

Appalachian Regional Clean Hydrogen Hub (ARCH2)

Neeraj Gupta, Battelle
Appalachian Carbon Forum
Lexington, KY, Mar 2024



Our mission and purpose

- Nonprofit, charitable trust formed in 1925
- Our mission: To translate scientific discovery and technology advances into societal benefits



Gordon Battelle, Founder

Research & Development

We're solving our customers greatest challenges today while funding internal research to address tomorrow's threats.

STEM Education

We're bringing quality science, technology, engineering and math (STEM) education to millions of students across the U.S.

Philanthropy

Our profits are reinvested not only in science and technology, but also in charitable causes.

Re-energizing Appalachia
Economically • Socially • Environmentally

And Then There Were 7

- **Appalachian Hydrogen Hub (Appalachian Regional Clean Hydrogen Hub (ARCH2); West Virginia, Ohio, Pennsylvania)**
- **California Hydrogen Hub (Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES); California)** — The California Hydrogen Hub will produce hydrogen exclusively from renewable energy and biomass. It will provide a blueprint for decarbonizing public transportation, heavy-duty trucking, and port operations
- **Gulf Coast Hydrogen Hub (HyVelocity H2Hub; Texas)** — The Gulf Coast Hydrogen Hub plans for large-scale hydrogen production using both natural gas with carbon capture and renewables-powered electrolysis, leveraging the Gulf Coast region's abundant renewable energy and natural gas supply to drive down the cost of hydrogen
- **Heartland Hydrogen Hub (Minnesota, North Dakota, South Dakota)** — The Heartland Hydrogen Hub will leverage the region's abundant energy resources to help decarbonize the agricultural sector's production of fertilizer,
- **Mid-Atlantic Hydrogen Hub (Mid-Atlantic Clean Hydrogen Hub (MACH2); Pennsylvania, Delaware, New Jersey)** — It plans to develop renewable hydrogen production facilities from renewable and nuclear electricity using both established and innovative electrolyzer technologies
- **Midwest Hydrogen Hub (Midwest Alliance for Clean Hydrogen (MachH2); Illinois, Indiana, Michigan)** — The Midwest Hydrogen Hub will enable decarbonization through strategic hydrogen uses including steel and glass production, power generation, refining, heavy-duty transportation, and sustainable aviation fuel.
- **Pacific Northwest Hydrogen Hub (PNW H2; Washington, Oregon, Montana)** — The Pacific Northwest Hydrogen Hub plans to leverage the region's abundant renewable resources to produce clean hydrogen exclusively via electrolysis. Its anticipated widescale use of electrolyzers will play a key role in driving down electrolyzer costs, making the technology more accessible to other producers, and reducing the cost of hydrogen production.

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Why ARCH2

RESOURCES

- Largest natural gas-producing formation in the United States (EIA, 2022)
- Natural gas spot prices consistently discounted to Henry Hub
- Renewable electricity sources for H₂ production
- Subsurface CO₂ and H₂ storage



COMMUNITIES

- Long history of energy production vital to US economic growth
- Disadvantaged by energy transition from coal
- Designated ENERGY COMMUNITY by IWG



LOCATION

- Close to major demand centers in all directions key for interhub connectivity
- Includes eight of the top 25 priority communities as designated by the Interagency Working Group (IWG) on Coal and Power Plant Communities and Economic Revitalization



