Policy Outlook for Carbon Capture in the 2020s

NARUC Subcommittee on Clean Coal and Carbon Management / NARUC-DOE Carbon Capture, Utilization, and Storage Partnership

JUNE 9, 2021| 2 – 3 PM (ET)

WELCOME

Commissioner Ellen Nowak

Wisconsin Public Service Commission

Vice Chair of the NARUC-DOE Carbon Capture, Utilization, and Storage Partnership and NARUC Subcommittee on Clean Coal and Carbon Management

SPEAKERS

- **Madelyn Morrison**, External Affairs Manager, Carbon Capture Coalition
- **Emeka Richard Ochu**, Research Associate, Center on Global Energy Policy, Columbia University
- **Angelos Kokkinos**, Associate Deputy Assistant Secretary, Office of Clean Coal and Carbon Management, Office of Fossil Energy and Carbon Management, U.S. Department of Energy

CARBON CAPTURE COALITION

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Wednesday, June 9, 2021

Madelyn Morrison
External Affairs Manager
Carbon Capture Coalition

CARBON CAPTURE COALITION

Unprecedented National Coalition in U.S. Energy & Climate Policy

Goal: Economywide deployment of the full suite of carbon management options—carbon capture, removal, transport, utilization and storage—to reduce emissions, foster domestic energy and industrial production, and support high-wage jobs.

Climate, jobs and energy/industrial benefits **unite diverse interests in a common purpose**

Over 80 members, including companies, unions and environmental NGOs

To learn more and view our complete membership list, visit www.carboncapturecoalition.org

CARBON CAPTURE COALITION

Participants

Accelergy
AFL-CIO
Air Liquide
Air Products
AK Steel
Alto Ingredients
American Carbon Registry
ArcelorMittal
Arch Resources
Archer Daniels Midland Co.
Baker Hughes
Bipartisan Policy Center
Calpine
Capital Power
Carbon180
Carbon America
Carbon Free
Carbon Wrangler LLC
Center for Climate and Energy Solutions
Citizens for Responsible Energy Solutions Forum
Clean Air Task Force
Conestoga Energy Partners
Core Energy LLC
DTE Energy
EBR Development LLC
Elysian Ventures
EnergyBlue Project
Energy Innovation Reform Project
GE Gas Power
Glenrock Energy
Great River Energy
Greene Street Capital
Impact Natural Resources LLC
ION Engineering LLC
International Brotherhood of Boilermakers
International Brotherhood of Electrical Workers
Jackson Hole Center for Global Affairs
Jupiter Oxygen Corporation
Lake Charles Methanol
LanzaTech
Linde, Inc.
Mitsubishi Heavy Industries America, Inc.
National Farmers Union
National Wildlife Federation
NET Power LLC
New Energy Risk
New Steel International, Inc.
NRG Energy
Occidental
Peabody
Prairie State Generating Company
Praxair, Inc.
Shell
SMART Transportation Division (of the Sheet Metal, Air, Rail and Transportation Workers)
Summit Agricultural Group
Summit Power Group
Svante
The Nature Conservancy
Third Way
Thunderbolt Clean Energy LLC
United Mine Workers of America
United Steel Workers
Utility Workers Union of America
White Energy

Observers

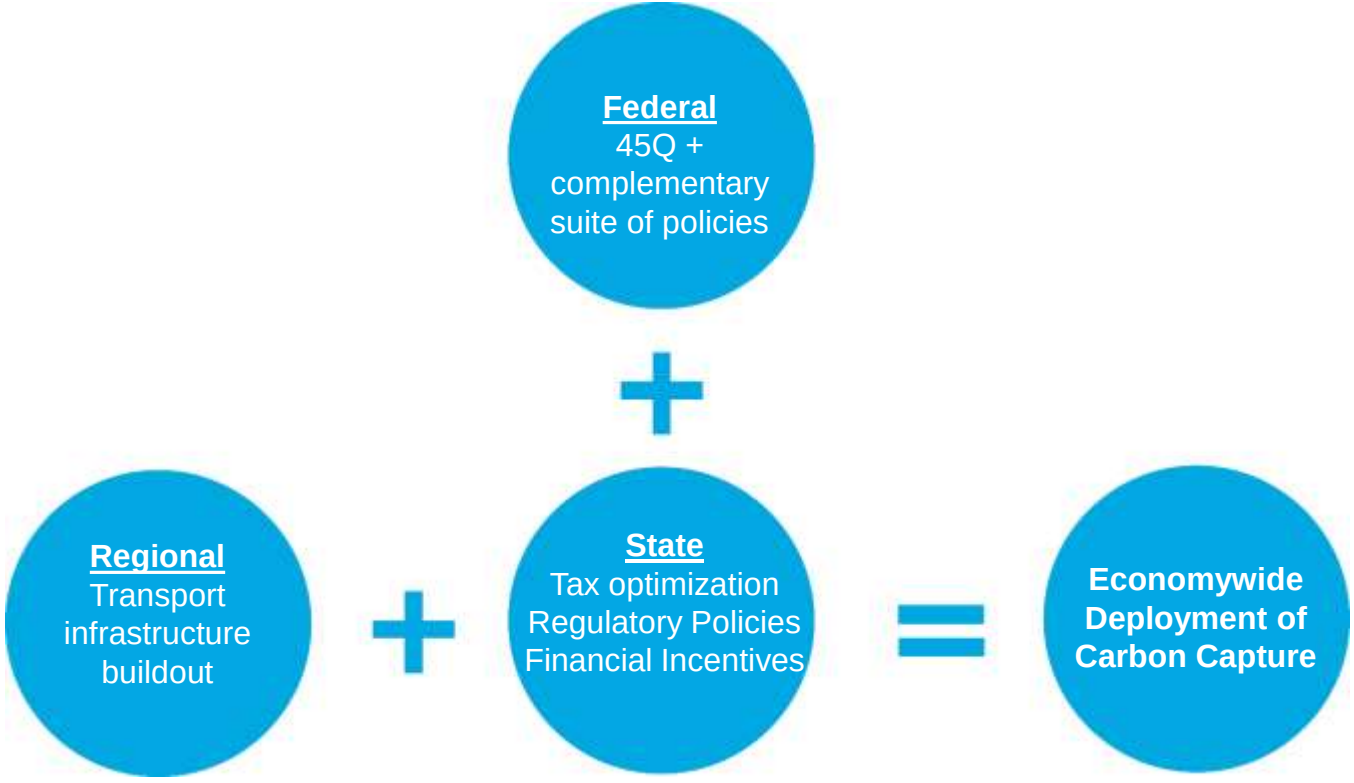
Algae Biomass Organization
Biomass Power Association
Brown Brothers Energy & Environment, LLC
Carbon Engineering
Carbon Utilization Research Council
Chart Industries
ClearPath
Cornerpost CO2 LLC
Enhanced Oil Recovery Institute, University of Wyoming
Environmental Defense Fund
Growth Energy
Institute of Clean Air Companies
Melzer Consulting
National Audubon Society
Portland Cement Association
Renewable Fuels Association
Republic Services
School of Energy Resources, University of Wyoming
Systems International | The ZEROS Project
Tellus Operating Group
Waste Management
World Resources Institute

STATE CARBON CAPTURE WORK GROUP

REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE

“All hands on deck” to achieve economywide deployment of carbon capture in the U.S.”

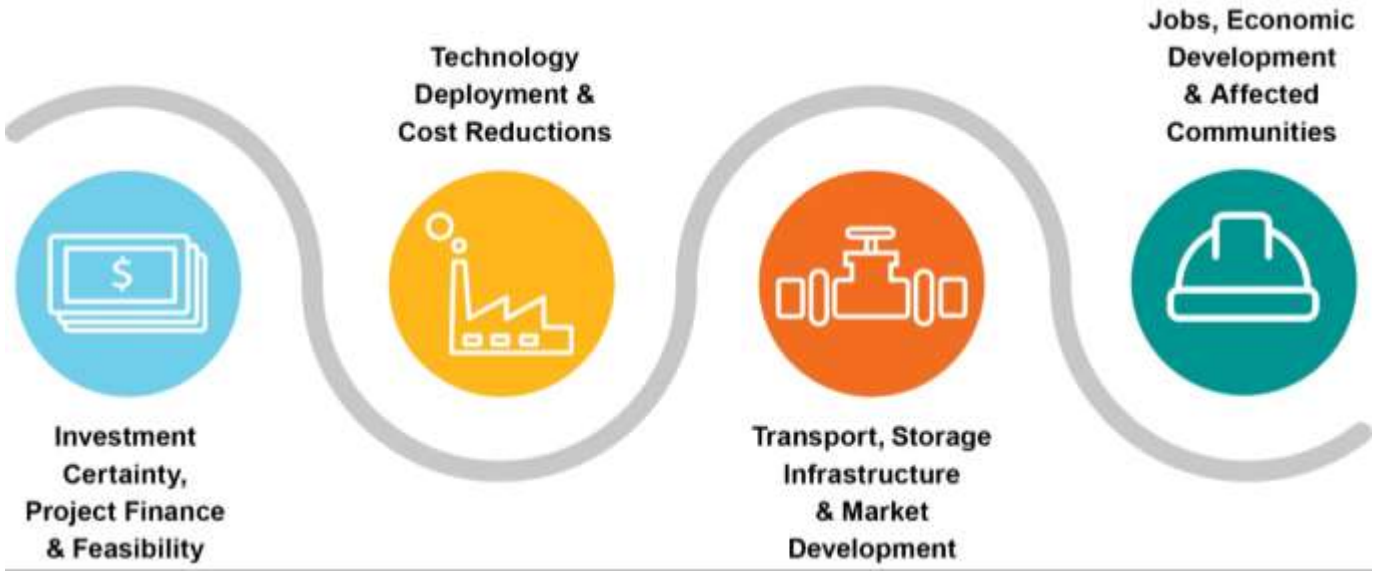
Integrated Federal, Regional & State Policy are Key to Success



Carbon Capture Coalition's Federal Policy Blueprint

- ✓ Agenda for economywide deployment.
- ✓ Recommends full policy portfolio, similar to current support for wind, solar and other low and zero-carbon technologies.
- ✓ Consensus of Coalition's 80+ companies, unions, and NGOs.

