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Slipstream Development & Testing of Post-Combustion CO2 Capture and Separation Technology for Existing Coal-Fired Plants

2.5 MWe Slipstream at TECO’s Big Bend Station utilizing Siemens Amino Acid Salt (AAS) Solvent

NETL CO2 Capture Technology Meeting
DOE/NETL PM: Dave Lang

Sampling of Siemens Product Markets

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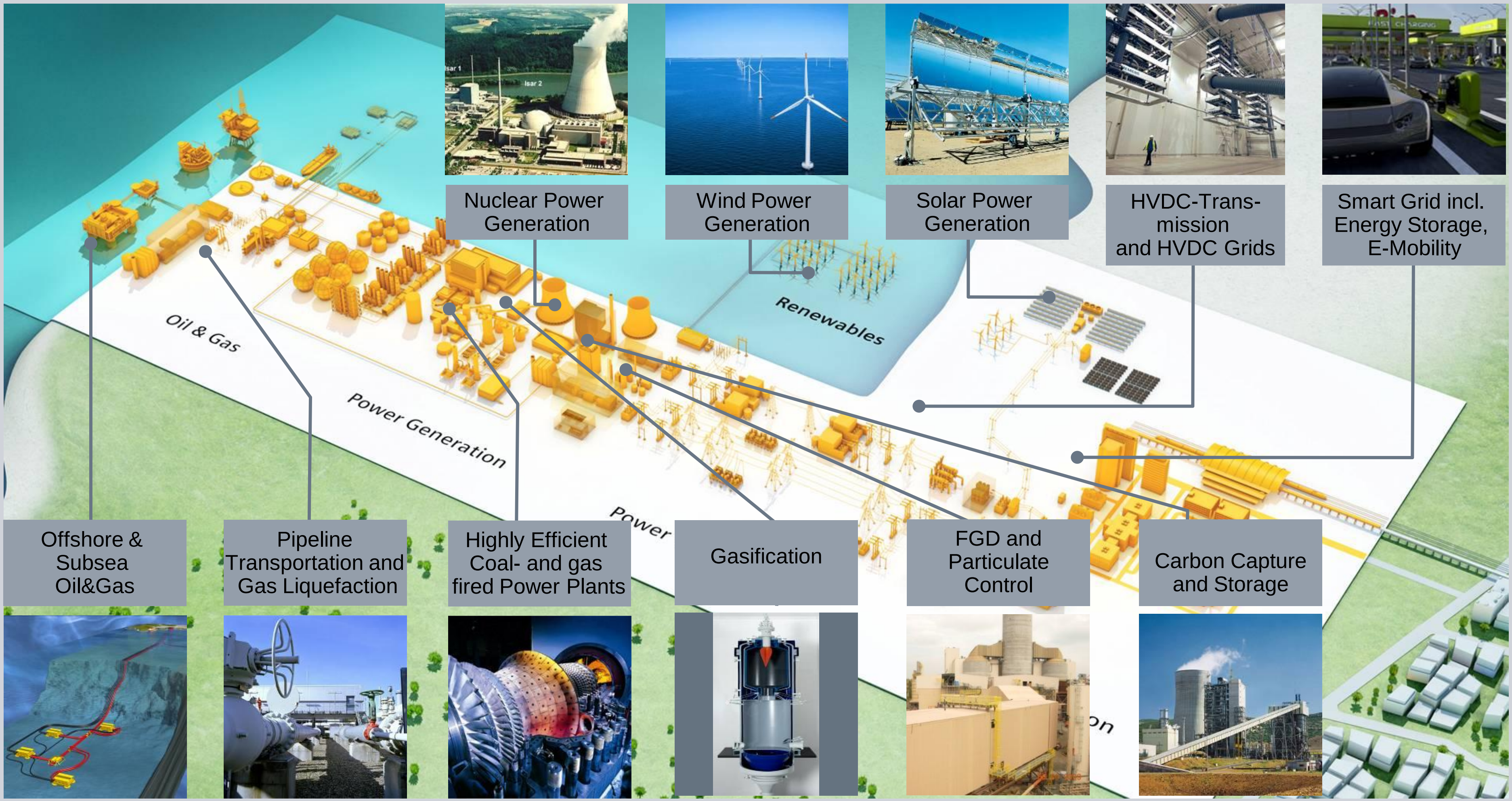

