



Mission Innovation

NATIONAL INNOVATION PATHWAY OF THE UNITED STATES

**WHITE HOUSE OFFICE OF SCIENCE AND TECHNOLOGY POLICY
UNITED STATES DEPARTMENT OF ENERGY
UNITED STATES DEPARTMENT OF STATE**

OCTOBER 2024

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When President Biden and Vice President Harris took office, they pledged to restore America’s climate leadership at home and abroad. Every day since, the Biden-Harris Administration has led and delivered on the most ambitious climate, conservation, clean energy, and environmental justice agenda in history, including securing the largest ever climate investment and unleashing a clean energy manufacturing boom that has attracted hundreds of billions of dollars in private sector investment; created hundreds of thousands of new clean energy jobs; and lowered energy costs for families while delivering cleaner air and water for communities across the country.

Across the world, communities are experiencing the devastating impacts of climate change. From record-high average temperatures and extreme heat to changing precipitation patterns and sea-level rise, climate impacts—including disasters made worse by climate change—are affecting every corner of society. The United States is taking bold action to tackle this crisis, and has set an ambitious goal to reduce net greenhouse gas (GHG) emissions by [50-52% from 2005 levels in 2030](#). Through the [Inflation Reduction Act \(IRA\) and Bipartisan Infrastructure Law \(BIL\)](#), President Biden and Vice President Harris have secured unprecedented investments in a clean power sector, launching a boom in solar, wind, battery storage, nuclear, and other clean energy technologies. While the United States continues to deploy these established technologies at scale, the Biden-Harris Administration is also committed to developing a robust clean technology innovation ecosystem for the future. This report focuses on the actions the United States is taking to maintain a pipeline of emerging technologies that are essential to reaching net-zero.

In publishing this updated report, the United States invites our fellow [Mission Innovation member countries](#) to further advance their own innovation efforts and to deepen international collaborations. Together we can catalyze research, development, and demonstration to make clean energy affordable, attractive, and accessible for all at scale, accelerating the progress needed to achieve the Paris Agreement goals and pathways to net zero.

Mission Innovation National Innovation Pathway – Report Overview

In 2023, the United States released the first Mission Innovation [National Innovation Pathway report](#) to highlight the Biden-Harris Administration’s ambitiously comprehensive approach to accelerating essential clean energy technology innovations. This report serves as an update to that document, highlighting the on-going and expanded investments, initiatives, and partnerships undertaken by the Administration to continue to drive towards achieving a [50-52% reduction in greenhouse gas emissions 2005 levels in 2030](#) and the Administration’s goal of a [100%carbon free](#) electricity grid by 2035.

In the collaborative spirit of Mission Innovation, the goals of this updated report are to:

1. Demonstrate continued U.S. commitment to clean energy technology development through federal investments, public-private partnerships, and government initiatives;
2. Facilitate exchange of knowledge in advancing clean energy innovation; and
3. Continue to build momentum and strengthen cooperation in decarbonizing key sectors and technologies to accelerate the net-zero transition.

In developing a comprehensive clean technology innovation pathway, it is important to consider innovation spanning the full spectrum of [Adoption Readiness Levels](#) of clean technologies: from basic research and development (R&D), to demonstration, deployment, and commercialization. This report

is therefore inclusive of U.S. actions across the full innovation life cycle. The United States approach to net-zero technology contains three key pillars:

1. **Invest in R&D** for a portfolio of game-changing innovations to ensure that there is an adequate suite of technologies to reliably, affordably, and equitably achieve net-zero emissions by 2050.
2. **Demonstrate** and support commercialization of emerging technologies.
3. **Accelerate manufacturing, deployment, and adoption** of technologies that are available today to facilitate economy wide decarbonization as quickly as possible

Despite the bold U.S. efforts in implementing the most ambitious climate, conservation, clean energy, and environmental justice agenda in history, the outcome of the 2023 [global stocktake](#) under the Paris Agreement makes clear that further innovation, demonstration, and deployment will be necessary to achieve our global net-zero ambitions. As members of [Mission Innovation](#), the United States is committed to championing clean energy solutions that will accelerate progress towards the Paris Agreement's goals by making clean energy affordable, attractive, and accessible to all.

This 2024 Mission Innovation Pathway updated report highlights the continued emergence and rapid expansion of the U.S. clean energy economy that is a result of the [IRA and BIL](#). For example, since the initial release the 2023 National Innovation Pathway report, the U.S. government has:

- Set new national goals for cost and/or deployment related to [freight decarbonization](#), [hydrogen](#), [industrial decarbonization](#), [carbon dioxide removal](#), [pipeline methane leak reduction](#), [building energy efficiency](#), and [offshore wind deployment](#);
- Released new or updated strategies for [fusion energy](#), [clean hydrogen](#), [zero-emissions freight corridors](#), [GHG measurement and monitoring](#), [building decarbonization](#), [offshore wind](#), and [grid modernization](#);
- [Appropriated additional funding](#) for key R&D across all sectors of the economy;
- Expanded its portfolio of clean energy R&D initiatives;
- [Partnered with the private sector](#) to expand clean technology manufacturing, bringing the total private sector investments to almost one trillion U.S. dollars from the beginning of the Biden-Harris Administration; and
- Launched new programs and initiatives to advance clean energy innovation as detailed in this report.

Across all of the Administration's investments in clean energy innovation, equity and community benefits are front and center. The Biden-Harris Administration strives for equitable investments via the [Justice40 Initiative](#), which aspires to have 40% of the overall benefits of certain federal climate, clean energy, affordable and sustainable housing, and other investments flow to disadvantaged communities that are marginalized by underinvestment and overburdened by pollution.

Through this report, the United States strives to continue to share information and best practices on successful policy levers that other countries can leverage to advance their innovation efforts and expand opportunities for international collaboration that can accelerate our collective drive towards achieving [the goals of the Paris Agreement](#). The report first describes innovation progress throughout the portfolio of clean energy technologies necessary to decarbonize across all economic sectors and then highlights the international partnerships that helps make these advancements possible.

United States Progress Advancing Net-Zero Technologies

To build cohesion across the federal clean energy innovation ecosystem, the White House convened an interagency [Climate Innovation Working Group](#) charged with gathering innovation priorities from federal agencies, identifying opportunities and needs for coordination, and developing a comprehensive innovation strategy to create options to reduce all emissions across the economy. One output of the working group was the [2022 report on U.S. Innovation to Meet 2050 Climate Goals](#). The report identified 37 “net-zero gamechangers” which represent a diverse portfolio of solutions which could provide options for eliminating most, if not all, emissions across the U.S. economy (Figure 1). Detailed innovation advancements across these pathways are highlighted in Table 4 of the appendix.

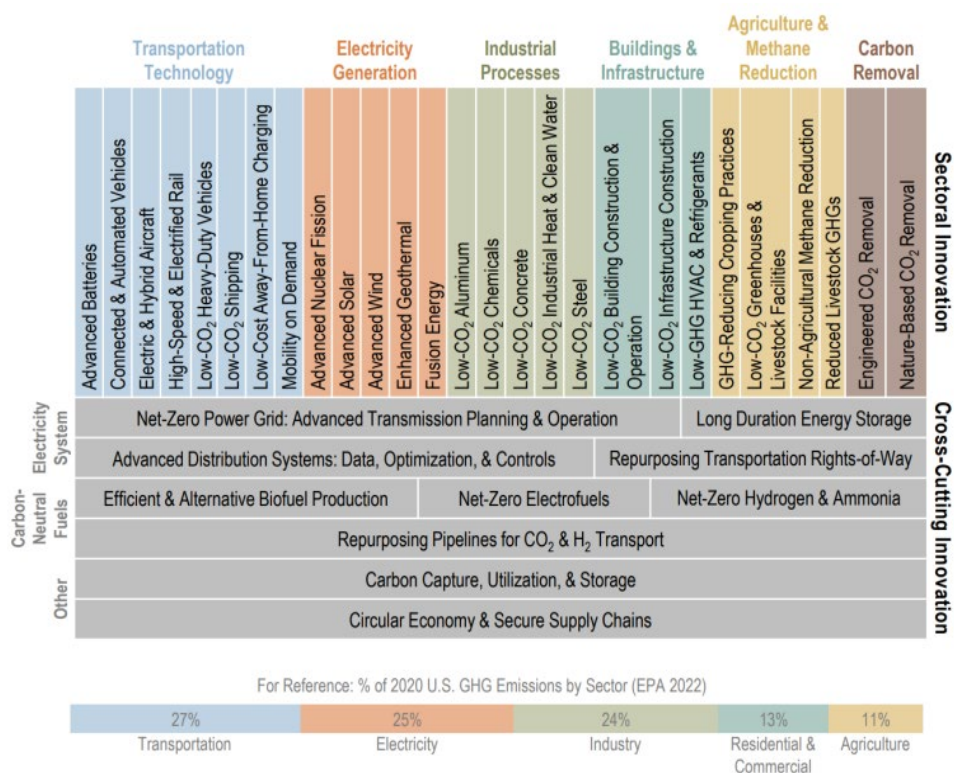


Figure 1: Portfolio of 37 Net-Zero Game Changers identified from Across the U.S. Interagency ([source](#))

