Department of Energy**
- **3.3 Increase Coordination Between Innovation Hub Programs**
- **3.4 Supercharge Energy Research Using AI**
- **3.5 Harness Innovation Synergies with Allies and Partners**

Federal, state, and local governments have undertaken significant steps to spur both national and local-level energy innovation through renewed investments, but it will take time for those investments to run their course before producing results.[68] To quickly leverage government initiatives and cement the nation's position as the world's energy leader, the United States must further optimize and organize its energy innovation ecosystem. The Department of Defense, Department of Commerce, Department of State, and others play important roles in shaping our energy future, but this report primarily focuses on the Department of Energy, which has the leading role in transformative science and technology solutions to energy challenges.[69]

3.1 Fund the Future

Federal legislation such as the BIL, IRA, and the CHIPS and Science Act all make historic investments into the energy sector.[70] However, most of this federal funding focuses on spurring the deployment of today's energy technologies rather than the discovery of next-generation energy technologies. The United States must continue to support over-the-horizon breakthroughs through sustained support for foundational knowledge discovery. By increasing investment in basic and applied research, the nation will be able to solve future energy problems that will require novel solutions.

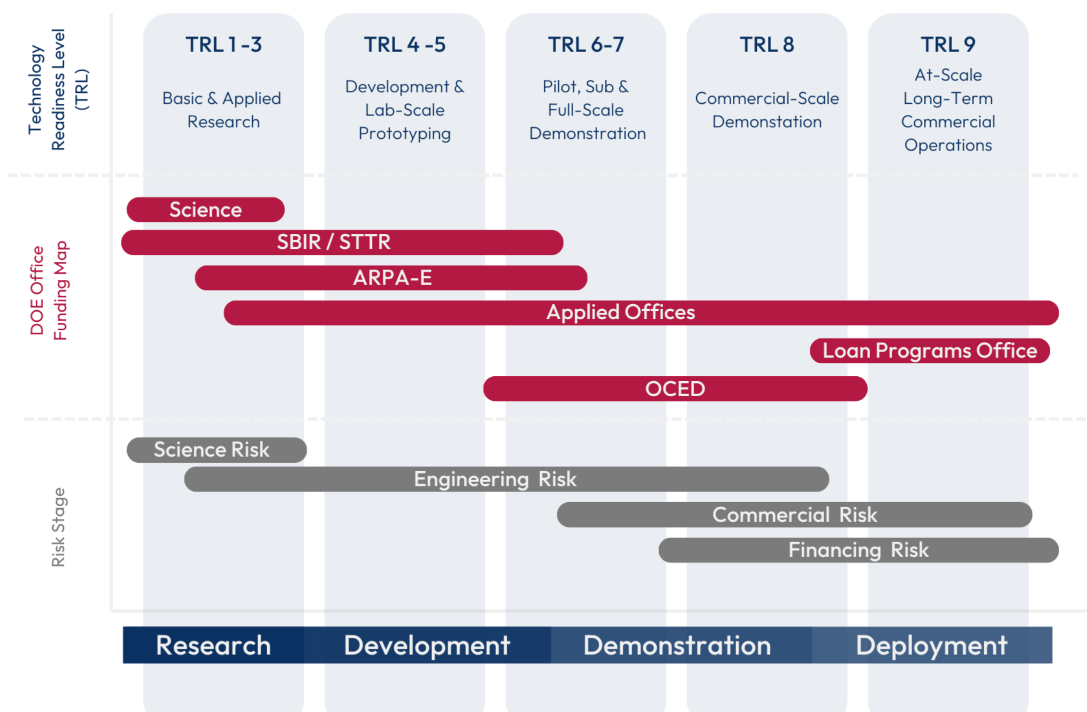
Objective: Spur the development of future energy technology by supporting basic and applied energy research.

Method: Congress authorized significant investments in energy research in the CHIPS and Science Act, including for DOE programs, but additional appropriations as requested by the Department of Energy's Office of Sciences are necessary.[71] As in the Department's Fiscal Year 2024 request, DOE should continue to increase its budget annually to expand support for its vast energy research portfolio and the Department's Earthshot initiatives.[72] DOE should also consider further collaborating and coordinating with other R&D agencies like the National Science Foundation (NSF) to maximize federal investments in the energy sector.

3.2 Establish a "Help Desk" for the Department of Energy

DOE is the primary cabinet-level federal agency overseeing the various initiatives, programs, loans, and grants relating to the energy sector. For startups and companies to gain access to these resources and for DOE to expand its public-private partnerships, these two corners of the energy ecosystem need greater bridges between them. To reach the nation's energy goals, the private sector and the government must work together and have coordinated points of entry to better synchronize and allocate public and private resources. Graphic Sources[73]

The Department of Energy's Funding Ecosystem



Objective: Move towards a single coordinated point of entry for private sector energy stakeholders to make DOE more accessible to all stakeholders within the innovation ecosystem.

