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# CO<sub>2</sub>-CAPTURE TECHNOLOGIES: AN OVERVIEW

*With a Closer Look at Direct Air Capture  
by **Carbon Engineering***

**North Jersey Section AIChE**

# YOUR PRESENTERS:

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B.S., Chemical Engineering - NJIT

MBA, Technology Management - University of Phoenix

Member, Industrial Advisory Board, NJIT Otto York Dept. of Chemical

# YOUR PRESENTERS:

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Robert A. Rossi

Process Engineering Consultant to Carbon Engineering  
Member, Industrial Advisory Board, NJIT Otto York Dept.  
of Chemical and Materials Engineering

B.S., Chemical Engineering - NJIT

Work experience includes:

- A/S Niro Atomizer

- Dorr-Oliver

- Combustion Power

- PSEG Power

- PG&E National Energy Group

- BOC Gases

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# ATTRIBUTION

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*Some information in this presentation was obtained (with permission) from:*

- **Geoff Holmes**, Business Development Manager, Carbon Engineering Ltd., Squamish, British Columbia, Canada
- ***“New CO<sub>2</sub>-Capture Approaches Push Against Cost Hurdles”***, Chemical Engineering magazine, August 2017

# CCS (Carbon Capture & Sequestration): Driving Forces

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# CCS (Carbon Capture & Sequestration): Driving Forces, cont'd:

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- **Currently, there is no financial incentive to permanently sequester carbon**
- **Consequently, carbon-capture projects have been carried out on a case-by-case basis**
- **HOWEVER: There is investment activity in ways to re-use the CO<sub>2</sub> after it is captured**
- **Sequestration is probable, but CO<sub>2</sub> recycling and re-use will be the real driver**



# CCS (Carbon Capture & Sequestration): The “2<sup>nd</sup> Generation”

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- Major investments in 2<sup>nd</sup> Generation uses for CO<sub>2</sub>, (*beyond enhanced oil recovery and carbonation...*)

**Conversion of CO<sub>2</sub> into bio-fuels**

**Incorporation of CO<sub>2</sub> into plastics and even concrete...**

- » *UCLA researchers are working on creating a closed-loop process to capture carbon from power plant smokestacks and use it to create a new building material - CO<sub>2</sub>NCRETE - that would be fabricated using 3D printers.*



# CCS (Carbon Capture & Sequestration): The Cost Problem

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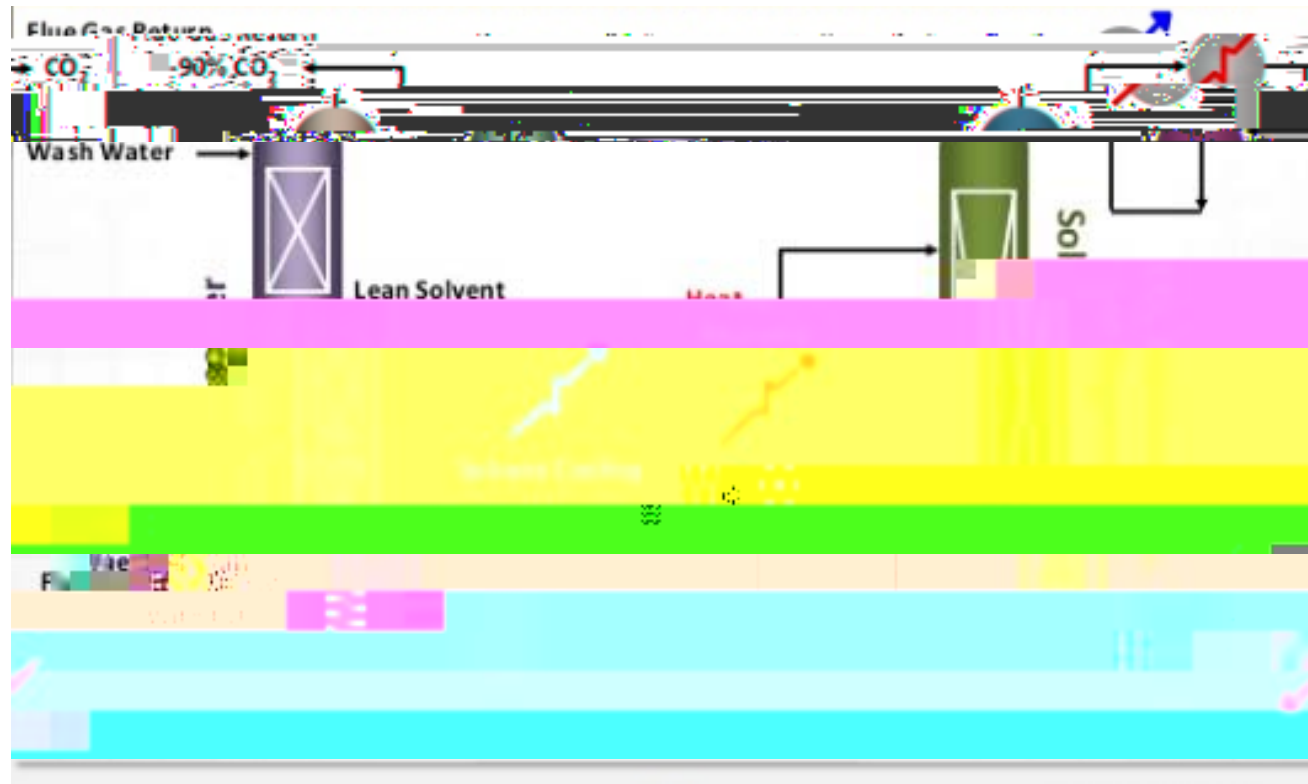


