Enhancing the Success Rate of Technology Development: An Ecosystem Approach

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Clean Air Task Force (CATF)
National Coal Council
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About the Clean Air Task Force

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

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

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**Exploration:**
CATF pushes our collective understanding of the tools needed to decarbonize our global energy system and options that increase the chance of success.

**Technology advocacy:**
CATF facilitates creating affordable, scalable, and financeable zero-carbon energy technology options through targeted policy and private sector solutions.

**Emissions limits:**
CATF delivers innovative & effective policies that ramp down greenhouse gas emissions through regulatory limits, which also drives technology innovation.
How Fast Can Carbon Capture beScaled?

• 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.

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.

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.

Carbon Capture & Storage Ecosystem

Ecosystem Elements/Bottlenecks/Nodes

1. Incentives or mandates to overcome capture cost premium
2. CO₂ Pipelines
3. Storage Sites
4. Safety and long-term care standards
5. Location restrictions
6. Scale of Financing Projects
7. Know-how

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

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<thead>
<tr>
<th>Ecosystem Elements</th>
<th>CCS</th>
<th>Wind</th>
<th>Wind (High)</th>
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<tbody>
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<td></td>
<td>Cost Premium</td>
<td>Restricted Geography</td>
<td>Storage sites</td>
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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

<table>
<thead>
<tr>
<th>7 Elements</th>
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<tbody>
<tr>
<td>Financing Large-Scale Complimentary Infrastructure</td>
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<tr>
<th>Carbon Capture (CCS)</th>
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<tbody>
<tr>
<td>1 Cost Premium</td>
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<tr>
<td>2 Restricted Geography</td>
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<tr>
<td>3 Storage Sites</td>
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<tr>
<td>4 Long-Term Care</td>
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<td>5 Pipelines</td>
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<td>6 Financing Projects</td>
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ONLY Two bottlenecks remain
What If Cost Premiums Disappear?

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<tr>
<th></th>
<th>Carbon Capture (CCS)</th>
<th>Wind (High Penetration)</th>
<th>Solar (High Penetration)</th>
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<td>1</td>
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<td>3</td>
<td>Storage Sites</td>
<td>Balancing</td>
<td>Balancing</td>
<td>Permitting</td>
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<td>4</td>
<td>Long-Term Care</td>
<td>Grid-Scale Energy Storage</td>
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<td>Waste Disposal</td>
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<tr>
<td>5</td>
<td>Pipelines</td>
<td>Advanced Grid</td>
<td>Advanced Grid</td>
<td>Construction Complexity</td>
</tr>
<tr>
<td>7</td>
<td>Financing Large-Scale Complimentary Infrastructure</td>
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<td>International Standards</td>
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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.