U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

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Carbon Transport & Storage

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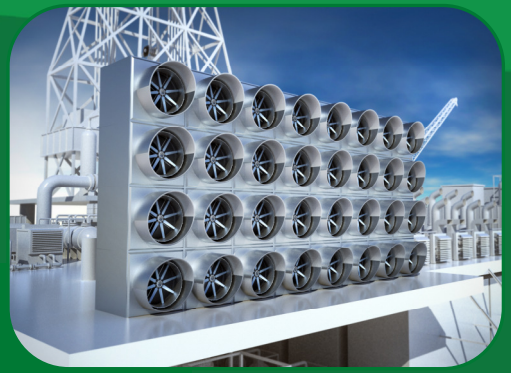
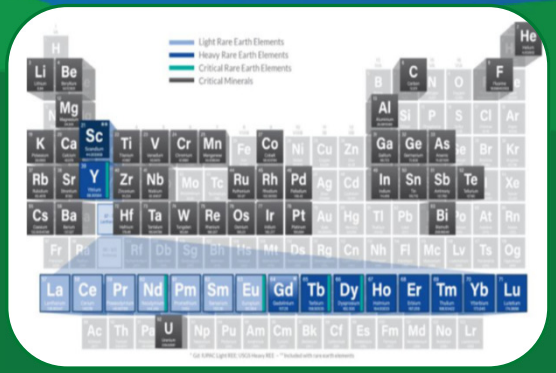



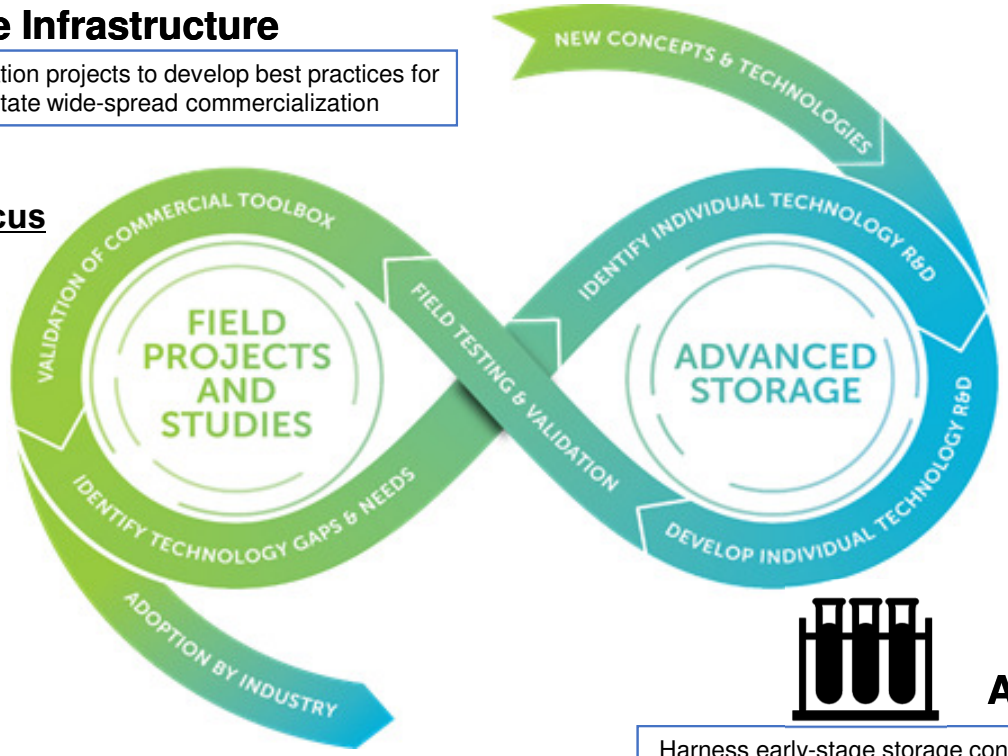
Carbon Transport and Storage RD&D: An Iterative Process towards Deployment

