

CCUS and Hydrogen Efforts in the United States March 12, 2021

Jarad Daniels Director Office of Strategic Planning, Analysis and Engagement

Biden Administration Approach



"We'll take steps towards my goal of achieving 100 percent carbon-pollution-free electric sector by 2035. Transforming the American electric sector to produce power without carbon pollution will be a tremendous spur to job creation and economic competitiveness in the 21st century, not to mention the benefits to our health and to our environment."

President Joseph R. Biden, Jr.

"You can't get to [the] goal of net carbon zero without technologies that are being deployed and researched at the Department of Energy like CCUS...hydrogen solutions...direct air capture... [and other] technologies that the Department of Energy is working on to reduce and manage carbon emissions. And I think that is an important piece of the energy mix to... reach the goal of net zero carbon emissions by 2050."



Jennifer Granholm, Nominee, Secretary of Energy



"Climate change is an existential threat and one of the dominant forces shaping the world and our economy. Meeting this challenge is an urgent need, and I am committed to doing whatever I can to address this impending crisis. Using the tax code to set incentives for businesses and individuals to adopt climate-friendly policies is a critical tool in this battle."

Janet Yellen, Secretary of the Treasury

Biden Administration: Climate Priorities

- Re-establishing U.S. leadership in climate: Climate crisis will be central to U.S. foreign policy and national security
 - Rejoining the Paris Agreement
 - Reconvene the Major Economies Forum on Energy and Climate
 - Leaders' Climate Summit to raise climate ambition
- Taking a government-wide approach to the climate crisis: National Climate Task Force
- Building a 100% clean energy economy
 - Reaching net-zero emissions by 2050
 - Carbon pollution-free electricity sector no later than 2035
- Developing a climate finance plan
- Modernizing infrastructure towards a sustainable economy
 - "Greening" federal government procurement
 - Ensuring procurement and awards support the use of American-made goods and services in the clean energy supply chain
- Empowering workers and marginalized communities

The Role of CCUS – Critical to Addressing the Challenge

- CCUS is a key pillar in efforts to put the world on a path to net zero emissions
- Reaching net zero will be virtually impossible without CCUS
- CCUS tackles emissions from existing infrastructures – power, heavy industry
- CCUS is a pathway to low-carbon hydrogen at scale
- Mid-century net zero targets require a significant scale-up of CCUS



Global Energy Sector CO₂ Emissions Reductions – Sustainable Development Scenario Compared to Stated Policies Scenario



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* Energy efficiency includes enhanced technology performance as well as shifts in end-use sectors from more energy-intensive to less energy-intensive products (including through fuel shifts).

Notes: CCUS = carbon capture, utilisation and storage. See IEA (2020a) and the ETP model documentation for the definition of each abatement measure. Hydrogen includes low-carbon hydrogen and hydrogen-derived fuels such as ammonia.

Biden Administration: Priorities for CCUS and Hydrogen

- <u>Energy</u>: DOE will be essential to President Biden's climate mission to push the frontiers of science and engineering and catalyze clean energy jobs through research, development, demonstration, and deployment.
 - Accelerate technology development and deployment
 - Leverage the expertise of DOE's program offices and national laboratories to pursue innovations
 - Restore evidence-based decisions guided by the best available science and data to combat the climate crisis

• <u>CCUS</u>

- Expanding net negative technologies such as direct air capture (DAC) and bio-energy with CCS (BECCS)
- Simultaneously bring new carbon capture technologies to market, continue to fund carbon capture RD&D
- Enhance tax incentives for CCUS
- Retrofits for existing power plants
- Decarbonizing industry, especially in hard-to-abate sectors

<u>Hydrogen</u>

- Drive down cost of green hydrogen
- Focus on "carbon-free" hydrogen

CCUS and Hydrogen: Consolidated Appropriations Act (2021)

