Pilot-Scale Silicone Process for Low-Cost CO_2 Capture

GE Global Research

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Overview

Program Team

GE Global Research

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

National Carbon Capture Center

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

24 Month, $5.7MM Program to Advance the Amino-Silicone Solvent Process for CO_2 Capture to Pilot Scale

Program Objectives: Design and optimize a new process for a novel silicone CO_2 capture solvent and establish scalability and potential for commercialization of post-combustion capture of CO_2 from coal-fired power plants. A primary outcome will be a system capable of 90% capture efficiency with less than $40/tonne CO_2 capture cost.

Design & Optimize Process

Establish Scalability & Commercial Value

Pilot of Post-Combustion CO_2 Capture

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_2 Capture
- $40/tonne CO_2 capture cost

Scope

This two-year 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 pilot-scale system and construct components

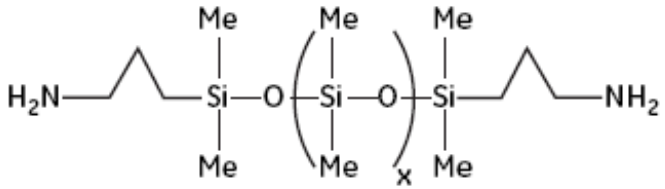
Phase II: 1/1/2015 - 12/31/2015

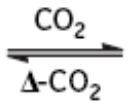
($4.2MM with 20% GE cost share)

- Integrate aminosilicone specific components with the NCCC pilot-scale system
- Obtain and analyze engineering data from pilot tests at 0.5 MW scale
- Perform techno-economic analysis and update cost of carbon capture
- Develop scale-up strategy
- Perform technology EH&S risk assessment
- Develop cost estimate for full-scale manufacture of solvent

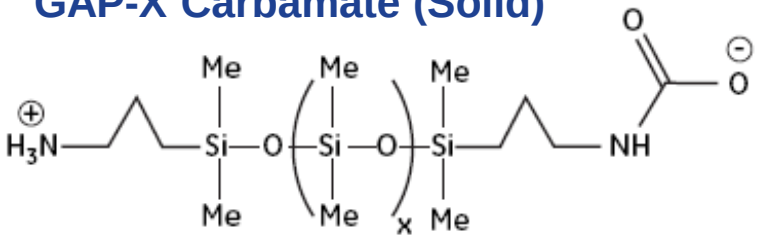
Aminosilicone Absorbent

GAP-X (Liquid)





