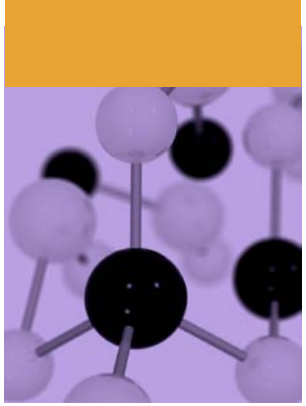
SRI International



Development of Mixed-Salt Technology for CO_2 Capture from Coal Power Plants

FE0012959

Presented By Indira S. Jayaweera
SRI International
CA, USA

2014 NETL CO_2 Capture Technology Meeting
July 28-August 1,
Pittsburgh PA

Project Goals

Overall Project Goal is to demonstrate that Mixed-Salt technology can capture CO_2 at a 90% efficiency and regenerate at 95% CO_2 purity at a cost of $40/tonne or less of CO_2 captured by 2025.

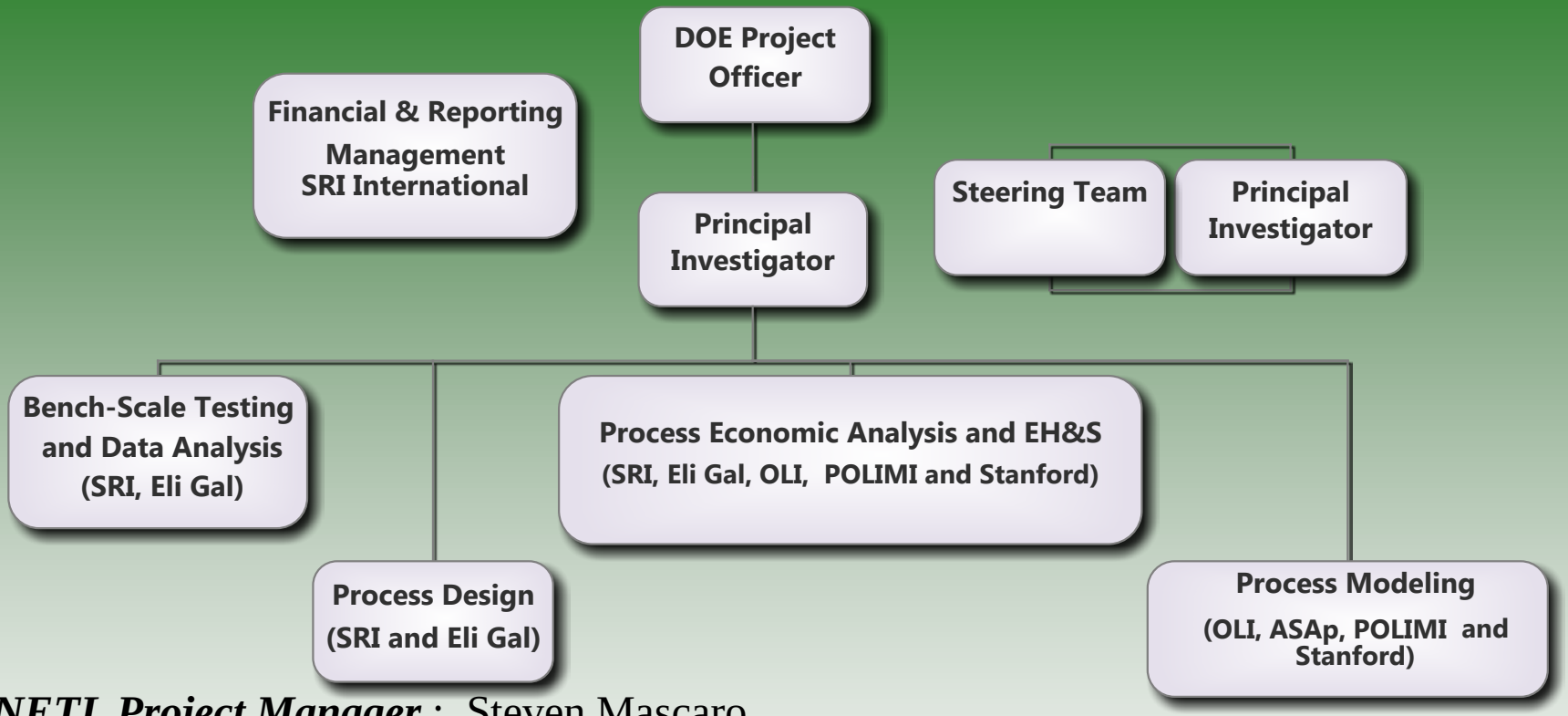
Budget Period 1:

- Demonstrate the absorber and regenerator processes individually with high efficiency and low NH_3 emission and reduced water use compared to the state-of-the-art ammonia-based technologies.

Budget Period 2:

- Demonstrate the high-pressure regeneration and integration of the absorber and the regenerator
- Demonstrate the complete CO_2 capture system with low cost production of CO_2 stream, optimize the system operation, and collect data to perform the detailed Techno-Economic analysis of CO_2 capture process integration to a full-scale power plant.

