Slipstream pilot plant demo of a amine-based post-combustion capture technology for CO_2 capture from coal-fired power plant flue gas

DOE funding award DE-FE0007453

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Coal Utilization Research Council
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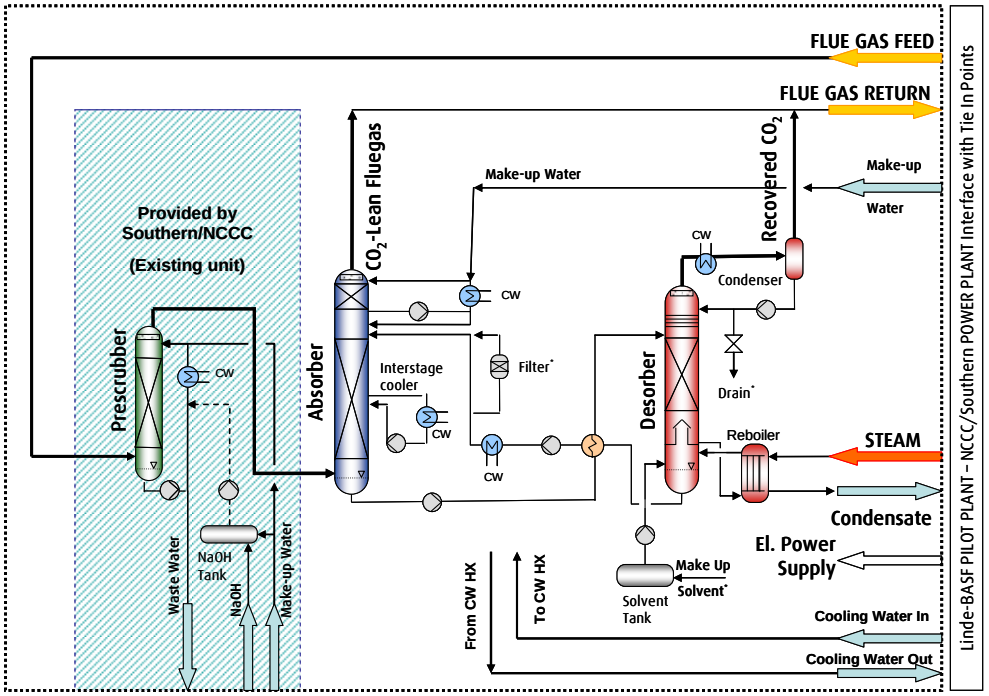
Project Fact Sheet



Scaled-up slipstream Pilot PCC Technology Demonstration

— Selected by DOE for funding

— Contract sign-off in Oct. 2011

— Pilot plant incorporates BASF's novel amine based solvent technology and BASF & Linde process enhancements

Project essentials

— Location: 880 MWel Gaston Power plant (operated by Southern Co.) in Wilsonville, AL

— Site of the US National Carbon Capture Center

— Capacity: Up to 6250 Nm^3/h flue gas from coal fired power plant (30 t/d CO_2)

— CO_2 purity 99+ vol % (Dry basis)

— Project start: November 2011

—Project Duration: 4 years

— Partners: Linde LLC, Selas Fluid Processing Corp., Linde Engineering Dresden, BASF, US DOE, EPRI, Southern Company (Host site)

— Project Cost: $18.8 million

— DOE funding: $15 million

Project Objectives

Overall Objective

— Demonstrate Linde-BASF post combustion capture technology by incorporating BASF's amine-based solvent process in a 1 MWel slipstream pilot plant and achieving at least 90% capture from a coal-derived flue gas while demonstrating significant progress toward achievement of DOE target of less than 35% increase in levelized cost of electricity (LCOE)

Specific Objectives

— Complete a techno-economic assessment of a 550 MWel power plant incorporating the Linde-BASF post-combustion CO_2 capture technology to illustrate the benefits

— Design, build and operate the 1MWel pilot plant at a coal-fired power plant host site providing the flue gas as a slipstream

— Implement parametric tests to demonstrate the achievement of target performance using data analysis

— Implement long duration tests to demonstrate solvent stability and obtain critical data for scale-up and commercial application