APPALACHIA

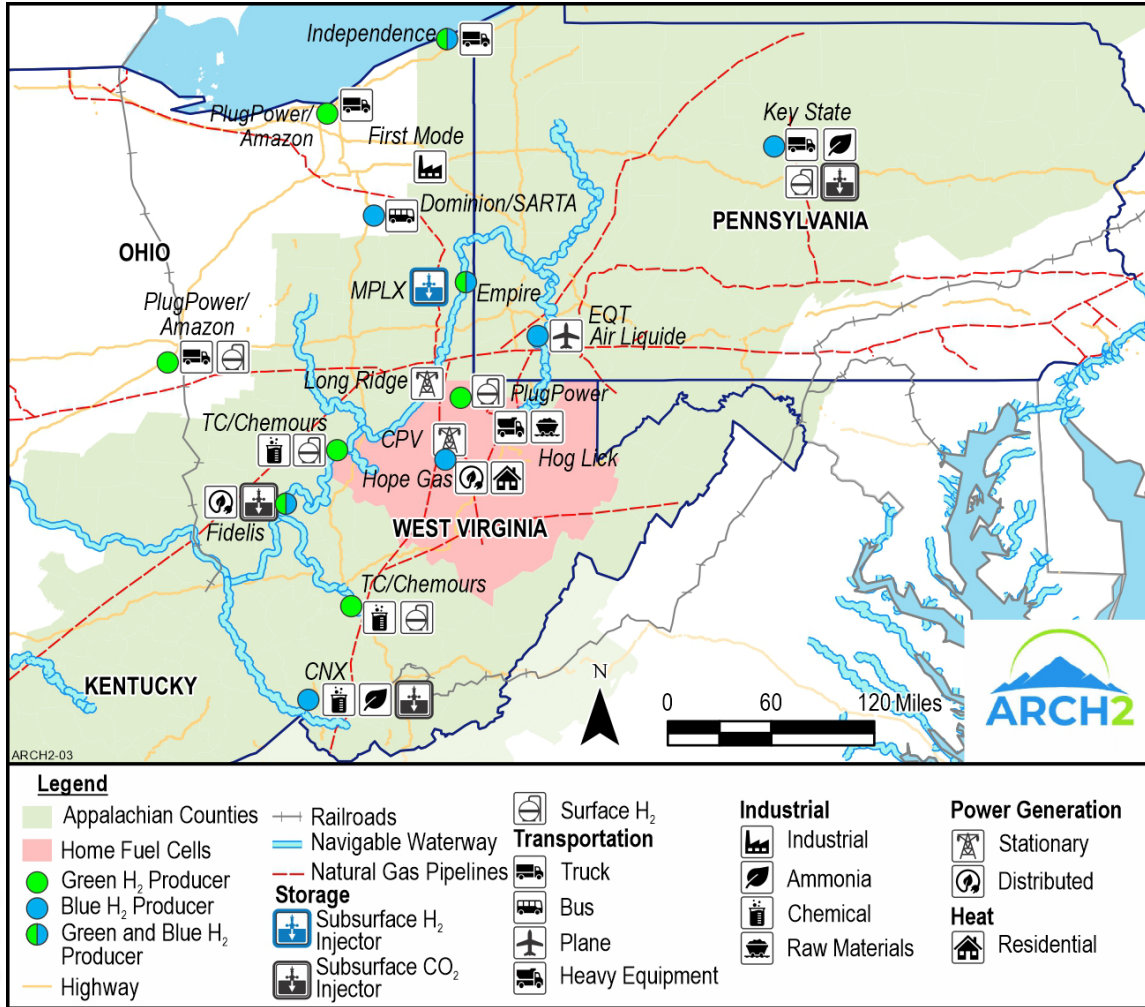
Project Development Partners

- Decades of expertise in the region
- Strong financial commitment to ARCH2
- Leadership in ESG and Climate initiatives



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ARCH2 Overview



PROGRAM MANAGEMENT AND TECHNICAL SUPPORT

BATTELLE GTI ENERGY AST TRC NATIONAL ENERGY TECHNOLOGY LABORATORY

PROJECT DEVELOPERS

Air Liquide Chemours CNX Dominion Energy EMPIRE Diversified Energy EQT FIDELIS NEW ENERGY HOG LICK AGGREGATES Hope Gas IH Independence Hydrogen KeyState Energy MPLX TC Energy Plug

