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Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

Energy and CO_2 Management: Carbon Capture and Storage

2022 Lignite Education Seminar
Bismarck, North Dakota

June 15, 2021

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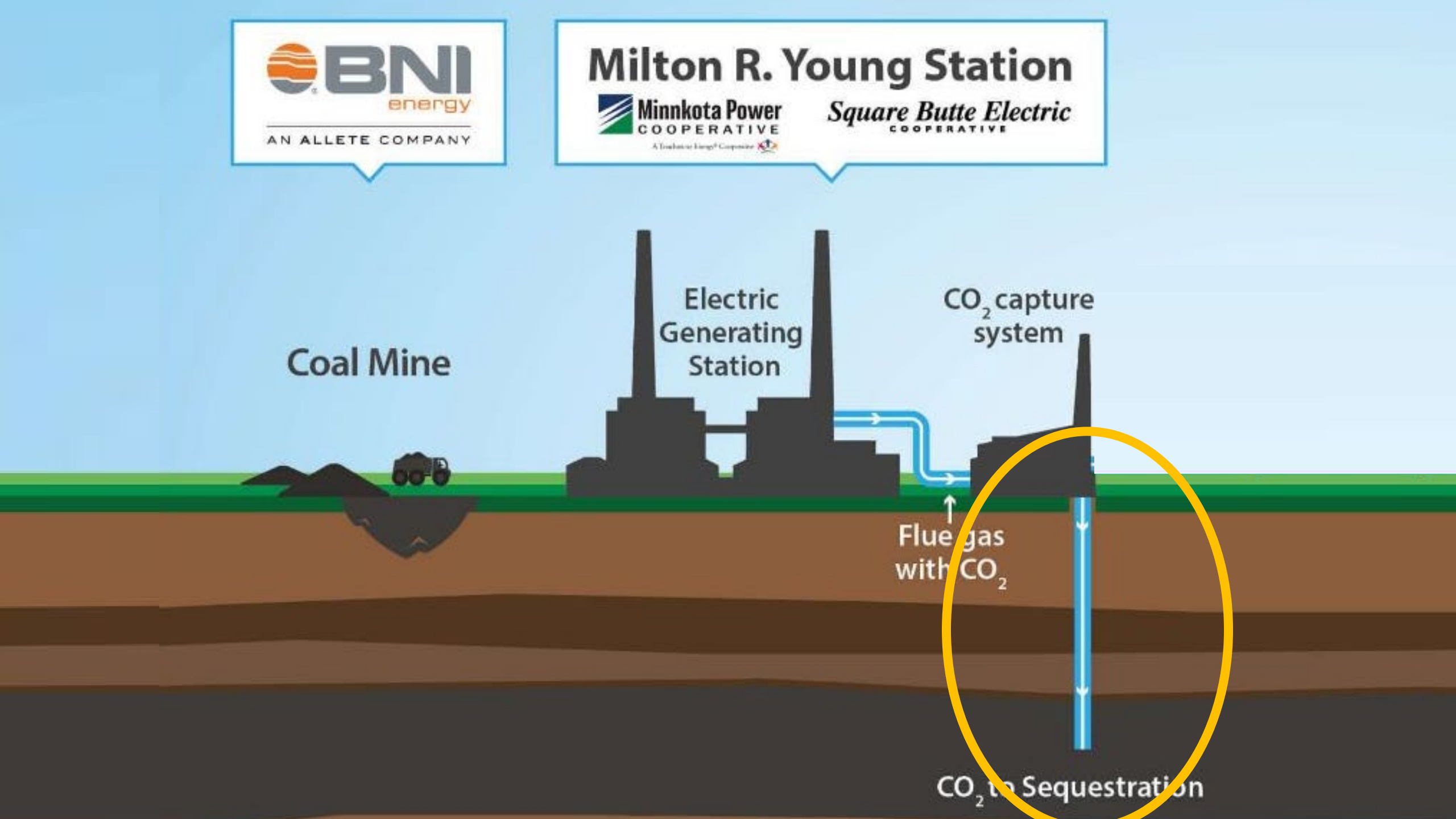
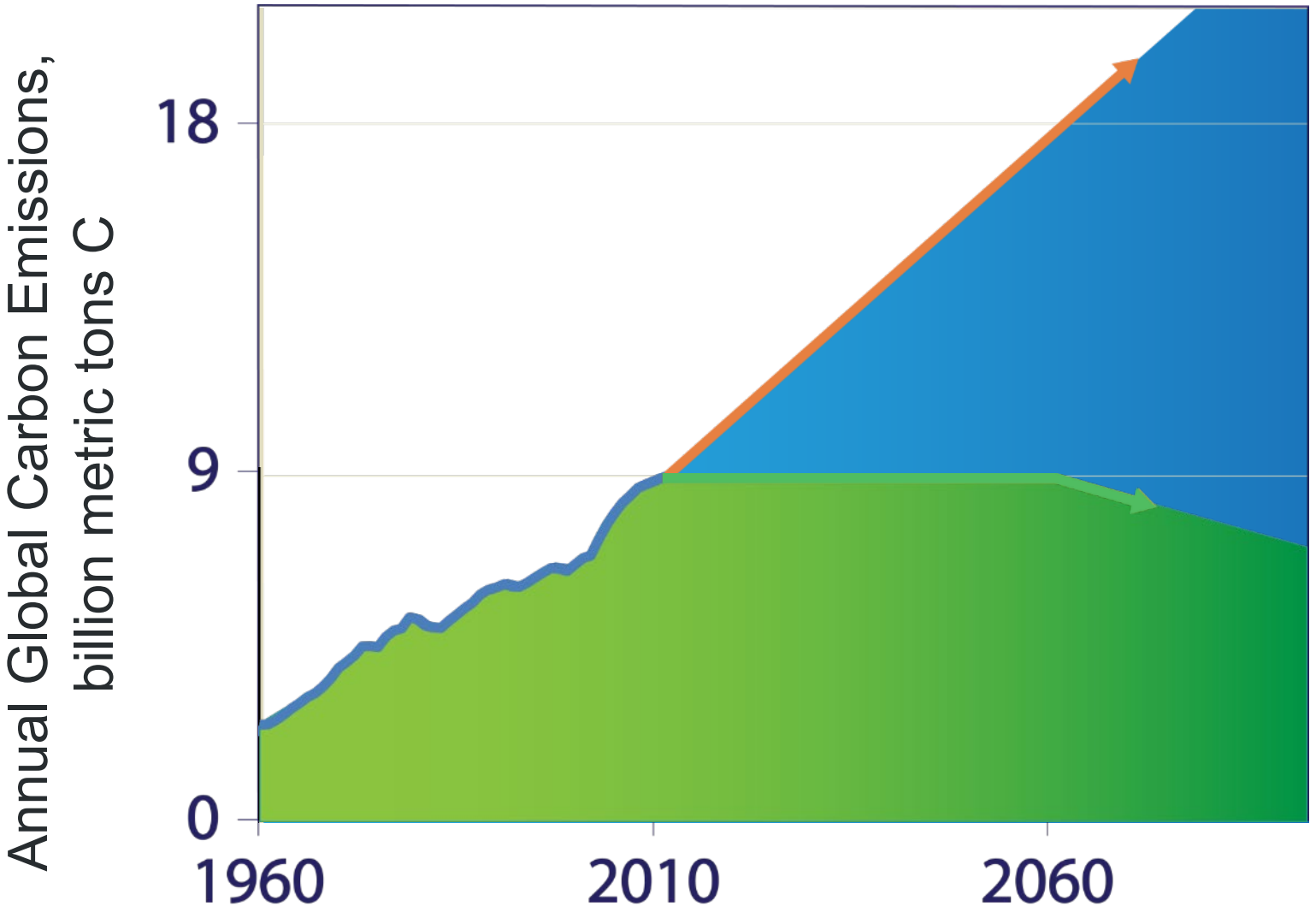

BNI energy
AN ALLETE COMPANY
Milton R. Young Station
Minnkota Power COOPERATIVE
Square Butte Electric COOPERATIVE
Coal Mine
Electric Generating Station
CO_2 capture system
Flue gas with CO_2
CO_2 to Sequestration

Presentation Outline

- A little history
- A little science
- A little current events

Business as Usual Carbon Emissions



▶ Humanity faces a choice between two futures: doing nothing to curb emissions (which poses huge climate risks) and bringing them under control (which has costs but also benefits).

A Plan to Keep Carbon in Check

Getting a grip on greenhouse gases is daunting but doable. The technologies already exist. But there is no time to lose

BY ROBERT H. SOCOLOW AND STEPHEN W. PACALA

OVERVIEW

- Humanity can emit only so much carbon dioxide into the atmosphere before the climate enters a state unknown in recent geologic history and goes haywire. Climate scientists typically see the risks growing rapidly as CO_2 levels approach a doubling of their pre-18th-century value.
- To make the problem manageable, the required reduction in emissions can be broken down into "wedges"—an incremental reduction of a size that matches available technology.

Retreating glaciers, stronger hurricanes, hotter summers, thinner polar bears: the ominous harbingers of global warming are driving companies and governments to work toward an unprecedented change in the historical pattern of fossil-fuel use. Faster and faster, year after year for two centuries, human beings have been transferring carbon to the atmosphere from below the surface of the earth. Today the world's coal, oil and natural gas industries dig up and pump out about seven billion tons of carbon a year, and society burns nearly all of it, releasing carbon dioxide (CO_2). Ever more people are convinced that prudence dictates a reversal of the present course of rising CO_2 emissions.

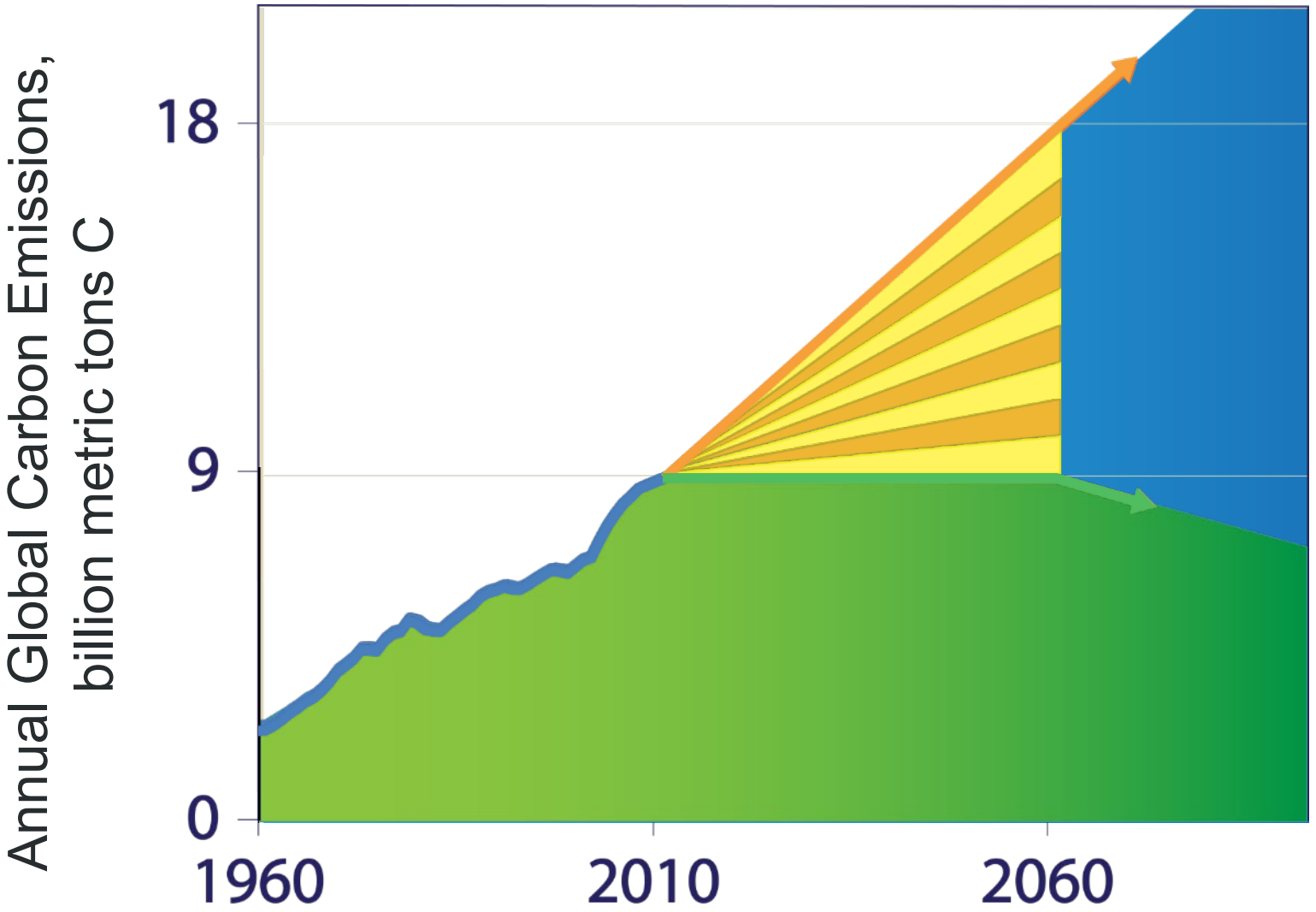
The boundary separating the truly dangerous consequences of emissions from the merely unwise is probably located near (but below) a doubling of the concentration of CO_2 that was in the atmosphere in the 18th century, before the Industrial Revolution began. Every increase in concentration carries new risks, but avoiding that danger zone would reduce the likelihood of triggering major, irreversible climate changes, such as the disappearance of the Greenland ice cap. Two years ago the two of us provided a simple framework to relate future CO_2 emissions to this goal.

