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

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Contents

Clean Energy Innovation Strategy

Summary

The United States' Nationally Determined Contribution (NDC) aims to reduce greenhouse gas (GHG) emissions by **50-52% from 2005 levels by 2030**, putting the United States on a path to achieve **net-zero emissions no later than 2050**. The Long-Term Climate Strategy of the United States outlines multiple pathways to meet these commitments. Key elements of this strategy include goals of a **carbon pollution-free electricity grid by 2035** and **50% zero-emission vehicle sales by 2030**, as well as improving energy efficiency across all sectors of the economy, electrifying end-use sectors (transport, buildings, and industry) where practical, shifting to zero-emission or carbon-neutral fuels for industries and transport modes that need energy-dense fuels, applying carbon capture and storage for industries with large process-related emissions, advancing carbon dioxide removal, reducing methane and other non-CO_2 emissions, and shifting to more sustainable agricultural, forestry, and land use practices. To support meeting the U.S. NDC and implementation of the Long-Term Strategy, **the United States has a threefold net-zero technology action plan** (as illustrated in Figure 1) which will:

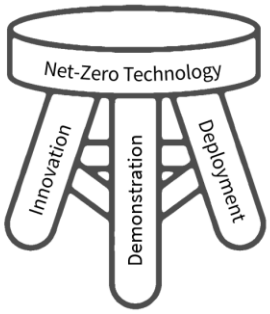

Figure 1. Threefold strategy for technologies needed to achieve net-zero GHG emissions by 2050.

- **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**. Examples include the U.S. Department of Energy (DOE) Energy Earthshots™ which target specific technology cost and performance goals in long duration energy storage, carbon removal, clean hydrogen, enhanced geothermal systems, floating offshore wind, and industrial heat. Additionally, the U.S. Departments of Energy, Transportation, Agriculture, and Defense, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, and the National Science Foundation have ongoing programs that invest in innovation from basic science to demonstration projects for climate mitigation and resilience. A whole-of-government Climate Innovation Working Group was established to assess current innovation investments and guide future investments (U.S. Innovation to Meet 2050 Climate Goals: Assessing Initial R&D Opportunities).
- **Demonstrate and support early deployment of emerging technologies.** The demonstration projects will increase market confidence and begin to make equitable investments in the infrastructure needed to enable widespread deployment. Examples include advanced offshore wind, carbon capture and storage, advanced nuclear power, and advanced grid technologies. The Bipartisan Infrastructure Law (BIL) provided $21.5 billion for clean energy demonstration projects in clean hydrogen, energy storage, carbon capture, advanced nuclear, direct air capture, and other technologies. The Inflation Reduction Act (IRA) of 2022 complements this with billions of dollars in deployment for carbon capture and storage, carbon dioxide removal, and hydrogen.

- **Use regulations and financial incentives to accelerate manufacturing, deployment, and adoption of technologies that are available today**, such as solar, wind, batteries, electric vehicles, and highly efficient appliances and equipment, as well as an expanded transmission network to support more renewable energy and electrification. Scale-up of these clean energy technologies is supported by new efforts to secure supply chains for critical materials and components. In addition to demonstration of emerging technologies, funding in the BIL (including the $62 billion provided to DOE alone) accelerates deployment of commercially available clean energy, clean transit and school buses, and grid modernization technologies. The BIL also invests in associated clean energy infrastructure (such as a nationwide electric vehicle charging network), domestic manufacturing and supply chain capacity, and workforce needs. The IRA provides $370 billion of incentives to deploy commercial and emerging clean energy technologies across the economy. The DOE Loan Program Office now has more than $100 billion in loan authority to help deploy and scale up innovative clean energy, advanced transportation, and tribal energy projects in the United States, and $250 billion in new loan authority to retool or repurpose energy infrastructure for the low-carbon economy. EPA is also developing rulemaking proposals to address some of our nation's largest sources of both climate- and health-harming pollution, such as the transportation, oil and natural gas, and power sectors and advance low and zero emissions technologies.

Documents summarizing the U.S. strategy and associated elements are provided in Table 1. The U.S. innovation strategy also fosters international partnerships through Mission Innovation, the First Movers Coalition, Net Zero World, the Glasgow Breakthrough Agenda and a number of bilateral agreements to share U.S.-led innovations, learn from the efforts of others, and coordinate efforts so that we can maximize the impact of our collective investments.

