



CO₂ Testing Program

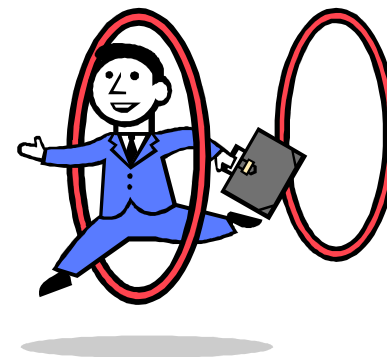
**An Industry/EPRI Initiative to Develop CO₂
Capture and Storage Test Capabilities**

Dick Rhudy

CO₂ Capture Network Meeting
June 16, 2006

History of the CO₂ Testing Issue

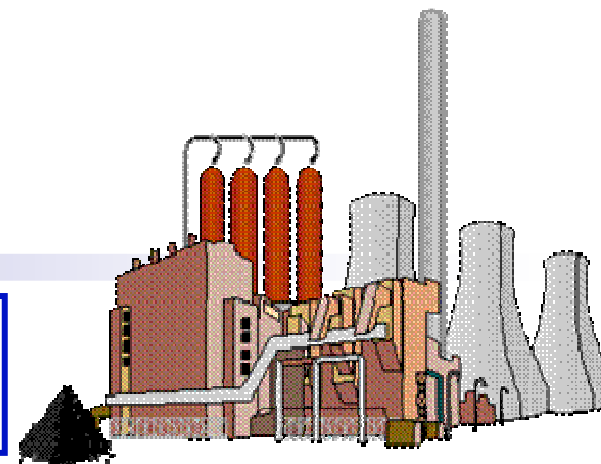
- Conceived of need for regional CO₂ Capture and Storage Test Centers as a necessary RD&D step
 - Several across country
 - Different power generation and storage depending on region
 - 10 MW (150 t CO₂/d)
- Conducted engineering cost and site selection study on pulverized coal (PC) power plant systems
 - PC is the only type of generation available in near-term
 - 4 sites identified
 - High cost



History of the CO₂ Testing Issue (cont.)

- Reviewed with EPRI BoD and Technical Review Committee
 - Identified need for better capture processes
- Decided to conduct study in two steps
 - 1-MW CO₂ capture pilot
 - 10-MW CO₂ capture and storage test facility
- Selected chilled ammonia process to test
- Alstom interest and collaboration
- Currently soliciting participation in 5-MW CO₂ capture pilot of chilled ammonia process

CO₂ Test Centers Current Plan



A multi-phase testing program to develop cost-effective and practical capture technologies

Phase 1

- 1-MW pilot plants
- Test solvent, solid and membrane capture technologies
- Test materials to be used for compression, transport and injection of flue-gas CO₂

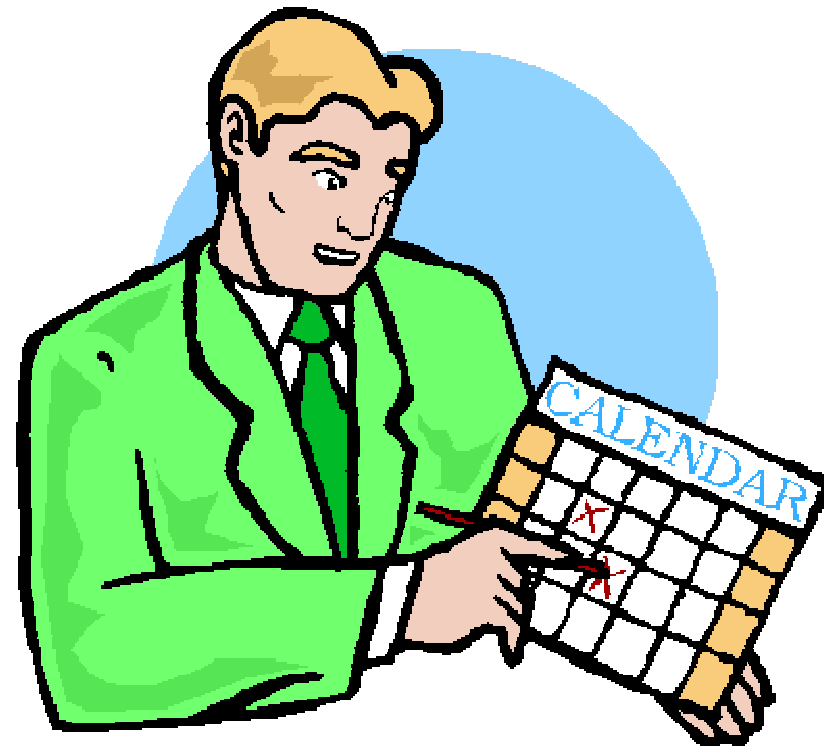
Phase 2

- 10-MW CO₂ Test Center (150 Tonnes/day)
- Capture and store CO₂ at substantial scale and real operating environments
- Future phases – larger demos to scale-up to full plant

