CCUS and Hydrogen Opportunities in Pennsylvania

October 4, 2022

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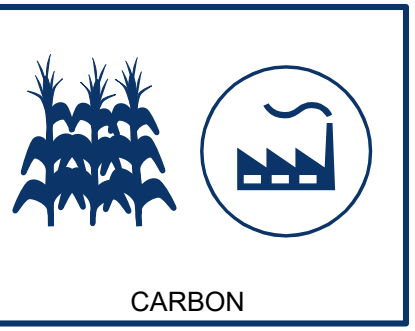
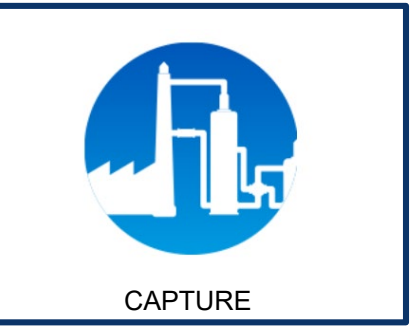
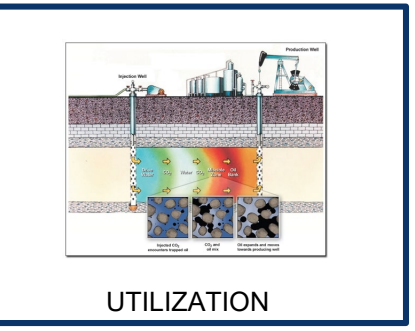
For Consideration Today…

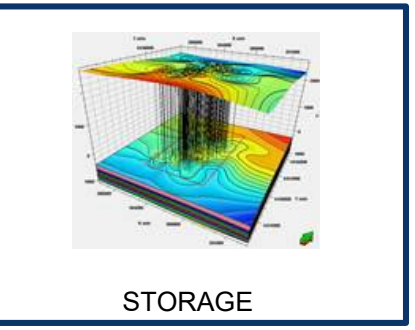
- What is CCUS, and why is it important?
- Pennsylvania and energy transitions
- What does hydrogen (H_2) have to do with CCUS and the current energy transition?
- What CCUS-related activities are in progress now?

What is CCUS, and why is it important?