We contrasted two 50-year futures. In one future, the emissions rate continues to grow at the pace of the past 30 years for the next 50 years, reaching 14 billion tons of carbon a year in 2056. (Higher or lower rates are, of course, plausible.) At that point, a tripling of preindustrial carbon concentrations would be very difficult to avoid, even with concerted efforts to decarbonize the world's energy systems over the following 100 years. In the other future, emissions are frozen at the present value of seven billion tons a year for the next 50 years and then reduced by about half over the following 50 years. In this way, a doubling of CO_2 levels can be avoided. The difference between these 50-year emission paths—one ramping up and one flattening out—we called the stabilization triangle [*see box on page 52*].

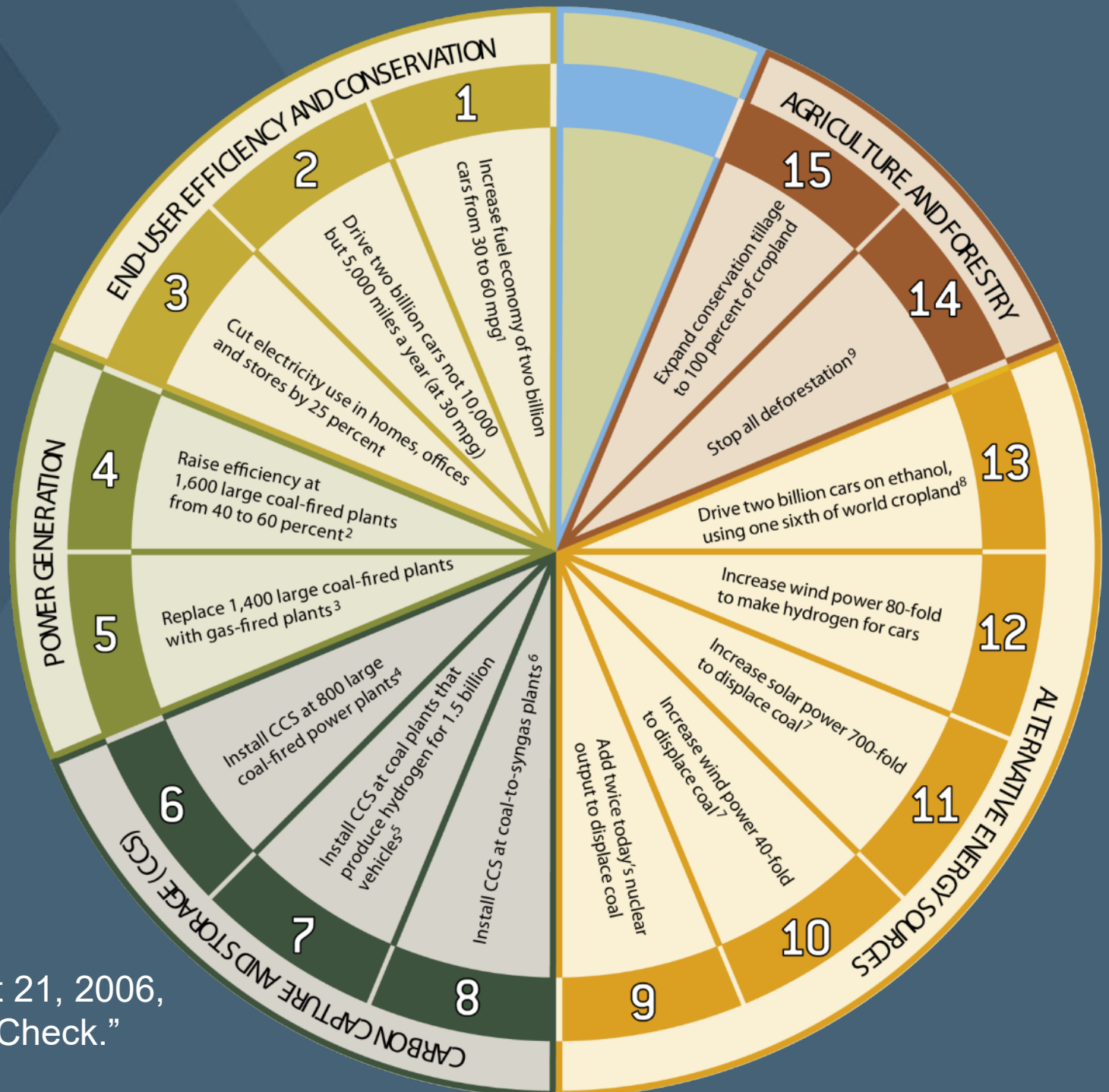
To hold global emissions constant while the world's economy continues to grow is a daunting task. Over the past 30 years, as the gross world

KENN BROWN

Divide and Conquer



Example Options for Cutting Carbon



Each wedge represents 25 billion tons of carbon not emitted over 50 years.

Scientific American, August 21, 2006, "A Plan to Keep Carbon in Check."


EERC
PCOR
Partnership

Carbon Capture and Storage

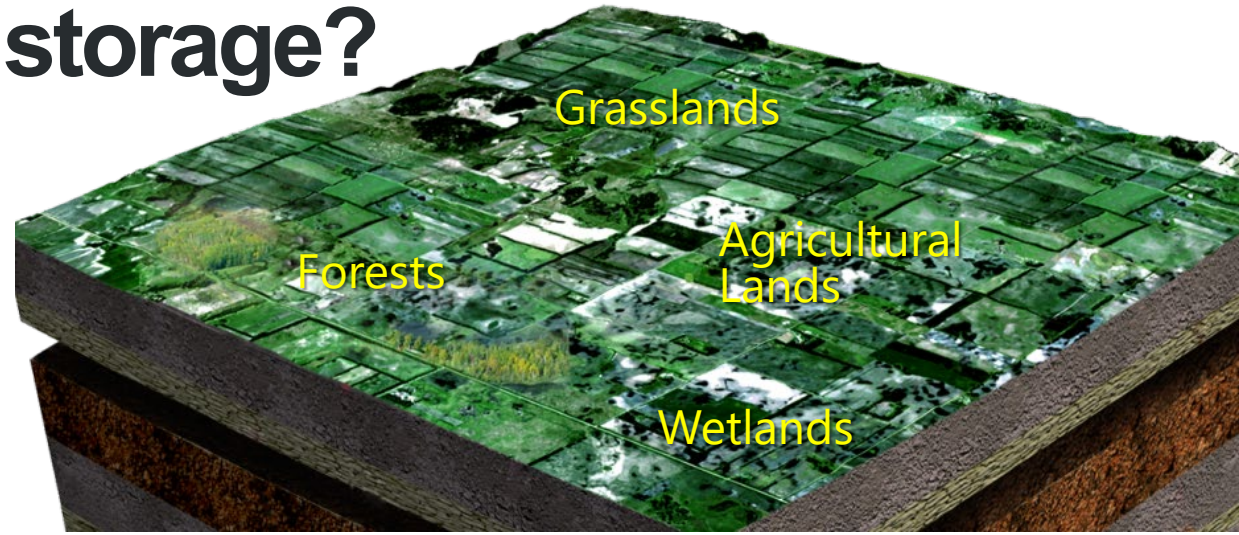
Also known as

CO_2 Sequestration

What is carbon capture and storage?

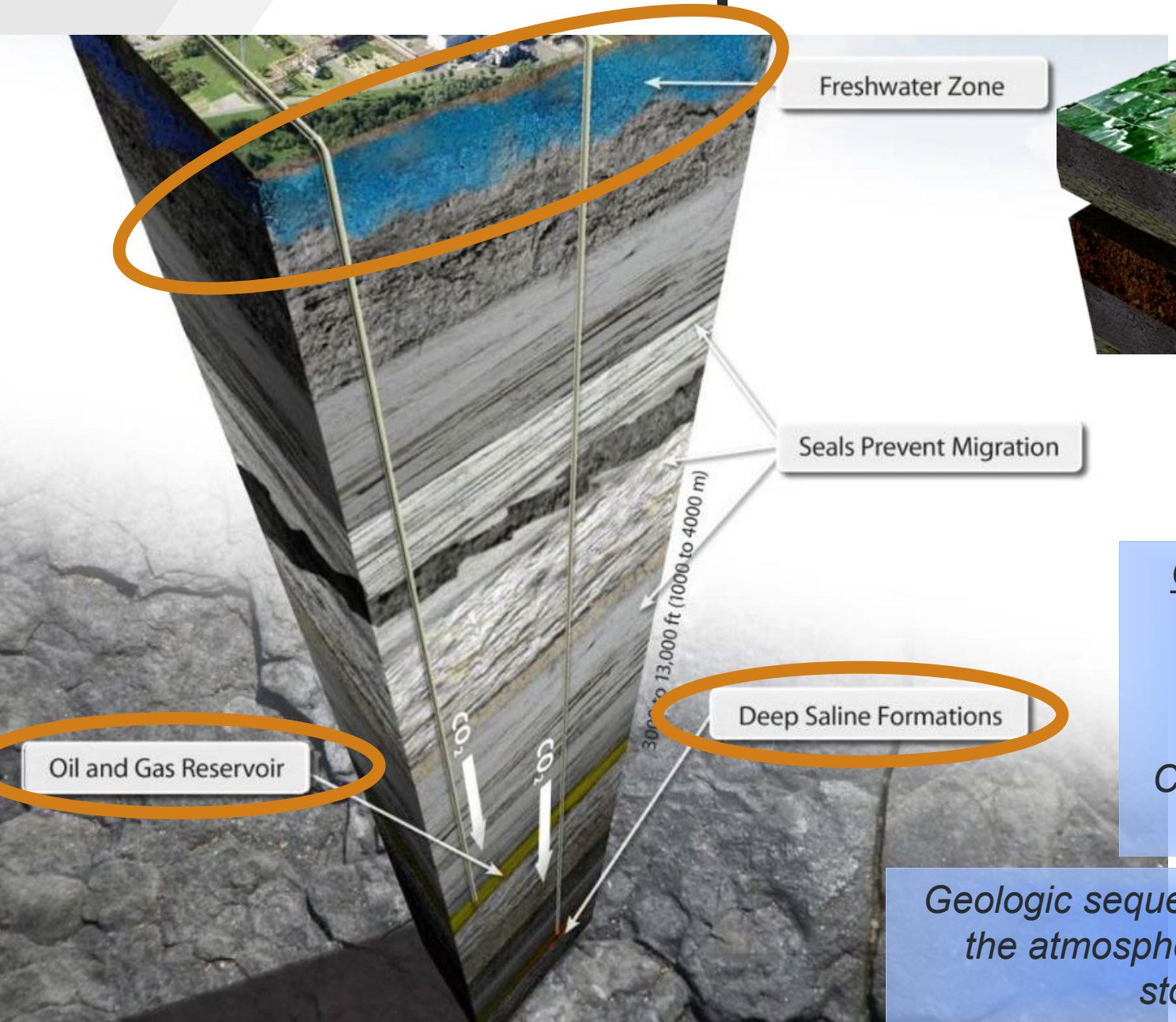
1. Capture and permanent sequestration of CO_2 from point-source emitters.
2. Using the CO_2 removed from an ethanol production facility to produce more oil (enhanced oil recovery).
3. A means to address CO_2 emissions from coal-fired plants.
4. Removing CO_2 from the atmosphere for long-term storage.

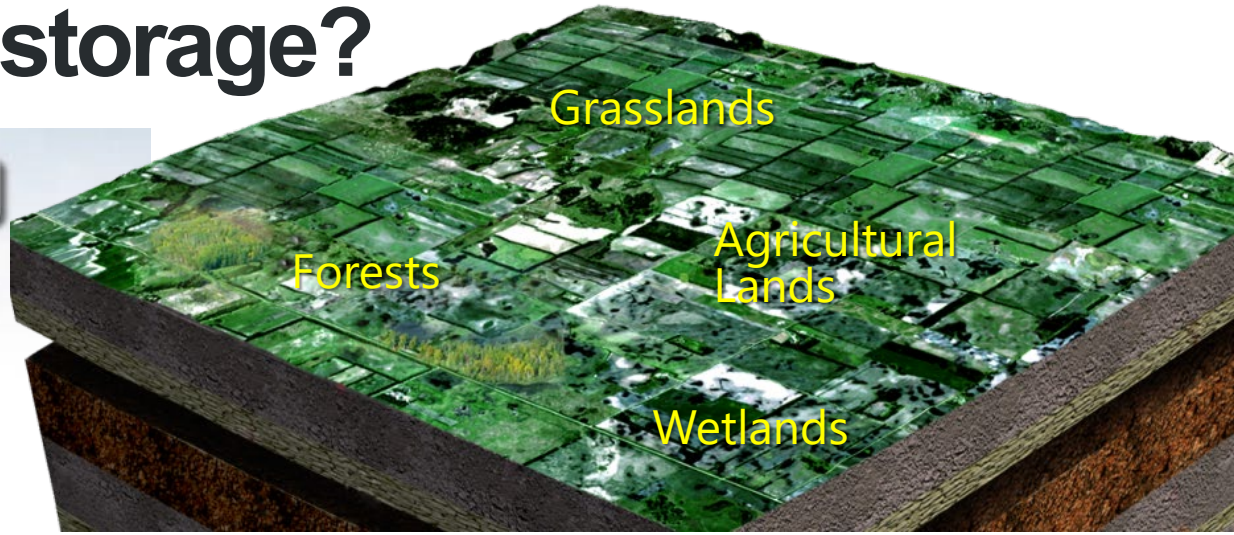
What is carbon capture and storage?