Project Overview – Project Participants

Tampa Electric – Host Site Provider, Big Bend Plant

DOE NETL – Project Sponsor / Awarding Agency

Siemens – Technology, Equipment, and Installation provider. Co-Sponsor

Project Overview – Overall Project Performance Dates

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Activity	
Kick-off	October 1, 2010
Phase 1 – Process Design	October 1, 2010 – July 31, 2011
Phase 2 – Procurement & Erection	Aug 1, 2011 – Aug 31, 2012
Phase 3 – Operation & Testing	Sept 1, 2012 – Jul 1, 2013
Issue Final Report (draft)	Jul 31, 2013

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Project Overview - Funding

	Budget Period 1 Process Design Oct 2010 – Jul 2011		Budget Period 2 Procurement & Erection Aug 2011 – Aug 2012		Budget Period 3 Operation & Testing Sep 2012 – Oct 2013	
	DOE share	Siemens share	DOE share	Siemens share	DOE share	Siemens share
Split (80/20) over 13 qtrs	$1,411 K	$353 K	$10,580 K	$2,645 K	$3,008 K	$752 K
DOE Project Total						**$15,000 K**
Siemens Project Total						**$3,750 K**

Project Objectives

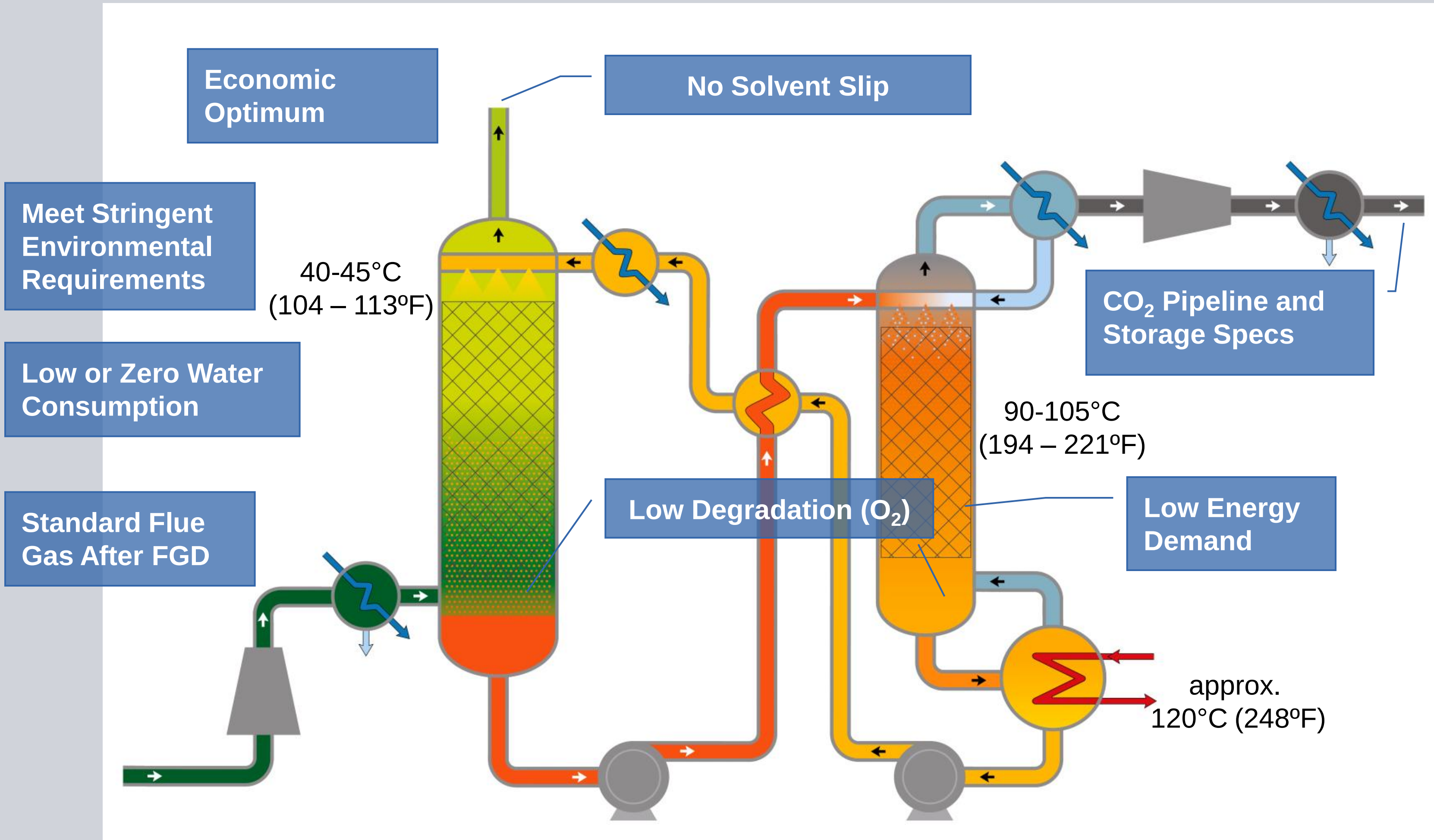
- Demonstrate the ability of POSTCAP technology to achieve 90% CO_2 removal and approach a 35% increase of cost of electricity produced.