Methodology

The U.S. national net-zero innovation pathway is informed by the National Long-Term Climate Strategy, which maps multiple pathways for achieving net-zero emissions no later than 2050. The long-term strategy was developed using a combination of two economy-wide energy models, GCAM and OP-NEMS. Together, the models provide sector-specific pathways for meeting near and longer-term climate goals. The models incorporate technologies that are available and cost-competitive today, as well as those requiring innovation to become ready for commercial deployment. Technologies that could play a major role in meeting our climate targets, but require innovation to bring them to market, are identified as innovation opportunities. Examples of innovation opportunities include the research areas listed in Table 4. Many additional clean energy technologies that are already broadly commercially available—such as conventional solar photovoltaics (PV), land-based wind, light-duty electric vehicles, and many energy efficiency technologies—are not included in this list.

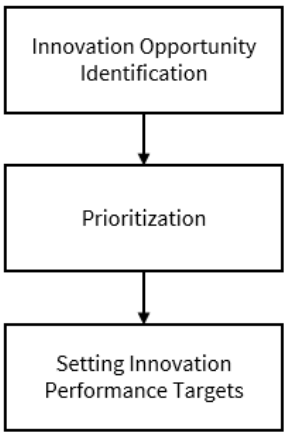

Figure 2. Methodology for identifying innovation pathways

Once innovation opportunities are identified, multiple criteria are used to assess technologies based on their potential benefits for climate and environment, equity and justice, economy, and security. Aligning the innovation portfolio across multiple objectives is key to sustained support for innovations over the next three decades. An interagency Climate Innovation Working Group is charged with gathering innovation priorities from the agencies, identifying opportunities and needs for coordination, and developing a comprehensive innovation strategy to create options to reduce all emissions across the economy.

After the opportunities are assessed and prioritized, cost and performance targets are developed to guide research and development efforts. Methods include technoeconomic modelling, stakeholder engagement, and expert elicitation, all of which can help develop R&D roadmaps and identify barriers to commercialization and adoption. Unlike conventional technoeconomic analysis, which has historically focused on technology-level performance metrics such as levelized-cost-of electricity, there is a growing awareness that interactions and synergies within and across sectors must be considered. A good example of this is the innovation needed to build a zero-emission grid. While solar and wind energy are often the lowest-cost source of electricity today, other emerging technologies like storage, advanced nuclear energy, carbon capture and storage, enhanced geothermal energy, and fusion energy could dramatically reduce the costs and enhance the resilience and reliability of 100% clean power systems in the future.

Table 1. Relevant Documents and Policies: **National Commitments and Goals**

Document/Policy	Description	Outcomes, Goals, or Targets	Year	Links
U.S. Nationally Determined Contribution (NDC)	U.S. nationally determined contribution submitted to the UNFCCC under the Paris Agreement.	Sets an economy-wide net GHG emissions target of 50-52% reduction from 2005 levels in 2030.	2021	Full Report
National Long-Term Climate Strategy	Biden-Harris Administration report on economy-wide and sectoral pathways to net-zero by 2050.	Broadly defines the technologies expected to play a role in meeting our NDC and long-term climate goals.	2021	Full Report
Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis	Biden-Harris Administration Executive Order on advancing scientific knowledge to address public health, the environment, and the climate crisis, with an emphasis on environmental justice and job creation.	Directs Federal agencies to do the following (non-exhaustive): (1) Review and address the Federal actions from 2017-2021 that conflict with national climate objectives; and (2) Establish an Interagency Working Group on the Social Cost of Greenhouse Gases.	2021	Executive Order 13990
Executive Order on Tackling the Climate Crisis at Home and Abroad	Biden-Harris Administration Executive Order on integration of climate policy into U.S. foreign policy and national security and for a government-wide approach to the climate crisis.	Orders the following to be established (non-exhaustive): (1) The U.S. NDC under the Paris Agreement; (2) A Presidentially appointed Special Presidential Envoy for Climate; (3) A White House Office of Domestic Climate Policy; (4) An interagency National Climate Task Force; (5) Federal clean procurement strategy.	2021	Executive Order 14008
Executive Order on America's Supply Chains	Biden-Harris Administration Executive Order on strengthening the resilience of supply chains that underlie the U.S. industrial base.	Orders the Department of Energy to perform an assessment of and outline strategies to strengthen supply chains for the energy industrial base (see "America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition" below).	2021	Executive Order 14017 2022 Capstone Report
Executive Order on Strengthening American Leadership in Clean Cars and Trucks	Biden-Harris Administration Executive Order that sets a goal for zero-emissions vehicle sales and calls on agencies to develop regulations in support of that goal.	Orders 50% of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles.	2021	Executive Order 14037

Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability	Biden-Harris Administration Executive Order that calls for the Federal Government to create sustainability goals which leverage its scale and procurement power to reduce emissions, which drives innovation and accelerates deployment.	Directs the Federal Government to achieve 5 ambitious goals: (1) 100% carbon pollution-free electricity by 2030, at least half locally supplied to meet 24/7 demand; (2) 100% zero-emission vehicle acquisitions by 2035, including 100% zero-emission light-duty vehicle acquisitions by 2027; (3) Net-zero emissions from Federal procurement by 2050, including a Buy Clean policy to promote use of clean construction materials; (4) Net-zero emissions building portfolio by 2035, including 50% emissions reduction by 2032; and (5) Net-zero emissions from overall Federal operations by 2050.	2021	Executive Order 14057 Full Plan Fact Sheet
Executive Action to Spur Domestic Clean Energy Manufacturing	Biden-Harris Administration presidential determination authorizing the use of the Defense Production Act (DPA) for clean energy.	Authorizes the use of the DPA to rapidly expand domestic manufacturing for: solar panel parts, building insulation, heat pumps, electrolyzers and fuel cells, and power grid equipment.	2022	Fact Sheet Presidential Determinations: solar panels, insulation, heat pumps, electrolyzers and fuel cells, power grid equipment

Table 2. Relevant Documents and Policies: **Legislation**

Document/Policy	Description	Outcomes, Goals, or Targets	Year	Links
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[1] for Federal research and innovation to bolster U.S. leadership in R&D and manufacturing capabilities for an emerging 21st 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
Bipartisan Infrastructure Law (BIL) of 2021	Wide-ranging bipartisan legislation providing investments in infrastructure, workers, families, and competitiveness, including $62 billion[2] for DOE.	DOE investments include $21.5 billion[3] 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
Energy Act of 2020	Bipartisan energy legislation focused on innovation, technology, commercialization, and domestic manufacturing. Authorizes new DOE programs for RDD&D in key energy and industrial technologies.	In addition to RDD&D programs across clean energy technologies, authorizes DOE to launch commercial scale technology demonstrations in advanced nuclear, carbon capture, direct air capture, grid-scale storage, and advanced geothermal.	2020	Legislation Text Congressional Fact Sheet

[1] 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.
[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. 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.

Table 3. Relevant Documents and Policies: **Roadmaps and Action Plans**

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) Hydrogen Shot – Reduce the cost of clean H_2 by 80% to $1 per 1 kg; (2) Long Duration Storage Shot – Reduce costs by 90% in storage systems that deliver 10+ hours of duration; (3) Carbon Negative Shot – 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) Enhanced Geothermal Shot – reduce the cost to $45/MWh by 2035; (5) Floating Offshore Wind Shot: reduce the cost by >70% to $45/MWh in deep waters by 2035; (6) Industrial Heat Shot – Develop cost-competitive technologies with at least 85% lower GHG emissions by 2035.	2021 – present	DOE Energy Earthshot Initiative Information
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
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

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
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

Clean Energy Innovation Priorities

Overview of Clean Energy Innovation Priorities

Table 4. Representative Clean Energy Innovation Priorities

	Focus of Innovation Activity	Targets/Goals	Technologies/Topics of Interest	RD&D Funding Highlights (Non-exhaustive)	Planned Demonstration Investments	Links
Advanced Batteries	Basic research through commercial-ization	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 National Battery Supply Chain Goal: By 2030, establish a secure materials and technology supply chain.	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,	DOE FY22 Funding: $420 million[4] for the Vehicle Technologies Office, including funding for batteries and charging. BIL Funding (FY22-26): $200 million[5] for battery recycling, $125 million[6] for battery and critical mineral recycling.	BIL Funding (FY22-26): $3 billion[7] for battery material processing demonstrations.	National Blueprint for Lithium Batteries
Advanced Nuclear	Basic research through demonstra-tion	DOE Nuclear Strategic Vision: Two demonstrations in mid-2020s under the Advanced Reactor Demonstration Program; also, 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 FY22 Funding: $1.6 billion[8] for the Office of Nuclear Energy. IRA Funding (FY22-27): $367 million[9] for national laboratories; $700 million[10] to develop and secure HALEU supply	BIL Funding (FY22 until expended): $2.5 billion[11] for Advanced Reactor Demonstration Program.	DOE Nuclear Energy Strategic Vision Demonstrations: Advanced Reactors; Microreactors

[4] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using 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. 150. 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. 201. 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. 166. See here.
[8] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Office of Nuclear Energy. Pg. 2. See here.
[9] Inflation Reduction Act of 2022, P.L. 117-169, §50172(a)(4) and §50172(c) (2022). See here.
[10] Inflation Reduction Act of 2022, P.L. 117-169, §50173(a) (2022). See here.
[11] 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.