The portfolio of net-zero game changers is a helpful framework for tracking innovation activities, investments, and progress in clean energy technologies across the U.S. government. Detailed information about deployment targets, innovation priorities, R&D funding, demonstration projects, and government reports and strategies for these technologies can be found in Appendix Tables 3 and 4. The following are examples of new milestones in the game changer technology areas since the previous report was published in 2023. These do not include game changer technologies that have already been widely commercially deployed, such as advanced solar and wind. These advancements are the result of collaborations and partnerships across the U.S. innovation ecosystem, which includes federal agencies, academia, private companies, and non-profit and non-governmental organizations (see Appendix Table 2 for more detailed information on stakeholders across the U.S. innovation ecosystem):

- **Advanced Batteries:** An additional \$450 million was appropriated for the Vehicle Technologies Office in Fiscal Year 2024 (FY 24), including funding for batteries and charging. Furthermore, the Department of Energy (DOE) has awarded [\\$1.82 billion to 14 projects](#) that will build and expand commercial-scale facilities to extract lithium, graphite, and other battery materials, manufacture components, and demonstrate new approaches, including manufacturing components from recycled materials. DOE also [awarded a second round of \\$3 billion](#) to build or expand manufacturing of advanced batteries.
- **Advanced Grid Technologies:** An additional \$280 million in funding was appropriated in FY24 for DOE's Office of Electricity and \$60 million in funding was appropriated for DOE Grid Deployment Office. DOE released its updated [Grid Modernization Strategy](#) and has selected or announced about [\\$5.7 billion](#) (across [65 projects](#)) under the BIL funded Grid Resilience and Innovation Partnerships (GRIP) Program. Additionally, DOE released its updated [Grid Modernization Strategy](#) and [Pathways to Commercial Liftoff: Innovative Grid Deployment report](#).
- **Advanced Nuclear:** DOE received an additional \$1.7 billion for the Office of Nuclear Energy, as well as \$2.7 billion for enriched uranium, \$900 million for Generation 3+ SMRs, and \$100 million to implement a new nuclear safety training program. DOE published an updated [Pathways to Commercial Liftoff: Advanced Nuclear report](#). DOE is supporting advanced reactor [demonstration projects](#) in Texas and Wyoming and plans to fund up to two small modular reactor [demonstrations](#). A High-Assay Low-Enrichment Uranium (HALEU) demonstration project also has [begun enrichment operations](#). Finally, President Biden signed the [ADVANCE Act](#) into law, which will streamline licensing for new nuclear technology.
- **Carbon Capture, Utilization, and Storage:** DOE received an additional \$428 million in funding for carbon management technologies. DOE has [selected projects](#) in California, North Dakota, and Texas (up to \$890 million) to demonstrate carbon capture at power plants and has made announcements and selections for projects across the CCUS life cycle, from [carbon capture demonstrations](#) to [carbon storage validation and testing](#) to [carbon transport](#). Additionally, DOE released a new [Pathways to Commercial Liftoff: Carbon Management report](#).
- **Carbon Dioxide Removal (CDR):** DOE initiated a new Energy Earthshots [Carbon Negative Shot Goal](#) to enable the removal of carbon dioxide from the atmosphere and durable storage at meaningful scales for less than \$100 per net metric ton of carbon dioxide equivalent emissions within a decade. DOE has announced [DAC demonstrations](#) in Louisiana and Texas (up to \$1.2 billion) and plans to award up to \$100 million for [pilot projects](#) under the [Carbon Negative Shot](#). Additionally, the federal government published two reports to support the commercialization of CDR, [Roads to Removal Report on U.S. CDR Capacity](#) and [Voluntary Carbon Markets Joint Policy Statement and Principles](#), and established a [Marine Carbon Dioxide Removal](#) Fast Track Action Committee.
- **Clean Shipping Fuels and Vessels:** DOE received \$895 million in FY24 for sustainable transportation and fuels RD&D. DOE signed a [Memorandum of Understanding](#) with the American Bureau of Shipping for information sharing and collaborative research for maritime decarbonization and [adopted a 2030 target](#) of 600 ships to use these zero-emission fuels across main deep sea shipping routes; 16 million tons of zero-emission fuel production; 20 large trade ports offering zero-emission bunkering. Additionally, several U.S. agencies are developing a [Maritime Decarbonization Action Plan](#) for release in 2024.

- **Enhanced Geothermal Systems:** DOE received \$118 million in FY24 for the Geothermal Technologies Office. All geothermal demonstration funding under the BIL has been announced; DOE-funded Frontier Observatory for Research in Geothermal Energy project has [successfully](#) stimulated demonstration wells, a major technological breakthrough. The Bureau of Land Management also adopted a [new categorical exclusion](#) to expedite geothermal permitting. DOE has [selected](#) demonstration projects in California, Texas, and Washington (up to \$60 million) and has [announced](#) another \$14 million for projects in the Eastern U.S. and published two reports to promote innovation and commercialization in enhanced geothermal systems: [Geothermal Technologies Office Program Plan and Next Generation Geothermal Commercial Liftoff](#).
- **Fusion Energy:** DOE received \$790 million in FY24 for Fusion Energy Sciences. DOE released a [new vision](#) for its Fusion Energy Sciences Office to support development of a competitive fusion power industry, an agency-wide [Fusion Energy Strategy](#) to complement [the U.S. International Fusion Strategy](#) released at COP28 last year. Additionally, DOE awarded [\\$46 million](#) to eight companies to pursue applied R&D toward fusion pilot plants as part of the Milestone-Based Fusion Development Program and published [Fusion Energy Sciences Vision and a DOE Fusion Energy Strategy](#).
- **Hydrogen:** DOE announced a new [Energy Earthshots Hydrogen Shot Goal](#) of reducing the cost of clean hydrogen by 80% to \$1 per 1 kilogram by 2031. Additionally, the United States announced a new [National Clean Hydrogen Strategy](#) which aims to catalyze R&D in electrolysis, thermal conversion, and new production pathways. Furthermore, the White House and 10 agencies released a new [Hydrogen Strategy and Roadmap](#); DOE selected [seven clean hydrogen hubs](#) across 16 states (\$7 billion) to demonstrate H₂ production, storage, delivery, and end-use, and published two reports relating to hydrogen innovation and commercialization: [Pathways to Commercial Liftoff - Clean Hydrogen](#) and [Hydrogen Shot Technology Assessment: Thermal Conversion Approaches](#).
- **Industrial Decarbonization:** DOE received \$452 million for industrial decarbonization, efficiency, and advanced manufacturing in FY24. DOE launched a new Energy Earthshot on [Clean Fuels & Products](#) with the goal of developing cost competitive clean fuels and products with at least 85% lower GHG emission by 2035. DOE selected [33 demonstration projects across 20 states](#) (up to \$6 billion) for decarbonizing chemicals and refining, cement and concrete, iron and steel, aluminum, food and beverage, glass, pulp and paper, and process heat. Furthermore, DOE published a series of liftoff reports assessing commercialization strategies for [industrial decarbonization](#), [chemicals & refining](#), and [low-carbon cement](#).
- **Long Duration Energy Storage:** DOE received \$92.5 million for energy storage RD&D. DOE has selected [15 projects across 17 states and 1 tribal nation](#) (up to \$325 million) for long-duration energy storage demonstrations and has issued a [notice of funding opportunity](#) for up to \$100 million more for non-lithium pilot projects. Furthermore, the federal government published several reports to promote innovation in long duration energy storage, including the [Energy Storage Grand Challenge Roadmap](#), [the Long Duration Energy Storage - Pathways to Commercial Liftoff](#), and [the Long Duration Storage Shot Technology Strategy Assessments](#).

