# Pilot-Scale Silicone Process for Low-Cost CO<sub>2</sub> Capture

**GE Global Research** 



**Benjamin Wood** 



DOE Award: DE-FE0013755

2015 NETL CO<sub>2</sub> Capture Technology Meeting June 24, 2015

#### **Overview**

#### Program Team



GE Global Research

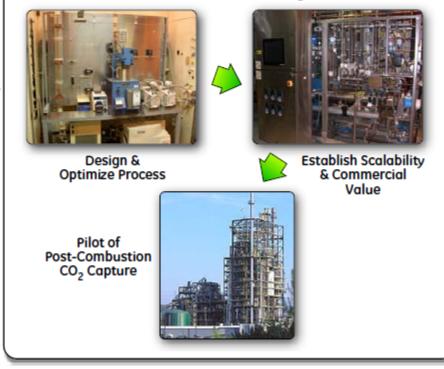
- Pilot-scale design
- Construction/Operation of Continuous System
- EH&S Assessment
- Techno-economic Assessment
- Plant Modeling



- Pilot-scale Operation
- Assessment of Data
- Integration of Components

#### 24 Month, \$5.7MM Program to Advance the Amino-Silicone Solvent Process for CO<sub>2</sub> Capture to Pilot Scale

**Program Objectives:** Design and optimize a new process for a novel silicone CO<sub>2</sub> capture solvent and establish scalability and potential for commercialization of post-combustion capture of CO<sub>2</sub> from coal-fired power plants. A primary outcome will be a system capable of 90% capture efficiency with less than \$40/tonne CO<sub>2</sub> capture cost.



#### **Technical Approach**

- Design and construct pilot-scale unit and obtain parametric data to determine key scale-up parameters
- Perform an EH&S and technical and economic assessment to determine feasibility of commercial scale operation
- Develop scale-up strategy

#### Outcomes

- Strategy for future scale-up
- Technical and economic feasibility determined
- Environmental assessment

#### Anticipated Benefits of the Proposed Technology

- 90% CO<sub>2</sub> Capture
- \$40/tonne CO<sub>2</sub> capture cost

#### •Continuation of previous DOE/NETL funded project (DE-FE0007502)



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#### Scope

This project is divided into two phases.

#### **Phase I:** 1/1/2014 - 12/31/2014

(\$1.5MM with 20% GE cost share)

- Develop preliminary process models and perform preliminary techno-economic analysis
- ✓ Perform preliminary EH&S risk assessment
- ✓ Design and construct pilot-scale aminosilicone desorber skid

#### Phase II: 1/1/2015 - 6/30/2016

(\$4.2MM with 20% GE cost share)

- Integrate skid with the NCCC pilot-scale system
- Perform pilot-scale testing (test moved from Spring 2015 to October 2015)
- Analyze data from pilot tests at 0.5 MW scale
- Perform techno-economic analysis and update cost of carbon capture
- Perform technology EH&S risk assessment
- Develop cost estimate for full-scale manufacture of solvent

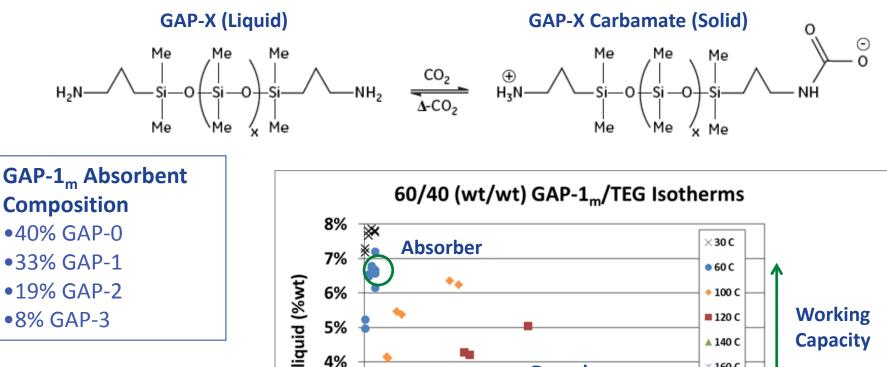


# **Summary of Aminosilicone Advantages**

- Lower volatility
  - Simplified separations
  - Less energy wasted vaporizing solvent and/or water
  - Lower airborne release rates
- Lower heat capacity
- Higher thermal stability (higher desorption T/greater capture capacity and/or pressure)
- Reduced corrosion
- Potentially decreased issues with aerosol formation

