



VISION

Tools for Capturing CO₂ How Feasible, How Soon?

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The United States Department of Energy, and virtually every major U.S. utility and oil company, is involved in projects exploring capture and sequestration of CO₂. Technology for capturing CO₂ dates back to the 1920s and has been evolving ever since. Here is our brief assessment. Let us know if you agree, or disagree, or want more.

How do CO₂ emissions and CO₂ consumption compare?

Per Chemical and Engineering News, April 30, 2007, "The global chemical industry uses up approximately 115 million metric tons of carbon dioxide each year as a feedstock in a variety of synthetic processes, according to the Intergovernmental Panel on Climate Change (IPCC) report 'Carbon Dioxide Capture and Storage,' which was issued in 2005. That number pales in comparison to the estimated 23.7 billion metric tons of annual global CO₂ emissions caused by human activities, primarily the burning of fossil fuels."

What are coal-fired power plants doing?

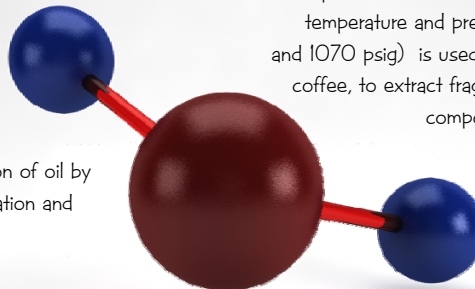
Integrated Gasification / Combined Cycle (IGCC)

Involves coal gasification and preliminary clean-up, followed by combustion of the gas in a Brayton Cycle turbine, recovery of the exhaust gas heat in a heat recovery steam generator, and use of the steam produced to make electricity in a steam turbine. Electricity is also produced in the Brayton cycle turbine. Cycle Efficiencies, converting from fuel to electricity, are superior to conventional coal fired steam power plants.

See CARBON DIOXIDE, page 2

What Are Some Uses for Carbon Dioxide?

To neutralize alkaline wastewater



Supercritical CO₂ (operating above CO₂'s critical temperature and pressure point of 32 degrees C and 1070 psig) is used as a solvent to decaffeinate coffee, to extract fragrances, and to extract active compounds for drug manufacturing

To enhance production of oil by pressurizing the formation and reducing viscosity

Dry ice is used as a sandblasting agent

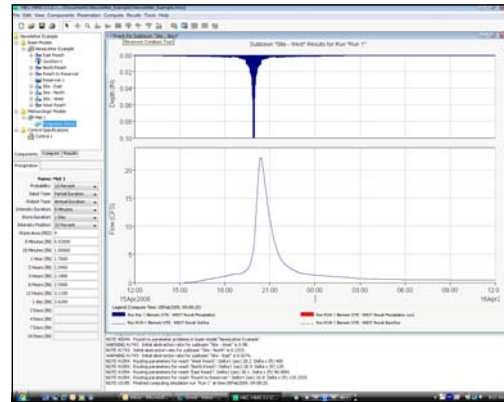
As a blowing agent to foam polymers such as polystyrene, and as an aerosol propellant

In the manufacturing of urea, salicylic acid, methanol, precipitated calcium carbonate

In this Issue:

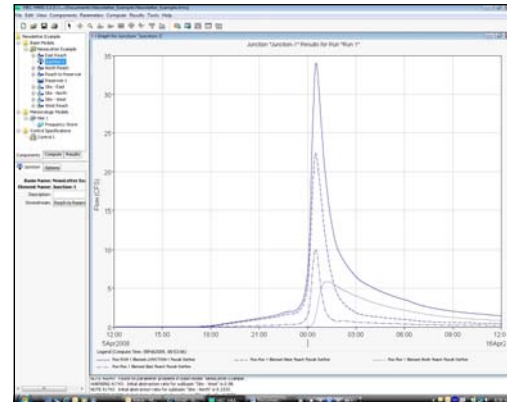
| EME Homer City | CRODA | Pure Energy | America's Energy Future | CO₂ Recovery Technologies |

Look What's New At Venture Engineering



Project: EME Homer City

Venture is working on with EME Homer City, including one to identify and evaluate alternatives for collection of storm water for reuse. Venture is using HEC-HMS to prepare hydrographs for various storm scenarios, and AutoCAD Land Development for design of the impoundment(s).



Project: CRODA

Venture recently completed a study for CRODA, a manufacturer of health care products, evaluating the feasibility of converting either or both of their gas fired package boilers to landfill gas.

After evaluating gas consumption records, the features of each boiler, the availability of landfill gas, and the capital and operating costs associated with each conversion scenario, one boiler was recommended for conversion.

Venture prepared cost estimates for various alternatives, line routing, and conversion requirements for each boiler as part of the deliverables.

Project: Pure Energy

Venture Engineering has entered into a ten year Strategic Alliance with Pure Energy, a bio-based fuels and chemicals company. See <http://www.pure-energy.com/>.

Venture's first project with Pure Energy involves initial engineering and design of a facility for the production of cellulosic ethanol using Pure Energy's proprietary technology.