Advanced Solar	Basic research through commercial-ization (including manufactur-ing and supply chain scale-up)	DOE SunShot Goals: *Utility-scale Solar PV*: $0.2/kWh by 2030; *Commercial Solar PV:* $0.04/kWh; *Residential Solar PV*: $0.05/kWh; *Concentrating Solar Power*: $50/MWh by 2030 for CSP system in the Southwest with at least 12 hours of thermal energy storage.	Solar PV; concentrating solar-thermal power (CSP); systems integration; balance of systems soft cost reduction; manufacturing competitiveness.	DOE FY22 Funding: $290 million[12] for the Solar Energy Technologies Office. BIL Funding (FY22 until expended): $80 million[13] including new solar technologies manufacturing; reuse and recycling; and research, development, demonstration, and commercialization.	Multi-MW pilot of high-temperature and high-efficiency Generation 3 Concentrating Solar Power system capable of 6 hours of thermal energy storage.	DOE Solar Energy Technologies Plan Solar Futures Study DOE Solar Technology Goals Gen3 CSP Demonstrations
Carbon Capture, Utilization, & Storage	Basic research through commercial-ization and development of monitoring, reporting, and verification (MRV) standards	DOE Strategic Vision: *Point Source Carbon Capture:* increase capture efficiency to 95+% for multiple applications; *Carbon Conversion*: convert CO_2 into environmentally responsible, equitable and economically valuable products; *Carbon Transport and Storage*: support rapid deployment of carbon storage necessary to meet climate goals.	Point-source carbon capture technologies such as pre-, post-, and oxy-combustion carbon capture; carbon conversion; carbon transport and storage.	DOE FY22 Funding: $240 million[14] for CCS and Power Systems Program. BIL Funding (FY22-26): $310 million[15] for carbon utilization RD&D, $100 million[16] for carbon capture technologies; and, $2.5 billion[17] for carbon storage RD&D.	BIL Funding (FY22-26): $2.5 billion[18] for CCUS demonstrations, $937 million[19] for CCUS pilots.	DOE Fossil Energy and Carbon Management Strategic Vision

[12] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Solar Energy Technologies Office. Pg. 1. See here.
[13] Infrastructure Investment and Jobs Act, P. L. 117-58, § 41007(c) (2021). See here.
[14] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. CCS and Power Systems Program. Pg. 3. See here.
[15] 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.
[16] Infrastructure Investment and Jobs Act, P. L. 117-58, § 40303 (2021). See here.
[17] 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.
[18] 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.
[19] 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.

Carbon Removal	Basic research through commercial-ization and development of MRV standards	DOE Carbon Negative Shot Goal: reducing the cost of carbon dioxide removal to less than $100 per metric ton by 2030. The removal should be long-term, at gigaton scale, and should account for the entire life cycle. First Movers Coalition Advanced Market Commitments: by 2030, companies commit to purchase 50,000+ tonnes of highly durable and scalable carbon dioxide removal in addition to maximal direct emissions reduction efforts.	Direct air capture (DAC) with storage; Enhanced mineralization; Biomass with Carbon Removal and Storage; Direct ocean capture with storage.	DOE FY22 Funding: Not less than $104 million[20] for CDR. BIL Funding (FY22-26): $15 million[21] for pre-commercial DAC prize.	BIL Funding (FY22-26): $3.5 billion[22] for regional DAC hubs.	DOE Fossil Energy and Carbon Management Strategic Vision DOE Carbon Negative Shot
Clean Shipping Fuels and Vessels	Basic research through commercial-ization	MI Targets adopted by U.S. Government: By 2030: 200+ ships to use these zero-emission fuels across main deep sea shipping routes; 5%+ of global deep-sea fleet to be ships capable of running on zero-emission fuels; 10 large trade ports covering 3+ continents supply zero-emission fuels. First Movers Coalition Advanced Market Commitments: by 2030, carriers commit that 5%+ of deep-sea shipping will be powered by zero-emission fuels; cargo owners commit that 10%+ of goods shipped internationally on ships powered by zero-emission fuels.	Shipping fuels that can be derived from SAF by-products. Life cycle assessment and technical support in developing green corridors.	DOE FY22 Funding: $420 million[23] for the Vehicle Technologies Office, including $96 million[24] in funding opportunities for advanced clean vehicle technologies (including marine vehicles). DOE provides additional funding for sustainable marine fuel RD&D.	No planned demonstrations at this time.	First Movers Coalition Commitment Scope DOE Clean Vehicle FOA DOE Sustainable Marine Fuels

[20] Joint Explanatory Statement for the Consolidated Appropriations Act, 2022, P. L. 117-103. Pg. 876. 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. 220. 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. 164. See here.
[23] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Vehicle Technologies Office. Pg. 1. See here.
[24] U.S. Department of Energy (2022). FY 2022 Funding Opportunity Announcement – Vehicle Technologies Office. See here.

