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 CO_2 transport infrastructure action plan preparation efforts

What is CCUS?

Carbon – Capture – Utilization – Storage

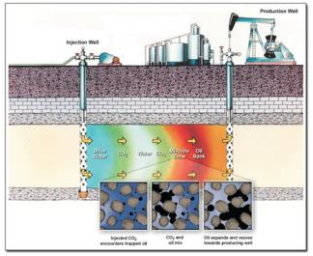
“Commoditization of Emissions”

CARBON

- Major Greenhouse Gas
- Carbon dioxide, aka CO_2
- Origin: entire planet

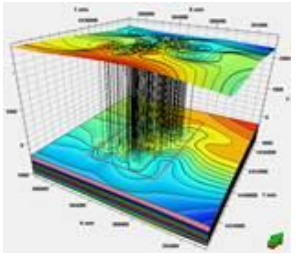
CAPTURE

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



UTILIZATION

- Enhanced Oil Recovery
- CO_2 is major but not only type of EOR
- Injection → Production



STORAGE

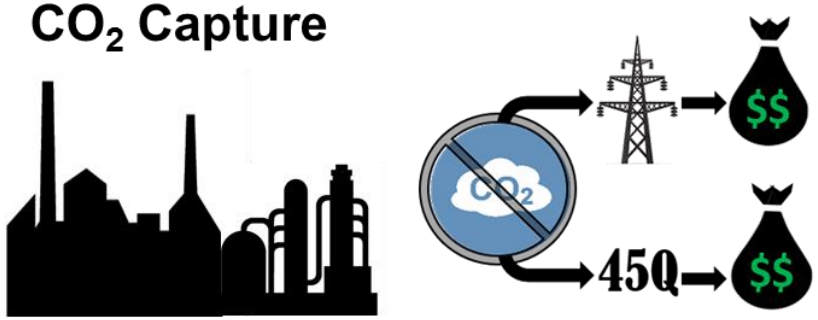
- ½ – 2 miles depth
- Porous rock beneath non-permeable rock
- Established technology

The Value Chain – CCUS leads to CCS

CO_2 Sources

Value: Raw materials in respective markets

CO_2 Capture

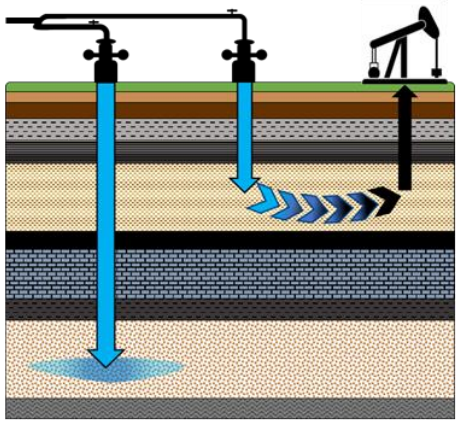


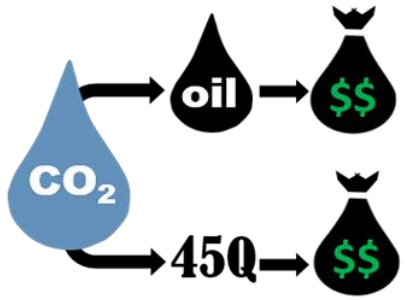
Value: **(1)** Reduced costs of GHG emission penalty; **(2)** Tax credits from capture, storage of CO_2; **(3)** Revenue from sale of CO_2; **(4)** Revenue from sale of low carbon fuels and energy to other industry sectors

CO_2 Transport

Value: Generate profit by transporting CO_2

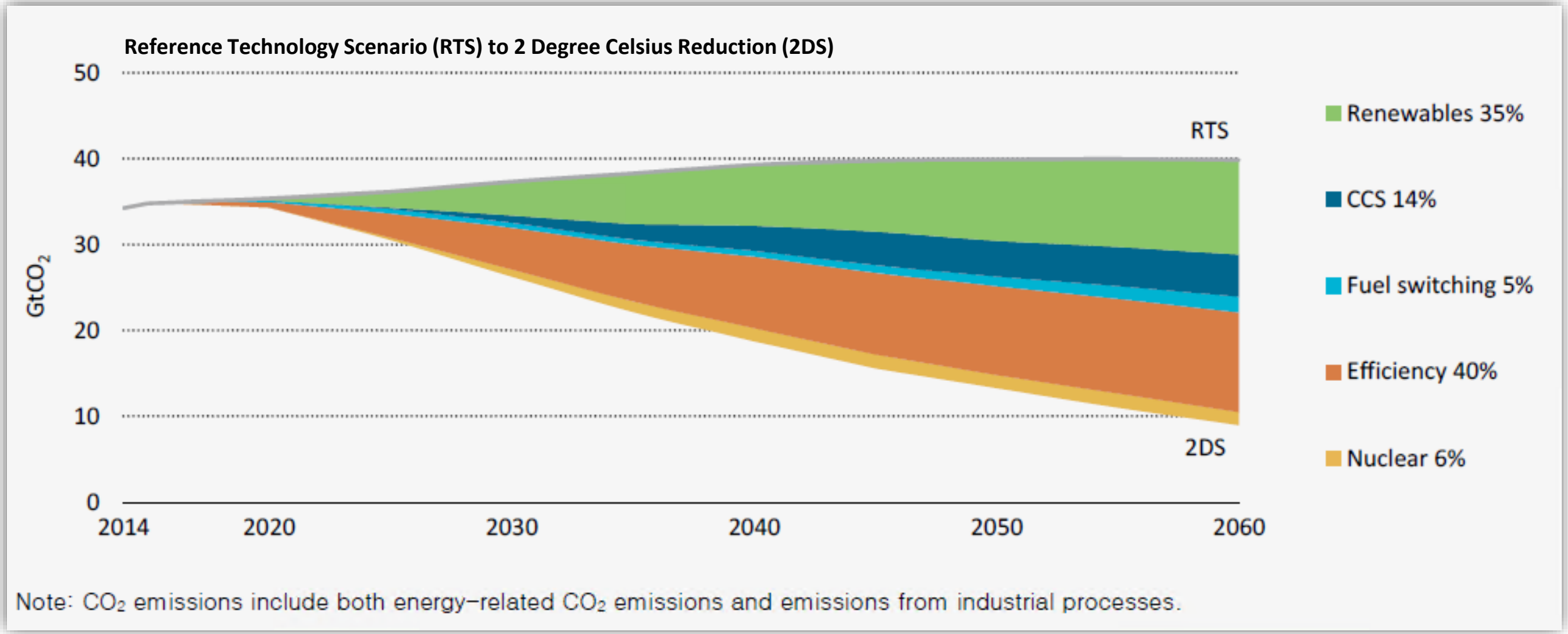
CO_2 Utilization and Storage





Value: **(1)** Revenue from permanent disposal of CO_2 in geologic formations; **(2)** Revenue from oil recovery

Very few scenarios achieve the 2-degree climate mitigation goal without CCS



Source: IEA Energy Technology Perspectives (2017)