- Sets out funding, programs, and reports on carbon dioxide removal; demonstration projects; direct air capture; industrial emissions; and hydrogen
- Requires interagency effort and coordination to support CCUS
 - Taskforces on carbon dioxide removal and permitting
 - Direct air capture technology board
 - Reports on regulations, storage, demonstration projects, and CO₂ utilization
- Directs agencies to conduct studies on blue hydrogen, commercializing carbon, CO₂ utilization

"The Energy Act represents the first modernization of our nation's energy policies in well over a decade. This bipartisan package will foster innovation across the board on a range of technologies that are critical to our energy and national security, our longterm economic competitiveness, and the protection of our environment..." -Sen. Lisa Murkowski, R-Alaska, Chairman of the Senate Energy and Natural Resources Committee

"The Energy Act of 2020 provides a down payment on the technologies that will be critical to reducing greenhouse gas emissions in the power sector, industry, and buildings and addressing climate change. This focus on research, development, and demonstration will create high quality jobs and ensure the United States continues to lead the world in the clean energy future..." -Senator Joe Manchin, D-W.Va., Ranking Member of the Senate Energy and Natural Resources Committee

Section 45Q Tax Credits

- Tax benefits have been available since 2008 for qualified CCUS projects in the United States
- In 2018, benefits were significantly expanded and extended to include:
 - Increased credit amount: Saline storage: \$50/tonne; utilization: \$35/tonne
 - Expanded qualified carbon oxides to include carbon monoxide (CO)
 - Expanded qualified uses to include CO₂ utilization other than enhanced oil or natural gas recovery
- Congress recently approved a two-year extension of credit (Consolidated Appropriations Act, 2021)
 - Construction must begin by January 1, 2026
- The Internal Revenue Service (IRS), in consultation with EPA, DOE, and other agencies, finalized the rule in January 2021, providing clarified guidance to stakeholders on areas such as:
 - Monitoring and verification for geologic storage
 - Life cycle analysis provisions for utilization
 - **Recapture** of carbon dioxide
 - Definition of carbon capture equipment
 - Qualified facility (ex: industrial or DAC)
- 35 projects are in initial planning stages, having been inspired by 45Q updates and state level incentives such as the California Low Carbon Fuel Standard (LCFS)

Active CCUS Projects in the United States

- 35 active CCUS projects in the U.S. across various industries:
 - 16 power projects, some including multiple stations/units
 - 7 ethanol projects
 - 11 industrial projects
 - 1 DAC project
- Many of these projects have been announced since the 45Q tax credit values were increased*
- Projects are in various stages of development:
 - 12 projects have only been announced with limited public information
 - 15 projects are actively working on pre-FEED or FEED studies
 - 8 projects are in detailed engineering and/or are ready for construction

**Clean Air Task Force (CATF),* "CCUS Project Tracker: Potential Carbon Capture Projects Database,": https://docs.google.com/spreadsheets/d/115hsADg3ymy3IKBy4PBQRXz_MBknptqlRtlfuv79XV8/edit#gid=0

Overview of CCUS RD&D in the United States

- 40+ year history of CO₂ utilization for EOR and over 600 million tons of associated storage with EOR
- Over 8,000 km of CO₂ pipelines in the United States
- Strong efforts in developing the human capital and enablers for CCUS deployment (scientists, engineers, trades)
 - Broad R&D program engaging private industry, universities, National Laboratories, small businesses, and the financial community
- World-class R&D program that advances technology and supports policy development
- Has successfully invested in major CCUS demonstrations
- As of December 30, 2020: approximately 12.57 million metric tons (MMT) of CO₂ have been captured
 - Air Products: ~6.66 MMT
 - Petra Nova: ~3.84 MMT
 - ADM: ~2.07 MMT



Air Products Facility (Port Arthur, TX) – Operations began in 2013



Petra Nova CCS (Thompsons, TX) – Operations began in 2017



ADM Ethanol Facility (Decatur, IL) – Operations began in 2017

U.S. Technical Support - Federal Investment in DOE CCUS R&D



Carbon Capture

R&D and scale-up technologies for capturing CO₂ from new and existing industrial and powerproducing plants, and direct air capture



