

CLEAN ENERGY INNOVATION IN THE UNITED STATES

Approaches to Commercializing CCUS and Hydrogen

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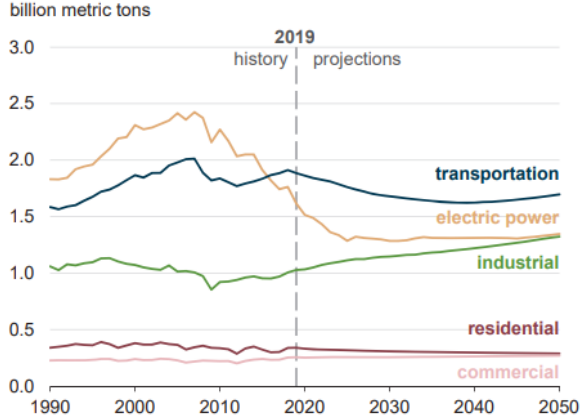


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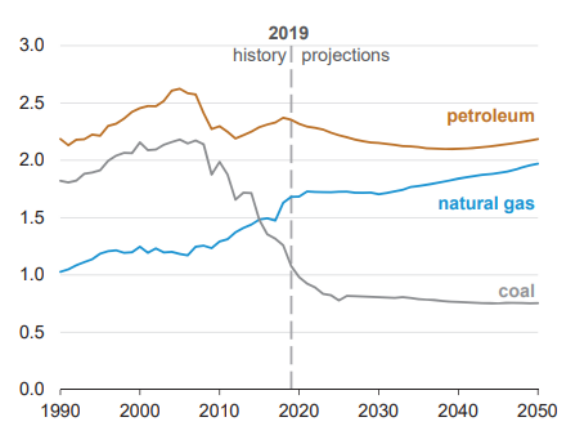
INTRODUCTION: THE UNITED STATES

AEO2020 energy-related carbon dioxide emissions increase in the industrial sector, increase as a result of natural gas consumption, but remain relatively flat in other sectors and fuels through 2050

Energy-related CO2 emissions by energy sector (AEO2020 Reference case)
billion metric tons



Energy-related CO2 emissions by fuel (AEO2020 Reference case)
billion metric tons



ADVANCING CCS

In this region, CCS deployment is supported by **strong policy frameworks, abundant geological storage, diverse stakeholder support and a wealth of private-sector experience**