Project Team and Organization



NETL Project Manager : Steven Mascaro

Project Team and Technical Leaders

SRI- Indira Jayaweera; **OLI Systems** (OLI)- Andre Anderko; **Stanford University** - Adam Brant; **Aqueous Systems Aps** (ASAp)- Kaj Thomsen; **Politechnico De Milano** (POLIMI)- Gianluca Valenti; and Eli Gal

Project Budget

	Budget Period 1 10/1/13 - 12/30/14	**Budget Period 2** 1/1/15 - 3/31/16	**Total** 10/1/13-3/31/16
Total Project Cost	$1,019,650	$1,102,092	$2,121,742
DOE Share	$819,534	$878,113	$1,697,647
Cost-Share	$200,116	$223,979	$424,095

Cost Share by SRI, OLI Systems, POLIMI, Aqueous Solutions Aps, Stanford University IHI Corporation

Mixed-Salt Technology Facts and Benefits

Technology uses potassium and ammonium salts

- Uses inexpensive, industrially available material
- Requires no feed stream polishing
- No hazardous waste generation
- Has a potential for easy permitting from many localities
- Uses known processes engineering

Compound	MW (g)	Moles in kg of 30 wt.% solvent
MDEA	119	2.5
MEA	61	4.9
NH3 (20 wt.%)	17	8.8
K2CO3	138	2.2
Piperazine	86	3.5

NO SOLIDS

Enhanced capture rates

High CO_2 loading capacity

Produces clean CO_2 stream at high pressure → reduced compression costs

Reduced energy consumption compared to MEA

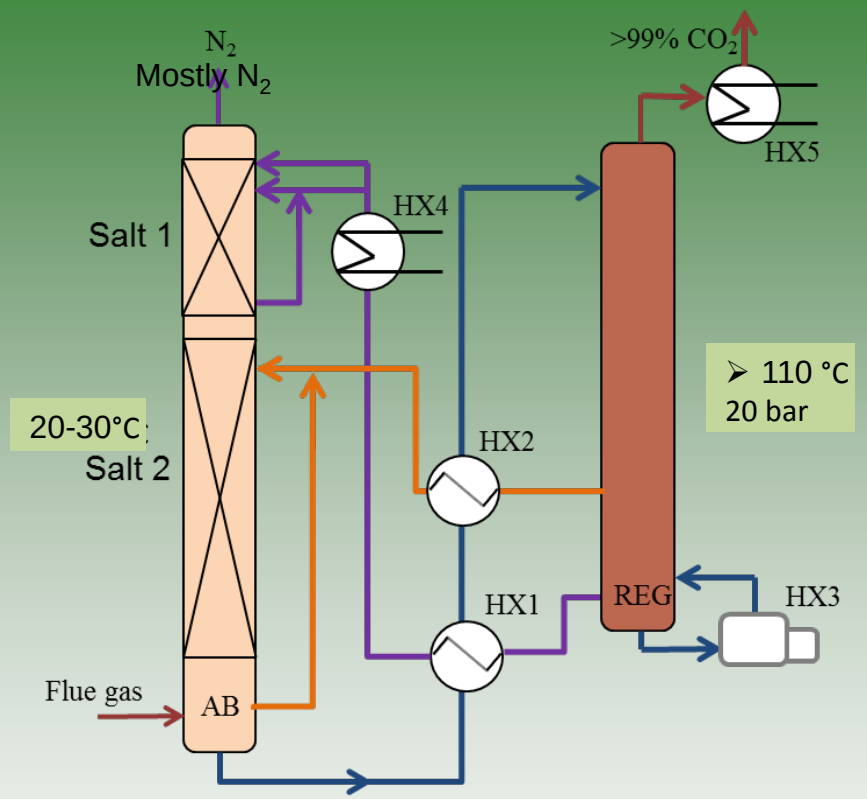
Reduced auxiliary electricity loads

Challenge:

Reduction of ammonia evaporation at higher reaction rates

Mixed-Salt Technology Process Conditions

- Process uses mixtures of potassium carbonate and ammonium salts
  - Dual absorber, and a selective regenerator
  - Heat of reaction 35 to 55 kJ/mol
- Absorber operation at 20° – 30°C at 1 atm with
  20-30 wt.% mixture of salts
- Regenerator operation at >110°C at 20-40 atm
  - Produce high pressure CO_2



CO_2 Lean

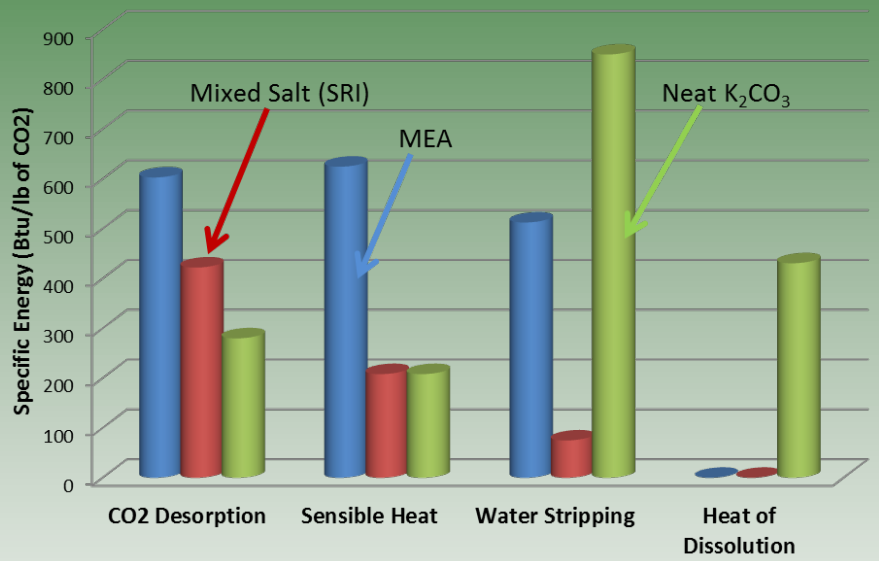
K_2CO_3–NH_3–xCO_2–H_2O system ←→ K_2CO_3 –NH_3–yCO_2–H2O system