Post combustion CO_2 capture: Challenges compared to CO_2 removal in NG/LNG plants

	NG/LNG	Flue gas
Pressure	50 – 100 bars	1 bara
CO_2 partial pressure	1 – 40 bars	30 – 150 mbars
Flowrate	up to 60 mio scf/hr	up to 120 mio scf/hr
Gas composition	CH_4, C_2H_6, …, CO_2, H_2S, COS, C_xH_y,S, H_2O	N_2, O_2, H_2O, CO_2, (SO_x) NO_x
Treated gas specification	50 ppm – 2 % CO_2 S < 4 – 10 ppm	CO_2 removal rate (90 %) low amine emissions
Energy efficiency	not a key issue	of highest priority η ↘ 7-10% points

- ❑ large volume flows @ low pressure
- ❑ solvent stability
- ❑ emissions of solvent
- ❑ overall power plant efficiency losses

Technology Development Path

Development Path

Laboratory

solvent screening
- screening methods

Mini Plant
0.015 MW_{el}
0.01 mt CO_2 / hr

proof of concept under „synthetic“ conditions
- comparision of solvents
- validate simulation models

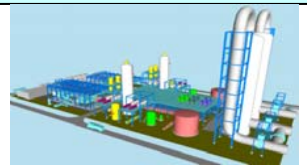
Pilot Plant (Niederaussem*)
0.45 MW_{el}
0.3 mt CO_2 / hr

litmus test for new process under real conditions

Pilot Plant (Current)
1 - 1.5 MW_{el}
0.8 - 1.2 mt CO_2 / hr

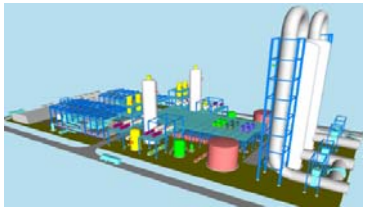
Advanced design and new materials aimed at emissions reduction and capex reduction in the large scale

Demo Plant
50 - 250 MMW_{el}
34 - 170 mt CO_2 / hr



test of complete CCS-chain capture, compression, transport, storage/EOR

Commercial Plant
500 - 1100 MW_{el}
340 - 750 mt CO_2 / hr



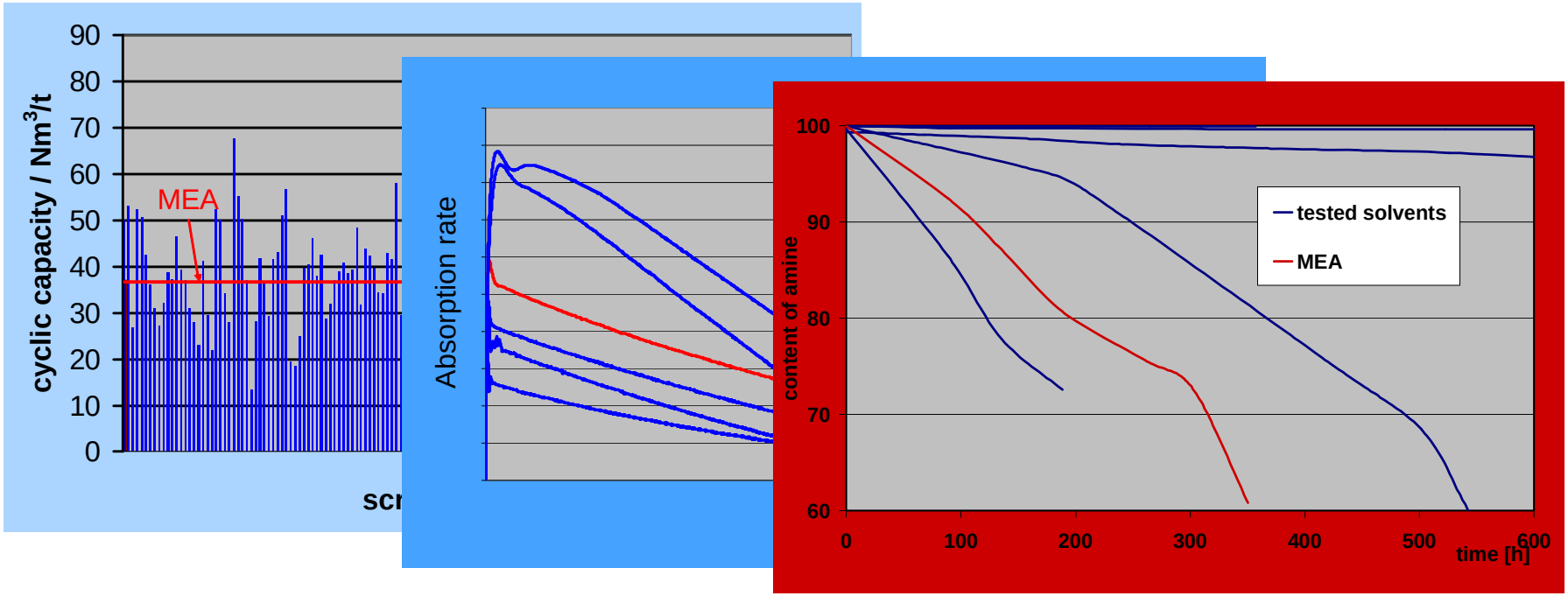
Safe, reliable, and economical operation in compliance with regional and national regulations