Storage Infrastructure

Large-scale demonstration projects to develop best practices for industry and facilitate wide-spread commercialization

Storage Infrastructure Focus

- CarbonSAFE
- Regional Initiatives
- Offshore Storage
- Brine Extraction Strategy Test **(BEST)**
- Transition of O&G infrastructure



Advanced Storage Focus

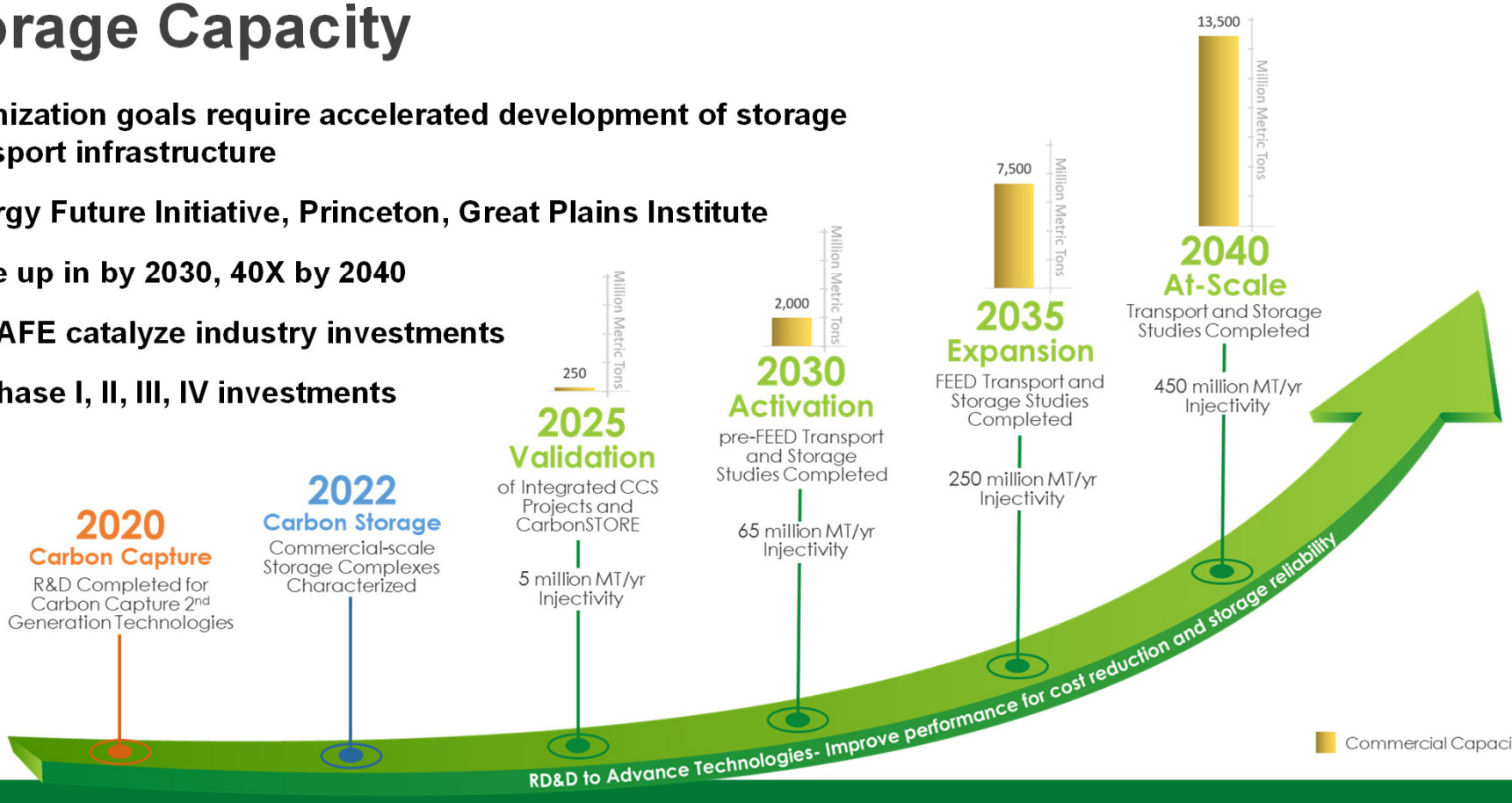
- Well Integrity and mitigation
- Monitoring, verification, and accounting
- Storage complex efficiency and security
- **SMART**: **S**cience-Informed **M**achine Learning for **A**ccelerating **R**eal **T**ime Decisions
- **NRAP:** National Risk Assessment Partnership