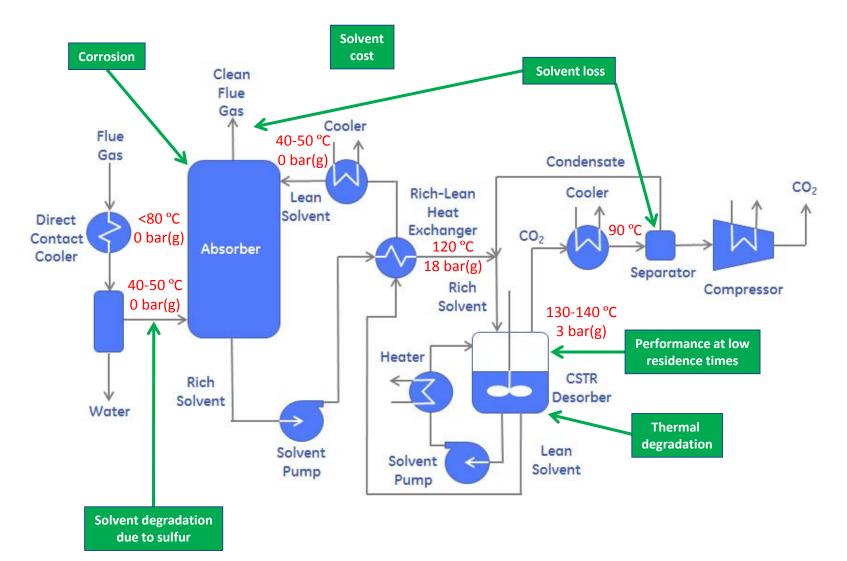


### **Aminosilicone Absorbent**



Carbamate does not precipitate in a 60/40 (wt/wt) GAP-1<sub>m</sub>/TEG mixture % CO $_2$  loading in liquid (%wt) 4% X 160 C Desorber 3% **A** . жж 2% ж ж ж 1% Ж¥ ¥ 0% 2 0 Δ 6 CO<sub>2</sub> pressure (bara)

### **Technical Risks**





### **Corrosion Studies (Stainless Steel)**

Location / Metal	Conditions	Unexposed samples	Exposed samples
Туре			
Lean Storage / 304L	~380 hours at ~34 °C and ~6138 hours at ~25 °C	10µm Mag = 2.50 K.X. Signi A+ SE2 11 Mar 2013 Bage ut 1 = 0.0*   BHT = 5.00 KV WD = 14.0 mm 3044W SN3 base metal 2 Star_14.8 F	Start Start NE   1 200 K X Web1+e8/24 m WD1+32 m NE H2 40
Absorber Sump/ 304L	~389 hours at ~52 °C and ~6138 hours at ~25 °C	10μm Mag = 250 KX. Spril A = SE2. 11 Mz 2013. Stage at T = 0.0°. HT = 5.00 KV. WD = 13.9 mm. Societ.W 2018 base mend 2 Soc_43.3 M	2m Sali Wé, Mante, 260, 25 m E/D v2.01   2m Sali Wé, Mante, 260, 25 m E/D v2.01   4m Wath + 62 Jan Woll + 62 Jan E/D v2.01
Desorber / 304L	~388hours at ~145 °C and ~6138 hours at ~25 °C	10µm Mag = 2.50 KX Signil A = SE2 12 Mar 2011 Sage at 1 = 0.0"   BHT = 5.00 KV WD = 13.9 mm 324LW Sh9 base medi 2 Sba_14.8 SF	2µm 2NLM 4 Lyndrox, 2501, 6M 10 Dri 201   1 May + 2601 K Wath++63 Hym ND+133 mm Dcf+ 2601 V Egyptia+c 622