Acknowledgement: * Partner and power plant owner/operator: RWE

BASF Gas Treatment Group

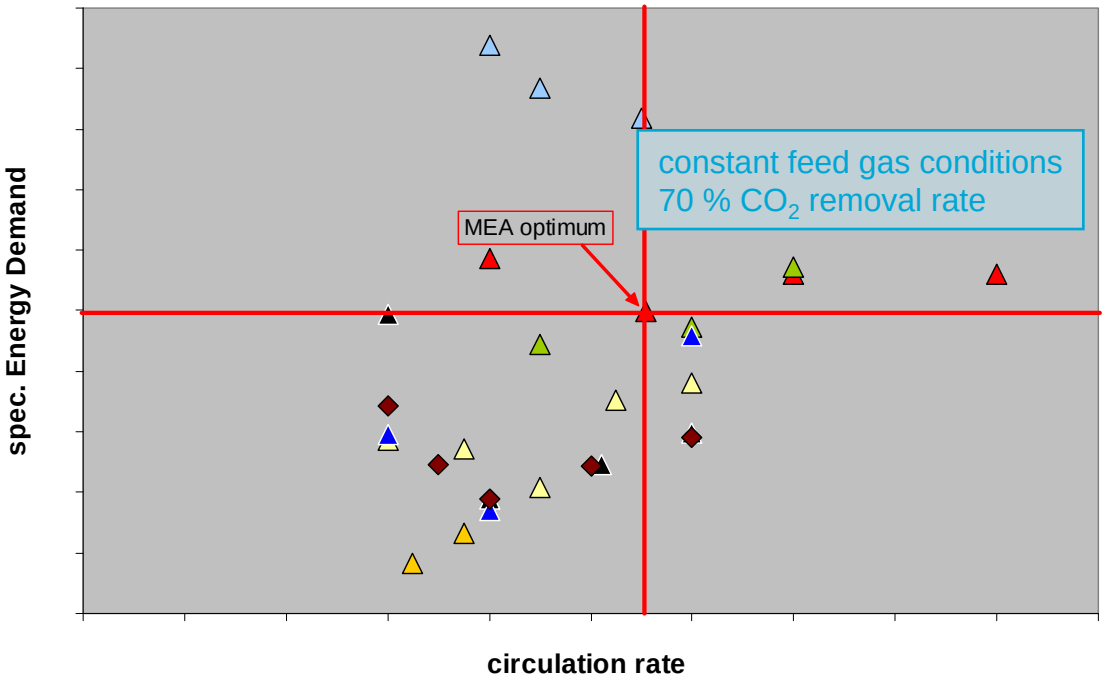
Wide range of solvents screened

Phase Equilibria → Kinetics → Losses/Stability



BASF Gas Treatment Group

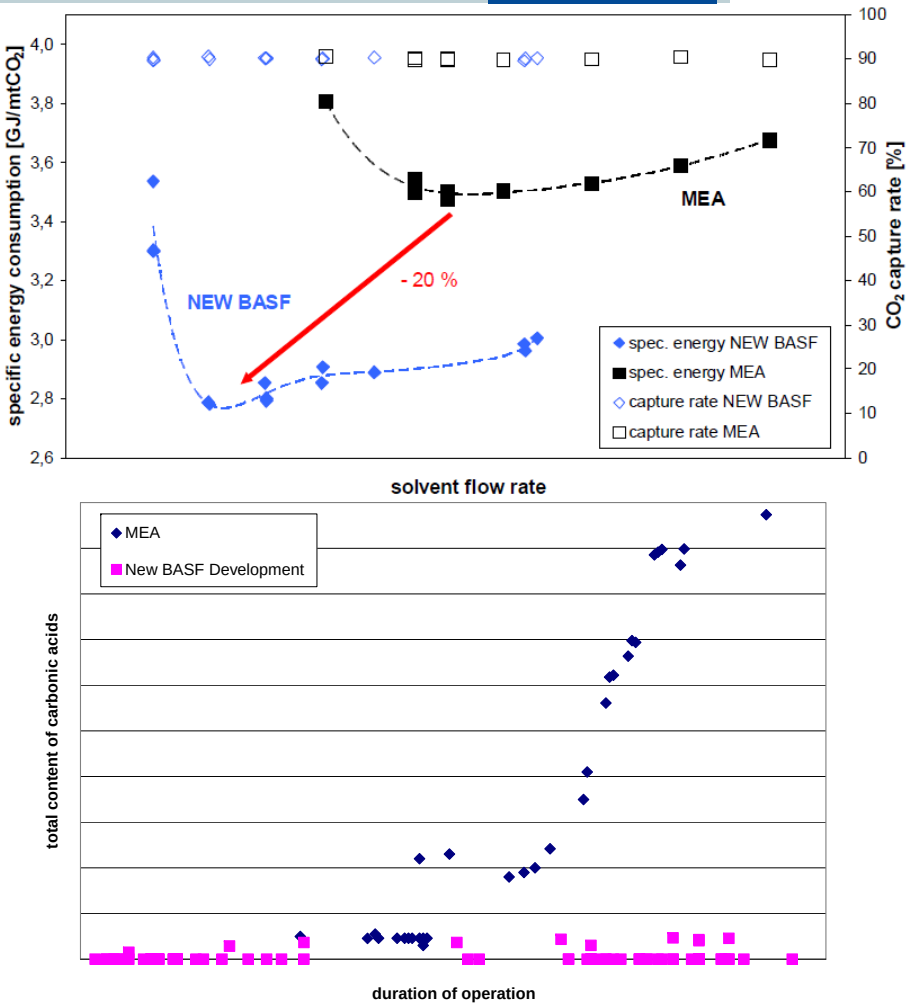
Mini plant – BASF site in Ludwigshafen



Verification of the screening results

Identification of options for an improved solvent

Niederaussem* pilot plant key results



>90% carbon capture rate achieved