- **Currently, fossil-fuel-powered electric generation plants are outfitted with carbon-capture systems that use a lot of steam:  
15% to 25% of generated steam is typically used for regenerating CO<sub>2</sub> from the amine capture solvent  
This means electricity production is reduced  
This puts the lowering of energy usage and fighting parasitic power losses front-and-center of the challenges facing CCS**

# CCS (Carbon Capture & Sequestration): What's Already Out There?



- Amine-based carbon capture technology has been around for a while



# Improving Amine-based Carbon Capture Technology

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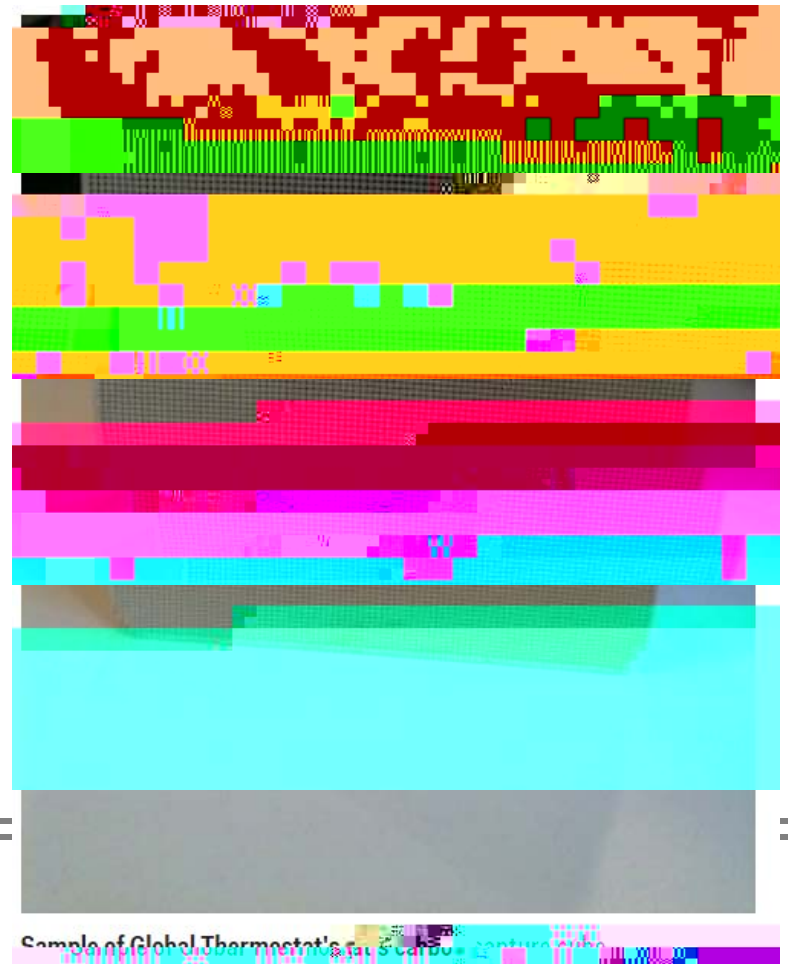
- **Aker Solutions ASA (Norway) is working on improving amine-based capture**  
Their design requires 35% less energy compared