Method: Develop a Help Desk for DOE that serves as a "front door" to the Department or a "match-maker" between private sector stakeholders and various DOE offices, programs, initiatives, and funding opportunities. Building off the Department's work to internally coordinate across the organization, a Help Desk could sit under the Under Secretary for Science and Innovation who oversees DOE's Office of Sciences and the DOE national laboratories.[74] This Help Desk function would better connect industry with DOE counterparts, finding where companies could advance the Department's mission across the energy sector, and helping startups and academic researchers find funding opportunities and grants to spur energy innovation.

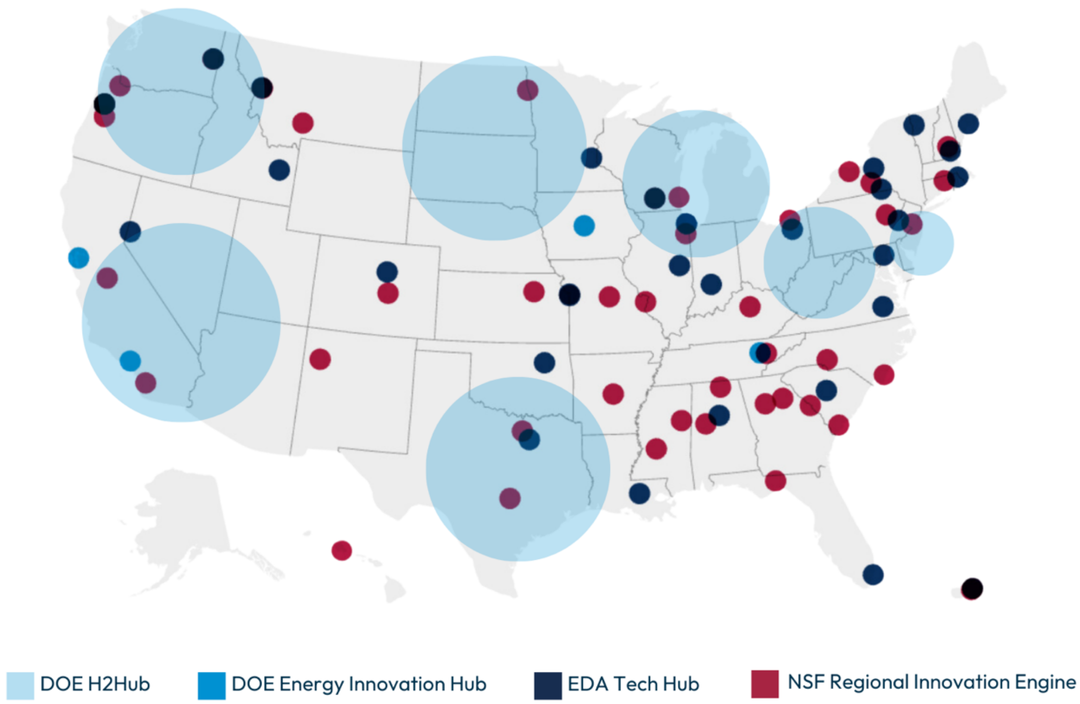
3.3 Increase Coordination Between Innovation Hub Programs

Many recent federal initiatives encourage place-based innovation, recognizing that work at a sub-national level and within labs, classrooms, workshops, and offices across the country significantly contribute to technological advances.[75] Just as importantly, this type of coordination lays the groundwork with transition partners to ensure breakthroughs are actually adopted. Examples of these various initiatives include the Department of Commerce's Economic Development Administration's Regional Technology and Innovation Hubs program and the National Science Foundation's Regional Innovation Engines, both of which aim to advance the development of critical technologies, such as artificial intelligence (AI).[76] The Department of Energy has also taken steps to encourage regional energy innovation through its own regional innovation hubs, including the recently announced H2Hubs Program.[77] With three departments and various initiatives, there is potential to optimize regional innovation for the energy sector itself, allowing states, cities, and localities to become leaders and producers of current and future energy technologies.

Objective: Increase coordination of energy hubs with other regional tech hubs to maximize the nation's innovation potential.