CO_2 Rich

Where $y > x$

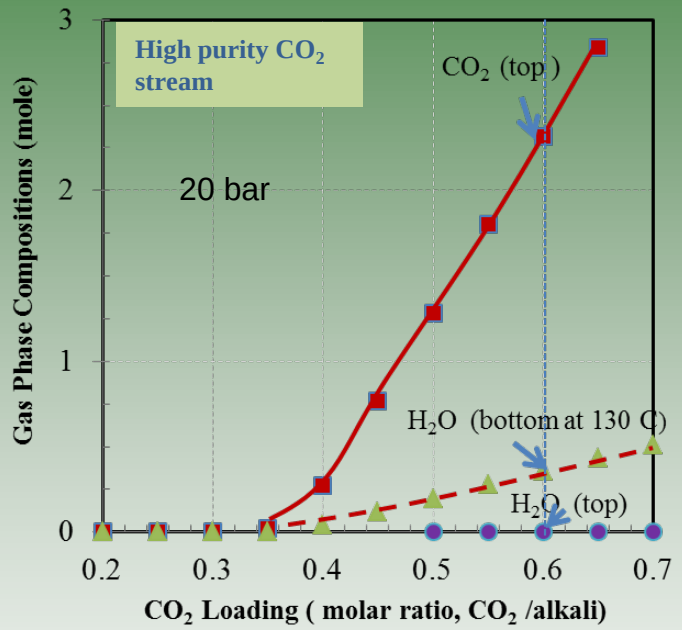
E.g., y= 6 and x= 3

Mixed-Salt: Reduced Energy Requirement for Solvent Regeneration



Estimated regenerator heat requirement for Mixed-Salt system with 0.2 to 0.6 cyclic CO_2 loading. Comparison with neat K_2CO_3 and MEA is shown

Sources: MEA Data: CSIRO Report (2012). EP116217
K_2CO_3 Data: GHGT-11; Schoon and Van Straelen (2011). TCCS-6
Mixed-Salt Data; SRI Modeling



Mixed-Salt process requires a minimal energy for water stripping

Mixed-Salt Development Time Line

Proof of Concept (6 *slph*)

2012

Small Bench-Scale Testing (50 *slpm* or 1.7 *acfm*)

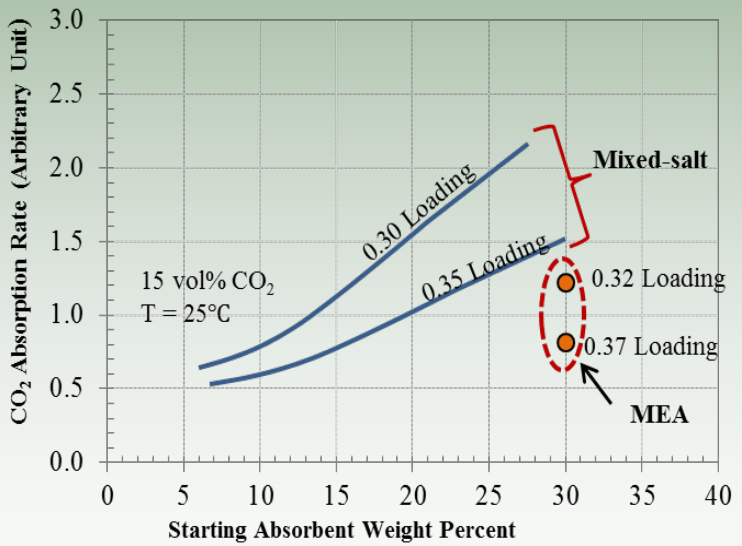
2013

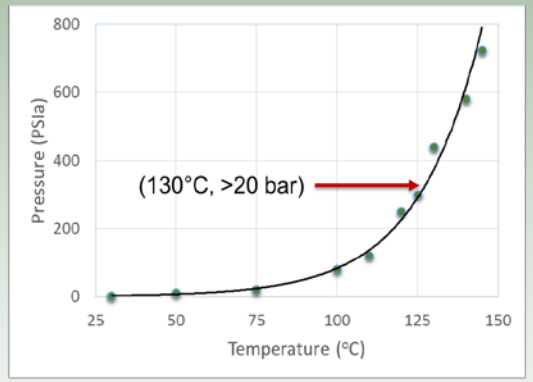
Current DOE Project

Large Bench-Scale Testing (>500 *slpm*)

10/2013 – 3/2016

Results from small bench-scale testing



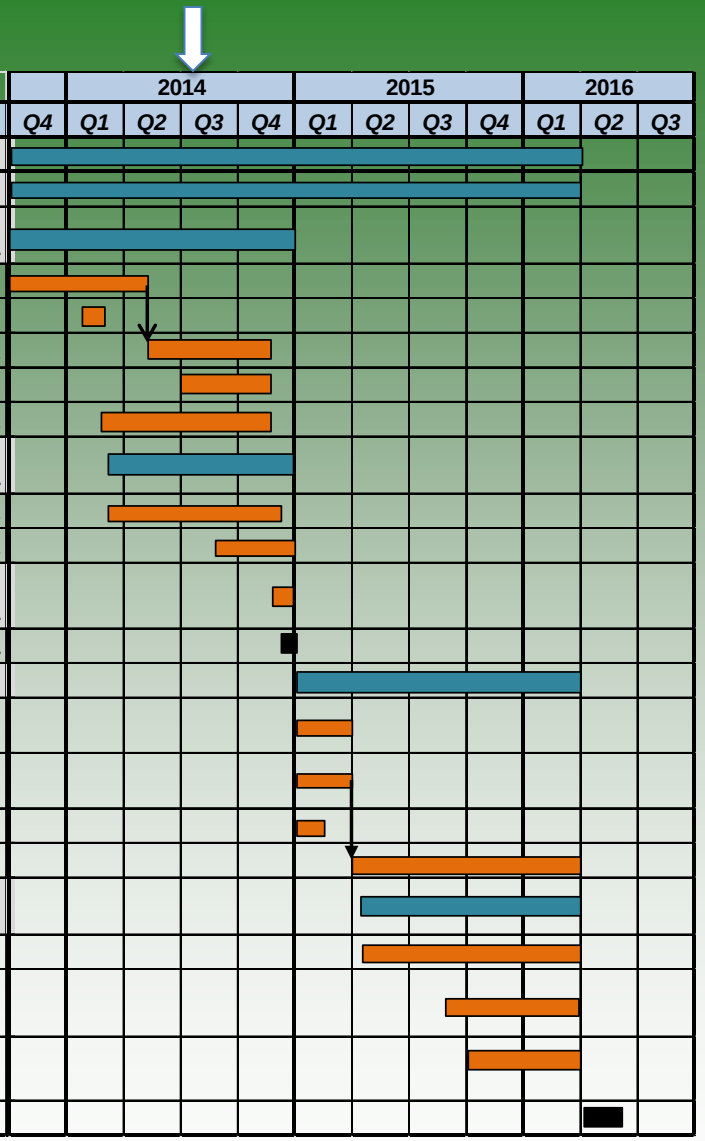


Attainable CO_2 pressure during solvent regeneration: Mixed-salt with CO_2 loading value of 0.6 CO_2/salt