Economywide Deployment of Carbon Capture to Achieve Net-Zero Emissions and Meet Midcentury Climate Goals



CARBON CAPTURE COALITION

Washington Landscape

- **Surge of complementary, bipartisan legislation introduced this Congress**
  - Storing and Lowering Emissions (SCALE) Act (S.799/H.R.1992)
  - Carbon Capture, Utilization and Storage (CCUS) Tax Credit Amendments Act (S.986)
  - Accelerating Carbon Capture and Extending Secure Storage (ACCESS) Act through 45Q (H.R.1062)
  - Coordinated Action to Capture Harmful (CATCH) Emissions Act (H.R.3538)
- **Biden Administration prioritizing carbon capture**
  - American Jobs Plan
  - President's Budget Request and Tax Reform Proposal

CARBON CAPTURE COALITION

Enhancing and Expanding Section 45Q

- Key provisions included in bipartisan legislation:
  - Direct Pay Option for clean energy tax credits
  - Increased 45Q Credit Values
  - Extends the Commence Construction Window
  - Eliminates Eligibility Thresholds

	Bill	Direct Pay	Increased Industrial/Power Credit Value	Increased DAC Credit Value	Commence Construction Window Extension	Eliminate Eligibility Thresholds
Senate						
Bipartisan	Carbon Capture, Utilization, and Storage Tax Credit Amendments Act of 2021 (S. 986)	✓		✓	✓	
House						
Bipartisan	ACCESS 45Q Act (H.R. 1062)	✓			✓	
Bipartisan	CATCH Act		✓			✓

Storing CO_2 and Lowering Emissions (SCALE) Act (S. 799 / H.R. 1992)

- Reintroduced in March 2021
- Strong bipartisan champions leading the effort
  - Sens. Chris Coons (D-DE) and Bill Cassidy (R-LA)
  - Reps. Marc Veasey (D-TX) and David McKinley (R-WV)
- Fills an urgent need to bolster the buildout of CO_2 transportation and storage infrastructure across the country
- Without comprehensive federal infrastructure policy like the SCALE Act, we risk falling behind other nations in deploying economywide carbon management technologies

The Federal Role in Facilitating the Buildout of CO_2 Transport and Storage Capacity

Interconnected transport infrastructure systems will:

- Enable more CO_2 capture by connecting storage sites and emitters.
- Realize economies of scale reducing the overall cost of the carbon capture system.
- Create a carbon management market, reduce risks, and facilitate innovation by connecting multiple capture and storage projects.

Additional federal investment will help address barriers facing infrastructure development and deployment:

- **Cost.** Section 45Q of the federal tax code enables economic CO_2 capture from many sources, but the credit value is not sufficient to also fund major new CO_2 infrastructure.
- **A chicken-and-egg challenge**. CO_2 transport and storage infrastructure must exist before CO_2 capture projects can be committed. But the CO_2 capture projects must also exist or be certain before the infrastructure can be committed.
- **Building for future demand**. CO_2 transport and storage infrastructure should be built with excess capacity to realize economies of scale and enable future growth.

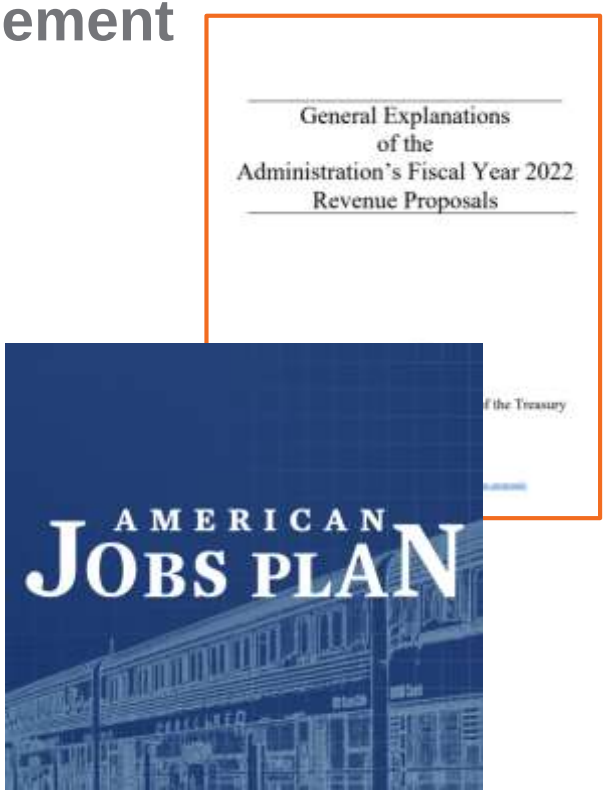
State MOU for CO_2 Transport Infrastructure

- **Includes** KS, LA, MD, MT, OK, PA and WY as signatories, with several other states considering joining
- **Recognizes** that development of CO_2 transport networks, together with financial incentives for carbon capture, can:
  - ✓ support long-term production and use of **domestic natural resources**;
  - ✓ create and preserve **high-paying jobs** in energy-producing, agricultural and industrial states; and
  - ✓ significantly **reduce net carbon emissions**
- **Provides** a collaborative mechanism to jointly develop and implement an action plan for building out regional CO_2 transport infrastructure and geologic storage to enable large-scale carbon management
- **Seeks** to accelerate, through state leadership and coordination, the deployment of common regional CO_2 transport infrastructure networks and carbon hubs to help industries take advantage of economies of scale




Significant Bipartisan Alignment between Congress and the Biden Administration on Carbon Management

- **Biden Administration's American Jobs Plan:**
  - Direct pay and 10-year extension for 45Q tax credit;
  - Enhanced 45Q credit values for industrial and power plant carbon capture and for direct air capture;
  - SCALE Act for buildout of CO_2 transport and storage infrastructure; and
  - Funding for 10 pioneer industrial carbon capture retrofits and 15 demonstrations of decarbonized hydrogen production.
- **Biden Administration's Budget Request and Tax Reform Proposals:**
  - Modest but important increases for the core carbon management programs at the Department of Energy's Office of Fossil Energy
    - 19% increase over FY2021 funding levels.
  - Direct pay for and extension for 45Q tax credit;
  - Enhanced 45Q credit values for direct air capture of $120/ton for saline geologic storage and $85/ton for "hard-to-abate industrial sectors" (cement, steel, hydrogen and petroleum refining are specifically referenced).



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What's Next?

- Continue to build bipartisan support
- Work with congressional leadership and key political players to ensure portfolio of essential measures are included in the next moving legislative vehicle:
  - Infrastructure Package
  - Budget Reconciliation
  - Appropriations Omnibus

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Thank You

Madelyn Morrison

External Affairs Manager

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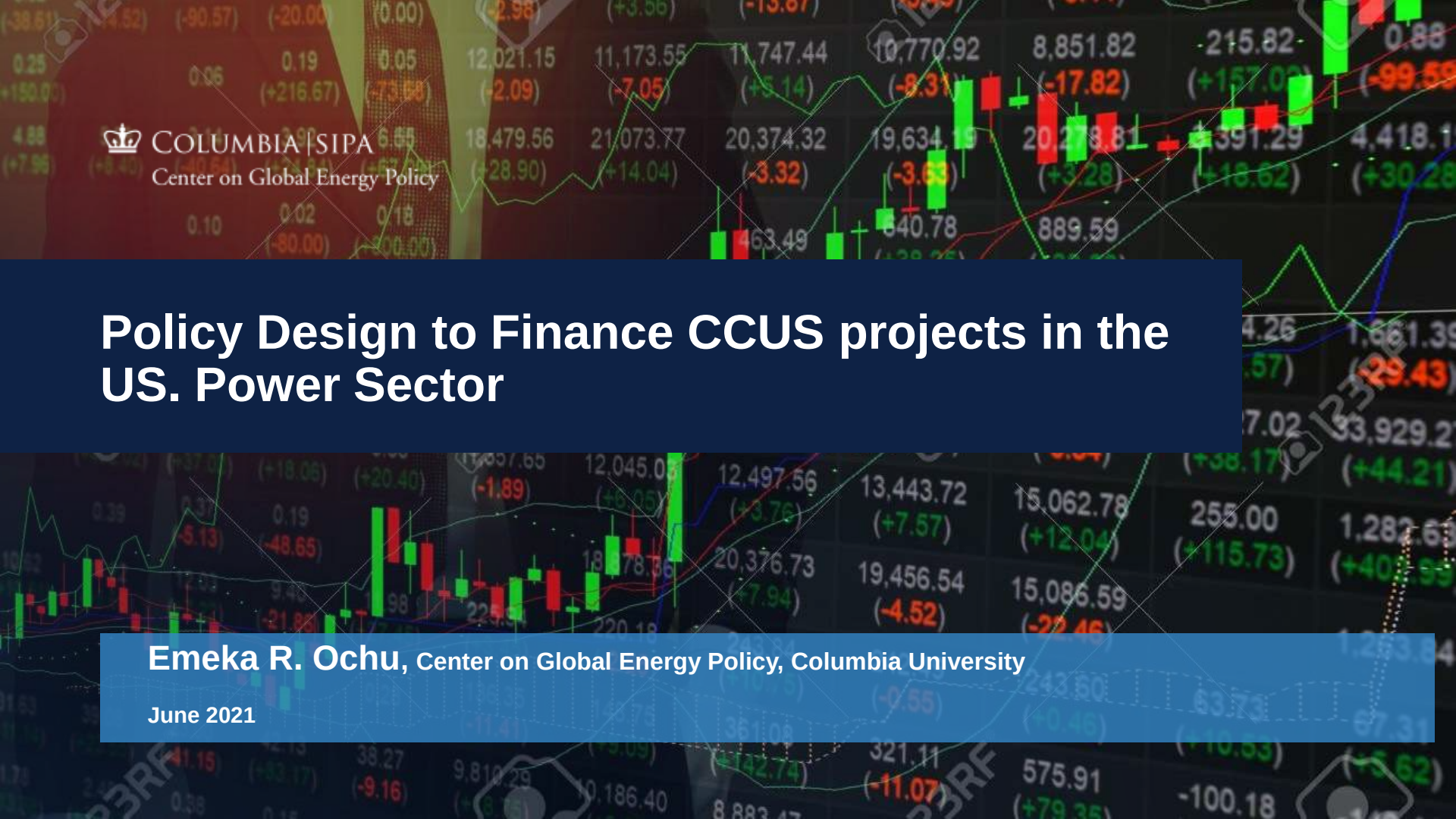