>20% improvement in specific energy compared to MEA

New BASF solvent is very stable compared to MEA

Acknowledgement: * Pilot project partner RWE

Concepts for a Large Scale PCC Plant
Key elements of plant costs

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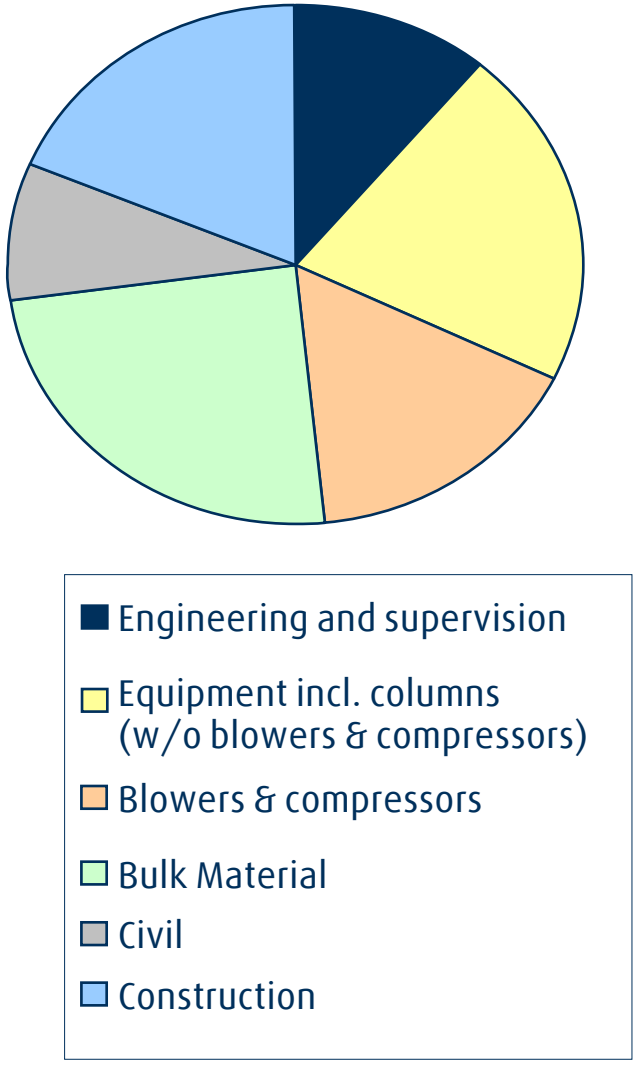
Main challenges

- Large equipment size requires new concepts
- Required plot area is very significant
- Alternative materials needs to be assessed
- New equipment arrangements needed
- FIeld fabrication
- Large pipe and duct