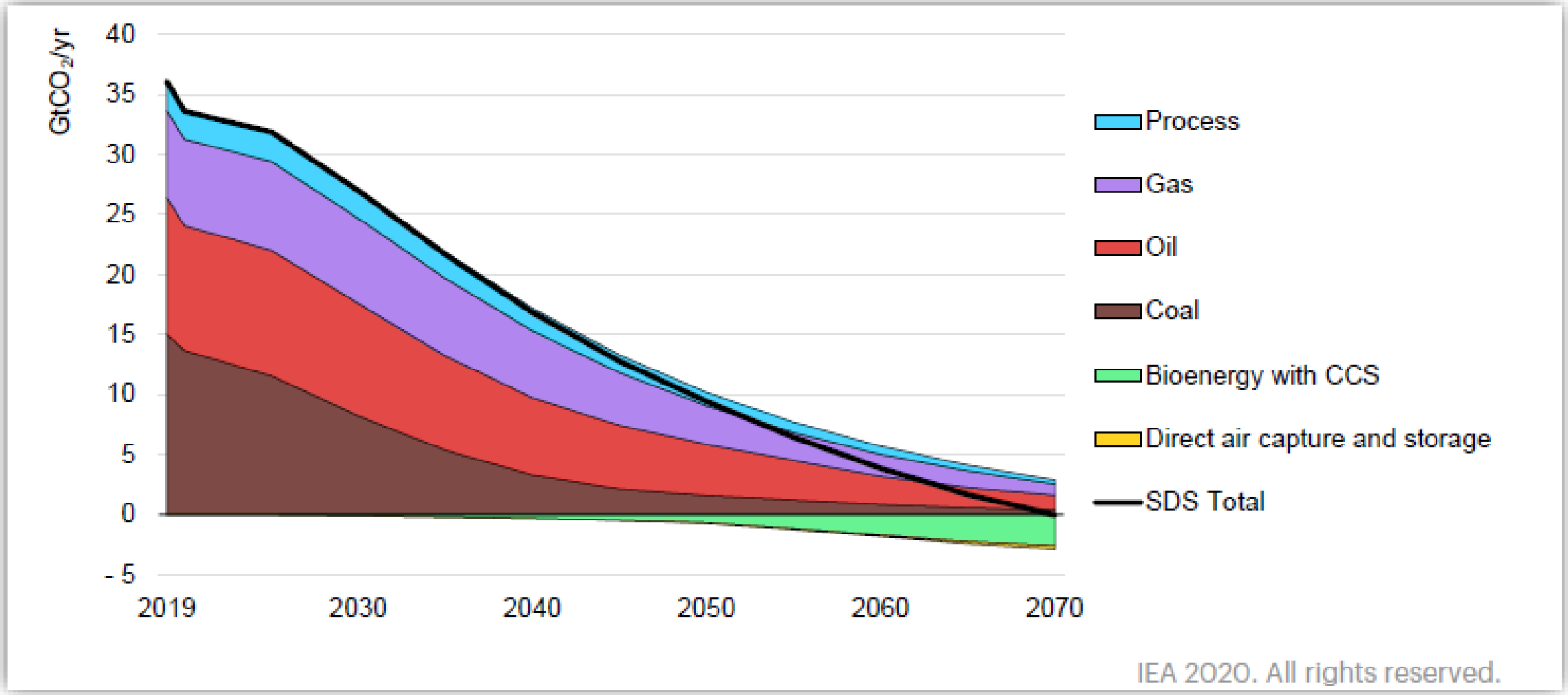




What is CCUS?

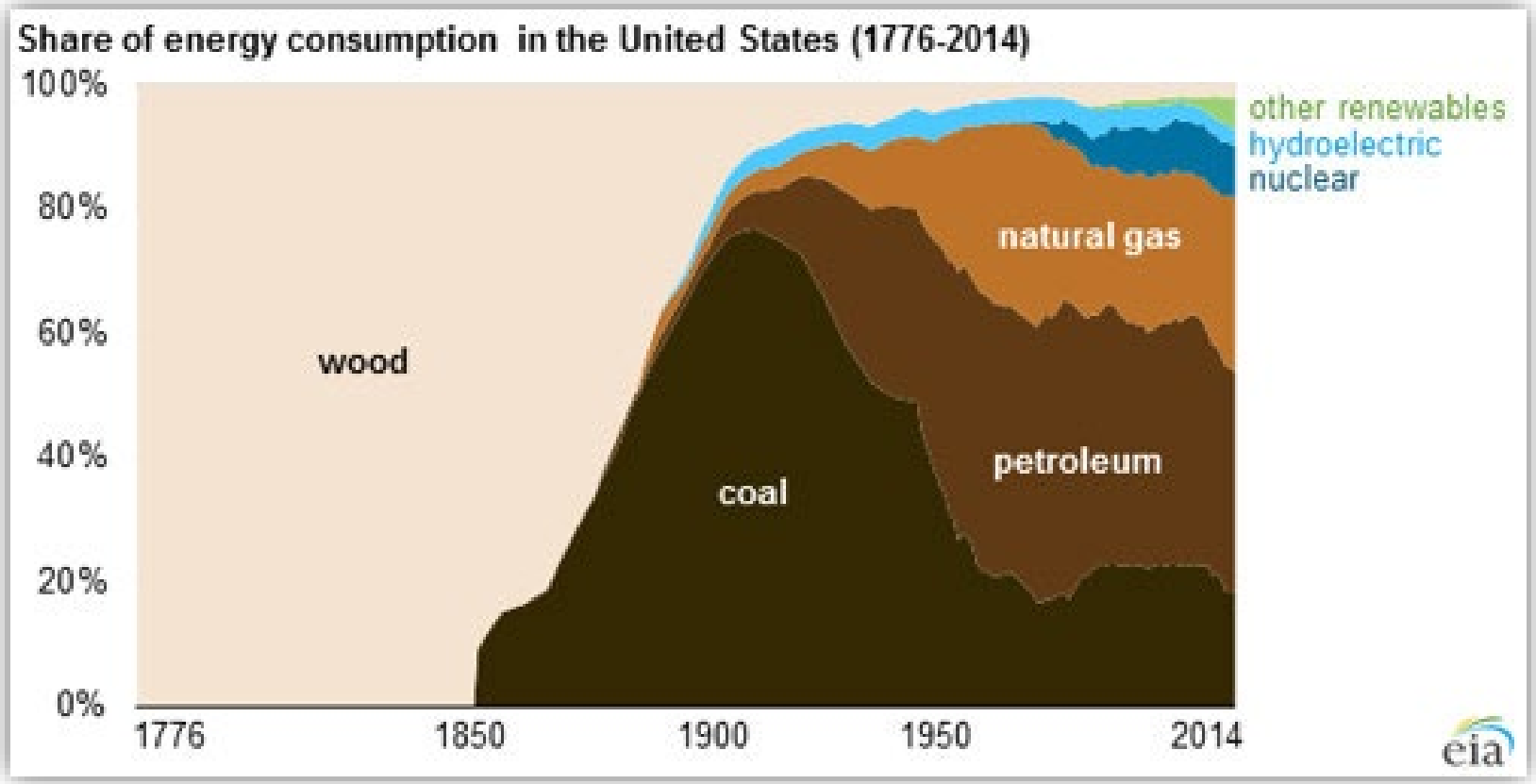
Carbon capture, utilization and storage (CCUS) refers to those technologies, activities and applications associated with the removal of carbon dioxide (CO_2) from the atmosphere for beneficial use applications and/or permanent disposal in porous, subsurface rocks by way of injection wells.