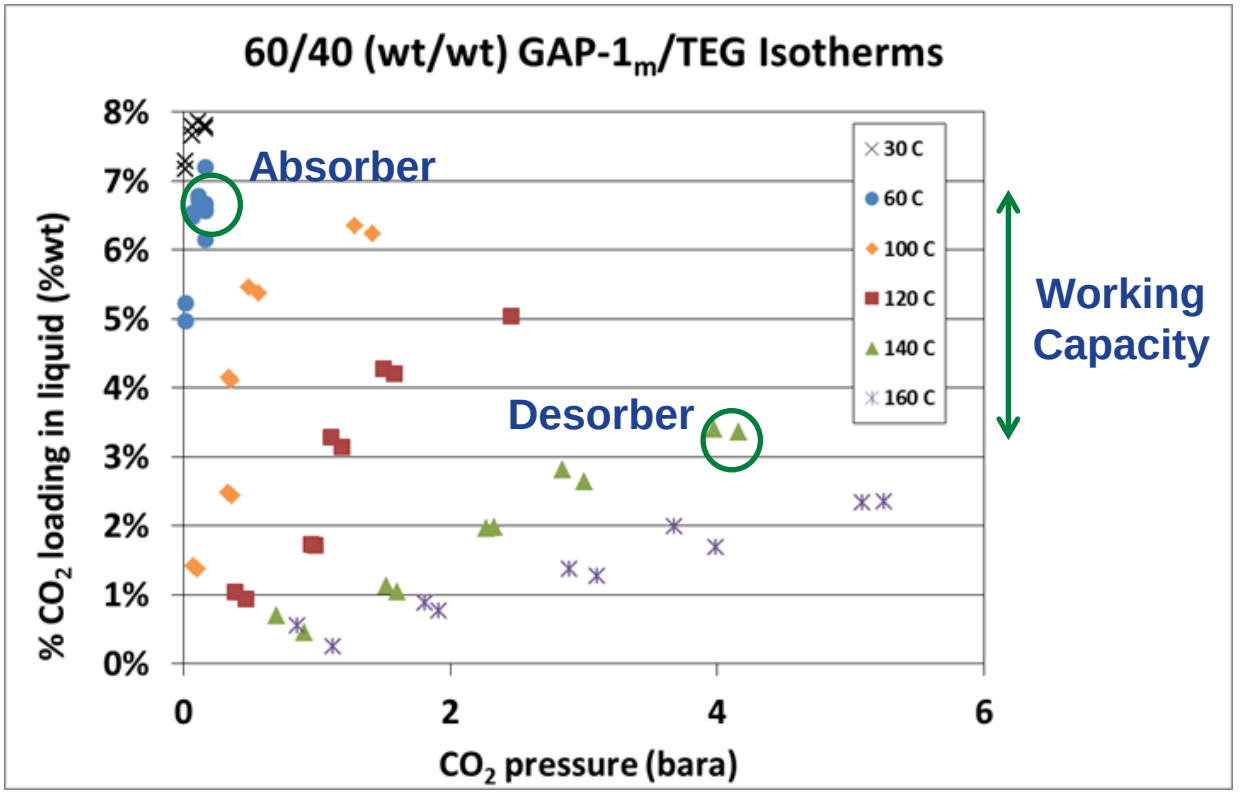
GAP-X Carbamate (Solid)



