Supporting Responsible Natural Resource Management, CO$_2$ Transport Infrastructure, and Economic Development in Pennsylvania

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Today’s Focus

• Define CCUS and its role in climate mitigation efforts
• Provide a summary of Pennsylvania’s geologic carbon storage research
• Introduce the work of the CCUS Inter-Agency Work Group
• Present current CO₂ transport infrastructure action plan preparation efforts
What is CCUS?
Carbon – Capture – Utilization – Storage
“Commoditization of Emissions”

Carbon
- Major Greenhouse Gas
- Carbon dioxide, aka CO₂
- Origin: entire planet

Capture
- Purification & Drying
- Compression to Super-Critical Fluid
- Transport via pipeline

Utilization
- Enhanced Oil Recovery
- CO₂ is major but not only type of EOR
- Injection → Production

Storage
- ½ – 2 miles depth
- Porous rock beneath non-permeable rock
- Established technology
The Value Chain – CCUS leads to CCS

**CO₂ Sources**
- **Value:** Raw materials in respective markets

**CO₂ Capture**
- **Value:** (1) Reduced costs of GHG emission penalty; (2) Tax credits from capture, storage of CO₂; (3) Revenue from sale of CO₂; (4) Revenue from sale of low carbon fuels and energy to other industry sectors

**CO₂ Utilization and Storage**
- **Value:** (1) Revenue from permanent disposal of CO₂ in geologic formations; (2) Revenue from oil recovery

**CO₂ Transport**
- **Value:** Generate profit by transporting CO₂
Very few scenarios achieve the 2-degree climate mitigation goal without CCS.
Utilization

✓ Size of source vs. volume of sink

✓ Active mining, natural gas extraction, natural gas storage, etc.

Stacked Reservoirs

✓ Pore Space Ownership/Access

Permanent Storage

Coordination of Resource Development

Coordination of Capture and Transport Infrastructure
Pennsylvania’s Work in the CCUS Space

- Carbon Sequestration Technical Assessment (CSTA): 2009
- Governor’s CCUS Inter-Agency Work Group: 2019 – present
- Midwest Regional Carbon Initiative (MRCI): 2019 – 2022 (proposed extension to 2024)
MRCSP was part of US DOE’s Regional Carbon Sequestration Partnership (RCSP) Initiative

• Established the first U.S. national network of companies and professionals focused on carbon storage
• Proved adequate large scale injectivity and available capacity in regionally important storage formations
• Provided examples of simulation models and monitoring technologies that predict CO₂ movement and confirm confining system integrity
• Contributed toward developing/evaluating innovative storage technologies for a cost-effective commercial toolbox
• Developed and implemented expert panel-based risk assessment strategies such as the Adaptive Management Approach
• Demonstrated the benefits of early engagement with local communities and stakeholders
• Contributed to a series of best practice manuals on major topics associated with geologic storage implementation
MRCSP’s Large-Scale Injection Project

- Objective – Inject/monitor 1+ Million tonnes (Mt) of CO$_2$ in collaboration with EOR operations
- Evaluate CO$_2$ injectivity, migration, containment
Results - Total LCA Results 1996 – 2017

• Analysis shows 1.9 Mt of CO\textsubscript{2}e emissions over 22 years of operation
  – Upstream CO\textsubscript{2}e Emissions – 478 Kt
  – Gate to Gate CO\textsubscript{2}e Emissions – 374 Kt
  – Downstream CO\textsubscript{2}e Emissions – 1.07 Mt

• Associated CO\textsubscript{2}e Storage 2.09 Mt

• MI reefs have net negative (-160 Kt) CO\textsubscript{2}e GHG “cradle to grave” balance

• Results certify environmental benefits of CO\textsubscript{2} EOR; ups/downs of CO\textsubscript{2}-EOR operations must be considered for life cycle GHG analysis
Existing Infrastructure and CO₂ Emissions