Terrestrial sequestration absorbs CO_2 from the atmosphere and stores it in plant materials and soils.

What is carbon capture and storage?





Terrestrial sequestration absorbs CO_2 from the atmosphere and stores it in plant materials and soils.

Geologic sequestration is also called:

Carbon capture and storage (CCS)

Geologic CO_2 sequestration

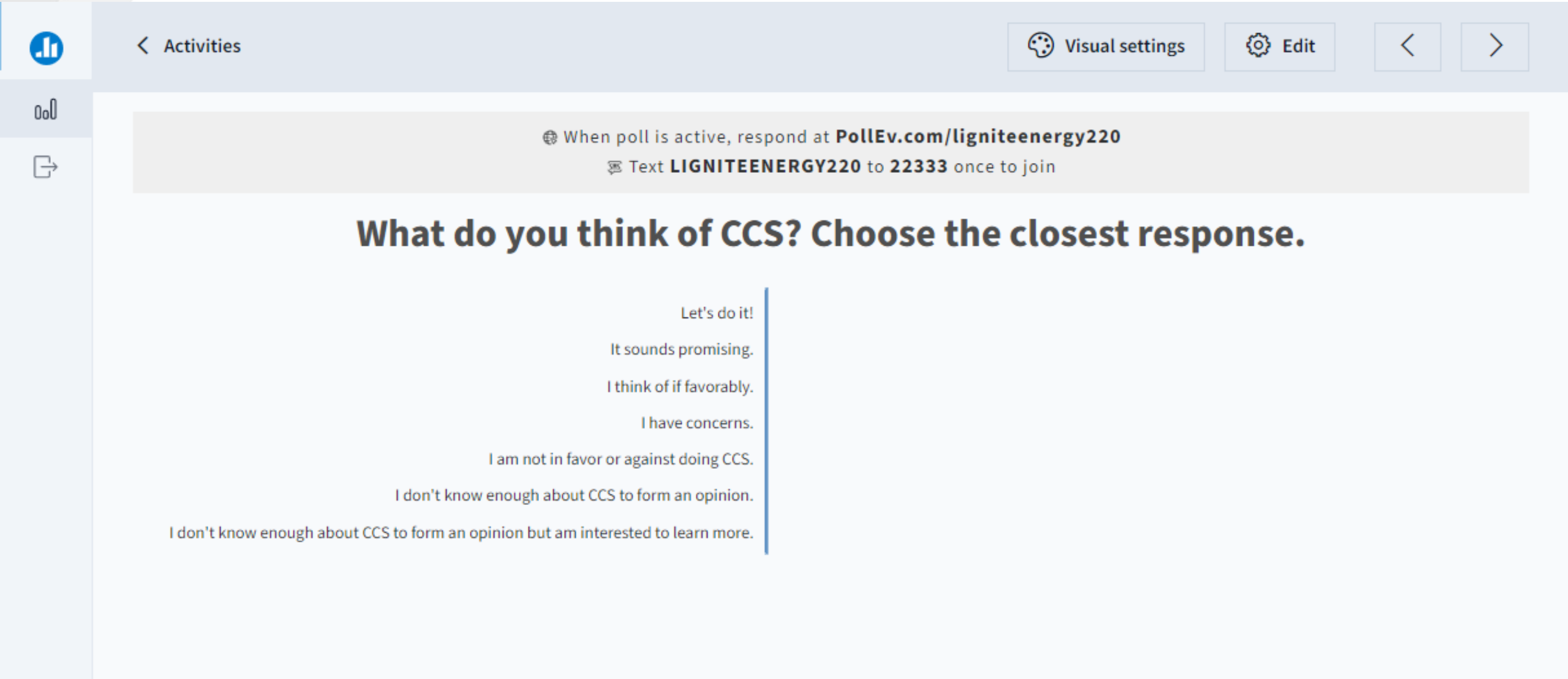
Carbon capture, utilization, and storage (CCUS)

Geologic sequestration captures CO_2 before it enters the atmosphere and puts it into safe, permanent storage deep underground.

Question

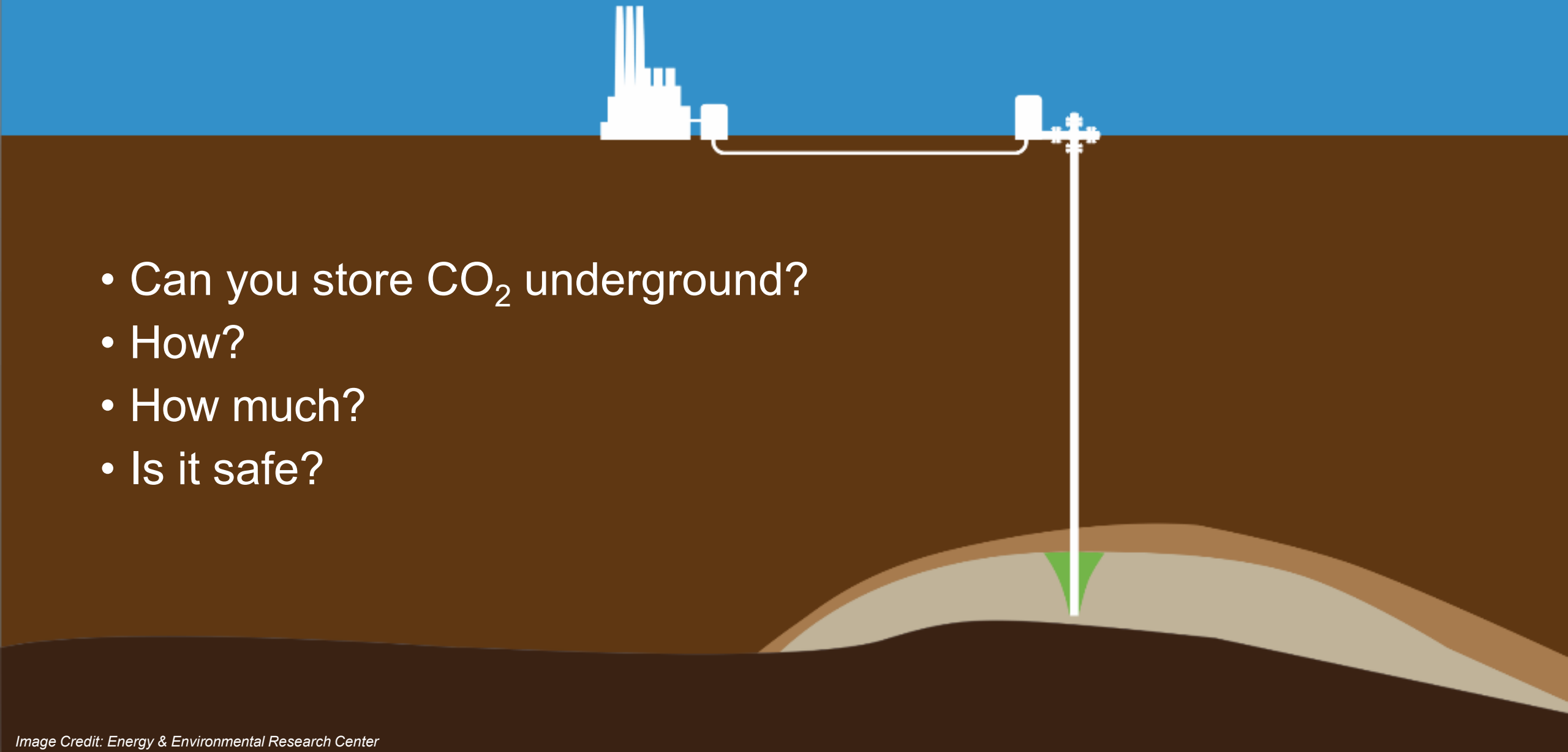

Activities
Visual settings
Edit
When poll is active, respond at PollEv.com/ligniteenergy220
Text LIGNITEENERGY220 to 22333 once to join
Have you heard of carbon capture and storage?
I have never heard of CCS
I have heard of CCS but do not know anything about it
I am somewhat familiar with CCS
I am familiar with CCS
I am very familiar with CCS

Question


Activities
Visual settings
Edit
When poll is active, respond at PollEv.com/ligniteenergy220
Text LIGNITEENERGY220 to 22333 once to join
What do you think of CCS? Choose the closest response.
Let's do it!
It sounds promising.
I think of if favorably.
I have concerns.
I am not in favor or against doing CCS.
I don't know enough about CCS to form an opinion.
I don't know enough about CCS to form an opinion but am interested to learn more.

Carbon Capture and Storage

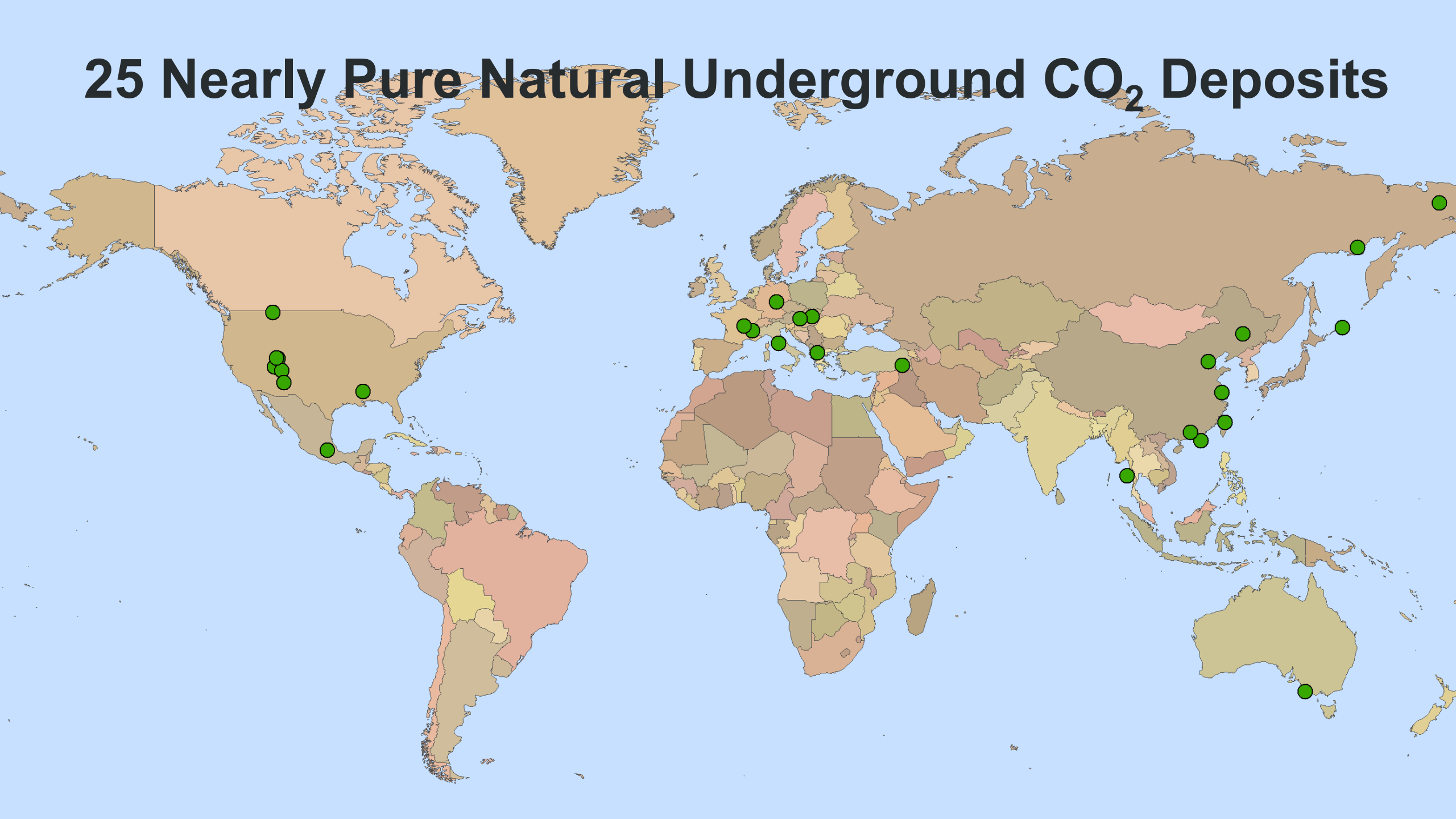
Carbon Capture and Storage



- Can you store CO_2 underground?
- How?
- How much?
- Is it safe?

