Enhancing the Success Rate of Technology Development: An Ecosystem Approach

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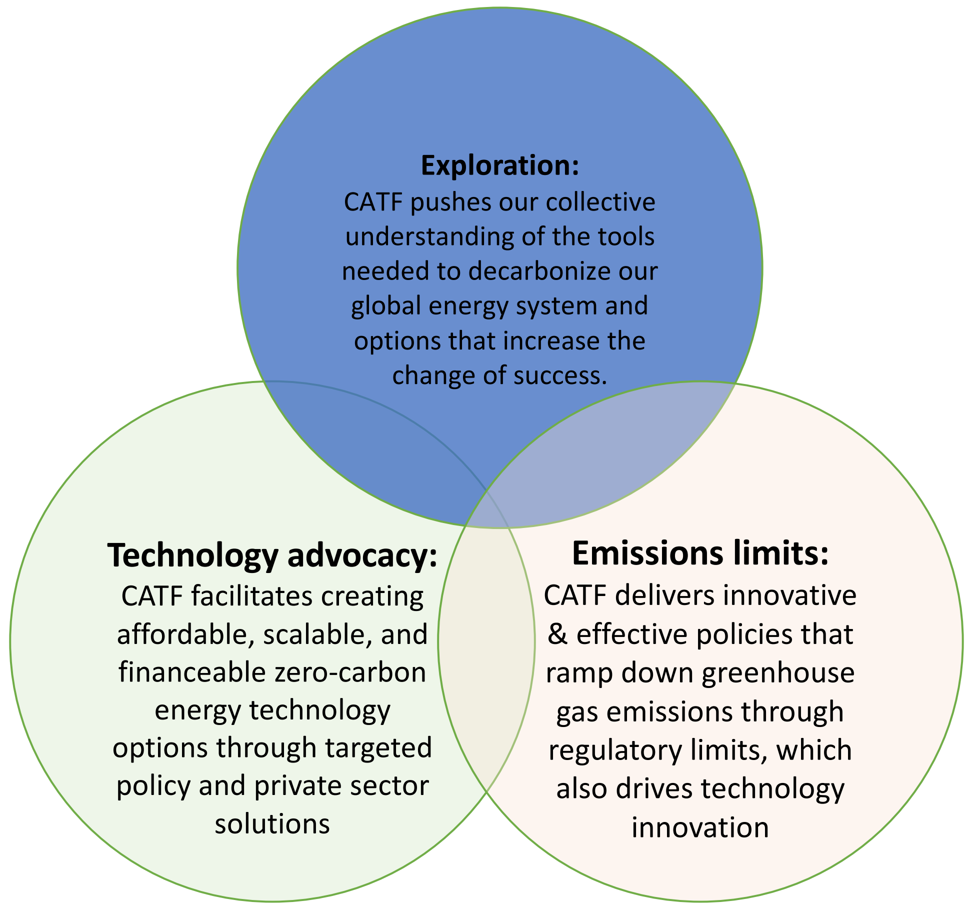
April 12, 2018

About the Clean Air Task Force

CATF Vision

Create the conditions that drive global deployment of technologies which will significantly reduce the of risk catastrophic climate change



Funding

- Grants from private foundations and individuals, no industry funding.

How Fast Can Carbon Capture be Scaled?

- This question is addressed in a broader CATF "lessons learned" from innovation policy report due out in 2018.

- To combat climate change, clean technologies including carbon capture must be used on very large scales soon. Scale imposes technology requirements, including:
    - Global applicability
    - Time and cost to construct
    - Ease of financing
    - Few "Ecosystem" bottlenecks

- This presentation focuses on "ecosystem" bottlenecks.

Importance of “Ecosystems”

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

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

- Accounting for what the authors call the supporting “ecosystem" the ***correlation with success rose from 48% to 82%*** in their statistics.

1. Ron Adner and Rahul Kapoor, *Innovation Ecosystems and the Pace of Substitution: Re-examining Technology S-curves, Strat. Mgmt. J.* (2015) *available at:* 2016-02-03-Adner-Kapoor-SMJ-2015_3.pdf

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 Adner 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 & Storage Ecosystem