U.S. Energy Information Administration

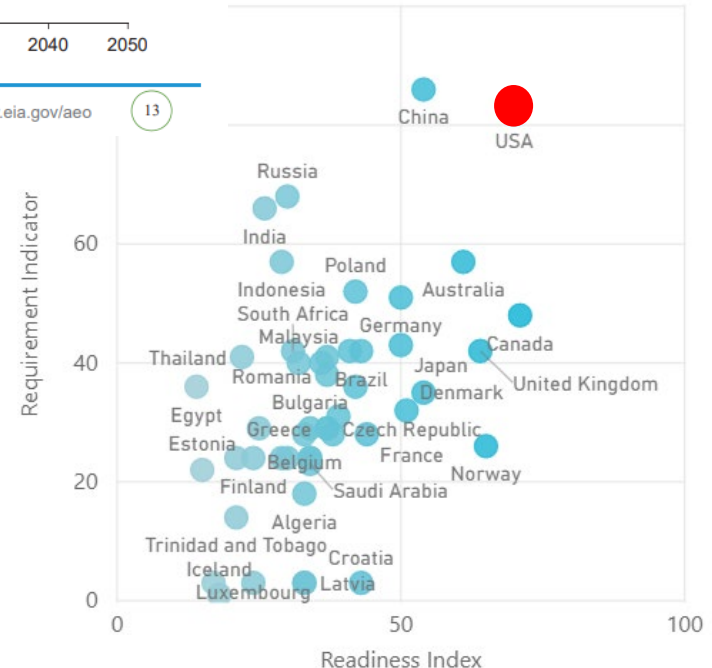
#AEO2020 | www.eia.gov/aeo

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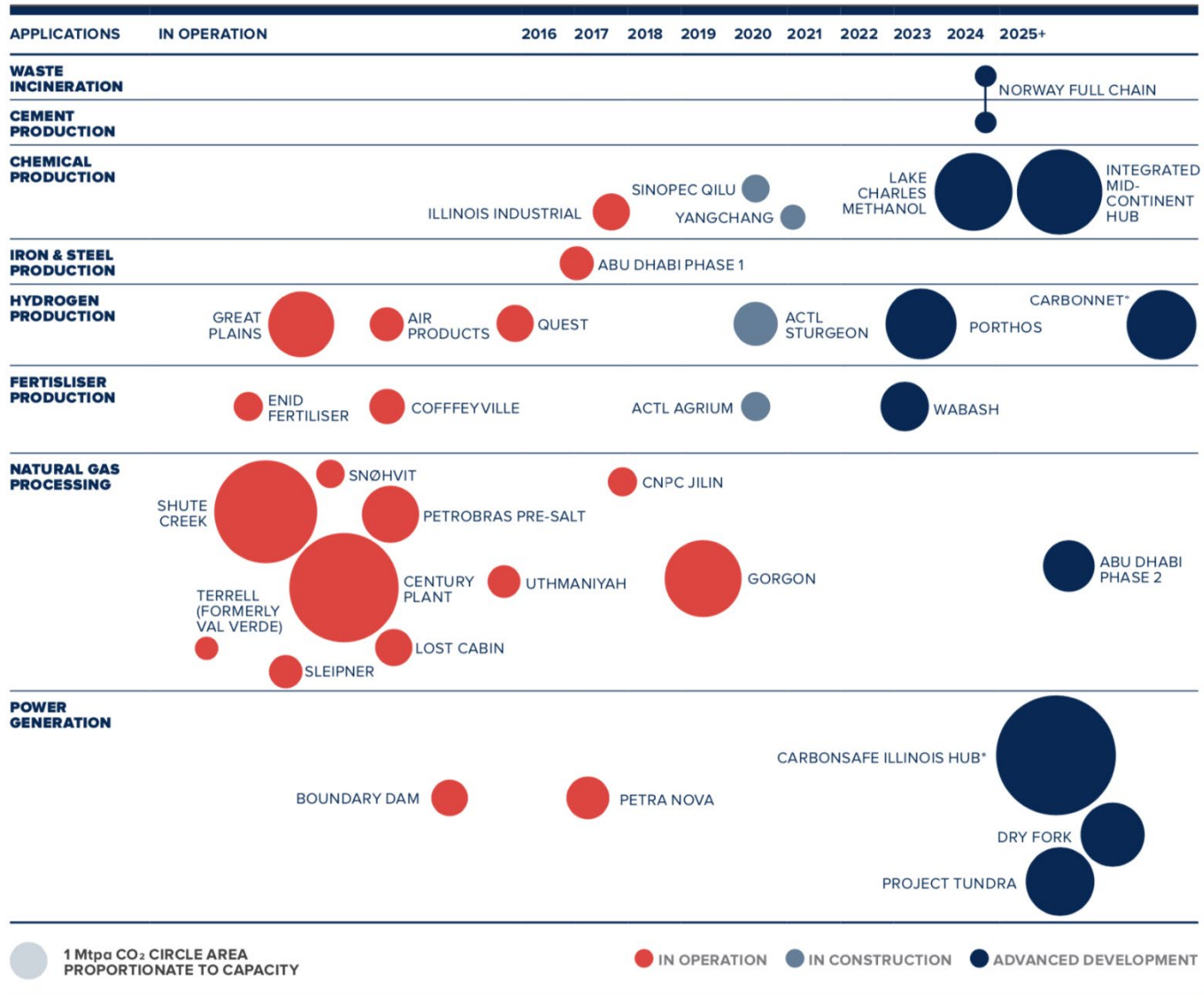
US EMISSIONS PROFILE AND THE POTENTIAL FOR CCS TO MAKE A DIFFERENCE...

Power sector accounts for **28% of the US's greenhouse gas emissions**. In 2019, the Institute added three power plant retrofits to our Institute database. When operational will capture up to a further **10.3 Mtpa of CO₂**.

10.3 MtCO₂
ADDED CAPTURE CAPACITY FROM COAL RETROFIT



1. THE US IS A LEADER IN CCS DEPLOYMENT



2. THE US IS IN AN IDEAL POSITION FOR THE LARGE-SCALE PRODUCTION OF HYDROGEN

1. CCS Projects

- Great Plains Synfuel Plant, 1300 tonnes H₂ per day, North Dakota, USA
- Coffeyville Gasification Plant, 200 tonnes H₂ per day, Kansas, USA
- Air Products SMR Valero Refinery, 500 tonnes H₂ per day, Texas, USA

