UNIVERSITY of DENVER

DEPARTMENT OF MECHANICAL & MATERIALS ENGINEERING

NAE GRAND CHALLENGES FOR ENGINEERING
NATIONAL ACADEMY OF ENGINEERING

NAE Grand Challenge:
Develop Carbon Sequestration Methods

Fall Quarter 2018

Dr. Jason Roney

jason.roney@du.edu

14 Grand Challenges for Engineering in the 21st Century

Carbon Sequestration Challenges:

Definition: Carbon sequestration is capturing the carbon dioxide produced by burning fossil fuels and storing it safely away from the atmosphere—CO_2 is responsible for Greenhouse Warming

1. how best to capture gaseous CO_2 from the atmosphere based on Chemistry and Physics
2. How best to capture CO_2 at the source (stack emissions)
3. what are the best methods for long-term storage
4. How does one scale these methods to deal with potentially capturing and storing 1 trillion tons of CO_2

All of these have engineering components; some are purely technical and others are systems challenges.

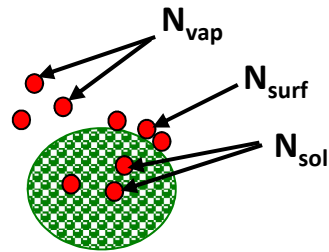# My Related Projects/Research Areas

Atmospheric Capture of CO_2;

The current atmosphere has an estimated 400 ppm (0.04%) of CO_2. These levels must be reduced by selectively reducing CO_2. By engineering adsorption techniques it may be possible to "strip" the atmosphere of CO_2. The technique could involved injecting "cleaning" particles into the atmosphere or cycling the atmosphere through capture devices with cleaning particles.
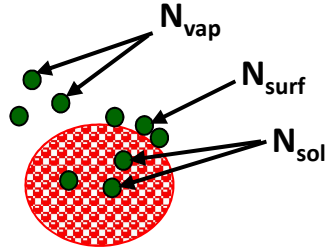
Atmospheric Capture of CO_2:

Developing Models and Techniques for Capturing Atmospheric CO_2

Models: Adsorption/Absorption (Gas molecules to Particles/Droplets)

N_{vap} = # gas molecules in vapor phase
N_{surf} = # gas molecules at surface of particle
N_{sol} = # gas molecules in solution

Gas CO_2/Particle Cleaner

Particle Cleaner/Gas CO_2

Model Techniques: Atmospheric-Sized CO_2 Scrubber
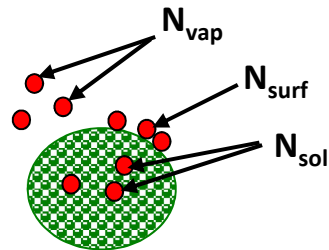
My Related Projects/Research Areas

CO2 Local Capture?

The best way to capture future CO_2 is to not let the gases into the atmosphere at all. Rather, a series of devices could be used to capture CO_2 at power plants, in tail-pipe emissions, factories, etc. This captured CO_2 could be more readily be used in products where it would be stored out of the atmosphere.
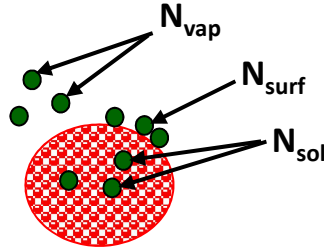
Capturing CO_2 at the Source

Developing Models and Techniques for Capturing Source CO_2

Models: Adsorption/Absorption (Gas molecules to Particles/Droplets)

N_{vap}

N_{surf}

N_{sol}

Gas CO_2/Particle Cleaner
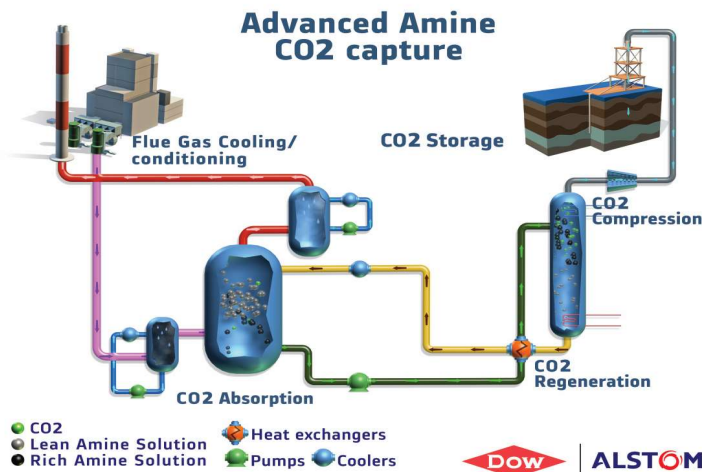
N_{vap}

N_{surf}

N_{sol}

Particle Cleaner/Gas CO_2

N_{vap} = # gas molecules in vapor phase
N_{surf} = # gas molecules at surface of particle
N_{sol} = # gas molecules in solution