Coordination of Capture and Transport Infrastructure

Pennsylvania's Landscape

- ✓ **Size of source vs. volume of sink**

Utilization

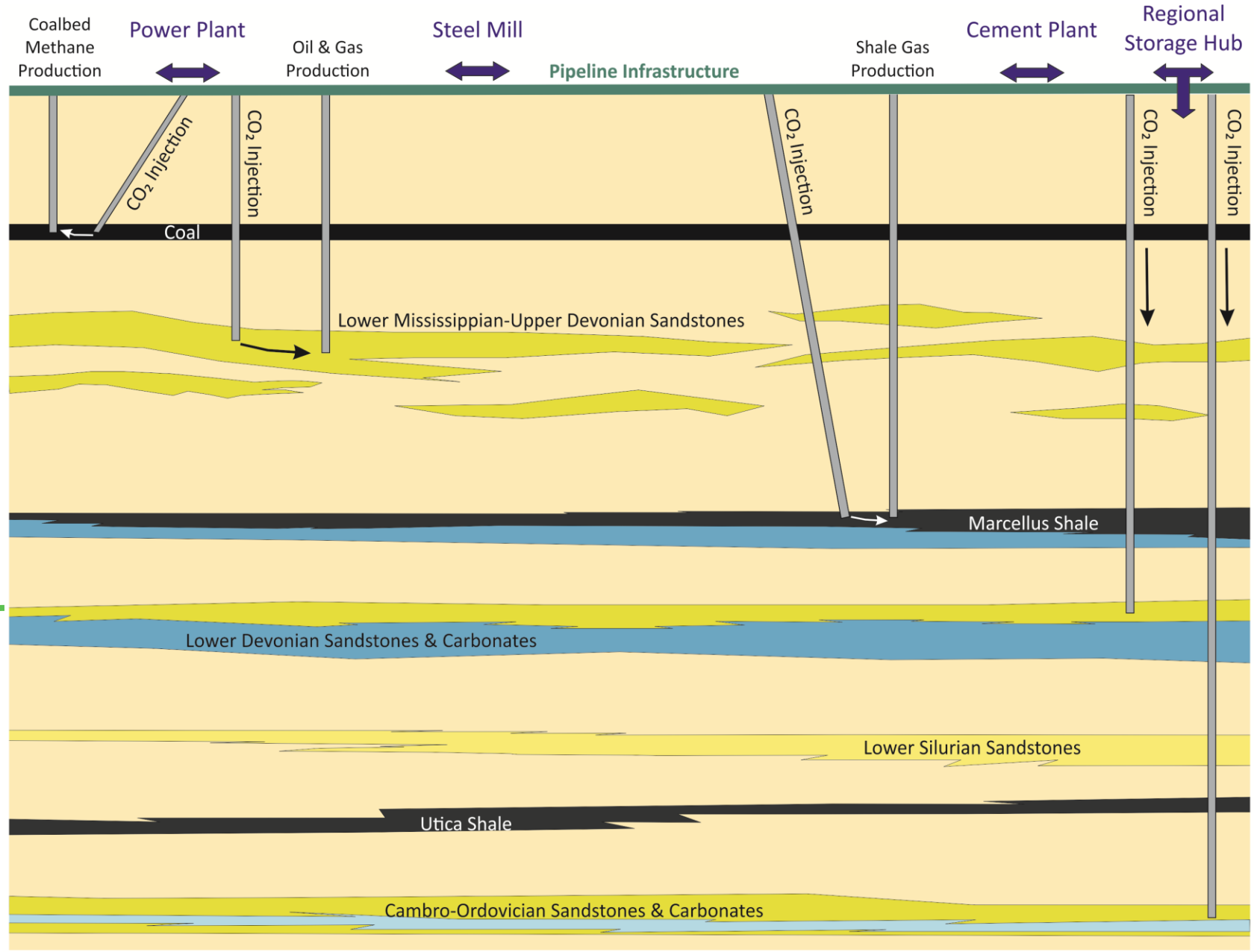
- ✓ **Active mining, natural gas extraction, natural gas storage, etc.**

Stacked Reservoirs

- ✓ **Pore Space Ownership/Access**

Permanent Storage

Coordination of Resource Development



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Pennsylvania's Work in the CCUS Space

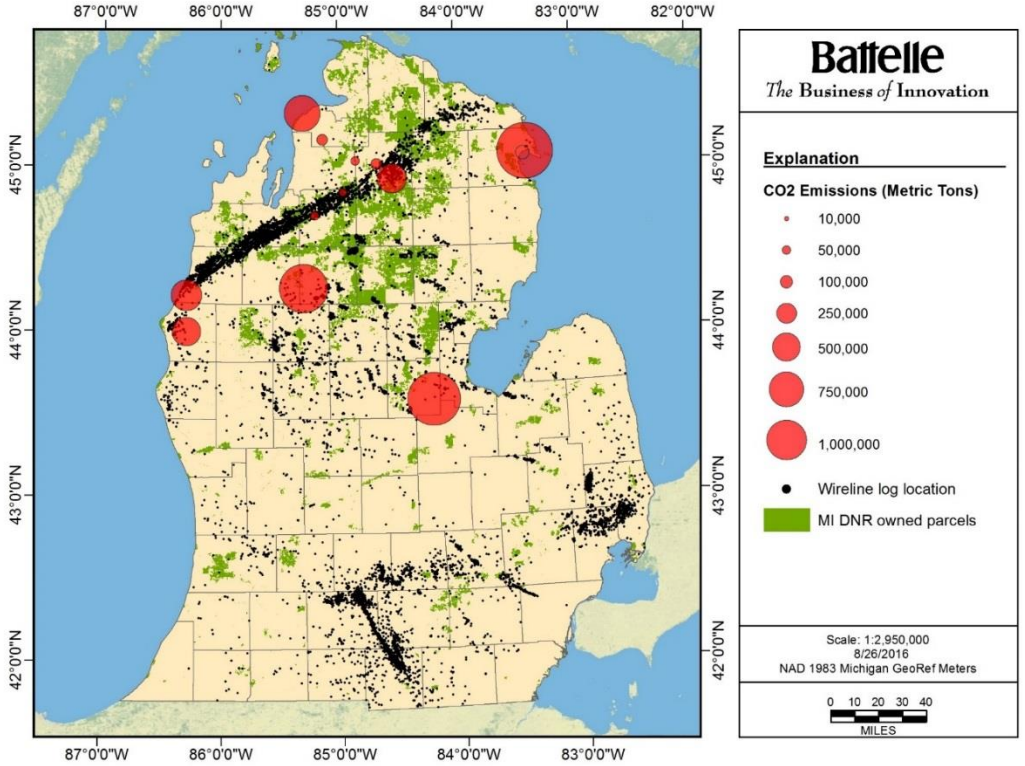
- Midwest Regional Carbon Sequestration Partnership (MRCSP): 2003 – 2019
- **Carbon Management Advisory Group (CMAG): 2008**
- **Carbon Sequestration Technical Assessment (CSTA): 2009**
- Mid-Atlantic U.S. Offshore Carbon Storage Resource Assessment: 2016 – 2019
- **Governor's CCUS Inter-Agency Work Group: 2019 – present**
- Midwest Regional Carbon Initiative (MRCI): 2019 – 2022 (proposed extension to 2024)