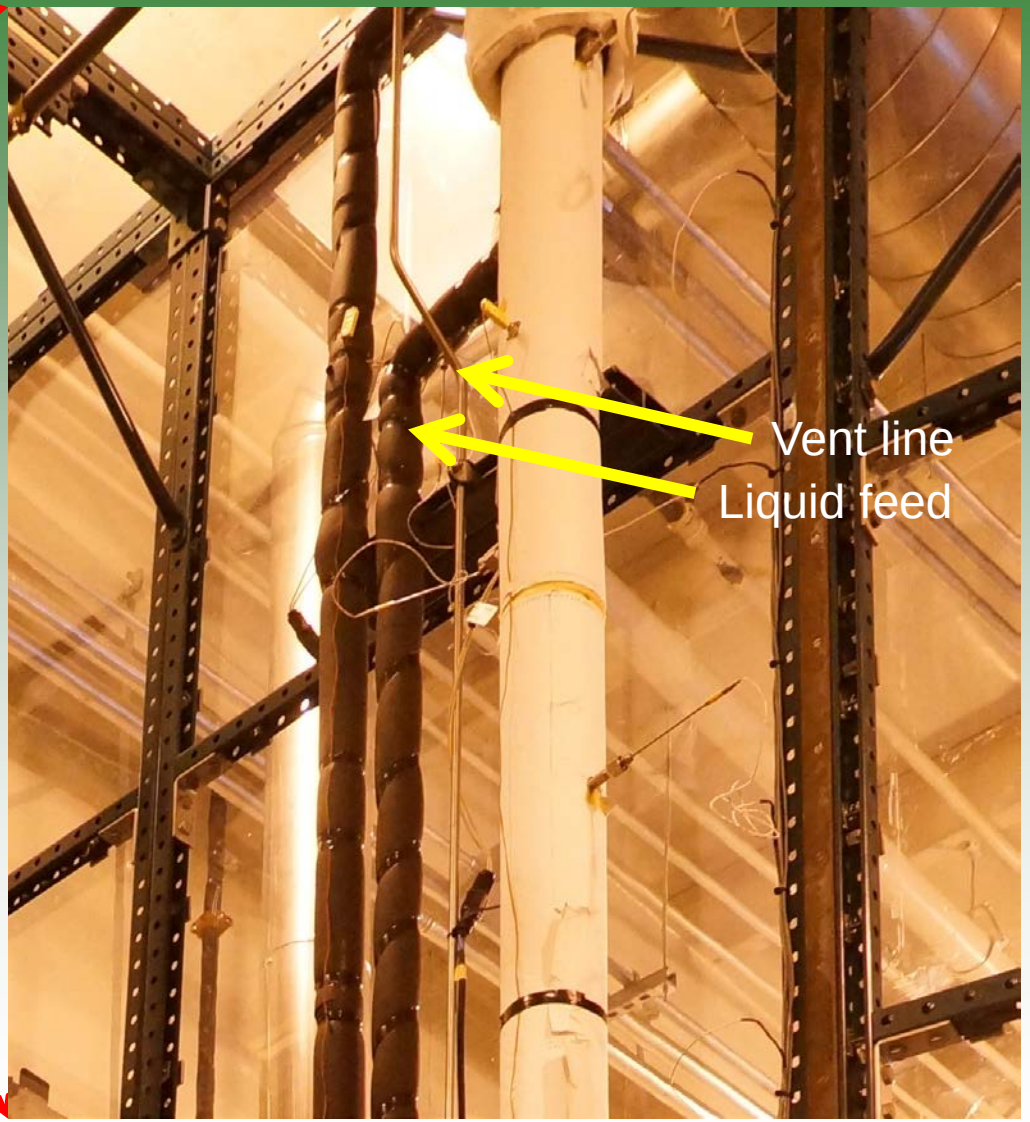
No thermal or oxidative degradation of mixed-salts in the regenerator.