Advanced Storage

Harness early-stage storage concepts to technology demonstration

Scaling Commercial Injectivity and Access to Storage Capacity

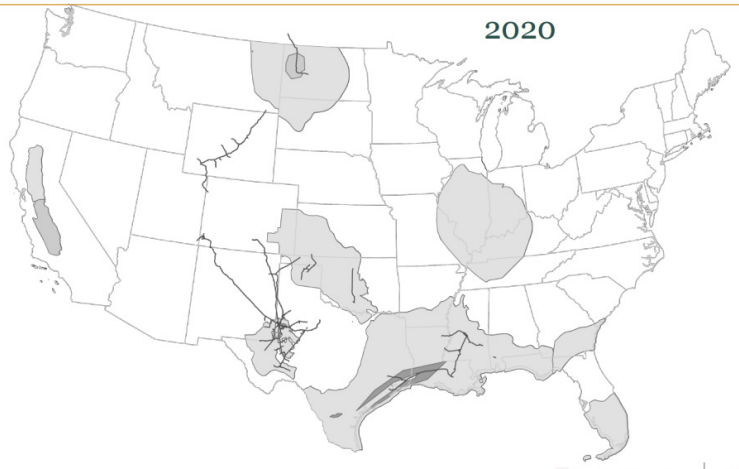
- **Decarbonization goals require accelerated development of storage and transport infrastructure**
  - **Energy Future Initiative, Princeton, Great Plains Institute**
- **10X scale up in by 2030, 40X by 2040**
- **CarbonSAFE catalyze industry investments**
- **FY22 – Phase I, II, III, IV investments**



Where is carbon storage today? Tomorrow?
Princeton NZA Study – Demand for Pipeline and Storage Infrastructure

Existing CO_2 pipeline network

- ~ 80 million tCO_2/yr transported
- ~ 8,500 km of pipelines
- Servicing enhanced oil recovery operations
- Majority in Permian Basin (West Texas and southeast New Mexico)



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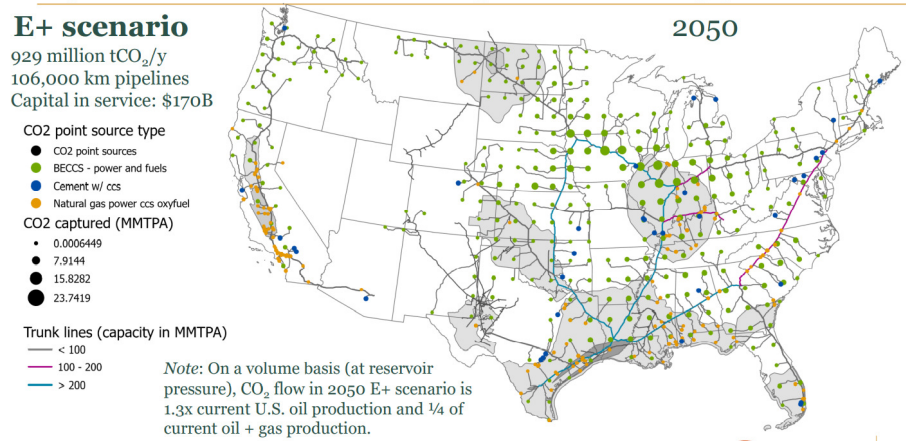
2050 totals: 21,000 km trunk lines + 85,000 km spur lines (equivalent to ~22% of US natural gas transmission pipeline total)

E+ scenario
929 million tCO_2/y
106,000 km pipelines
Capital in service: $170B



Note: On a volume basis (at reservoir pressure), CO_2 flow in 2050 E+ scenario is 1.3x current U.S. oil production and ¼ of current oil + gas production.