  - **AAS technology can reach 90% CO_2 removal**
  - **Challenge of approaching 35% increase in COE**

- Demonstrate the scalability and feasibility of progressing the POSTCAP technology to full-scale commercial application (550 MW) on post-combustion CO_2 capture for coal fired power plants and to full-scale commercial application for industrial sources of CO_2 emissions.

  - **Proving scalability**
  - **Proving feasibility**

Technology Fundamentals



Technology Fundamentals – Amino Acid Salt is the basis of our solvent

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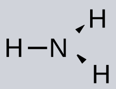
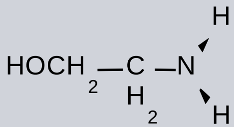
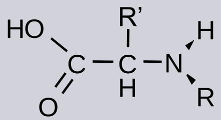


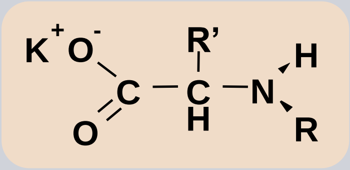
Ammonia



MEA



Amino acid



Amino acid salt

No vapor pressure

Chemically stable

Naturally present

Salts have no vapor pressure

- No thermodynamic solvent emissions
- Not flammable
- Not explosive
- Odorless
- No inhalation risk

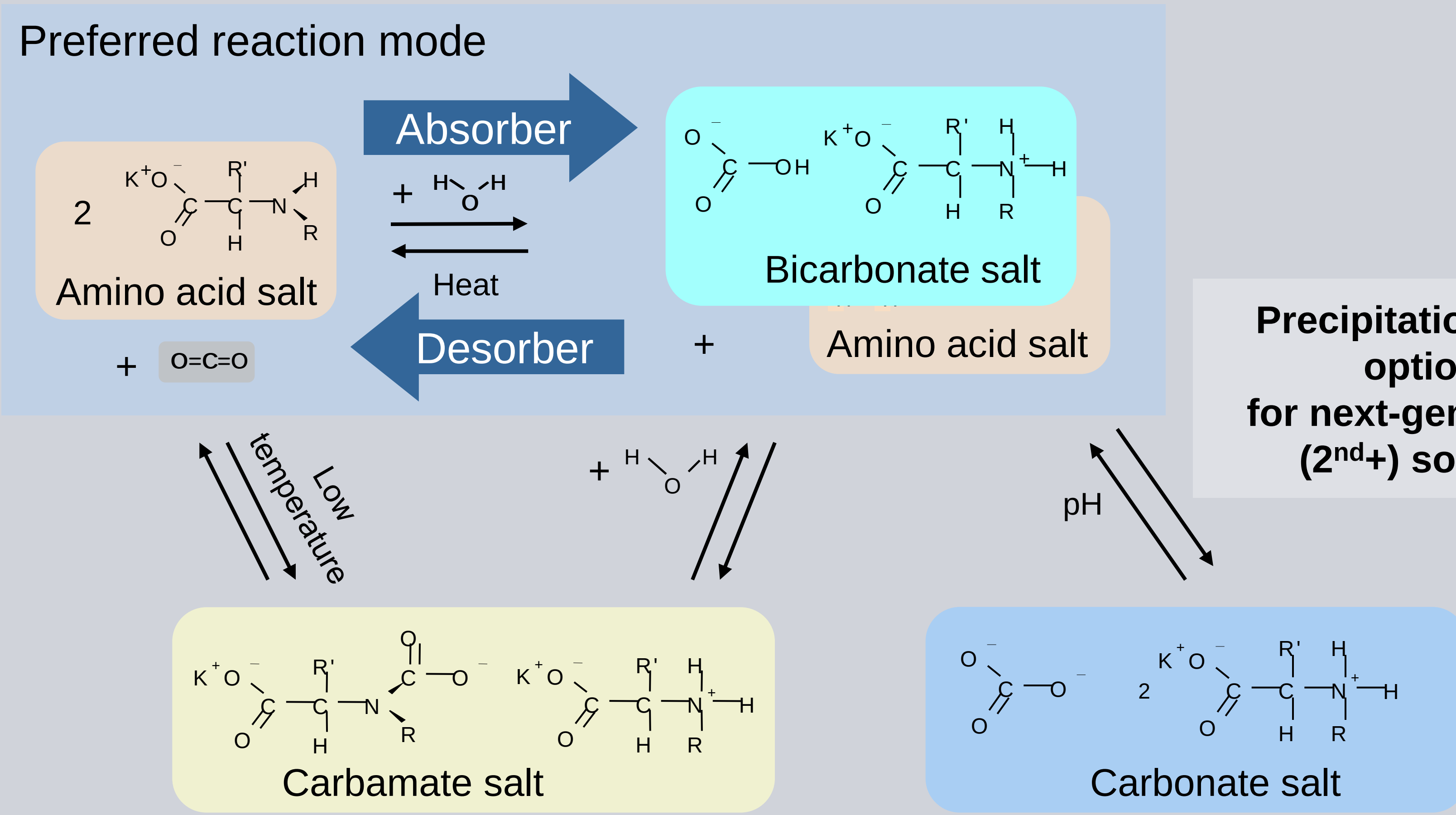
Negative ion is less sensitive to O_2

- Low degradation

Amino acids are naturally present

- Biodegradable
- Nontoxic
- Environmentally friendly

Technology Fundamentals



Precipitation is an option for next-generation (2nd+) solvent

Intermediate reaction products fulfill the same HSE standard as amino acid salts

Technology Background - Solvent Stability and Current Performance

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Components	Amino Acid Salt w/o H_2O wash
VOC	not detectable
Formaldehyde	not detectable
Methylamine	not detectable
∑Nitrosamines	not detectable
Ammonia	<1 ppm

- the solvent is highly stable and does not lead to measurable loss of active substance due to degradation
- by-products in the liquid phase are salts with no vapor pressure
- No production of any mentionable amounts of emissions
- small amounts of heat stable salts (HSS) and nitrosamines will be removed with reclaimers

The amino-acid salt is stable against thermal stress and oxygen environments

Background - Siemens lab plant for CO_2 capture tests at Frankfurt Hoechst Industrial Park

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Background – E.ON Energie's Staudinger 100 kW Pilot