Determine the viability of combustion-based coal plants in a carbon constrained future

Project Schedule

- Assembling funding in early 2006
- Start on engineering/procurement in 2006
- Operation of pilot starting in 2007



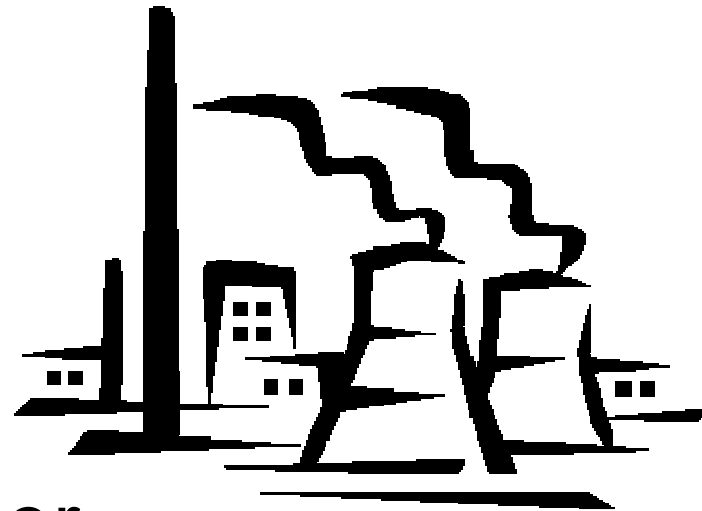
First Capture Process to be Tested

- Chilled ammonia
 - Under development by EPRI



Conventional Ammonia Scrubbing

- Advantage
 - Potentially lower regeneration energy
- Challenges
 - Ammonia volatility
 - Poor kinetics in absorber



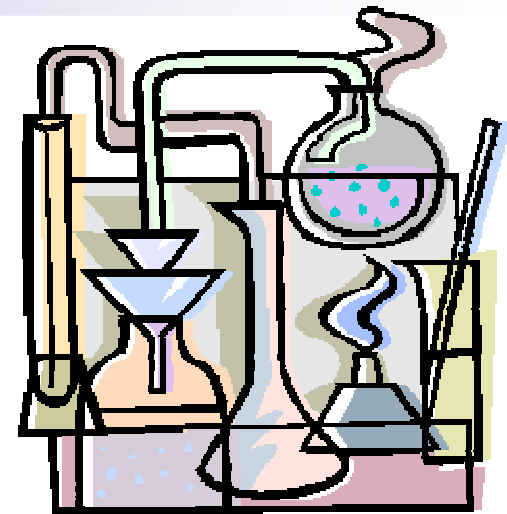
Chilled Ammonia Process: Key Design Features

- Low temperature CO₂ Absorption--minimize NH₃ emissions
 - Absorber operation at optimal temperature of 2-16C (35-60F)
- High concentration of Ammonium Carbonate/Ammonium Bicarbonate (AC/ABC)--improve CO₂ removal
 - High CO₂ loading per recycled slurry
- High pressure regeneration--saves energy



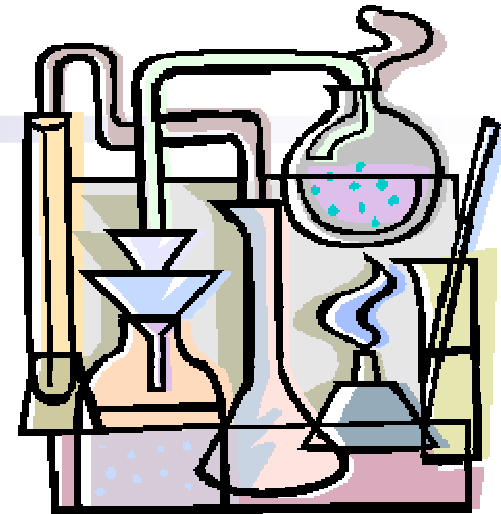
Chilled Ammonia Lab Tests

- Phase 1 (2004)
 - Ammonia emission not an issue during absorption at 0-5C (32-40°F)
 - High CO₂ absorption efficiency can be achieved in bubbler absorber
 - High pressure regeneration—at least 20 Bar (300psi) is feasible
 - NH₃ and H₂O concentration in regeneration gas stream is very low