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https://netzeroamerica.princeton.edu/

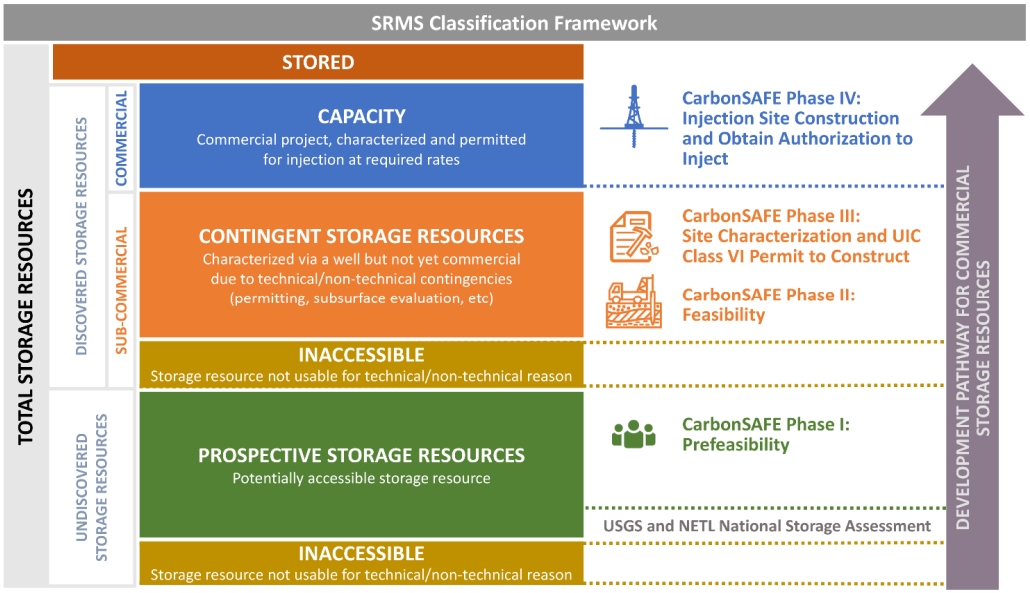
Carbon Transport and Storage Program

Storage Infrastructure R&D

Field projects and supporting **studies,** including regional characterization and field validation testing of technologies. Ongoing initiatives:

- (RIC and NLs)
- CarbonSAFE Phase II and III
- Regional Initiatives
- Support FWPs
- Offshore Characterization
- Associated Storage
- Brine Extraction Storage Test
- Offshore Partnerships

- **New awards**
  - **Additional CarbonSAFE Phases (FOA)**
    - Scale up projects(+50 MMT over 30 yrs and 10 yrs.)
    - Large storage complexes
    - Geographic distribution for regional hubs
- **Ongoing awards:**
  - Regional Initiatives, Support FWPs
- **FWPs**
  - Carbon Storage Analysis



Regional Initiatives to Accelerate CCUS

- 7 RCSPs → 4 Regional Initiatives

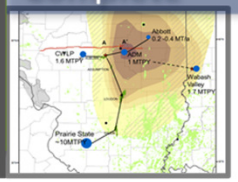
Four Key Activities

- Promote regional technology transfer
- Address certain technical challenges
- Facilitate data collection, sharing, and analysis
- Evaluate existing regional infrastructure

Carbon Storage Assurance Facility Enterprise (CarbonSAFE)

Phase I: Integrated CCS Pre-Feasibility
18-month initiative
- Formation of a team; development of a feasibility plan; and high-level technical evaluation of the sub-basin and potential CO2 sources
- Thirteen projects funded

Complete

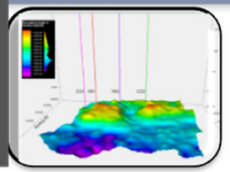


Phase II: Storage Complex Feasibility
2–year initiative
- Data collection; geologic analysis; analysis of contractual and regulatory requirements; subsurface modeling; risk assessment; evaluate monitoring requirements; and public outreach
- Six projects funded