CCUS is necessary to achieve climate mitigation goals...



Pennsylvania and Energy Transitions

Pennsylvania and Energy Transitions



www.eia.gov/todayinenergy/detail.cfm?id=21912 (7/2/2015)

- Pennsylvania has been a part of every energy transition since the colonization of America
- Penn's Woods helped to fuel the 18th century
- Three fossil fuel sources (petroleum, natural gas and coal) have comprised ≥80% of total U.S. energy consumption for more than a century

Energy Transition, Defined

HISTORICAL CONTEXT:

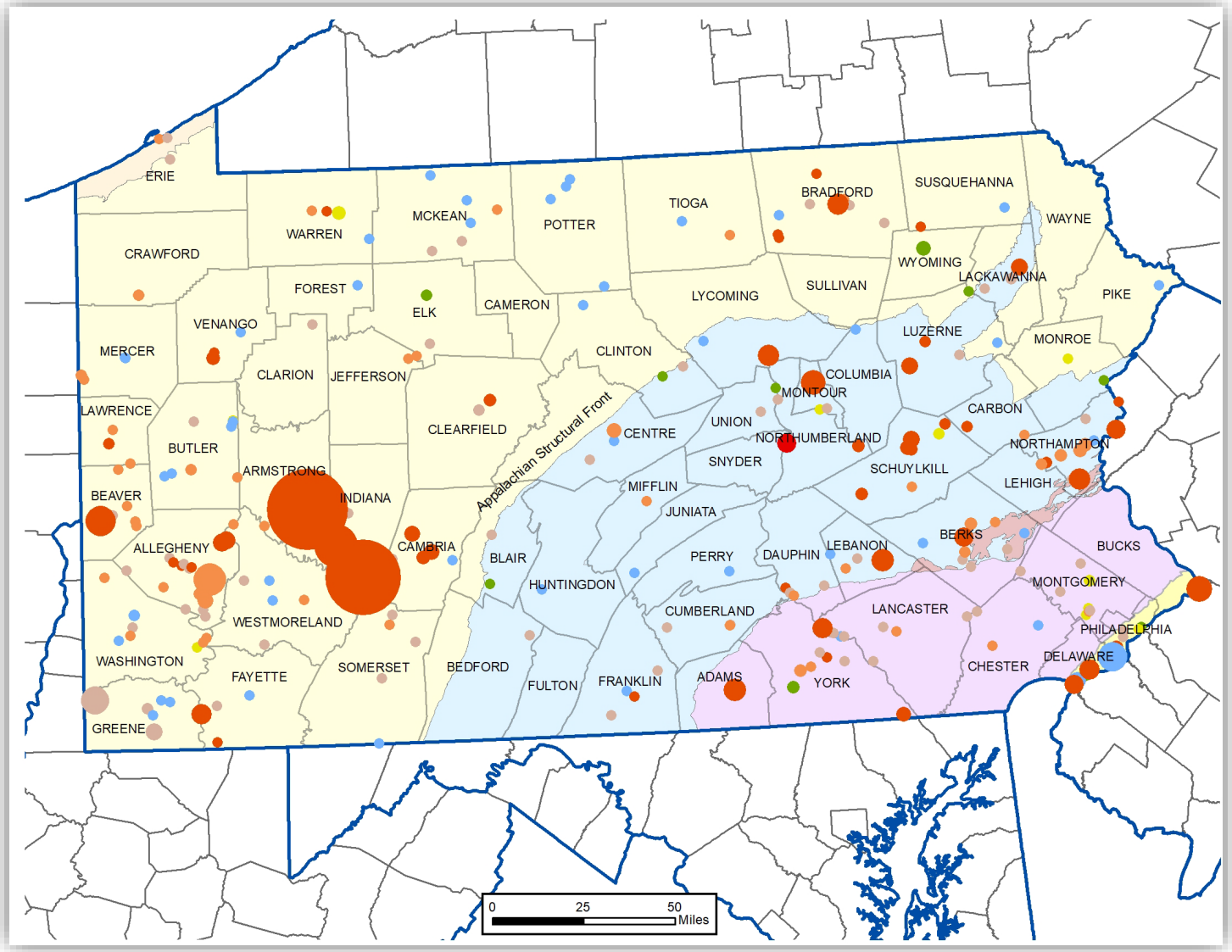
"a significant structural change in an energy system, driven by energy resource availability, energy efficiencies and/or energy demands"