- Road, rail and waterways
- Power plants are the largest (and most common) source; 40% of PA’s power plants emit >1 Mt CO₂/yr
- But...other emissions exist, too (steel/metals, minerals, chemicals, petroleum products/refineries, pulp and paper...); steel/metals emit ~10,000 t – 1 Mt CO₂/yr; minerals: ~18,000 t – 800,000 t CO₂/yr
- Industrial emissions cannot necessarily decarbonize simply by fuel-switching
Pennsylvania Oil Field Case Studies (2019)

<table>
<thead>
<tr>
<th>Drillers’ Sand Name</th>
<th>Top Formation (ft)</th>
<th>Thickness (ft)</th>
<th>Porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Avg</td>
</tr>
<tr>
<td>Hundred-Foot</td>
<td>1813</td>
<td>3306</td>
<td>2563</td>
</tr>
<tr>
<td>Gantz</td>
<td>1813</td>
<td>3306</td>
<td>2633</td>
</tr>
<tr>
<td>Fifty-Foot</td>
<td>1839</td>
<td>3342</td>
<td>2591</td>
</tr>
<tr>
<td>Nineveh</td>
<td>1968</td>
<td>3395</td>
<td>2708</td>
</tr>
<tr>
<td>Gordon Stray</td>
<td>2018</td>
<td>3451</td>
<td>2745</td>
</tr>
<tr>
<td>Gordon</td>
<td>2050</td>
<td>3482</td>
<td>2792</td>
</tr>
<tr>
<td>Fourth</td>
<td>2116</td>
<td>3555</td>
<td>2896</td>
</tr>
<tr>
<td>Fifth</td>
<td>2175</td>
<td>3611</td>
<td>2979</td>
</tr>
</tbody>
</table>
• Given this example, potential CCS reservoirs may offer 1.4 – 4.4 billion tonnes (Bt)

• Mode value – 2.4 Bt
# Mode Storage for Selected Geologic Intervals in Pennsylvania

<table>
<thead>
<tr>
<th>Geologic Interval</th>
<th>Reservoir Count</th>
<th>Mode Storage Volume (Bt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Mississippian-Upper Devonian sandstones</td>
<td>1,718</td>
<td>1.03</td>
</tr>
<tr>
<td>Lower Devonian sandstones and carbonates</td>
<td>293</td>
<td>0.12</td>
</tr>
<tr>
<td>Lower Silurian sandstones</td>
<td>803</td>
<td>1.25</td>
</tr>
<tr>
<td>Cambro-Ordovician sandstones and carbonates</td>
<td>64</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>2,878</strong></td>
<td><strong>2.4</strong></td>
</tr>
</tbody>
</table>
Midwest Regional Carbon Initiative (MRCI)

- Bigger geographic footprint (20 states and U.S. Mid-Atlantic offshore)
- Responsible infrastructure siting and development
- Match sources to sinks using infrastructure
- Stacked potential

<table>
<thead>
<tr>
<th>Source Type</th>
<th>2017 Emissions (Mt)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Plant</td>
<td>694</td>
<td>73%</td>
</tr>
<tr>
<td>Metals</td>
<td>72.5</td>
<td>8%</td>
</tr>
<tr>
<td>Minerals</td>
<td>44.4</td>
<td>5%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>38.3</td>
<td>4%</td>
</tr>
<tr>
<td>Petroleum, Natural Gas, and Refineries</td>
<td>28.4</td>
<td>3%</td>
</tr>
<tr>
<td>Other</td>
<td>28.0</td>
<td>3%</td>
</tr>
<tr>
<td>Ethanol</td>
<td>16.9</td>
<td>2%</td>
</tr>
<tr>
<td>Pulp and Paper</td>
<td>10.7</td>
<td>1%</td>
</tr>
<tr>
<td>Waste</td>
<td>7.9</td>
<td>1%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>3.5</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>945</strong></td>
<td><strong>-</strong></td>
</tr>
</tbody>
</table>
CCUS Inter-Agency Work Group