GAP-1_m Absorbent Composition

- 40% GAP-0
- 33% GAP-1
- 19% GAP-2
- 8% GAP-3

Carbamate does not precipitate in a 60/40 (wt/wt) GAP-1_m/TEG mixture



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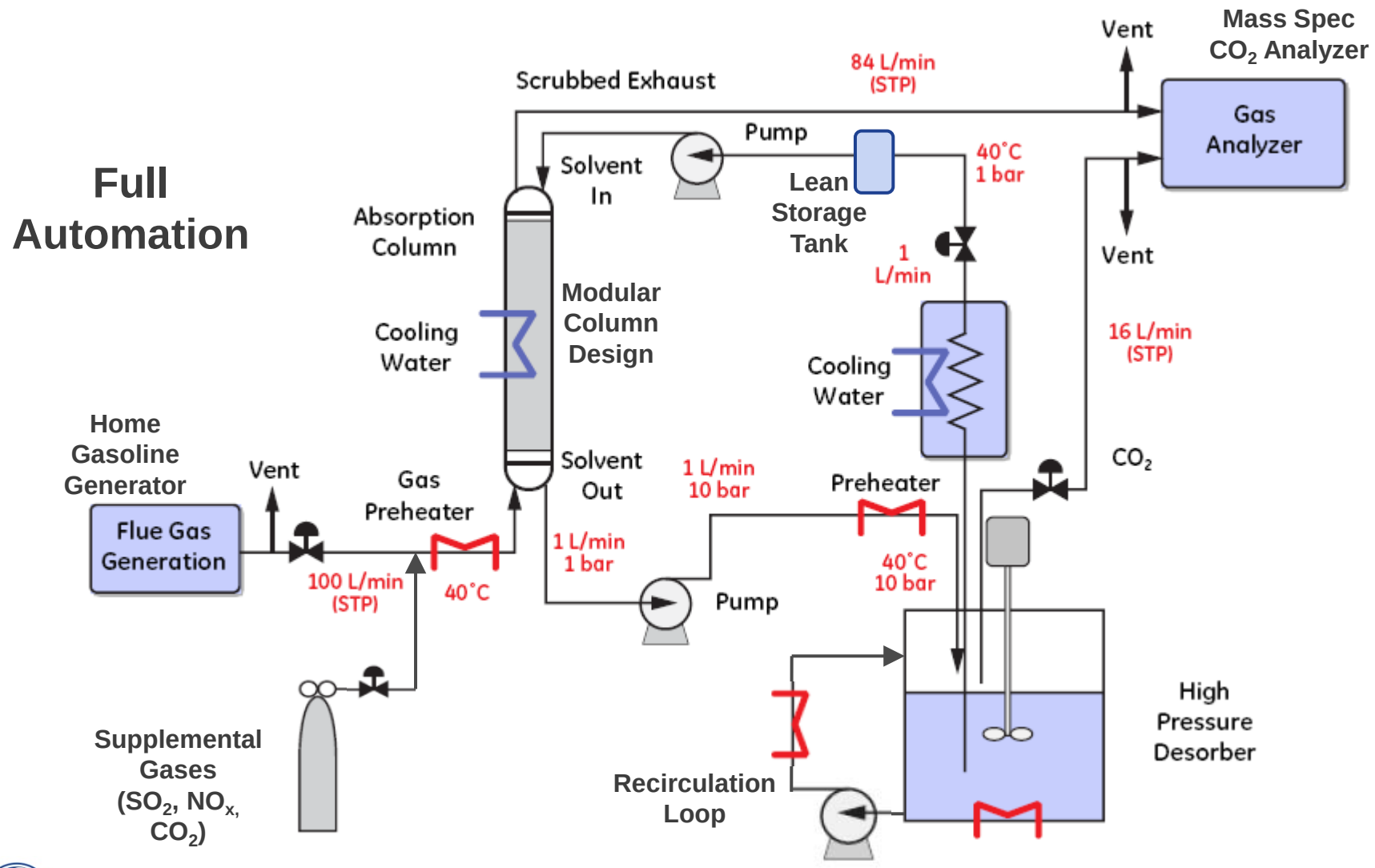
Summary of Aminosilicone Advantages

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

Challenges

- High viscosity (at low T and high loading)
- Higher heat of reaction
- Solvent cost

Bench-Scale Schematic



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Bench-Scale CO_2-Capture System

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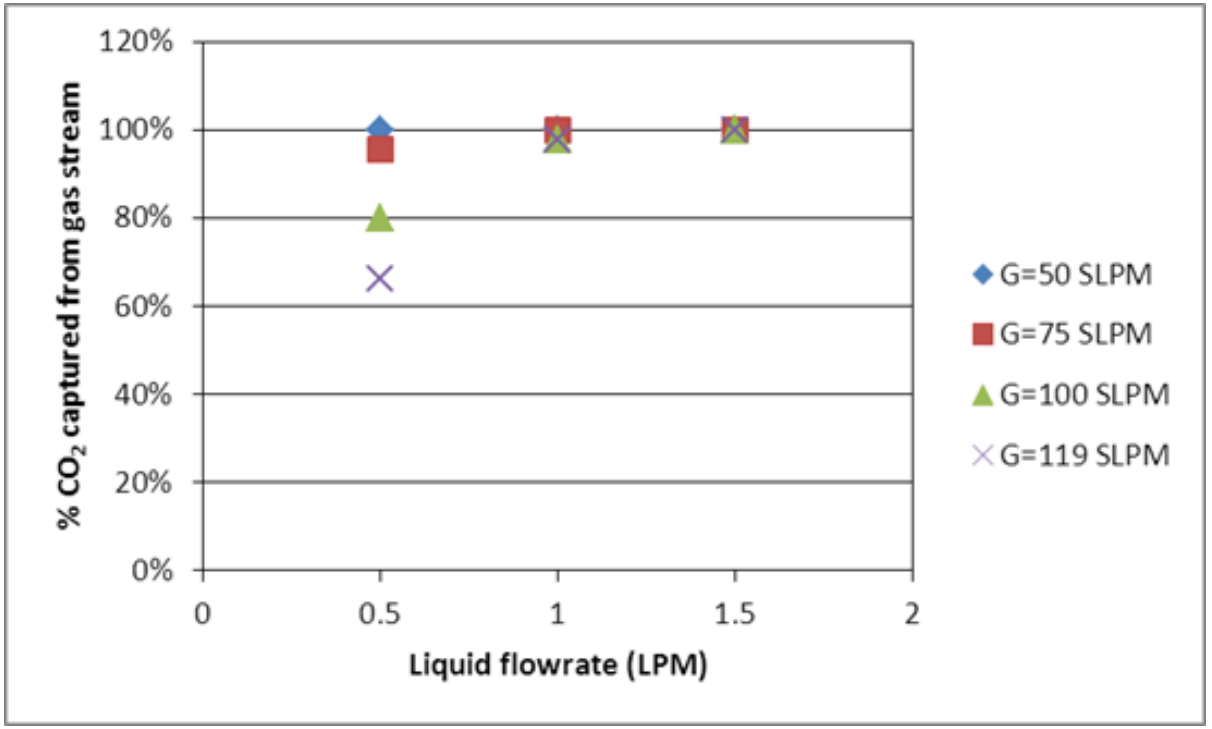
Bench-Scale System Tests