Image Credit: Energy & Environmental Research Center

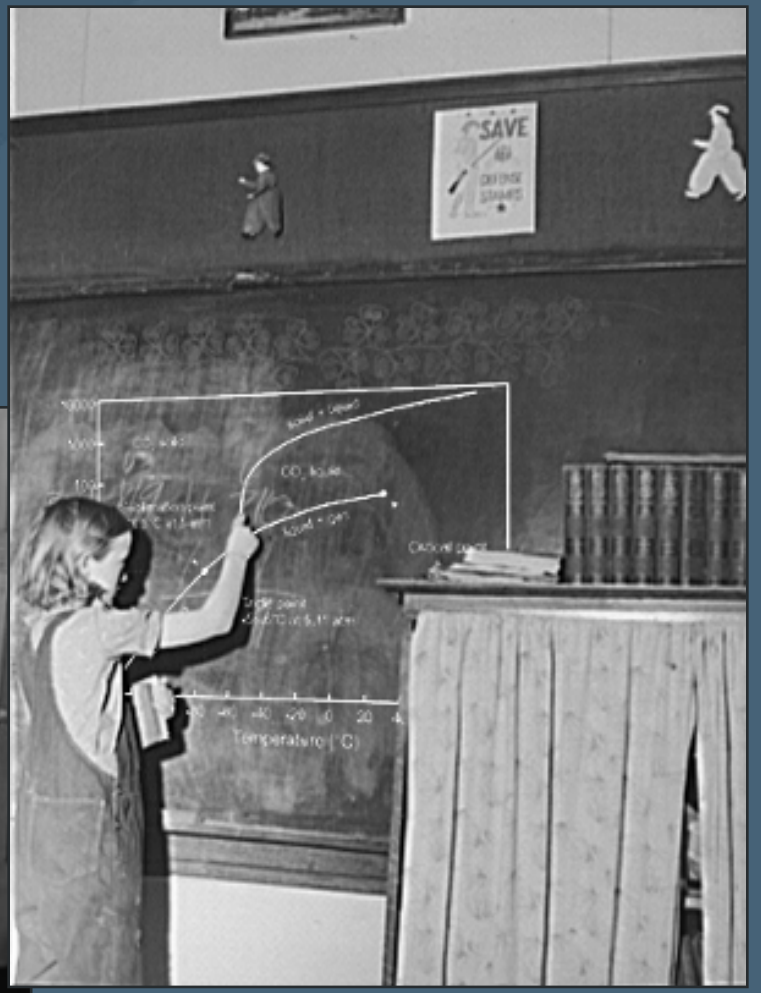
25 Nearly Pure Natural Underground CO_2 Deposits



CCS Bill of "Rights"

- Right form of CO_2
- Right conditions underground
- Right rocks
- Right operation
- Right safeguards
- Right development path

Now, we're gonna get technical!



Supercritical Fluid!

Highly Compressed Matter

For CO_2, that point is 88°F and 73 columns of atmosphere on your head at sea level (1074 psi).

Supercritical-Phase CO_2

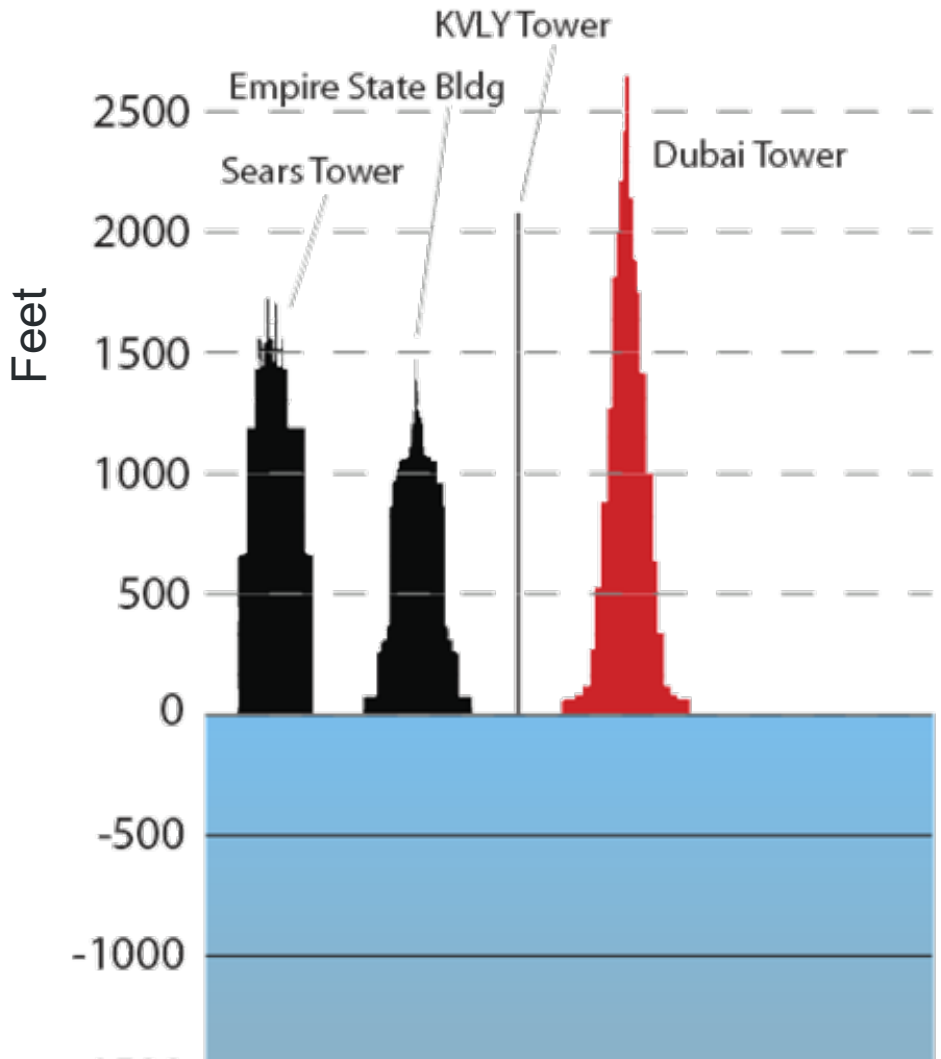
400 m^3 compressed to 1 m^3

Maximum Storage Capacity!

The Deeper Underground

- The higher the temperature.
- The higher the pressure.
- **At 2500 feet below the surface, CO_2 is naturally in the supercritical phase.**

Storage Depth



Zone of Fresh Water

Zone of Prime Targets in the Williston Basin of North Dakota

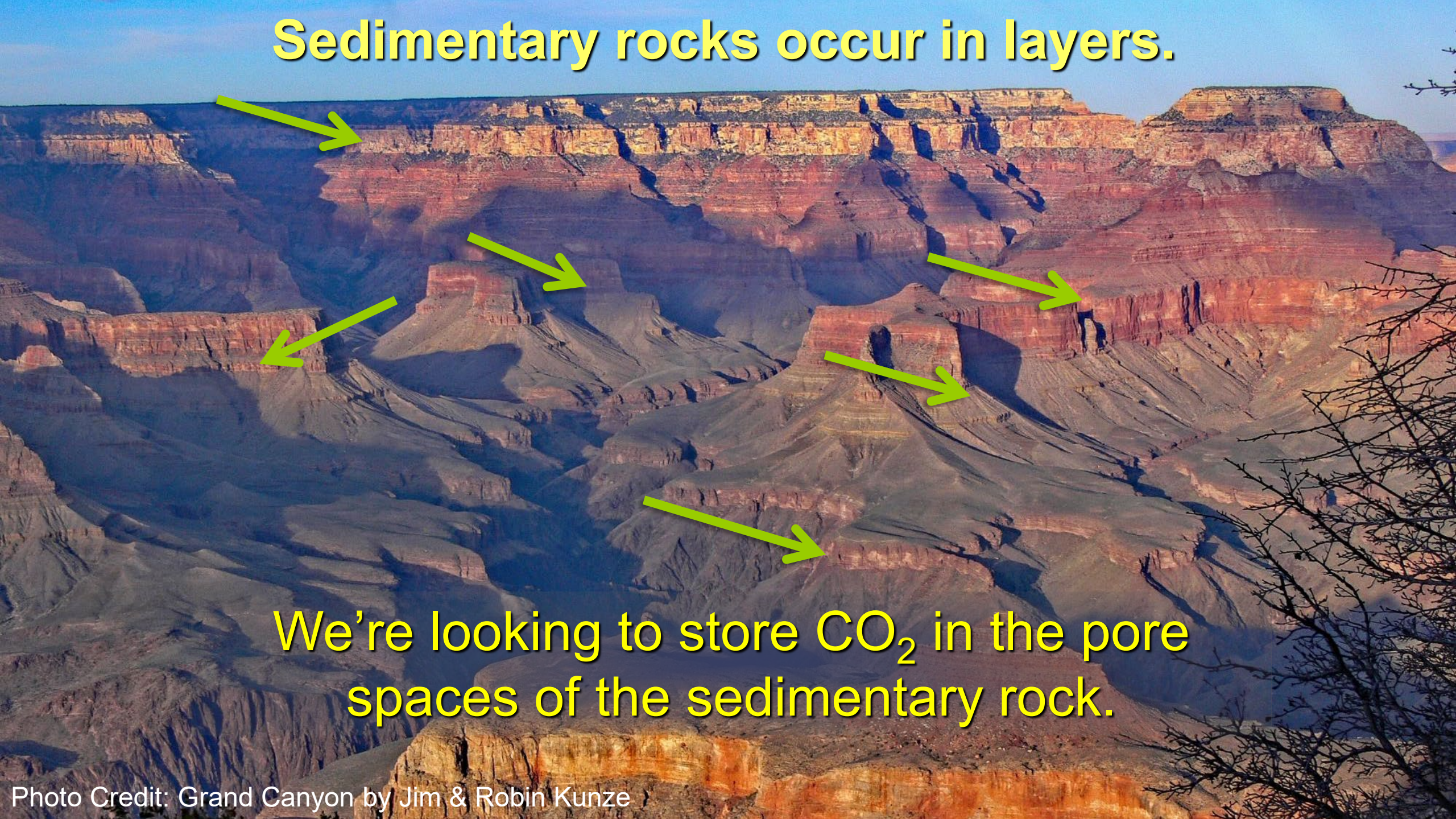
Photo Credit: Grand Canyon by Jim & Robin Kunze

Pores + Connections = Permeability

A good storage zone has connected pores!

What Works for Oil Works for CO_2

Sedimentary rocks occur in layers.

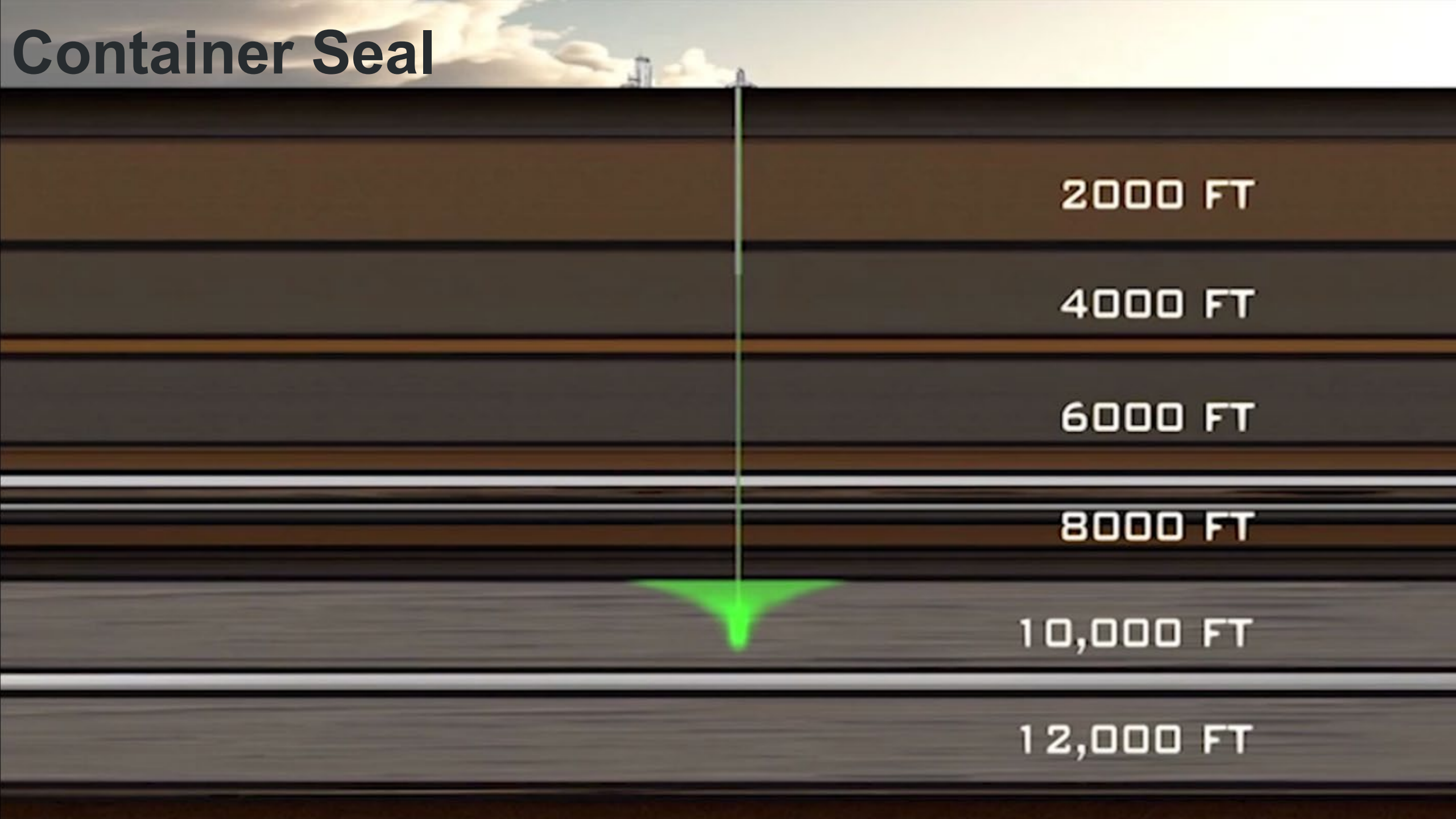


We're looking to store CO_2 in the pore spaces of the sedimentary rock.

