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ION Novel Solvent System for CO_2 Capture

2012 NETL CO_2 Capture Technology Meeting
July 10, 2012
Pittsburgh, PA

Partners, Funding & Cost Share

Partners & Contractors

- University of Alabama
- WorleyParsons
- EERC
- EPRI
- Xcel Energy
- Evonik
- Eltron R&D

Funding Sources

DOE/NETL:	$4,836,424
ION & Partners:	$1,618,335
Total	$6,454,759
Project Start:	10/01/2010
Project End:	04/30/2013

THE UNIVERSITY OF ALABAMA

EERC Energy & Environmental Research Center®

WorleyParsons resources & energy

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NETL National Energy Technology Laboratory

EPRI Electric Power Research Institute

Solvent Development & Testing at ION Engineering

Bench Scale Solvent Property Measurement and Screening

ASPEN+ Process and Economic Modeling of ION Solvents

Lab Pilot Unit Steady State Evaluation of Solvents

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Overall Project Goals

Novel Solvent System for Post-Combustion CO_2 Capture

1. Evaluate ION's non-aqueous organic solvents (NAOS) for post combustion CO_2 capture using simulated and real flue gas

2. Advance ION's solvent and process technology to TRL 5 – real flue gas testing and ready for slipstream testing

Major Project Objectives

Phase 1

- Solvent development
- Lab pilot construction
- Simulation for NAOS

Phase 2a

- Improved solvent development
- Expand operating conditions in lab pilot
- Validated NAOS simulations
- Establish solvent performance potential
- Preliminary economic analysis at scale

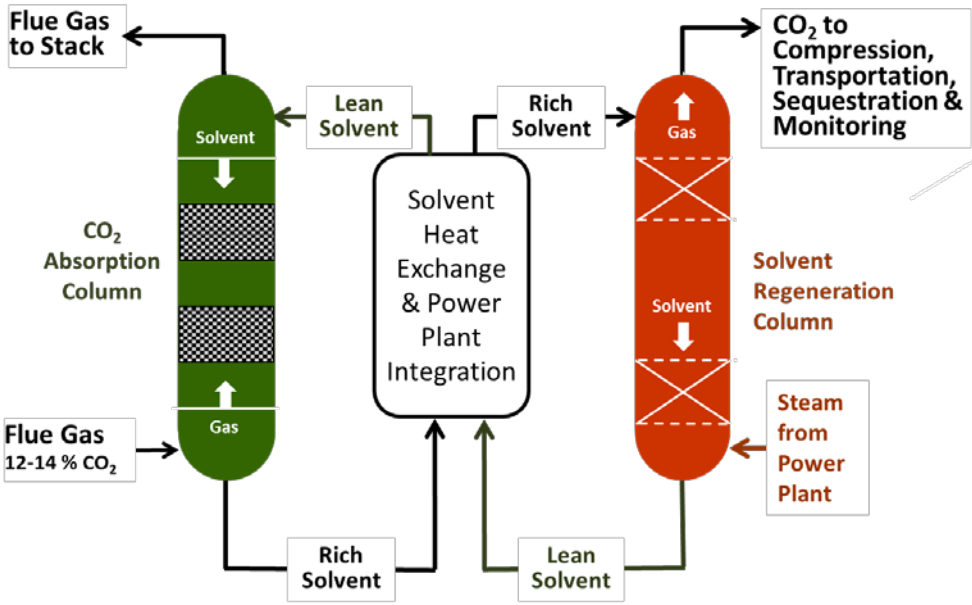
Phase 2b

- Advanced solvent development
- Testing with real flue gas at EERC
- Benchmark to aqueous – MEA and others
- Complete technology evaluation and economic analyses at scale