Parameter	Units	Value
Desorber temperature	°C	160
Desorber agitator speed	RPM	300
Desorber recirculation loop pump speed	% of max	50
Desorber level	in H_2O	7.5
Desorber pressure	psig	0
Inlet absorber temperature (gas and liquid)	°C	40
Absorber sump level	in H_2O	5.0
CO_2 concentration in inlet gas to column	mol%	16
Gas source		bottled

The effect of varying liquid and gas flow rates on CO_2 capture were studied.



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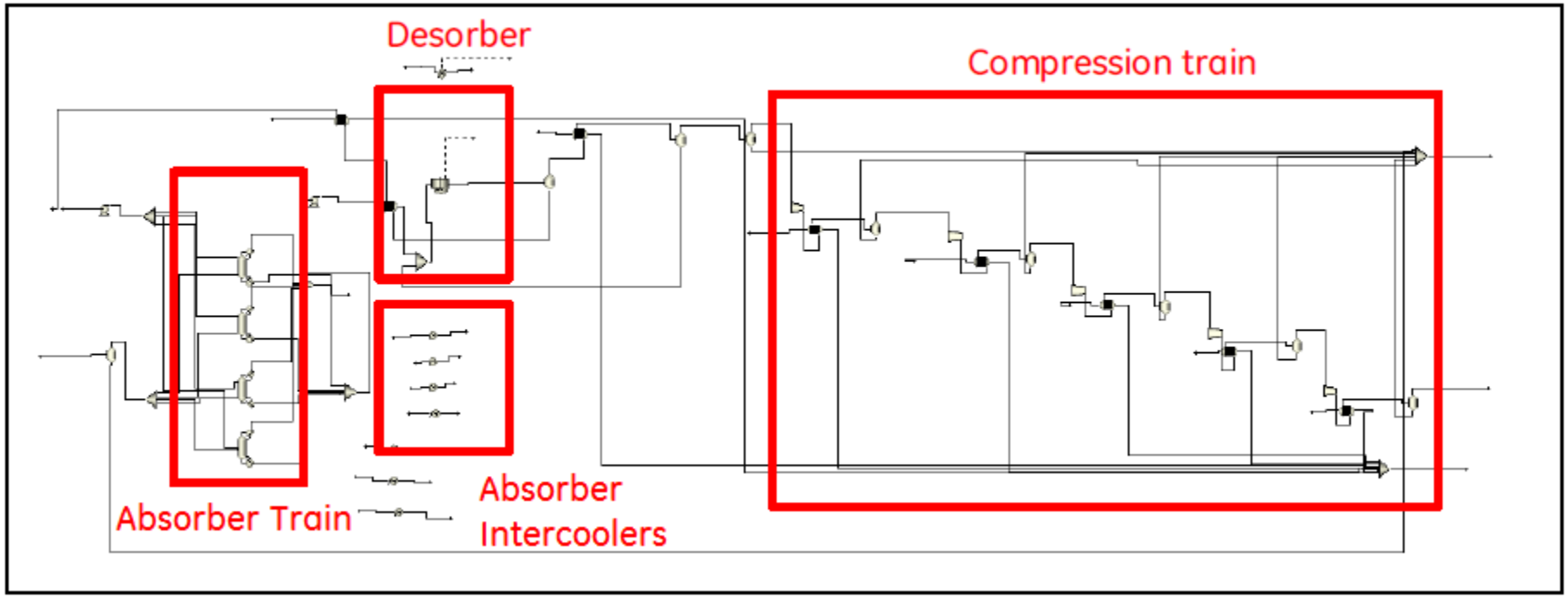
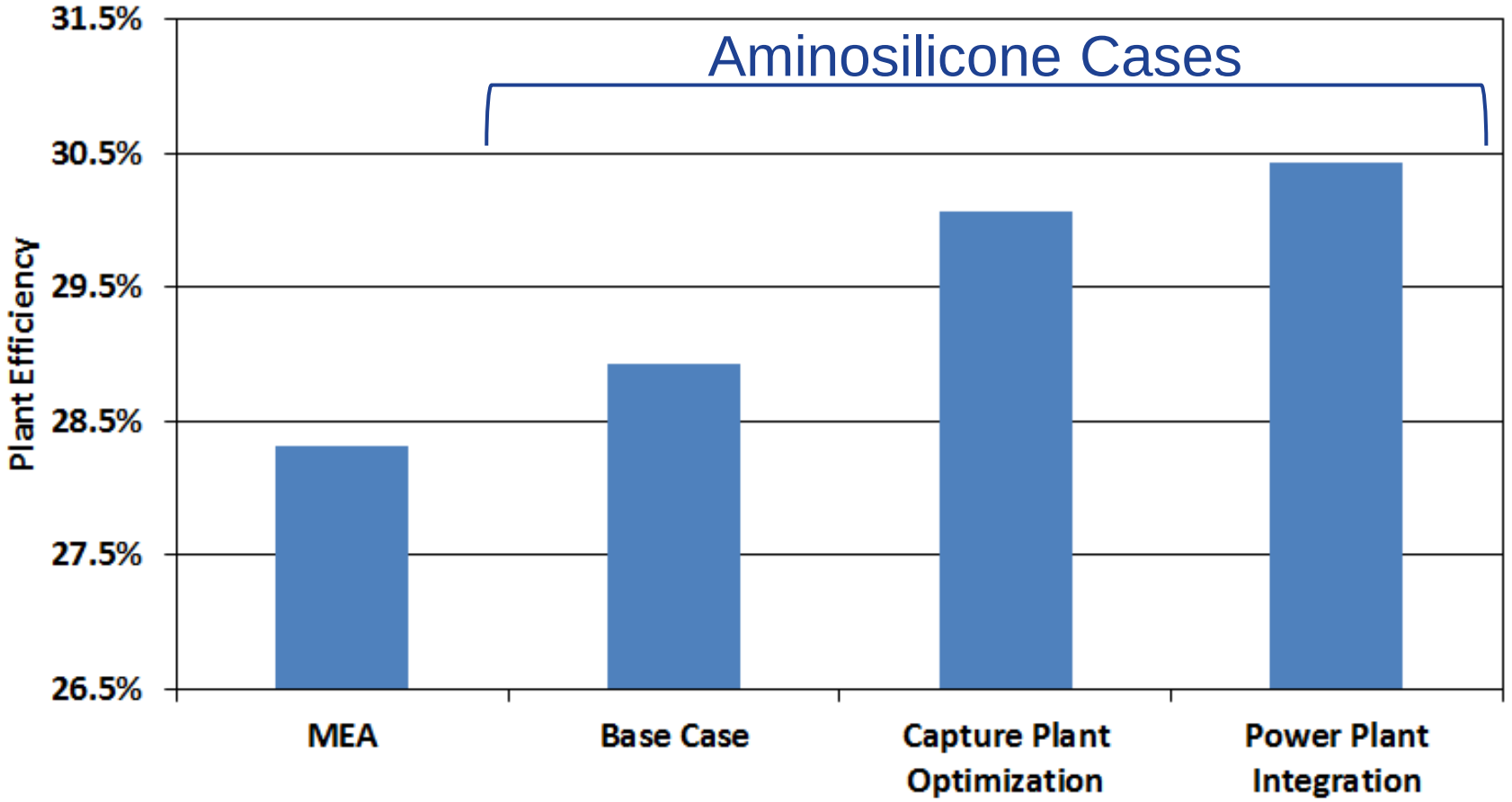
Process Modeling