Active

Phase III: Site Characterization and Permitting
3-year initiative
- Detailed site characterization; obtain Underground Injection Control (UIC) Class VI Permit to construct; CO_2 Capture Assessment; NEPA approvals
- Five Projects funded

Active



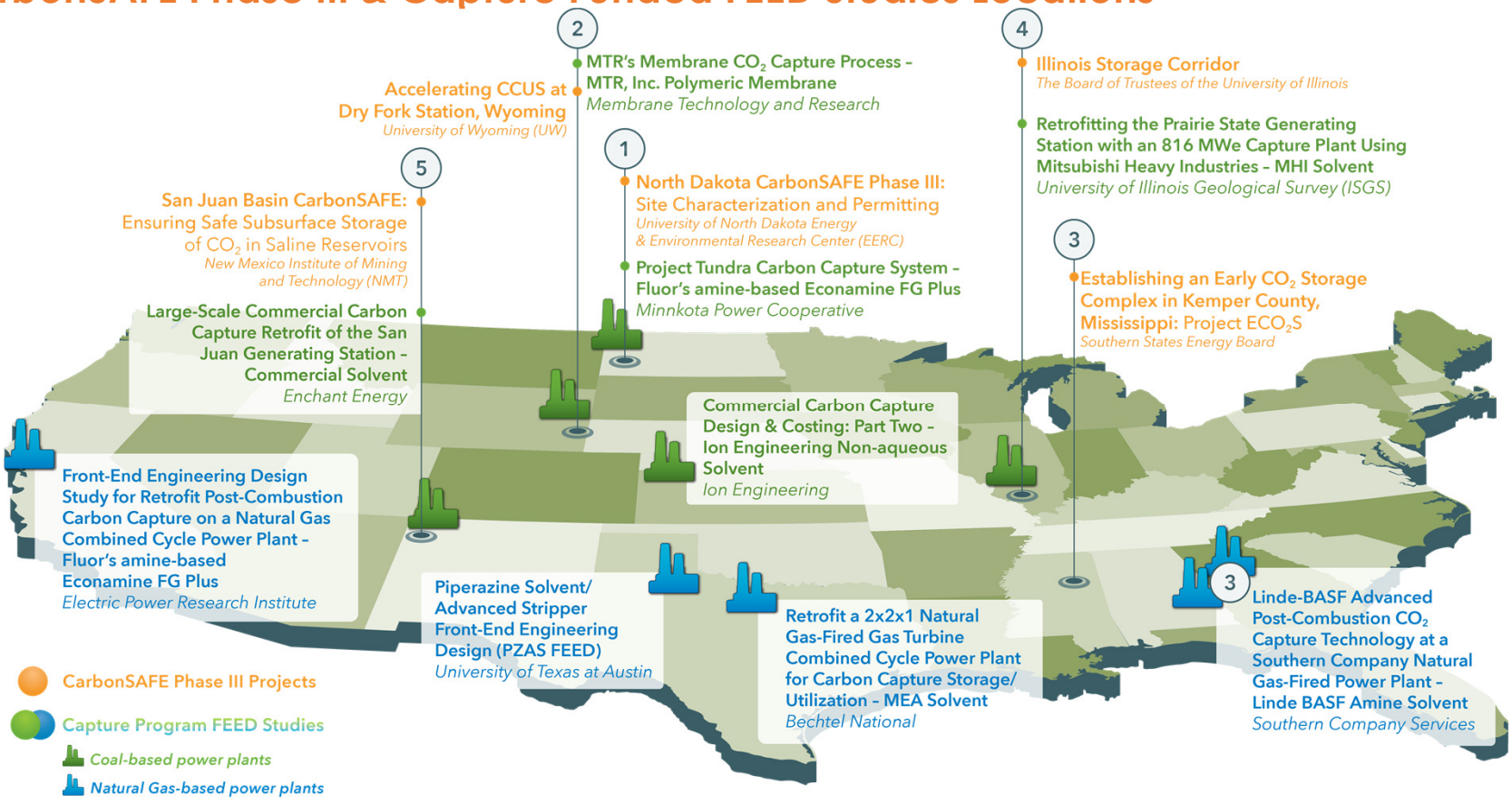
Phase IV: Construction of Storage Complex
2.5-year initiative
- Drill and complete injection and monitoring wells; obtain UIC Class VI authorization to inject; develop risk and mitigation plans
- Subject to funding