ION Solvent Technology

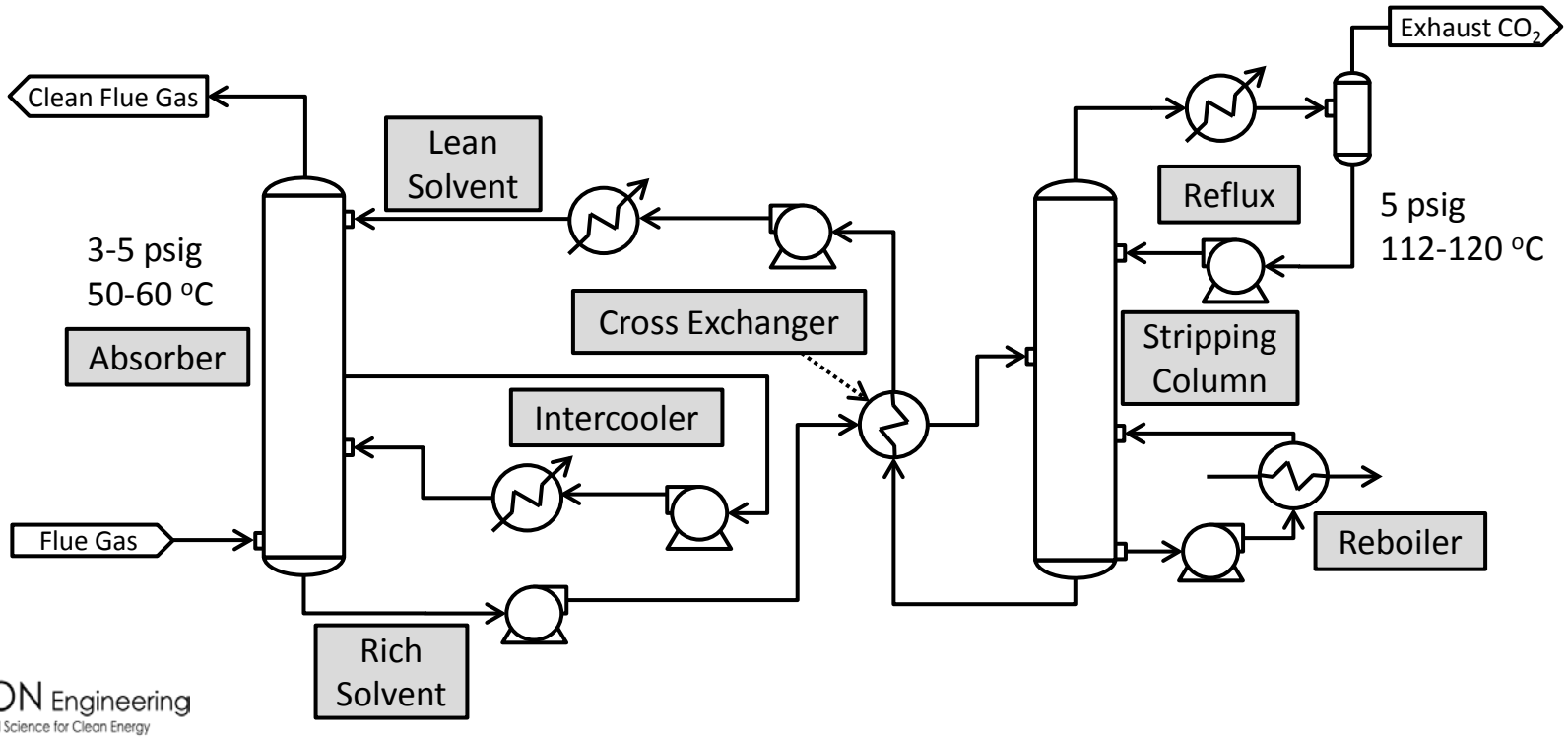
2nd Gen CCS Solvents

- Replace H_2O with tailored, organic solvents
  - Low volatility
  - Improved CO_2 solubility
  - Improved regeneration energy
- **Replacement** for 1st generation aqueous amine solvent systems



ION's NAOS Used in Conventional CO_2 Capture Processes

- ION solvent will be used in conventional aqueous amine processes
  - Stripping column solvent regeneration



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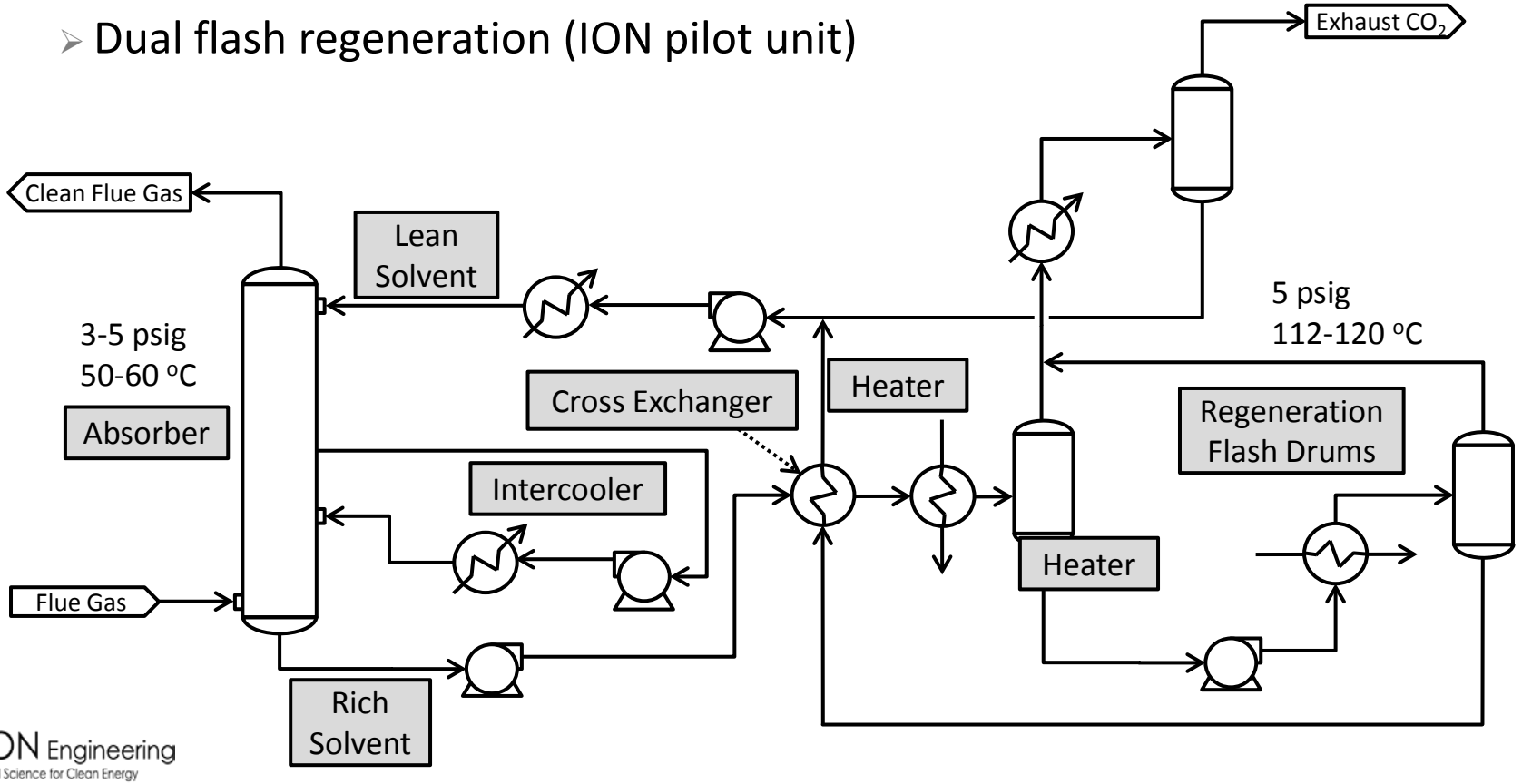
  - Dual flash regeneration (ION pilot unit)