- 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

ASPEN Plus Model of Carbon-Capture System

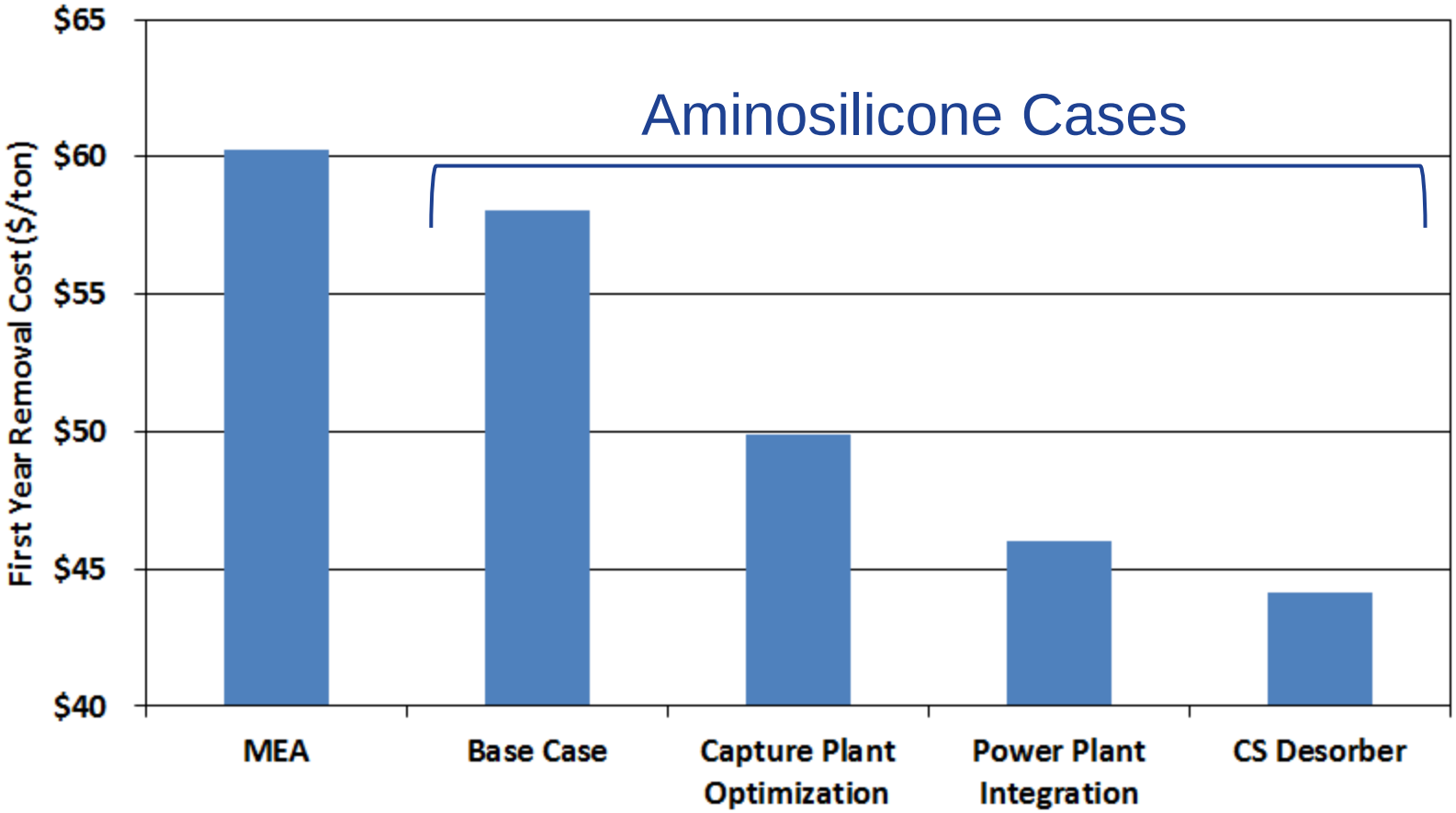


Plant Efficiency