Enhanced Geothermal Systems	Basic research through demonstra-tion	DOE 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 FY22 Funding: $110 million[25] for Geothermal Technologies Office.	BIL Funding (FY22 until expended): $84 million[26] for 4 EGS pilots.	GeoVision Report Geothermal Technologies Office Program Plan
Fusion Energy	Basic research through demonstra-tion	National Goal: Pursue R&D to enable the design, construction, and operation of a fusion pilot plant (FPP) on a decadal time scale.	Viable plasma fusion core (magnetic, inertial, and magneto-inertial approaches); Advanced low-activation materials; Tritium breeding, separation, processing; Balance-of-plant technologies.	DOE FY22 Funding: $713 million[27] for Fusion Energy Sciences, $45 million[28] to launch a milestone-based public-private partnership program. IRA Funding (FY22-27): $280 million[29] for fusion research facilities.	None at this time, but $45M[25] of FY22 funding supports a new milestone-based public-private-partnership to support applied R&D toward one or more FPPs.	White House Fact Sheet Fusion Energy Sciences Advisory Committee Report National Academies Report

[25] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Geothermal Technologies Office. Pg. 1. See here.
[26] U.S. Department of Energy (2022). Bipartisan Infrastructure Law Request for Information - Enhanced Geothermal Systems Pilot Demonstrations. See here.
[27] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Fusion Energy Sciences Program. Pg. 4. See here.
[28] Energy and Water Development and Related Agencies Appropriations Bill, 2022, House Report 117-98, 117th Congress (2021). Pg. 150. See here.
[29] Inflation Reduction Act of 2022, P.L. 117-169, §50172(a)(3) (2022). See here.

Hydrogen (H_2)	Basic research through commercial-ization	DOE Hydrogen Shot Goal: $1/kg for clean hydrogen production within 10 years. DOE Delivery and Dispensing Goal: $2/kg by 2030. DOE Storage Goal: $9/kWh by 2030. DOE Electrolyzer Goal: $150/kW; 73% efficiency; 80,000-hour durability. DOE Fuel Cells for Heavy-Duty Trucks Goal: $80/kW; 25,000-hr durability.	Production: electrolysis; natural gas with CCUS; advanced renewable pathways; other carbon-based feedstocks. Use: Storage and Infrastructure; Fuel Cells; Turbines & Combustion; Systems Analysis.	DOE FY22 Funding: $158 million[30] for H_2 and Fuel Cell Technologies Office. BIL Funding (FY22-26): $1 billion[31] for Clean H_2 Electrolysis, $500 million[32] for Clean H_2 Manufacturing and Recycling.	BIL Funding (FY22-26): $8 billion[33] for clean hydrogen hubs.	DOE Hydrogen Shot DOE Hydrogen Program Plan
Industrial Decarbonization	Basic research through commercial-ization	DOE Industrial Heat Shot Goal: Develop cost-competitive technologies with at least 85% lower GHG emissions by 2035. First Movers Coalition Advanced Market Commitments: 2030 purchasing of near-zero carbon steel and aluminum and will include standards for highly decarbonized cement/concrete and chemicals by early 2023.	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	DOE FY22 Funding: $416 million[34] for the Advanced Manufacturing Office, including $70 million[35] to create a new Clean Energy Manufacturing Innovation Institute.	BIL Funding (FY22 until expended): $500 million[36] for industrial emissions demonstrations. IRA funding: $5.8 billion[37] for advanced industrial facility demonstration projects.	Fact Sheet First Movers Coalition Commitments: Steel; Aluminum DOE Thermal Process Intensification Industrial Decarbonization Roadmap

[30] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Hydrogen and Fuel Cell Technologies Office. Pg. 1. See here.
[31] 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.
[32] 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.
[33] 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.
[34] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Advanced Manufacturing Office. Pg. 1. See here.
[35] U.S. Department of Energy (2022). Funding Opportunity Announcement - Clean Energy Manufacturing Innovation Institute for Industrial Decarbonization. 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.

Long Duration Energy Storage	Basic research through commercial-ization	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 in 1 decade.	Low-cost long duration storage technologies.	DOE FY22 Funding: Not less than $500 million[38] for energy storage, including funding for RD&D activities that support the Energy Storage Grand Challenge.	BIL Funding (FY22 until expended): $505 million[39] Long Duration Energy Storage for Everyone, Everywhere Initiative.	DOE Long Duration Storage Shot BIL Initiative Energy Storage Grand Challenge Roadmap
Clean Heavy-Duty Vehicles (HDVs)	Basic research through demonstra-tion	2021 Executive Order: Establish air emission, GHG, and fuel efficiency standards for HDVs for 2027+. First Movers Coalition Advanced Market Commitments: Zero-emission medium and heavy-duty vehicles (battery or fuel-cell) and clean electricity/H_2 refueling. DOE RD&D Goals: *SuperTruck III:* Demonstrate 75% reduction in GHG and air emissions; Reduce total cost of ownership compared to 2020/21. *Fuel Cells for Heavy-Duty Trucks*: $80/kW; 25,000-hr durability.	Cost-competitive low-carbon alternatives for heavy on-road trucking and off-road vehicles, including: electrification, hydrogen, biofuels, and electrofuels, including planning for clean corridor infrastructure.	DOE FY22 Funding: $420 million[20] for the Vehicle Technologies Office, including $96 million[21] in funding opportunities for advanced clean vehicle technologies (including HDV technology and refueling).	DOE recently awarded $127 million[40] for projects under the SuperTruck III program. BIL also provides funding via the Joint Office for Energy and Transportation for pilots and demonstrations to support a nationwide EV charging network.	Executive Order 14037 Biden-Harris Administration Clean Trucks Plan