Method: The Department of Energy should work more closely with the Economic Development Administration and the National Science Foundation's Directorate for Technology, Innovation, and Partnerships to establish hydrogen and other energy hubs. Increased collaboration when designating, co-locating, or even cross-awarding the many forms of regional technological hubs could enable resource sharing and talent exchanges between various stakeholders within an area's innovation ecosystem. Also, better coordination across the interagency, including with the Department of State, such as the Special Representative for City and State Diplomacy, when furthering regional innovation could enable cities and towns across the nation to work more closely with allied and partner localities to solve the world's greatest energy challenges.[78]

Map of Federal Tech Hub Programs



Graphic Sources[79]

3.4 Supercharge Energy Research Using AI

AI revolutionizes how nations invent, adopt, and adapt to new technologies.[80] As AI converges with every scientific and technological field, it is changing research and development (R&D) at its core—from speeding up every step of the scientific process to advanced modeling and simulation of market-ready prototypes.[81] AI has automated operations within nuclear fusion reactors, helping to recreate the Sun's power on Earth, and AI enabled by quantum computing can identify new materials for critical energy technologies, such as EV batteries.[82] AI can help lead to more effective solutions to the nation's biggest energy problems and help the nation achieve DOE's various Earthshots.[83] Harnessing AI's catalytic potential for energy R&D is necessary for innovation and, thus, the energy transition.

Objective: Accelerate energy research and development across the energy innovation ecosystem using AI.

Method: The Department of Energy's National Laboratory System should develop a joint program or S&T Discovery Platform designed to unlock new AI-enabled capabilities and approaches for the discovery, design, testing, building, and deployment of innovative energy science and technologies.[84] As directed by the White House's recent Executive Order on AI, DOE's newly appointed Director of the Office of Critical and Emerging Technology and Chief Artificial

Intelligence Officer could oversee the development of this proprietary AI model for energy applications, and the effort could be housed within one of the National Labs to provide shared access to sector-specific datasets, computing resources, and scientific expertise.[85]

3.5 Harness Innovation Synergies with Allies and Partners

The massive scale of shifting more of the energy system to clean sources requires many people driving many breakthroughs. One of the greatest strengths of the United States is its network of allies and partners. The United States will ultimately be stronger and better positioned in relation to the PRC if it closely coordinates energy research and development with its allies and partners.

Objective: Harness the combined innovation power of allied and partner nation ecosystems through deeper energy research collaborations.

Method: DOE should build off its existing international engagement efforts to more closely connect its national research ecosystem with the public research institutions in allied and partner nations.[86] DOE should build and maintain a list identifying which allied and partner nations are leading in priority areas of energy research. DOE's new Office of Critical and Emerging Technology could serve as the initial lead and focus on its priority technology list: AI, biotechnology, quantum technologies, and semiconductors. Then, in coordination with the DOE Office for Science and Energy Crosscuts, additional connections can be made between relevant U.S. teams and leading ally and partner teams for targeted collaborative research.[87]

ACTION PLAN RECOMMENDATION 4 / 6

Assure: Supply Chains for Energy Technologies

4.1 Stockpile Critical Minerals for National Security and to Boost Domestic Production
4.2 Advance Improved Mining Technologies
4.3 Use Public-Private Partnerships to Increase Domestic Processing Capacity and Technology
4.4 Expand the Critical Mineral Supply to Include Alternative Sources
4.5 Build a Global Network for Critical Mineral Supply Chain
4.6 Increase Manufacturing Capacity of Production Components

The growth of clean energy innovation and deployment requires an evolving supply chain to meet demand, which includes critical mineral mining, materials processing, and the manufacturing of subcomponents, components, and end-use products.[88] Today the PRC dominates this supply chain.[89] Ensuring U.S. leadership does not require fully domestic supply chains, but it does need sufficient inputs and manufacturing capacity to protect against geopolitical disruptions. There are no quick fixes in these areas, but the United States is already taking significant actions.[90] In a vast, fast-moving space, the following recommendations are moves to build off existing efforts or create new programs worthy of additional attention.

Contesting China's Dominance in Electric Vehicle Batteries

The EV sector is projected to account for over two-thirds of vehicle sales by 2030, but the PRC currently holds a dominant lead in EV battery production.[91] Catching up requires tackling a range of challenges across the entire supply chain, encompassing critical minerals mining and processing, as well as creating additional production capacity. While still in the early stages, U.S. action has already produced promising developments. To bolster U.S. leadership in battery innovation, the Department of Energy (DOE) unveiled its Energy Storage Grand Challenge and Roadmap in December 2020, laying out a comprehensive array of solutions for bolstering supply chain resilience and driving innovation.[92] The Inflation Reduction Act (IRA) subsequently reshaped the U.S. battery market by introducing tax credits aimed at bolstering domestic production. As of February 2024, a significant portion of IRA investments, some 72 percent of the $98 million announced thus far, has gone towards battery projects.[93] Major auto manufacturers have also made billions of dollars in investments and commitments.