Policy Design to Finance CCUS projects in the US. Power Sector

Emeka R. Ochu, Center on Global Energy Policy, Columbia University

June 2021

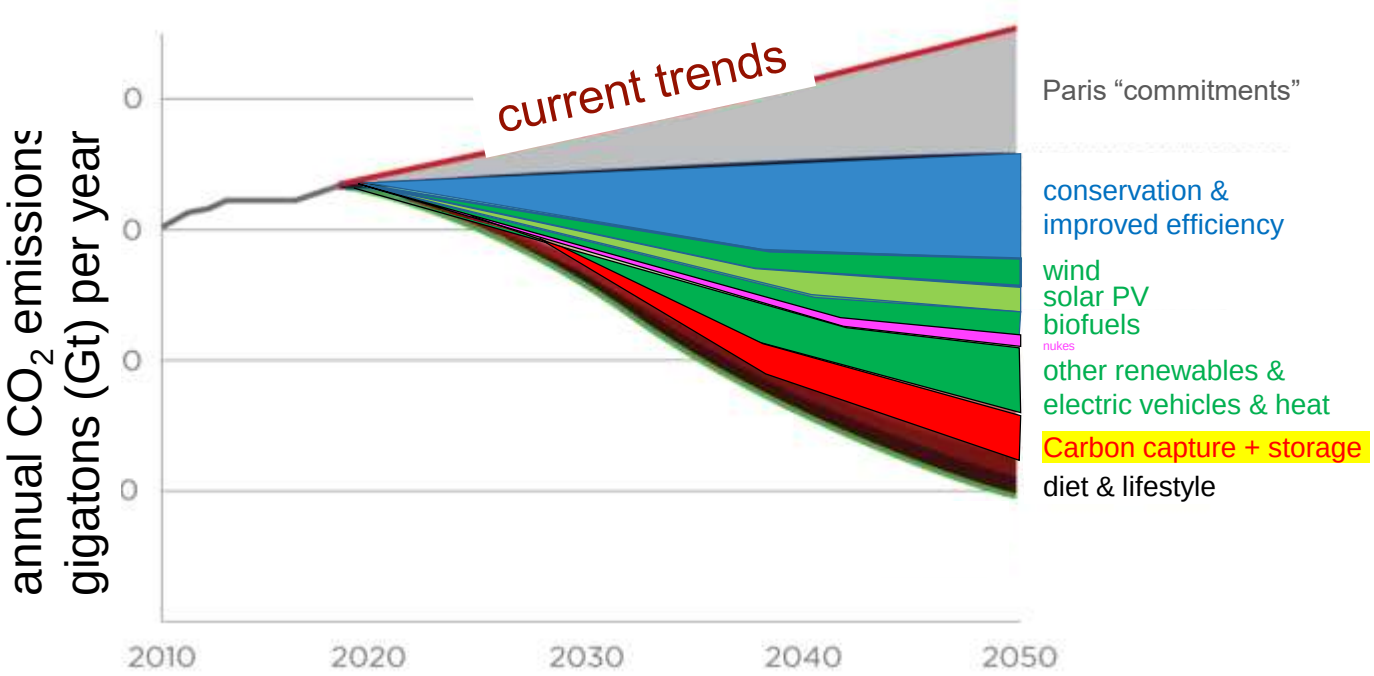
The core arithmetic of net-zero is harsh and unforgiving: We are failing, out of time and need rapid, deep decarbonization

Deep decarbonization requires CCUS

The issue today is not COST –

The issue today is FINANCE

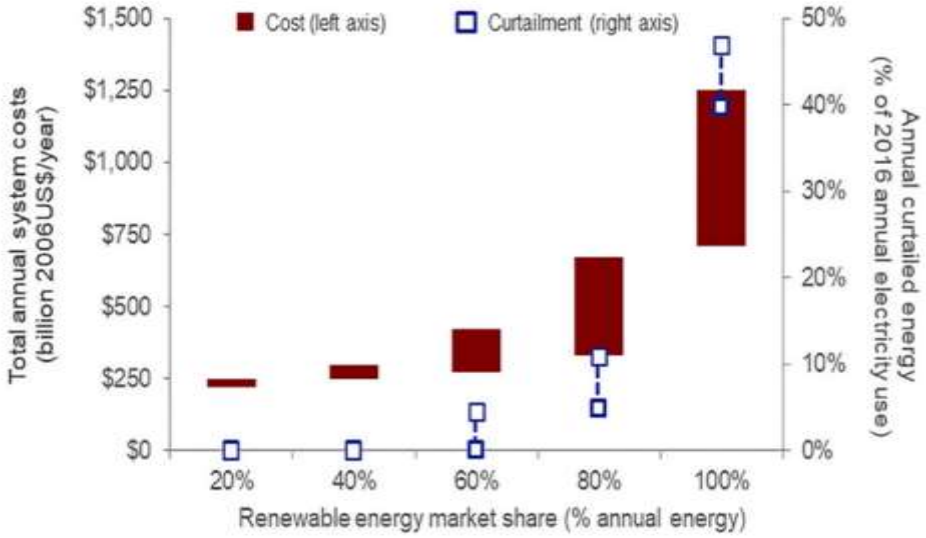
This is a policy issue



International Energy Agency, Net-zero roadmap (2021)

CCUS can add value & services to power sector decarbonization

- **Uses existing assets:** retrofit existing operating plants
- **Supports resilience and reliability:** Can help balance variable renewable loads
- **Helps communities:** Preserves jobs and tax base
- **Provides speed in decarbonization:** Can proceed in parallel with renewable generation
- **Helps to add renewables:** See last two points
- **Reduces total cost of decarbonization:**
  - Especially important beyond 80% emission reduction
  - Avoids excessive curtailment



Source: Jenkins et al. 2018

Key findings to design policy to finance CCUS deployment in the U.S. power sector (existing fleet)

Findings for project finance

- Existing policies, notably 45Q tax code amendments, are insufficient to ignite investment in the power sector.
- For each MWh generated, 45Q provides more support because coal produces more CO_2 than gas
- The ownership structure of any potential power plant strongly affects the financeability of a CCUS retrofit project
- Revenue enhancements, especially production tax credits, provide the lowest risk and best chance of deployment, especially for natural gas power plants
- Because coal CCUS projects are larger and more capital intensive, capital treatments provide better support for coal retrofits.
- Direct pay helps enhance the value of 45Q and improves the financeability of projects
- The CATCH enhanced 45Q will make the 45Q tax credit sufficient

Energy policy is needed to close the finance gap

Figure 2:
Finance gap associated with a power plan CUS project

Note: For any given project, higher power prices are needed to generate the revenues needed for profitability.
Source: Authors' computation

Many policy options could close the finance gap.

Key options are active today in the US, overseas, or in draft legislation

Capital treatments

- Investment tax credits
- Private activity bonds
- Accelerated depreciation
- Master Limited Partnership treatments

Revenue Enhancements

- Existing (recent) 45Q amendments
- Enhanced 45Q (higher values)
- Production tax credit
- Contract for differences

Other Policies

- Government Procurements, Mandates (e.g. zero-carbon power standards; retrofits), Innovations support (industrial policy)

We examined two key plant types (coal & gas)
We examined two ownership structures (IOU & IPP)
These 4 classes represent ~50% of US power generation

We used baseline power prices *without CCUS* to quantify the finance gap for a CCUS retrofit

The ownership structure affects the baseline power price needed to give investors a return

Figure 3: Required power price per MWh for unabated assets

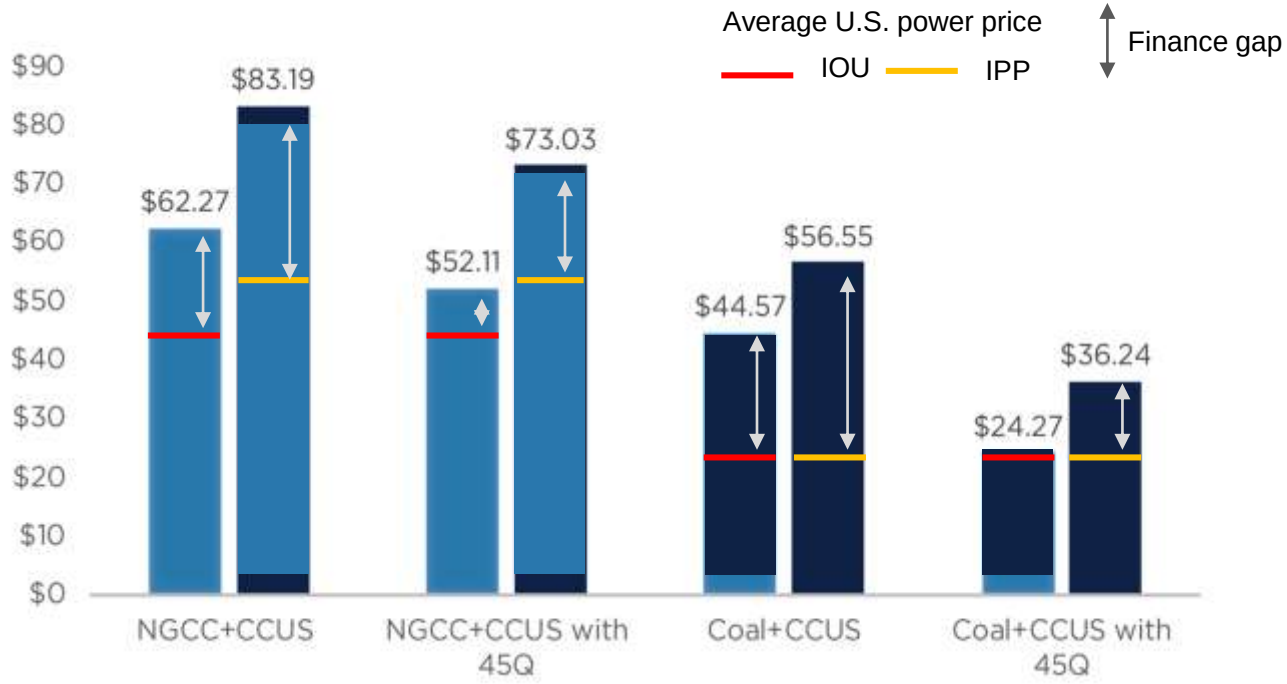
Source: Energy Information Administration, 2019

Today's 45Q tax credits value: ~$10/MWh for gas plants ~$20/MWh for coal plants

*For comparison, the wind production tax credit paid for existing projects in 2017 was **$24/MWh**.*