### **Corrosion Studies (Carbon Steel)**

Location / Metal Type	Conditions	Unexposed samples (interface images)	Exposed samples (interface images)
Lean Storage / C1018	~380 hours at ~34 °C and ~6138 hours at ~25 °C	10 µm Mag = 250 x x Spyrit A = 552 12 Nm 5013 Stope at F = 0.9   10 µm Mag = 250 x X Spyrit A = 552 12 Nm 5013 Stope at F = 0.9	2 Mage 2201X With # 83µm We-132m We-132W Burk # 30V Burk # 12
Absorber Sump / C1018	~389 hours at ~52 °C and ~6138 hours at ~25 °C	T0µm Mag* 250 KX Signid A - SE2 12 Mm 2013 Slage at T = 0.0*   EHT = 5.06 KV WD = 127 mm C1018W SM startises 12x,54.8/	2 m Mg = 201X W W + 45 Jan W − 12 m Br + 503 W Br + 43 m 201
Desorber / C1018	~388hours at ~145 °C and ~6138 hours at ~25 °C	10 µm Meg = 250 K X Spyrid A = SE2 13 Mer 2013 Stops at T = 0.0* H HT = 5.00 KV WD = 13.3 rm C1016W SN9 skertice 12 ks_22.8*	210 COURSE, MARKE, MOL, KM 2000 200 Mag + 120 KX MARK-4, MOL, KM 2010 200 Market, MOL



#### **Corrosion Studies**

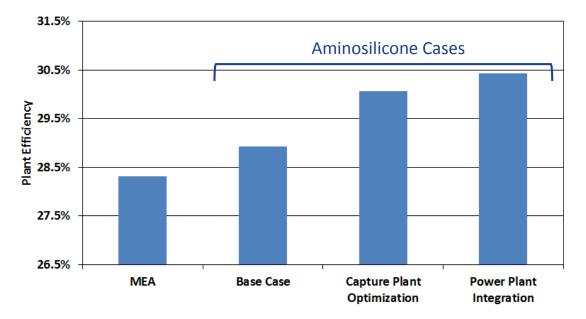
- Significant corrosion only seen with carbon steel under desorber conditions
- Carbon steel should be fine for other process components

Sample	Corrosion rate (µm/yr)
C1018 – lean storage	1.27
C1018 - absorber	0.47
C1018 - desorber	2188
304L – lean storage	0.31
304L – absorber	0.53
304L – desorber	-0.50



## **Process Modeling**

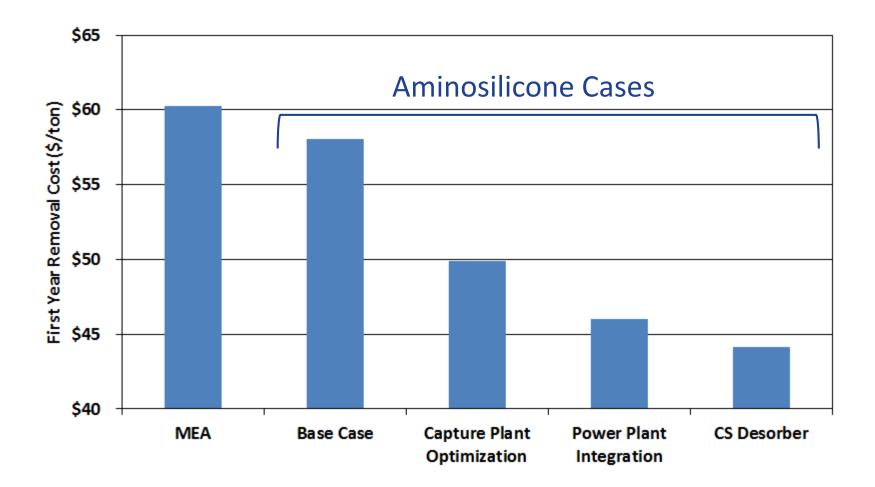
- Data from the bench-scale system were used to tune bench-scale carbon-capture model in ASPEN Plus
  - Model scaled up to pilot- and 550 MW commercial-scale
- Process modeling of the coal-fired power plant was performed in Thermoflow by GE Power and Water
  - Model without carbon capture was tuned to match Case 11 from Bituminous Baseline Study
- Power plant model and carbon capture model were integrated