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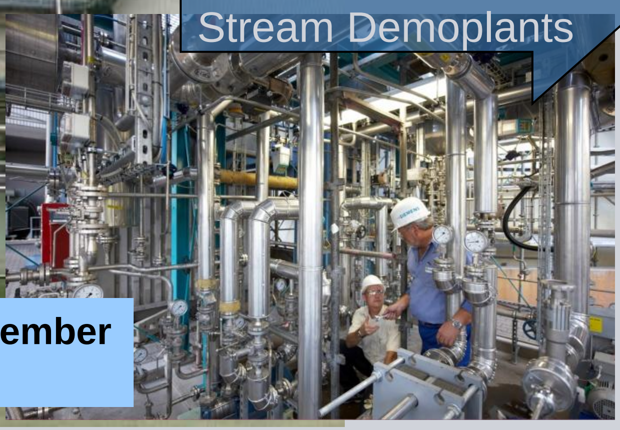
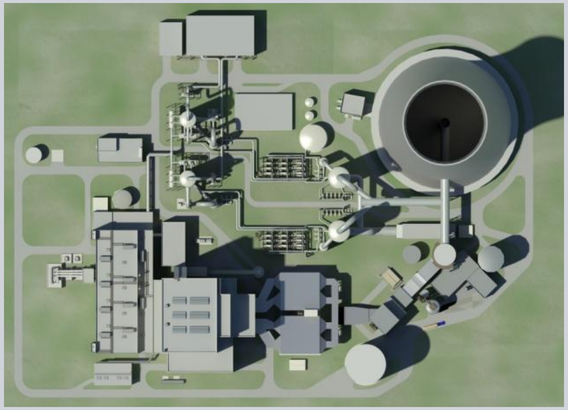
FGD

CO_2 Absorber/ Desorber

Operational September 2009



Upscaling via Slip-Stream Demoplants



Advantages – Solvent Comparison of Amines and Amino Acid Salt Formulations at 90% Capture Rate

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		Amines	Siemens POSTCAP
Environmental Considerations	**Capital Cost**	High Vapor Pressure requires additional equipment	Zero Vapor Pressure requires no additional equipment
	Operations	Inhalation Risk requires more stringent handling procedures	No Inhalation Risk; no complicated handling procedures
	Public Acceptance	Spill Considerations	Environmentally Friendly Odorless
Chemical Efficiency (Reagent Degradation)		Sensitive to Oxygen	75% less than MEA
Siemens Auxiliary System Experience		Limited Compression, Flue Gas Clean-up, Steam Extraction Experience	Demonstrated Experience in Flue Gas Clean-up, CO_2 Compression and Steam Extraction

Challenges - applying AAS solvent technology to existing PC and industrial plants

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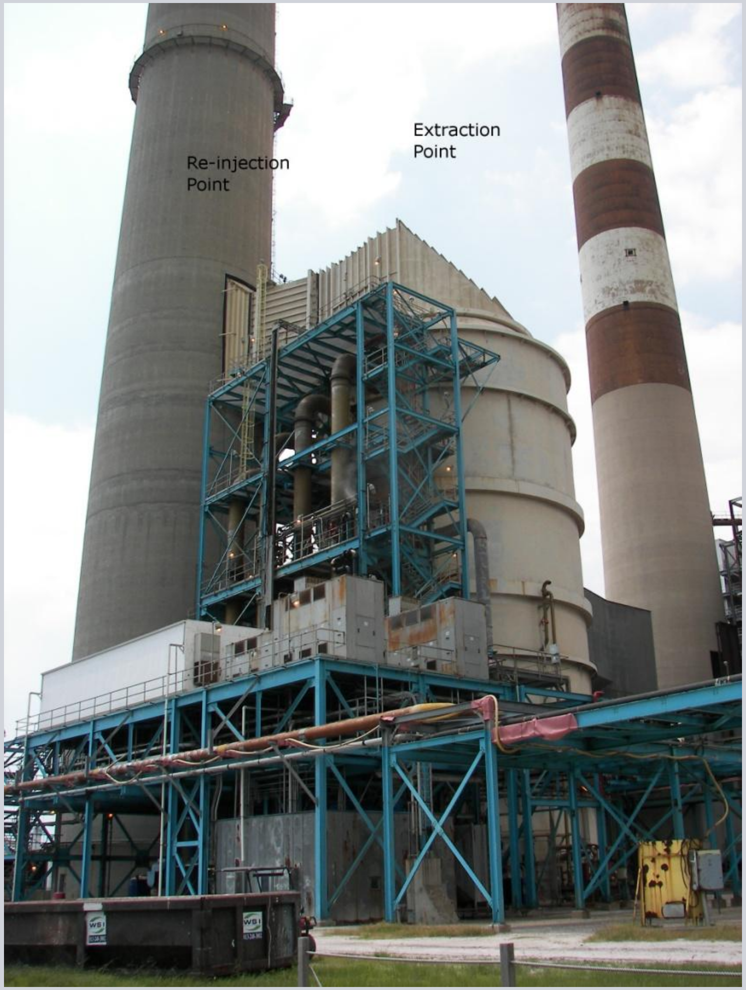
- Developing solvent suppliers on a large, commercial scale
- Minimize energy consumption
- Available footprint for large-scale carbon capture retrofits
- Combined cycle challenges to be overcome:
  - ✓ Low CO_2 concentration in flue gas
  - ✓ High oxygen content in flue gas
  - ✓ Operation with frequent load changes
  - ✓ Fewer integration options for low temperature heat from the capture plant