- **Clean Heavy-Duty Vehicles (HDV):** DOE received \$895 million for sustainable transportation and fuels RD&D. The United States announced a new national goal of 30% zero-emission HDV sales by 2030 and 100% zero-emissions HDV sales by 2040, as well as an [EV charging station goal](#) of 500,000 EV charging ports by 2030. Furthermore, the U.S. government released a new [National Zero-Emission Freight Corridor Strategy](#). Additionally, the Biden-Harris Administration announced a new [national goal](#) to transition to a zero-emissions freight sector for truck, rail, aviation, and marine, along with a new national zero-emissions freight strategy.
- **Methane Reduction:** DOE received \$55 million for methane mitigation technologies in FY24. The United States announced a new [Pipeline Goal](#) to repair or replace 1,000 miles of leak-prone gas pipelines by 2036. Furthermore, the White House launched a [Cabinet-level Methane Task Force](#); federal agencies have collectively announced [hundreds of millions of additional dollars](#) for methane measurement and mitigation RD&D in across sectors; and the White House released a new [National Strategy to Advance an Integrated U.S. GHG Measurement, Monitoring, and Information System](#). The Environmental Protection Agency also launched a methane [Super-Emitters Program](#) and released a [final rule](#) to expand and update methane emissions reporting requirements for petroleum and natural gas systems under the IRA's [Methane Emissions Reduction Program](#).
- **Net-Zero Buildings:** DOE received an additional \$332 million of FY24 appropriations for the Building Technologies Office. DOE also initiated a new [Energy Earthshots Affordable Home Energy Shot Goal](#) to reduce the cost to decarbonize affordable housing by 50% while reducing energy bills by 20% by 2035, as well as [National Blueprint Goals](#) to reduce on-site energy intensity 35% by 2035 and 50% by 2050; reduce on-site GHG emissions 25% by 2035 and 75% by 2050; triple demand flexibility potential by 2050; and reduce embodied emissions from materials and construction 90% by 2050. Additionally, DOE supported a variety of low-carbon building demonstrations across the country through its [Advanced Building Construction Initiative](#).
- **Offshore Wind:** DOE received an additional \$137 million for FY24 for its Wind Energy Technologies Office. Federal agencies have invested over [\\$950 million](#) for floating offshore wind technologies since 2022. The United States also established a new goal of 15 gigawatts of floating offshore wind deployment by 2035 and DOE released a new [offshore wind strategy](#). DOE also released two reports to promote offshore wind innovation: [Pathways to Commercial Liffoff: Offshore Wind](#) and [Floating Offshore Wind Shot Progress and Priorities Report](#).
- **Sustainable Aviation Fuels (SAF):** DOE received an additional \$275 million of funding in FY24 for its Bioenergy Technologies Office and DOT received \$71 million for Federal Aviation Administration (FAA) for clean aircraft technologies and fuels. The White House also announced a new [national goal](#) to transition to a zero-emissions freight sector for truck, rail, aviation, and marine, and new national zero-emissions freight strategy. Additionally, DOE launched a new [Earthshots Clean Fuels and Products](#) goal to develop cost-competitive sources with at least 85% lower GHG emissions by 2035, and published a [SAF roadmap](#).

International Collaboration Driving Clean Energy Innovation

The U.S. government engages in numerous international science and technology collaborations that are accelerating innovation and driving down the costs of clean energy technologies to make them affordable and accessible. DOE holds strategic energy dialogues with allies and partners to set out

collaboration priorities that are implemented through working groups and other mechanisms. For example, it carries out bilateral engagements such as the [U.S.-Brazil Energy Forum \(USBEF\)](#), the [U.S.-Israel Binational Industrial Research and Development \(BIRD\) Energy program](#), and the [U.S.-India Strategic Clean Energy Partnership \(SCEP\)](#). Under the USBEF, the United States and Brazil adopted the [2023-2024 Action Plan](#), which calls for increased cooperation on renewable energy and energy efficiency, particularly in strategic sectors such as clean hydrogen, offshore wind, sustainable fuels, and grid modernization and storage, among other themes. In 2023, the BIRD Energy Executive Committee approved nine clean energy projects, to [receive \\$9.75 million](#) in funding on selected projects such as agrivolataics, battery technology, carbon dioxide reduction, energy efficiency, solar energy, and energy storage. This program supports research and development by focusing on commercializing clean energy technologies for climate action. Under the SCEP, the U.S. and India have launched a [New and Emerging Renewable Energy Technologies Action Platform](#) to accelerate the development of key technologies to advance common ambitious clean energy goals.

The U.S. Government also engages in multiple multilateral fora, including leadership positions in [Mission Innovation \(MI\)](#) and the [Clean Energy Ministerial \(CEM\)](#). In Mission Innovation, DOE chairs the Steering Committee (2022 - 2024) and has a senior representative on the Steering Committee. Further, DOE co-leads three of the research Missions—Clean Hydrogen, Zero-Emission Shipping, and Carbon Dioxide Removal, and participates in the Net-Zero Industries Mission. Under Mission Innovation, the United States conducted a [US-Korea green shipping corridor feasibility study](#) in support of developing 1-3 corridors, launched the [Carbon Dioxide Removal Mission's](#) first sprint, the [CDR Launchpad](#), to encourage information sharing on large-scale demonstration and pilot projects, and announced a [\\$7 billion contribution](#) to the [goal of delivering 100 hydrogen hubs globally](#) by 2030. The U.S. government is also in a leadership position in CEM as a co-chair and leads or participates in numerous workstreams under CEM. The United States has additionally engaged in international efforts that aim to keep 1.5 degrees Celsius in reach, including the [Declaration to Triple Nuclear Energy](#), the [Global Renewables and Energy Efficiency Pledge](#), [Agricultural Innovation Mission for Climate](#), and the [Carbon Management Challenge](#), among others. These efforts recognize the need to enhance and scale new technological solutions, including through support in research, development and innovation. Additionally, the United States plays a leading role in multilateral cooperation on technology and innovation through the United Nations Framework Convention and Paris Agreement, particularly the [Technology Mechanism](#) comprised of the [Technology Executive Committee](#) and the [Climate Technology Center and Network](#).

The U.S. government is also utilizing international collaboration on the [Energy Earthshots](#) to develop innovative clean energy solutions, drive down the costs of technologies that are necessary for deep decarbonization, and support the development of clean energy markets globally. Japan joined as the first international collaborator announcing their intent to meet the global ambition in line with the U.S. Floating Offshore Wind Shot ([U.S.-Japan Joint Leaders Statement](#)).

The United States is additionally accelerating public finance in line with its net zero emission goals. The [Clean Energy Technologies Demonstration Challenge](#) is an international effort to raise at least \$90 billion in public funding globally by 2026 to build commercial-scale demonstration projects that the International Energy Agency reports are needed to achieve net-zero emissions by 2030. This goal was exceeded by \$4 billion, four years early, at the [2021 Global Clean Energy Action Forum](#). The United States, through DOE's Office of Clean Energy Demonstrations, is mobilizing over \$25 billion in commercial-scale clean energy projects as part of this goal. These public investments are leveraging orders of magnitude more private investments in projects to advance innovative technologies already

in demand by the world's largest companies through efforts such as [the First Movers Coalition](#). Together, the new supply being created through the demonstration challenge can be matched with aggregated demand from the private sector for some of the highest emitting technologies, helping to create a market for emerging clean energy technologies.

Appendix

The tables in the appendix provide non-exhaustive but comprehensive detailed information relevant to framing the U.S. clean technology innovation efforts. Table 1 describes the core legislative components of the U.S. climate policy; Table 2 describes stakeholders across the U.S. innovation ecosystem; Table 3 highlights the roadmaps and action plans to accelerate innovation published by the U.S. Federal government; and finally, table 4 provides more detailed insights into the net-zero game changer innovation progress described in the report body.