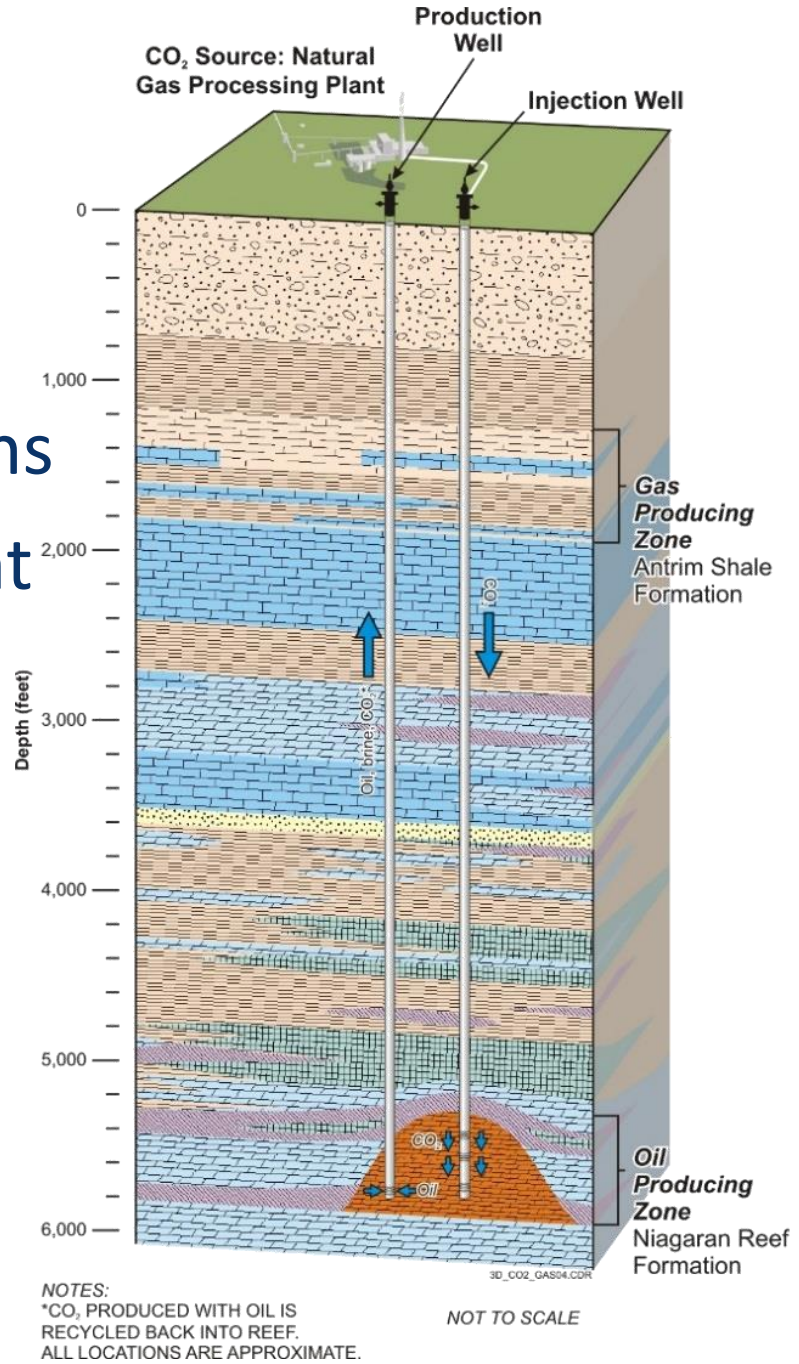
MRCSP was part of US DOE's Regional Carbon Sequestration Partnership (RCSP) Initiative

- 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 CO_2 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

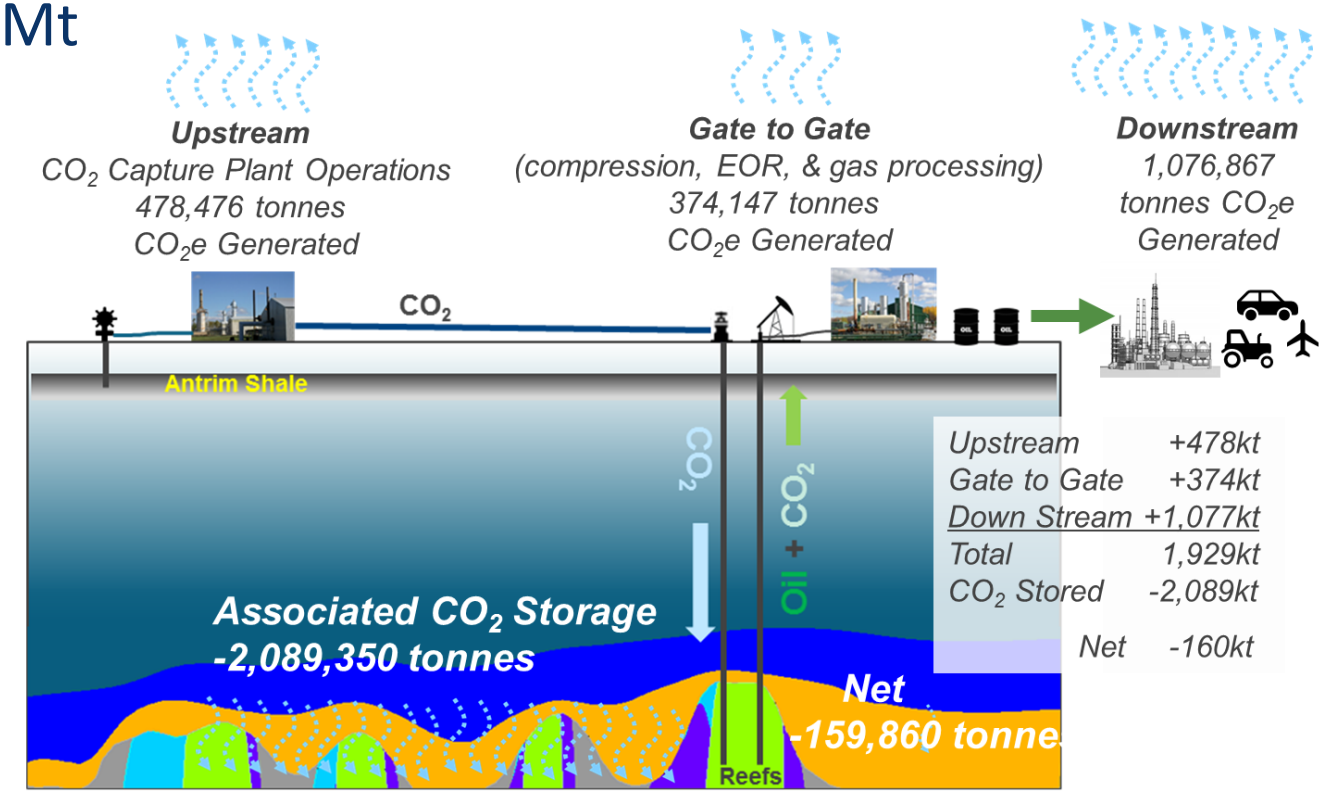
- Objective – Inject/monitor 1+ Million tonnes (Mt) of CO_2 in collaboration with EOR operations
- Evaluate CO_2 injectivity, migration, containment