ARCH2 ECOSYSTEM

Executive Board	BATTELLE GTI ENERGY AST EQT
Advisory Board	WEST VIRGINIA UNIVERSITY WEST VIRGINIA UNIVERSITY WEST VIRGINIA UNIVERSITY WEST VIRGINIA UNIVERSITY
Educational Alliance	WVSU Mountwest Community & Technical College THE OHIO STATE UNIVERSITY KENT STATE UNIVERSITY CLEVELAND STATE UNIVERSITY 1964 MARSHALL
Transit Authorities	SARTA POTOMAC VALLEY TRANSIT AUTHORITY Fairmont-Marion County Transit Authority MTA Mountain Transit Authority OHIO VALLEY EASTERN OHIO
Connective Infrastructure	National Fuel ENBRIDGE APPALACHIAN POWER TRILLIUM H ₂ POWER CLEAN ENERGY JOBS & MANUFACTURING DT Midstream
Community/Business Groups	AFL-CIO CA TF CLEAN AIR TASK FORCE JobsOhio IN-MARKET

Note: Proposed project locations based on preliminary siting are subject to change during the detailed planning phase (phase 1).

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ARCH2 Regional Outreach

Labor / Trades / Workforce Development



> 10 unions, trades organizations, and employment agencies

Business Development / Industry Organizations



> 40 service providers

Community / Environment / Non-Profits



> 15 environmental, special interest groups, and faith-based organizations

Academia



> 15 universities, community colleges, and trade schools

Government



> 25 federal, state, local, and tribal

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Carbon capture, utilization, and storage (CCUS)

Value chain – underpinned by subsurface science and engineering

Enterprise Strategic Planning

- Carbon footprint analysis – local, corporate, regional, national, global scales

CO₂ Sources and Capture

- High purity – ethanol, ammonia (NH₃), gas processing
- Low purity – power, steel, cement etc.
- Atmospheric – direct air capture

CO₂ Handling and Transport

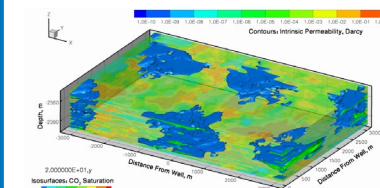
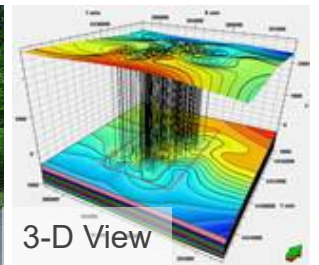
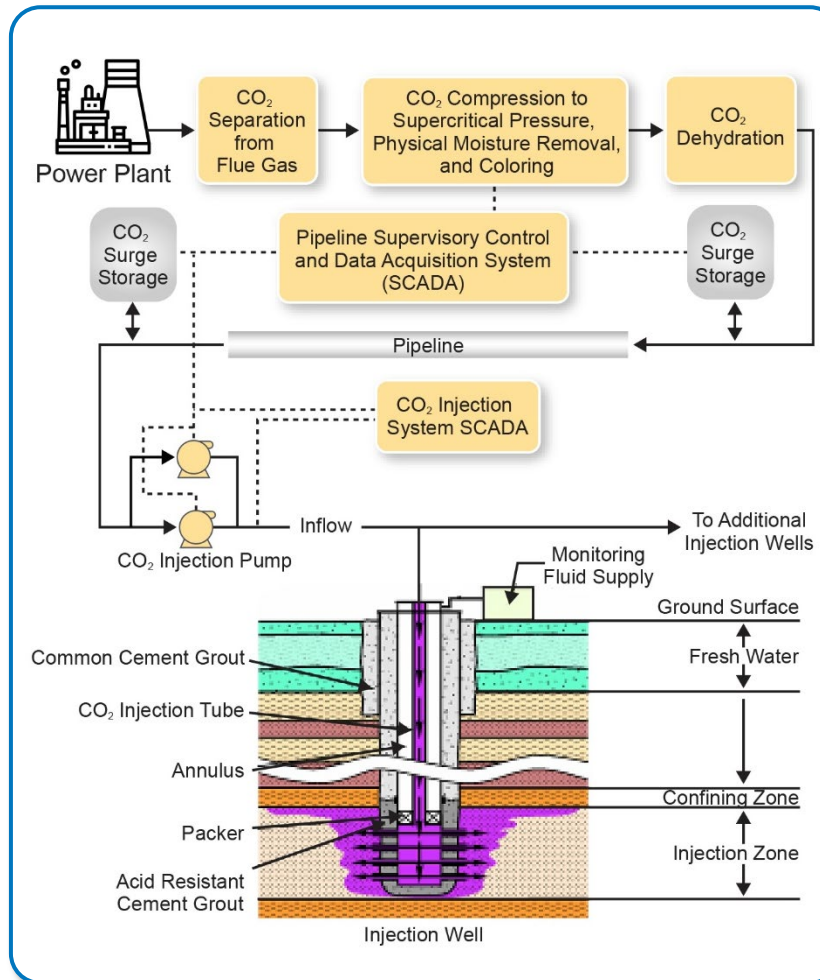
- Regional infrastructure
- Compression, pipeline, or truck
- Optimization and regional integration
- Monitoring (inspection, corrosion analysis)