DOE Project Schedule

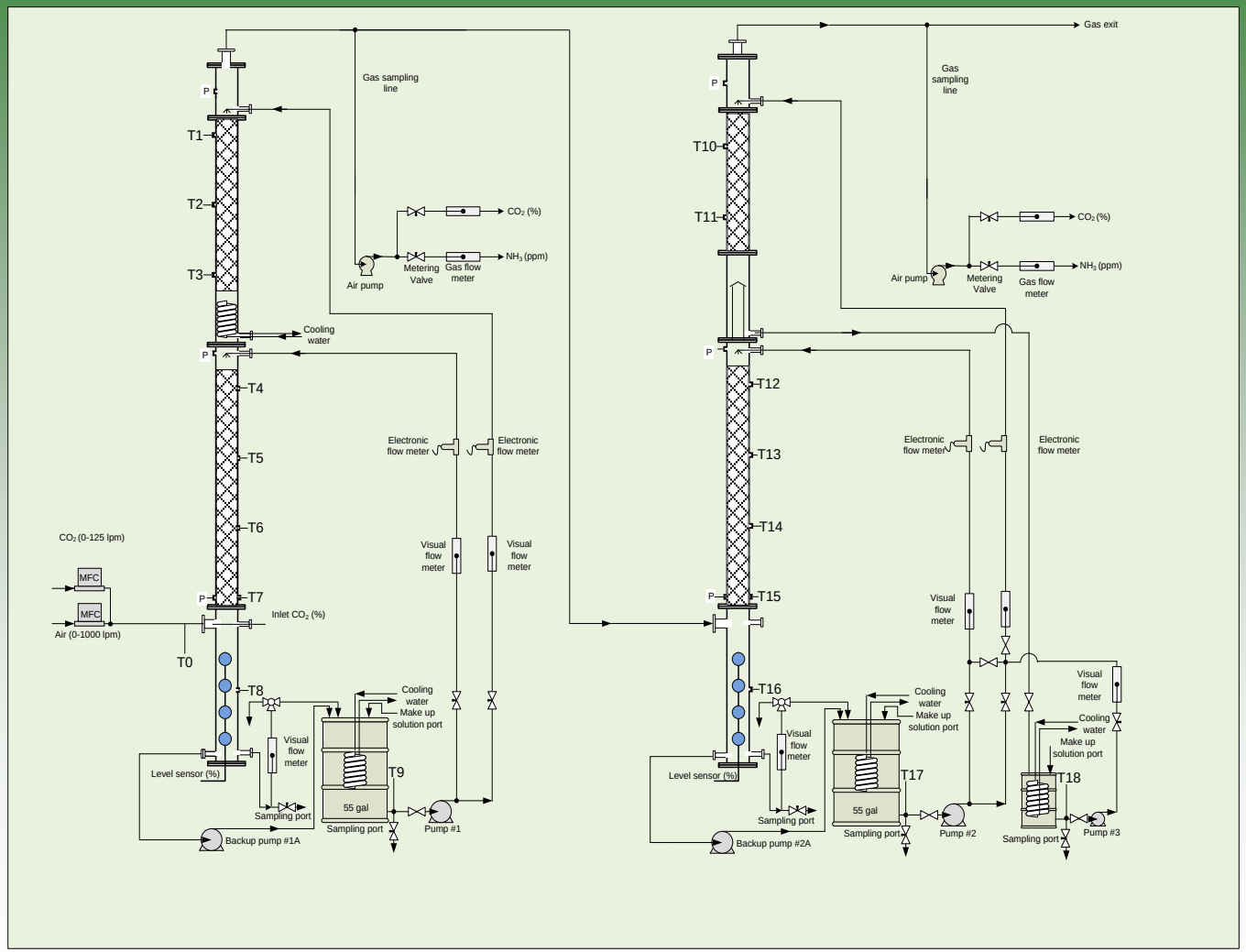
Task	Start Date	End Date
Mixed-Salt BP1 and BP2	**10/1/2013**	**3/31/2016**
Task 1.0 - Project Management and Planning	**10/1/2013**	**3/31/2016**
Task 2-0: Individual Absorber and Regenerator Testing in Semi-Continuous mode	**10/1/2013**	**11/30/2014**
Subtask 2.1 - Test Systems Design and Installation	10/1/2013	4/28/2014
Subtask 2.2 - Test Plans	2/1/2013	2/30/2014
Subtask 2.3 - Absorber Tests	4/30/2014	11/30/2014
Subtask 2.4 - Regenerator Tests	7/1/2014	11/3/2014
Subtask 2.5 - Bench-Scale Test Data Analysis	2/28/2014	11/30/2014
Task 3.0 - Preliminary Process Modeling and Techno-Economic Analysis	**3/1/2014**	**12/15/2014**
Subtask 3.1 - Process Modeling	3/1/2014	11/30/2014
Subtask 3.2 - Preliminary Economic Analysis	8/1/2014	12/15/2014
Task 4.0 - Budget Period 2 Continuation Application	**12/1/2014**	**12/30/2014**
Continuation Report Submission	**12/30/2014**	**12/30/2014**
Task 5.0 - Bench-Scale Integrated System Testing	**1/15/2015**	**3/31/2016**
Subtask 5.1 - Design of the Bench-Scale Integrated Test System	1/15/2015	3/31/2015
Subtask 5.2 - Installation of the Bench-Scale Continuous, Integrated Test System	1/15/2015	3/31/2015
Subtask 5.3 - Bench-Scale Test Plans	1/15/2015	2/15/2015
Subtask 5.4 - Bench-Scale Tests and Data Analysis	4/1/2015	3/31/2016
Task 6.0 - Process Modeling and Techno-Economic Analysis	**5/1/2015**	**3/31/2016**
Subtask 6.1 - Process Modeling	5/1/2015	3/1/2016
Subtask 6.2-Techno-Economic Analysis	8/1/2015	3/30/2016
Subtask 6.3- Technology EH&S Risk Assesment	9/1/2015	3/30/2016
Final Report Submission	**4/30/2016**	**5/30/2016**