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Implementing ION's Solvent Technology

Advantages of ION Solvent

- Improved separation performance
- Lower regeneration energy
- Minimal water use
- Solvent properties readily tailored
- Solvent can be refilled/retrofitted into existing CC units
- Solvent can be used with non-conventional separation technologies

Key Challenges Moving Forward

- Validate heat duty with real flue gas
- Validate solvent lifetime with real flue gas
- Reduce regeneration energy/optimize solvent capture performance
- **Mitigate project risk through slip-stream testing**
- **Improve solvent performance & drive down COE**

ION R&D Approach and Capabilities

Bench Scale Measurements and Improving Solvent Performance

- Vapor-liquid equilibrium
  - Vapor pressure data
  - CO_2 loading data
- Calorimeter
  - Heat of reaction measurement
- GC/MS
  - Solvent degradation analysis
- Fully equipped synthesis hood
  - Development of functional amines and physical solvents

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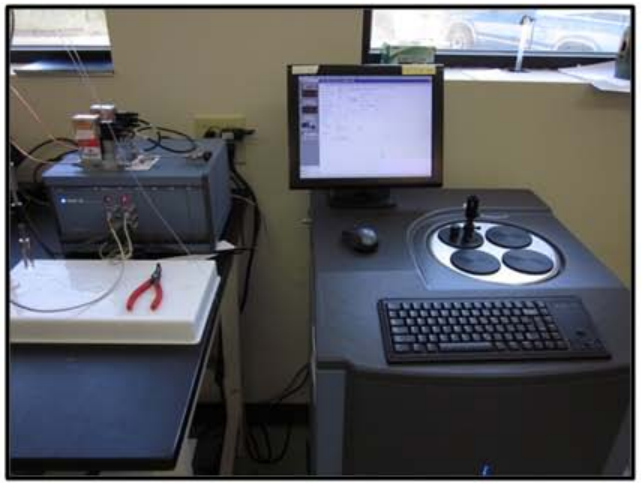

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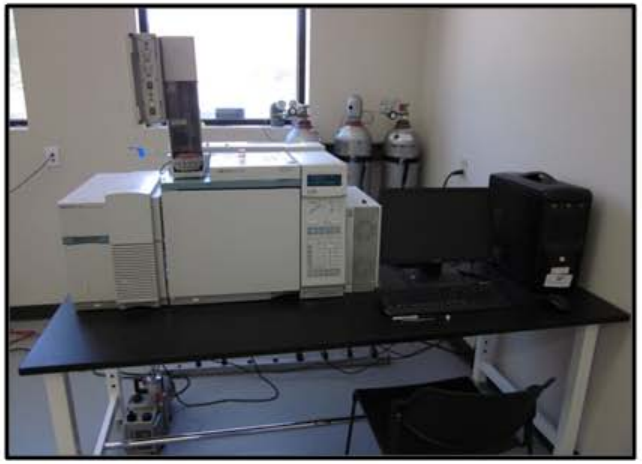

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Used to develop ASPEN+ process simulation

- Model a wide range of operating conds.
- Predict heat duties
- **Investigate process performance of new solvents –amine mixtures**

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Next gen solvent development

- Keeps ION technology competitive
- **Driving toward improved performance**

ION Pilot Unit Operation and Capability

- ION's Pilot Unit
  - 22' x 3" Absorber column
  - 10' Structured packing
  - Dual flash regeneration
  - Simulated flue Gas: $CO_2/N_2/H_2O$
  - Up to 180 SLPM gas flow
  - Up to 12 gph liquid flow