- 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

First Year Removal Cost of CO_2



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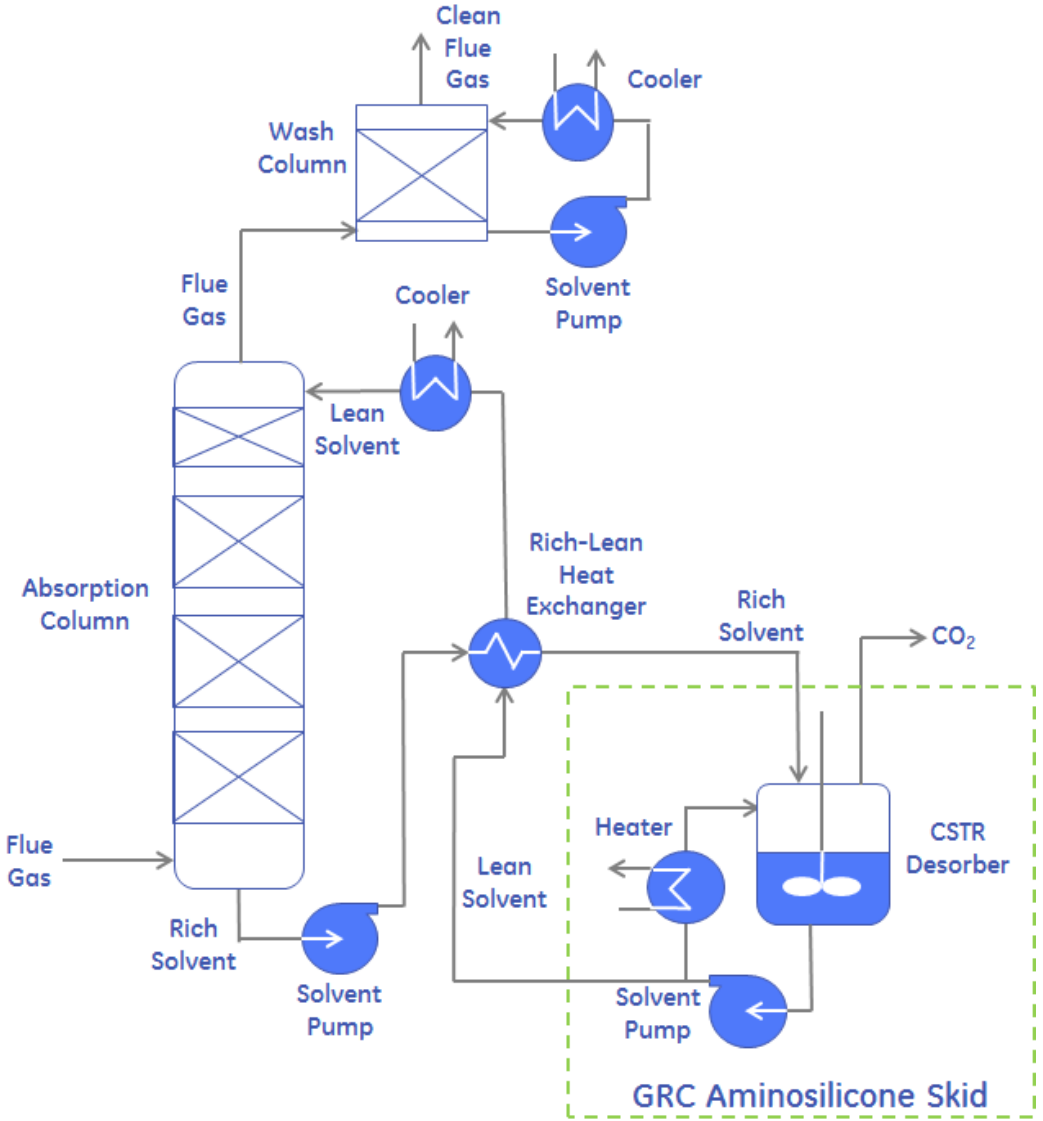
Pilot-Scale Process