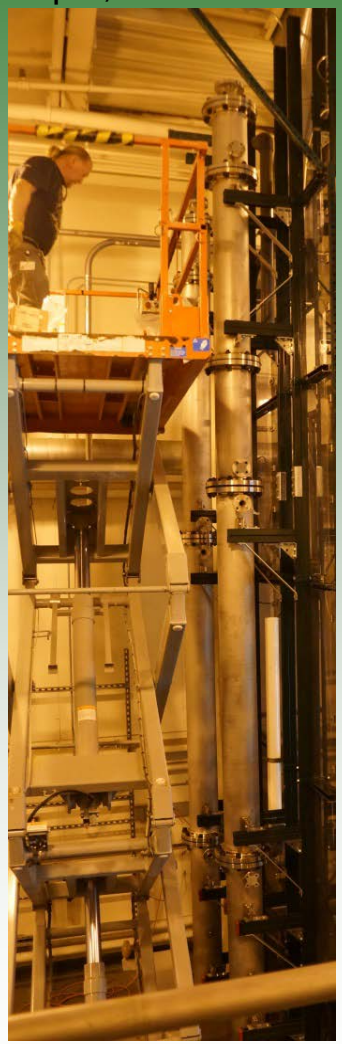
Regenerator System



Schematic of the Absorber System



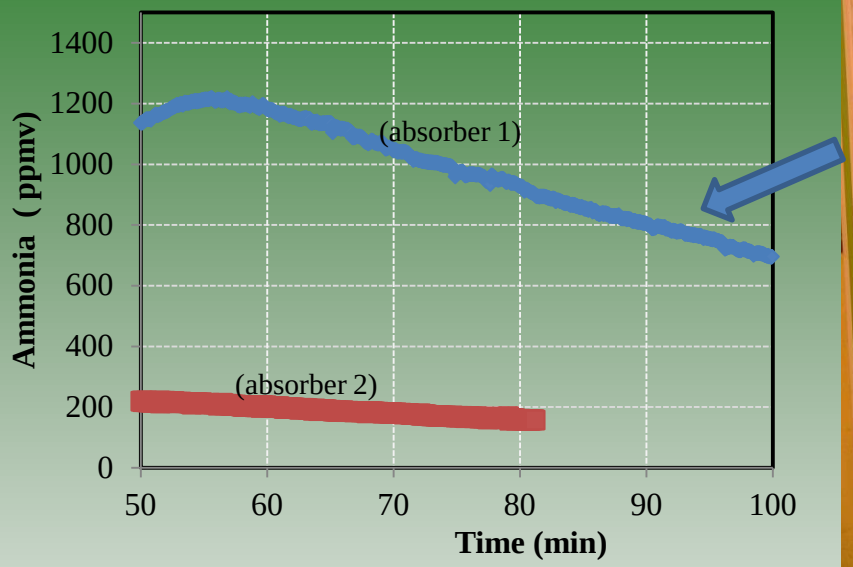
April, 2014

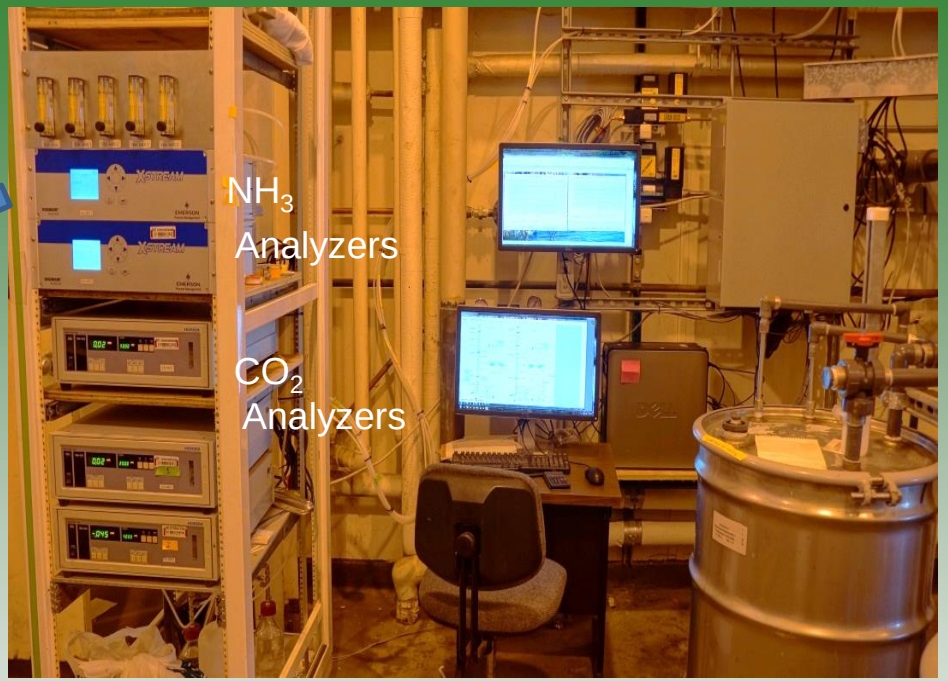


Photographs of the Completed System

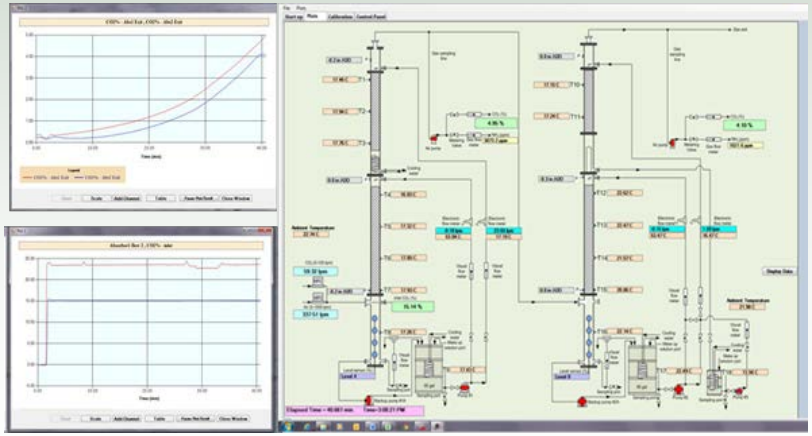
Mixed-Salt System
Commissioned on
May 29, 2014

