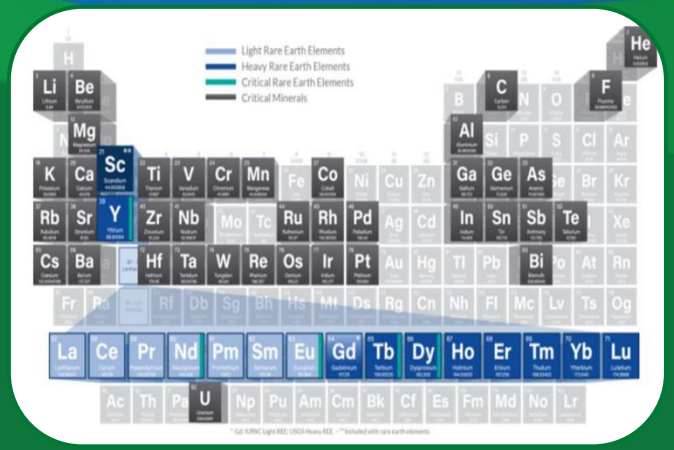
U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

FECM Carbon Storage Program

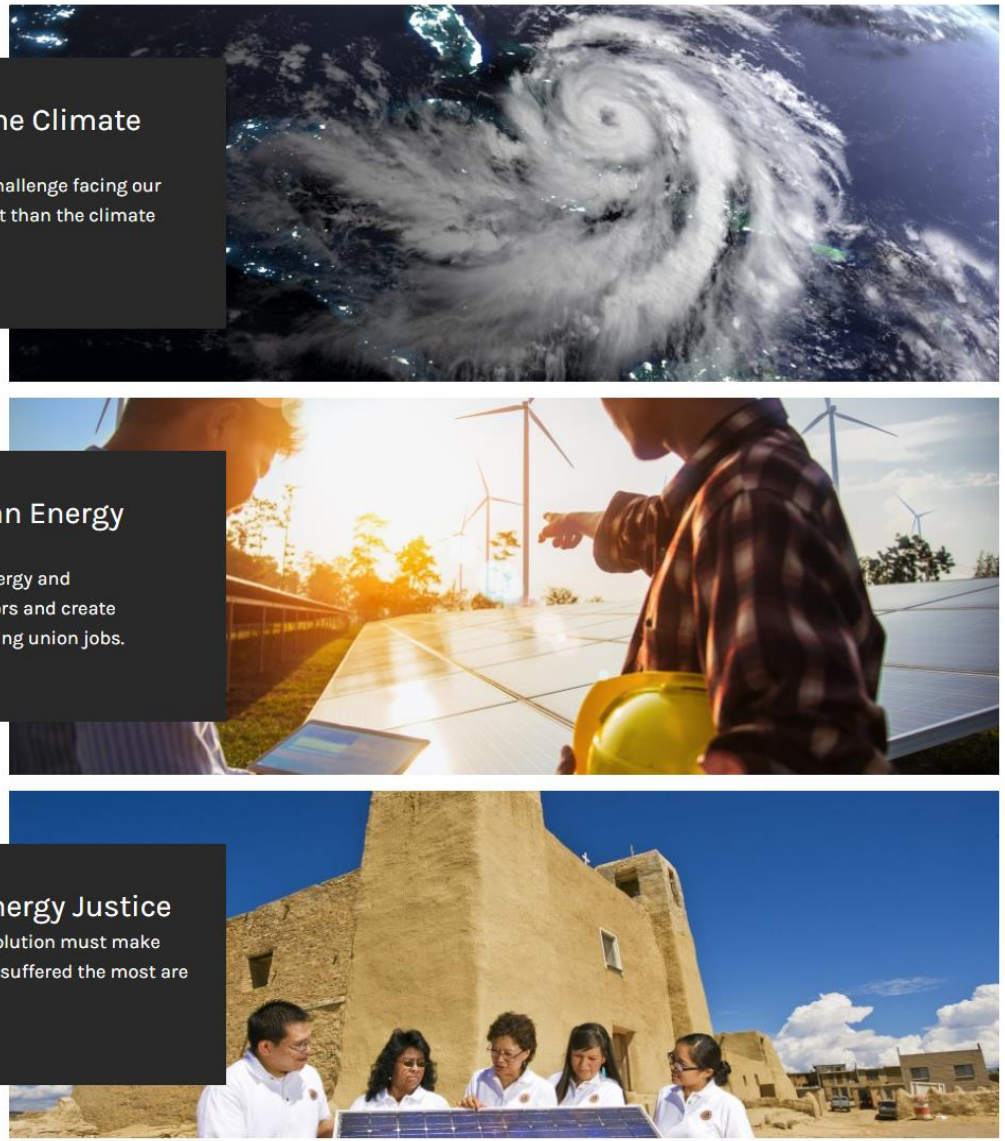
New Directions

August 4, 2021