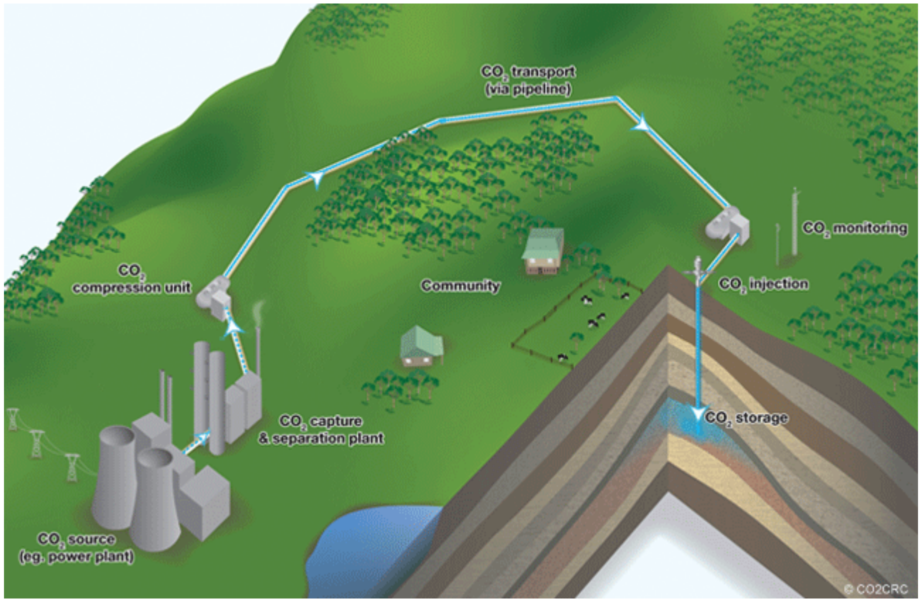


Image Courtesy of: CRC for Greenhouse Gas Technologies (CO2CRC)

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

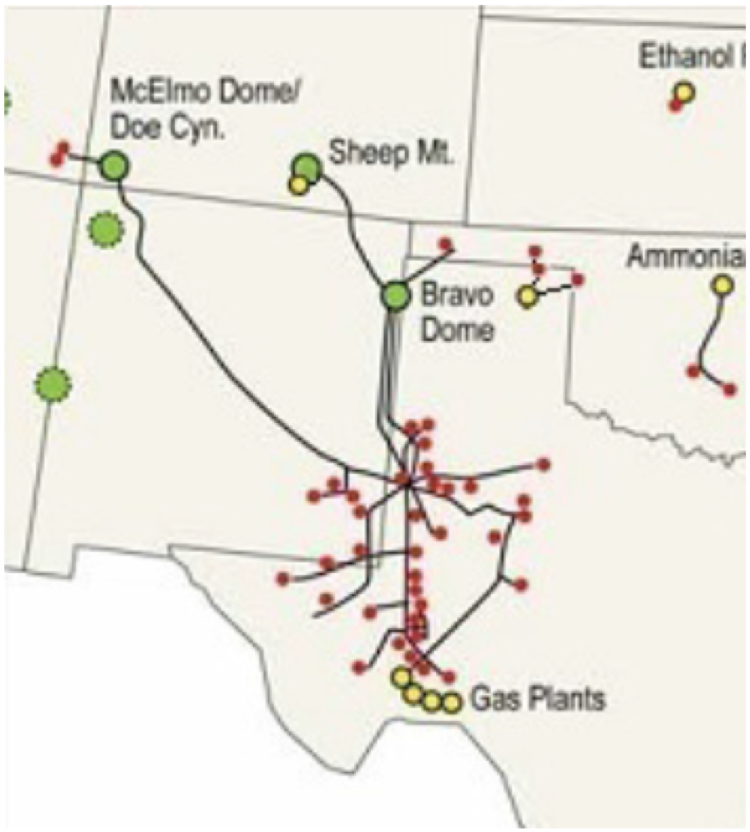
- Adoption of new technology in the marketplace is not only a function of price and performance, but also how much the ecosystem must adapt. ***The more ecosystem elements, the slower the adoption of the technology.***

		Ecosystem Elements						
CCS		Cost Premium	Restricted Geography	Storage sites	Long-term Care	Pipelines	Financing Projects	Financing Infrastructur e
Wind		Cost Premium						
Wind (High)		Cost Premium	Restricted Geography	Balancing	Grid-Scale Storage	Advanced Grid	Back-up Generation	Financing Infrastructur e

At higher levels of penetration, new wind ecosystem 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

ONLY Two bottlenecks remain

What If Cost Premiums Disappear?

	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.)

Must eliminate remaining elements to scale up.

Implications of 45Q Tax Credits for Carbon Capture & Storage

Example:

- 45Q tax credits may make some coal plants near the Permian Basin attractive for carbon capture retrofits.

- Key barriers such as cost and access to EOR are reduced.

- Other policies may be needed:
  - Capital investment in a de-regulated electricity market.
  - Getting enough projects in the pipeline to eliminate the risk that equipment vendors place all development costs on first project.

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 significantly scale for climate mitigation, it's not enough to focus on cost reduction policies. Policies must also focus on actions that overcome CCS ecosystem bottlenecks. Top priorities include:
  - Pipeline build-out
  - 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, 45Q tax credits will help carbon capture on industrial and power sources. Experience from early projects is likely to lower future carbon capture costs that help over the longer term.
  - Gas prices are low. This favors uncontrolled gas, but may help gas with CCS too.
  - Changes to create an "advanced grid" may favor intermittent renewables over base-load generation (like CCS).
  - In the medium-term, carbon capture & storage applications 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.