Amid intensifying competition in this space, the United States has a long road ahead but it is imperative to capitalize on these positive strides. In 2019, only two operational battery factories existed in the United States, but as of mid-2023, approximately 30 are either planned, under construction, or already operational.[94] The United States should also explore alternative battery chemistries. EV batteries require high energy density coupled with the need to be durable under diverse environmental conditions for extended durations. While lithium-ion batteries presently dominate the market, discovering novel chemistries and configurations to enhance performance and address supply chain complexities will be needed to offset PRC dominance.[95]

4.1 Stockpile Critical Minerals for National Security and to Boost Domestic Production

Critical minerals are necessary for a range of clean energy technologies, but also for the defense industry.[96] The U.S. National Defense Stockpile (NDS) was created just before World War II and was intended to decrease dependence on foreign supply sources during emergencies.[97] Valued at $42 billion in today's dollars in 1952, the stockpile now only stands at only $888 million – a fraction of its Cold War high.[98] Stockpiling critical minerals and other important materials (such as copper) would protect against PRC market manipulation and, at the same time, could be used to boost domestic production through domestic-content requirements.[99]

Objective: Enhance resilience by building up the amount of critical minerals in the U.S. National Defense Stockpile.[100]

Method: The FY2024 National Defense Authorization Act (NDAA) directs DoD to take a range of actions to improve critical mineral supply chain independence.[101] These requirements include evaluating the use of the NDS to expand supply chains and processing in the United States and with allies and partners, and leveraging the NDS to develop and purchase strategic and critical materials from reliable sources.[102] DoD has also been granted multiyear purchase authority for rare earth elements and permanent magnets.[103] The Department should rapidly leverage these authority to expand the critical minerals stockpile.[104]

4.2 Advance Improved Mining Technologies

To enhance the efficiency as well as public acceptance of mining operations at home and abroad, the United States needs new technologies which make these ventures cleaner, less disruptive, and more economically viable. Future mining sites will likely extract material of lesser quality, as most high-quality sites have already been exploited and friendshoring policies could make previously unattractive lower-quality deposits in allied and partner nations economically viable.[105]

Objective: Develop and deploy improved mining technologies.

Method: ARPA-E's Mining Innovations for Negative Emissions Resources (MINER) program supports technologies that increase mineral yield while decreasing energy and tailing losses.[106] This program deserves continued support for the deployment of promising technologies. In addition, ARPA-E should consider expanding the range of supported mining technologies that would allow for less disruptive approaches for the surrounding environment and for workers, such as AI-enabled mining robots. DOE's Loan Program Office should also increase its support of mining projects using advanced mining techniques and technologies.[107]

4.3 Use Public-Private Partnerships to Increase Domestic Processing Capacity and Technology

Mineral processing is a critical step in the supply chain in which the valuable minerals are separated from the ore into a usable product.[108] The PRC controls 60% to 100% of global mineral processing, depending on the mineral, while the United States controls less than two percent.[109] Increasing domestic processing capacity is necessary to create greater protection against geopolitical leverage. While DoD and DOE have begun to address this problem through grant and loan programs, deep public-private collaboration is needed to address this challenge over the long-term.[110]

Objective: Increase domestic critical mineral processing capacity and technology.

Method: DOE should create two new public-private partnerships. One should be led by the Office of Fossil Energy and should bring together downstream industries, such as battery makers, that need critical minerals into a cost-sharing agreement to build capital intensive processing facilities. The second should be led by the Critical Materials Innovation Hub at Ames National Lab to bring together processing companies to conduct collaborative technology and process research and testing.[111]

4.4 Expand the Critical Mineral Supply to Include Alternative Sources

The process of establishing new mines, spanning approximately 16 to 17 years from initial exploration to actual production, demands significant capital investment.[112] To address escalating demand, it is crucial for the United States to explore alternative strategies to increase mining output and boost efficiencies. Among the most promising of these strategies are the substantial enhancement of recycling efforts and the extraction of critical minerals from residual mining tailings and byproducts.[113]

Objective: Scale up the use of recycling and extraction from mining tailings and byproducts to help meet growing demand for critical minerals.[114]

Method: Support for recent initiatives to boost recycling and extract critical minerals from unconventional sources like mining waste should continue and if proven initially successful, expanded.[115] To build off these efforts, DOE's Critical Minerals and Materials Crosscut Team, which coordinates the Critical Minerals Research, Development, Demonstration, and Commercialization Application (RDD&CA) Program, should look for additional opportunities to advance technologies in these areas.[116]

4.5 Build a Global Network for Critical Minerals Supply Chain

Communities in critical mineral-rich parts of the world – especially in Africa, which holds about one-third of the world's mineral resources – have long suffered from negative repercussions of mining operations, including water pollution, land degradation, dangerous working conditions, and displacement.[117] The United States and its allies and partners should seek this opportunity to outcompete PRC investors globally by serving as cleaner and more responsible mining and processing partners.[118]

Objective: Diversify the global critical minerals supply chain.[119] Focus on establishing mining and processing capabilities in allied and partner nations as well as collaborating with them to outcompete PRC critical mineral investors in third countries.