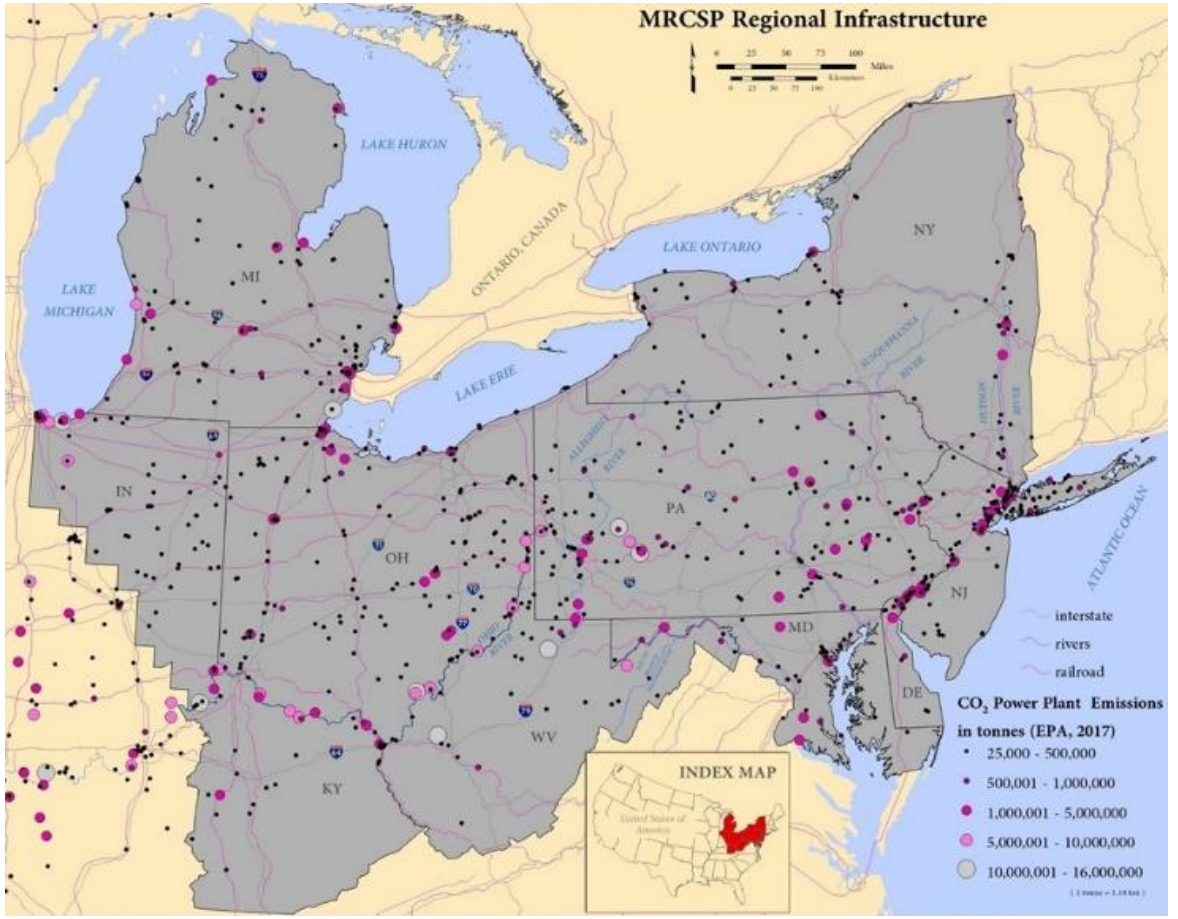


Results - Total LCA Results 1996 – 2017

- Analysis shows 1.9 Mt of CO_2e emissions over 22 years of operation
  - Upstream CO_2e Emissions – 478 Kt
  - Gate to Gate CO_2e Emissions – 374 Kt
  - Downstream CO_2e Emissions – 1.07 Mt
- Associated CO_2e Storage 2.09 Mt
- **MI reefs have net negative (-160 Kt) CO_2e GHG "cradle to grave" balance**
- Results certify environmental benefits of CO_2 EOR; ups/downs of CO_2-EOR operations must be considered for life cycle GHG analysis

