Estimating Rates of Carbon Capture Adoption

John Thompson
Clean Air Task Force (CATF)
China-US Clean Coal Industry Forum
Morgantown, VA
November 30, 2017

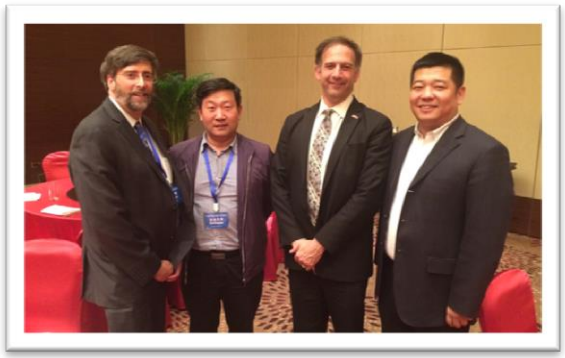
CATF's Role: Building US-China CCS Bridges

- We are a resource and partner in building robust CCUS industries in both the U.S. and China.

- Our work seeks CO_2 reductions through enhanced oil recovery and saline storage from carbon capture.

Clean Air Task Force - China

- Provincial-level CCUS workshops
- Support joint US-China CCUS projects
- Technical and policy exchanges.
- Reports and conferences



Can Carbon Capture be Scaled-Up in Time to Address Climate Change?

- This specific question is part of a broader topic: Can the success of new technologies in the marketplace be predicted?

- New research on the semiconductor industry provides insights on technology adoption that apply to clean energy, and especially carbon capture technology.

- This presentation adapts this semiconductor industry research to better understand the barriers/solutions that influence how quickly power plants could add carbon capture.

The Semiconductor Industry

- Adner and Kapoor examined technology change over a nearly 40-year period of printing semiconductor circuits in the computing industry.[1]

- Only 48% of the substitution of a new technology for an older one could be attributed to traditional factors including:
  - Price-adjusted performance differences,
  - Number of rival products,
  - How long the old technology had been used.

- Accounting for something the authors call the supporting "ecosystem" and how the old and new technologies compete against each other, the ***correlation with success rose from 48% to 82%*** in their statistical analysis.

1. Ron Adner and Rahul Kapoor, *Innovation Ecosystems and the Pace of Substitution: Re-examining*

What's an Ecosystem?

- Adner and Kapoor note that some technologies immediately surpass their predecessors (inkjet printers overtaking dot matrix printers) while others take decades (HDTV replacing traditional televisions).[2]

- To account for these differences, the authors focus on the "**ecosystem"- how much the new technology must rely on external innovations such as complimentary technologies services, standards, and regulations**.

2. Ron Adner and Rahul Kapoor, *Right Tech, Wrong Time Disruption: Its Not the Tech, It's the Timing*, Harvard Business Review, (November 2016), *available at*: https://hbr.org/2016/11/right-tech-wrong-time.

Key Points from Ander and Kapoor

- It's important to analyze the ecosystem needed for a new technology, not just the performance of the technology itself.
- Ecosystem bottlenecks must be removed to advance promising technologies.
- Incumbent technologies can innovate with either extensions of their existing technologies or through changes to their ecosystem to delay or stop new technologies.
- Each time a competing technology improves, the bar is raised for new technologies seeking to displace incumbents.

Ron Adner and Rahul Kapoor, *Right Tech, Wrong Time Disruption: Its Not the Tech, It's the Timing*, Harvard Business Review, (November 2016), *available at*: https://hbr.org/2016/11/right-tech-wrong-time.