[38] Joint Explanatory Statement for the Consolidated Appropriations Act, 2022, P.L. 117-103. Pg. 876. 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 (2021). DOE Announces Nearly $200 Million to Reduce Emissions From Cars and Trucks. See here.

Methane Reduction	Basic research through commercial-ization	Global Methane Pledge: Reduce overall methane emissions by 30% below 2020 levels by 2030. Landfill Goals: 70% emissions capture at all U.S. landfills; 50% reduced food waste by 2030. Agriculture Goals: Promoting agricultural practices and commodities that reduce methane (and sequester carbon); Measuring and monitoring emissions and sequestration. EPA Methane Partnership: Address methane in agriculture, coal mining, oil and gas, and landfills.	Agriculture: Measuring, monitoring, and reducing methane and N_20 emissions from livestock and crop production. Other Sources: Measuring, monitoring, and reducing methane emissions from non-agricultural Sources, such as oil and gas systems, landfills, and reservoirs.	DOE FY22 Funding: Includes funding for methane mitigation and quantification RD&D. USDA FY22 Funding: Includes funding for livestock methane RD&D. EPA FY22 Funding: Including funding for methane measurement RD&D.	No planned demonstrations at this time.	U.S. Methane Emissions Reduction Action Plan Methane Partnership DOE Methane Emissions Reduction
Net-Zero Buildings	Basic research through commercial-ization	RD&D goals under development.	Cost-competitive net-zero building construction and operation, including net-zero or net-negative building materials.	DOE FY22 Funding: $308 million[41] for the Building Technologies Office.	DOE recently awarded $32 million[42] for a series of Advanced Building Construction demonstrations.	DOE Building Efficiency Demonstration Projects

[41] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Building Technologies Office. Pg. 1. See here.
[42] U.S. Department of Energy. DOE Awards $32 Million to Accelerate Next-Generation Building Upgrades. See here.

Offshore Wind	Basic research through commercial-ization	National Goal: 30 GW of offshore wind deployment by 2030. DOE Floating Offshore Wind Shot: reduce the cost by >70% to $45/MWh in deep waters by 2035.	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.	DOE FY22 Funding: $114 million[43] for Wind Energy Technologies Office.	DOE supports a portfolio of offshore wind demonstration projects, including projects under construction off the coasts of Lake Erie and New England.	White House Fact Sheet National Offshore Wind Strategy Demonstration Projects
Sustainable Aviation Fuels (SAF)	Basic research through commercial-ization	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. First Movers Coalition Advanced Market Commitments: airlines and transport companies replace 5%+ jet fuel demand/airfare; freight purchasers replace 5% of demand with SAFs with 85%+ GHG reduction or near-zero emissions propulsion technologies.	Utilizing all potential biomass and CO_2 feedstocks; Multiple new conversion pathways will be explored in addition to the 7 already approved.	DOE FY22 Funding: $262 million[44] for Bioenergy Technologies Office. DOT FY22 Funding: $16 million[45] for Federal Aviation Administration (FAA) on SAF. USDA FY22 Funding: Includes funding that supports biofuel production R&D.	Annual investments in scaling up SAF technologies planned through 2030.	SAF Grand Challenge Fact Sheet & MOU First Movers Coalition Commitment FAA Climate Action Plan

[43] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Wind Energy Technologies Office. Pg. 1. See here.
[44] U.S. Department of Energy (2022). FY 2023 Statistical Table by Appropriation, Using Enacted. Bioenergy Technologies Office. Pg. 1. See here.
[45] Federal Aviation Administration (2022). Sustainable Aviation Fuels (SAF). See here.

Tracking Progress

Numerous indicators are used to track progress of our innovation priorities. The indicators are tracked by the Federal Government, but also by universities, research institutions such as national labs, and private sector investors. These include the following.