*New projects in 2018 would receive **$18/MWh**.*

Figure 4: Required power price per MWh for retrofitted assets with 45Q

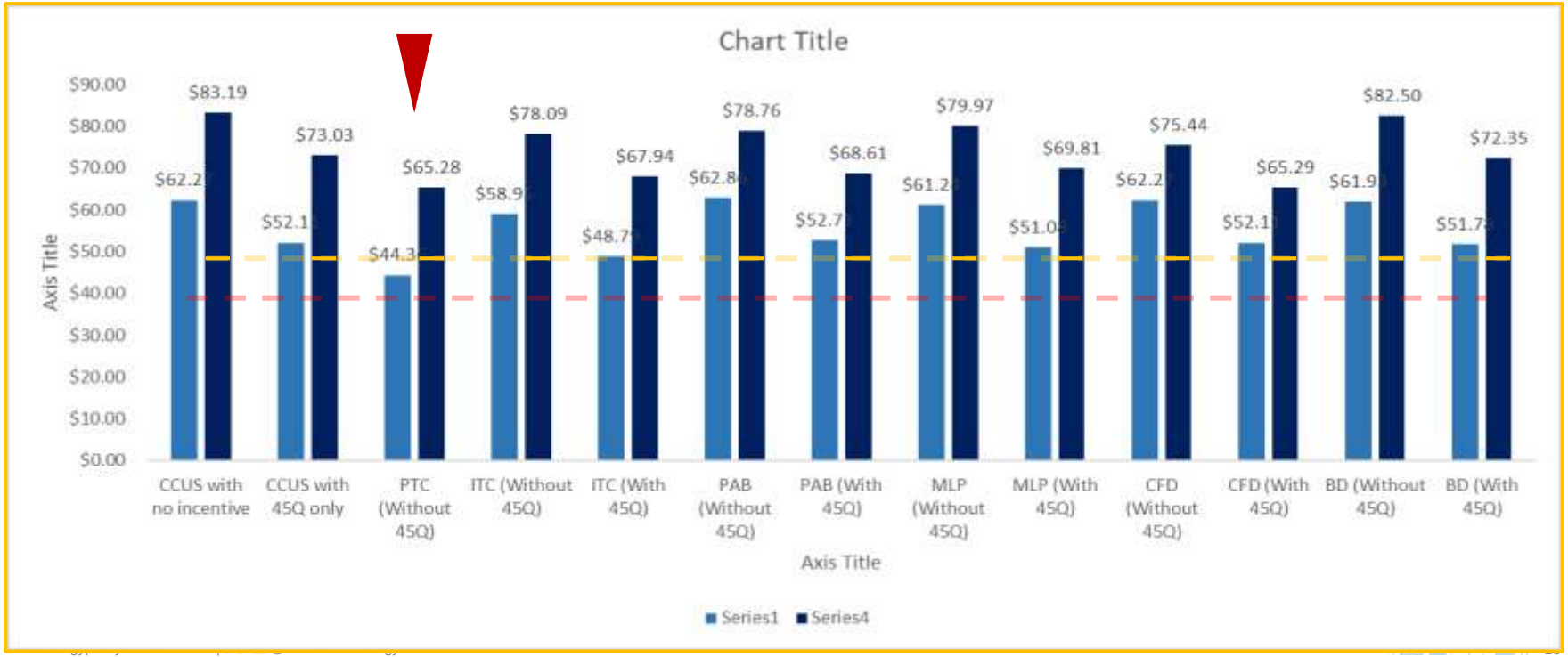


For natural gas power plants, the production tax credit gives the most robust returns with lowest risk

Average US Power Prices

Unabated IOU
Unabated IPP

Figure 5: Required power price per MWh for retrofitted assets with 45Q

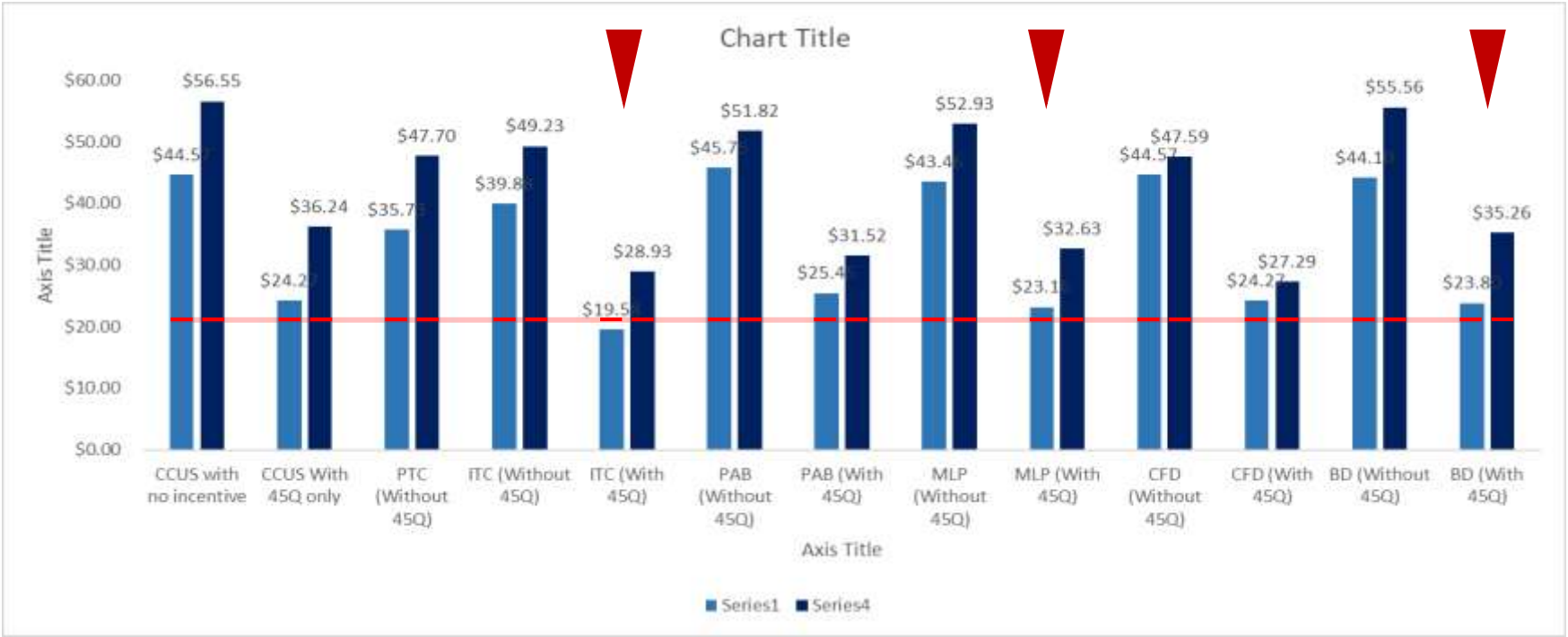


For coal-fired power plants, the ITC and other capital treatments help when combined with 45Q

Average US Power Prices

Unabated Coal

Figure 6: Summary of rates for combined incentives for coal IOU and IPP plants



How Does Direct pay and the CATCH Act help?

Carbon Capture Utilization and Storage Tax Credit Amendments Act

- Plans to extend the date for projects to qualify by 5 years
- Created a direct pay option for the 45Q
- Allow existing power plants to combine 48A ITC with 45Q
- Helps eliminate need to seek tax equity investors and their high interest rates

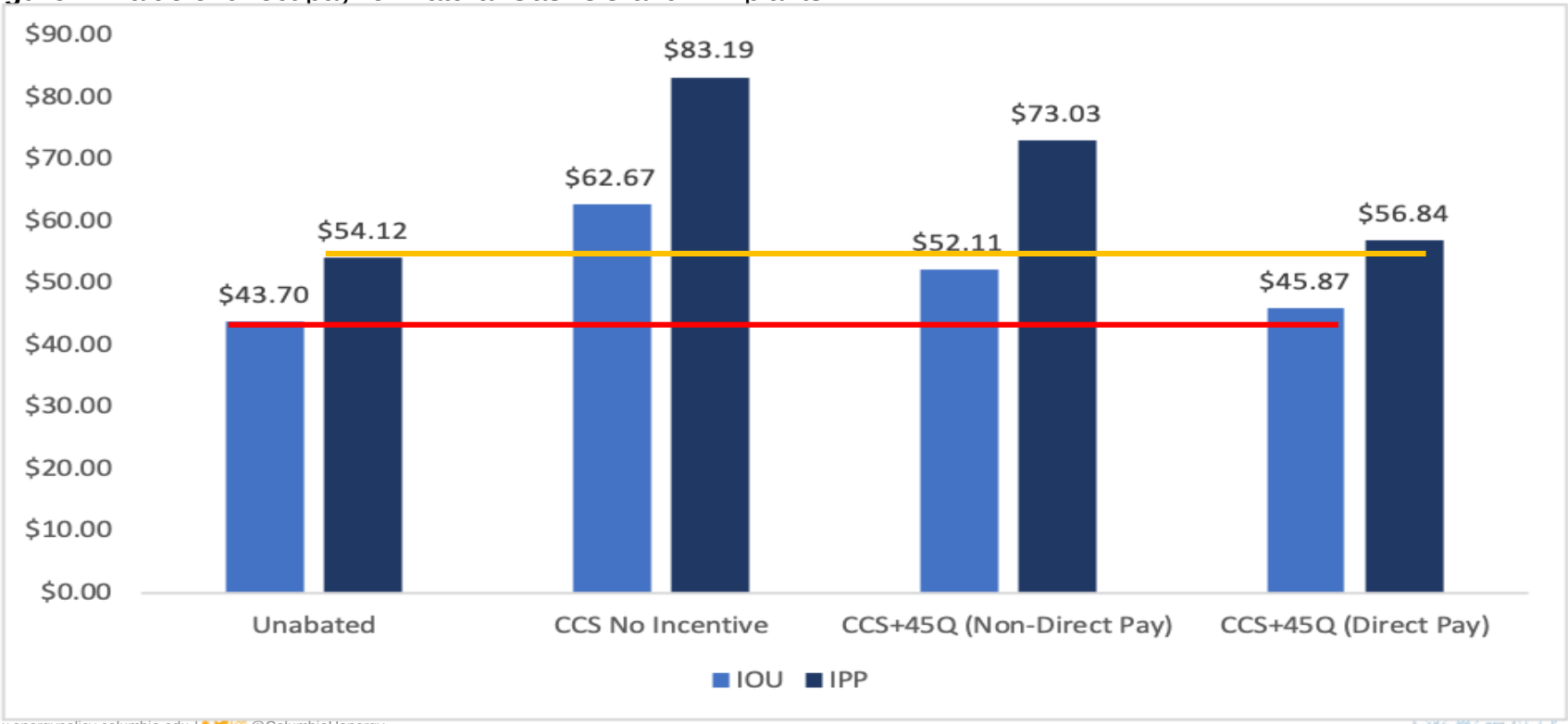
The Coordinated Action to Capture Harmful (CATCH) Emissions Act

- Proposes an enhanced 45Q of $85/MT for CO2 capture and storage in saline geological formations
- $65/MT for storage in oil and gas fields for EOR, etc.