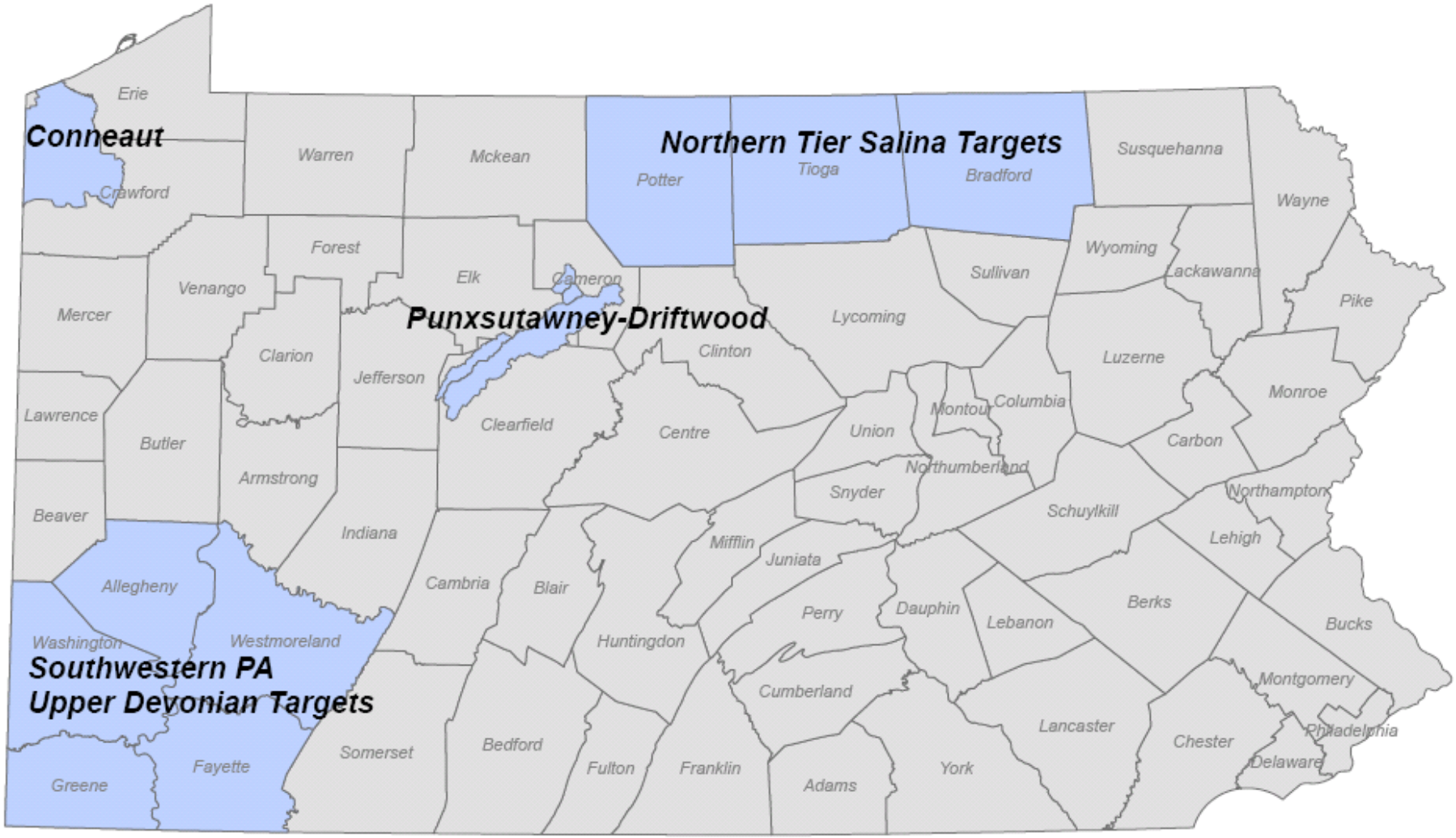


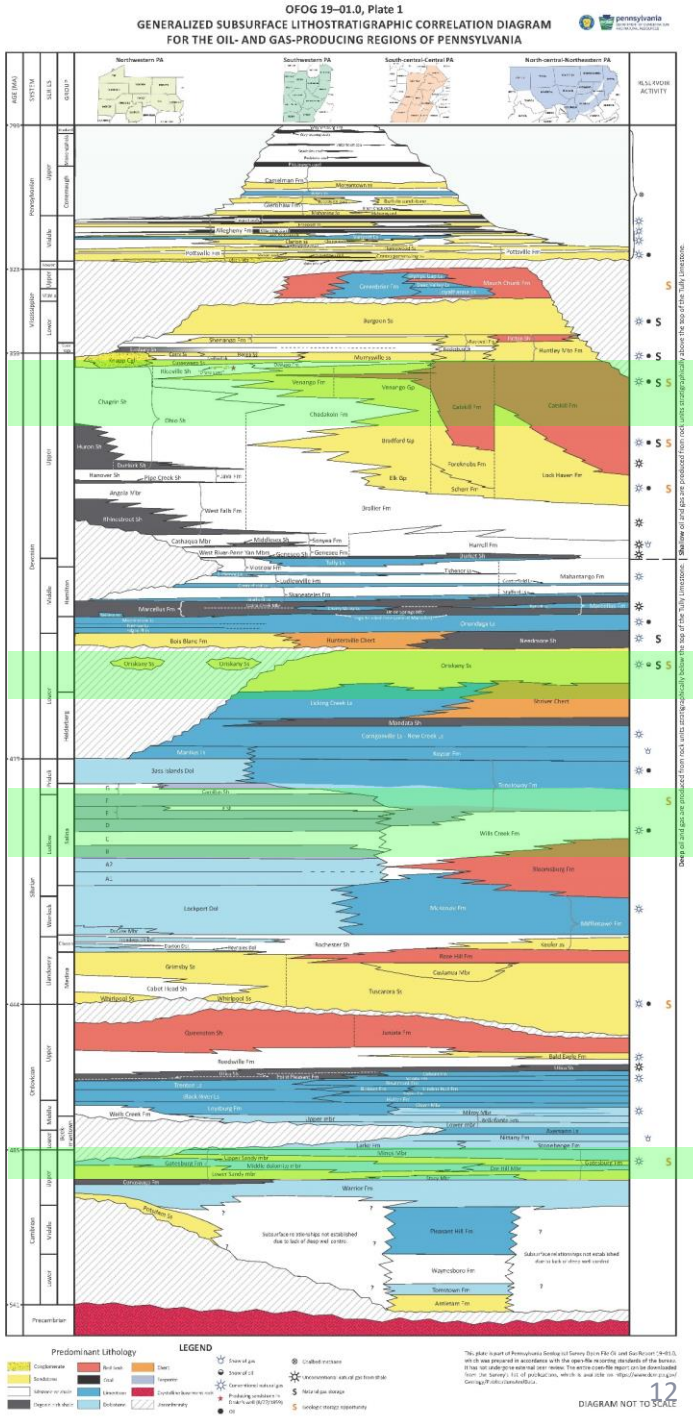
Existing Infrastructure and CO_2 Emissions



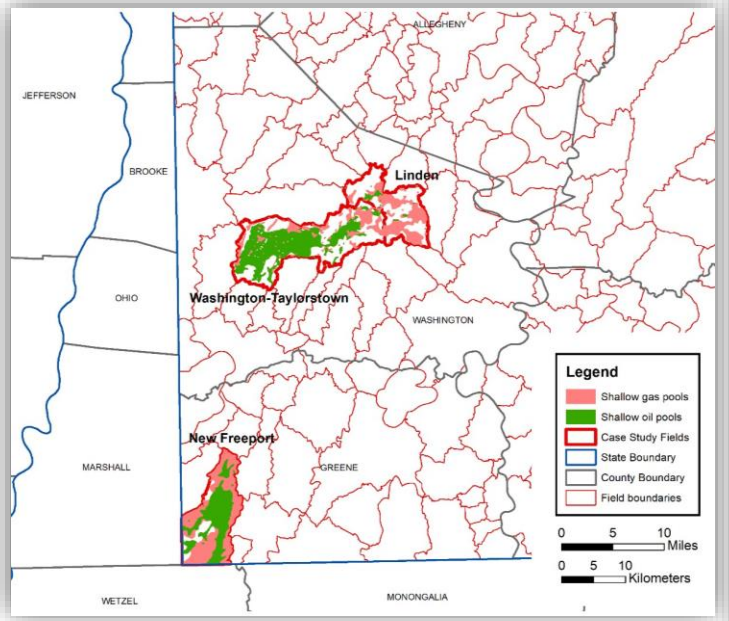
- Road, rail and waterways
- Power plants are the largest (and most common) source; 40% of PA's power plants emit >1 Mt CO_2/yr
- But...other emissions exist, too (steel/metals, minerals, chemicals, petroleum products/refineries, pulp and paper…); steel/metals emit ~10,000 t – 1 Mt CO_2/yr; minerals: ~18,000 t – 800,000 t CO_2/yr
- Industrial emissions cannot necessarily decarbonize simply by fuel-switching

Geologic Storage Opportunities in Pennsylvania (2009)