Table 1. U.S. Congressional Legislation Relevant to U.S. Climate Policy and Clean Energy Innovation, non-exhaustive (January 2021-October 2024)

Document/Policy	Description	Outcomes, Goals, or Targets	Year	Links
Bipartisan Infrastructure Law (BIL) of 2021	Wide-ranging bipartisan legislation providing investments in infrastructure, workers, families, and competitiveness, including \$62 billion ¹ for DOE.	DOE investments include \$21.5 billion ² in funding for clean energy demonstration and research hubs, as well as investments in key clean energy supply chains and manufacturing capabilities.	2021	Legislation Text White House Fact Sheet DOE Fact Sheet
Inflation Reduction Act (IRA) of 2022	Recent energy and healthcare legislation that includes a historic \$370 billion investment in the modernization of the U.S. energy system.	Will help drive 2030 economy-wide GHG emissions to 40% below 2005 levels, in support of 2030 target of 50-52% reduction. Will lower cost for U.S. consumers, enhance U.S. energy security, improve human health, mitigate climate change, create high-quality jobs and new economic opportunities for workers, and address historical inequities in our energy system.	2022	Legislation Text Congressional Summary DOE Inflation Reduction Act Fact Sheet
CHIPS and Science Act of 2022	Recent bipartisan legislation to strengthen American industry, supply chains, and research infrastructure.	Authorizes \$170 billion ³ for Federal research and innovation to bolster U.S. leadership in R&D and manufacturing capabilities for an emerging 21 st century technologies (including nanotechnology, clean energy, quantum computing, and artificial intelligence), create regional innovation hubs and STEM job opportunities throughout the country, and drive equity in the U.S. innovation ecosystem.	2022	Legislation Text Executive Order 14080 on Implementation Congressional Fact Sheets White House Fact Sheet
Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act	Legislation that strengthens the United States civilian nuclear energy sector and accelerates the deployment of nuclear technologies.	Directs the U.S. Nuclear Regulatory Commission (NRC) to reduce certain licensing application fees and authorizes increased staffing for NRC reviews to expedite the process; provides federal funding to cover licensing and other relevant costs for the first advanced nuclear power operator to successfully deploy its technology.	2024	Legislation Text White House Statement

¹ U.S. Department of Energy (2022). DOE Fact Sheet: The Bipartisan Infrastructure Deal Will Deliver For American Workers, Families and Usher in the Clean Energy Future. See [here](#).

² U.S. Department of Energy (2022). DOE Fact Sheet: The Bipartisan Infrastructure Deal Will Deliver For American Workers, Families and Usher in the Clean Energy Future. See [here](#).

³ U.S. House of Representatives (2022). The CHIPS and Science Act Fact Sheet. https://science.house.gov/imo/media/doc/chips_and_science_act_leadership_fact_sheet.pdf.

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Table 2: U.S. Federal Government Clean Energy Innovation Agencies and Institutions (Non-exhaustive)

Institution Name	Description of Role	Relevant Innovation Priorities from Table 4	Description of Funding Modalities	Links
U.S. Department of Energy (DOE)	DOE supports research from early stage to commercialization across a wide set of Innovation priorities, as well as other crosscutting topics that critically contribute to these innovations, including Critical Minerals and Materials, Artificial Intelligence, Biotechnology and Biomanufacturing, Quantum, Microelectronics, and Energy-Water. This work is supported through a set of basic and applied research programs, the Loan Program Office, and ARPA-E (see below).	Batteries, Nuclear, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels, Grid.	DOE performs Federal RD&D through a system of national laboratories and also provides grants, contracts, and loans across the development cycle to universities, research institutions, businesses, and state, local, and Tribal governments throughout the country.	DOE
DOE National Laboratories	DOE supports its 17 National Laboratories to perform research to develop low carbon technologies and provide access to cutting edge research user facilities. DOE National Laboratories also engage in collaborative research with outside parties and perform research for other Federal agencies, states, and to a limited degree, the private sector.	Batteries, Nuclear, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels, Grid.	The National Laboratories receive grants and contracts from Federal and state agencies, and to a limited degree from the private sector and philanthropic community.	National Laboratories
DOE Advanced Research Projects Agency–Energy (ARPA-E)	Agency advancing high-potential high-impact energy technologies that are too early for private-sector investment through funding, technical assistance, and market readiness.	Batteries, Nuclear, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels, Grid; Also supports Critical Minerals and Materials.	ARPA-E has provided over \$3 billion in R&D funding for more than 1,300 potentially transformational energy technology projects. 190 teams have together raised more than \$10 billion in private-sector follow-on funding, and as of April 2022, ARPA-E has had 25 exits with a total reported value of \$21.6 billion.	ARPA-E

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U.S. Department of Agriculture (USDA)	USDA performs RD&D on agricultural practices, conservation, bio-based products and energy primarily through its Agricultural Research Service, National Institute of Food and Agriculture, and Forest Service. USDA also performs technoeconomic research on renewable energy, bio-based products, and climate-smart agricultural commodities.	Carbon Removal, Methane Reduction, Sustainable Aviation Fuels.	USDA performs Federal RD&D through a system of Federal laboratories and also provides grants and contracts for research across the development cycle to universities, research institutions, and businesses throughout the country.	ARS Forest Service NIFA
U.S. Department of Transportation (DOT)	DOT performs R&D on advanced transportation safety approaches and technologies, connectivity-enabled Intelligent Transportation Systems, and innovative infrastructure materials and construction and maintenance processes. DOT's newly created Advanced Research Projects Agency-Infrastructure (ARPA-I) will fund high-risk, high-reward next-generation transportation and infrastructure technologies.	Batteries, Buildings and Industry (low-carbon materials), CCUS (carbon transport), HDVs, Shipping, Sustainable Aviation Fuels.	DOT provides grants, contracts and cooperative agreement to universities, national laboratories, and companies, to support R&D and functional testing. In addition, DOT has several Federal laboratories that also perform research and testing.	DOT ARPA-I

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U.S. Environmental Protection Agency (EPA)	EPA is developing rulemakings to address GHGs from the transportation, oil and natural gas, and power sectors. This includes, for example, facilitating the transition to next-generation technologies that do not rely on HFCs, and speeding the transition of the light-duty vehicle fleet toward a zero-emissions future. EPA Research Centers and Programs also perform research on environmental, human health, and justice impacts of clean energy transitions, and is performing RD&D on carbon removal in near-shore marine environments and methods for measuring and mitigating methane emissions.	Methane Reduction, Carbon Removal, Batteries, CCUS, HDVs, Buildings (HFC phase-out), Sustainable Aviation Fuels.	EPA provides grants and contracts to universities, national laboratories, and companies, to support RDD&D. In addition, EPA has a number of Research Centers and Programs that also perform research.	EPA
U.S. Department of Defense (DoD)	DoD is the single largest energy consumer in the United States, with petroleum-based fuels by far the dominant source. DoD contributes to development of next-generation energy technologies, including the following focus areas: reduced dependence on fossil fuels, smart and secure energy management, increased building efficiency, distributed generation, and increased sustainability of its weapons system and vehicle manufacturing, maintenance, and operation.	Nuclear, Buildings, HDVs, Sustainable Aviation Fuels, Batteries.	DoD performs Federal research, development, and demonstration and provides grants and contracts across the development cycle to universities, research institutions, and businesses throughout the country. DOD has a number of regional federal laboratories that also perform research.	SERDP/ESTCP OECIF

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U.S. Department of Commerce	<p>The Department of Commerce houses the National Institute of Standards and Technology (NIST) —which performs research on advanced manufacturing, advanced transportation, advanced material, cyber-physical infrastructure, and GHG emission measurements, among other things.</p> <p>It also houses the National Oceanic and Atmospheric Administration (NOAA), which performs R&D on measurement, monitoring, and modelling of the ocean, atmosphere, and coastal resources.</p>	<p>NIST: Batteries, Nuclear, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.</p> <p>NOAA: Solar, Offshore Wind, Carbon Removal, CCUS, Shipping, Methane Reduction.</p>	<p>The Department of Commerce performs Federal RD&D through a system of Federal laboratories and also provides grants and contracts for research across the development cycle to universities, research institutions, and businesses throughout the country.</p>	<p>NIST NOAA</p>
National Science Foundation (NSF)	<p>NSF supports fundamental scientific research that advances our understanding of climate change and underpins many of the developments needed in all of these climate and energy technologies. Additionally, NSF’s newly created Directorate for Technology, Innovation, and Partnerships works across NSF’s research areas to advance technology translation and development.</p>	<p>Batteries, CCUS, Carbon Removal, Shipping, Geothermal, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels, Grid.</p>	<p>NSF supports science and engineering research projects, facilities, and STEM education. NSF funds research in all states and U.S. territories - reaching 2,000 academic and other private and public institutions. NSF also supports innovation by small businesses, partnerships among academia, industry, and national laboratories, and research in non-profit non-academic organizations.</p>	<p>NSF</p>