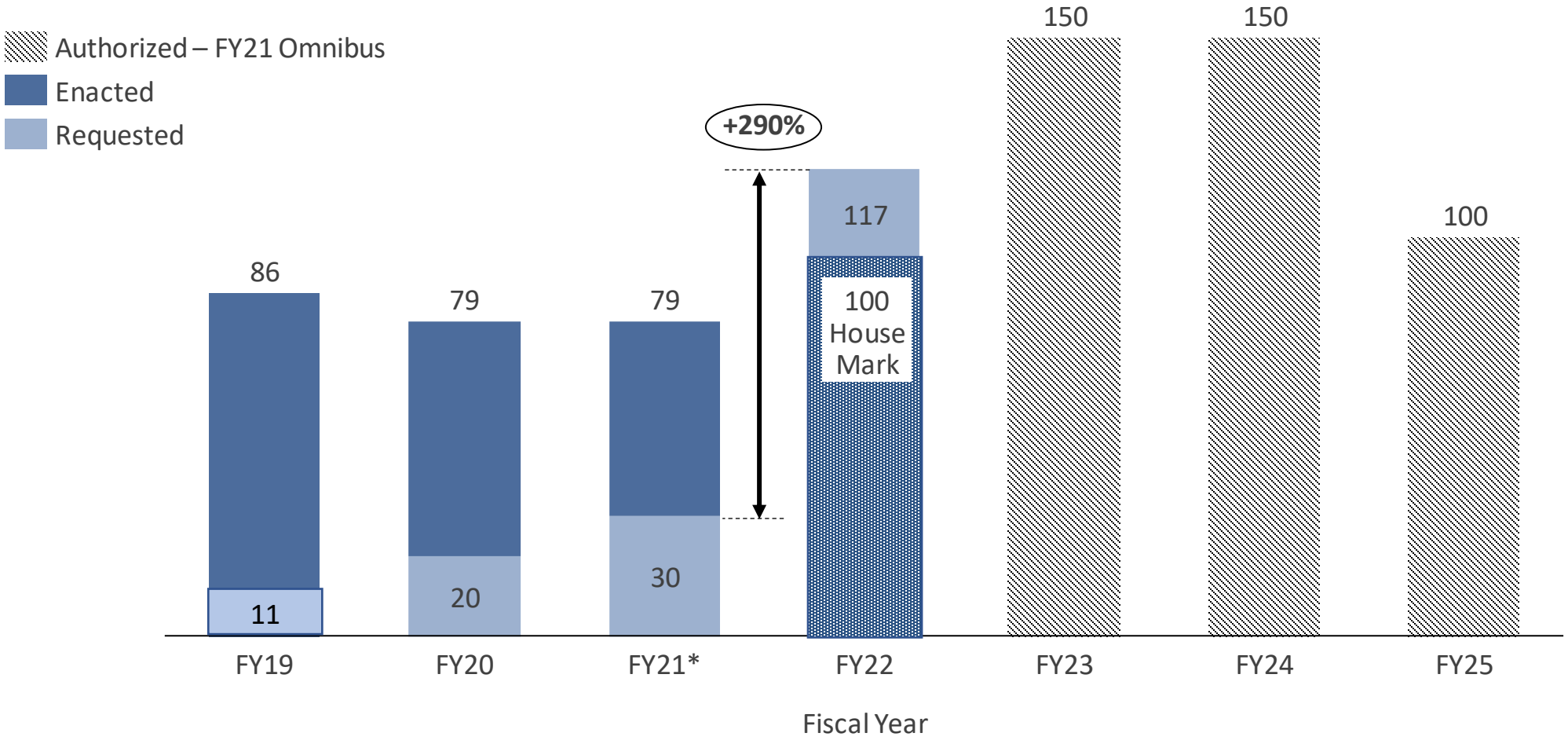


FECM Priorities

Point source carbon capture and reliable storage (CCS), as well as CO_2 removal to address our hardest to decarbonize sectors, are essential to meeting our climate goals.