Process Control And Monitoring



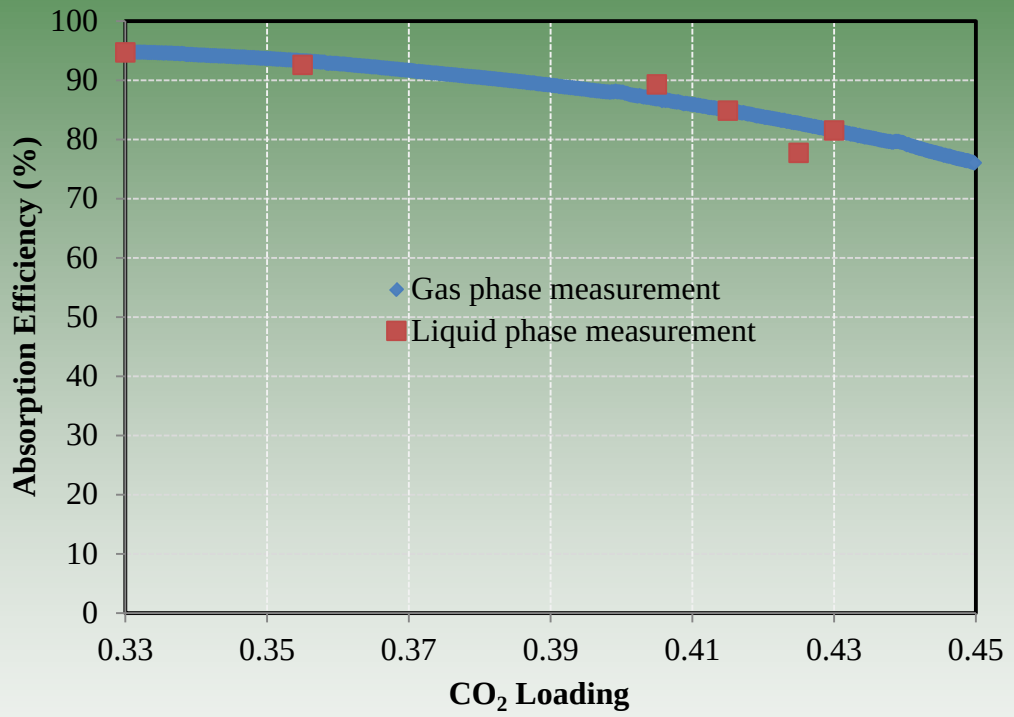


Data acquisition and control hardware interface

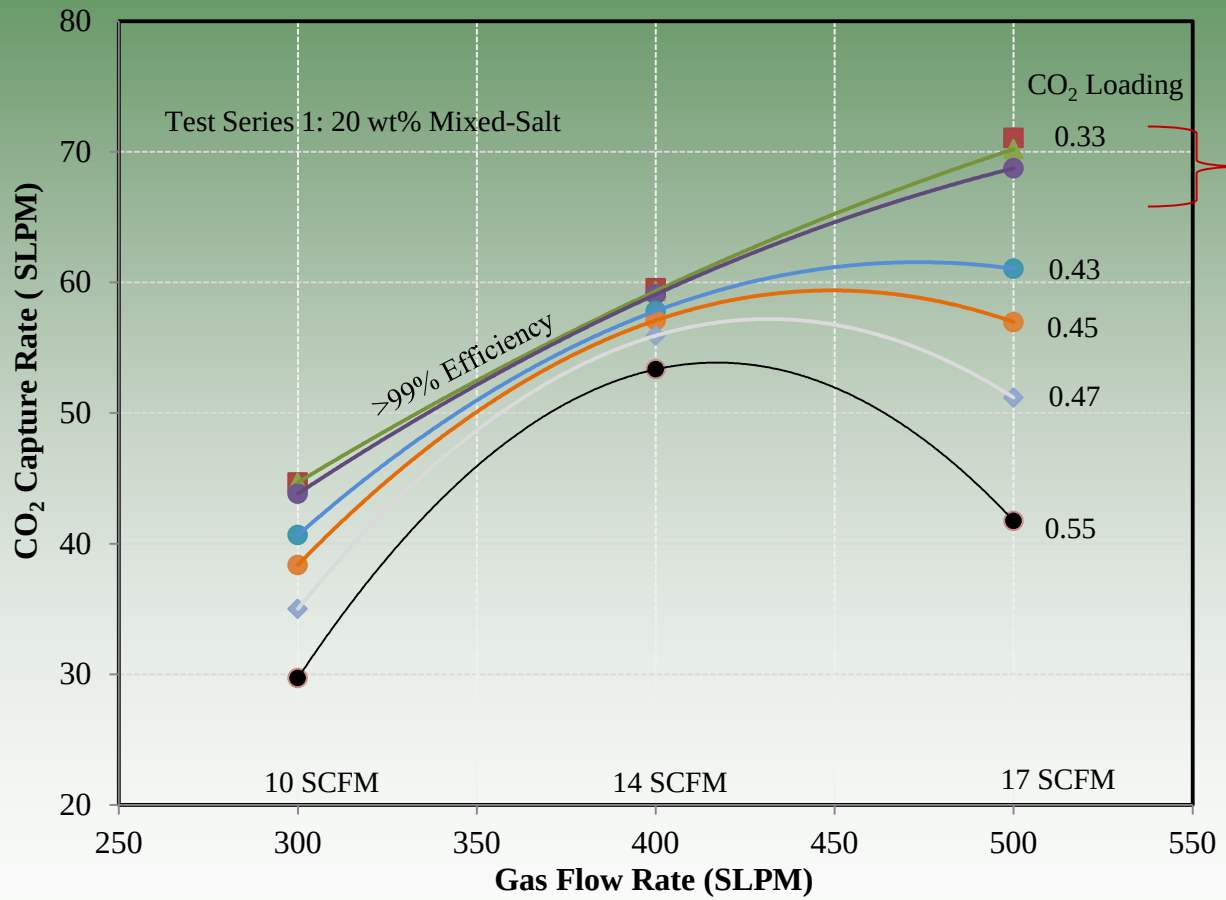


Online data monitoring

Absorber Data with 20 wt% Mixed-salt at 20ºC: Mass Balance



Absorber Data with 20 wt% Mixed-salt at 20ºC: CO_2 Capture Rate



Achieved equilibrium capture rates

Parametric Testing

⇓

Rate Based Model Development

⇓

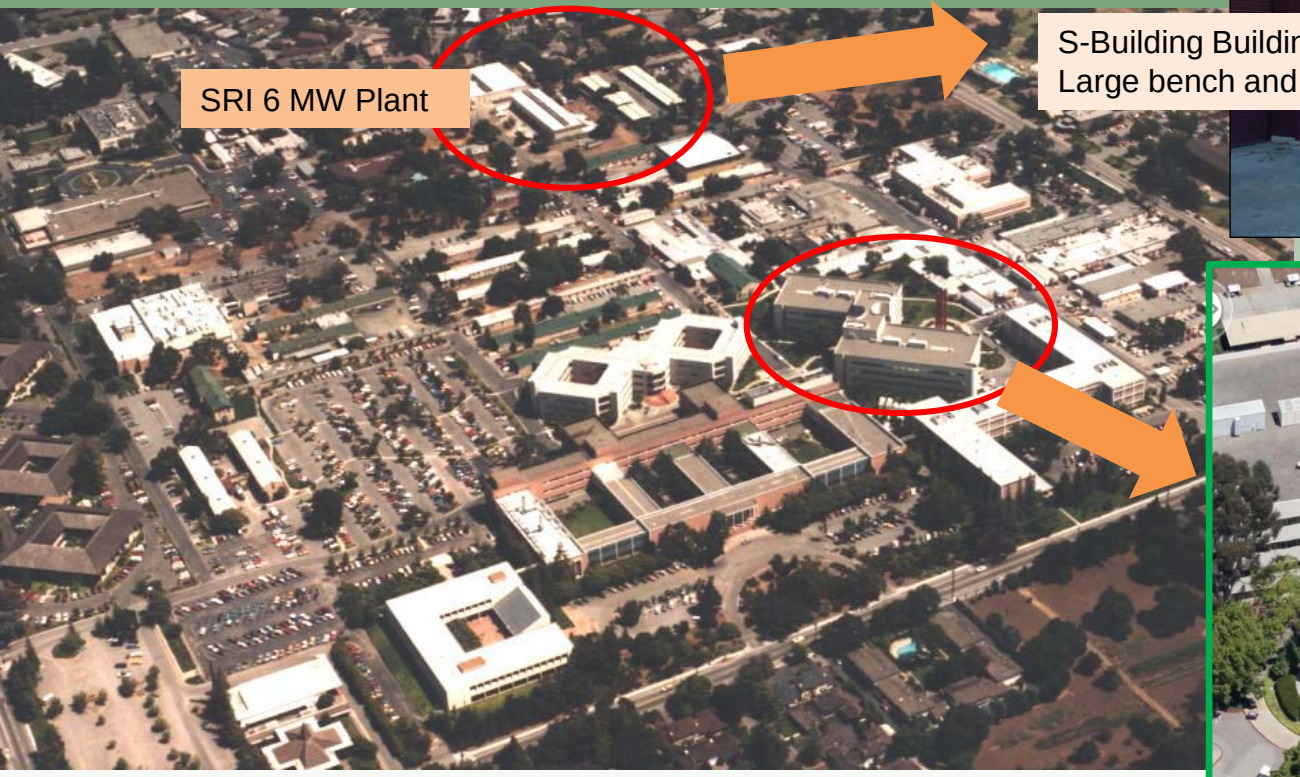
Techno Economic Analysis

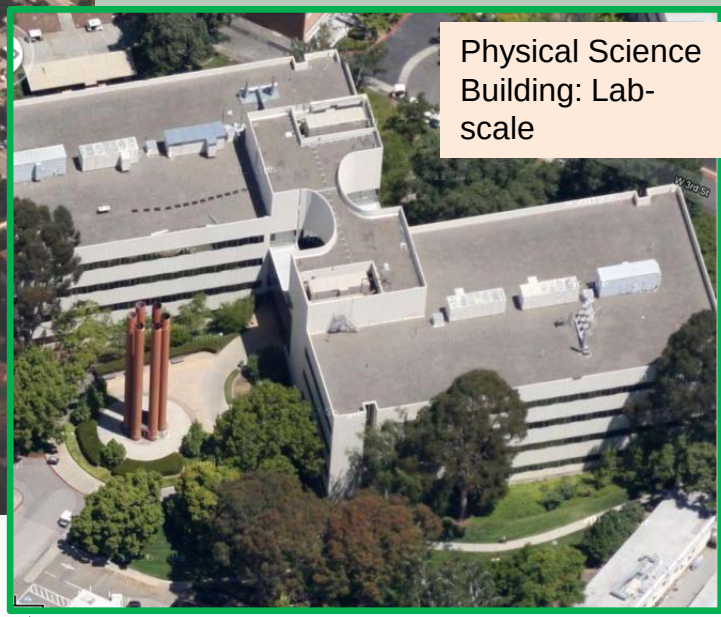
Project Status as of July 15, 3014

- Program Management Plan Updated
- Design and Installation of Absorber Completed
- Regenerator modification and Installation Completed
- Absorber Testing in progress
- Modeling:
  - VLE model update for K_2CO_3-NH_3-CO_2-H_2O completed
  - Power cycle integration for reference plant completed (good agreement with NETL model)

Project Location

S-Building Building:
Large bench and mini-pilot





Physical Science Building: Lab-scale

SRI's site in Menlo Park, CA (~ 65 acres)
SRI also has a test site near Livermore, CA (480 acres)

Acknowledgements

- NETL: Steven Mascaro and Lynn Brickett
- SRI Staff:
  - Palitha Jayaweera, Regina Elmore, Jianer Bao; Srinivas Bhamidi, Bill Olsen, Robert Bell, David Thibert, Paul Zuanich, Gopala Krishnan, Marcy Berding, Kelli Connolly, Karen Withington.
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- Consultant:
  - Eli Gal

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