Table 3. U.S. Government Roadmaps and Action Plans to Advance Clean Energy Technology, non-exhaustive (January 2021-October 2024)

Document/Policy	Description	Outcomes, Goals, or Targets	Year	Links
DOE Energy Earthshots	DOE initiative aiming to accelerate breakthroughs of more abundant, affordable and reliable clean energy solutions within the decade.	(1) <u>Hydrogen Shot</u> – Reduce the cost of clean H ₂ by 80% to \$1 per 1 kilogram; (2) <u>Long Duration Storage Shot</u> – Reduce costs by 90% in storage systems that deliver 10+ hours of duration; (3) <u>Carbon Negative Shot</u> – Develop CO ₂ removal pathways that will capture atmospheric CO ₂ and durably store it at gigaton scales for <\$100/net metric ton of CO ₂ equivalent; (4) <u>Enhanced Geothermal Shot</u> – reduce the cost to \$45/MWh by 2035; (5) <u>Floating Offshore Wind Shot</u> : reduce the cost by >70% to \$45/MWh in deep waters by 2035; (6) <u>Industrial Heat Shot</u> – Develop cost-competitive technologies with at least 85% lower GHG emissions by 2035; (7) <u>DOE Clean Fuels & Products Shot Goal</u> : Develop cost-competitive carbon sources with at least 85% lower GHG emissions by 2035, as well as meet 2050 projected demand for 100% of aviation fuel; 50% of maritime, rail, and off-road fuel; and 50% of carbon-based chemicals; (8) Affordable Home Energy Shot Goal: Reduce the cost to decarbonize affordable housing by 50% while reducing energy bills by 20% by 2035.	2021 – present	DOE Energy Earthshot Initiative Information
U.S. Methane Reduction Action Plan	Biden-Harris Administration whole-of-government action plan to reduce methane emissions from oil and gas, landfills, and agriculture	Outlines a combination of regulations, incentives, actionable data, and partnerships that is needed to reduce methane emissions by 30% below 2020 levels by 2030, per the Global Methane Pledge.	2021	Full Report
America’s Strategy to Secure the Supply Chain for a Robust Clean Energy Transition	Whole-of-government plan to secure U.S. supply chains that are critical to the energy transition, prepared by DOE in response to Executive Order 14017 on America’s Supply Chains.	Outlines a U.S. plan to build a secure energy sector industrial base, through both a comprehensive strategy report and 13 deep-dive assessments on specific technologies and crosscutting topics.	2022	Executive Order 14017 Full Report and Assessments
U.S. Innovation to Meet 2050 Climate Goals: Assessing R&D Initial Opportunities	First step in developing a whole-of-government strategy for early-stage net-zero innovation.	Identifies opportunities for net-zero game-changing technologies that could play a major role in meeting our climate targets, but require innovation to bring them to market; Assesses the potential impacts of each opportunity in terms of climate, environment, equity, economy, and security; Prioritizes 5 initial net-zero technologies for enhanced interagency coordination.	2022	Full Report

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Document/Policy	Description	Outcomes, Goals, or Targets	Year	Links
U.S. Industrial Decarbonization Roadmap	DOE report to Congress providing RDD&D priorities for U.S. industrial sector decarbonization, covering both cross-cutting and subsector-specific technologies in iron and steel, chemicals, food and beverage, petroleum refining, and cement.	Cross-cutting and subsector-specific decarbonization pathways and RDD&D priorities across: (a) energy efficiency; (b) electrification; (c) low-carbon fuels, feedstocks, and energy sources; and (d) carbon capture, utilization and storage (CCUS).	2022	Full Report Fact Sheet
SAF Grand Challenge Roadmap	Comprehensive strategy for scaling up new technologies to produce SAF on a commercial scale.	Primary objectives include: (1) Expanding SAF supply and end use; (2) Reducing the cost of SAF; (3) Enhancing the sustainability of SAF.	2022	Full Report
DOE Strategy to Advance Offshore Wind Energy in the United States	Comprehensive summary of DOE's role in the nationwide effort to deploy 30 GW of offshore wind energy by 2030 and setting the nation on a pathway to 110 GW or more by 2050.	Primary objectives include: (1) Reduce wind energy costs; (2) Support optimized siting and regulation; (3) Invest in supply chain development; (4) Address grid integration challenges.	2023	Full Report
U.S. National Clean Hydrogen Strategy and Roadmap	Comprehensive national framework for facilitating large-scale production, processing, delivery, storage, and use of clean hydrogen to help meet decarbonization goals across virtually all sectors of the economy.	Primary objectives include: (1) Target strategic, high-impact end uses; (2) Reduce the cost of clean hydrogen; (3) Focus on regional networks.	2023	Full Report
U.S. Transportation Decarbonization Blueprint	Biden-Harris Administration report identifying the pathways to 2050 decarbonization, prepared by DOE, DOT, EPA, and HUD.	Outlines a whole-of-government approach to transportation decarbonization.	2023	Full Report Fact Sheet
National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System	Strategy by Greenhouse Gas Monitoring and Measurement Interagency Working Group that provides a vision, framework, objectives, and near-term focus areas guiding collective efforts to enhance information on GHG emissions and removals.	Provides a conceptual framework for establishing a U.S. integrated GHG Measurement Monitoring, and Information System; implements a set of national objectives to focus collective GHG measurement and monitoring efforts; and a phased implementation approach to support short-term climate mitigation actions and long-term policies.	2023	Full Report

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Document/Policy	Description	Outcomes, Goals, or Targets	Year	Links
Decarbonizing the U.S. Economy by 2050: A National Blueprint for the Buildings Sector	Biden-Harris Administration comprehensive plan to reduce GHG emissions from buildings by 65% by 2035 and 90% by 2050.	Primary objectives include: (1) Increasing building energy efficiency; (2) Accelerating onsite emissions reductions; (3) Transforming the interactions between buildings and the electricity grid; (4) Minimizing the emissions from producing, transporting, installing, and disposing of building materials.	2024	Full Report
DOE Fusion Energy Strategy & Building Bridges: A Vision for the Office of Fusion Energy Sciences	Strategy to accelerate the viability of commercial fusion energy in partnership with the private sector. Vision to establish the steps needed to help advance fusion energy.	Primary objectives include: (1) Resolving the scientific and technological gaps to a fusion pilot plant; (2) Paving the way for Commercial fusion deployment; (3) Cultivating and expanding partnerships Vision: (1) Workforce development and sustainment; (2) Bridging gaps in R&D and supply chains; (3) Transformational scientific innovation.	2024	DOE Fusion Energy Strategy & Vision for the Office of Fusion Energy Sciences
National Zero-Emission Freight Corridor Strategy	Strategy to prioritize investments, planning, and deployment for medium- and heavy-duty vehicle fueling infrastructure to advance zero-emission freight along our nation’s corridors.	Identify viable pathways and implementation actions that promote at least 30% of medium- and heavy-duty vehicle sales are ZEVs by 2030, with a goal of 100% by 2040.	2024	Full Report
DOE Grid Modernization Strategy 2024	DOE Grid Modernization Initiative’s updated strategy to ensure a resilient, reliable, secure, affordable, flexible, environmentally sustainable, and equitable grid.	Integrate all sources of electricity, improve the security of our Nation’s grid, solve challenges of energy storage and distributed generation, and provide a critical platform for U.S. competitiveness and innovation in a global energy economy.	2024	Full Report
DOE Pathways to Commercial Liftoff	The Pathways to Commercial Liftoff report series provides public and private sector capital allocators with a perspective on how and when various technologies could reach full-scale commercial adoption.	These reports, which are “living documents”, provide a common analytical fact base and critical signposts for investment decisions on: <ul style="list-style-type: none"> • Advanced Nuclear: Report and Webinar • Carbon Management: Report and Webinar • Clean Hydrogen: Report and Webinar • Industrial Decarbonization: Report and Webinar • Innovative Grid Deployment: Report and Webinar (sneak peak) • Long Duration Energy Storage: Report and Webinar • Next-Generation Geothermal Power: Report and Webinar • Offshore Wind: Report • Virtual Power Plants: Report and Webinar 	2024	All Reports

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Table 4. Targets, Strategies, Investments, and Progress in Innovation for a representative subset of the Net-Zero Game Changers, non-exhaustive (January 2021-October 2024)

This table contains a non-exhaustive synthesis of milestones representing U.S. government activities, investments, and strategies towards progress in clean technology innovation. This was compiled through a review of Federal announcements and public facing communications around research, development, and demonstration of net-zero game changer technologies. It is not inclusive of all Federal innovation activities and milestones, especially efforts that cut across multiple categories of clean energy technologies.

Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Advanced Batteries	<p>DOE EV Battery Goals: Reduce cost of EV batteries to <\$100/kWh; increase range of EVs to 300 miles; decrease charge time to 15 minutes or less</p> <p>National Battery Supply Chain Goal: By 2030, establish a secure materials and technology supply chain.</p>	<p>Alternative concepts that reduce critical materials such as cobalt and nickel; New electrode and electrolyte materials for Li-ion batteries; solid state batteries; novel manufacturing methods; battery recycling.</p>	<p>DOE FY24 Funding: \$450 million⁴ for the Vehicle Technologies Office, including funding for batteries and charging.</p> <p>BIL Funding (FY22-26): \$325 million^{5,6} for battery and critical mineral recycling; \$6 billion⁷ for material processing and manufacturing</p>	<p>So far, DOE has awarded \$1.82 billion to 14 projects that will build and expand commercial-scale facilities to extract lithium, graphite, and other battery materials, manufacture components, and demonstrate new approaches, including manufacturing components from recycled materials.</p>	<p>National Blueprint for Lithium Batteries</p>	<p>DOE awarded a second round of \$3 billion to build/expand manufacturing and demonstrate new approaches</p>
Advanced Grid Technologies		<p>System modeling and planning, control systems, devices, components, and materials for grid modernization and expansion.</p>	<p>DOE FY24 Funding: \$280 million⁸ for the Office of Electricity; \$60 million⁹ for the Grid Deployment Office.</p> <p>BIL Funding (FY22-26): \$10.5 billion¹⁰ for the Grid Resilience and Innovation Partnerships (GRIP) Program.</p>	<p>So far, DOE has selected 65 projects (up to \$5.7 billion) for innovative grid demonstrations under the GRIP program.</p>	<p>Grid Modernization Strategy</p> <p>Pathways to Commercial Liftoff: Innovative Grid Deployment</p>	<p>DOE released its updated Grid Modernization Strategy; DOE has selected or announced about \$5.7 billion under the GRIP program so far</p>

⁴ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Vehicle Technologies Office. Pg. 1. See [here](#).

⁵ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 154. See [here](#).

⁶ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 197. See [here](#).

⁷ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 162. See [here](#).

⁸ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Total, Electricity. Pg. 1. See [here](#).

⁹ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Total, Grid Deployment Office. Pg. 4. See [here](#).

¹⁰ U.S. Department of Energy. Grid Resilience and Innovation Partnerships (GRIP) Program, Using Program Information. See [here](#).

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Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Advanced Nuclear	DOE Nuclear Strategic Vision : Two demonstrations in mid-2020s under the Advanced Reactor Demonstration Program; demonstration of a microreactor and capabilities for advanced fuel.	Small modular reactors, including light-water-cooled; non-light-water-cooled (e.g., molten salt or gas); microreactors; advanced fuel (e.g., high-assay low-enriched uranium - HALEU).	DOE FY24 Funding: \$1.7 billion ¹¹ for the Office of Nuclear Energy. IRA Funding (FY22-27): \$367 million ¹² for national laboratories; \$700 million ¹³ to develop/secure HALEU supply BIL Funding: \$2.5 billion ¹⁴ for Advanced Reactor Demonstration Program (FY22 until expended) ; \$2.72 billion for enriched uranium ¹⁵ (FY24-25), \$900 million for Generation 3+ SMR, and \$100 million to implement a new nuclear safety training program ¹⁶ (FY24-26)	DOE is supporting advanced reactor demonstration projects in Texas and Wyoming and plans to fund up to two small modular reactor demonstrations . High-Assay Low-Enrichment Uranium (HALEU) demonstration project began enrichment operations	DOE Nuclear Energy Strategic Vision Pathways to Commercial Liftoff: Advanced Nuclear	One advanced reactor demonstration project has now begun construction; the new ADVANCE Act will streamline licensing for new nuclear technology.

¹¹ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Total, Nuclear Energy. Pg. 2. See [here](#).

¹² Inflation Reduction Act of 2022, P.L. 117-169, §50172(a)(4) and §50172(c) (2022). See [here](#).

¹³ Inflation Reduction Act of 2022, P.L. 117-169, §50173(a) (2022). See [here](#).

¹⁴ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 171. See [here](#).

¹⁵ Consolidated Appropriations Act of 2024, H.R. 4366, Sec. 312. See [here](#).

¹⁶ Consolidated Appropriations Act of 2024, H.R. 4366, Sec. 311. See [here](#).

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Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
<p>Carbon Capture, Utilization, & Storage</p>	<p>DOE Strategic Vision: increase capture efficiency to 95+% for multiple applications; convert CO₂ into environmentally responsible, equitable and economically valuable products; support rapid deployment of carbon storage necessary to meet climate goals.</p> <p>Energy Earthshots Clean Fuels & Products Shot Goal: Develop cost-competitive carbon sources with at least 85% lower GHG emissions by 2035; meet 50% of 2050 demand for carbon-based chemicals.</p>	<p>Point-source carbon capture technologies such as pre-, post-, and oxy-combustion carbon capture; carbon conversion; carbon transport and storage.</p>	<p>DOE FY24 Funding: \$428 million¹⁷ for carbon management technologies.</p> <p>BIL Funding (FY22-26): \$310 million¹⁸ for carbon utilization RD&D, \$100 million¹⁹ for carbon capture technologies; \$2.5 billion²⁰ for carbon storage RD&D; \$2.5 billion²¹ for CCUS demonstrations; \$937 million²² for CCUS pilots</p>	<p>So far, DOE has selected projects in California, North Dakota, and Texas (up to \$890 million) to demonstrate carbon capture at power plants.</p>	<p>DOE Fossil Energy and Carbon Management Strategic Vision</p> <p>Pathways to Commercial Liftoff: Carbon Management</p>	<p>DOE has made announcements and selections for projects across the CCUS life cycle, from carbon capture demonstrations to carbon storage validation and testing to carbon transport.</p>

¹⁷ U.S. Department of Energy (2024). FY 2025 Comparative Appropriation by Congressional Control, Using FY24 Enacted. Carbon Management Technologies Office. Pg. 2. See [here](#).
¹⁸ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 190. See [here](#).
¹⁹ Infrastructure Investment and Jobs Act, P. L. 117-58, § 40303 (2021). See [here](#).
²⁰ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 170. See [here](#).
²¹ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 168. See [here](#).
²² The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 175. See [here](#).

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Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Carbon Dioxide Removal	<p>Energy Earthshots Carbon Negative Shot Goal: Enable removal of CO2 from the atmosphere and durable storage at meaningful scales for less than \$100/net metric ton of CO2-equivalent within a decade.</p>	Direct air capture (DAC) with storage; Enhanced mineralization; Biomass with Carbon Removal and Storage; Direct ocean capture with storage.	<p>DOE FY24 Funding: \$428 million²³ for carbon management technologies.</p> <p>BIL Funding (FY22-26): \$15 million²⁴ for pre-commercial DAC prize; \$3.5 billion²⁵ for regional DAC hubs</p>	So far, DOE has announced DAC demonstrations in Louisiana and Texas (up to \$1.2 billion) and plans to award up to \$100 million for pilot projects under the Carbon Negative Shot.	<p>DOE Fossil Energy and Carbon Management Strategic Vision</p> <p>Roads to Removal Report on U.S. CDR Capacity</p> <p>Voluntary Carbon Markets Joint Policy Statement and Principles</p>	DOE made its first selections for regional DAC demonstrations, and is supporting early-stage project development and assessment for potential future demonstrations.
Clean Shipping Fuels & Vessels	<p>MI Targets adopted by U.S. Government: By 2030: 600 ships to use these zero-emission fuels across main deep sea shipping routes; 16 million tons of zero-emission fuel production; 20 large trade ports offering zero-emission bunkering.</p> <p>Energy Earthshots Clean Fuels & Products Shot Goal: Develop cost-competitive carbon sources with at least 85% lower GHG emissions by 2035; meet 50% of 2050 demand for maritime, rail, and off-road fuel</p>	Shipping fuels that can be derived from SAF by-products; Life cycle assessment and technical support in developing green corridors.	DOE FY24 Funding: \$895 million ²⁶ for sustainable transportation and fuels RD&D.	No planned demonstrations at this time.	DOE Sustainable Marine Fuels	DOE signed a Memorandum of Understanding with the American Bureau of Shipping for information sharing and collaborative research for maritime decarbonization; Several U.S. agencies are developing a Maritime Decarbonization Action Plan for release in 2024; New national goal to transition to a zero-emissions freight sector for truck, rail, aviation, and marine, and new national zero-emissions freight strategy.