Carbon Storage Program Appropriation ($ in MM)



*Carbon utilization funding separated from carbon storage in FY21.

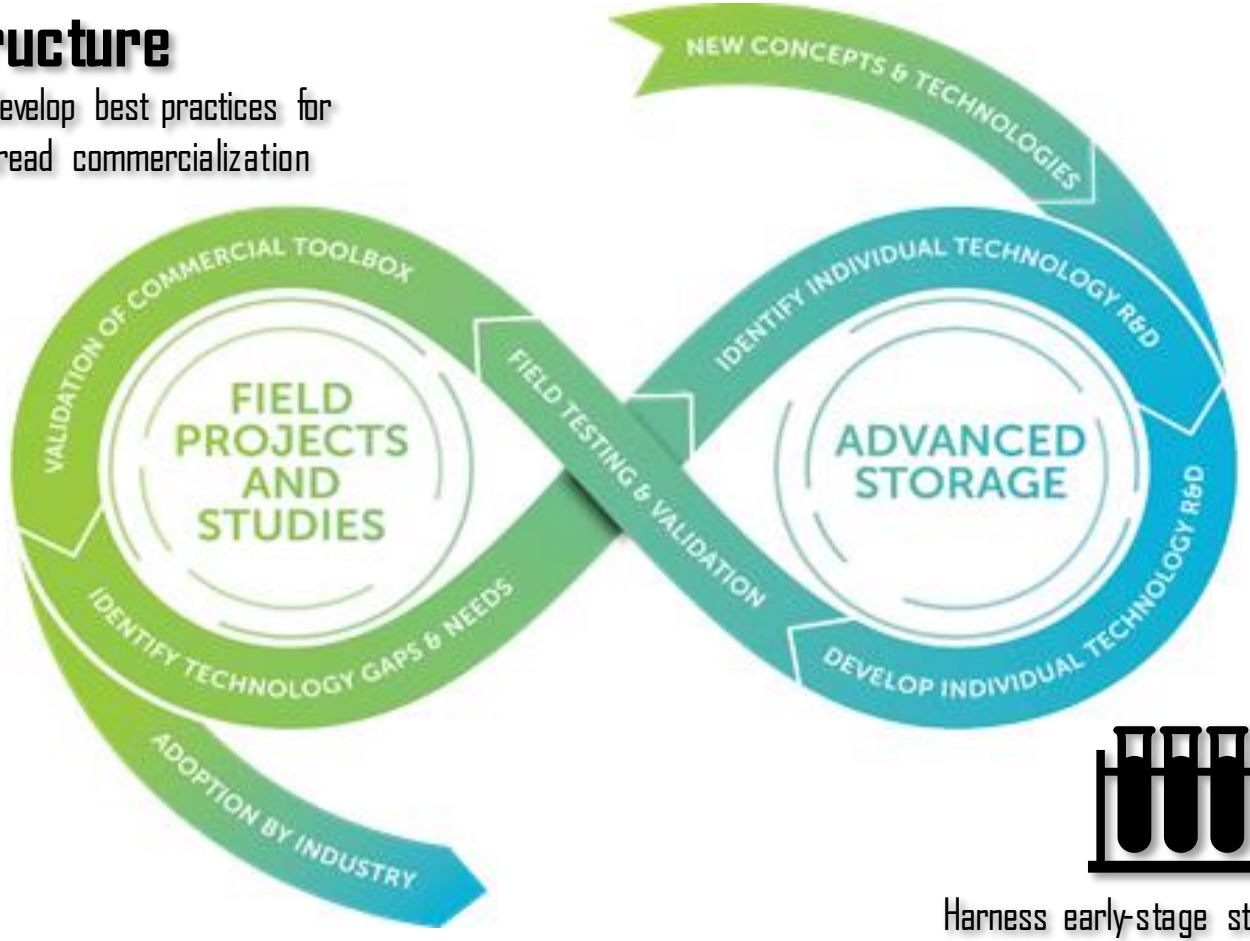
Iterative Process towards Deployment

Storage Infrastructure

Large-scale field 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)
- Associated Storage (CO_2 EOR)