Carbon Capture Ecosystem

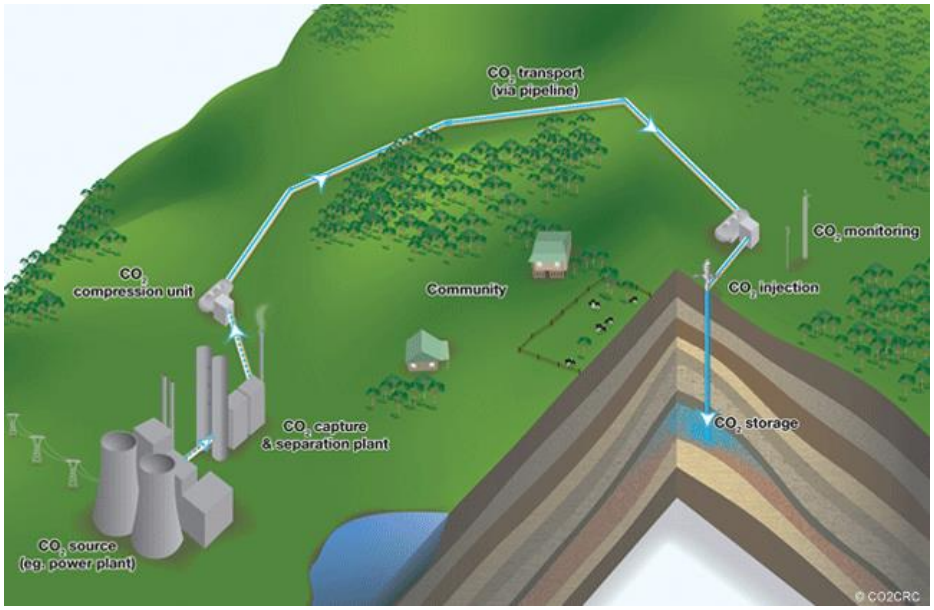


Image Courtesy of: CRC for Greenhouse Gas Technologies (CO2CRC)

Ecosystem Elements/Bottlenecks/Nodes		
1	Incentives or mandates to overcome capture cost premium	
2	CO_2 Pipelines	
3	Storage Sites	
4	Safety and long-term care standards	
5	Location restrictions	
6	Scale of Financing Projects	
7	Know-how	

Rate of Adoption

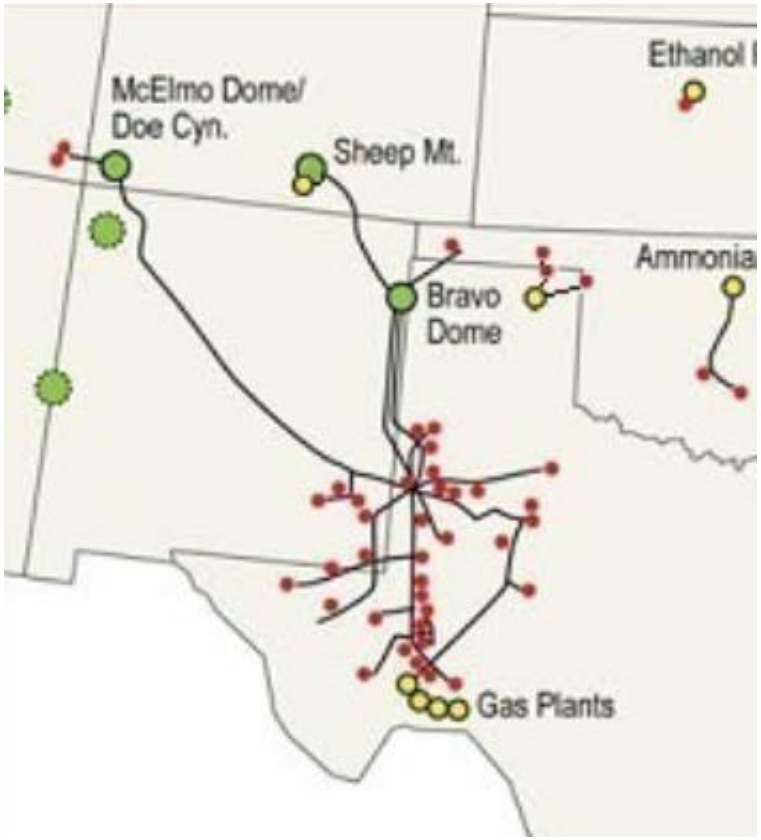
- Adoption of new technology in the marketplace is not only a function of price and performance, but also how much the ecosystem must adapt. ***The more ecosystem elements, the slower the adoption.***

		Ecosystem Elements						
CCS		**Incentives**	**Pipeline**	**Storage sites**	**Safety/ Long-term care**	**Location Restrictions**	**Scale of Financing**	**Know-how**
Wind		Incentives						

At higher levels of penetration, new wind elements appear!

First Projects Can Choose Sites that Eliminate Ecosystem Bottlenecks

Example: New carbon capture project in Permian Basin



	Carbon Capture (CCS)
1	Cost Premium
2	~~Restricted Geography~~
3	~~Storage Sites~~
4	~~Long-Term Care~~
5	~~Pipelines~~
6	Financing Projects
7	~~Financing Large-Scale Complimentary Infrastructure~~
	7 Elements

Two bottlenecks remain

What If Cost Premiums Disappears?

	Carbon Capture (CCS)	Wind (High Penetration)	Solar (High Penetration)	Nuclear
1	Cost Premium	Cost Premium	Cost Premium	Cost Premium
2	Restricted Geography	Restricted Geography	Restricted Geography	Restricted Geography
3	Storage Sites	Balancing	Balancing	Permitting
4	Long-Term Care	Grid-Scale Energy Storage	Grid-Scale Energy Storage	Waste Disposal
5	Pipelines	Advanced Grid	Advanced Grid	Construction Complexity
6	Financing Projects	Back-Up Generation	Back-Up Generation	Financing Projects
7	Financing Large-Scale Complimentary Infrastructure	Financing Large-Scale Complimentary Infrastructure	Financing Large-Scale Complimentary Infrastructure	International Standards
	7 Elements	7 Elements	7 Elements	7 Elements
	6 Elements	6 Elements	6 Elements	6 Elements

Assume the cost premium between the clean technology and existing generation disappears.