The NCCC PSTU

CO_2-capture process for pilot-scale



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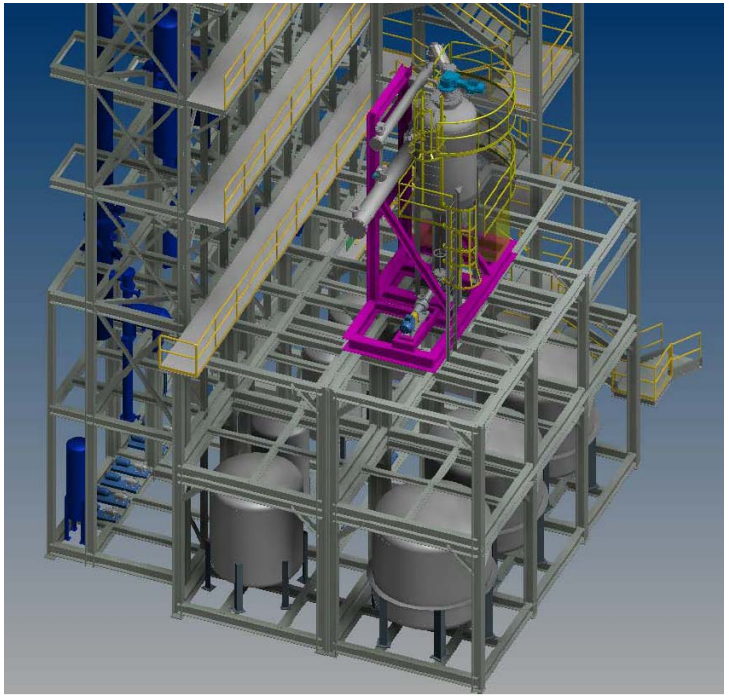
Aminosilicone desorber skid will be integrated with PSTU at the NCCC

Skid Design

- Basic Engineering Package Completed
  - Detailed P&IDs
  - Initial designs/specs for major equipment
  - Material and energy balances
- Working with the NCCC
  - Kick-off meeting in first quarter of 2014
  - Transmitted Basic Engineering Package (Tier 1 information)
  - Conducted Preliminary Hazard Review



Future Work

- Remainder of 2014
  - Complete detailed design of skid
  - Fabricate skid for delivery at the NCCC early next year
  - Perform preliminary EH&S Risk Assessment
- 2015
  - Integrate skid with PSTU at the NCCC
  - Perform tests (~3 months)
  - Use data to update process models
  - Update Techno-Economic Analysis and EH&S Risk Assessment
- Beyond
  - Determine next scale for testing
    - Consider adjacent applications with intermediate scale
  - Look for partners
    - Test site
    - Solvent manufactures
      - Need to grow solvent supply

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