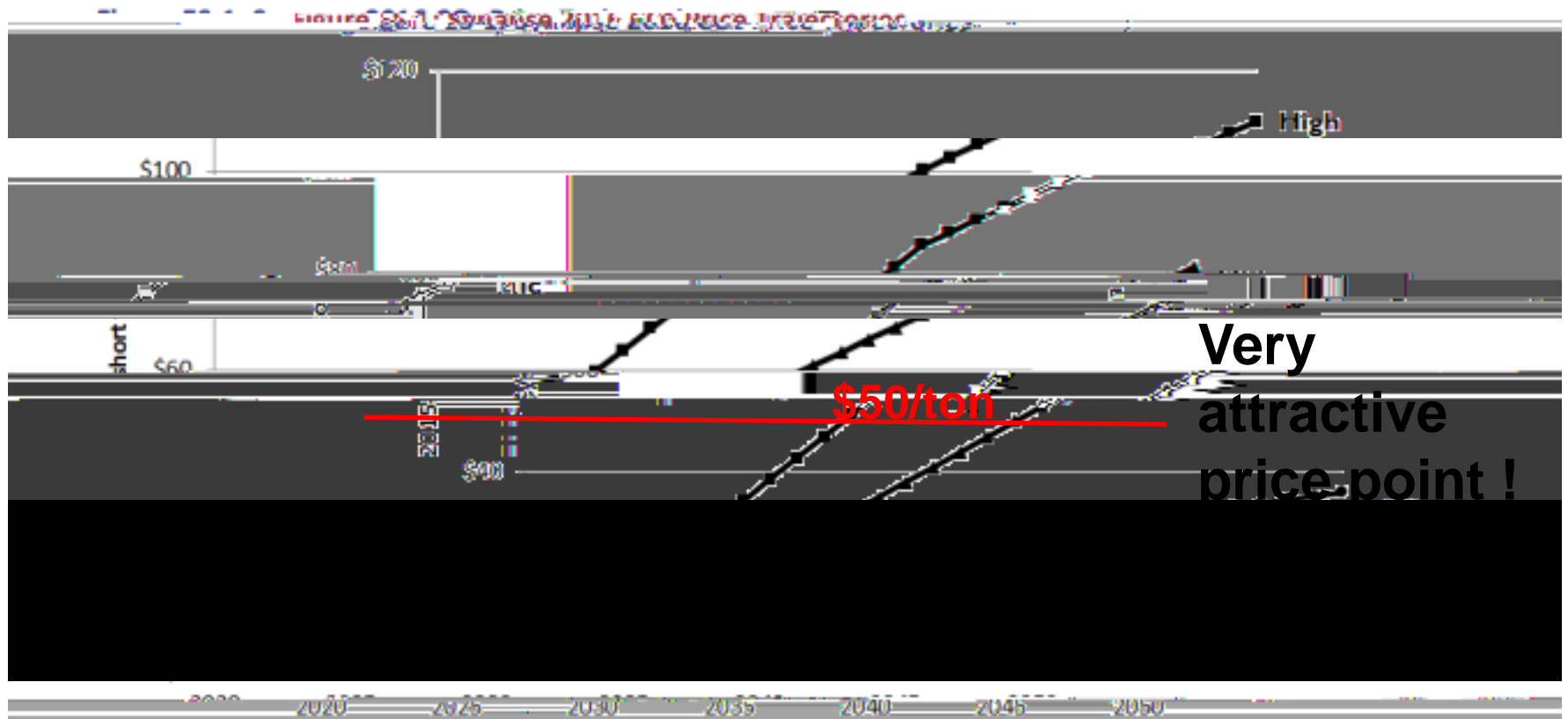
# Improving Amine-based Carbon Capture Technology



- **Global Thermostat, LLC (U.S.A.) is developing technology around solid amine absorbents:**
  - ★ **Solid, amine-based sorbent material-coated monoliths utilize capture and desorption process**
  - ★ **Capable of producing CO<sub>2</sub> at \$50/ton or less (*why is this figure so interesting?*)**



# Projected CO<sub>2</sub> Price Trajectories



Source: *Source: Energy Economics, Inc. 2010*



# What About Non-Amine-based Carbon Capture Technologies?

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# What About Non-Amine-based Carbon Capture Technologies?

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- **GEOENGINEERING** - the deliberate large-scale intervention in the Earth's natural systems to counteract climate change.

*There is wide range of proposed geoengineering techniques. Generally, these can be grouped into two categories:*





## Geoengineering, cont'd

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- 1. Solar Radiation Management (SRM) or *Solar Geoengineering*:** aim is to reflect a small proportion of the Sun's energy back into space. Some proposed techniques include:

***Albedo enhancement.*** Increasing the reflectiveness of clouds or the land surface so that more of the Sun's heat is reflected back into space.

***Space reflectors.*** Blocking a small proportion of sunlight before it reaches the Earth.

***Stratospheric aerosols.*** Introducing small, reflective particles into the upper atmosphere to reflect some sunlight before it reaches the surface of the Earth.