Energy Transition, Defined

TODAY:

"a significant structural change in an energy system, driven not just by energy availability, energy efficiency and demand but also the desire to decarbonize our world so to mitigate climate change, promote environmental justice and equitable access to energy resources, and provide energy for the growing global population, all while retaining our existing way of life and economic prosperity"

Pennsylvania's Economy and Diverse Geology



- CO_2 emitters from multiple sectors
  - Power plants
  - Natural gas and petroleum products and systems
  - Minerals, metals
  - Chemicals, refineries
  - Pulp and paper
  - Waste, other
- Located in diverse geologic settings
  - Appalachian Plateaus Province
  - Ridge and Valley Province
  - Piedmont Province
  - New England Province
  - Central Lowlands Province
  - Atlantic Coastal Plain Province

Appalachian Plateaus

Coordination of Capture and Transport Infrastructure

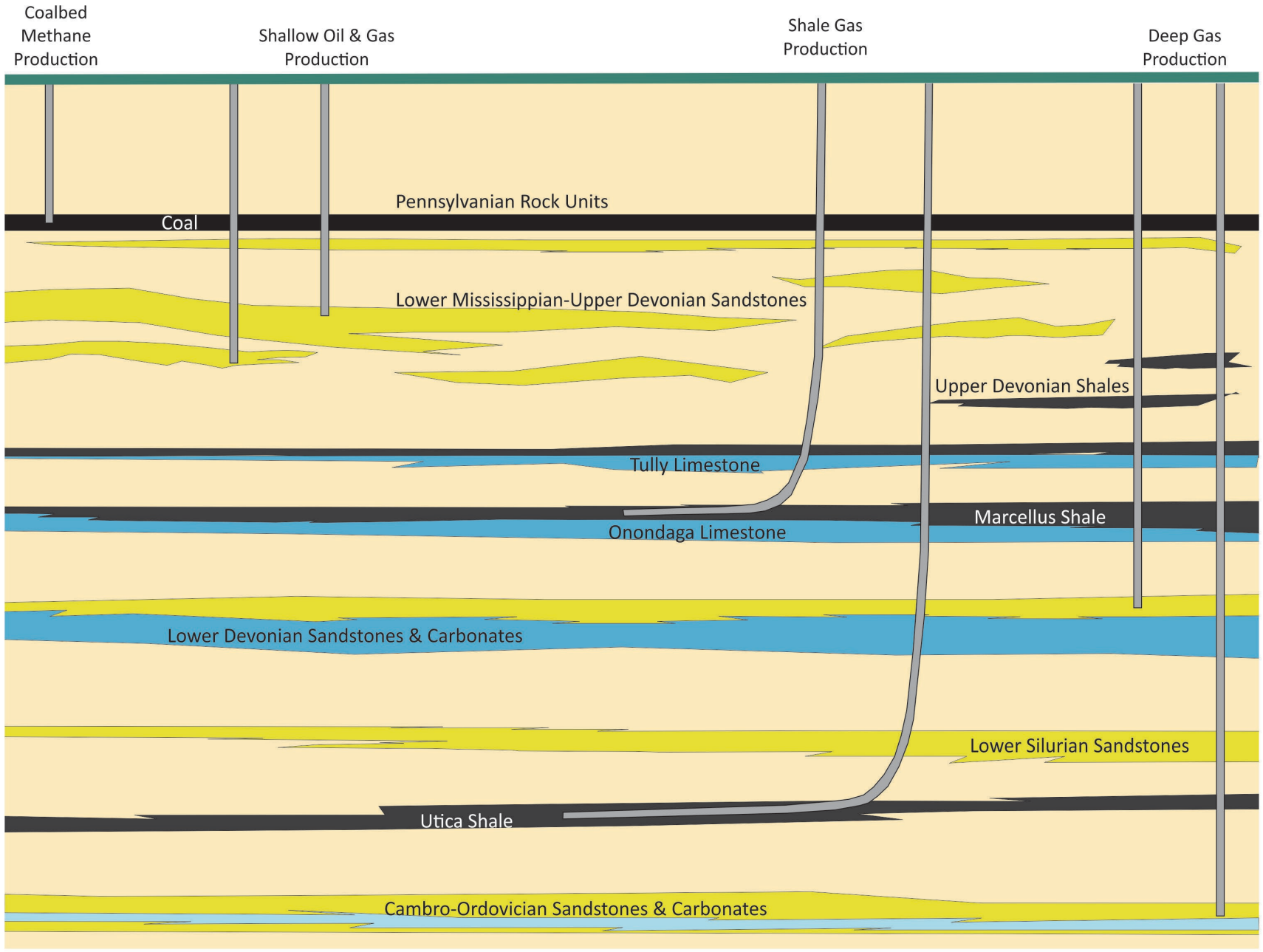
- ✓ **Size of source vs. volume of sink**
- ✓ **OUT: Active mining, petroleum hydrocarbon production**
- ✓ **IN: Energy storage (CH_4, H_2), Carbon sequestration, Wastewater disposal**
- ✓ **Pore Space Ownership/Access**