Future Funding

- CarbonSAFE was conceived to address the knowledge gaps associated with the development of a commercial-scale (50+ million metric tons CO_2) storage complex.
- Projects envisioned as staged efforts to develop an integrated CCS storage complex constructed and permitted for operation in the 2025–30 timeframe.
- 13 pre-feasibility projects (Phase I) were selected November, 2016; $15M total DOE funding.
- 6 feasibility projects (Phase II), two are currently active; $60M total DOE funding.
- 5 site characterization and permitting projects (Phase III) are currently active; $85M total DOE funding.
- Expansion of fourth phase being planned.
- Notice of Intent issued to support additional CarbonSAFE projects from FY22 R&D program

Carbon Storage Assurance Facility Enterprise (CarbonSAFE)

CarbonSAFE Phase III & Capture Funded FEED Studies Locations



CCUS Progresses Towards Net Zero

The Future of CCUS

Completed:

- 7 Regional Carbon Sequestration Partnerships Projects
  - 7 Large-scale field projects
  - 19 Small-scale field projects
- 4 Phase II CarbonSAFE
- 5 Offshore Characterization
- 13 Fit-for-purpose Associated Storage

Active:

- 2 Phase II CarbonSAFE
- 5 Phase III CarbonSAFE projects
- 4 Regional Initiatives
- 2 BEST Projects
- 2 Offshore Partnerships
- 3 Associated Storage

Future Needs:

- Further refine storage resource estimates
- Solve nontechnical challenges
- Regional Initiatives
- CarbonSAFE Phase IV
- Offshore Pilot Demonstration
- Infrastructure build-out
- O&G Conversion to storage

Scope of NASEM CCUS Infrastructure Study

1) Markets
a. Identify potential markets, industries, or sectors that may benefit from greater access to commercial carbon dioxide to develop products which may contribute to a net zero carbon future; identify the markets that are addressable with existing utilization technology, and which still require research, development and demonstration;
b. Determine the feasibility of, and opportunities for, the commercialization of coal-waste-derived carbon products in commercial, industrial, defense, and agricultural settings; for medical, construction and energy applications; and for the production of critical minerals;
c. Identify appropriate Federal agencies with capabilities to support small business entities; and determine what assistance those Federal agencies could provide to small business entities to further the development and commercial deployment of carbon dioxide-based products;

2) Infrastructure
a. Building off the study's first report, **assess infrastructure updates needed to enable safe and reliable carbon dioxide transportation, use, and storage for carbon utilization purposes. Assessment of infrastructure will consider how carbon utilization fits into larger carbon capture and sequestration infrastructure needs and opportunities;**

2)
b. Describe the economic, **climate, and environmental impacts of any well-integrated national carbon dioxide pipeline system** as applied for carbon utilization purposes, including suggestions for **policies that could: (i) improve the economic impact of the system; and (ii) mitigate climate and environmental impacts of the system;**

3) Research, Development and Demonstration
a. Identify and assess the progress of emerging technologies and approaches for carbon utilization that may play an important role in a circular carbon economy, as relevant to markets determined in section 1a.
b. Assess research efforts underway to address barriers to commercialization of carbon utilization technology, including basic, applied, engineering, and computational research efforts; and identify gaps in the research efforts;
c. Update the 2019 National Academies comprehensive research agenda on needs and opportunities for carbon utilization technology RD&D, focusing on needs and opportunities important to commercializing products that may contribute to a net zero carbon future.

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Questions?

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