2. Abundance of cheap natural gas & geologic storage

3. Private sector expertise

4. California a leader in hydrogen policy and deployment



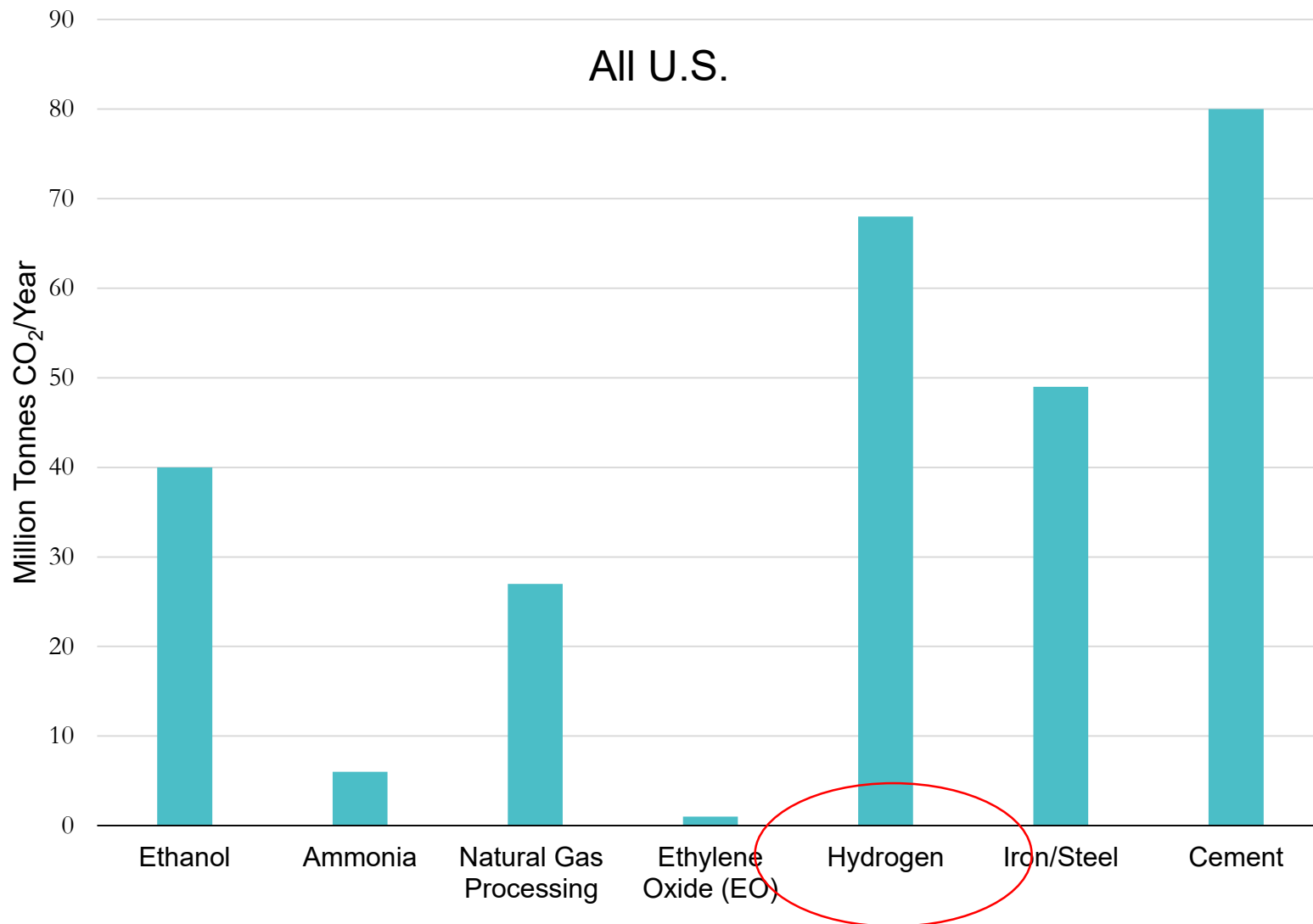
3. HYDROGEN DEPLOYMENT ROADMAP & POLICIES

- Strong demand-side mechanisms:
- Renewable Energy Tax Credits
- Fuel Cell Investment Tax Credit through 2022

	Today	2022	2025	2030
	Immediate next steps	Early scale-up	Diversification	Broad rollout
H ₂ demand, metric tons 	11 m	12 m	13 m	17 m
FCEV sales 	2,500	30,000	150,000	1,200,000
Material-handling FCEVs 	25,000	50,000	125,000	300,000
Fueling stations ¹ 	63	165 ²	1,000 ²	4,300 ³
Material-handling fueling stations ⁴ 	120	300	600	1,500
Annual investment		\$1 bn	\$2 bn	\$8 bn