Utilization

Stacked Reservoirs

Permanent Storage

Coordination of Resource Development



Cartoon not to scale

What does hydrogen (H_2) have to do with CCUS and the current energy transition?

Hydrogen, a Low-Carbon Opportunity

- "Blue hydrogen" – H_2 is produced from natural gas (CH_4), with CO_2 emissions captured and permanently sequestered underground
- Pennsylvania's shale gas production, when combined with CCUS, offers low-carbon power generation relative to that of other nonrenewable energy resources
- Blue hydrogen affords cost advantages and allows for scale-up of production processes, creating wider market demand for hydrogen as a transportation fuel, for power generation and/or for industrial uses
- Blue hydrogen will lead the way for green hydrogen (using renewable energy resources to produce H_2 from H_2O through electrolysis)

What CCUS-related activities are in progress now?

Current CCUS Work

- CCUS Inter-Agency Work Group
- Energy Horizons Cross-Sector Collaborative
- CO_2 Transport Infrastructure Action Plan (GPI)
- Keystate Natural Gas Synthesis Plant (Clinton County)
- 21st Century Power Plant (southwestern PA/ northern WV)
- Midwest Regional Carbon Initiative (MRCI) Project

CCUS Inter-Agency Work Group

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES
DCNR

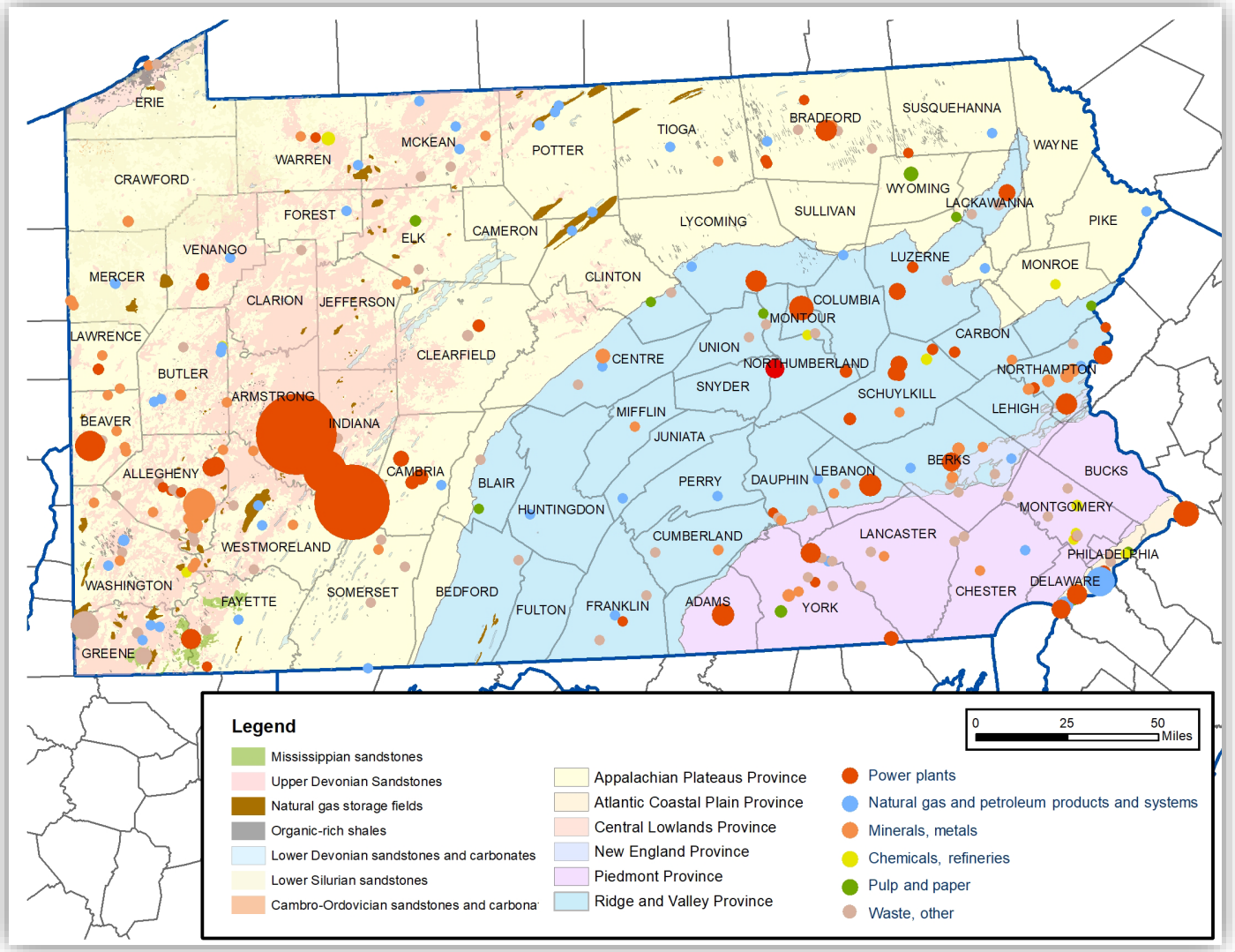
PA pennsylvania
DEPARTMENT OF COMMUNITY
& ECONOMIC DEVELOPMENT