²³ U.S. Department of Energy (2024). FY 2025 Comparative Appropriation by Congressional Control, Using FY24 Enacted. Carbon Management Technologies. Pg. 2. See [here](#).

²⁴ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 220. See [here](#).

²⁵ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 164. See [here](#).

²⁶ U.S. Department of Energy (2024). FY 2025 Comparative Appropriation by Congressional Control, Using FY24 Enacted. Sustainable Transportation and Fuels. Pg. 1. See [here](#).

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Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Enhanced Geothermal Systems	Energy Earthshots Enhanced Geothermal Shot Goal : reduce the cost of Enhanced Geothermal Systems (EGS) electricity to \$45/MWh by 2035.	Resource characterization; well construction; reservoir production capable of higher fluid flows for larger generation capacity.	DOE FY24 Funding : \$118 million ²⁷ for Geothermal Technologies Office BIL Funding (FY22 until expended) : \$84 million ²⁸ for 4 EGS pilots	So far, DOE has selected demonstration projects in California, Texas, and Washington (up to \$60 million) and has announced another \$14 million for projects in the Eastern U.S.	GeoVision Report Geothermal Technologies Office Program Plan Next Generation Geothermal Commercial Liftoff Report	All geothermal demonstration funding under BIL has been announced; DOE-funded Frontier Observatory for Research in Geothermal Energy (FORGE) project has successfully stimulated demonstration wells, a major technological breakthrough; the Bureau of Land Management adopted a new categorical exclusion to expedite geothermal permitting.
Fusion Energy	National Goal : Pursue R&D to enable the design, construction, and operation of a fusion pilot plant (FPP) in a decade.	Viable plasma fusion core (magnetic, inertial, and magneto-inertial approaches); Advanced low-activation materials; Tritium breeding, separation, processing; Balance-of-plant technologies.	DOE FY24 Funding : \$790 million ²⁹ for Fusion Energy Sciences. IRA Funding (FY22-27) : \$280 million ³⁰ for fusion research facilities.	DOE awarded \$46 million to eight companies to pursue applied R&D toward fusion pilot plants as part of the Milestone-Based Fusion Development Program	White House Fact Sheet Fusion Energy Sciences Vision DOE Fusion Energy Strategy International Fusion Engagement Strategy	DOE released a new vision for its Fusion Energy Sciences Office to support development of a competitive fusion power industry, as well as an agency-wide Fusion Energy Strategy .

²⁷ U.S. Department of Energy (2024). FY 2025 Comparative Appropriation by Congressional Control, Using FY24 Enacted. Geothermal Technologies Office. Pg. 1. See [here](#).

²⁸ U.S. Department of Energy (2022). Bipartisan Infrastructure Law Request for Information - Enhanced Geothermal Systems Pilot Demonstrations. See [here](#).

²⁹ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Fusion Energy Sciences Office. Pg. 4. See [here](#).

³⁰ Inflation Reduction Act of 2022, P.L. 117-169, §50172(a)(3) (2022). See [here](#).

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Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Hydrogen (H₂)	<p>Energy Earthshots Hydrogen Shot Goal Reduce the cost of clean H₂ by 80% to \$1 per 1 kg by 2031.</p> <p>National Clean H₂ Strategy: By 2025, catalyze R&D in electrolysis, thermal conversion, and new production pathways.</p>	<p>Production: electrolysis; natural gas with CCUS; advanced renewable pathways; other carbon-based feedstocks.</p> <p>Use: Storage and Infrastructure; Fuel Cells; Turbines & Combustion; Systems Analysis.</p>	<p>DOE FY24 Funding: \$170 million³¹ for H₂ and Fuel Cell Technologies Office.</p> <p>BIL Funding (FY22-26): \$1 billion³² for Clean H₂ Electrolysis, \$500 million³³ for Clean H₂ Manufacturing and Recycling; \$8 billion³⁴ for clean hydrogen hubs (\$7 billion for hubs and \$1 billion for demand-side support).</p>	DOE has selected seven clean H₂ hubs across 16 states (\$7 billion) to demonstrate H ₂ production, storage, delivery, and end-use.	<p>National Clean Hydrogen Strategy and Roadmap</p> <p>DOE Hydrogen Program Plan</p> <p>Pathways to Commercial Liftoff - Clean Hydrogen</p> <p>Hydrogen Shot Technology Assessment: Thermal Conversion Approaches</p>	The White House and 10 agencies released a new Hydrogen Strategy and Roadmap ; DOE has announced selections for its clean H ₂ hubs as well as a consortium to design robust demand-side support measures.
Industrial Decarbonization	<p>Energy Earthshots Industrial Heat Shot Goal: Develop cost-competitive technologies with at least 85% lower GHG emissions by 2035.</p> <p>Energy Earthshots Clean Fuels & Products Shot Goal: Develop cost-competitive carbon sources with at least 85% lower GHG emissions by 2035.</p>	Cost-competitive, low- or zero-carbon alternatives for process heating and integration of clean heat; Cost-competitive, low- or zero-carbon steel, cement, and chemicals production.	<p>DOE FY24 Funding: \$452³⁵ for industrial decarbonization, efficiency, and advanced manufacturing.</p> <p>BIL Funding (FY22 until expended): \$500 million³⁶ for industrial emissions demonstrations.</p> <p>IRA funding (FY22-26): \$5.8 billion³⁷ for advanced industrial facility demonstration projects.</p>	DOE selected 33 demonstration projects across 20 states (up to \$6 billion) for decarbonizing chemicals and refining, cement and concrete, iron and steel, aluminium, food and beverage, glass, pulp and paper, and process heat	<p>Industrial Decarbonization Roadmap</p> <p>Pathways to Commercial Liftoff: Industrial Decarbonization</p> <p>Pathways to Commercial Liftoff: Decarbonizing Chemicals & Refining</p> <p>Pathways to Commercial Liftoff: Low-Carbon Cement</p>	DOE launched a new Energy Earthshot on Clean Fuels & Products ; DOE has made selections for a combined \$6 billion from BIL and IRA for industrial decarbonization.

³¹ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Hydrogen and Fuel Cell Technologies Office. Pg. 1. See [here](#).

³² The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 173. See [here](#).

³³ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 182. See [here](#).

³⁴ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 159. See [here](#).

³⁵ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Industrial Efficiency & Decarbonization Office and Advanced Materials & Manufacturing Technologies Office. Pg. 1. See [here](#).

³⁶ The White House (2022). A Guidebook for the Bipartisan Infrastructure Law for State, Local, Tribal, and Territorial Governments, and Other Partners. Pg. 184. See [here](#).

³⁷ Inflation Reduction Act of 2022, P.L. 117-169, §50161(a) (2022). See [here](#).