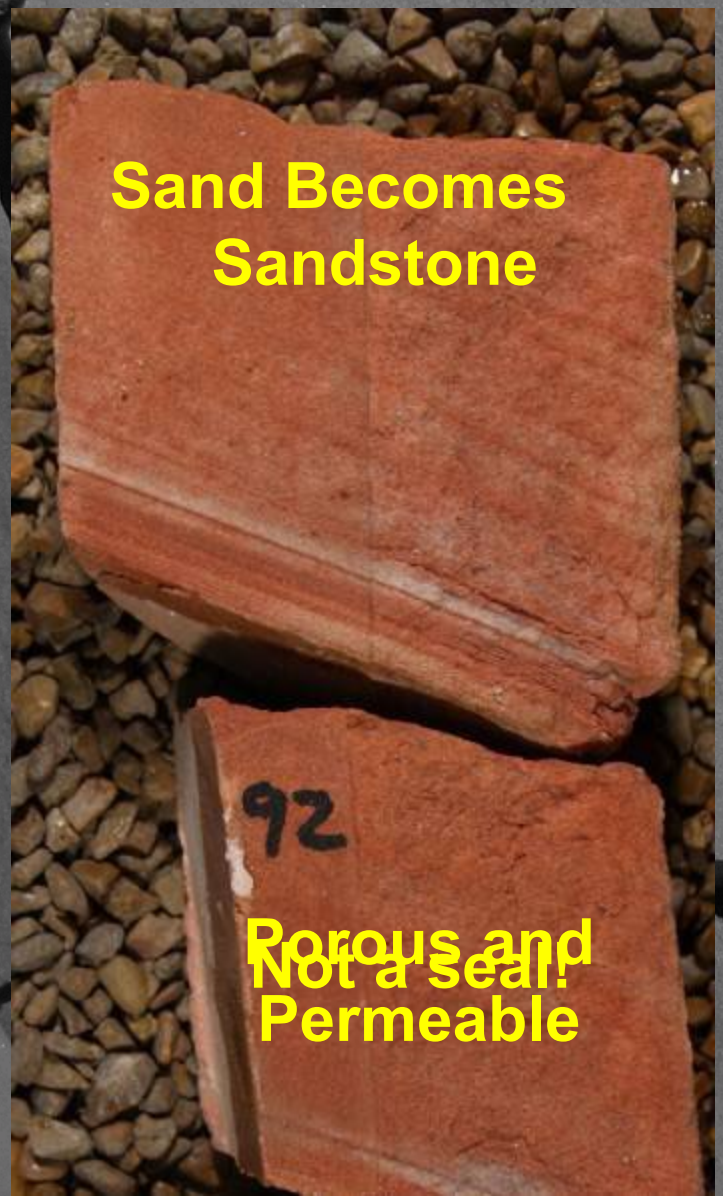
Photo Credit: Grand Canyon by Jim & Robin Kunze

Sedimentary Rocks as Storage Zones

Container Seal



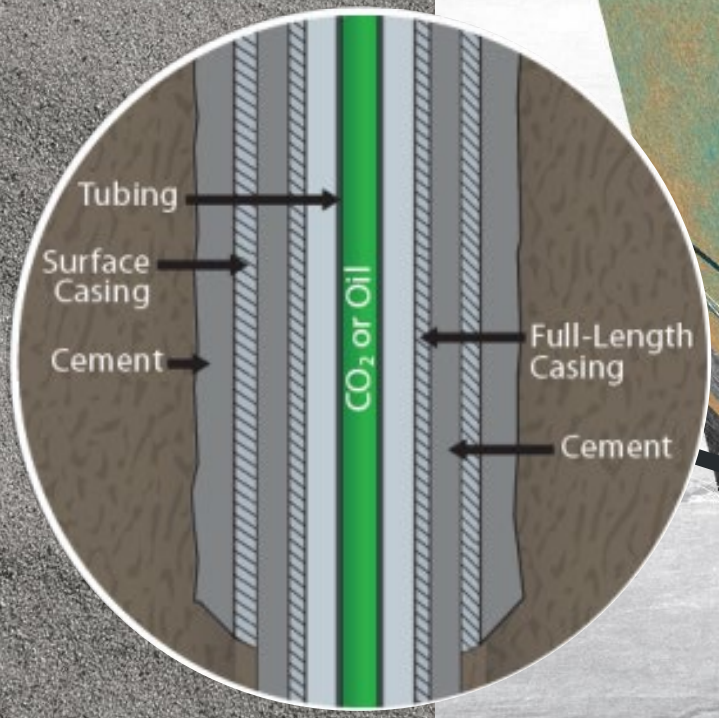
Sedimentary Rocks as Seals

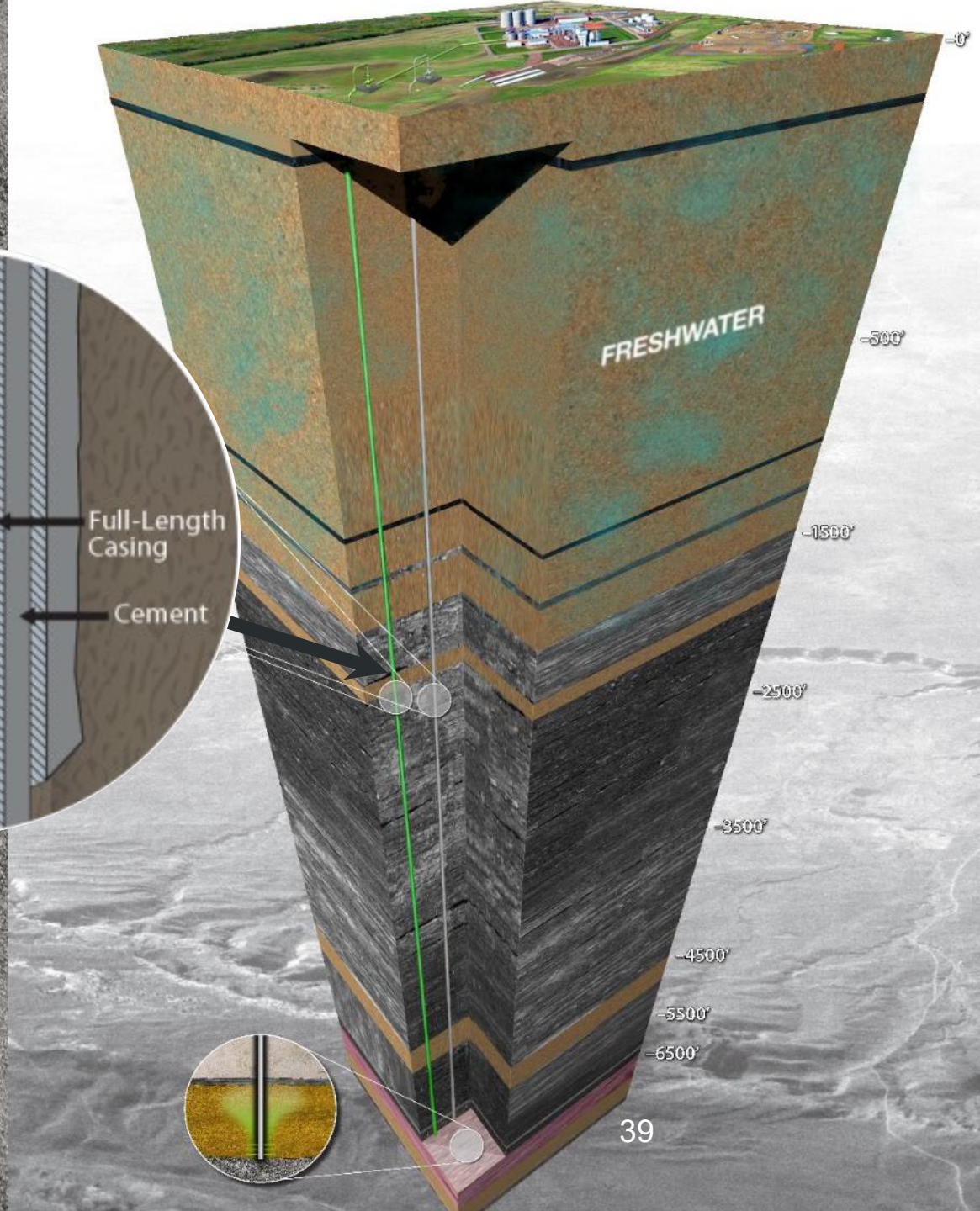


Drinking Water Protection

Regulations require:

- **Three layers of steel.**
- **Two layers of durable cement.**



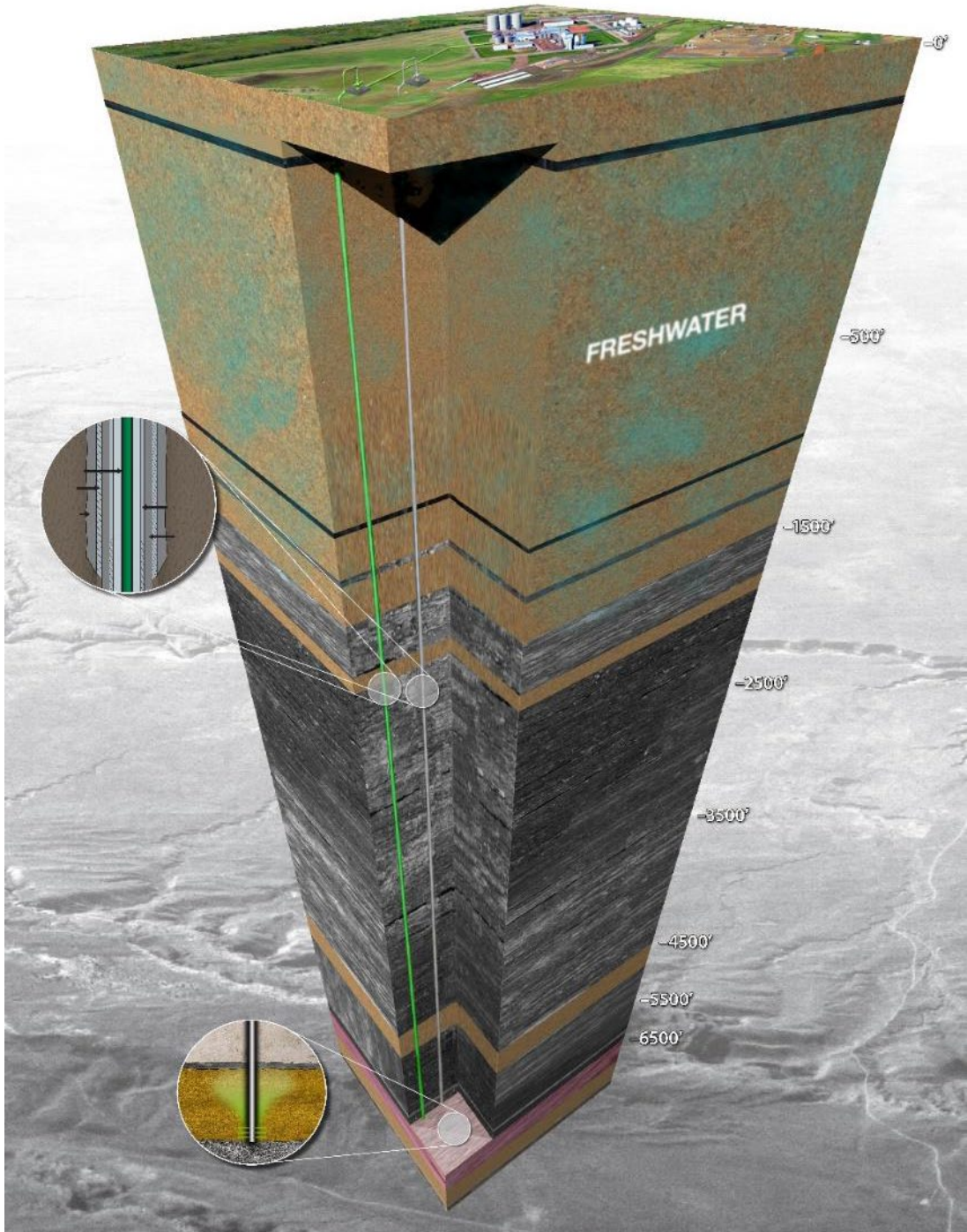


Injection!