What is Cellulosic Ethanol?

Conventional ethanol is derived from starches which must be diverted from food or animal feed production. Cellulosic ethanol is derived from lower value, inedible feedstock; more specifically cellulose (cell wall) plant fiber. Cellulose feedstocks are diverse and include wood waste, stover, corn cobs, bagasse, and other materials.

Blog: America's Energy Future

During the 2008 Presidential Race, President Barack Obama's election platform included environmental and energy plans.

After the election he appointed Lisa Jackson as Administrator of the Environmental Protection Agency and Steven Chu as Secretary of Energy.

Since then the pundits, analysts, and managing editors have offered their answers to what we can anticipate in terms of programs and regulatory initiatives. So we thought, 'Why not us?'

We encourage all our readers to visit www.VentureEngr.com/blog to read first-hand our thoughts on these topics.

Note: Final updates were pending at the time of print. Please keep checking for updates, or subscribe to the RSS feed.

Process	Sorbent	Principal of Operation	Applications	Owner/ Licensee
Selexol	Mixture of dimethyl ethers of polyethylene glycol $\text{CH}_3(\text{CH}_2\text{CH}_2\text{O})_n\text{CH}_3$	Physical	IGCC	Dow/UOP
Rectisol	Chilled methanol	Physical	Synfuels, IGCC	Lurgi & Linde
Purisol	N-Methyl-2-Pyrrolidone	Physical	IGCC	Lurgi
Fluor Solvent™	Propylene Carbonate	Physical	IGCC	Fluor Daniel
Fluorinated Solvents	Perfluoropolyethylene, Perfluoropolypropylene, Perfluoroalkylpolysiloxanes	Physical	Bench scale, University of Pittsburgh	University of Pittsburgh
Amines	Alkanolamines, hindered amines	Chemisorption	Mitsubishi, various locations, Commonly used for sour gas	Several
Chilled Ammonia	Ammonium carbonate	Chemisorption (carbonate/bicarbonate)	Alstom/AEP demonstration Alstom/We demonstration Powerspan/First Energy	Alstom, Powerspan
Benfield Process, Flexsorb, and variations thereof	Hot Potassium Carbonate	Chemisorption (carbonate/bicarbonate), with activators	IGCC	UOP, Exxon
Coral	Amino-acides, alkali salts & amines	Hallow fiber membrane contactor	E.on demonstration	TNO
Pressure Swing Adsorber	Various	Adorption onto a solid such as a zeolite.	IGCC	Air Products, others

Overview of Selected CO₂ Recovery Technologies

The Who's and What's in Recovering CO₂

From CARBON DIOXIDE, page 1

Post-combustion recovery of CO₂ in which low-pressure CO₂ is captured after combustion from flue gas. There is a negative impact on plant efficiency – as much as 30 to 60% according to some sources. There is a strong drive to identify new and better solvents or chemical sorbents to reduce the parasitic electric consumption for CO₂ recovery.

Pure oxygen combustion in which fossil fuel is burned in the presence of cryogenically produced oxygen. This eliminates nitrogen from the flue gas, allowing maximum use of storage space for CO₂. There are impacts on the burner and the firebox.

Renewable Fuels — such as biomass have seen renewed interest, as a supplemental feedstock to coal fired power plants, and for new waste-to-energy plants.

Who has integrated CO₂ recovery from flue gas with chemical manufacturing?

Mitsubishi flue gas recovery technology produces CO₂ as a raw material for urea manufacturing at a Petronas plant in Malaysia, at a Ruwais Fertilizer Industries plant in Abu Dhabi, UAE, and at Indian Farmers Fertilizer Co in India (two locations). A project is underway for Engro Chemical in Pakistan. Technology is offered for methanol and acetic acid manufacturing as well.

In Japan, Mitsui Chemicals Inc plans to build a demonstration plant to capture flue gas CO₂ as raw material for methanol production.

What CO₂ recovery technology is available?

A sampling of the recovery options is summarized on page three. This is not an exhaustive list of CO₂ recovery technologies being tested and evaluated.

Which technologies will be the winners, and which will be the losers, in recovery of CO₂?

It's still very much a horse race. For flue gas from conventional coal fired power plants, chilled ammonia and amine technology seem to be leading. The amine processes, like others, have been making great strides and the potential has not been fully realized. In both process the CO₂ is sorbed out of the flue gas and the spent sorbent is regenerated, which generates a concentrated CO₂ by-product stream. After desorption, the regenerated sorbent is recycled back for further CO₂ absorption.

If IGCC gains traction, then physical solvents such as Selexol and Purisol will likely be the winners.

Numerous cooperative pilot and demonstration plant validations are underway at power plants across North America, Europe and Japan in order to evaluate process costs, CO₂ recovery rates, trace pollutant degradation, equipment materials of construction and energy consumption.

What are the problems?

- The swings in temperature and pressure involved in sorption/desorption add a significant parasitic electric load. A lot of effort is currently being put into process optimization.
- Certain sorbents are subject to contamination and require regeneration or replacement on a regular or frequent basis. The selection of sorbents is case specific.