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Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Long Duration Energy Storage	<p>Energy Earthshots Long Duration Storage Shot Goal: Reduce storage costs by 90% from a 2020 Li-ion baseline in storage systems that deliver 10+ hours of duration by 2031.</p>	Low-cost long duration storage technologies.	<p>DOE FY24 Funding: \$92.5 million³⁸ for energy storage RD&D.</p> <p>BIL Funding (FY22 until expended): \$505 million³⁹ Long Duration Energy Storage for Everyone, Everywhere Initiative.</p>	DOE has selected 15 projects across 17 states and 1 tribal nation (up to \$325 million) for long-duration energy storage demonstrations and has issued a notice of funding opportunity for up to \$100 million more for non-lithium pilot projects.	<p>Energy Storage Grand Challenge Roadmap</p> <p>Long Duration Energy Storage - Pathways to Commercial Liftoff</p> <p>Long Duration Storage Shot Technology Strategy Assessments</p>	DOE has announced \$325 billion of its BIL funding for long duration energy storage demonstrations and began making awards in June 2024.
Clean Heavy-Duty Vehicles (HDVs)	<p>National Goal: 30% zero-emission HDV sales by 2030; 100% by 2040</p> <p>SuperTruck 3 R&D Goals: Demonstrate 75% reduction in GHG and air emissions; Reduce total cost of ownership compared to 2020/21</p> <p>EV Charging Station Goal: 500,000 EV charging ports by 2030</p>	Cost-competitive low-carbon alternatives for heavy on-road trucking and off-road vehicles, including: electrification, hydrogen, biofuels, and electrofuels; clean corridor infrastructure and vehicle-grid integration.	DOE FY24 Funding : \$895 million ⁴⁰ for sustainable transportation and fuels RD&D.	BIL provides funding via the Joint Office for Energy and Transportation for pilots and demonstrations to support a nationwide EV charging network.	<p>Blueprint for Transportation Decarbonization</p> <p>National Zero-Emission Freight Corridor Strategy</p>	New national goal to transition to a zero-emissions freight sector for truck, rail, aviation, and marine, and new national zero-emissions freight strategy.

³⁸ U.S. Department of Energy (2024). FY 2025 Comparative Appropriation by Congressional Control, Using FY24 Enacted. Geothermal Technologies Office. Pg. 1. See [here](#).

³⁹ U.S. Department of Energy (2022). Bipartisan Infrastructure Law Request for Information - Long Duration Energy Storage for Everyone, Everywhere (LD ESEE) Initiative. See [here](#).

⁴⁰ U.S. Department of Energy (2024). FY 2025 Comparative Appropriation by Congressional Control, Using FY24 Enacted. Sustainable Transportation and Fuels. Pg. 1. See [here](#).

NATIONAL INNOVATION PATHWAY OF THE UNITED STATES

Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Methane Reduction	<p>Global Methane Pledge: Reduce overall methane emissions by 30% below 2020 levels by 2030.</p> <p>Landfill Goals: 70% emissions capture at all U.S. landfills; 50% reduced food waste by 2030.</p> <p>Agriculture Goals: Promote agricultural practices/commodities that reduce methane (and sequester carbon).</p> <p>Pipeline Goal: Repair or replace 1,000 miles of leak-prone gas pipelines by 2036.</p>	<p>Agriculture: Measuring, monitoring, and reducing methane and N₂O emissions from livestock and crop production.</p> <p>Other Sources: Measuring, monitoring, and reducing methane emissions from non-agricultural Sources, such as oil and gas systems, landfills, and reservoirs.</p>	<p>DOE FY24 Funding: Includes \$55 million⁴¹ for methane mitigation technologies.</p> <p>USDA FY24 Funding: Includes funding for livestock production research.⁴²</p> <p>EPA FY24 Funding: Including funding for methane reduction partnerships.⁴³</p>	No planned demonstrations at this time.	<p>U.S. Methane Emissions Reduction Action Plan</p> <p>National Strategy to Advance an Integrated U.S. GHG Measurement, Monitoring, and Information System</p>	The White House launched a Cabinet-Level Methane Task Force ; Federal agencies have collectively announced hundreds of millions of additional dollars for methane measurement and mitigation RD&D in across sectors; The White House released a new National Strategy to Advance an Integrated U.S. GHG Measurement, Monitoring, and Information System to support tracking of mitigation efforts
Net-Zero Buildings	<p>Energy Earthshots Affordable Home Energy Shot Goal: Reduce the cost to decarbonize affordable housing by 50% while reducing energy bills by 20% by 2035.</p> <p>National Blueprint Goals: Reduce on-site energy intensity 35% by 2035 and 50% by 2050; Reduce on-site GHG emissions 25% by 2035 and 75% by 2050; Triple demand flexibility potential by 2050; Reduce embodied emissions from materials and construction 90% by 2050</p>	Cost-competitive net-zero building construction and operation, including net-zero or net-negative building materials; Increasing building energy efficiency; Safe, cost-competitive alternatives for high-global warming potential refrigerants.	DOE FY24 Funding: \$332 million ⁴⁴ for the Building Technologies Office.	DOE support a variety of low-carbon building demonstrations across the country through its Advanced Building Construction Initiative .	<p>National Blueprint for the Buildings Sector</p> <p>DOE Affordable Home Energy Shot</p>	DOE launched a new Energy Earthshot on Affordable Home Energy ; DOE released a new National Blueprint for the Buildings Sector , in collaboration with several Federal agencies

⁴¹ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Methane Mitigation Technologies Office. Pg. 2. See [here](#).

⁴² U.S. Department of Agriculture (2024). FY 2025 Budget Summary, Using Livestock Production. Pg. 91. See [here](#).

⁴³ U.S. Environmental Protection Agency (2024). Fiscal Year 2025 Justification of Appropriation Estimates for the Committee on Appropriations. Pg. 239. See [here](#).

⁴⁴ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Building Technologies Office. Pg. 1. See [here](#).

NATIONAL INNOVATION PATHWAY OF THE UNITED STATES

Technology Area	Targets	Innovation Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Demonstration Projects	Report & Links	Notable Progress Since Prior National Innovation Pathway (2023)
Offshore Wind	<p>National Goal: 30 GW of offshore wind deployment by 2030; 15 GW of floating offshore wind deployment by 2035</p> <p>Energy Earthshots Floating Offshore Wind Shot: reduce the cost by >70% to \$45/MWh in deep waters by 2035.</p>	Robustness to ocean conditions; reduced environmental impacts; technical challenges with installation and grid connection; improved efficiencies and economies of scale; develop floating platform designs for deeper waters.	<p>DOE FY24 Funding: \$137 million⁴⁵ for Wind Energy Technologies Office.</p>	DOE supports a portfolio of offshore wind demonstration projects .	<p>White House Fact Sheet</p> <p>DOE National Strategy: Advancing Offshore Wind Energy in the United States</p> <p>Pathways to Commercial Liftoff: Offshore Wind</p> <p>Floating Offshore Wind Shot Progress and Priorities Report</p>	Federal agencies have invested over \$950 million for floating offshore wind technologies since 2022; DOE released a new offshore wind strategy .
Sustainable Aviation Fuels (SAF)	<p>SAF Grand Challenge: 3 billion gal SAF by 2030 (50%+ life cycle GHG reduction); meet 100% of aviation demand by 2050; approval of additional conversion pathways.</p> <p>Energy Earthshots Clean Fuels & Products Shot Goal: Develop cost-competitive carbon sources with at least 85% lower GHG emissions by 2035.</p>	Utilizing all potential biomass and CO ₂ feedstocks; Multiple new conversion pathways will be explored in addition to the 7 already approved.	<p>DOE FY24 Funding: \$275 million⁴⁶ for Bioenergy Technologies Office.</p> <p>DOT FY24 Funding: \$71 million⁴⁷ for Federal Aviation Administration (FAA) on clean aircraft technologies and fuels.</p> <p>USDA FY24 Funding: Includes funding that supports biofuel R&D.⁴⁸</p> <p>IRA funding (FY22-26): \$245 million⁴⁹ for SAF infrastructure; \$47 million for sustainable aviation RD&D</p>	Annual investments in scaling up SAF technologies planned through 2030.	<p>SAF Grand Challenge Fact Sheet, MOU, Roadmap</p> <p>First Movers Coalition Commitment</p> <p>FAA Climate Action Plan</p> <p>2023 Billion-Ton Report: An Assessment of U.S. Renewable Carbon Resources</p>	The White House announced a new national goal to transition to a zero-emissions freight sector for truck, rail, aviation, and marine, and new national zero-emissions freight strategy.

⁴⁵ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Wind Energy Technologies Office. Pg. 1. See [here](#).

⁴⁶ U.S. Department of Energy (2024). FY 2025 Statistical Table by Appropriation, Using FY 2024 Enacted. Bioenergy Technologies Office. Pg. 1. See [here](#).

⁴⁷ Federal Aviation Administration (2022). Sustainable Aviation Fuels (SAF). See [here](#).

⁴⁸ U.S. Department of Agriculture (2024). FY 2025 Budget Summary, Using Livestock Production. Pg. 91. See [here](#).

⁴⁹ Inflation Reduction Act of 2022, P.L. 117-169, §40007 (2022). See [here](#).