Project Methodology

Slipstream Project Work

- Preliminary Engineering
- Detailed Engineering & Design
- Development of Equipment/Procurement Packages
- Retrofit installation into existing Big Bend scrubber outlet
- Commissioning, Operation and Testing of plant
- Data Analysis, Report out
- Decommissioning/Dismantling



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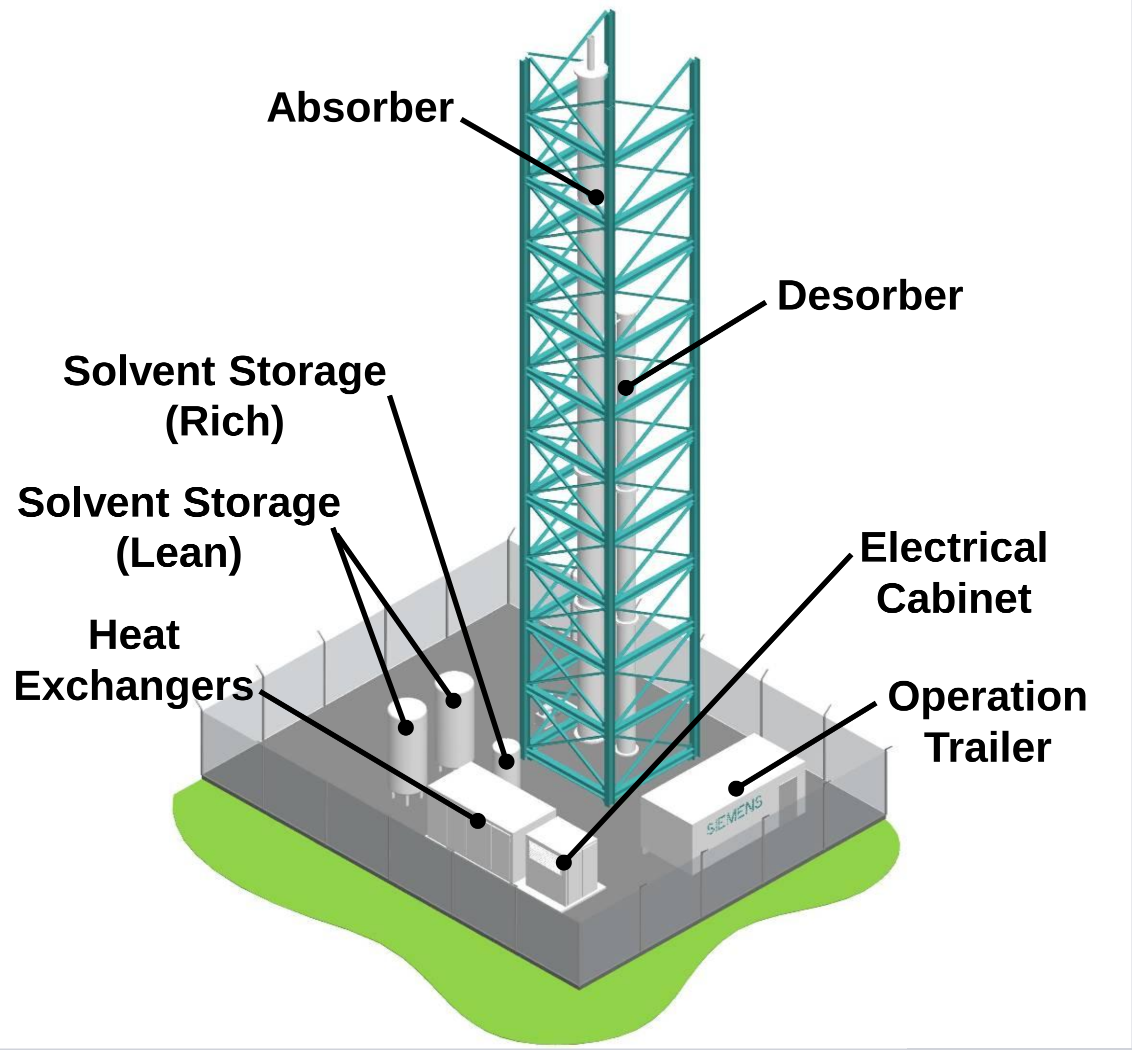
Project Methodology – basic plant layout