Reduces capital cost of projects, increases access to debt financing, reduces risk of projects, lowers cost of financing

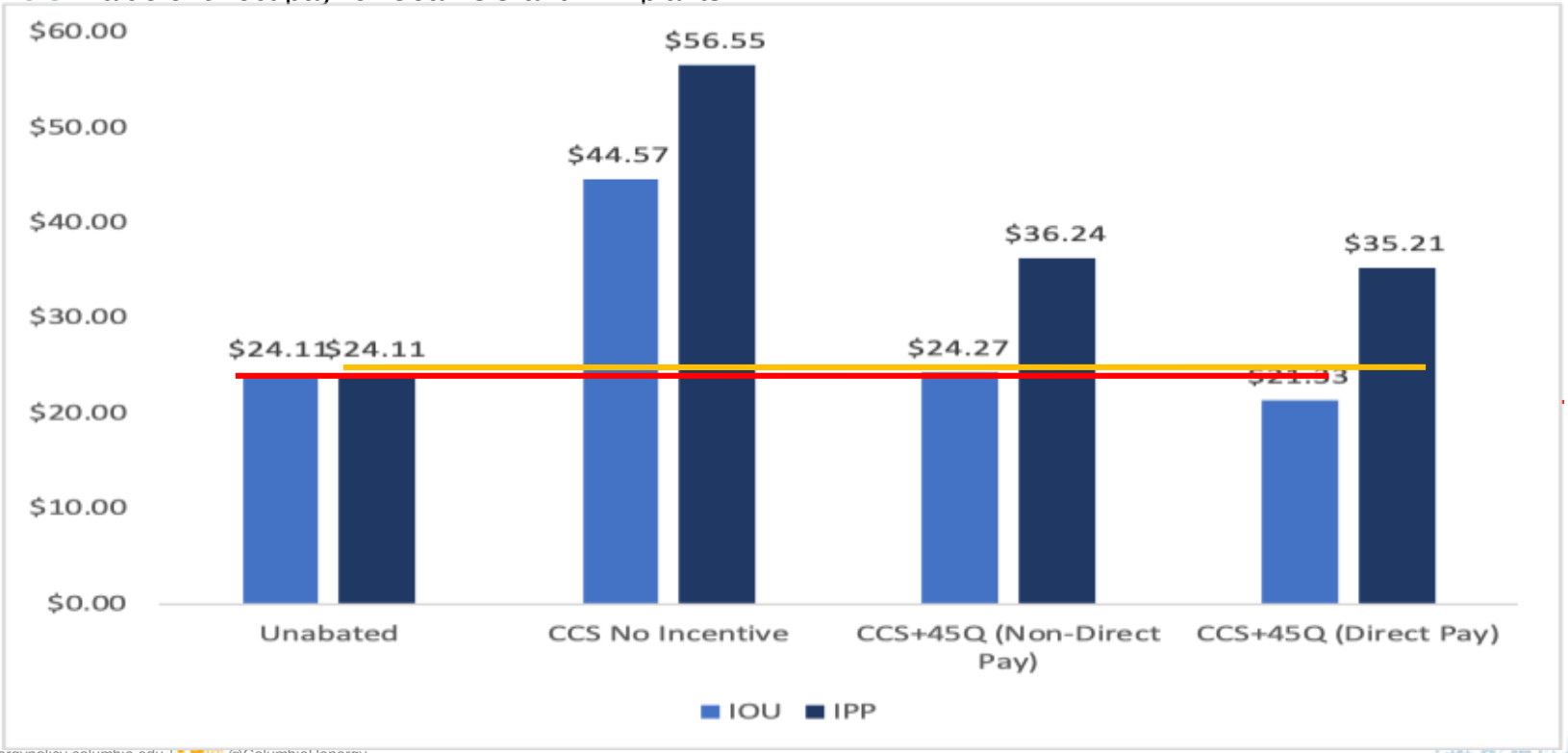
For natural gas power plants, direct pay comes close to closing the finance gap

Figure 7: Value of direct pay for Natural Gas IOU and IPP plants



For coal-fired power plants, direct pay closes the finance gap in the IOU case

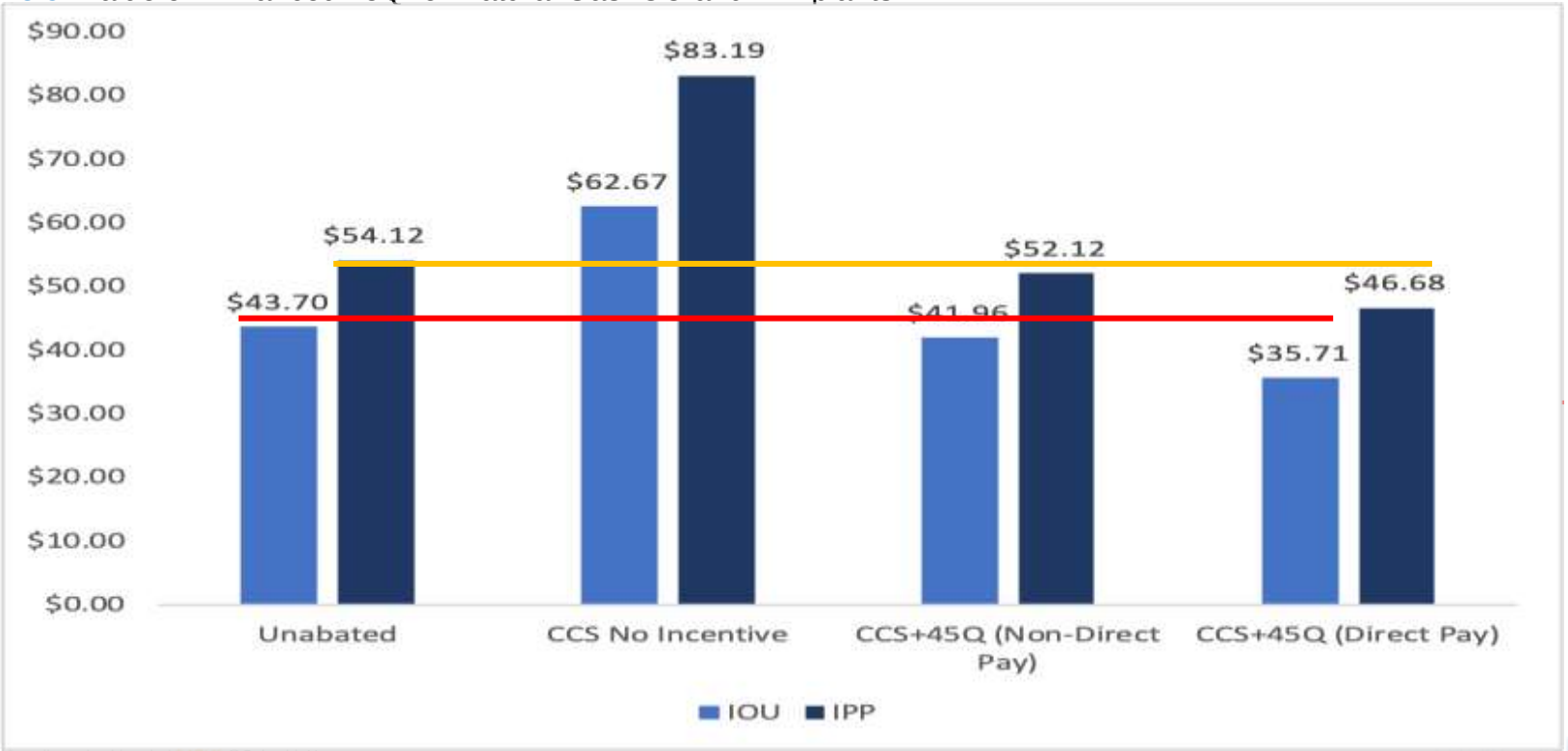
Figure 8: Value of direct pay for Coal IOU and IPP plants



For natural gas power plants, 45Q at $85 closes the finance gap both with direct pay or not

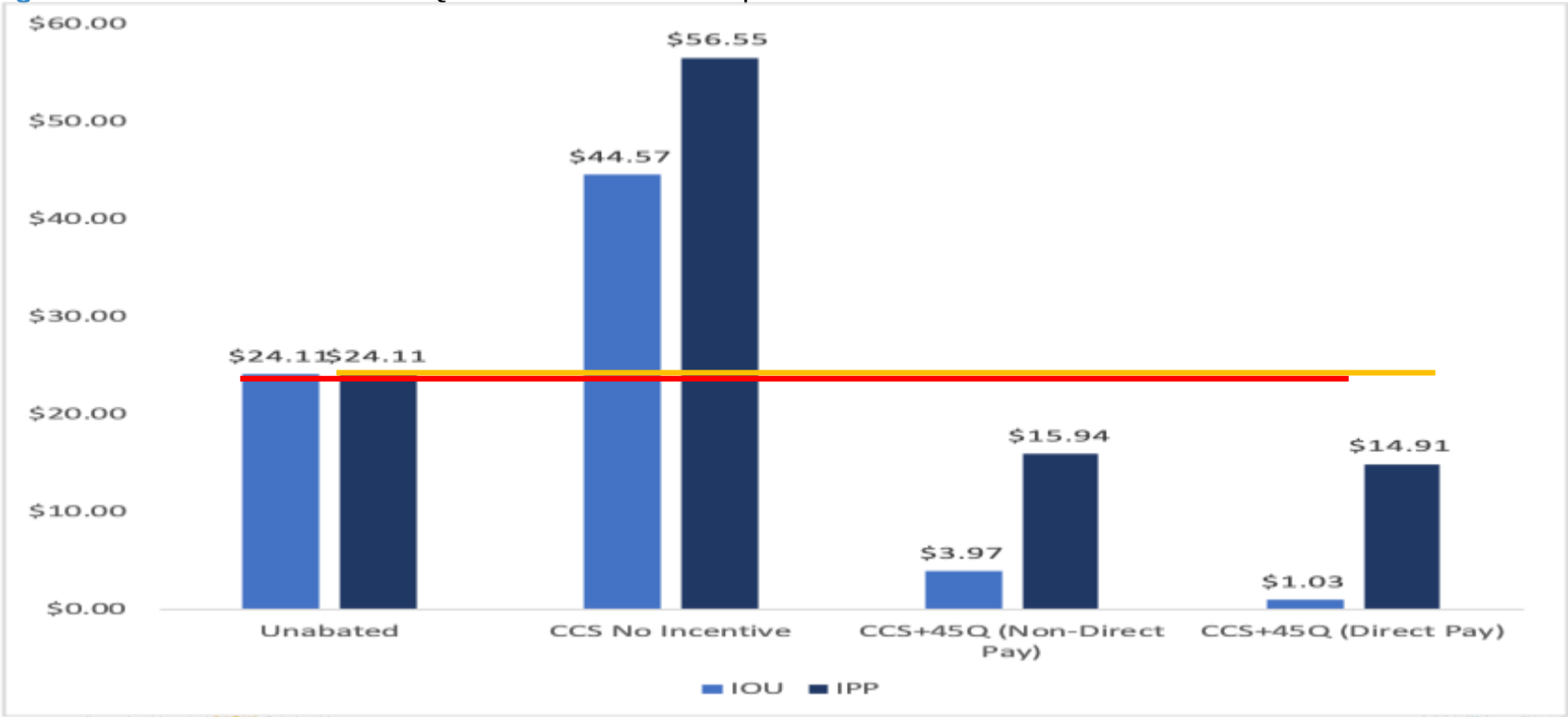
Average US Power Prices
Unabated IOU
Unabated IPP