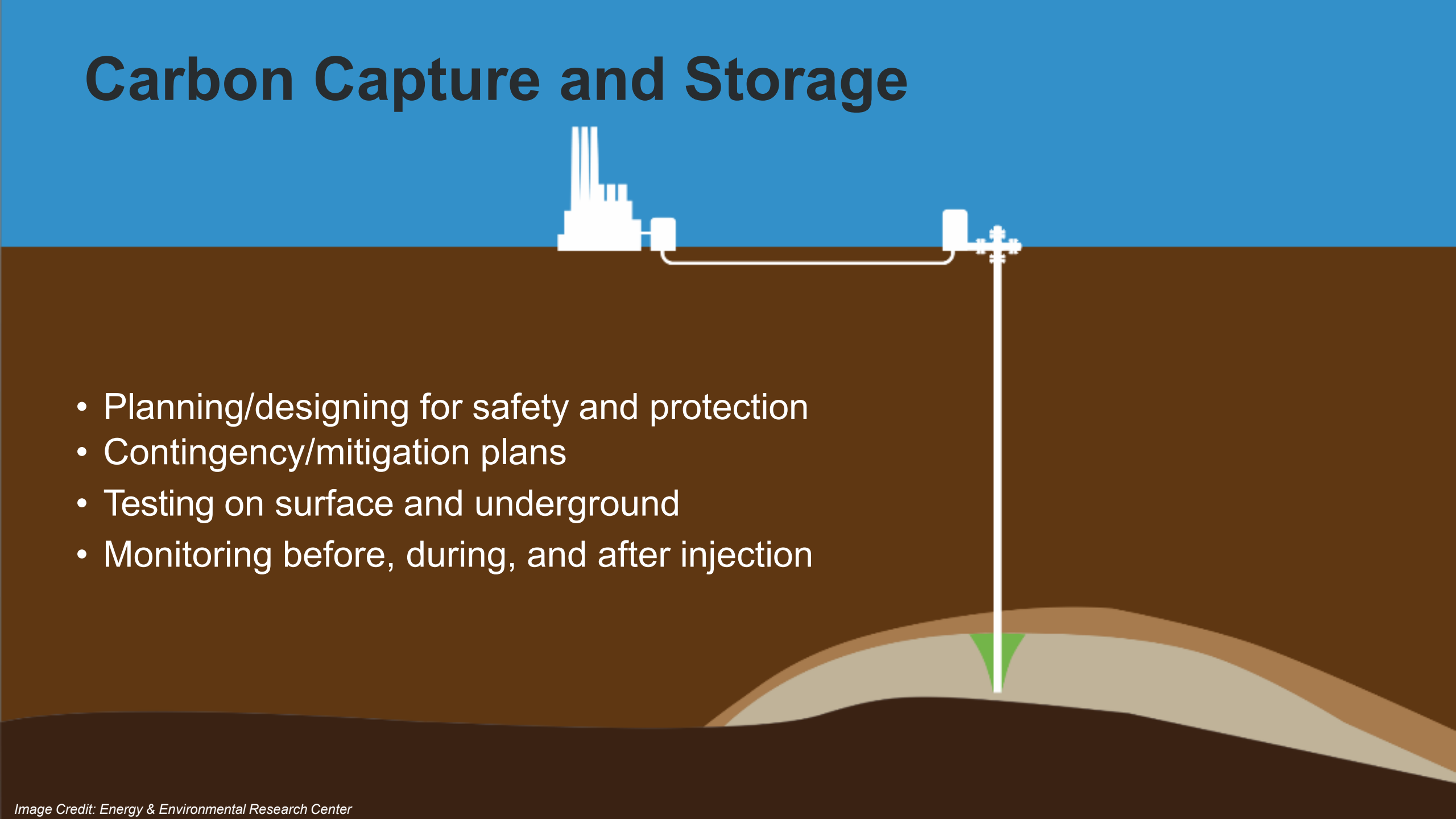
Safe Injection

- Injection pressure – enough pressure to get the CO_2 in place without disrupting the injection zone

- Periodic monitoring
  - Pressure and temperature in and above the injection zone
  - Soil and surface water



Carbon Capture and Storage

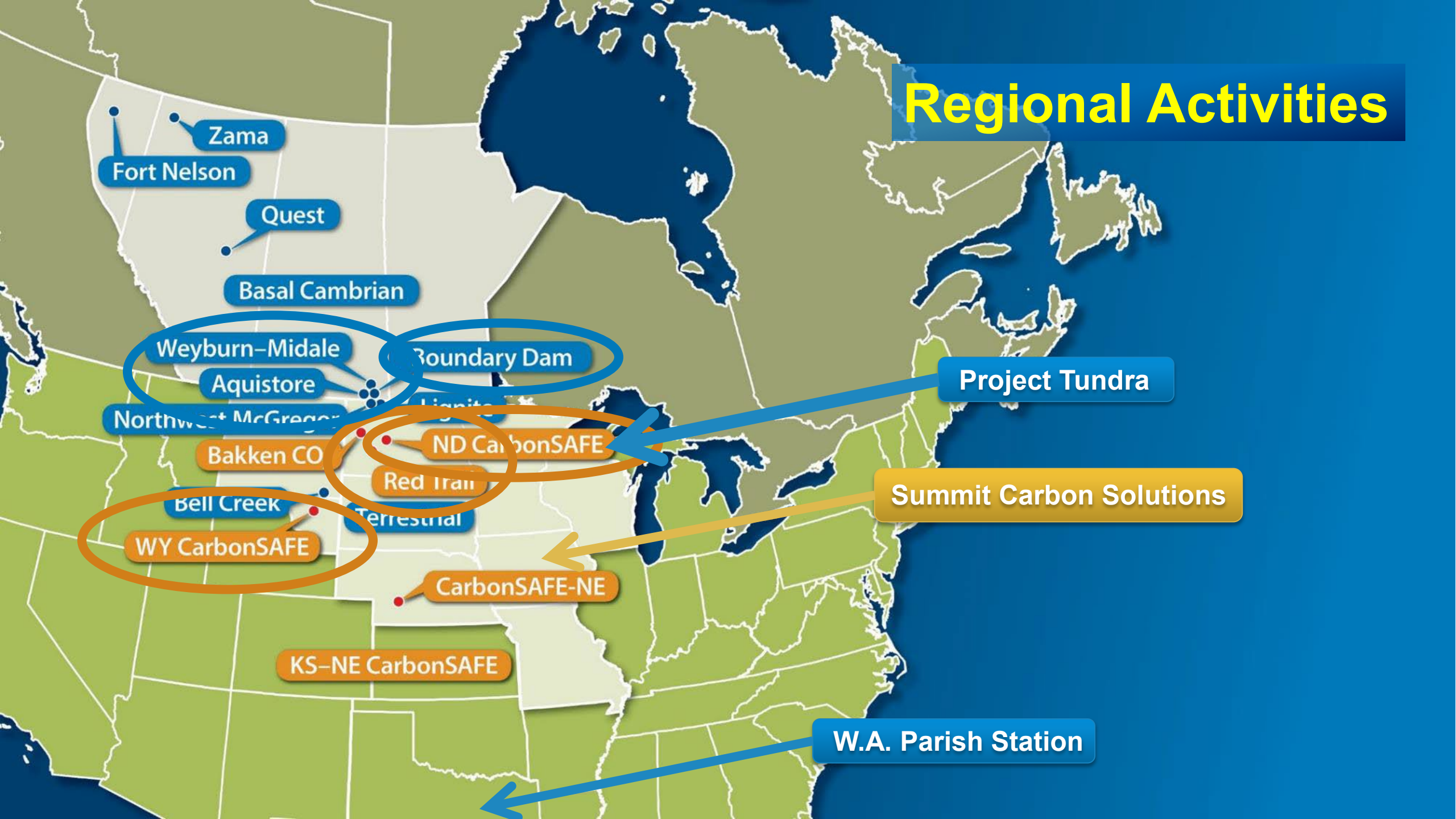


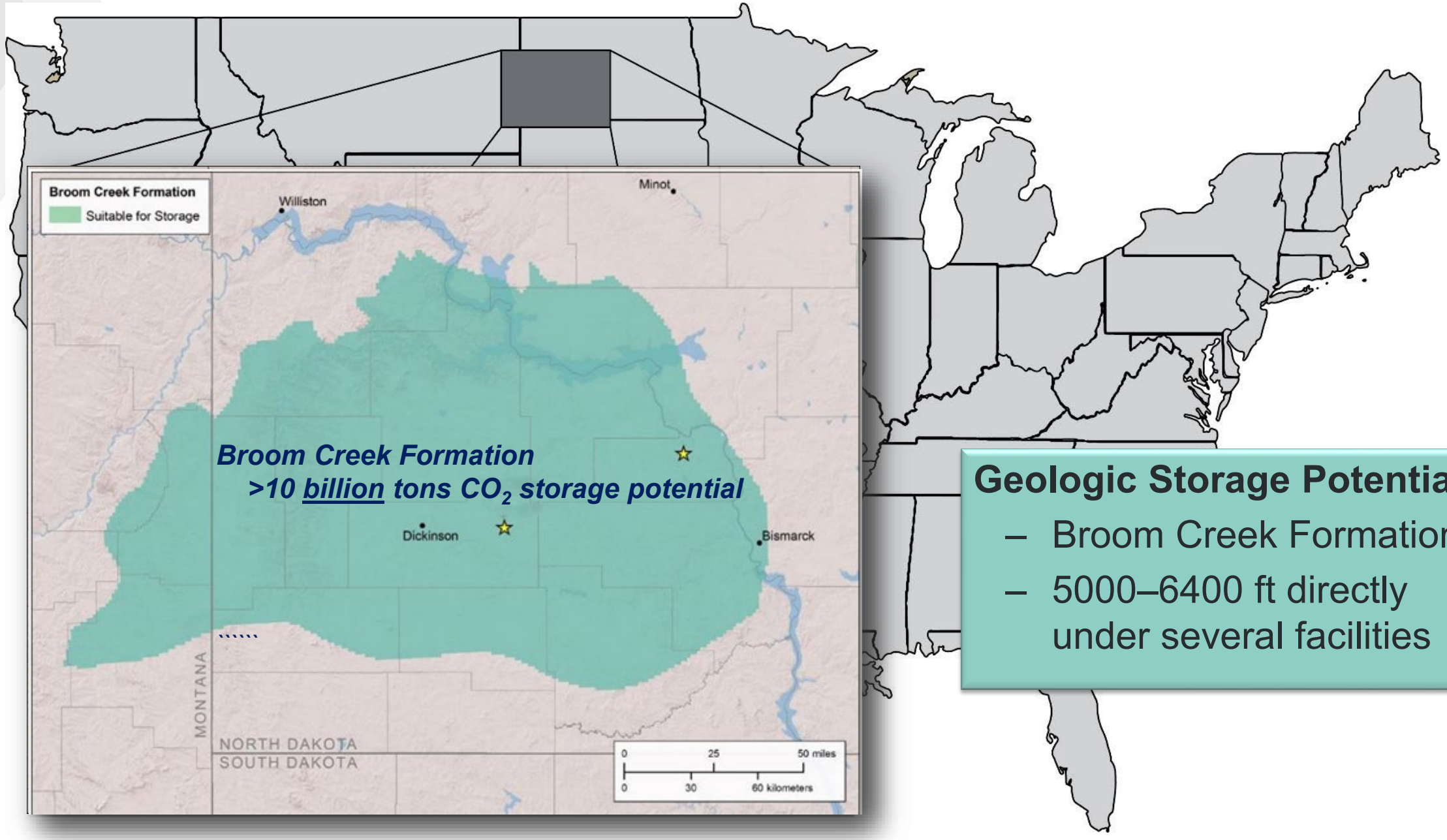
- Planning/designing for safety and protection
- Contingency/mitigation plans
- Testing on surface and underground
- Monitoring before, during, and after injection

Image Credit: Energy & Environmental Research Center

Where?