CO₂ Utilization R&D and technologies to convert CO₂ to value-added products



Carbon Storage

Safe, cost- effective, and permanent geologic storage of CO₂



Carbon Capture Carbon Storage Carbon Utilization

Carbon Capture: Post-Combustion, Pre-Combustion, and Direct Air Capture - Focus on Cost Reduction, Energy Penalty, and Integration

Kiln off-gas







World-class testing capabilities at the National Carbon Capture Center

Stripping vent

Distillation gas

CO, vent

- Create products that capture and store CO₂ indefinitely and provide a new revenue stream.
- Explore multiple pathways.
- Evaluate lifecycle emissions.



Carbon Storage Program: Improving and Optimizing Performance



CarbonSAFE





Brine Extraction Storage Tests (BEST)



National Risk Assessment Partnership (NRAP) is developing toolsets to reduce uncertainty and quantify potential impacts related to release of CO₂ and induced seismicity



Advancing monitoring and measurement tools: improving characterization and reducing the uncertainty about the CO₂ and pressure fronts.



Fiber Optic Distributed Acoustic Sensing (DAS)



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Knowledge Sharing Products



DOE-FE Investments in Hydrogen R&D

DOE is committed to developing technologies to enable expansion of low-carbon hydrogen production, transport, storage, and use in the United States. The Office of Fossil Energy, in coordination with the Offices of Energy Efficiency and Renewable Energy, Nuclear Energy, Electricity, and Science as well as ARPA-E, contributes to the implementation of the DOE Hydrogen Program Plan.

Aligning H₂ R&D with the DOE Hydrogen Program Plan

- Carbon-Neutral Hydrogen Production Using Gasification and Reforming Technologies
- Large Scale Hydrogen Transport Infrastructure
- Large Scale On-site and Geological Hydrogen Storage
- Hydrogen Use for Electricity Generation, Fuels, and Manufacturing.

Demonstration Project FEED Studies

 Gasification of coal, biomass and waste plastics for net-negative-carbon power and hydrogen: 2 awards

Commercial Projects

 Air Products' Port Arthur low-carbon hydrogen production facility: SMR with CCUS



State of Hydrogen Production Today

- Currently 99% of 10 MMT in the U.S. supplied by fossil fuels least cost
 - 96% by SMR
 - 3% by gasification
 - 1% by electrolysis
- 70 MMT produced globally
 - 76% by SMR
 - 22% by gasification
 - 2% by electrolysis
- Small fraction includes CCUS
- Economics dominates production mix



International Collaborations in CCUS, Carbon Recycling and Hydrogen

Multilateral Partnerships

International Energy Agency (IEA)

- Working Party on Fossil Energy (WPFE)
- CCUS Unit CCUS Roadmap and International CCUS Regulatory Network <u>Technology Cooperation Programmes (TCP)</u>:
- Greenhouse Gas R&D Programme (GHG)
- Clean Coal Centre
- Hydrogen

Clean Energy Ministerial (CEM) CCUS Initiative Carbon Sequestration Leadership Forum (CSLF) Mission Innovation Carbon Capture Challenge APEC Expert Group on Clean Fossil Energy (APEC EGCFE) UN Economic Commission for Europe (UNECE) Accelerating CCS Technologies (ACT) initiative

U.S.-Japan collaboration – recent activities

Memorandum of Cooperation on CCUS and Carbon Recycling (including blue hydrogen)

- DOE-METI CCUS and Carbon Recycling Workshop held in October 2020
- DOE-METI Hydrogen Workshop held in January 2021



Clean Energy Ministerial (CEM) CCUS Initiative

- **Members:** Canada, China, Japan, Mexico, Netherlands, Saudi Arabia, South Africa and United Arab Emirates, United Kingdom, and the United States
- **Mission:** Accelerating CCUS through:
 - Bringing together governments, private sector, and investment community
 - Facilitating identification of both near and longer-term investment opportunities
 - Disseminating best practices in CCUS policy, regulation, and investment

• The CEM CCUS Initiative engages with:

- Industry: oil, gas, cement, and steel
- Financial institutions: private banks, investment firms, multilateral banks (MDBs)
- Organizations: CSLF, IEA, IEAGHG, Oil and Gas Climate Initiative (OGCI), etc.