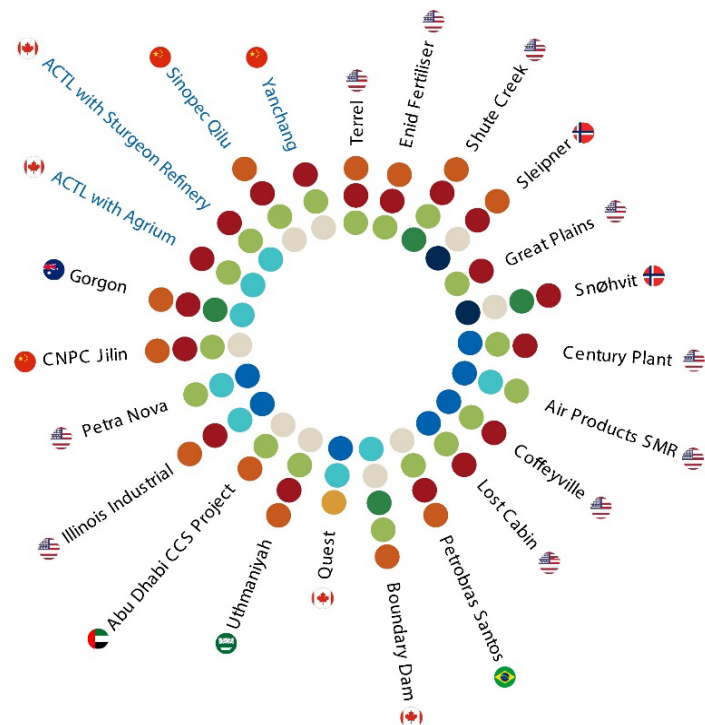


OPPORTUNITIES FOR INDUSTRIAL CAPTURE



CCS DEPLOYMENT FRAMEWORK

1. A value on carbon
2. Reducing risk and enabling investment
3. Infrastructure and geologic storage



POLICIES & PROJECT CHARACTERISTICS

- Carbon Tax
- Tax Credit or emissions credit
- Grant Support
- Provision by Government or SOE
- Regulatory Requirement
- Enhanced Oil Recovery
- Low Cost Capture
- Low Cost Transport and Storage
- Vertical Integration

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The facilities in light blue are under construction.

GLOBAL CCS INSTITUTE

APRIL 2019 THOUGHT LEADERSHIP REPORT

POLICY PRIORITIES TO INCENTIVISE LARGE SCALE DEPLOYMENT OF CCS

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General Manager – Commercial

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45Q TAX CREDITS

- Provides capture operators with credits for each tonne of CO₂ stored or utilised that can be used to reduce their tax liability
- Reformed under the Bipartisan Budget Act in 2018, which included an increase to the tax credit value
- IRS guidance and rule pending
- Can be combined with the LCFS

TYPE OF CO ₂ STORAGE/USE	MINIMUM SIZE OF ELIGIBLE CARBON CAPTURE PLANT BY SIZE (KtCO ₂ /YR)			RELEVANT LEVEL OF TAX CREDIT GIVEN IN OPERATIONAL YEAR (USD/tCO ₂)									
	POWER PLANT	OTHER INDUSTRIAL FACILITY	DIRECT AIR CAPTURE	2018	2019	2020	2021	2022	2023	2024	2025	2026	LATER
DEDICATED GEOLOGICAL STORAGE	500	100	100	28	31	34	36	39	42	45	47	50	
STORAGE VIA EOR	500	100	100	17	19	22	24	26	28	31	33	35	INDEX LINKED
OTHER UTILISATION PROCESSES*	25	25	25	17	19	22	24	26	28	31	33	35	

*Each CO₂ source cannot be greater than 500 ktCO₂/yr. Any credit will only apply to the portion of the converted CO₂ that can be shown to reduce overall emissions.