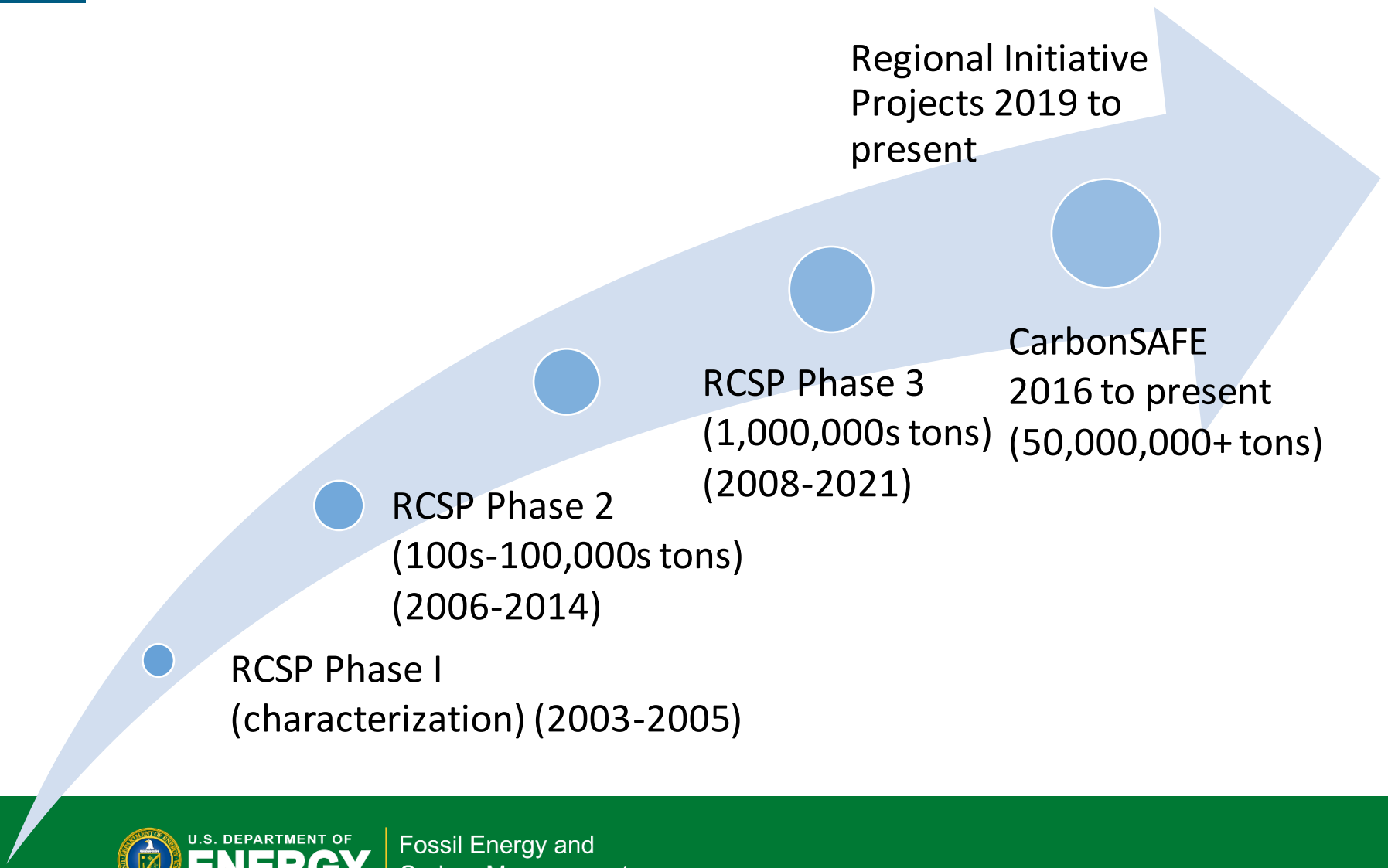
Advanced Storage Focus

- 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

Carbon Storage Field Activity Progression



Setting the stage for deployment but many more projects needed to meet emission reduction targets