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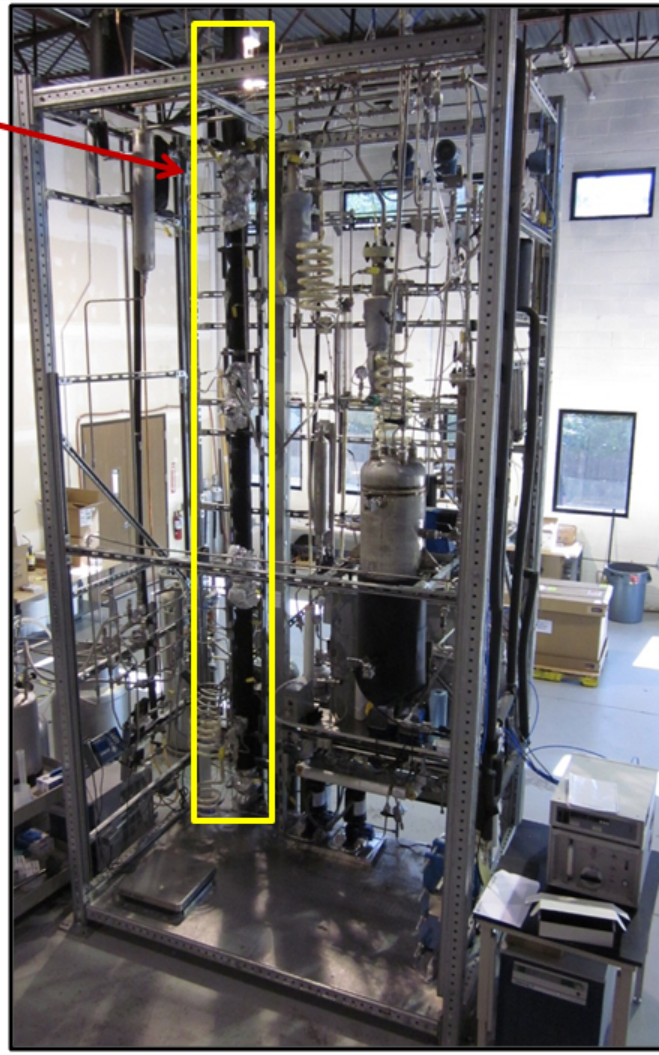
Absorber Column



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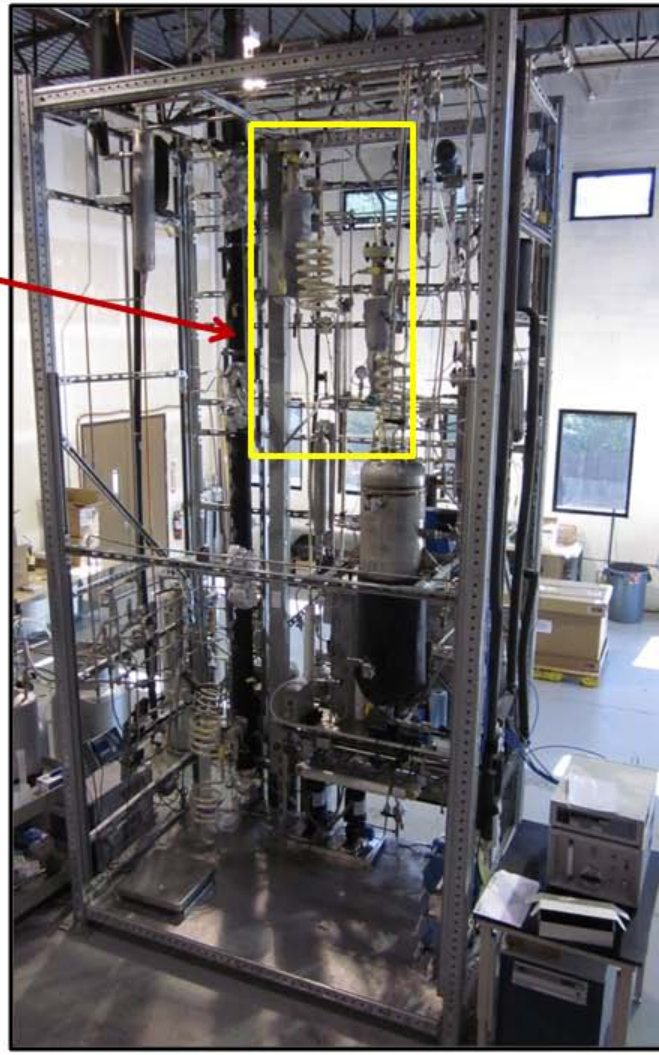
Dual Flash Regeneration



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- Mass Balance Analytics
  - Total Inorganic Carbon (TIC)
  - Karl Fischer titrator
  - CO_2 Analyzer

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  - 10' Structured packing
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  - Simulated flue Gas: $CO_2/N_2/H_2O$
  - Up to 180 SLPM gas flow
  - Up to 12 gph liquid flow
- **Validation & improvement of Aspen+ model**
  - **Scaled process simulations**
  - **Risk mitigation**

Expansion of ION Pilot Unit Capabilities

- Pilot Unit Upgrades
  - Improved mass balance closure (±2%)
  - Wider operational range
  - Increased process robustness