LCFS CCS PROTOCOL



DIRECT AIR CAPTURE PROJECTS



CCS AT OIL & GAS PRODUCTION FACILITIES



CCS AT REFINERIES PROJECTS



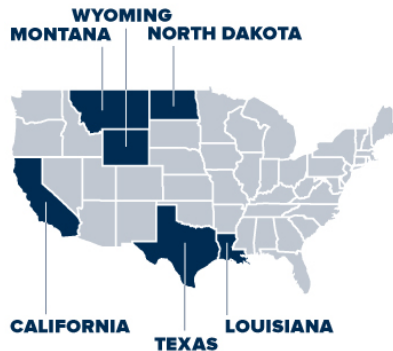
ALL OTHER CCS PROJECTS (E.G. CCS WITH ETHANOL)

Location of CCS project	Anywhere in the world	Anywhere, provided they sell the transportation fuel in California	Anywhere, provided they sell the transportation fuel in California	Anywhere, provided they sell the transportation fuel in California
Storage site	Onshore saline or depleted oil and gas reservoirs, or oil and gas reservoirs used for CO ₂ -EOR			
Credit method	Project-based	Project-based, under the Innovative Crude Provision	Project-based, under the Refinery Investment Credit Program	Project-based or fuel pathway
Earliest date which existing projects eligible	Any	2010	2016	Any
Requirements	Project must meet requirements specified in the CCS Protocol			
Additional restrictions	None	Must achieve minimum CI or emission reduction	None	None



ACTIVE STATES

In the US, states that are active in CCS incentives and progression are: **California, Montana, Texas, North Dakota, Louisiana and Wyoming.**



KEY US POLICY

Section 45Q of the Internal Revenue Code establishes tax credits for storage of CO₂.

Several CCS supportive bills were introduced in 2019 including the USE IT Act.

California's LCFS is a credit-based trading mechanism applies to CCS projects that lower the emissions intensity of fuels in the California market.



STATE POLICIES

- Clean Energy Standards
- Technology-neutral support for hydrogen
- Climate Neutrality in California
- Permitting Primacy
- Tax Credits and Further Incentives