Method: To break the PRC's dominance in mining around the world, the United States should take efforts to formalize the current ad-hoc practice of bidding coalitions. Currently, allies and partners are independently monitoring PRC acquisition attempts abroad, and trying to form transnational public-private coalitions to outbid PRC investors. This monitoring and coalition mechanism could become a part of the broader Minerals Security Partnership (MSP) effort.[120]

4.6 Increase Production Capacity Energy Components[121]

China is the leading manufacturer of clean energy technology components, which creates supply chain vulnerabilities beyond critical minerals.[122] Building up domestic manufacturing capacity for components like solar panels, wind turbines, and large-capacity batteries is capital intensive. The U.S. government is starting to address this challenge through policy measures such as the Inflation Reduction Act's 45X production tax credits and the DOE Loan Program Office's Title 17 Clean Energy Finance Program.[123] More can be done to build off this progress.

Objective: Increase capital available for manufacturing energy technologies.

Method: SCSP has called for a standing techno-industrial financing mechanism to provide additional patient capital to scale manufacturing in critical sectors.[124] Such a mechanism should prioritize support for scaling production capacity for energy components where the United States faces supply chain vulnerabilities.

ACTION PLAN RECOMMENDATION | 5 / 6

Scale: Commercial Deployments of Clean Energy Technologies

The invention of new breakthrough energy technologies is not sufficient on its own for global leadership. Innovations must transition to commercialization at scale to realize the full economic, security, and foreign policy benefits. The United States needs to establish robust policy frameworks and financial mechanisms that not only facilitate the deployment of existing technologies but also pave the way for the swift introduction of more advanced and future-proof solutions. A critical step in this process involves overcoming two major obstacles for next-generation technology commercialization: the bottlenecks caused by regulatory hurdles and the shortage of financial capital during certain phases of the development cycle.

Geopolitical competitors, such as the PRC, have rapidly deployed energy technologies thanks in part to the country's immense industrial base, but also due to lower environmental protection standards and labor safety practices. The United States should continue to lead efforts to curb the PRC's malpractices that undercut global innovation, particularly as it pertains to the energy sector.[125] At the same time, Washington should redouble efforts to address the systemic challenges that are holding innovators back from propelling the nation toward the next-generation of energy technologies.

5.1 Speed Up Regulatory Approvals and Permitting

The United States needs to significantly expand its energy and infrastructure deployment, though such projects face long approval timelines and other bureaucratic hurdles which raise costs, stymie innovation, and ultimately can hold back economic growth. The U.S. government is already taking important actions to address these challenges and there are calls for further reforms from both parties with hope for bipartisan agreement.[126] The 2023 Fiscal Responsibility Act and subsequent proposed rulemaking updated the National Energy Policy Act (NEPA) to shorten approval times and limit which kinds of projects require full environmental reviews.[127] The

Federal Energy Regulatory Commission (FERC) approved a new rule in 2023 to make the grid connection process more efficient.[128] Though there is more to be done in these areas, recent actions reflect significant progress. One important area that still requires attention however is judicial review reform.[129]

Objective: Improve the judicial review process for energy and infrastructure projects while preserving the right of individuals and communities to prevent undue harm.

Method: The United States should reform the judicial review process to accelerate energy and infrastructure project development. This could include a range of actions, such as reducing the statute of limitations and standing, establishing a technical court with jurisdiction over federal permitting decisions, and narrowing the scope of decisions.[130]

5.2 Make More Deployment Finance Available

As startups progress through the lifecycle of new energy technologies – from conceptualization to lab experimentation, from validation to large-scale demonstration, and finally to first-of-a-kind or full-scale commercial implementation and deployment – they encounter a need for capital at every turn. The funding landscape is tenuous, with different investors offering varying levels of risk tolerance and capital availability. Although there's a need for more investment at every stage to boost the pace of energy innovation, the most acute funding gap often takes place in the intermediate stages of development.[131]

At the earlier stages, government grants and venture capital are often available to support new companies that need less capital but present high risks. Conversely, at the far end of the spectrum, where technologies are fully developed and carry lower risk, substantial funding is accessible from traditional financial institutions to facilitate widespread deployment.[132] However, the transitional phase presents a significant challenge. In this middle ground, startups aiming to execute large and costly demonstration projects, which are still deemed risky, frequently encounter a scarcity of funding options, creating a critical bottleneck in the path to commercialization.[133]

The landscape of energy financing is undergoing a dynamic shift, with innovative strategies emerging to channel additional funds into these critical investment gaps.[134] A pivotal player in this evolving ecosystem is the DOE's Loan Program Office (LPO), which stands out for its dedicated role in forging connections between emerging energy projects and private sector financing.[135] The conspicuous shortfall in mid-stage capital necessitates the role and mission of LPO, but furthermore, it is increasingly essential to establish frameworks that guide nascent companies through the increasingly complex layers of financing, ensuring they can secure the necessary capital to evolve and succeed.