Improved Liquid Flow Metering

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Enhanced Liquid Flow Capacity

Expansion of ION Pilot Unit Capabilities

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Increased Flash Temperature Range

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Expansion of ION Pilot Unit Capabilities

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Improved Water Management

Expansion of ION Pilot Unit Capabilities

- Pilot Unit Upgrades
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  - Increased process robustness

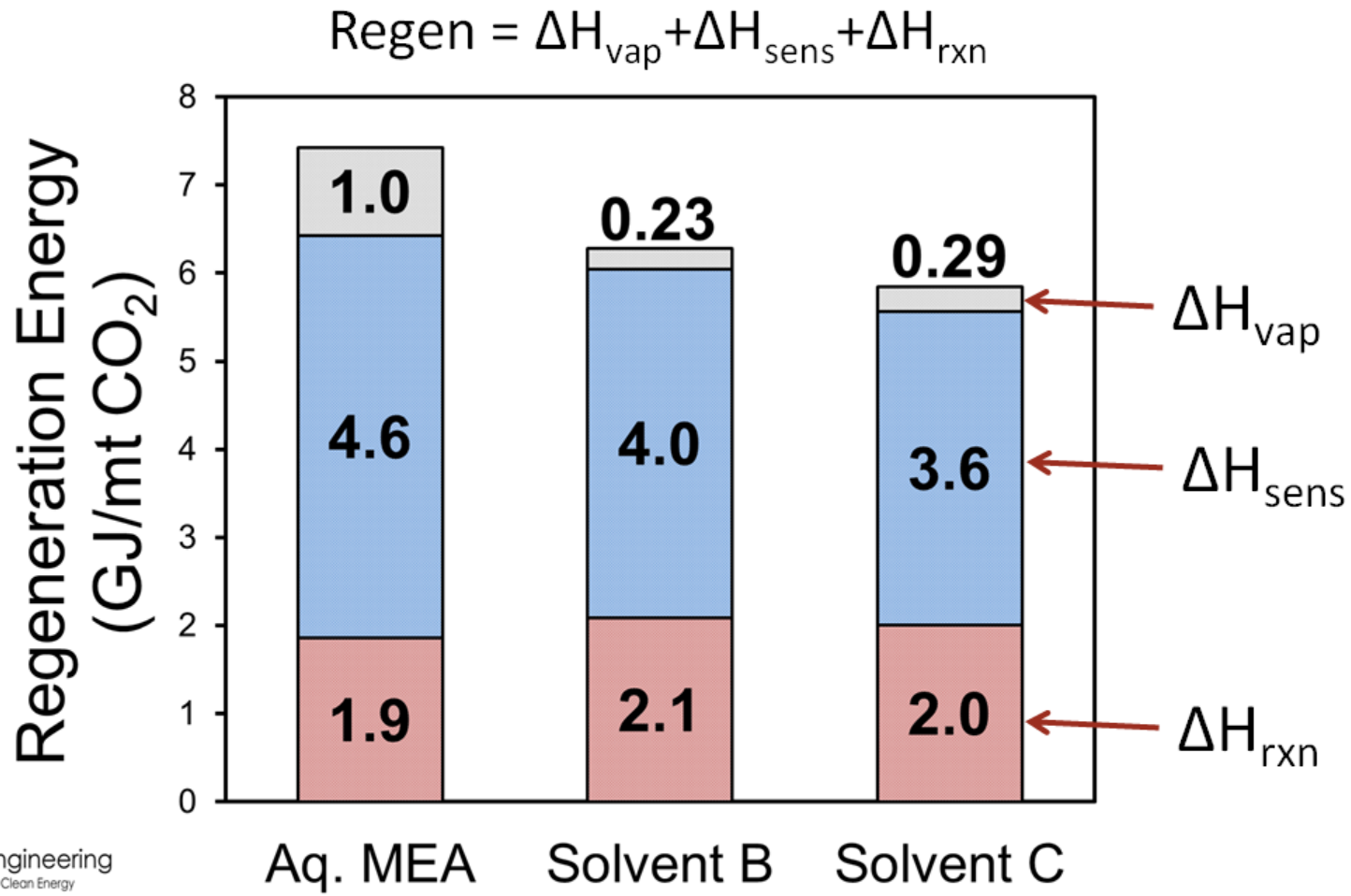
Improved Gas Flow Metering

Expansion of ION Pilot Unit Capabilities

- Pilot Unit Upgrades
  - Improved mass balance closure (±2%)
  - Wider operational range
  - Increased process robustness
- Additional Upgrades:
  - Organic/light gas GC for improved gas phase analytics
  - Stripping column for rigorous solvent evaluation