Figure 9: Value of Enhanced 45Q for Natural Gas IOU and IPP plants



For coal-fired power plants, 45Q at $85 closes the finance gap in the both cases also

Figure 10: Value of Enhanced 45Q for Coal IOU and IPP plants



Additional policies help

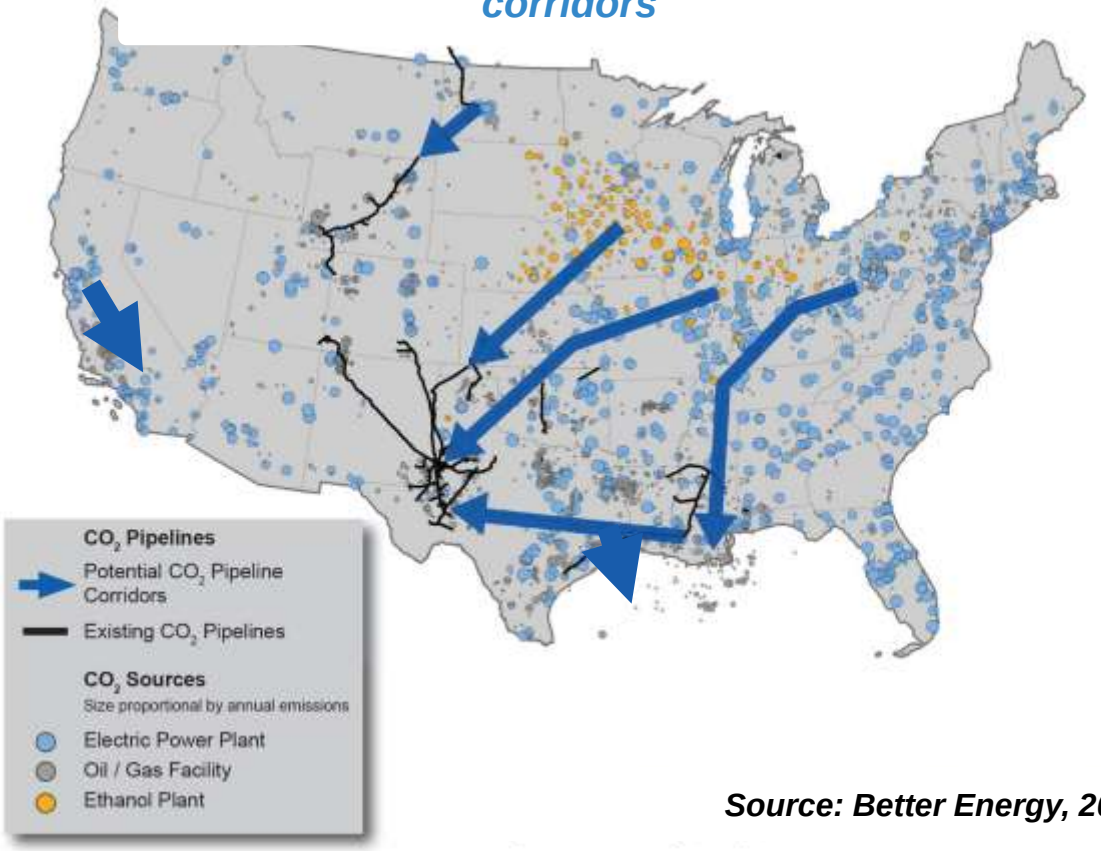
Infrastructure first:

- Hubs & Clusters
- CO_2 pipelines

Ecosystem cultivation

- Innovation policy

Existing and potential CO_2 pipeline corridors



Source: Better Energy, 2017

Recommendations for US. Power Plants

Recommendations

- Policy makers must augment current policies to achieve deployment of CCUS in the power sector
- Policy makers should consider revenue enhancing policies first to ignite investment in power sector CCUS projects.
- More analysis is needed to understand investment viability given variations by geography, market, and technology

Non-finance policies (e.g., infrastructure and innovation) can help but are not substitutes

The goal: rapid emissions reduction through rapid deployment

Thank You

COLUMBIA | SIPA
Center on Global Energy Policy

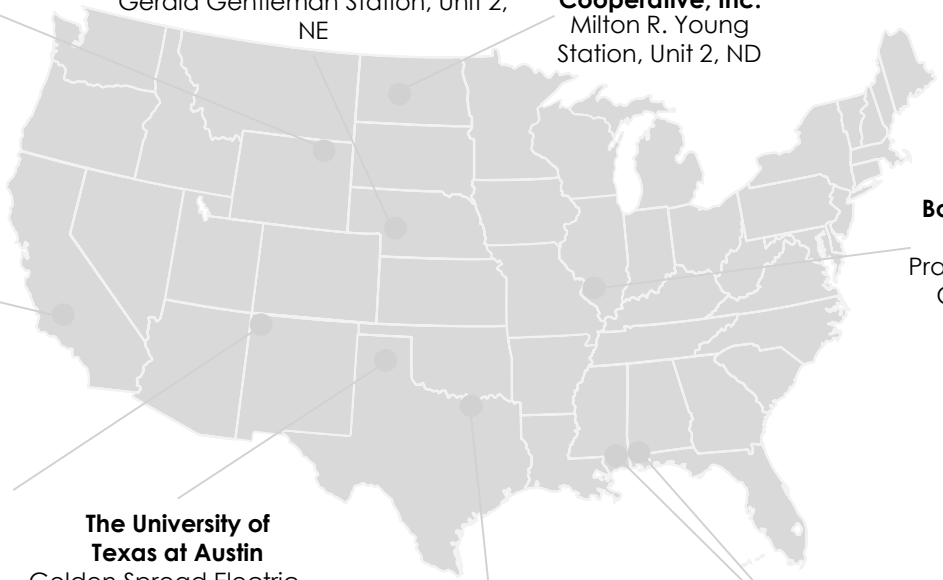
ANGELOS KOKKINOS

Associate Deputy Assistant Secretary

Office of Clean Coal and Carbon Management, Office of Fossil Energy and Carbon Management, U.S. Department of Energy

FRONT-END ENGINEERING DESIGN (FEED) STUDIES
ANGELOS KOKKINOS
NARUC – JUNE 9, 2021

HOST SITES – FOA 2058



Membrane Technology and Research, Inc.
Basin Electric Dry Fork Station, WY

Ion Engineering LLC
Nebraska Public Power District Gerald Gentleman Station, Unit 2, NE

Minnkota Power Cooperative, Inc.
Milton R. Young Station, Unit 2, ND

Board of Trustees of the University of Illinois
Prairie State Generating Company's Energy Campus, IL

Electric Power Research Institute, Inc.
Elk Hills Power Plant, CA

Enchant Energy LLC
San Juan Generating Station, NM

The University of Texas at Austin
Golden Spread Electric Cooperative Mustang Station, TX

Bechtel National, Inc.
Panda Power Funds Sherman Generating Station, TX

Southern Company Services, Inc.
Plant Barry 6 & 7 or Plant Daniel 3 & 4, AL or MS

COAL

FEED Studies for Retrofitting Existing, Domestic Coal Power Plants with Carbon Capture

FRONT-END ENGINEERING & DESIGN: PROJECT TUNDRA CARBON CAPTURE SYSTEM

Minnkota Power COOPERATIVE
A Touchstone Energy® Cooperative

Plant Site

- Minnkota Power Cooperative's Milton R. Young Station Center, North Dakota
- 477 MWe (Unit 2)
- Fueled by North Dakota lignite

Milton R. Young Station

Photo Source: https://www.minnkota.com/milton-r.-young-station.html

Fluor's Econamine FG Plus^{SM} (EFG+)

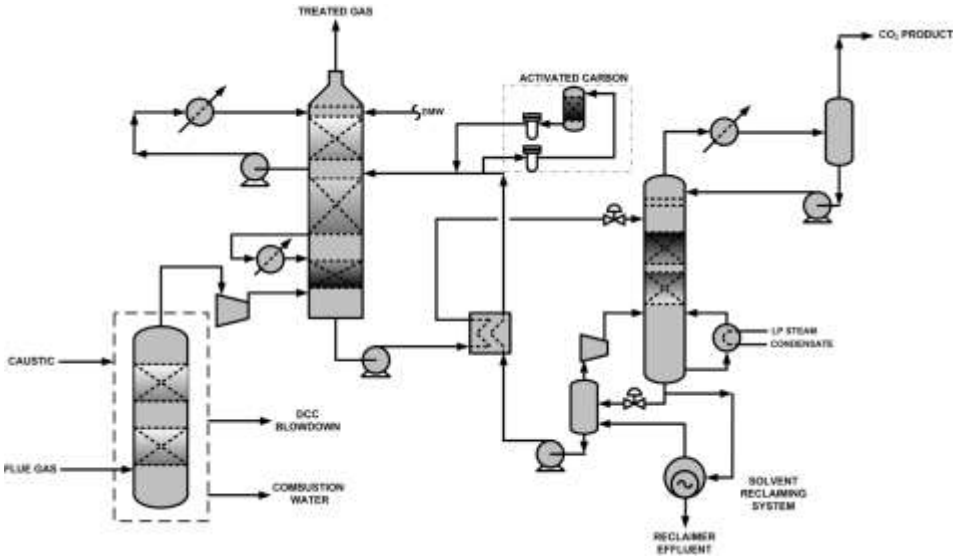
- Amine-based solvent process
- Patented 2-stage direct contact cooler for flue gas cooling & SO_2 removal
- Patented absorber intercooling technology

MINNKOTA POWER COOPERATIVE, INC.