## Geoengineering, cont'd

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***Direct /Ambient Air Capture.*** Building large machines that can remove carbon dioxide directly from ambient air and store it elsewhere.

***Ocean Fertilization.*** Adding nutrients to the ocean in selected locations to increase primary production which draws down carbon dioxide from the atmosphere.

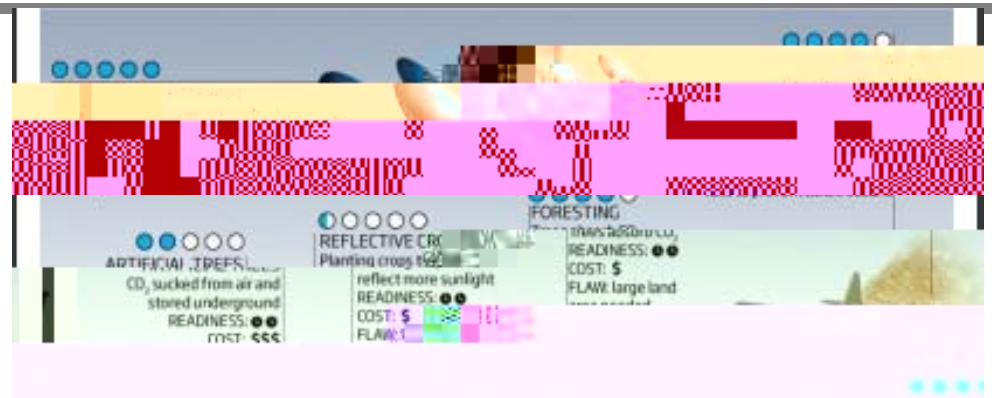
***Enhanced Weathering.*** Exposing large quantities of minerals that will react with carbon dioxide in the atmosphere and storing the resulting compound in the ocean or soil.

***Ocean Alkalinity Enhancement.*** Grinding up, dispersing, and dissolving rocks such as limestone, silicates, or calcium hydroxide in the ocean to increase its ability to store carbon and directly ameliorate ocean acidification.

## Geoengineering, cont'd



*These geoengineering technologies are in various stages of development, with*





## Introducing Direct Air Capture

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- **Direct Air Capture (DAC) is a technology that**



## Defining the baseline, cont'd:

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*Many scientists believe the planet is already experiencing noticeable climate change impacts at the current 406 ppm level and these impacts may have started years ago at the 325 ppm level.*

*The Paris Climate Accord goal of not exceeding 450 ppm CO<sub>2</sub> by 2100 correlates to a 2°C temperature rise. The scientific basis for this goal was based on the then most recent report of the UN's Intergovernmental Panel on Climate Change (IPCC).*

*The IPCC created 116 scenarios (algorithms) that tested a global temperature rise outcome of  $\leq 2^\circ\text{C}$ . 101 of those scenarios concluded that “negative CO<sub>2</sub> emissions” were required to meet the mandated global temperature rise outcome.*

*The IPCC initially determined that at a 450 ppm CO<sub>2</sub> concentration in 2100, the total atmospheric CO<sub>2</sub> content should not exceed 1,000 Gigatons. The current annual anthropogenic emission rate is 40 GTY.*



## Defining the baseline, cont'd:

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*At 40 GTY, it would only take 25 years (about 2040) to “break the budget” of 1000 GT total content so reaching the ultimate goal would result in a total collapse of the global fossil fuel based economy.*

*This is obviously not a tenable solution which is why the IPCC concluded “negative CO<sub>2</sub> emissions” are needed to attain the  $\leq 2^{\circ}\text{C}$  goal by 2100 without reverting mankind to the Stone Age.*

- *The only known negative CO<sub>2</sub> emissions technique is **Direct Air Capture** followed by sequestration.*







## Direct Air Capture Technology, cont'd

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- **Another DAC company is:**
- **Carbon Engineering** - a Squamish, British Columbia-based company commercializing technology to capture CO<sub>2</sub> directly from the atmosphere, as well as technology to use that CO<sub>2</sub> along with renewable electricity to make clean transportation fuels.

*At this point, I'd like to turn this presentation over to Mr. Robert Rossi, consultant to Carbon Engineering, who will go into more detail about their particular technology...*



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**THE END**

A 3D rendering of the words "THE END" in a bold, blue, sans-serif font. The letters are slightly tilted and have a slight shadow. They are set against a background of a road with white lane markings that recede into the distance, creating a sense of perspective. The road is dark gray, and the sky is a light gray.



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*“There is no expedient to which a man will not*