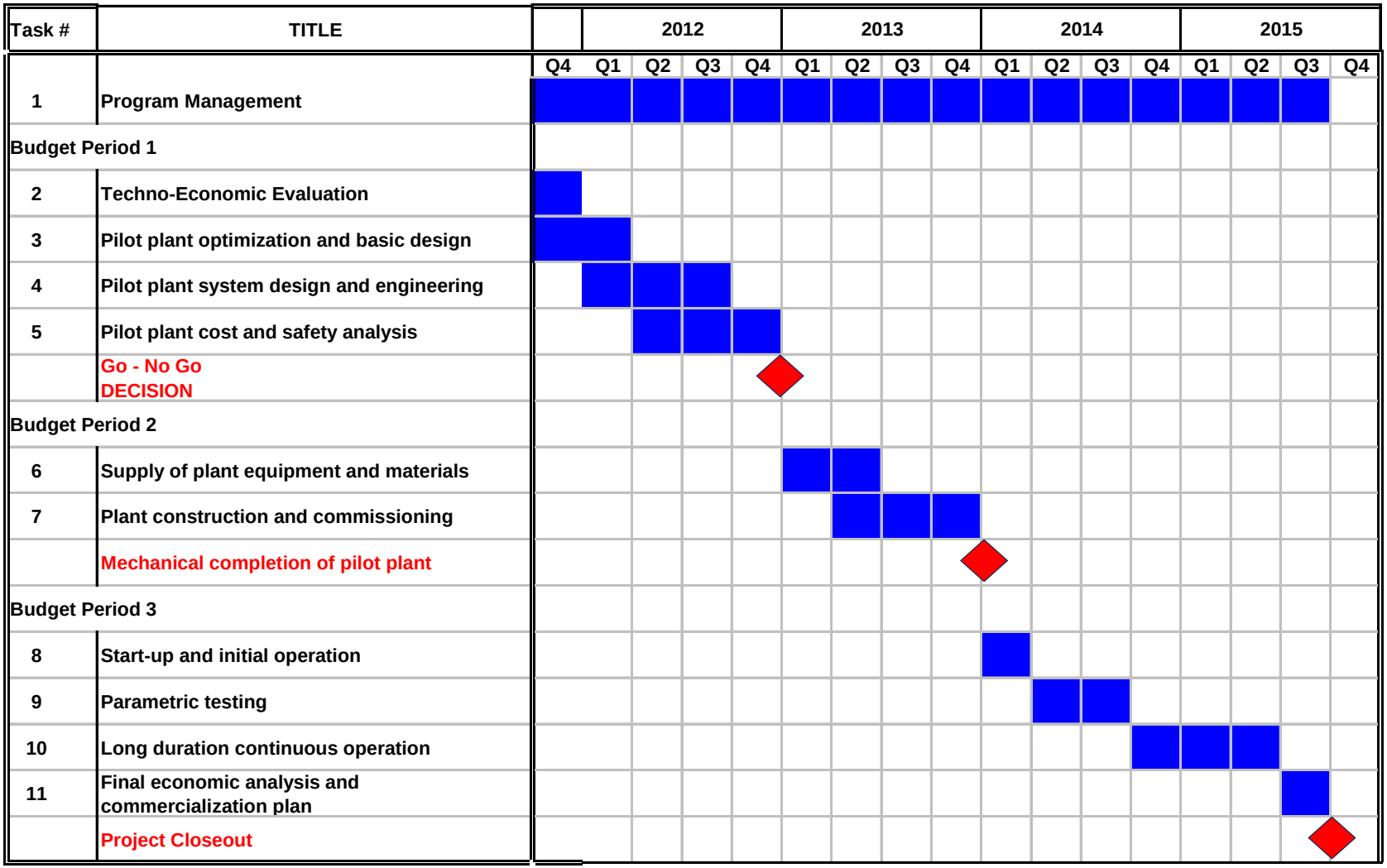
Linde studies to address challenges

- Scaling to a very large single train
- Optimize equipment arrangement (flue gas blower, pre-cooler, absorption columns sump etc)
- Develop new column construction materials
- Optimize machinery options

Total plant cost distribution



Project Timeline



Key Project Milestones

- **Budget Period 1 (Nov. 1, 2011 – Jan. 31, 2013)**
  - Project kick-off meeting with DOE-NETL (11/17/2011)
  - **550 MWel power plant with integrated carbon capture techno-economics report (Dec. 31, 2011)**
  - Optimal design parameters identified and pilot plant design completed (April 30, 2012)
  - Host site agreement (Sep. 30, 2012)
  - Pilot plant engineering and equipmen t sizing complete for cost assessment (Oct. 31, 2012)
  - Development and submission of bid packages (Nov. 30, 2012)
  - **Completed pilot plant costs based on vendor quotes (Dec. 31, 2012)**
- **Budget Period 2 (Feb. 1, 2013 – Jan. 31, 2014)**
  - Pilot plant equipment and modules shop fabrication completed (June 30, 2013)
  - Completed ES&H assessment (Dec. 31, 2013)
  - **Mechanical completion of pilot plant and start-up enabled (Jan. 31, 2014)**
- **Budget period 3 (Feb. 1, 2014 – Oct. 31, 2015)**
  - Pilot plant operations validated and ready for testing (April 30, 2014)
  - **Performance validated against targets (Oct. 31, 2014)**
  - **Long term operability and solvent stability demonstrated (July 31, 2015)**
  - **Technology advantages demonstrated/Ready for commercial (Oct. 31, 2015)**