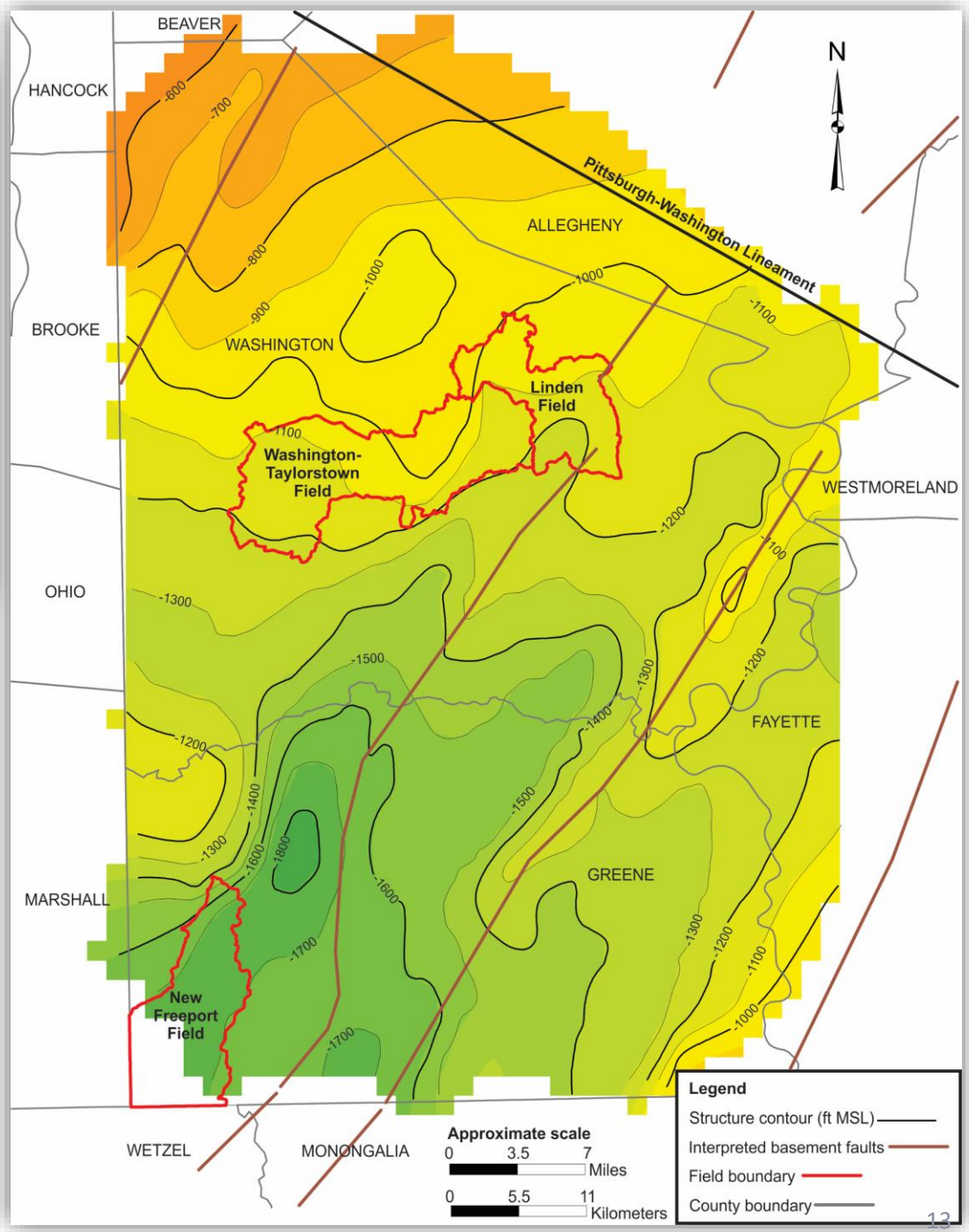




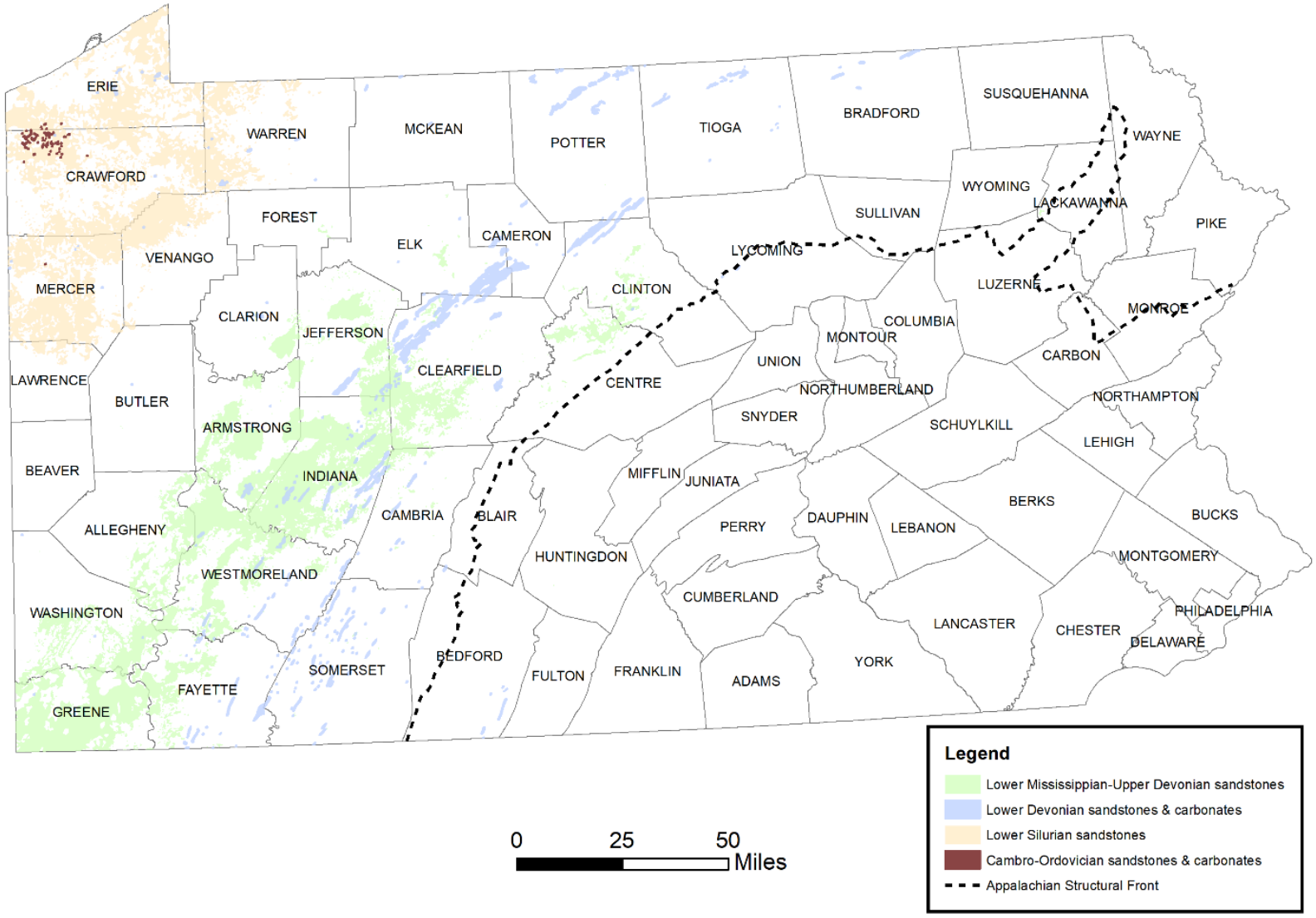
Pennsylvania Oil Field Case Studies (2019)

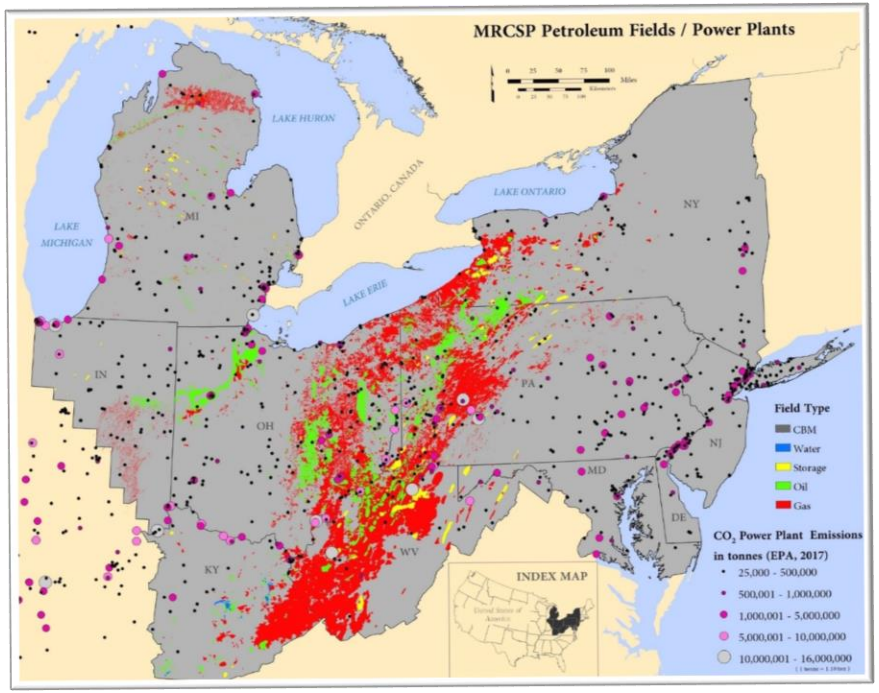


Drillers' Sand Name	Top Formation (ft)			Thickness (ft)		Porosity (%)		
	Min	Max	Avg	Gross	Net	Density	Neutron	Average
Hundred-Foot	1813	3306	2563	81	55	11	6	9
Gantz	1813	3306	2633	18	11	14	6	10
Fifty-Foot	1839	3342	2591	60	48	7	6	7
Nineveh	1968	3395	2708	39	23	12	7	10
Gordon Stray	2018	3451	2745	13	7	9	9	9
Gordon	2050	3482	2792	43	30	11	7	9
Fourth	2116	3555	2896	26	16	8	6	7
Fifth	2175	3611	2979	40	29	11	6	9