Supporting field projects

- Pressure and Water Management (BEST)
- CO_2-EOR and associated storage – leveraging existing infrastructure for dedicated storage; net negative oil.
- Offshore Storage

Vision of the Carbon Storage Program to Accelerate Storage Technologies and Deployment



Characterization Phase → Operating Phase → Post-Injection Phase

Higher Performance

Ability to understand subsurface behavior prior to injection delivers *higher performance* from Day 1:

- Enable lifecycle and permitting through strong site selection
- **Identify state of stress and fault identification early in project life** to deliver higher performance

Better Decisions

Ability to be react proactively during operations allows for *better decisions*:

- Conduct history matching with ongoing injection and models
- Process **data real-time** to ensure operations remain in nominal status
- **Structure and automate processing of data** into learning models

Greater Confidence

Ability to accurately predict, monitor, and de-risk post injection phase demonstrates *greater confidence:*

- Develop technologies to improve **plume detection and post-injection monitoring**
- Define fit-for-purpose permitting requirements as plume monitoring and confidence matures to improve business case

Storage Program Priority R&D

Subsurface stress

- improved capability to forecast risk of induced seismicity & compromise of seal integrity

Wellbore integrity

- Find & assess legacy wells and novel materials/techniques for remediation

Secure storage

- Improve AZMI tools

Plume detection and storage efficiency

- Locate plume margins & pressure increase; improve use of pore space)

Site characterization

- Map reservoir & seal heterogeneities and deep faults

Regional resource estimates

- filling the data gaps & realistic basin-scale storage estimates)

Transformational sensing

- Micro/nano and optical fiber sensing capabilities; wireless power/telemetry systems; edge computing to enable intelligent monitoring systems

FOA2401 - Emerging CO_2 Storage Technologies: Optimizing Performance Through Minimization of Seismicity Risks and Monitoring Caprock Integrity

AOI 1: Fault Detection, Characterization, and Hazard Assessment
Focused on developing new characterization methods for providing high-fidelity data on faults, fault slip or potential fault slip, assessment of faults during active injection, criteria for cost-effective methods for assessing and choosing a site, and other related research

AOI 2: Monitoring for CO_2 and Native Fluid Migration Through and Above Main Caprock Layers
Focused on the development of tools and/or methods that improve the detection and quantification of CO_2 and/or native fluids flow through the first main seal in the deep subsurface.

- **University of Houston** (Houston, Texas) – developing and testing cost-effective seismic data processing technologies including a system to automatically detect faults on 3D seismic migration images.
- **The New Mexico Institute of Mining and Technology** (Socorro, New Mexico) – deploying a novel geochemical technology that uses drill cuttings and cores to locate faults and evaluate their effects on subsurface fluids system.
- **Battelle Memorial Institute** (Columbus, Ohio) – developing an acoustic emissions (AE)-based technique to predict the location and movement of CO_2 through a confining layer in a geologic carbon storage (GCS) system.
- **William Marsh Rice University** (Houston, Texas) – developing a new strategy for monitoring seal integrity which has the potential to provide a powerful platform for identifying CO_2 leakage through reactivated faults or fracture zones.

National Labs Advancing Key Storage Technologies

SNL

- Developing a wireless downhole power supply based on a thermopile concept

PNNL

- Advancing a new class of acoustically responsive injectable contrast monitoring agents
- Developing an autonomous electrical resistivity tomography (ERT)-seismic inversion.
- Developing a regional geologic model of the basalts in northwestern US.

LBL

- Permanent seismic imaging using surface orbital vibrators and distributed acoustic sensing (SOV-DAS)
- Developing high-sensitivity vector-optical sensors (HS-VOS) for deep reservoir monitoring
- Advancing joint electromagnetic (EM)-Seismic methods
- Evaluating the mechanical effects of CO_2 injection on a fault zone affecting a reservoir caprock (Mont Terri, Switzerland)

LLNL

- Quantifying chemical alteration impacts on CO_2 injection and storage capacity in arkosic sandstone reservoirs.