Subsurface and Injection

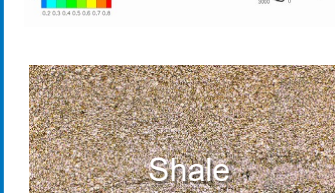
- Site characterization – geoscience, reservoir engineering
- Permitting and environmental
- Well field design and implementation
- Injection operations

Measurement, Monitoring, and Verification

- Long-term monitoring technologies
- Data analysis and machine learning
- Site closure and handover



Reservoir Modeling



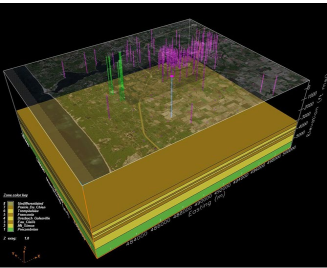

Battelle CCUS includes government, industry, & international projects on CO₂ storage over 25 years

MRCSP/MRCI Large-Scale Public-Private Partnership


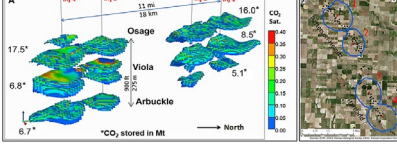




Commercial Carbon Storage Development

CarbonSAFE Scaling Up

Nebraska & Kansas, Ohio, Michigan, Mississippi

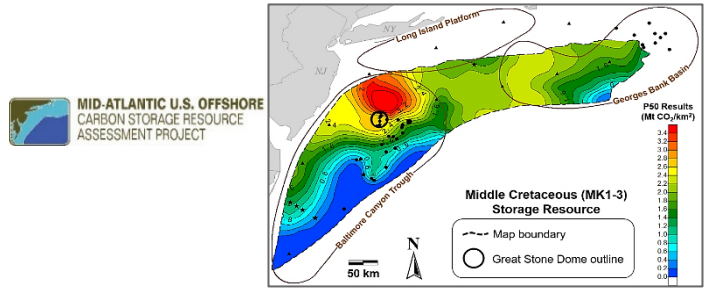
International CCUS Development



AEP Mountaineer Pilot and FutureGen



Offshore Carbon Storage



MID-ATLANTIC U.S. OFFSHORE CARBON STORAGE RESOURCE ASSESSMENT PROJECT

Middle Cretaceous (MK1-3) Storage Resource

Map boundary

Great Stone Dome outline

50 km

PSZ Results (Mt CO₂/km²)