Same ideas, but may have cleaning surfaces/or particles since emissions would be concentrated

Model Techniques: Source CO_2 Capture

Advanced Amine CO2 capture

Flue Gas Cooling/ conditioning

CO2 Storage

CO2 Compression

CO2 Regeneration

CO2 Absorption

- CO2
- Lean Amine Solution
- Rich Amine Solution
- Heat exchangers
- Pumps
- Coolers

Dow | ALSTOM

First designs are beginning to enter the market, but technology is likely to rapidly change with more research and capture becoming more efficient as methods improve. Do the models agree with implementation, why or why not?

My Related Projects/Research Areas

CO_2 Storage

To keep CO_2 that is captured from coming back into the Earth's atmosphere, there needs to be long-term storage techniques. Some of the methods proposed include pumping into shale and other sedimentary rock that is far below the surface. Also thoughts have been given to pumping into the greatest depths of the ocean. The challenge is knowing how often or likely the CO_2 may desorp (coming out of the rocks or the ocean).
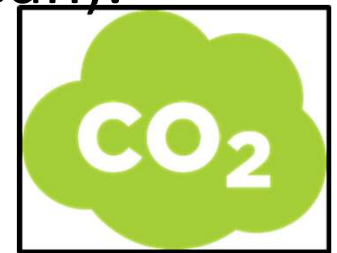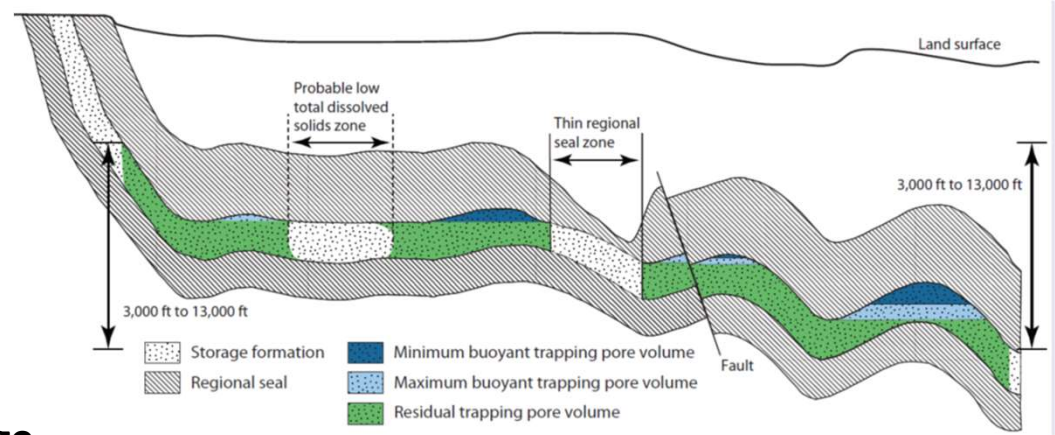
Long term Storage of CO_2: Modeling

Apply Eventually to More Realistic Formations
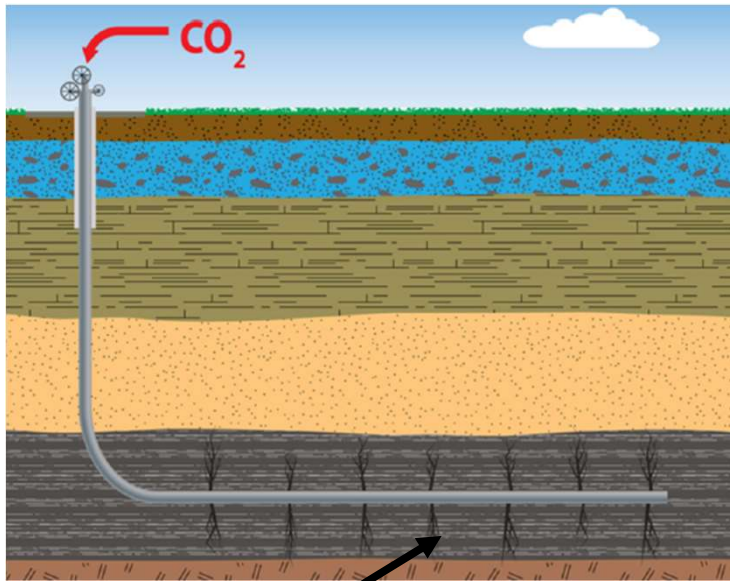
Model the Adsorption/Desorption Bed (Shale) with "Simple" Model

Quantify how effective long term storage might be in different types of sedimentary rock formations in the Earth's surface.