Recent activities:

- CCUS workshop at Asia Clean Energy Forum (ACEF) in June 2020
- Creation of Finance Sector Lead Group for CCUS and Launch of Key Financing Principles for CCUS at CEM11 Meeting in September 2020
- Webinar series on topics such as: CCUS in the cement sector; country updates from the Netherlands, Japan, and China; and direct air capture of CO₂

CEM CCUS Initiative: accelerating CCUS together by:



Key Financing Principles for CCUS (1)

Industry, governments and the financial sector should communicate the *importance of CCUS*.



Key Financing Principles for Carbon Capture, Utilisation and Storage















These Key Financing Principles for CCUS were prepared in close consultation with public and private financial sector organisations, through a series of meetings held under Chatham House Rule between January-July 2020. The development process for the Principles engaged several Multilateral Development Banks, major international private banks, regional and national finance institutions, institutional investors, other investment firms and advisers.







Government policies should establish a *revenue stream* for CCUS to facilitate private sector investment.

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The financial sector, industry and government should work together to facilitate CCUS investment and help *mitigate the risks* of CCUS deployment.

Industry, the financial sector and governments should work together to establish a *pipeline of CCUS projects*.

The financial sector should ensure CCUS is part of their *climate change strategies* and is eligible for sustainable finance.



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Key Financing Principles for CCUS (2)

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The financial sector should strive to accelerate the development of *novel financing approaches* to CCUS



Governments should consider CCUS as part of their *Nationally Determined Contributions* (NDC) under the Paris Agreement.



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Governments should utilize existing development and climate institutions to advance CCUS in *developing countries*.

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Governments should consider CCUS investment as a means of creating and preserving sustainable jobs and providing a *low-carbon stimulus* to the economy.

Industry, governments and the financial sector should consider CCUS investment as a means of driving *innovation* and supporting broader *industrial development*.



Key Financing Principles for Carbon Capture, Utilisation and Storage











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Carbon Sequestration Leadership Forum (CSLF)

- **Multilateral initiative** focused on developing improved cost-effective technologies for carbon capture and storage (CCS). It also promotes awareness and champions legal, regulatory, financial, and institutional environments conducive to such technologies.
- **Mission** to facilitate development of CCS technologies via collaborative efforts that address key technical, economic, and environmental obstacles.

Ongoing and planned activities:

- Refresh of Technology Roadmap with recommendations to ministers of CSLF countries on technology developments needed to accelerate CCUS deployment (Spring 2021)
- Academic Task Force
- Workshops on targeted topics of interest, e.g. hubs and clusters, industrial capture.





Accelerating CCS Technologies (ACT) Initiative

- International initiative to facilitate RD&D and innovation
- Includes members from 16 countries, regions, and provinces
- Members include funding agencies from Alberta Province (Canada), Denmark, France, Germany, Greece, India, Italy, the Netherlands, Norway, Nordic Energy, Romania, Spain, Switzerland, Turkey, United Kingdom, and United States
- Second funding call in November 2019: 7 of 12 projects selected have U.S. involvement and funding
- FE committed \$4 million for national laboratories to collaborate with international partners on these seven projects
- Third funding call announced on June 2, 2020



www.act-ccs.eu

International Energy Agency (IEA)

- IEA CCUS Unit
- IEA Working Party on Fossil Energy (WPFE)
- IEA Technology Collaboration Programmes (TCPs)
 - <u>IEA Clean Coal Centre</u>: World's foremost provider of information on clean and efficient use of coal, which is balanced and objective without political or commercial bias
 - <u>IEA Greenhouse Gas R&D Programme:</u> International collaborative research program established in 1991 to evaluate technologies that can reduce greenhouse gas emissions derived from the use of fossil fuels
 - IEA Hydrogen: In process of rejoining









For More Information



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