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Project Methodology

Schedule

Task 1.0 Preliminary Design Engineering	10/1/2010	2/28/2011
Task 2.0 Generation of Heat & Material Balance	10/1/2010	11/30/2011
Task 3.0 Generation of PFD's	10/1/2010	11/30/2011
Task 4.0 Plant Interface Engineering	10/1/2010	6/30/2011
Task 5.0 Preliminary Design	10/1/2010	2/28/2011
Task 6.0 Detail Design/Engineering	3/1/2011	7/31/2011
Task 7.0 Site Civil Work	8/1/2011	8/31/2011
Task 8.0 Plant Equipment & Material Procurement	8/1/2011	8/30/2012
Task 9.0 Complete Erection of Structural Steel	9/1/2011	2/15/2012
Task 10.0 Absorber/Desorber Installation Complete	9/1/2011	5/9/2012
Task 11.0 Mechanical Installation Complete	9/1/2011	5/9/2012
Task 12.0 Piping Component Installation	12/1/2011	8/30/2012
Task 13.0 Complete Electrical Installation	2/1/2012	7/13/2012
Task 14.0 Complete I&C Installation	2/1/2012	8/30/2012
Task 15.0 Test Plan Development	6/1/2012	8/31/2012
Task 16.0 Phase 3 - Commissioning, Testing, and Reporting	9/1/2012	7/31/2013
Task 17.0 Perform System Hydro Test	9/1/2012	10/1/2012
Task 18.0 Perform Plant Startup	10/31/2012	12/3/2012
Task 19.0 Steady State Plant Operation	12/3/2012	7/1/2013
Task 20.0 Perform Testing	12/3/2012	7/1/2013
Task 21.0 Data Analysis	7/2/2013	7/31/2013
Task 22.0 Decommission	8/1/2013	10/31/2013
Task 23.0 Disassemble (If Required)	8/1/2013	10/31/2013

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Future Development / Commercialization

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Post-Combustion
Capture Process

- **Scale up to larger demonstration units**
- **Integrated PostCAP Process Design Package (PDP) to Engineering, Construction and Commissioning.**
- **Project execution within Siemens Energy Sector**
- **Entirely Done within Siemens**
- **Collaboration with external engineering and construction contractors as needed**

Siemens Scope
applicable for retrofits and for new power plants

To be provided by third party on behalf of investor (e.g. civil, Infrastructure, not process related)

Polishing of FGD Unit

Power Plant Integration

CO_2 Compression

Balance of Plant Activities