ION Solvent Performance and Benchmarking

Regeneration Energy: ASPEN+ Predictions – Coal Conditions



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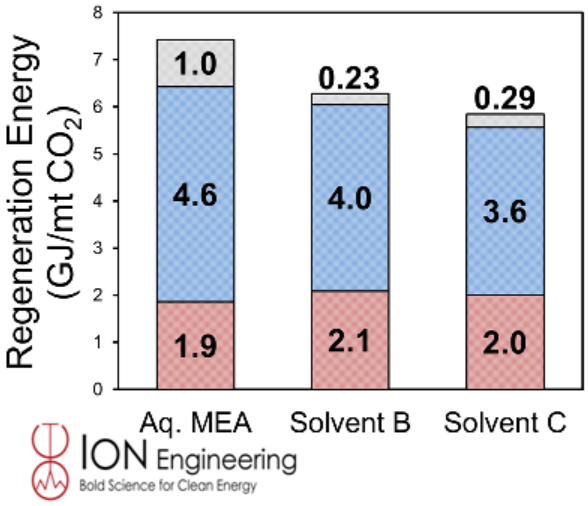

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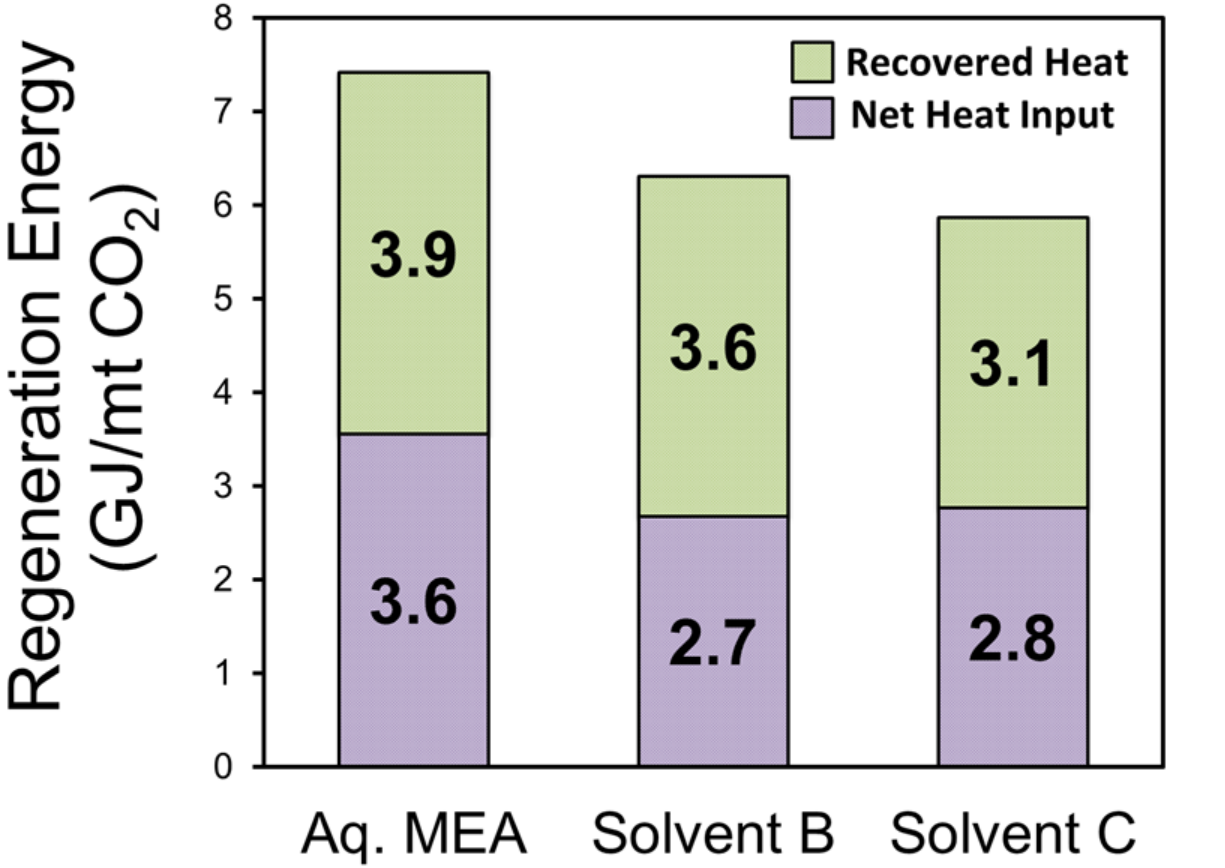
Regen = Net Heat Input + Recovered Heat



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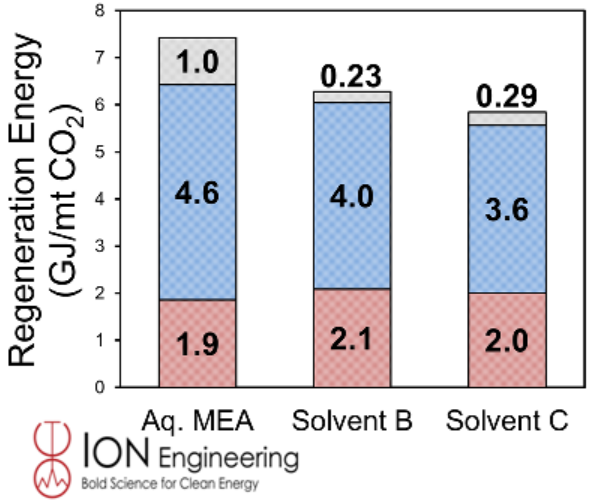