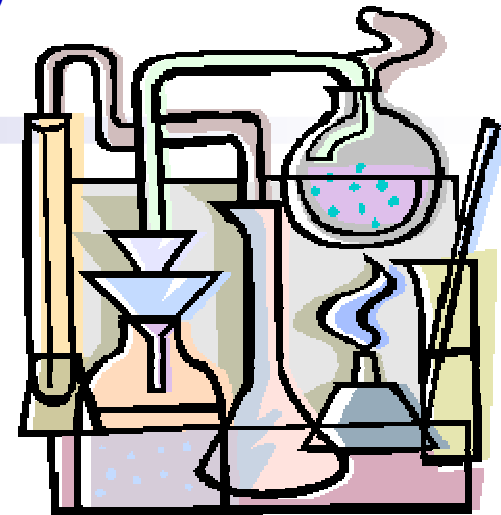
Chilled Ammonia Lab Tests

- Phase 2 (2005)
- Absorption
 - Measurements of absorption rates were completed
 - CO₂ removal in the 2" flow reactor was limited by mass transfer
 - A large scale absorber (1-2 ft) diameter needs to be built and tested to demonstrate high efficiency and high mass transfer rates



Chilled Ammonia Lab Tests (cont.)

- Phase 2 (2005)
- Regeneration
 - 800 psig was measured with regeneration simulation from ammonium bicarbonate
 - High pressure regeneration can be designed to regenerate ammonium carbonate at 125°C



Chilled Ammonia Process Cost Prediction (Early Data Only)

Used Parsons Study for basis	Supercritical PC without CO ₂ Removal	Supercritical PC with MEA CO ₂ Removal	Supercritical PC with NH ₃ CO ₂ removal
Levelized cost of Power, c/KWh	5.15	8.56	6.50
% increase		66	26
Avoided Cost, \$/ton CO ₂	Base	51	20

Source: Nexant

Chilled Ammonia Process Performance Prediction (Early Data Only)

Used Parsons Study for Basis	Supercritical PC Without CO ₂ Removal	Supercritical PC With MEA CO ₂ Removal	Supercritical PC With NH ₃ CO ₂ Removal
LP Steam extraction, lb/hr	0	1,220,000	270,000
Power Loss, KWe	0	90,000	20,000
GROSS POWER, KWE	491,000	402,000	471,300
AUXILIARY LOAD, KWE			
Induced Draft Fan	5,000	19,900	10,000
Pumping CO ₂ system,	0	1,900	5,000
Chillers	0	0	8,900
CO ₂ compressor	0	30,000	9,500
NET POWER OUTPUT	462,000	330,000	415,000
% POWER REDUCTION		29	10

Source: Nexant

Chilled Ammonia Looks Good to Test at 1 MW

- Data from Technology Innovation bench-scale work looks good
- Economics are very preliminary and supplier derived
- Appropriate for scale-up



CO₂ Capture Pilot Project Launch

- In early February, PON released and participation solicitation initiated
- Initial calls made to potential anchor tenant members
- 16 companies have agreed to participate
- Funding from these members represents about 2/3 of the project funding



Alstom Discussions

- Based on
 - Common interests (e.g., we jointly bid the chilled ammonia project to DOE but was not selected)
 - Alstom's desire to push scale-up and commercialize the chilled ammonia process
- Organizations agreed to collaborate on the construction and testing of a 5-MW pilot CO₂ test unit of this process
- Could accelerate our currently proposed scale-up at no cost to the EPRI funders
- Could move us to scale for CO₂ storage



Alstom Collaboration Benefits

- Enables us to leverage our funder's investment even more
- Allows us to accelerate both the development and commercialization path
 - A 5-MW pilot is big enough to use commercial components (e.g., slurry pumps) designed for such an application
 - Teaming with the company that views this technology as their offering of choice will accelerate its commercialization
 - Can move into a size which allows CO₂ storage testing at least 2-3 years faster

