WHAT IS CARBON CAPTURE, UTILIZATION & SEQUESTRATION? WHY NOW, WHY HERE?

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OUTLINE

- Underlying the Energy Transition: Energy Trilemma
 - Environmental & Climate Challenges
 - Global Demand & Supply Challenges
 - Capacity & Growth
- Technology Opportunities
 - Temporal & Spatial Applicability
 - Risk Tolerance & Capital Availability



ADDRESSING THE ENERGY TRANSITION



Source: OurWorldinData.org – Research and data to make progress against the world's largest problems. Source: Climate Watch, the World Resources Institute (2020).

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CO₂ MANAGEMENT SYSTEM



Rocky Mountain Coal Mining Institute, Atlas IV, as modified by NPC, 2019

- CO₂ emissions captured from industrial sources OR directly from the air.
- Compressed and transported via pipeline, truck, rail or ship.
- CO₂ injected underground for enhanced oil recovery or saline reservoir storage OR converted directly into products.

THE HISTORY OF CO₂ CAPTURE



lst fertilizer

UNITED STATES PATENT OFFICE





Mongstad



Ist oxy-fuel



Images from the Baker Hughes digital library and courtesy ZeroCO2.no, Statoil, Google Earth, CO2 Norway, DOE/NETL and US Patent office Adapted from Howard Herzog / MIT Energy Initiative using information from ZeroCO2.no and the GCCSI

TOP 10 US CO₂ CAPTURE EXAMPLES



	WY	Gas Plant, Fremont County,	
H.	Operator	ConocoPhillips	-
Q.	Start date	2013	
6	Size	0.9 Mtpa	\searrow
	CO2 Source	Natural Gas Processing	
	Transport	232-mile pipeline	
	Storage	EOR in Belle Creek fields in MT	

Shute Creek Gas Plant, La Barge, WY			
Operator	ExxonMobil		
Start date	1986		
Size	7 Mtpa		
CO2 Source	Natural Gas Processing		
Transport	142-mile pipeline		
Storage	EOR in fields in WY, CO, MT		

and the state	Century Plant, Pecos County, TX			
* / + k	Operator	Occidental Petroleum		
	Start date	2010		
a la serie de l	Size	8.4 Mtpa		
	CO2 Source	Natural Gas Processing		
	Transport	100-mile pipeline		
	Storage	EOR in fields in West Texas		

	Terrell Natural Gas Processing, Fort Stockton, TX		
The second second	Operator	Occidental Petroleum	
	Start date	1972	
	Size	0.5 Mtpa	
	CO2 Source	Natural Gas Processing	
	Transport	220-mile Val Verde pipeline	
	Storage	EOR in fields in West Texas	

	Great Plain	s Synfuels Plant, Beulah, ND				
	Operator	Dakota Gasification Company				
A CONTRACTOR OF A CONTRACTOR	Start date	2000				
	Size	3 Mtpa			Illinois Indu	strial CCS, Decatur, IL
Mat I and a set	CO2 Source	Coal gasification			Operator	Archer Daniels Midland
187 Transform Witch Forman	Transport	205-mile pipeline			Start date	2017
and many hard want of the	Storage	EOR in fields in SK, CAN			Size	I.I Mtpa
				State State	CO2 Source	Ethanol Production
					Transport	2-mile pipeline
>	iost Plains Synfuels				Storage	Mount Simon Saline Formation
					Coffeyville	Gasification, KS
Lost Cabin Oas Plant			1		Operator	Coffeyville Resources
Shute Creek Cas Plant			1		Start date	2013
					Size	I Mtpa
		2 7		A AREA I	CO2 Source	Fertilizer production
N N		Minors Industrial CCS (ADM		2 1 1 / A	Transport	68-mile pipeline
					Storage	EOR in North Burbank Unit field, OK
2 2 1		Collegville Gasification	2		Enid Fertili	zer, OK
	Enid Fertilizer				Operator	Koch Nitrogen Company
				THE BALL	Start date	1982
\sim 1	5				Size	0.7 Mtpa
					CO2 Source	Fertilizer production
	8		Y S		Transport	120-mile pipeline
TY/		27			Storage	EOR in fields in OK
Certury Plant	latural Gas Processin Air Prode	ads EMP				
	1	RetraNova (WA Parish)			Air Produc	ts SMR, Port Arthur, TX
					Operator	Air Products
	Petra Nova	(WA Parish), Houston, TX		A DA	Start date	2013
	Operator	NRG Energy			Size	I Mtpa
	Start date	2017			CO2 Source	Hydrogen production
	Size	I.4 Mtpa			Transport	13-mile pipeline
Absorption and regeneration columns	CO2 Source	Coal-fired power generation	Vacuum St Adsorption V	ting essels	Storage	EOR in fields in TX
	Transport	80-mile pipeline			5	
	Storage	EOR in West Ranch field, TX	High Pressure	High Purity	Dilute	Very Dilute Extremely D

Source: Adapted from National Petroleum Council Report on Meeting the Dual Challenge, 2019, Chapter 5 "CO2 Capture". Additional photos from SPE, DOE/NETL/ZeroCO2.no

CCUS: CAPTURE PHASE

- Globally 26 projects capture ~ 40 MM tons of CO₂ annually (captured and sequestered or utilized)
 - 0.1% of annual anthropogenic CO₂ emissions
- Critical challenges for capture technologies
 - Cost-effective capture
 - Energy efficient capture
 - Parasitic load
 - Scaling-up
 - Retrofit and application to existing infrastructure and fleet



Parasitic energy load of CCUS



Global status of CCUS as of 2021



CAPEX for CO_2 separation as a function of CO_2 concentration in input stream

LIABILITY MANAGEMENT: TRAPPING MECHANISMS SURFACE GAS VS. SUBSURFACE FLUID MANAGEMENT



KEY POINTS

- Carbon Capture and Carbon Sequestration are mature technological fields
 - The size, scale and speed of delivering a safe, reliable and economical carbon value chain is unprecedented
- Carbon Valorization is key
- Need to keep global leadership here in Greater Houston Area