- Fluor EFG+ Technology Retrofit

Project & Technology Advantages

- More than 30 licensed commercial applications
- Reduced regeneration steam requirement
- High solvent working capacity (3x higher than MEA)
- Absorber intercooling reduces net steam demand
- Minimal pressure drop
- Reduces solvent loss/make-up requirements



Fluor's EFG+ CCS Process

COMMERCIAL CARBON CAPTURE DESIGN & COSTING:

ION Clean Energy

Plant Site

- Nebraska Public Power District's Gerald Gentleman Station
- Sutherland, Nebraska
- 681 MWe (Unit 2)
- Fueled with low sulfur, PRB coal

ION's advanced solvent technology

- Water-lean amine solvent
- Two 300-MWe carbon capture trains
- Supersonic compressor system (DATUM-S) incorporated into each 300 MWe train

Proposed location of commercial CO_2 capture island at Gerald Gentleman Station

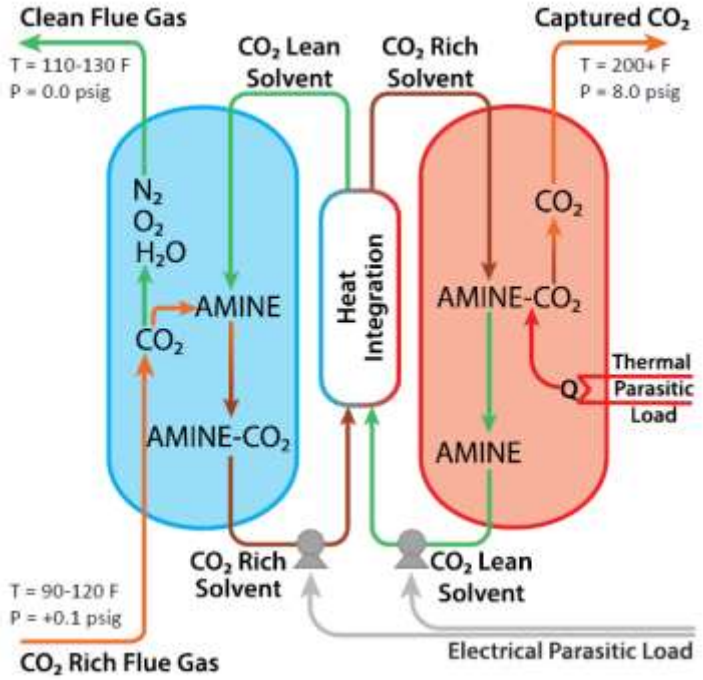
ION CLEAN ENERGY, LLC

ION ENGINEERING

- FEED Study: ION Solvent-Based Capture Technology Retrofit

Project & Technology Advantages

- Successful test campaign at TCM (12 MWe) completed in 2017
- High solvent CO_2 capacity
- Reduced water content in solvent
- Faster solvent kinetics results in smaller absorber
- Advanced operation control slows degradation, minimizing solvent loss/make-up requirements
- Heat recovery reduces steam usage for solvent regeneration



ION Solvent Process

COMMERCIAL-SCALE FRONT-END ENGINEERING DESIGN STUDY FOR MTR

Membrane Technology and Research, Inc.

Plant Site

- Basin Electric Power Cooperative's Dry For
- Gillette, Wyoming
- 400 MWe
- Fueled with sub-bituminous coal

Dry Fork Station

MTR's membrane CO_2 capture process

- Two-stage membrane system that captures 60% of CO_2 in flue gas
- Pre-fabricated container-sized membrane module skids

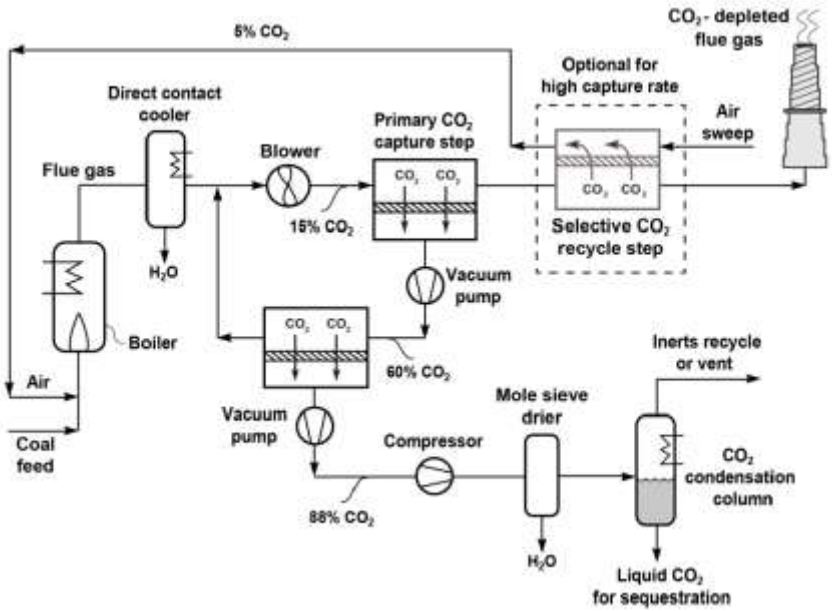
Photo source: https://www.basinelectric.com/Facilities/Dry-Fork/

MEMBRANE TECHNOLOGY AND RESEARCH, INC.

- FEED Study: MTR Membrane Process Retrofit

Project & Technology Advantages

- Leverages design & layout work from ongoing EPRI pre-FEED project
- 10x the CO_2 permeance of conventional membran
- Compact modular system
- Low-pressure drop membrane module
- Optional selective recycle step increases CO_2 concentration in flue gas
- Cost-effective partial CO_2 capture (50-70%)



MTR's Two-Stage Membrane Process

FULL-SCALE FEED STUDY FOR RETROFITTING THE PRAIRIE STATE GENERATING STATION WITH AN 816 MWE CAPTURE PLANT USING MITSUBISHI HEAVY INDUSTRIES OF AMERICA

ILLINOIS

University of Illinois at Urbana-Champaign

Prairie State Energy Power Plant

Plant Site

- Prairie State Generating Company's Energy Campus, Unit #2
- Marissa, Illinois
- 800 MWe
- Fueled with high-sulfur Illinois coal

MHI's Advanced Kansai Mitsubishi Carbon Dioxide Recovery (KM CDR) Process™

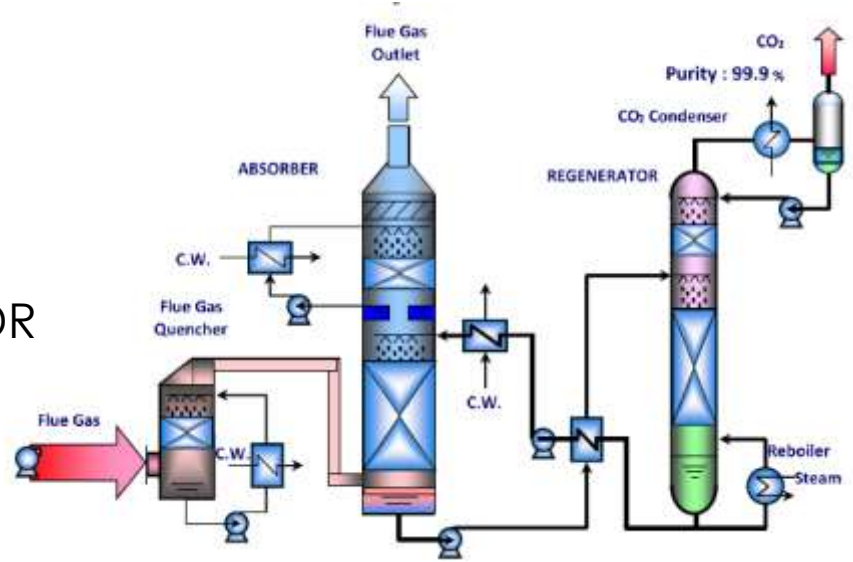
- Amine-based technology using KS-1™ solvent
- Amine purification system, automatic load adjustment control system, & amine emission **reduction system**

Photo source: https://www.stltoday.com/business/local/accident-shuts-down-half-of-prairie-state-s-generating-capacity/article_f45f0983-5c1d-5de6-840a-bfb4ddca6143.html

ILLINOIS

University of Illinois at Urbana-Champaign

MHI's KM CDR Process™



Project & Technology Advantages

- KM CDR Process operates at commercial scale (240 MWe) at the W.A. Parish Generating Station
- Low solvent volatility reduces height of water wash section of CO_2 absorber
- Reduced solvent loss due to high resistance to oxidative & thermal degradation
- Reduced regenerator size & CO_2 compression requirements
- Low heat of absorption reduces steam consumption

LARGE-SCALE COMMERCIAL CARBON CAPTURE

ENCHANT ENERGY CORPORATION

Plant Site

- San Juan Generation Station (SJGS)
- Waterflow, New Mexico
- 847 MWe
- Fueled with coal from San Juan Coal Company

Amine-based technologies

- Amine-based technology using KS-1™ solvent
- Technology Readiness Level of 8 or 9

San Juan Generating Station

Photo source: https://www.daily-times.com/story/news/local/four-corners/2015/12/16/prc-approves-san-juan-generating-station-plan/77368644/

Studies for Commercial-Scale Carbon Capture Units on New or Existing (Retrofit) Domestic Gas-Fired Power Plants or New Domestic Coal Plants

BECHTEL

Southern Company

THE UNIVERSITY OF TEXAS AT AUSTIN

EPRI ELECTRIC POWER RESEARCH INSTITUTE

FEED STUDY FOR RETROFITTING A 2X2X1 NATURAL GAS-FIRED GAS TURBINE COMBINED CYCLE POWER PLANT FOR CARBON CAPTURE STORAGE/UTILIZATION

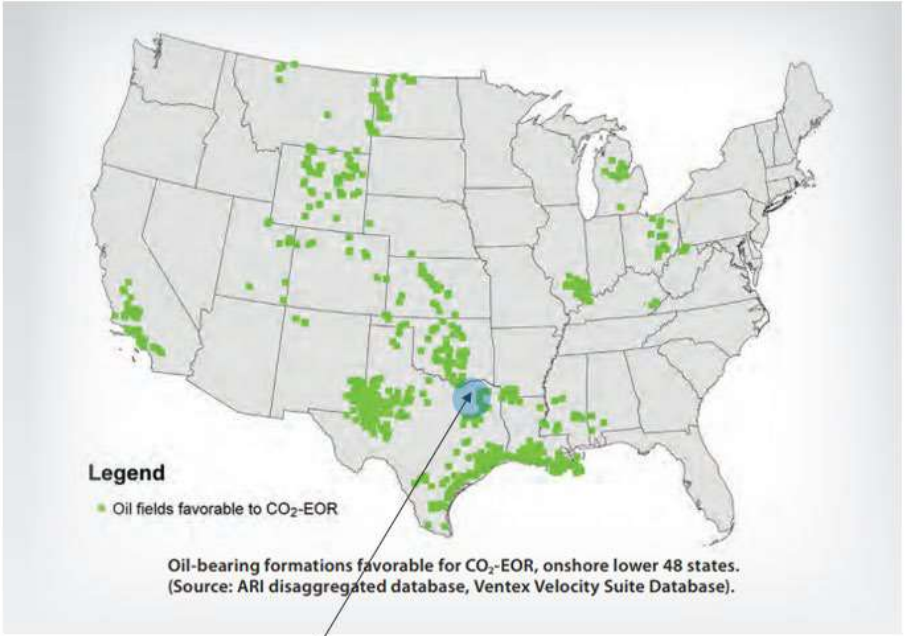
Bechtel National, Inc.