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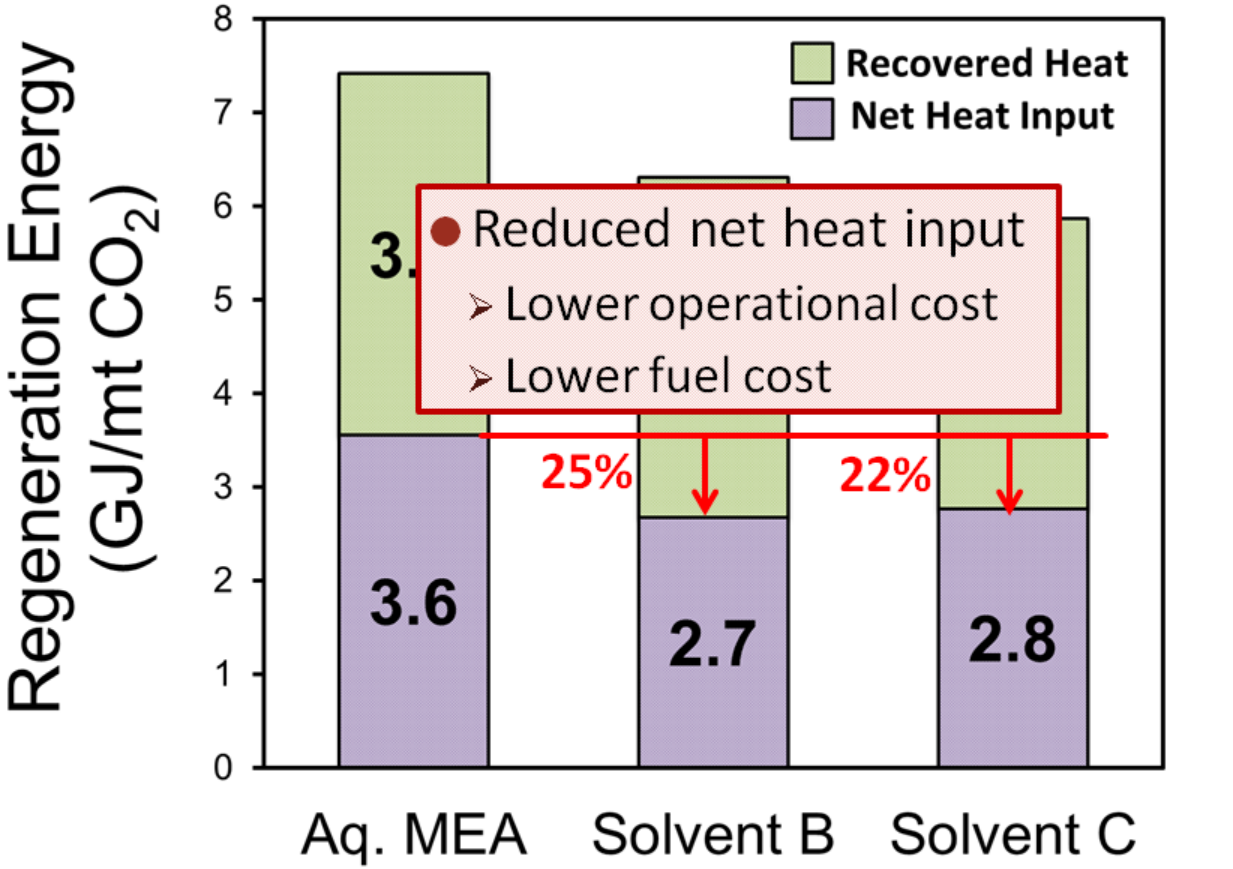