pennsylvania
DEPARTMENT OF ENVIRONMENTAL
PROTECTION

- Formed by the Wolf Administration in October 2019
- Our work is framed and supported by four pillars: technical, regulatory, economic and policy drivers
- Provides a vehicle for collaborative work – review/input to DEP's Climate Action Plan, DCNR's CCUS projects (e.g., MRCSP, MRCI), etc.
- Inter-agency collaboration has been galvanized through execution of an inter-agency MOU

CCUS Inter-Agency Work Group

- Signatory state to Great Plain Institute's **regional CO_2 transport infrastructure Action Plan** (October 2021)
- CCUS/H_2 Stakeholder Engagement (October 2021-present) – **Energy Horizons Cross-Sector Collaborative**



Road Map for the Deployment of Carbon Management and Hydrogen Projects in the Commonwealth of Pennsylvania

September 2022

PA Energy Horizons Cross-Sector Collaborative

Prepared by the Great Plains Institute Carbon Management Team on behalf of Team Pennsylvania

TEAM PENNSYLVANIA

GREAT PLAINS INSTITUTE

Two Scenarios: Near-Term & Midcentury

Near-term carbon capture opportunities scenario

Source: Figure authored by Elizabeth Abramson, 2022. Based on results of the SimCCS model and data from EPA GHGRP, 2020; NATCARB, 2015; SCO_2T, 2020.

Optimized transport network for near-term CO_2 capture and storage

- Regional CO_2 infrastructure (modeled)
- Potential CO_2 storage area

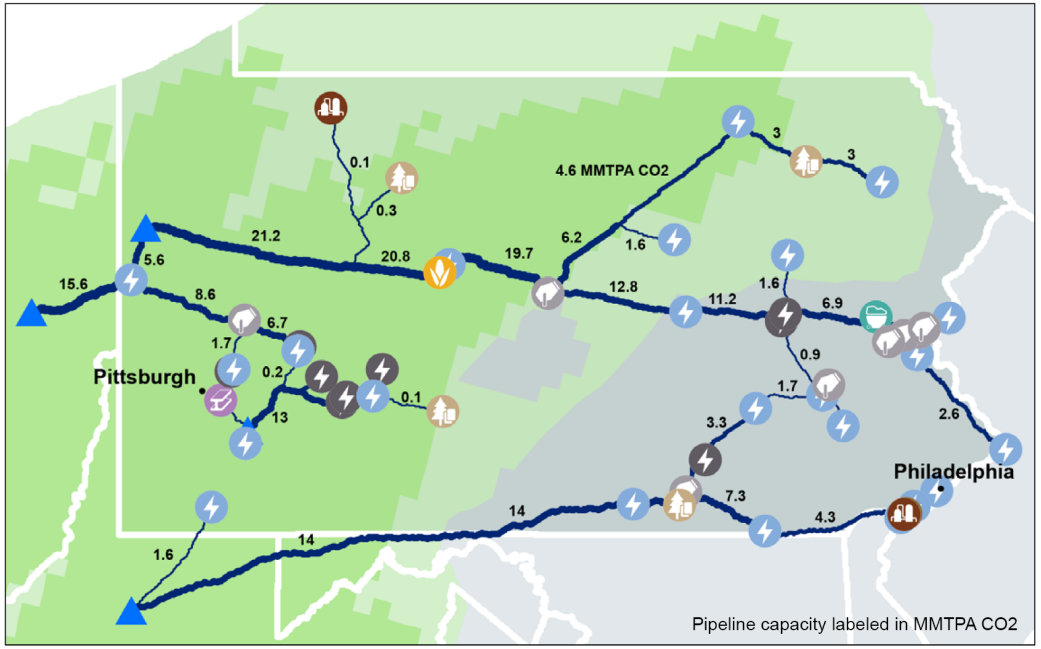
Geologic storage opportunity

- Assessed low-cost saline storage
- Saline CO_2 storage formation

Capture sources

- Cement & lime
- Coal power
- Ethanol
- Gas power
- Pulp & paper
- Refineries
- Steel
- Waste