Plant Site

- Sherman, Texas
- Panda Power Funds 2×2×1 natural gas-fired NGCC
- 758 MWe

Amine-based capture technology

- Conventional absorber-stripper scrubbing system
- A non-proprietary solvent such as aqueous MEA

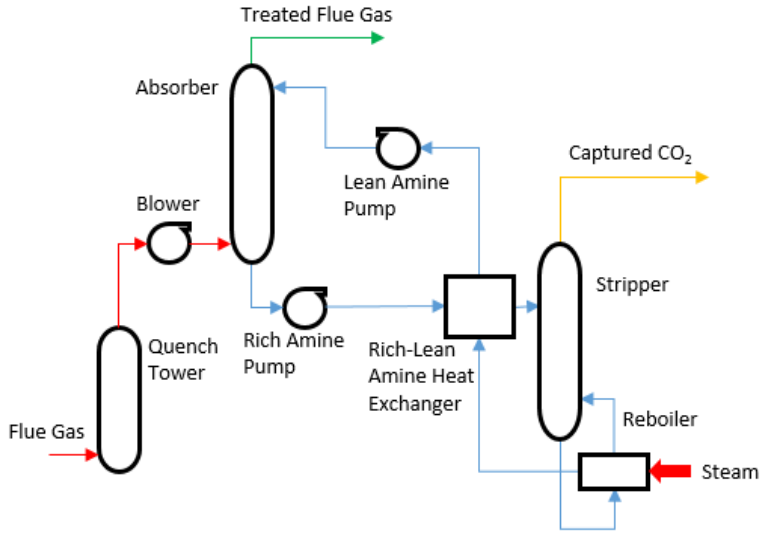


BECHTEL NATIONAL, INC.

- FEED study: NGCC carbon capture retrofit

Project & Technology Advantages

- Uses conventional absorber & scrubber technologies
- Open technology
  - Operators in full control rather than “black box” technology
  - Ability to update hardware with latest technology
- Open access
  - Non-proprietary solvent facilitates procurement at competitive prices
- Enhanced oil recovery (EOR) in a nearby oil field



Generic flowsheet for amine-based

FRONT END ENGINEERING DESIGN OF LINDE-BASF ADVANCED POST-COMBUSTION CO_2 CAPTURE TECHNOLOGY AT A SOUTHERN COMPANY NATURAL GAS-FIRED POWER PLANT

Southern Company Services

Plant Site

Plant Daniel

- Moss Point, Mississippi
- Mississippi Power Company
- NGCC 525 MWe

Figure 7: Plant Daniel NGCC Units 3 & 4

Linde-BASF aqueous amine solvent-based technology

- BASF OASE® blue solvent
- High-capacity structured packing
- Fast-response reboiler design

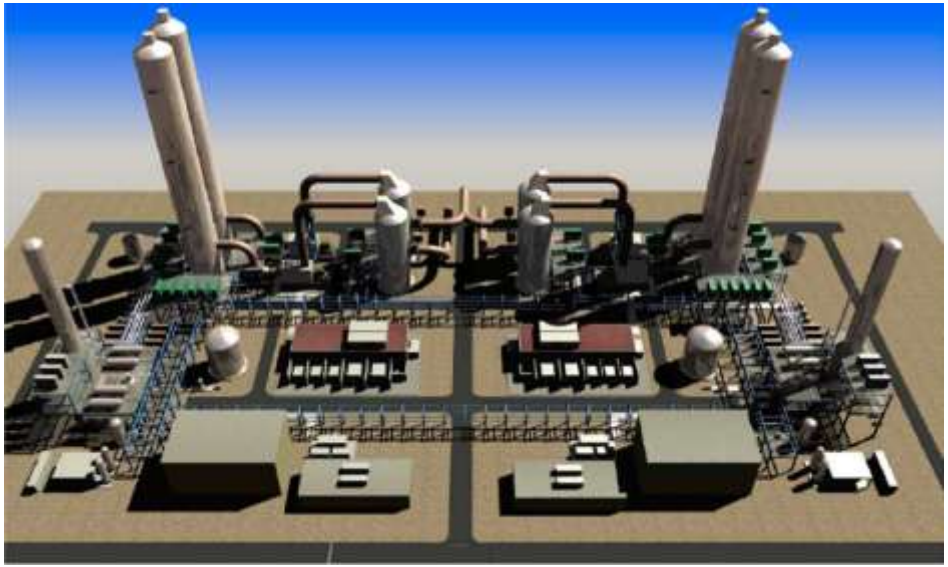
SOUTHERN COMPANY SERVICES

Southern Company

- FEED study: NGCC carbon capture retrofit

Project & Technology Advantages

- Efficient CO_2 capture from low pressure sources
- Favorable reaction kinetics
- Reduced reboiler steam energy
- Longer stability than monoethanolamine (MEA)
- Reduced absorber diameter due to high-capacity structured packing
- Regeneration of CO_2 at elevated pressure (3.4 bara)
- Novel solvent emissions control



3D model of Linde-BASF plant for NGCC

FRONT-END ENGINEERING DESIGN STUDY FOR RETROFIT POST-COMBUSTION CARBON CAPTURE ON A NATURAL GAS COMBINED CYCLE POWER PLANT

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Plant Site

- Elk Hills Oil Field near Tupman, Kern County, California
- California Resources Corporation (CRC)
- Elk Hills Power Plant (EHPP)
- NGCC 550 MWe

Fluor's Econamine FG Plus^{SM} (EFG+) process

- Aqueous amine-based technology
- Advanced reclaiming technologies
- Improved heat balance designs

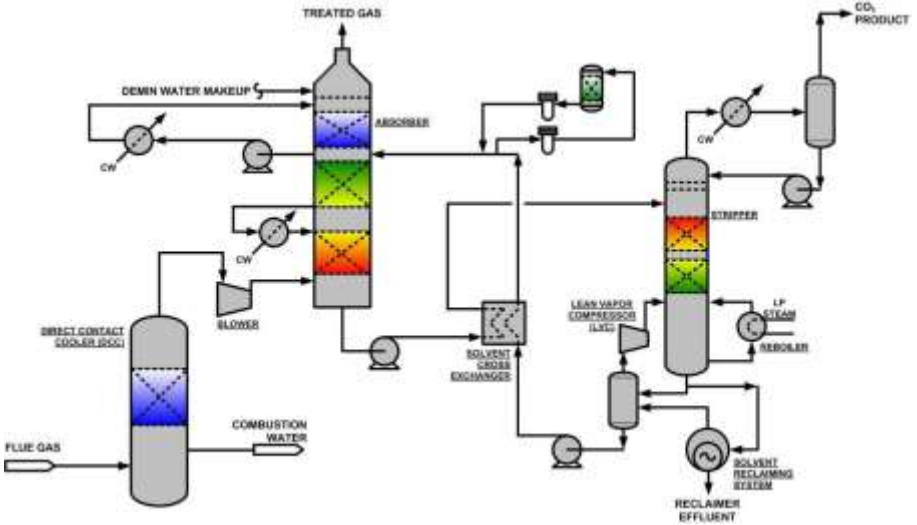
Elk Hills Region in California (From CRC)

ELECTRIC POWER RESEARCH INSTITUTE

- FEED study: NGCC carbon capture retrofit

Project & Technology Advantages

- Nearly 30% lower steam consumption
- 20% lower electric power demand
- 50% lower solvent consumption
- Smaller environmental footprint
- Effective for removal of CO_2 from low-pressure, oxygen-containing **streams**



Simplified Schematic of EFG+ CO_2 Capture Process

PIPERAZINE ADVANCED STRIPPER FRONT END ENGINEERING DESIGN (PZAS FEED)

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Plant Site

- Denver City, Texas
- Golden Spread Electric Cooperative (GSEC)
- Mustang Station
- NGCC 464 MWe

PiperaZine Advanced Stripper (PZAS) process

- Second generation (2G) amine scrubbing process
- Advanced solvent regeneration

Mustang Station

Photo source: https://www.gsec.coop/Public/Plants

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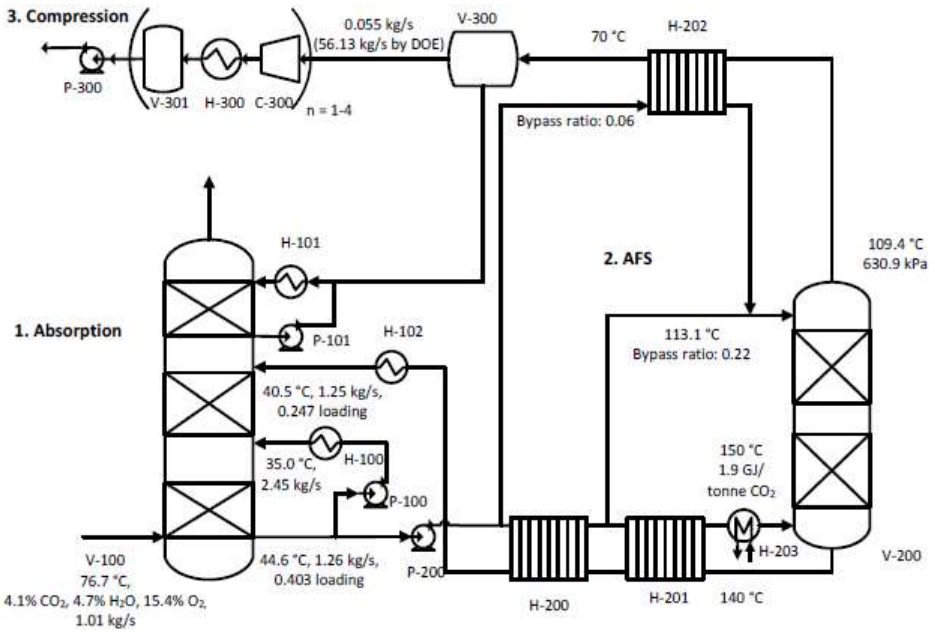
- FEED study: NGCC carbon capture retrofit

Project & Technology Advantages

- Efficient & stable solvent
- Smaller absorber
- Reduced absorber costs
- Efficient stripper
- Environmental benefits
- Reduce material of construction costs



PZAS Process Flowsheet

QUESTIONS?

Please submit your questions using the “Questions” tab in the tool bar

UPCOMING NARUC EVENTS

Innovation Webinars

- June 17, 3-4PM (ET): Balancing the Clean Grid: Reliability and Renewable Energy
- August 12, 3-4PM (ET): Virtual Power Plants in the 20s: Moving from Theory to Practice

NARUC Summer Policy Summit – Jul 14-15 (virtual) and 18-21 (hybrid virtual and in-person in Denver, CO)

- Registration open
- https://www.naruc.org/meetings-and-events/naruc-summer-policy-summits/2021-summer-policy-summit/

THANK YOU

Chair Anthony O'Donnell, Montana

Vice Chair Ellen Nowak, Wisconsin

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