Regional Activities





Geologic Storage Potential

- Broom Creek Formation
- 5000–6400 ft directly under several facilities

Storage Layer Core

Red Trail Energy, LLC
Richardton, North Dakota

928 Investors

46 Employees

Over $149 million in Gross Sales

233,000 tons of Coproducts

Coproducts Support 220,000 head of Cattle

23 million bushels of Corn

Approximately $350 million of Economic Impact

64 million gallons of Ethanol

RTE

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Red Trail Energy, LLC
Richardton, North Dakota

Low-Carbon Fuels

- A transportation fuel having a lower “carbon intensity” than conventional petroleum fuels
- Ethanol, natural gas

Photograph by Lars Plougmann

Carbon Intensity by Fuel Type

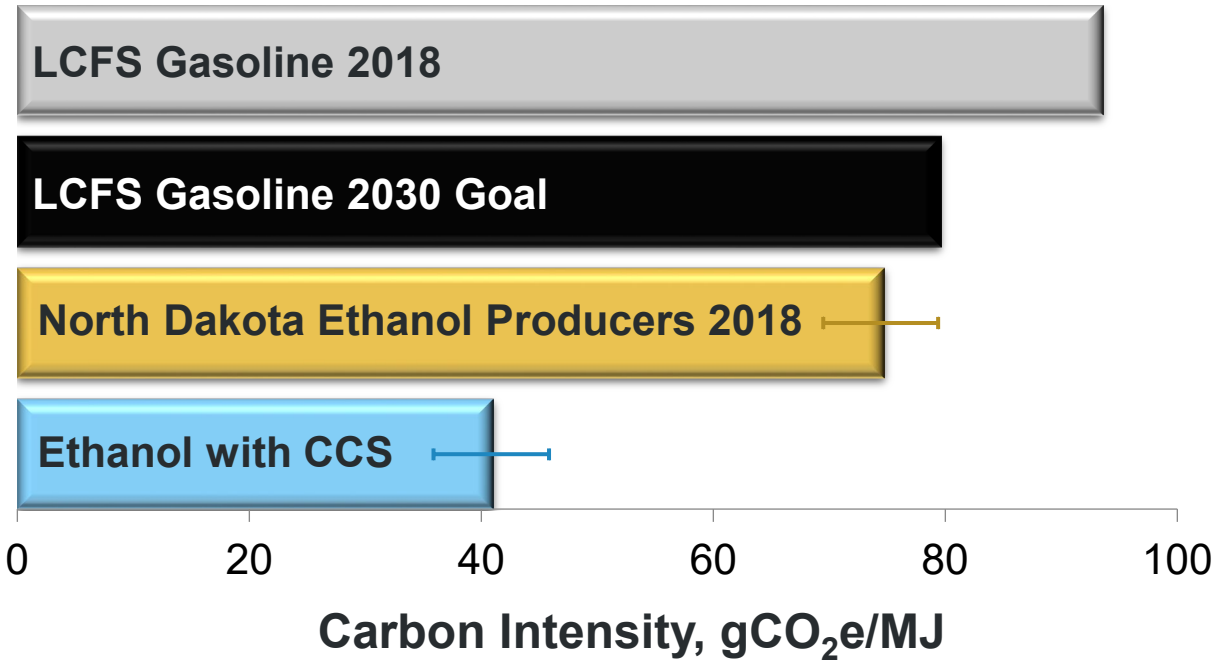
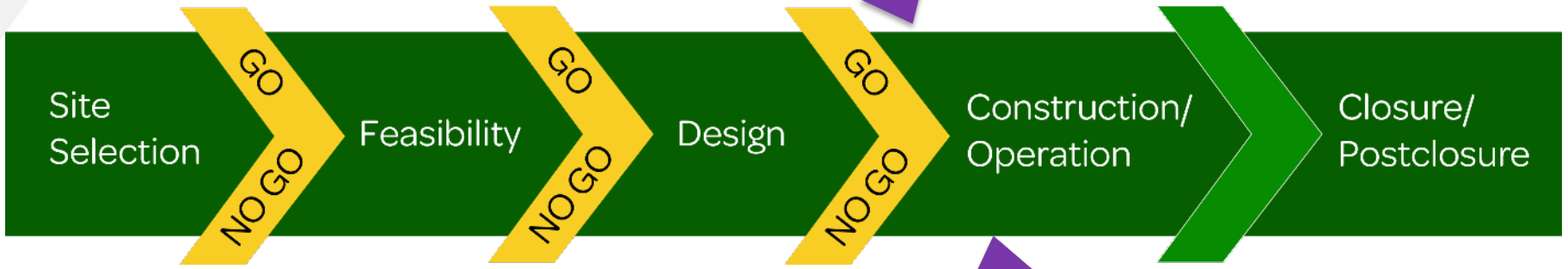


Image Credit: Energy & Environmental Research Center
Data Source: California Air Resources Board (August 2018)

RTE CCS:
Partners and Progress

The first North Dakota CCS Permit Application Submitted February 9, 2021

November 2016 – June 2022



Operations Plan to Start June 2022

EERC RTE renewable ENERGY PROGRAM NORTH DAKOTA INDUSTRIAL COMMISSION

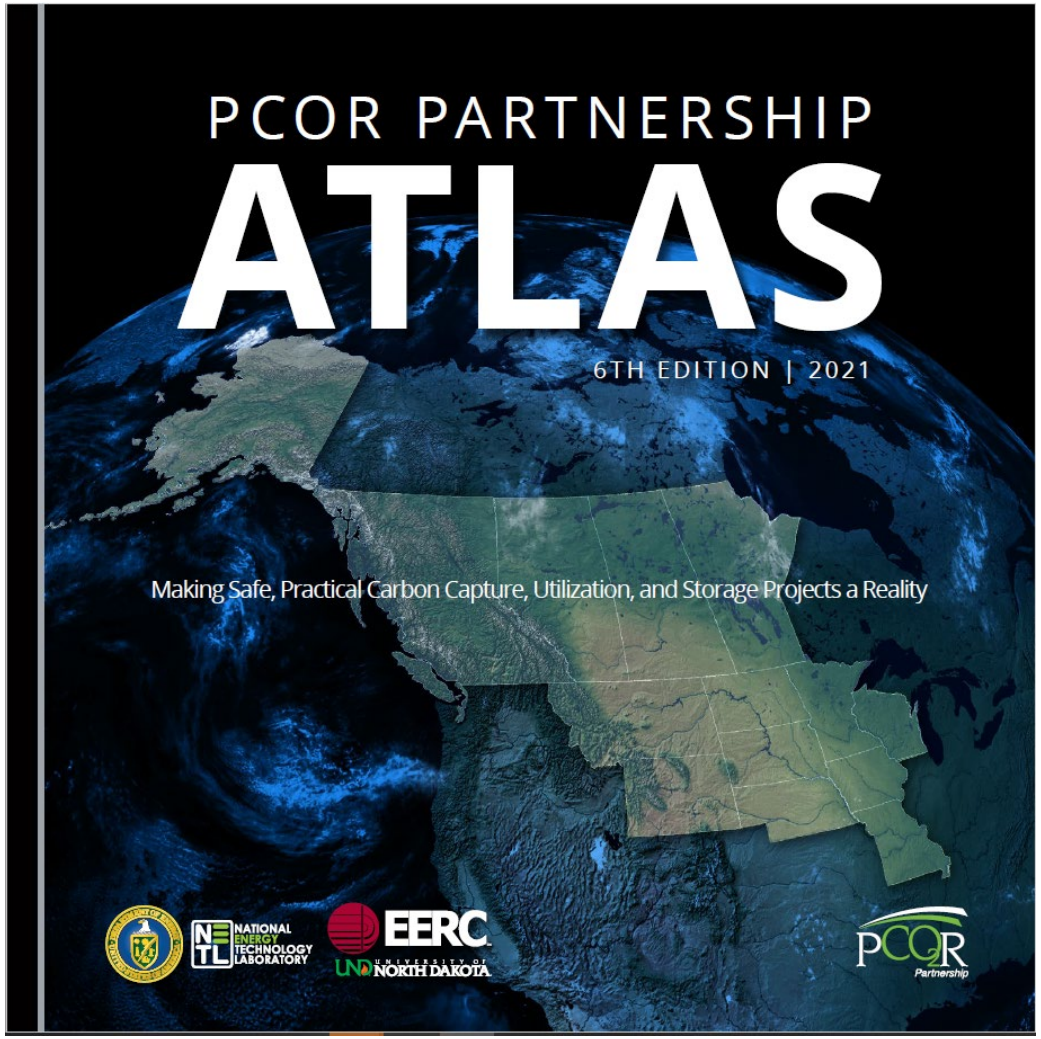
U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

TRIMERIC CORPORATION

Schlumberger CMG COMPUTER MODELLING GROUP LTD.

Image Credit: Energy & Environmental Research Center

EERC Teacher Packet



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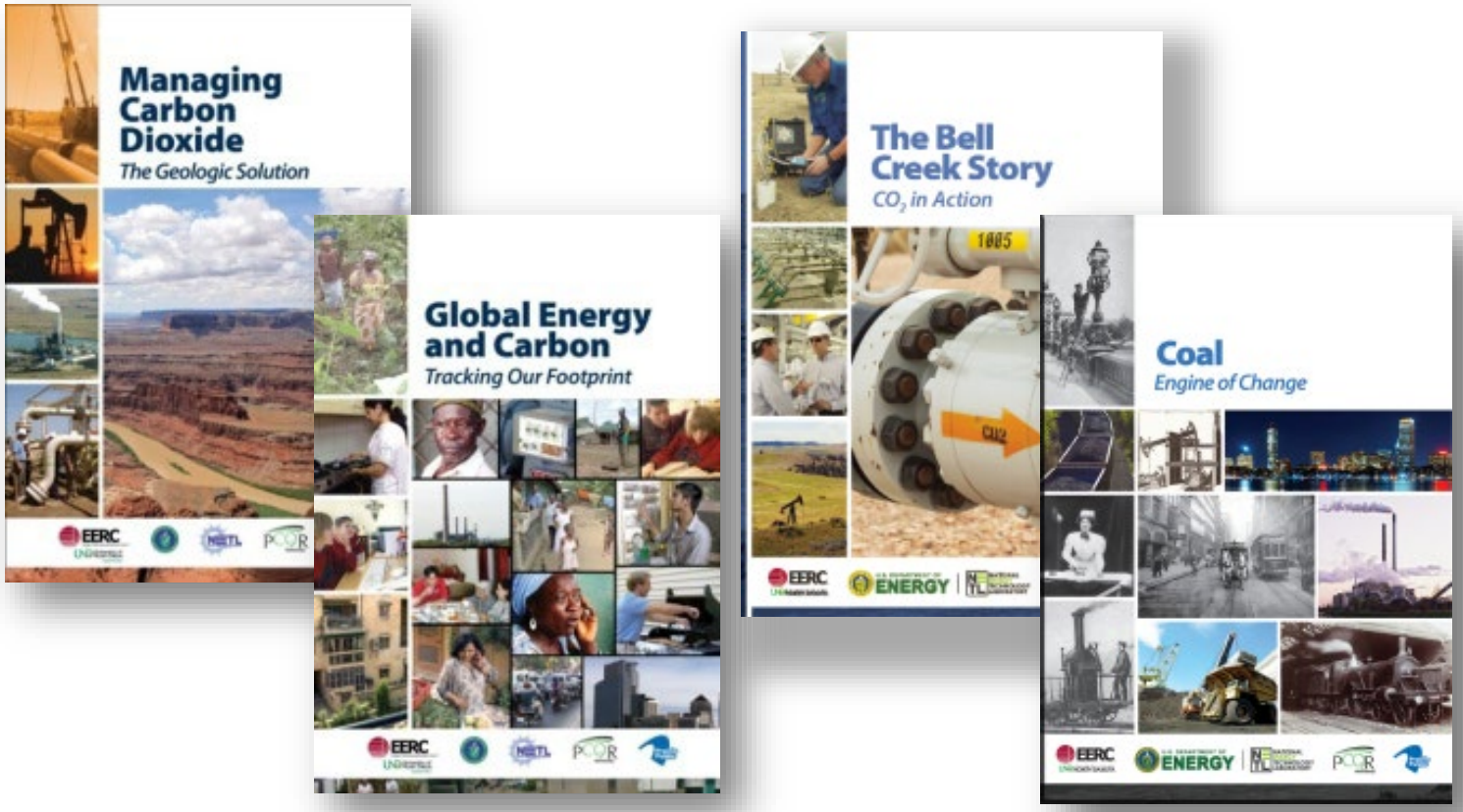
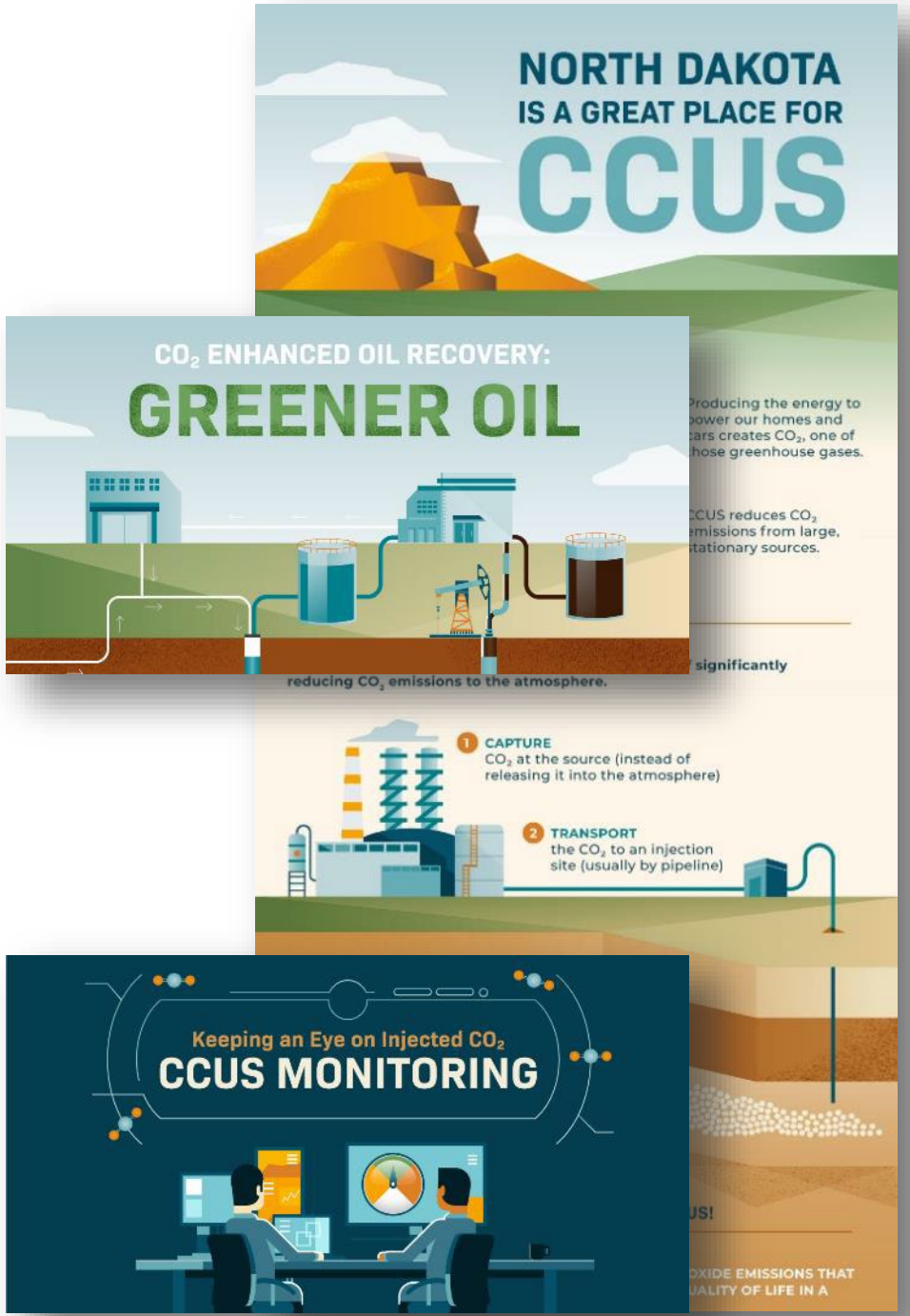
EERC Online Resources