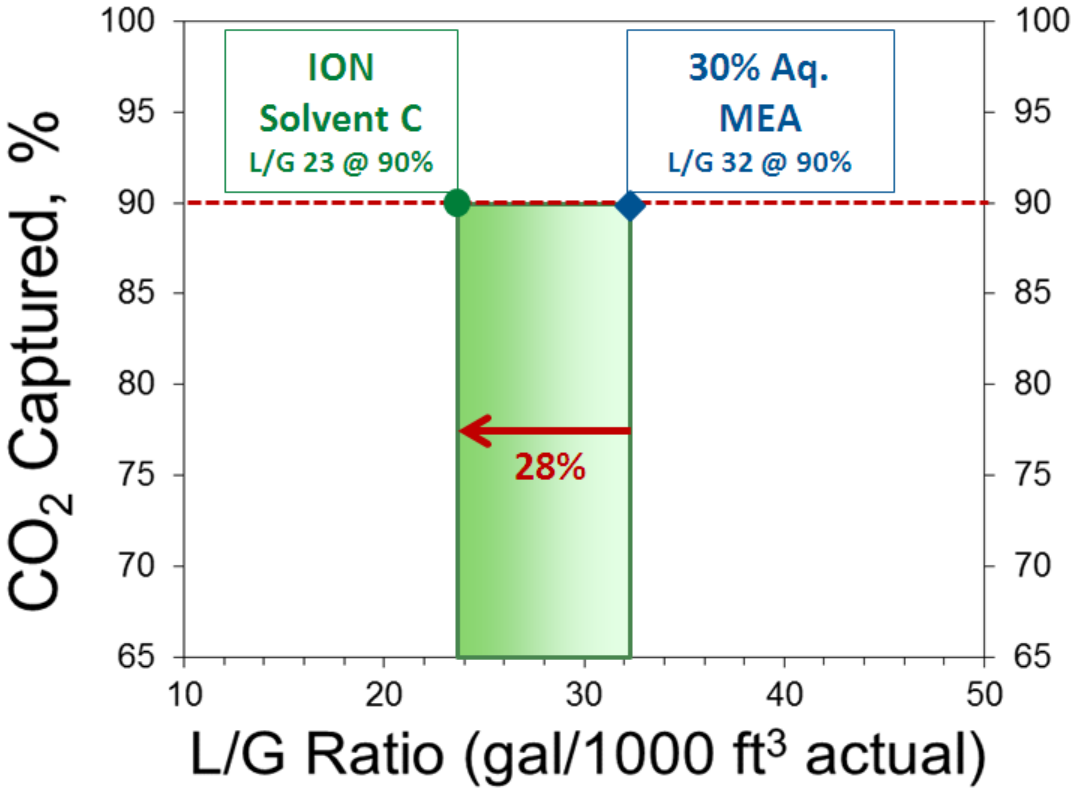
CO_2 Capture Efficiency

Leveraging Combined Solvent Properties for

Efficient CO_2 Capture

- L/G @ 90% CO_2 capture
  - Solvent circulation rate
  - Capital costs
  - Operating Costs

Solvent	Carrying Capacity (mol CO_2/gal)
Aq. MEA	3.6
ION C	4.8



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ION's Value Proposition

Demonstrated reduction of ***Latent Heats*** is possible with ***Advanced Physical Solvents***

- Tailored physical and chemical solvent mixtures
  - Lower regeneration energy **<** ***Operating costs***
  - Higher CO_2 carrying capacity **<** ***Capital costs***
- 2nd generation CO_2 capture solvents that
  - ***Retrofit existing plants*** and
  - ***Refill 1st gen CCS facilities***
- ***Economic*** removal of CO_2 from coal and natural gas fired flue gas

The next 12 months at ION

- Solvent development activities – ongoing
- Process simulations & Lab pilot
  - Validate predictive ability for scale-up
  - Expand operating conditions, optimize process
- EERC solvent testing, performance validation & benchmarking
- Prepare to initiate Slipstream Project – Q3/Q4 2013

EERC Test Campaigns Planned for 2012/2013

ION Testing Program at EERC

- Directly measure performance in coal and natural gas environments
- Solvent and process optimization in real flue gas environments

EERC CTF Facilities

- 550,000 Btu/hr (O.2 MW) multi-fuel capability
- Highly instrumented CO_2 capture facility, adjustable absorber & stripper columns, variable packing materials

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ION's Technology Development Timeline

Initiate 1-5 MW Slipstream Project in Q3/Q4 2013

- Identify potential partners
  - Host site
  - Engineering & Construction

- Partner commitments

- Finalize partner & contractor agreements

Q3 2012 | **Q4 2012** | **Q1 2013** | **Q2 2013** | **Q3 2013**

EERC Testing

- 0.2 MW operating data for flue gas
- Continue solvent & process optimization

Prepare for Slip Stream

- Preliminary design & costing for slipstream project
- Secure project funding

- Initiate slipstream project

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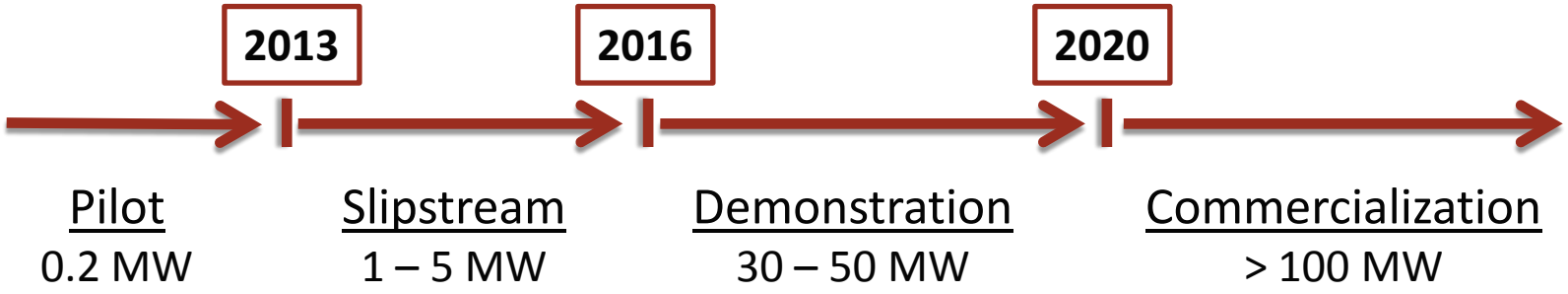
ION's CO_2 Capture Commercialization Timeline

Scale up & Demonstration of ION Technology to drive Economic CO_2 Capture for Coal and Natural Gas Fired Power Generation



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