Midcentury carbon capture opportunities scenario



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- Cement & lime
- Coal power
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- Gas power
- Metals, minerals & other
- Pulp & paper
- Refineries
- Steel
- Waste

Next Steps Prioritized

The Road Map presents issues with longer implementation times first. All steps should address environmental justice concerns during their respective processes.

- Update & Revise PA's Statutory Framework
- Apply for UIC Class VI Primacy
- Consider Regional Approaches (intra- and inter-state opportunities)
- Prepare for DOE Hydrogen Hubs
- Solicit Bipartisan Infrastructure Law (BIL) Funding
- Commission Future Studies
- State-wide Digitization of Geologic Data
- Comment and Engage Where Possible
- Use/Acceptance of Standards and Best Practices

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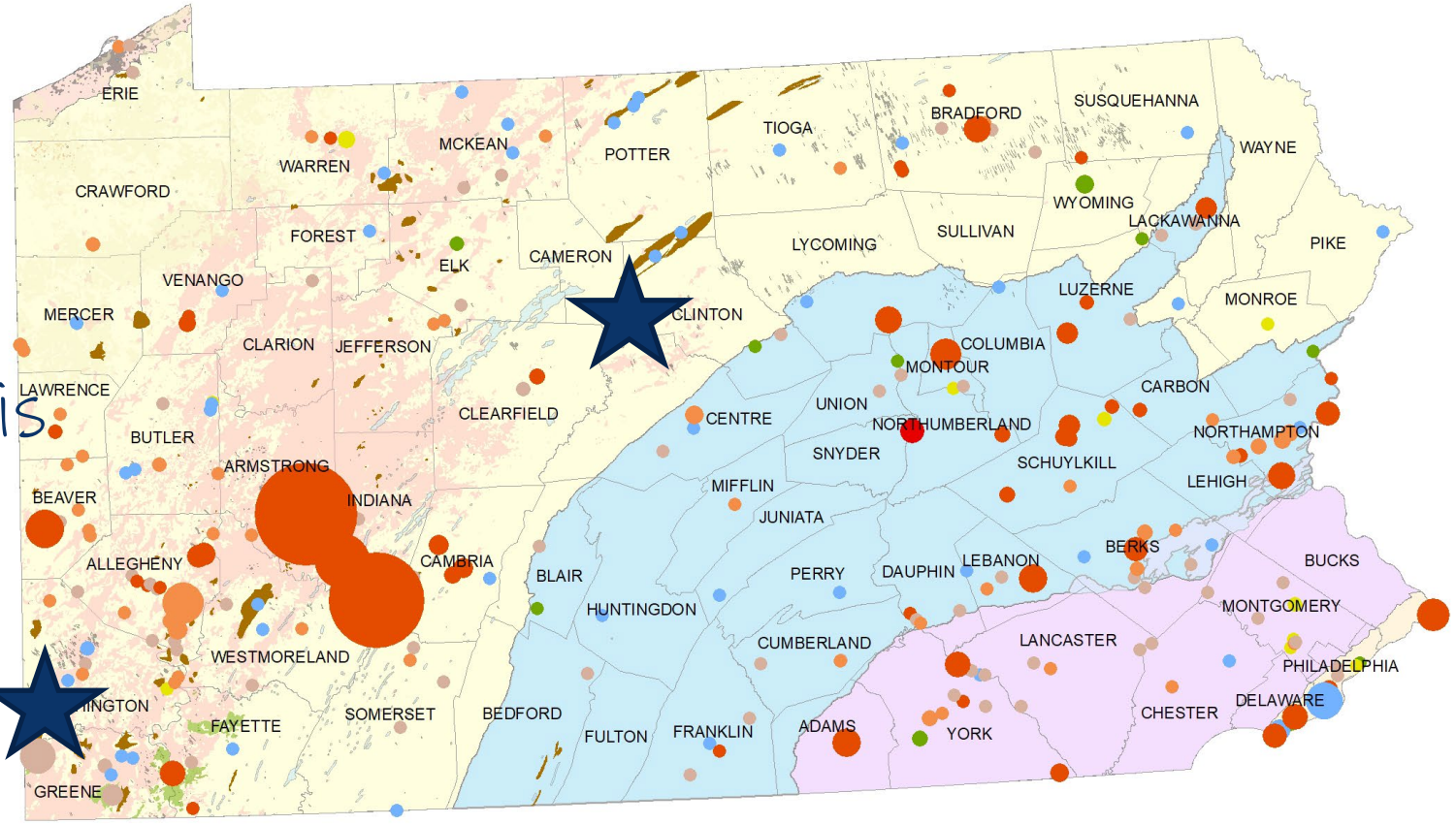
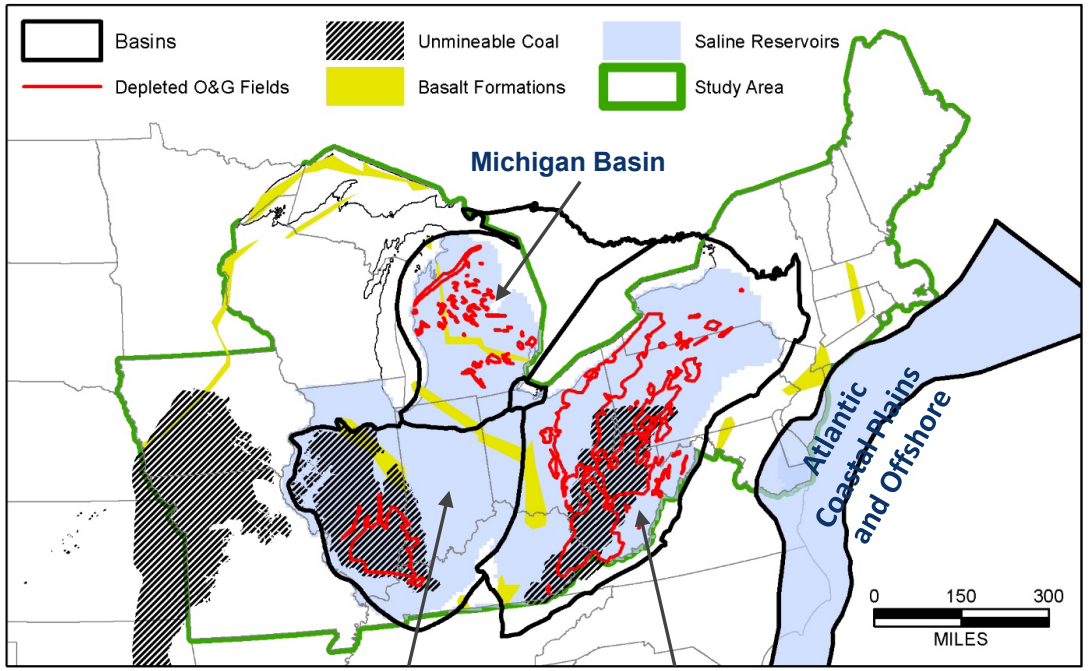
Pennsylvania CCUS Projects