Objective: Continue providing critical financing to companies trying to scale deployments through continued support to the LPO.

Method: DOE should continue to prioritize its support of the LPO, ensuring necessary resourcing – including necessary administrative and staffing resources – and working with Congress as needed to ensure the LPO's three lending authorities do not expire.[136] Finally, oversight of LPO's decisions is important to protect taxpayer interests, but overly critical oversight will slow our national energy progress.[137] The LPO's mission is to take smart risks to advance the state of energy technology, but the risks nonetheless will result in some failed projects. These should not be unduly politicized or prevent the continuation of the mission.

Objective: Support companies deploying new energy technologies as they navigate the complex project capitalization process.

Method: DOE should stand up a new public-private partnership to convene the many different types of energy project financers to provide growth stage companies education, technical assistance, and network access. This would create a central ecosystem to increase knowledge sharing and accelerate project development.[138]

ACTION PLAN RECOMMENDATION 6 / 6

Build: The Foundation for the Energy Transition: The Grid of the Future

- **6.1 Modernize the Grid**
- **6.2 Build a More Connected and Expansive Grid**
- **6.3 Secure the Grid**

The structure of the U.S. power grid has mostly remained unchanged since the 19th century: a network where transmission lines link substations, drawing from fossil-fueled generators, to deliver electricity to residential and commercial end-users.[139] The result of this is a highly distributed network of eleven thousand power plants, three thousand utilities, and more than two million miles of power lines—all built to serve a nation reliant on coal.[140] However, today, initiatives like the Inflation Reduction Act and states' clean energy goals, encourage the United States to move away from a heavy reliance on fossil fuels for power during a time when the nation's need for electricity is growing.[141] New energy sources, revolutionary forms of storage, and novel approaches to electricity transmission are being developed and adopted to meet the rising supply and demand for energy—all of which will need to touch the grid in some way. The U.S. power grid is therefore the backbone of the energy transition, and thus, needs to be maintained, updated, adapted, and, most importantly, drastically expanded.[142]

6.1 Modernize the Grid

A modernized grid will optimize the use of existing infrastructure and allow the United States to take full advantage of nascent forms of energy generation and storage technologies.[143] Modernizing the grid by deploying various grid-enhancing technologies (GETs) is one key way to bolster the grid's ability to bridge energy supply and demand.[144] Even though these technologies exist today and can maximize energy transmission and even save costs for consumers, GETs are not implemented across the bulk power system since the economic incentives are not aligned for transmission owners to fully adopt them.[145] Today's electricity markets and regulatory structures operate under a return-on-equity business model where consumers pay for the assets needed to build the grid, thus encouraging transmission owners to focus on new infrastructure buildout with an eye toward bigger returns on investment, rather than optimizing existing transmission lines.[146] Therefore, changing the incentive structure for transmission owners to adopt GETs is necessary to help address the current and future complexity of the grid.[147]

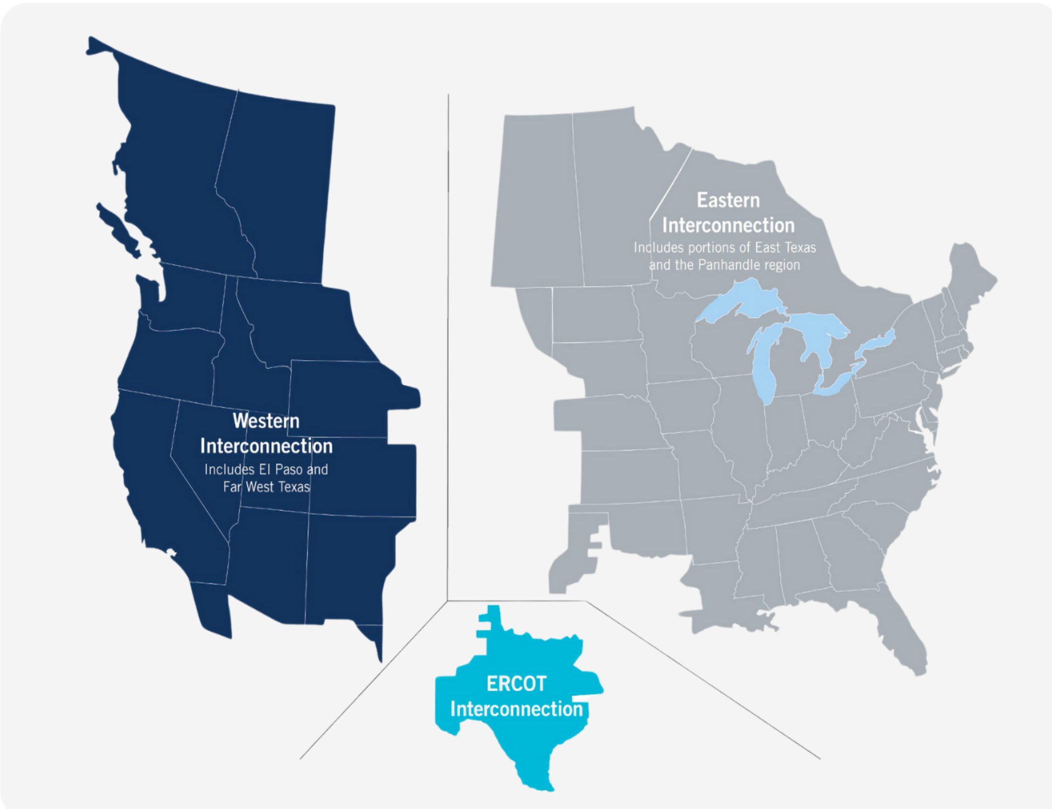
Objective: Expand the adoption of grid-enhancing technologies across the country's current and future transmission lines.