LANL

- Novel methods to detect small leaks over large areas
- Monitoring for faults at a critical state of stress

https://edx.netl.doe.gov/nrap/

National Risk Assessment Partnership

NATIONAL ENERGY TECHNOLOGY LABORATORY

BERKELEY LAB

Lawrence Livermore National Laboratory

Los Alamos NATIONAL LABORATORY EST. 1943

Pacific Northwest NATIONAL LABORATORY

NRAP Tools

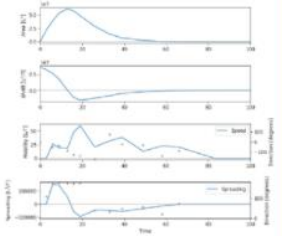
- Open-IAM
- DREAM 2.0
- PSMT
- SOSAT
- STSF
- RiskCat

NRAP is establishing workflows for:

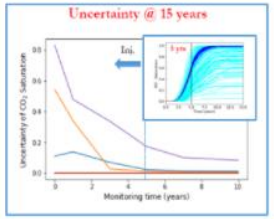
Containment effectiveness and leakage risk

Risk-based AoR

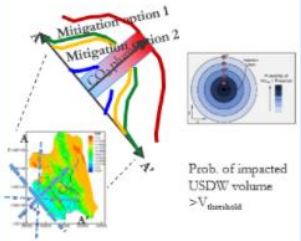
Metrics for Plume Stability



Conformance assessment and uncertainty reduction



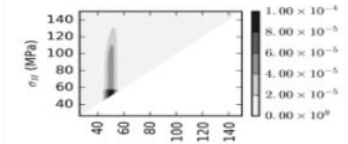
Risk Management and Site Closure Evaluation



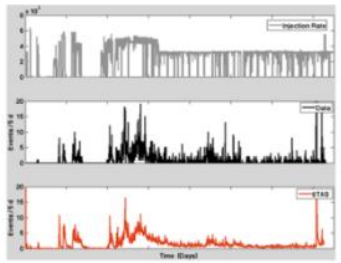
Induced Seismicity Risk

State of Stress Characterization

Stress probability distribution

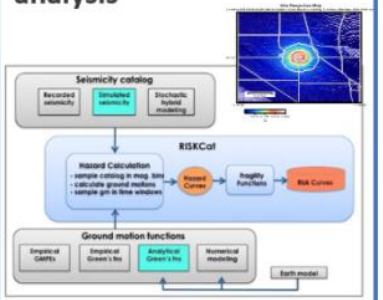


Short-term seismicity forecasting



(Bachmann et al., 2014)

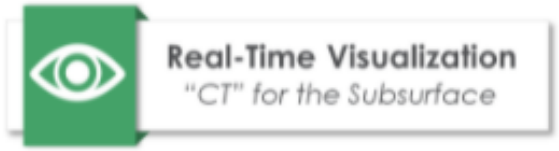
Probabilistic seismic risk analysis



https://edx.netl.doe.gov/smart/

Science-informed Machine learning to Accelerate Real-Time decisions for carbon storage (SMART-CS)

Transforming our understanding of the subsurface through…



Real-Time Visualization of key subsurface features and flows

Virtual Learning for rapid prediction of reservoir behavior

Real-Time Forecasting of actively managed carbon storage systems

Phase 1 Winners in SMART Visualization Platform Prize Challenge announced

- **Red Volta Visualization Platform**
- **Subsurface XR**
- **GeoDeck**
- **RocVision**

Energy Data Exchange

Virtual library and data laboratory built to find, connect, curate, use and re-use data to advance fossil energy and environmental R&D

Geocube is a customizable web mapping application that connects users to data collections and resources spanning the subsurface to the surface via EDX

Carbon Storage

COLLECTION

The Carbon Storage Open Database is a collection of spatial data obtained from publicly available sources published by several NATCARB Partnerships and other organizations

Keywords: ccs, co2, carbon storage, coal, gas natcarb, oil, saline, sequestration, sources

Global Oil and Gas Infrastructure

COLLECTION

Geodatabase containing 4.8 million records demonstrating the global footprint of oil and natural gas infrastructure. Datasets were acquired from 700+ authoritative, open-access data resources and refined into a unified inventory of oil and gas data. Data is represented from all 193 United Nations Member States and their respective exclusive economic zones. Oil and gas infrastructure from Antarctica is included as well. This information was collected to build a data framework to more accurately estimate methane emissions from oil and gas infrastructure. Report summarizing methodology and preliminary findings available here: https://edx.netl.doe.gov/dataset/development-of-an-open-global-oil-and-gas-infrastructure-inventory-and-geodatabase Geodatabase available for download from the link below.