1. Milestone tracking. At the most basic level, government-supported innovation tracks progress towards milestones laid out in grant applications and contracts. Milestones are typically tied to a date when important goals are met, such as: proof-of-concept achieved; notable performance improvement; technology and system optimization; demonstration; and commercialization.
2. Tracking cost and performance goals. Key performance indicators such as energy efficiency, energy return on investment, energy density, cycle life or longevity, life cycle emission reductions, and progress towards cost parity are tracked for government and private sector investment in innovative technologies.
3. Number of patents issued. Generation of intellectual property, as a key indicator of progress and success, is tracked for all government research grants.
4. Publications and citations. Numbers of publications and citations are tracked for government sponsored research grants.
5. Level of private sector investment. Direct or follow-on investment by the private sector is a key indicator of success and is tracked for most government research grants.
6. Number of companies started, generating income, and achieving profitability. The number of companies formed during or after completion of a research grant is tracked for some, but not all, research grants. In addition, it has become a best practice to track investment in those companies, when and if they go public, when they start generating revenue, and when they become profitable.

Non-Federal Government and Private Sector Engagement

Partnerships with the private sector are central to the U.S. approach to clean energy innovation, from RD&D through full scale commercial deployment. DOE partners with industry, national laboratories, universities, non-profits, state and local governments, and other stakeholders across the United States to advance primary science and early technological breakthroughs to commercially viable demonstrations. Creating the right enabling environment for private sector innovation requires ongoing and open dialogue between industry and government, with a common fact base around the path to commercial scale and success.

Early-stage incubators like DOE's Advanced Research Projects Agency–Energy (ARPA-E) and technology transfer programs like the Lab Embedded Entrepreneurs Program accelerate the transition from lab to market. Grants, cooperative agreements, prizes, and other forms of financial and technical assistance play a critical role in enabling and de-risking technologies as they move from applied research to pilot and first-of-a-kind commercial demonstration projects. The new DOE Office of Clean Energy Demonstrations (OCED) was created to fill a critical gap in funding innovative large-scale demonstrations on the path to commercial scale. Public sector finance entities like DOE's Loan Programs Office work to accelerate the bankability of technologies by providing the first debt financing these innovative technologies receive, educating private lenders and institutional investors on how to underwrite deployments.

The Manufacturing USA initiative, which involves multiple Federal agencies engaging in public-private partnership with thousands of organizations, is another element to scaling up many clean energy technologies and training the next-generation workforce to enable the United States to deliver clean products at home and export them abroad. Other public-private partnership programs such as the First Movers Coalition mobilize collective demand, creating voluntary advanced market commitments for innovative climate technologies that drive innovation and accelerate deployment. The First Movers Coalition is a global initiative that harnesses the purchasing power of companies to decarbonize hard-to-abate industrial sectors that currently account for 30 percent of global emissions.

Finally, state policies like clean energy standards, low-carbon fuel standards, and other procurement mandates and advanced market commitments create strong and stable demand signals for clean energy technology companies. At the Federal level, incentives provide an additional source of stability and risk mitigation. Most recently, the Inflation Reduction Act of 2022 extended or created tax credits for adoption of clean technologies across many sectors—including for clean electricity, clean hydrogen and other fuels, carbon capture and carbon removal, energy efficiency, and electric vehicles and appliances—as well as for manufacturing of many clean energy technologies.

International Collaboration

The U.S. Government engages in multiple international science and technology collaborations in order to maintain the strength and global leadership of the U.S. innovation base. It prioritizes international collaboration to tackle clean energy innovation priorities in many ways. It holds multiple strategic energy dialogues with partners and allies to set out collaboration priorities on a bilateral basis and implements those ideas through working groups and other mechanisms. For example, it carries out bilateral engagements such as the U.S.-India Partnership to Advance Clean Energy-Research (PACE-R), and the U.S.-Israel Center of Excellence in Energy, Engineering and Water Technology (Energy Center). It has also launched a new program called Net Zero World Initiative which works hand-in-hand with partner countries to co-create and implement tailored, actionable technical and investment roadmaps to increase the speed and scale of transition to net zero energy systems.

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, it sits on the Steering Committee in a Vice-Chair role, and will assume the Chairmanship for 2023. Further, it co-leads three of the research Missions—Clean Hydrogen, Zero-Emission Shipping, and Carbon Dioxide Removal—as well as an innovation community on Sustainable Aviation Fuels in partnership with India. To build on the Zero-Emissions Shipping Mission, the United States and Norway will also announce a Green Shipping Challenge to encourages governments and companies to collaboratively address emissions from the international shipping sector. 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 U.S. Government also launched two international initiatives: the First Movers Coalition and the Clean Energy Technologies Demonstration Challenge. The First Movers Coalition has welcomed nine government partners in addition to the United States (Denmark, Germany, India, Italy, Japan, Norway, Singapore, Sweden, and the United Kingdom). 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 IEA reports are needed to achieve net-zero emissions by 2030. The United States, through DOE's OCED, is expected to mobilize over $27 billion in support of the Challenge. These public investments will leverage additional private investments and advance innovative technologies already in demand by the world's largest companies through efforts such as the First Movers Coalition.