Method: The Federal Energy Regulatory Commission (FERC) can incentivize transmission owners to adopt GETs by establishing performance-based incentives like a shared-saving mechanism (SSM). An SSM will allow transmission owners to gain a profit when the benefits of applying GETs greatly outweigh the costs.[148] Additionally, FERC should explore requiring transmission owners to deploy GETs if transmission development studies and planning processes prove that GETs provide net cost-savings, which is in line with FERC's Final Rule on Improvements to Generator Interconnection Procedures and Agreements.[149]

6.2 Build a More Connected and Expansive Grid

The United States needs to more than double its transmission capacity and increase power flow across the nation to meet the needs of the current and future energy transition.[150] Today's grid consists of three sections or interconnections—the Western Interconnection, the Eastern Interconnection, and the Texas Interconnected System—largely managed by Regional Transmission Organizations (RTOs).[151] However, these interconnections and their respective RTOs are physically and operationally separated, with little power flowing between the interconnections and little collaboration occurring between RTOs.[152] Connecting these three interconnections and increased coordination between the RTOs would be a critical step towards increasing the nation's transmission capacity, allowing, for example, solar power to move east to west at times when the sun is not shining.[153] As the nation continues to electrify and transition to clean energy sources, increased transmission and coordination between the sections of the grid would create a more integrated, reliable, and efficient power system.[154]

The U.S. Interconnections



Graphic Source[155]

Objective: Build more high-voltage direct current (HVDC) transmission lines between the Western Interconnection, Eastern Interconnection, and the Texas Interconnected System to eliminate the "seams" that currently prevent power from being shared across the nation.[156]

Method: The Department of Energy (DOE) and the Federal Energy Regulatory Commission (FERC) should be the nation's "mission managers" for this project, using their existing and expanded authorities and working closely with RTOs and other regional, state, and local stakeholders to quickly build out these new transmission lines.[157] First, FERC should use its congressionally-authorized backstop siting authority to name these cross-seam transmission lines as projects of national interest to expedite the regulatory processes related to transmission expansion.[158] Then, DOE should utilize its ability to become an "anchor tenant" and purchase fifty percent of the total capacity of the transmission lines to reduce risks for project developers by providing a guaranteed customer, allowing for the build-out of transmission lines.[159] Lastly, Congress should double the budget of DOE's Transmission Facilitation Program to expand the Department's ability to provide capital for the project.[160]

6.3 Secure the Grid

The nation's electrical grid is becoming more distributed and thus more susceptible to threats.[161] There are several points of vulnerability across the bulk power system, especially as more and more digital technologies are deployed to optimize grid operations.[162] Foreign actors can exploit these links in critical infrastructure, as exemplified by the cyberattack on Ukraine's power system by Russian hackers or the infiltration of an oil and gas pipeline by a cyber group linked to China's People's Liberation Army.[163] Therefore, increasing security measures across every point of the electrical grid, from energy generation to distribution, is key to the nation's energy and national security.

Objective: Ensure the entire grid is secure by design as it continues to expand, modernize, and digitize.[164]

Method: The Department of Energy should work with the Department of Homeland Security, the Federal Energy Regulatory Commission (FERC), the North American Electric Reliability Corporation (NERC), the Electricity Information Sharing and Analysis Center (E-ISAC), and other regional, state, and local stakeholders to develop a comprehensive cybersecurity framework for the entirety of the electric power grid. This federal-level cybersecurity framework should have clear, measurable guidelines for every node of the energy system—including distribution utilities—with corresponding enforcement policies and agencies.[165] A more comprehensive cybersecurity strategy would help the energy sector secure critical nodes currently at risk and protect against future risk as the energy transition unfolds.