POLICY DRIVES INNOVATION TRENDS



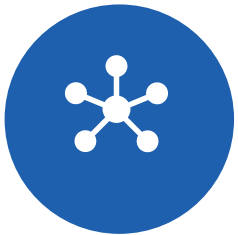
**NEGATIVE
EMISSIONS**



**INDUSTRIAL
CARBON
CAPTURE**



**NEW BUSINESS
MODELS**



**HUBS &
CLUSTERS**



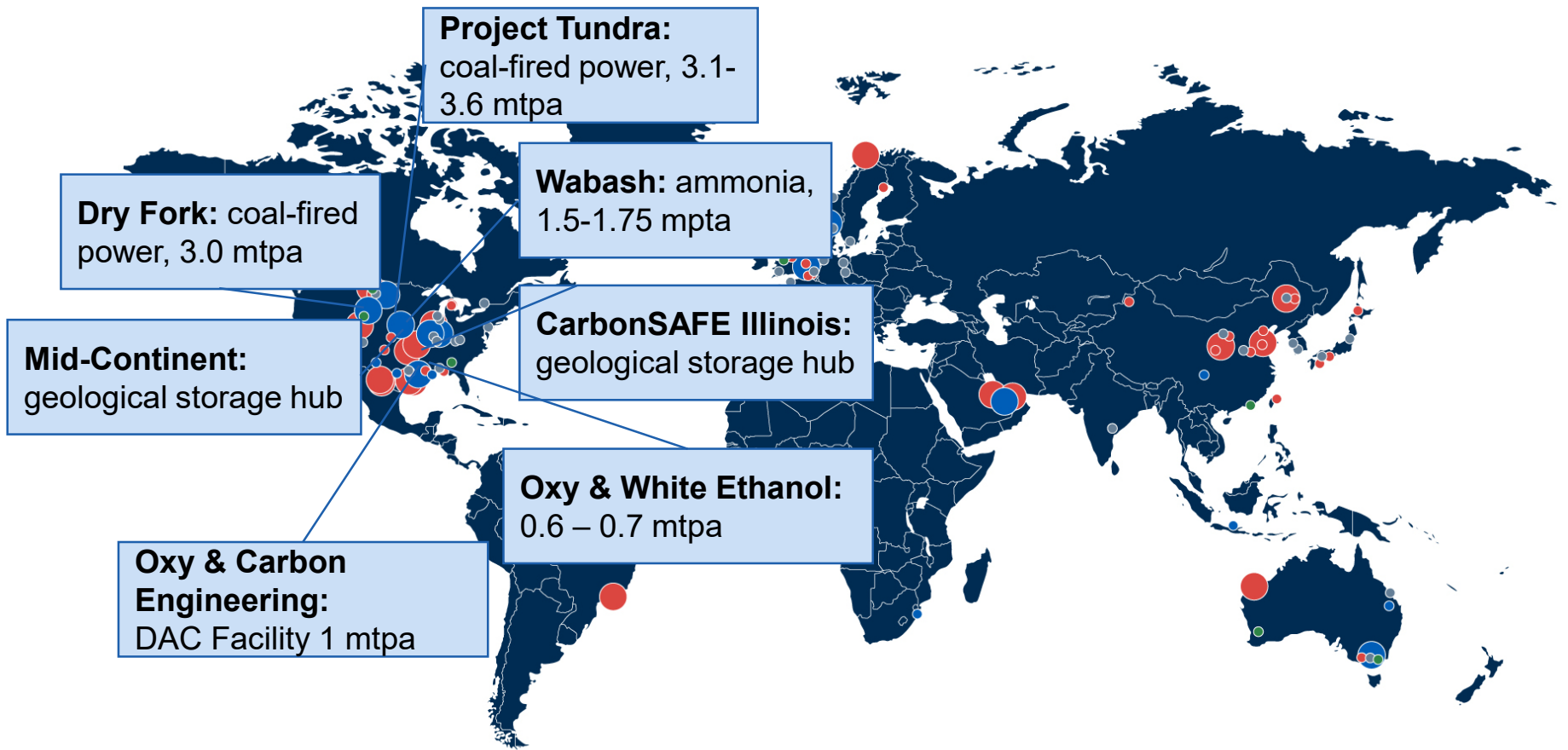
UTILIZATION



**NEW
PARTNERSHIPS**



POLICY PRESENCE LEADS TO PROJECTS



- LARGE SCALE CCS FACILITIES IN OPERATION & CONSTRUCTION
 - LARGE SCALE CCS FACILITIES IN ADVANCED DEVELOPMENT
 - LARGE SCALE CCS FACILITIES COMPLETED
 - PILOT & DEMONSTRATION SCALE FACILITY IN OPERATION & CONSTRUCTION
 - PILOT & DEMONSTRATION SCALE FACILITY IN ADVANCED DEVELOPMENT
 - PILOT & DEMONSTRATION SCALE FACILITY COMPLETED
 - TEST CENTRE
- LARGE SCALE = >400,000 TONNES OF CO₂ CAPTURED PER ANNUM



NEW PROJECTS AND TRENDS

BUSINESS // ENERGY

Oxy, Total partner on carbon capture project in Colorado



Jordan Blum

Los Angeles Times

CLIMATE & ENVIRONMENT

Turning carbon into concrete could win UCLA team a climate victory — and \$7.5 million



US leads new wave of carbon capture and storage deployment

BY BRAD PAGE, OPINION CONTRIBUTOR — 01/05/20 01:00 PM EST
THE VIEWS EXPRESSED BY CONTRIBUTORS ARE THEIR OWN AND NOT THE VIEW OF THE HILL

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ENVIRONMENT JANUARY 9, 2019 / 6:10 AM / A YEAR AGO

Just In...

76 SHARES



Chevron, Occidental invest in CO2 removal technology

// Industry 14th October 2019



Velocys signs CCUS agreement for its US biomass-to-fuel plant

Article by Amanda Doyle



CO2 UTILIZATION UPDATES

- Strongly driven by smaller players and the private sector
- CarbonCure, Blue Planet, and Solidia Technologies have various sized concrete and aggregates projects underway worldwide, many in North America.
- BluePlanet bubbles waste gases from California's largest power plant at Moss Landing through seawater, collecting CO2. Around 90 per cent is removed and then combined with minerals in the water to create limestone.
- Lanzatech creates chemical products and fuels using emissions from industrial facilities, and has several projects around the globe.
- Cemvita Factory uses CO2 as the feedstock for sustainable production of intermediate chemicals and polymers.



CHALLENGES AHEAD

- Near-term roll-out of hydrogen
- CCS on natural gas
 - Average age of a natural gas plant is 21 years in the US
- Expanding enabling policies
 - Demand-side policies e.g. buy clean
 - Recognizing CCS under cap-and-trade schemes
 - No new, unabated sources of emissions & regulation of emissions
 - Clean Energy Standards
 - Carbon-negative oil through Enhanced Oil Recovery
- Investment support mechanisms: Grants, investment tax credits
- Support for hubs & clusters





**URGENT ACTION
IS REQUIRED TO
ACHIEVE CLIMATE
CHANGE TARGETS
CARBON CAPTURE &
STORAGE IS VITAL**