(Perhaps through a technology breakthrough, a subsidy, or emissions from existing sources are heavily taxed.)

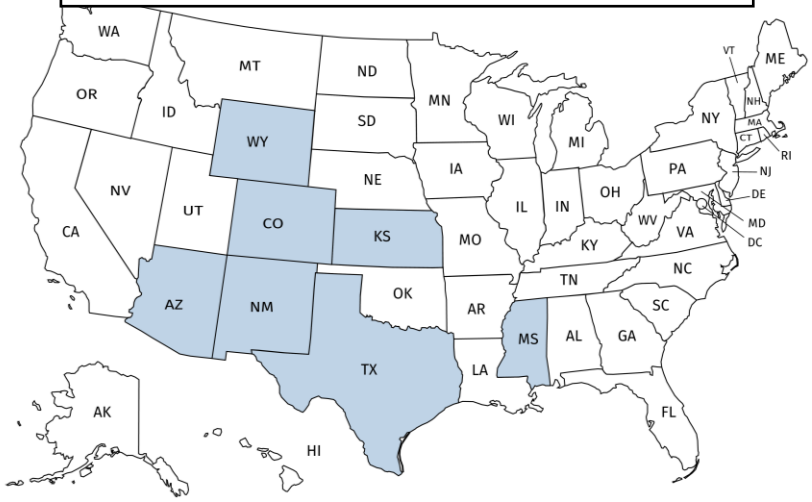
Remaining elements will still hinder the advancement of clean energy options.

Congress is Considering Carbon Capture Incentives

Modeling shows these incentives could drive significant amounts of carbon capture, but lack of infrastructure (an ecosystem bottleneck) will likely dampen impacts.

45Q only in 2030

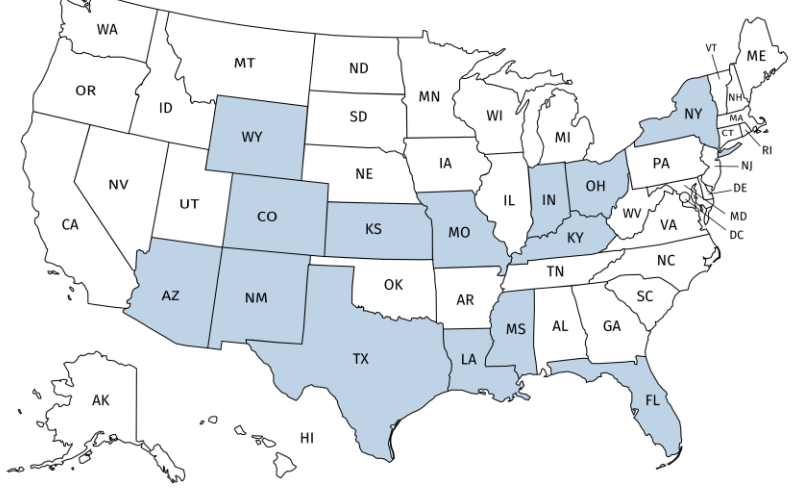
Approximately 15 units with carbon controls



CO2 is predominantly sequestered through EOR

45Q + PAB & MLP in 2030

Approximately 42 units with carbon controls



CO2 is predominantly sequestered through saline

Concluding Thoughts

- Although renewables made impressive gains over the past decade, at higher levels of penetration on the electric grid, new and more challenging ecosystem bottlenecks will appear that are likely to hinder deployment.

- CCS has started slower, but the CCS ecosystem bottlenecks don't appear to any more challenging than those renewables will face at higher penetration levels.

- However, for CCS to advance, it's not enough to focus on cost reduction policies. Policies must also focus on actions that overcome CCS ecosystem bottlenecks.
  - Pipeline build-out
  - Workable long-term care requirements
  - Ensuring capital is available to finance multi-billion dollar projects.

Concluding Thoughts (continued)

- The ecosystem for the current electric system is not static:
  - In the short-term, continued reduction in gas prices and efficiency improvements at new gas plants will favor uncontrolled NGCC plants. But over the longer term, these factors may benefit carbon capture on gas plants over other clean energy technologies.
  - Changes to create an "advanced grid" may favor intermittent renewables over base-load generation (like CCS).
  - In the medium-term, carbon capture will depend on enhanced oil recovery (EOR) for storage. EOR competes with other forms of oil production. If unconventional oil production continues to realize cost reductions, EOR may need to see technology breakthroughs to compete and attract oil industry interest.