- Base Case Desorber at 140 °C and 4 bar(a)
- Capture Plant Optimization Optimization of desorber T, absorber column intercoolers, packing type, etc.
- Power Plant Integration Cooling water integration and waste heat recovery

imagination at work

### **First Year Removal Cost of CO<sub>2</sub>**



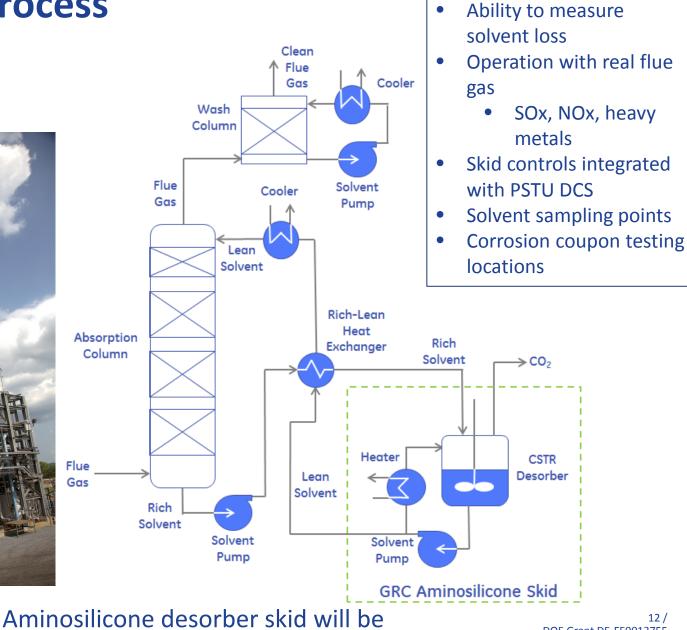


### **Pilot-Scale Process**

The NCCC PSTU



imagination at work



integrated with PSTU at the NCCC

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# **Pilot-Scale Skid Design and Fabrication**

- ✓ Detailed Engineering Package complete
- ✓ Skid construction is complete
- ✓ Solvent delivered to NCCC

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- Working with the NCCC to complete
  - ✓ Detailed HAZOP (completed 12/4/14)
  - Integration of skid with PSTU

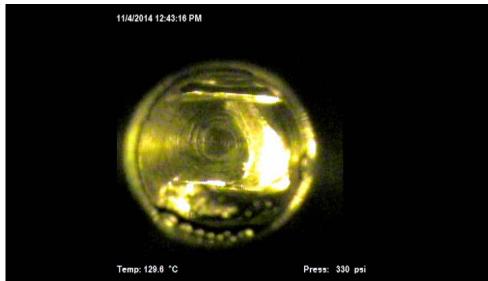


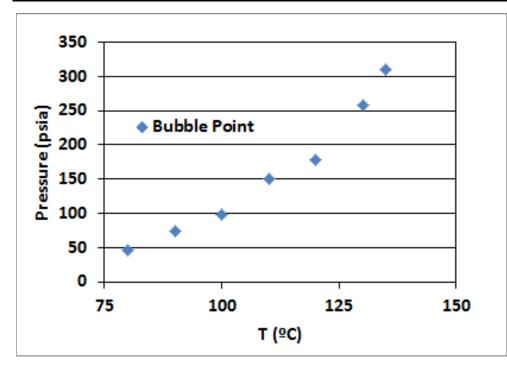


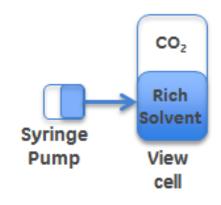


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### **Bubble Point Measurements**







#### **Bubble Point Measurements**

- Heated pressure cell with syringe pump and window
- Set temperature and adjusted pressure until boiling occurred
- Bubble point data is critical to determining acceptable operating conditions for the rich/lean heat exchanger (120 °C and 275 psig)
  - Bubble formation can damage equipment and reduce heat transfer

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### **Future Work**

- 2015-2016
  - Integrate skid with PSTU at the NCCC
  - Perform tests (~2 months)
  - Use data to update process models
  - Update Techno-Economic Analysis and EH&S Risk Assessment
- Beyond
  - Determine next scale for testing
  - Look for partners
    - Test site
    - Solvent manufactures
      - Need to grow solvent supply



### Thanks

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