- The chemical cocktail has to be right for the application. Corrosion is a problem.

- What do you do with CO₂ gas? Demand from the chemicals industry is limited, and areas for sequestering enhanced oil recovery may be remote from the point of generation.

- No matter what the outcome, look for your cost per kilowatt to increase by 50 to 100%.

What will Pennsylvania do?

At this point, we do not know. The Report of Carbon Management Advisory Group of PADCNr, dated May 2008, cautiously states that "Even in a carbon-constrained world, economics will likely dictate that coal continue to be major energy source. The key to clean energy from coal is capturing and then storing its carbon dioxide in geological formations." In the near term, that

points to western Pennsylvania, which has a long history of oil and gas exploration. If that is the case, piloting, mapping and other steps will be necessary and infrastructure will be needed to deliver carbon dioxide to the area. Other options under consideration include forestry (re-entrainment in growing trees) and cap-and-trade.

Best References

Published eleven years ago, this book is well worth the \$305 price tag:

Kohl, A.L., Nielsen, R.B., Gas Purification, Fifth Edition, Gulf Professional Publishing House, Houston, Texas, 1997

If you are looking for a nice, reasonably comprehensive summary, a good place to start would be:

Chemical Engineering, *Capturing CO₂*, December 2008, pp 16-20

A message from Process Engineer Travis Buggy: Renewable Energy and Carbon Capture Basics

What's the difference between Renewable Energy Certificates/Credits and carbon offsets? RECs are primarily concerned with promoting the generation of renewable energy, while carbon offsets are primarily concerned with reducing greenhouse gas emissions.

More specifically, RECs represent the attributes that are associated with the production of renewable electricity. Renewable electricity is generated by sunlight, wind, tides, geothermal heat, and the burning of biomass or landfill gas. 1 REC = 1 megawatt hour (MWh) of renewable energy generation. A REC can be sold and traded, and the owner of the REC can claim to have purchased renewable energy.

In order to create a REC, the project site must produce electricity in a state where there is a renewable portfolio standard that recognizes the feedstock as renewable. Alternatively, the project may supply electricity to a power grid that has a state with an RPS and which allows RECs to be created in other states.

A carbon offset is a certificate representing the reduction of greenhouse gas emissions to the equivalent of one metric ton (2,205 lbs) of carbon dioxide emissions. Certain emissions have been identified as having more potential for "greenhouse effect" than others (i.e. methane); therefore carbon dioxide is used as the standard. Every ton of carbon dioxide equivalent reduced results in the creation of one carbon offset. Project developers can then sell these offsets to finance their projects.

No United States Federal government standard for carbon offsets currently exist. The voluntary market is awash in competing protocols and standards. Regional initiatives have begun developing compliance systems to reduce CO₂ emissions from power plants, increase renewable energy, track RECs, and establish baselines.

Of particular interest to Pennsylvania is the Regional Greenhouse Gas Initiative. The RGGI is composed of 10 member states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Pennsylvania is considered an observer. RGGI members must comply with baseline emissions in the 2009-2014 period, with a 2.5% reduction annually 2015 – 2018.

RGGI's obligations apply to fossil fuel generators ≥25 MW and carbon dioxide emissions only. The

first RGGI "pre-compliance" auction was September 25th, 2008. All 12.5MM CO₂ allowances offered for sale were sold at \$3.07/allowance raising \$38.6MM. The second RGGI "pre-compliance" auction was December 17, 2008. All 31.5MM CO₂ allowances offered for sale were sold at \$3.38/allowance raising \$106.5MM.

◇ *1 REC = 1 MWh of energy generation that can be sold and traded.*

◇ *Every ton of carbon dioxide equivalent reduced results in the creation of one carbon offset.*

Looking Ahead: Although the Lieberman-Warner Climate Security Act did not pass, look for this bill to come back in some form. Meanwhile, if capture and sequestration of CO₂ is not something you can do easily, consider an alternative carbon strategy, such as buying or generating carbon credits. One proven way to generate credits: convert landfill gas to high BTU gas, or to electricity. Landfill gas is eligible as a renewable source in all RPS programs.

For the more adventurous, cellulosic ethanol is a possibility, with grants, low interest loans, and loan guarantees available through the U.S. Department of Agriculture. Supplementing coal with biomass, converting boilers firing natural gas to boilers firing landfill gas, and making or firing with biodiesel are some of the many options available to reduce the "carbon footprint."

Contact Travis Buggy at (412) 231 – 5890 ext. 325 for more information.



Venture News

Congratulations!

Alyson Holler, CAD coordinator and structural designer, received her AutoCAD 2009 Associate Certification while attending Autodesk University in December.

Employee News

Amanda Artzberger, executive assistant, adopted her very first pet, a puppy named Lucy! She is a purebred Pembroke Welsh Corgi.

Mechanical Designer Rob Armstrong and wife Stacy are expecting child No. 2 in July.

Happy Birthday

February

Dan Cook

March

Alyson Holler