Slipstream PCC Pilot Plant: Process Schematic

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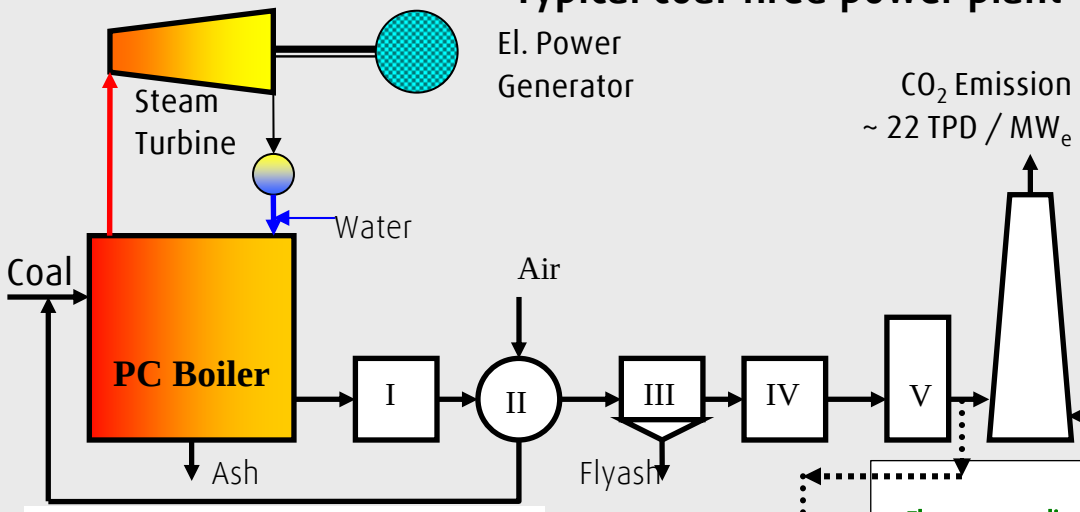
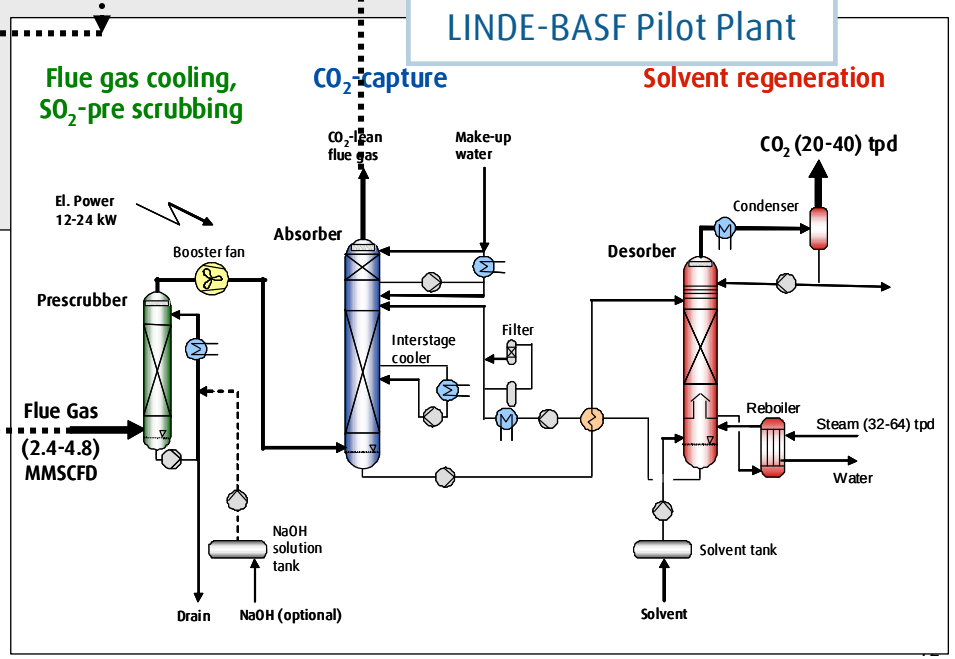
Typical coal-fired power plant



I - NOx Control; II - Air Heater; II - PM Control; IV - Hg Control; V - FGD; VI - Stack

Host Site: 880MWel Gaston coal fired power plant, Wilsonville, AL (managed by Southern Co.). The facilities are part of the National Carbon Capture Center.

LINDE-BASF Pilot Plant



Power plant provides:
steam for PCC regeneration,
cooling water for all HX,
and electrical power.
Accepts flue gas return after CO_2 capture

Power Plant schematic Source: DOE-NETL FOA '403

Technical validation to optimize performance and reduce capex and opex for future commercial offering

- Select leading solvent (from development till date) for pilot plant design and planned testing. One potential additional solvent to be considered in 2014 when pilot plant in operation.

- Process testing and validation for lower capex & opex and for emission reduction:
  - New absorber construction materials (e.g. Concrete columns with in-liner)
  - Advanced absorber structured packing material
  - Absorber intercooling without forced recirculation
  - Optimized equipment arrangement (blower, sump, intercoolers)
  - Advanced stripper design
  - Optimized process parameters to reduce steam consumption (e.g. Regeneration pressure)
  - Reduced emisson losses through optimized wash system

Acknowledgement and Disclaimer

Acknowledgement: This presentation is based on work supported by the Department of Energy under Award Number DE-FE0007453.

Thank you for your attention!

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