Field-Level Reservoir Mapping and Pool-Level Attribution (2019)

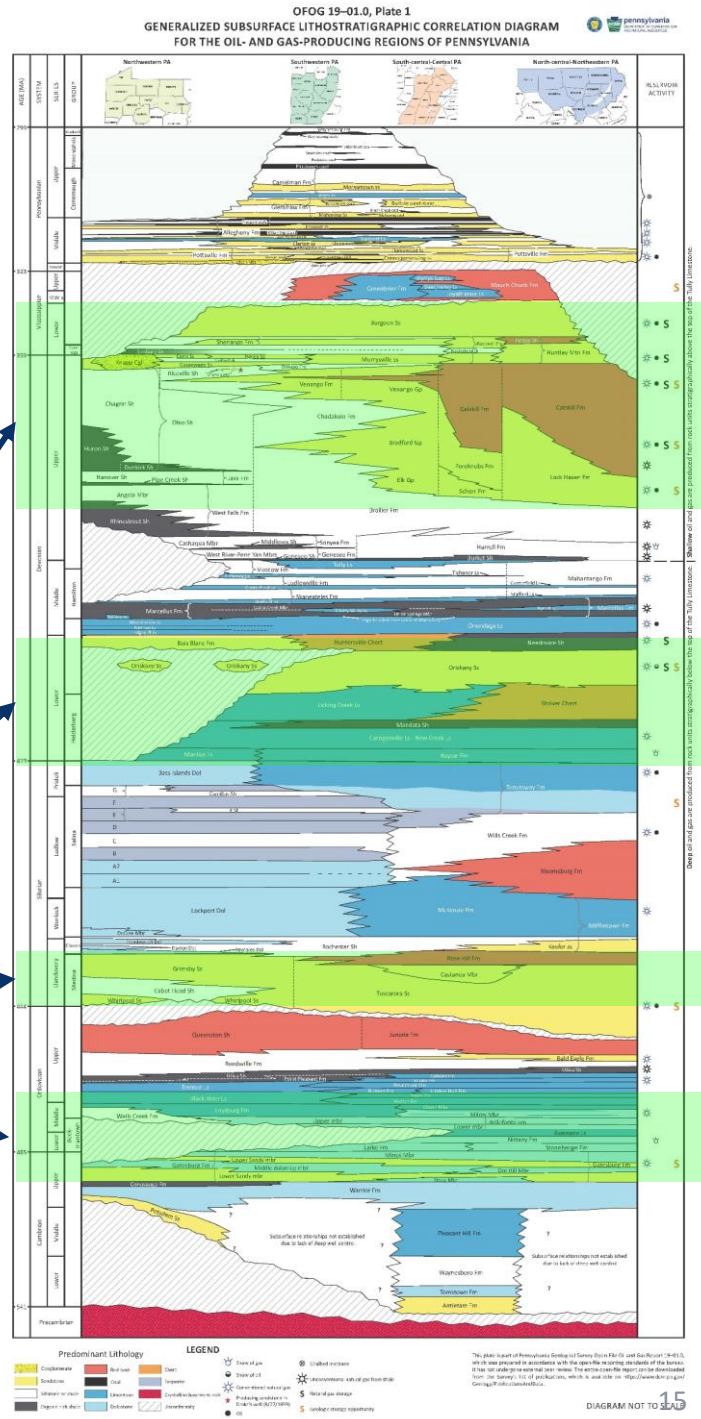




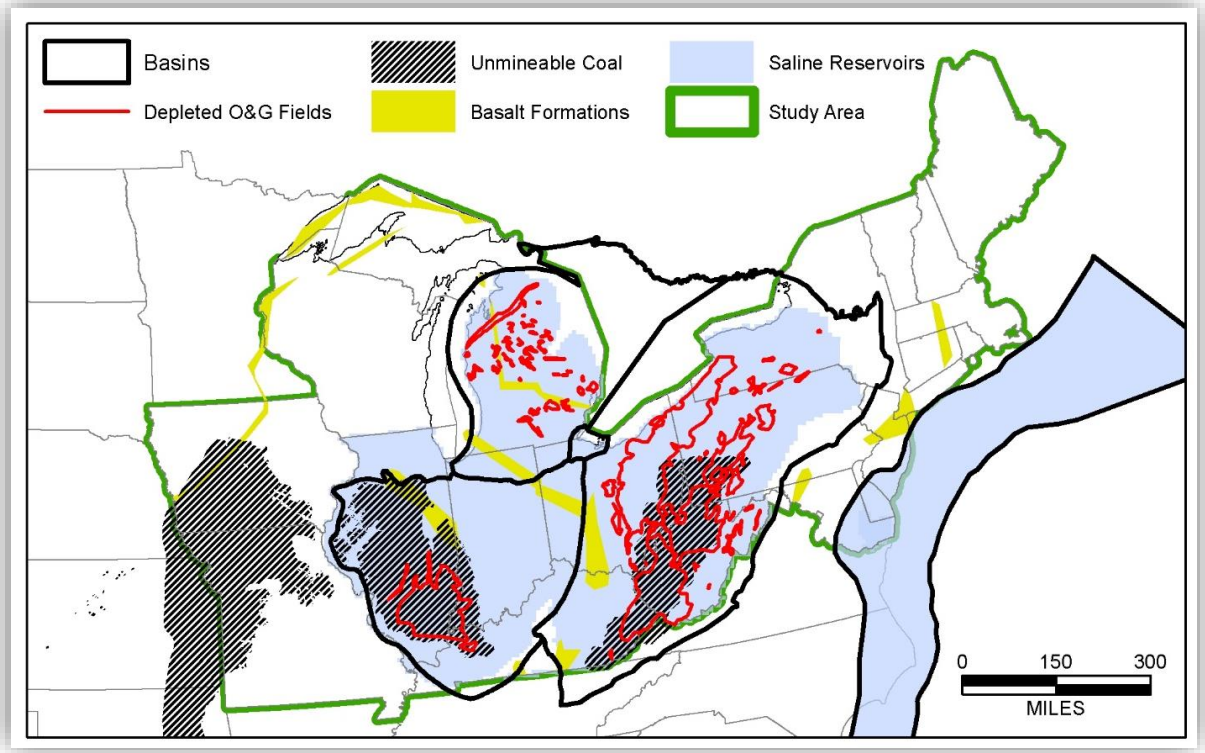
- Given this example, potential CCS reservoirs may offer **1.4 – 4.4 billion tonnes (Bt)**
- Mode value – **2.4 Bt**