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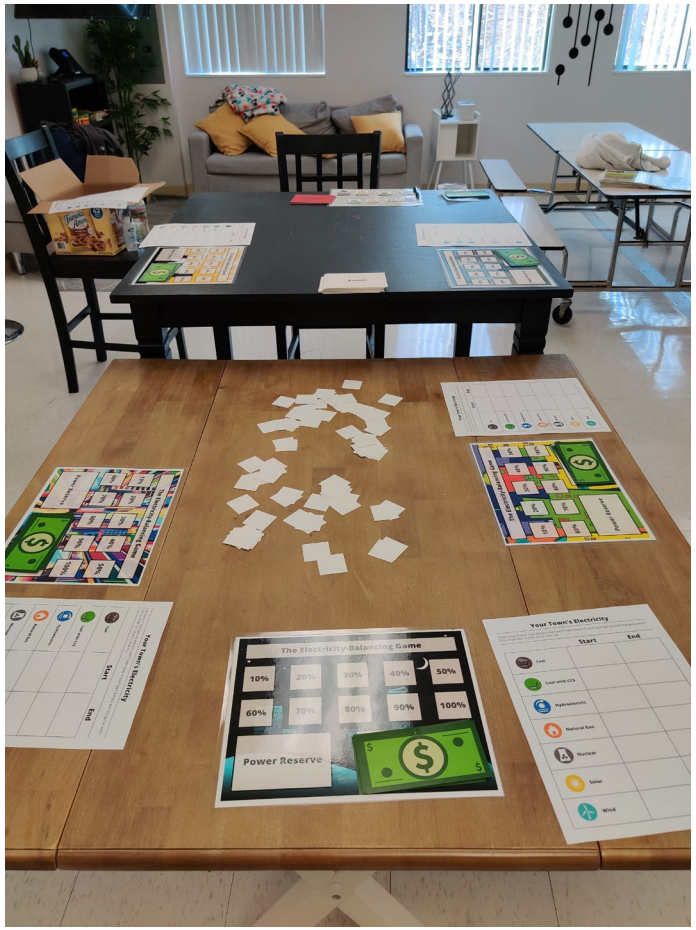
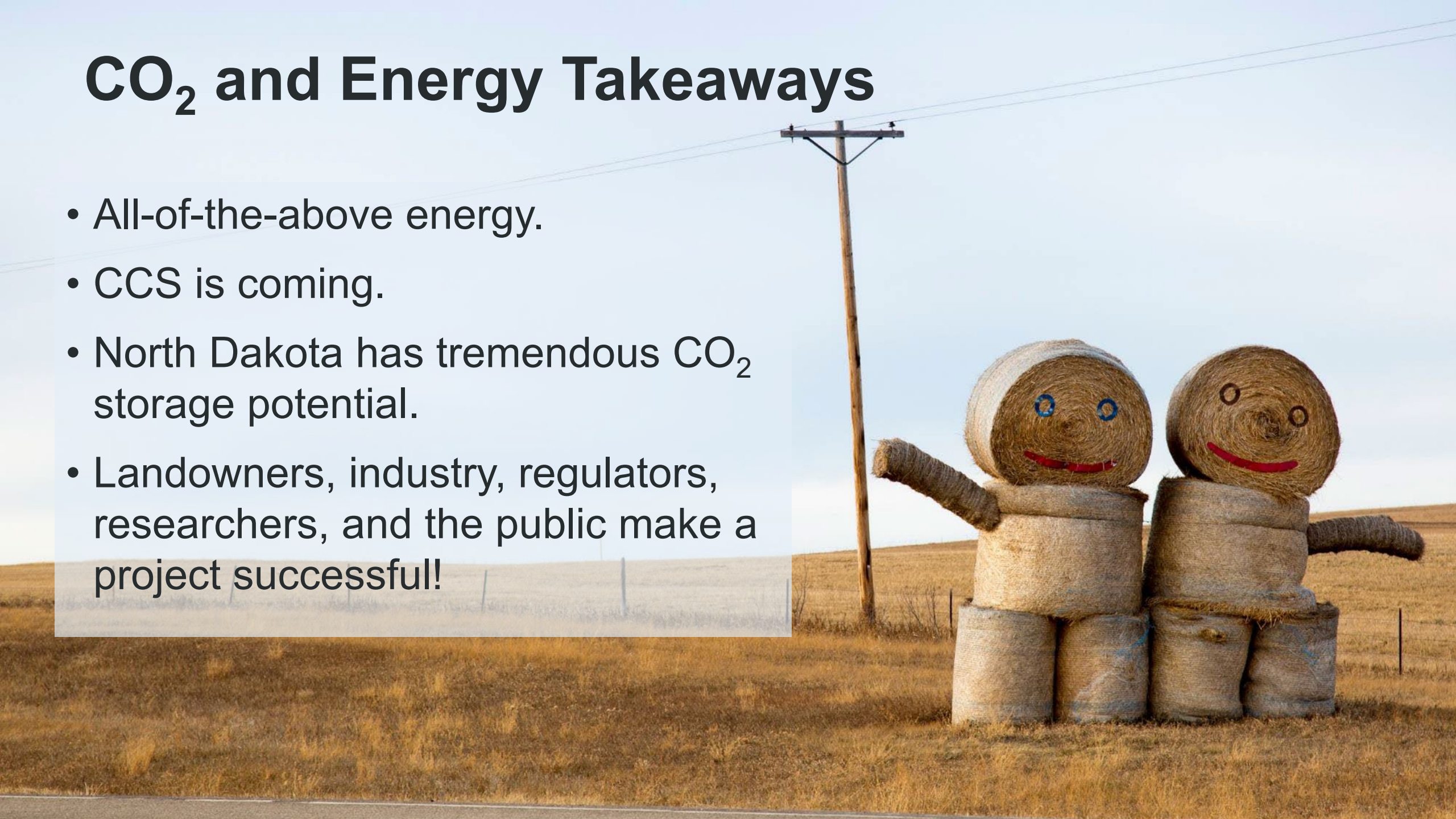
Coming Soon!

Power Balance



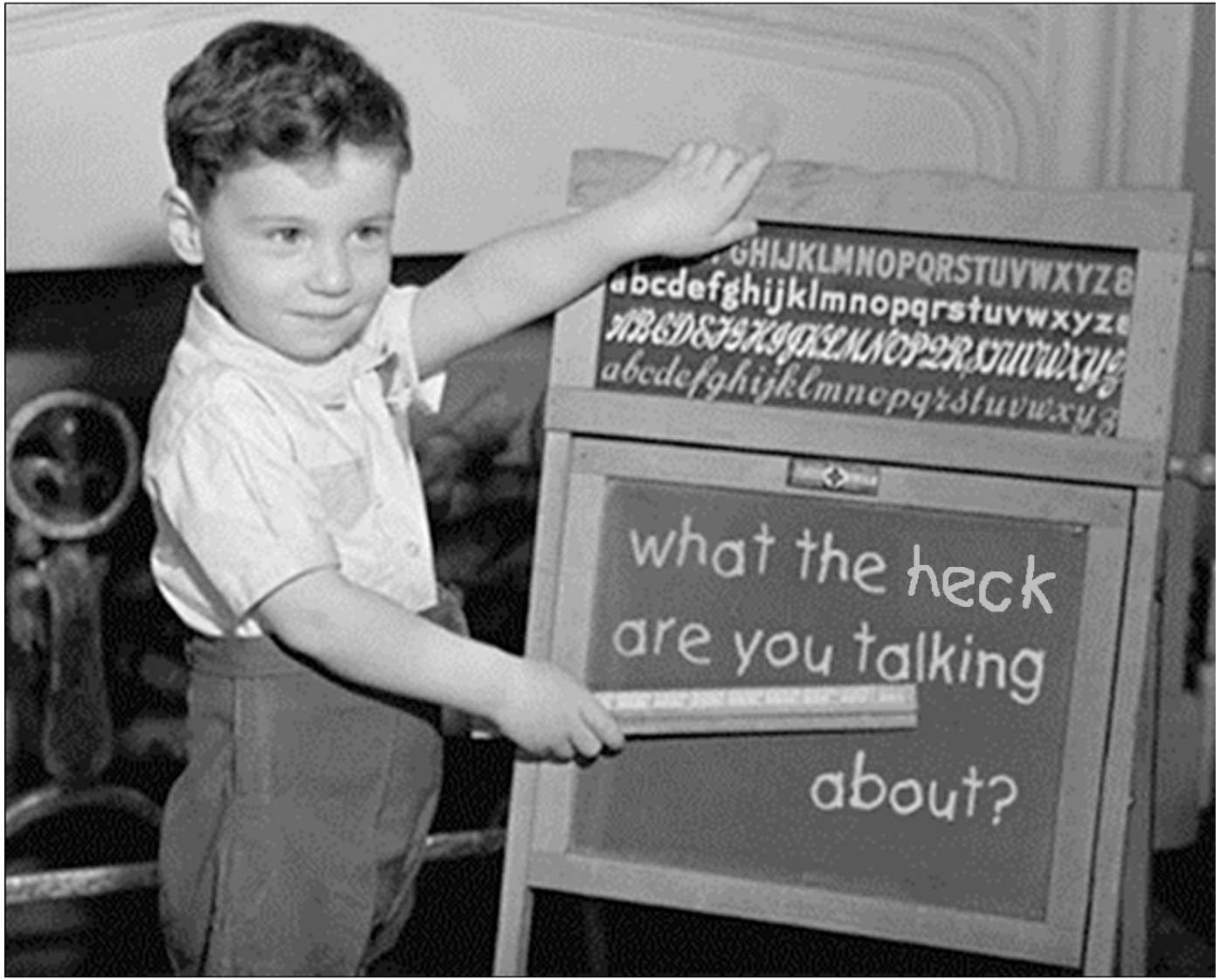
CO_2 and Energy Takeaways

- All-of-the-above energy.
- CCS is coming.
- North Dakota has tremendous CO_2 storage potential.
- Landowners, industry, regulators, researchers, and the public make a project successful!



Question – same as earlier but less one option

Any questions?



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THANK YOU

Critical Challenges. Practical Solutions.