- KeyState to Zero, Clinton County – Onsite shale gas supply, onsite gas synthesis (H_2, NH_3, Urea/DEF), local carbon sequestration
- 21st Century Power Plant, southwestern PA/ northern WV – modular PFBC power plant, fueled with biomass and coal waste, local carbon sequestration



Geologic Carbon Storage Systems

- **Thick, regional saline reservoir** – clastic rocks with significant thickness (50+ ft) and porosity, more than 2,600 ft deep, with a good seal
- **Local large saline reservoir** – some type of secondary saline reservoir with a regional seal, and other conditions as above
- **Stacked reservoir** – cumulative porosity-ft comprised of multiple formations. There could be different groupings of "stacked" reservoirs based on the units and seals envisioned; major regional seals would be good first-order divisions
- **Depleted reservoirs with EOR potential** – could be a standalone system, superimposed on saline reservoir system, or part of the stacked reservoir potential



Take Home Points…

- Pennsylvania has **hundreds of CO_2 point-source emissions** across multiple physiographic provinces and **must embrace all options for CCUS to mitigate climate change** while retaining our industry and manufacturing sectors.
- Given its natural resources, industry base and central location in the Mid-Atlantic region, **Pennsylvania is uniquely poised to be an integral part of the current energy transition.**
- As a signatory to the CO_2 Transport Infrastructure Action Plan, **Pennsylvania supports the deployment of regional CO_2 transport infrastructure networks and carbon hubs**; this infrastructure is intended to provide large-scale carbon management solutions while creating and preserving high-paying jobs throughout the Mid-Atlantic region.
- Based on the Road Map commissioned by the PA Energy Horizons Cross-Sector Collaborative, the **commonwealth must act presently** to take advantage of federal funding and collaboration opportunities to advance CCUS and H_2 in the region.

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