Mode Storage for Selected Geologic Intervals in Pennsylvania

Geologic Interval	Reservoir Count	Mode Storage Volume (Bt)
Lower Mississippian-Upper Devonian sandstones	1,718	1.03
Lower Devonian sandstones and carbonates	293	0.12
Lower Silurian sandstones	803	1.25
Cambro-Ordovician sandstones and carbonates	64	0.001
Totals	2,878	**2.4**



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

Source Type	2017 Emissions (Mt)	% of Total
Power Plant	694	73%
Metals	72.5	8%
Minerals	44.4	5%
Chemicals	38.3	4%
Petroleum, Natural Gas, and Refineries	28.4	3%
Other	28.0	3%
Ethanol	16.9	2%
Pulp and Paper	10.7	1%
Waste	7.9	1%
Manufacturing	3.5	<1%
TOTAL	**945**	-

CCUS Inter-Agency Work Group

pennsylvania DEPARTMENT OF ENVIRONMENTAL PROTECTION

pennsylvania DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

PA pennsylvania DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

- 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)

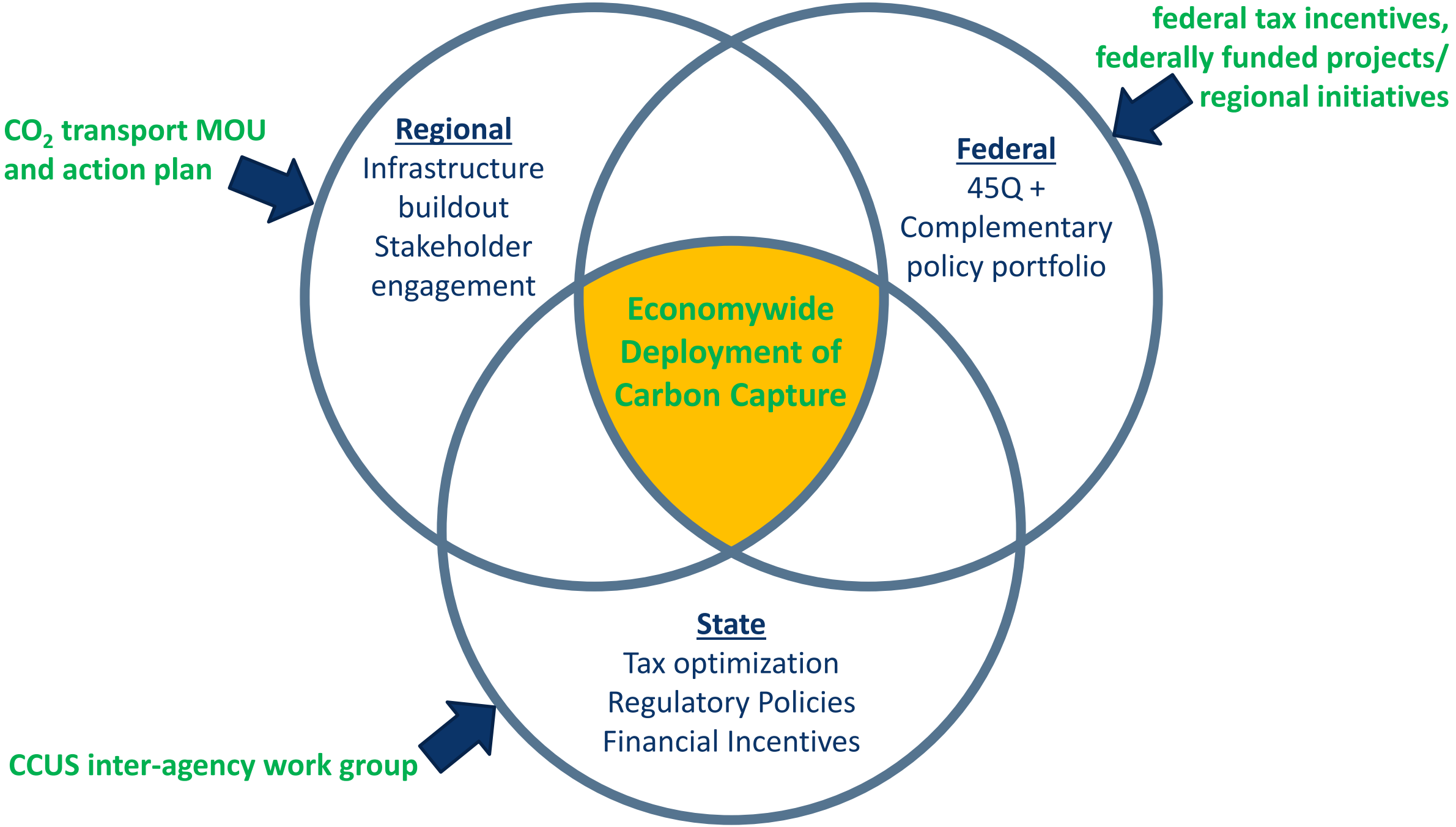
- Introduction
- Background
- Federal government policy support
- State level government policy support
- Federal and state recommendations



Anticipated Follow-On Work for 2021

- Additional State Outreach
- Stakeholder Engagement
- Learning Webinars
- Action Plan Development




federal tax incentives, federally funded projects/ regional initiatives
CO_2 transport MOU and action plan
Regional
Infrastructure buildout
Stakeholder engagement
Federal
45Q + Complementary policy portfolio
Economywide Deployment of Carbon Capture
State
Tax optimization
Regulatory Policies
Financial Incentives
CCUS inter-agency work group

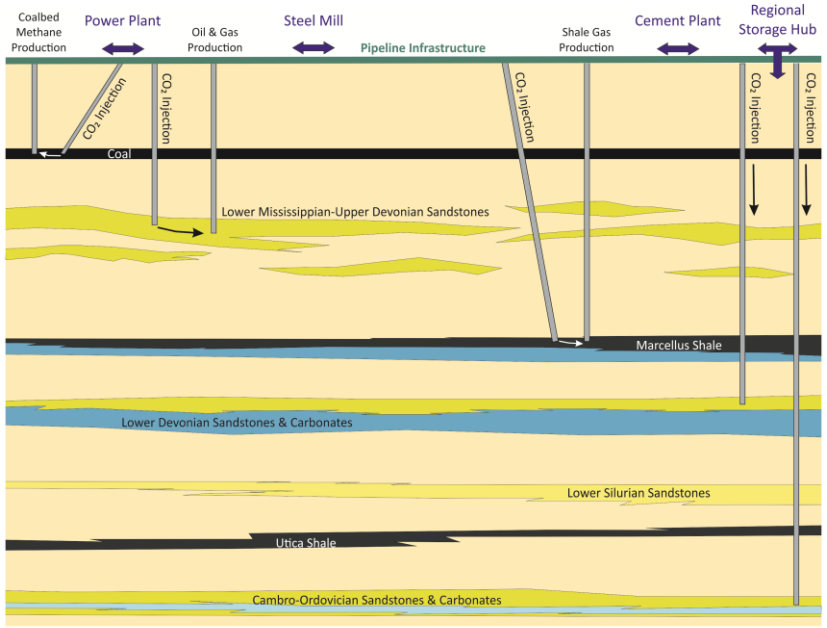
Take Home Points…

- 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



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- 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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