Keywords: database, global, netl, oil and gas infrastructure, gdb, gogi

NATCARB Viewer 2.0

COLLECTION

The National Carbon Sequestration Database (NATCARB) is an online collection of data layers describing carbon capture, use and storage (CCUS) potential across the United States. The NATCARB collection is a product of DOE Fossil Energy.

Keywords: atlas, atlas v, ccs, co2, carbon storage, coal, gas, natcarb, oil, saline, sequestration, sources

Offshore Gulf of Mexico

COLLECTION

Spatial data acquired from credible sources and created using analytical methods for the Gulf of Mexico. This data contains information on public and industrial infrastructure, environment, and socio-economic factors. Much of this data was originally collected to measure the potential impacts of oil spills and has continued to build into a robust and wide-ranging geodatabase, available here (point to EDX).

Keywords: co2, edx, esri, gom, gases, geochemistry, geology gulf of mexico, mapping application, navigable waterways, oil, petrophysical physical properties, shoreline, stratigraphy, tool, insight, platforms

Rare Earth Elements & Coal Open Database

COLLECTION

The REE and Coal Open Database is an online collection of subsurface contextual data from publicly available geological, geochemical, and geospatial resources. These data align to and support execution of NETL's REE coal assessment method. The database includes basin- and national-level spatial datasets, in addition to other non-spatial data that support the assessment approach. Data in this collection are sourced from a range of authoritative, public sources, including NETL, U.S. Geological Survey (USGS), Energy Information Administration (EIA), and state geological surveys.

Illinois State Geological Survey (ISGS), Illinois Basin - Decatur Project (IB... NETL

Three geological models in Petrel (Mark of Schlumberger) and data output from shallow groundwater modeling using TOUGH Codes from Lawrence Berkeley National Laboratory, included...

HTML

Dataset Size: 0 bytes | 1 Resource | Show Resources

Illinois State Geological Survey (ISGS), Illinois Basin - Decatur Project (IB... NETL

Data, analyses, and documentation from near-surface and subsurface monitoring at the IBDP site, including: downhole distributed temperature sensor monitoring from the CCS1...

HTML

Dataset Size: 0 bytes | 1 Resource | Show Resources

Illinois State Geological Survey (ISGS), Illinois Basin - Decatur Project (IB... NETL

During the Illinois Basin - Decatur Project (IBDP), there were three deep wells drilled: CCS1 (API 1211523415); VW1 (API 1211523460); and GM1 (API 1211523438). Well summary...

ZIP

Dataset Size: 4.278 GB | 1 Resource | Show Resources

Illinois State Geological Survey (ISGS), Illinois Basin - Decatur Project (IB... NETL

These data are intended to provide a GIS-based portrayal and spatial archival of the IBDP project wells and the distribution of near-surface monitoring and sampling...

ZIP

Dataset Size: 12.398 GB | 1 Resource | Show Resources

Illinois State Geological Survey (ISGS), Illinois Basin - Decatur Project (IB... NETL

Selected photos taken during the Illinois Basin - Decatur Project (IBDP).

ZIP

Dataset Size: 600.061 MB | 1 Resource | Show Resources

International Collaborations - ACT

- ACT is an international initiative to facilitate RD&D and innovation within CCUS
- 16 countries, regions, and provinces are working together
- Members include funding agencies from: Alberta Province (Canada), Denmark, France, Germany, Greece, India, Italy, the Netherlands, Norway, Nordic Energy, Romania, Spain, Switzerland, Turkey, United Kingdom, and United States
- Second funding call in November 2019: 7 of 12 projects selected have U.S. involvement and funding
  - FE announced $4 million in federal funding for national laboratories to collaborate with international partners on these seven projects
- Third funding call announced on June 2, 2020. In March 2021 36 proposals were received. 12 projects were notified of their selection. Expect to announce awards in October 2021.

www.act-ccs.eu

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Questions?