APPENDIX

Additional Elements of Success

Our future energy abundance will rely on a host of energy generation, storage, and transmission technologies. Detailed plans for the most promising technologies are outside the scope of this Action Plan. However, there are three important technology areas beyond the mature solar and wind sectors that 1) will almost certainly play increasingly larger roles in the future energy system, 2) are continuous and therefore require less overhaul of the grid, unlike intermittent energy sources like wind and solar, and 3) are already experiencing significant progress through U.S. government and private sector efforts.

These three energy technologies deserve acknowledgment here as part of the full story of U.S. leadership in energy. This section briefly summarizes the importance of each technology, current challenges in scaling these technologies, and key U.S. government efforts already underway. Sustaining the existing U.S. government initiatives and taking strong action in each of the enabling areas described above in the Action Plan will position the U.S. private sector to advance overall U.S. leadership.

Nuclear Fission

As it stands today, nuclear power produced solely through fission has supplied roughly a fifth of America's power each year since 1990.[166] Yet innovation in fission energy has been fraught with a mix of inertia and risk aversion. Uncertain and unpredictable customer pipelines, public distrust, and a challenging regulatory environment have stifled domestic deployment and scaling of advanced reactor technologies.[167] Indeed, the United States has the largest fleet of nuclear fission reactors in the world, yet almost no new reactors have come online in the 21st century.[168] Rather, over the past few decades, the United States has ceded its competitive advantage as a world leader in civilian fission energy to other countries like China and Russia.[169] For example, the PRC has already built five small modular reactors (SMRs) – a promising next-generation advanced nuclear fission reactor design – while the United States has none.[170] Yet U.S. policymakers and the public alike have begun to recognize the critical role of nuclear power in our energy future. Perhaps most notably, the United States joined 25 countries at the COP28 summit in a pledge to triple nuclear power generation by 2050. [171] [172] [173]

Doubling down on innovation in next-generation nuclear technologies is the most likely way to overcome the obstacles that have precluded wider adoption and construction of previous generations of fission technology. DOE's Pathways to Commercial Liftoff report for Advanced Nuclear identifies five critical areas for improvement: workforce, fuel supply chain, component supply chain, licensing, and spent nuclear fuel disposal.[174] DOE's Advanced Reactor

Demonstration Program is helping drive promising breakthroughs in SMRs and other advanced reactor designs that could reduce the footprint and capital requirements for new reactor builds.[175] ARPA-E is exploring novel approaches for reducing, storing, and disposing of nuclear waste that could de-risk the fuel cycle.[176] On the commercial side, there is a growing ecosystem of new entrants working on advanced reactors and enriched uranium.[177]

Hydrogen

Hydrogen is the most abundant element in the universe and holds tremendous potential to transform the global energy system given its applicability across a diverse range of applications, from industrial heat to heavy transportation to electricity generation.[178] Hydrogen can be produced in a variety of methods, and then stored, transported, and burned, leaving water as its only byproduct.[179] The hydrogen sector is rapidly evolving, with government incentives and regulations looking to boost production and demand, while companies test business models to achieve cost competitiveness at scale. Key technological challenges center on how to viably produce no- or low-carbon hydrogen at commercial scale, and on how to deliver it to end users.[180] Additional promising approaches for clean hydrogen include growing excitement around potentially unlimited subterranean hydrogen deposits that can be directly tapped into and replicating natural hydrogen-producing geologic processes by pumping water through iron-rich rock formations.[181]

The U.S. government is already organizing to put tremendous resources into scaling the production and use of no- or low-carbon emission hydrogen. DOE published its Pathway to Clean Hydrogen Commercial Liftoff report in March 2023 that outlines the significant remaining challenges in this sector and lays out a plan to address them with a series of cross-cutting programs.[182] As part of the effort, DOE is leading a bold and ambitious Hydrogen Earthshot with the goal of reducing the cost of clean hydrogen by 80% to $1 per one kilogram in one decade ("1 1 1").[183] The DOE Regional Clean Hydrogen Hubs program, funded through the Bipartisan Infrastructure Law, is putting $7 billion towards the creation of networks of hydrogen producers, consumers, and connected infrastructure.[184] The Treasury Department and IRS are finalizing guidance on the 45V Clean Hydrogen Production Tax Credit established in the IRA.[185]

Geothermal Energy

Geothermal energy harnesses the heat under the surface of the earth to produce electricity or heat for industrial purposes.[186] Today, the use of geothermal energy is limited to areas where geothermal resources are close to the earth's surface, such as parts of the western United States and Iceland.[187] However, the potential exists to access geothermal energy anywhere in the world through new technologies. To achieve cost-competitive energy generation, companies have to overcome technological, engineering, and business model challenges. Some of the most notable

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[12] Cissy Zhou, CATL Says Ford Project on Track Despite New U.S. Battery Rules, Nikkei Asia (2023). A key metric for evaluating these cases is whether the agreements result in meaningful transfer of know-how and technology access to the United States that contribute to positive follow-on effects in that sector.

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