National Energy Innovation Ecosystem

The scale of the climate crisis requires a historic effort between the public and private sectors in the national energy innovation ecosystem to conduct basic science research that leads to new discoveries, advance early-stage research from the lab to prototypes, demonstrate emerging technologies to accelerate innovation, and scale technologies to broader market adoption. Technologies emerge and advance through an iterative non-linear feedback process in this ecosystem of curiosity-driven research, invention and design, testing and evaluation, demonstration, learning-by-doing, manufacturing, and market adoption all contributing to new knowledge driving innovation. Each component is a critical element, and U.S. public and private institutions play a key role.

The U.S. Department of Energy and its 17 National Laboratories are essential institutions in the national energy innovation ecosystem, providing unparalleled science, technology, computing, engineering, and other expertise that scale science from discovery to adoption. Over the next five years, the Bipartisan Infrastructure Law enables DOE to launch 60 new programs (including 16 demonstration and 32 deployment programs) and expand funding for 12 existing research, development, demonstration, and deployment programs. The Inflation Reduction Act provides DOE with an additional $35 billion for programs to support innovation and deployment in industrial decarbonization, building energy efficiency, and energy infrastructure, among other technology areas. The Department of Energy's basic and applied science and energy programs, ARPA-E program, Loan Program Office, Office of Technology Transitions, and Office of Clean Energy Demonstrations help discover, design, demonstrate, deploy, and scale up innovative clean energy in the United States.

Many other Federal agencies are critical components of this system, including the Departments of Agriculture, Transportation, Interior, Defense, and Commerce, the Environmental Protection Agency, and National Science Foundation. An expanded, optimized, and sustained effort by Federal agencies on net-zero R&D efforts will advance the clean energy innovation necessary to reach net-zero emissions. Private technology, finance, engineering, infrastructure, and other firms are foundational institutions in this ecosystem in order to scale and diffuse new clean energy technologies. Philanthropic and non-governmental institutions fill important funding and advocacy roles. Finally, universities and colleges generate new knowledge and train the next generation workforce needed for the clean energy transition.

Table 5: Clean Energy Innovation Institutions

Institution name	Description of role	Innovation priorities from Table 4 that they contribute to	Description of funding modalities	Links
U.S. Department of Energy (DOE)	DOE supports research from early stage to commercialization through a set of basic and applied research programs, the Loan Program Office, and ARPA-E (see below).	Batteries, Nuclear, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.	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 National Laboratories to perform research to develop low carbon technologies and provide access to cutting edge research user facilities. The 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, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.	The National Laboratories receive grants and contracts from Federal and state agencies, and to a limited degree from the private sector.	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, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.	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

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.	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
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 U.S., 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 RD&D 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
U.S. Department of Commerce	The Department of Commerce houses the National Institute of Standards and Technology (NIST) – which performs research on advanced manufacturing, advanced transportation, advanced material, and cyber-physical infrastructure, among other things. 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.	NIST: Batteries, Nuclear, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels. NOAA: Solar, Offshore Wind, Carbon Removal, CCUS, Shipping, Methane Reduction.	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.	NIST NOAA
National Science Foundation (NSF)	NSF supports fundamental scientific research that underpins many of the developments needed in all of these climate and energy technologies.	Batteries, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.	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.	NSF

First Movers Coalition	Public-private initiative spurring innovation development and deployment by creating advanced market commitments for highly decarbonized materials.	Carbon Removal, Shipping, Industrial Decarbonization, HDVs, Sustainable Aviation Fuels.	Private companies, with support of the U.S. Government, commit to purchasing specific amounts of materials that meet shared decarbonization standards by 2030. Commitments are sector-specific (steel, aluminum, cement, chemicals, shipping, trucking, aviation, carbon removal) so clean technology companies receive clear demand signals and assurances about market size within the next decade.	First Movers Coalition
Universities and Colleges	Universities across the country perform research – from basic science to applied research on a broad range of topics related to the priority innovations discussed here. Universities are also the source of many clean energy start-ups.	Batteries, Nuclear, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.	Universities receive gifts, grants, and contracts for performing research and workforce training.	
Non-Profits and Foundations	There are many private sector companies, investors, consortia and partnerships investing in next generation clean energy technologies.	Batteries, Nuclear, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.	Various	
Private Sector Organizations	There are many private sector companies, investors, consortia and partnerships investing in next generation clean energy technologies.	Batteries, Nuclear, Solar, CCUS, Carbon Removal, Shipping, Geothermal, Fusion, Hydrogen, Industrial Decarbonization, Long Duration Energy Storage, HDVs, Methane Reduction, Buildings, Offshore Wind, Sustainable Aviation Fuels.	Various	