- Formed in October 2019
- Our work is framed and supported by four pillars: technical, regulatory, economic and policy drivers
- Preparing an inter-agency MOU to galvanize our collaborative efforts for the commonwealth
- Opportunities for collaboration – the MRCI Project, Climate Action Plan, regional infrastructure buildout, RGGI, etc.
MOU for a Regional CO$_2$ Transport Infrastructure Action Plan

- **Recognizes** that development of CO$_2$ transport networks, together with financial incentives for carbon capture from various sources/sectors, 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**

- **Establishes** a collaborative mechanism to develop and implement an action plan for the buildout of regional CO$_2$ transport infrastructure to enable large-scale carbon management

- **Seeks** to accelerate, through state leadership and coordination, the deployment of regional CO$_2$ transport infrastructure networks and carbon hubs in which industries take advantage of economies of scale through common transport and geologic storage infrastructure
Action Plan Work – Scope and Schedule

- **Focused webinar offerings** – Oct-Dec 2020
- **Stakeholder engagement** – Oct 2020-Oct 2021
- **Outreach to additional states** – Oct 2020-Oct 2021
- **Action plan document preparation**
  - Develop outline – Oct-Dec 2020
  - Review/finalize outline – Dec 2020
  - Prepare action plan – Jan-June 2021
  - Review action plan – June 2021
  - Finalize action plan and develop public distribution plan for release – Sept 2021
  - Release final action plan – **Oct 2021**
4th Quarter 2020 Webinars

- November 10: 10:00 – 11:00 am CT | Analysis Overview & Federal Landscape
- November 17: 10:00 – 11:00 am CT | Overview of Alberta Trunk Line Project and Wyoming Pipeline Corridor Initiative
- December 9: 10:00 – 11:00 am CT | Class VI Update and Announced Projects
- December 17: 11:00 am – 12:00 pm CT | Action Plan Preview
  - Elicit feedback on the action plan outline
  - Tee-up work plan for 2021
Action Plan Elements (Working Outline)

- Introduction
- Background
- Federal government policy support
- State level government policy support
- Federal and state recommendations
Anticipated Follow-On Work for 2021

• Additional State Outreach
• Stakeholder Engagement
• Learning Webinars
• Action Plan Development
CCUS inter-agency work group

Regional
Infrastructure buildout
Stakeholder engagement

Federal
45Q +
Complementary policy portfolio

State
Tax optimization
Regulatory Policies
Financial Incentives

Economywide Deployment of Carbon Capture

CO₂ transport MOU and action plan

federal tax incentives, federally funded projects/regional initiatives
Take Home Points...

• CCS and CCUS technical research is well-established for the state, region and country

• Full-scale CCS and CCUS projects have been successfully and safely deployed, both domestically and abroad

• CCS is necessary for meeting emission reductions and for achieving the 2-degree climate mitigation goal

• Coordination will be required to responsibly manage subsurface resources, CCUS projects and permanent carbon storage solutions
Take Home Points...

- Pennsylvania has significant and varied geologic resources that could be used to **beneficially use and/or permanently store** CO$_2$
- At any given site, one or more reservoirs may be needed to accommodate source emissions, so **stacked potential** will be important
- **Infrastructure** will be important to match sources to sinks, and Pennsylvania is one of seven signatory states (first in the Mid-Atlantic) supporting the regional CO$_2$ transport infrastructure action plan MOU
Helpful Weblinks

• Midwest Regional Carbon Sequestration Partnership – www.mrcsp.org

• The Midwest Regional Carbon Initiative – www.MidwestCCUS.org

• State Carbon Capture Work Group – https://carboncaptureready.betterenergy.org/resources/#state-work-group

• The Regional Carbon Capture Deployment Initiative – https://carboncaptureready.betterenergy.org/regions/

• DCNR climate change webpage – https://www.dcnr.pa.gov/Conservation/ClimateChange/Pages/default.aspx

• Follow DCNR on social media https://www.dcnr.pa.gov/Pages/Follow-Us.aspx
Thank you!

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