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# Siemens' Carbon Capture Technology

March 2011

Siemens Energy Sector  
Fossil Division  
New Technologies

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Energy Sector

## Siemens preferred solutions for CO<sub>2</sub> capture

### IGCC / Pre-combustion carbon capture

**“Technology units proven or ready”, integration in new build IGCC plants**

- Gasification technology with multi-fuel capability
- Scrubbing Technologies from oil & gas
- F-class LC Gas Turbine
- Alternative route for chemical / fuel production / SNG and hydrogen economy

**Mastering technological / contractual complexity.**



Siemens Fuel Gasifier



Siemens IGCC technology applied in Puertollano (E)

### Post-combustion carbon capture

**“Scalable” market introduction, for new build and retrofit power plants**

- Enhancement potential for solvents, scrubbing process and for integration into the power plants
- Siemens has developed proprietary process based on amino acid salt formulations (PostCap)
- Preferred solution for CCS demo projects

**Mastering scale-up from pilot to demo plant.**



Siemens scrubbing process test lab



Post-Combustion carbon capture plant design

**Siemens solutions are ready for the implementation in the upcoming CCS demonstration projects.**

# Siemens Post-Combustion Carbon Capture Technology for Steam Power Plants



CO<sub>2</sub> Absorption,  
Desorption  
is proven technology  
in chemical processing  
and oil & gas industry



## SIEMENS PostCap Process

based on: **AMINO ACID SALT** Formulations



SPP with PostCap Process



validated in pilot plant

# Requirements for “best in class” carbon capture technology, e.g. Post Combustion.

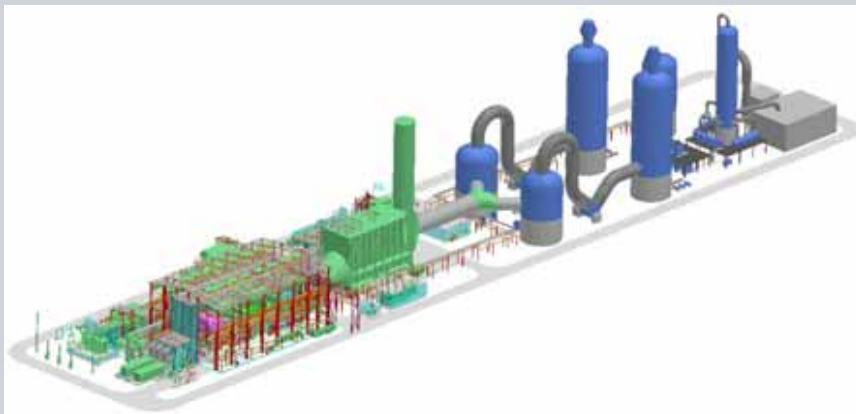
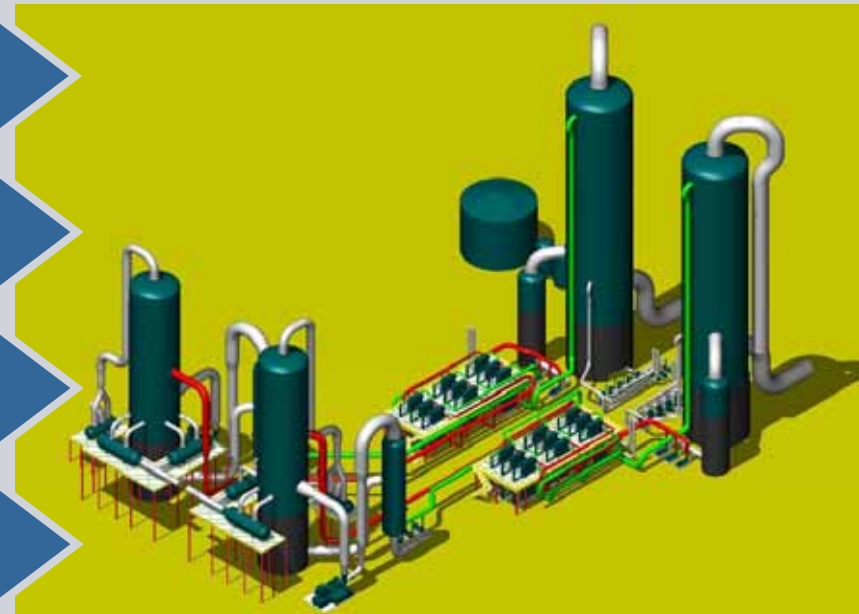
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“Zero emission” solvent, no additional washing steps required

State of the art reclaiming system with very limited solvent losses

Limited solvent degradation ( $O_2$ ,  $SO_x$ ,  $NO_x$ , thermal)

Energy consumption for regeneration  $< 2.7 \text{ GJ/tCO}_2$



## Optimal integration in power plant

...  $< 6\%$  efficiency drop

...  $< 30\text{min}$  response time to full capacity in gas-fired CCPP

## Siemens lab plant for CO<sub>2</sub> capture tests at Frankfurt Hoechst Industrial Park

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Desorption column

Reboiler made of glass so that boiling retardation effects can be recognized

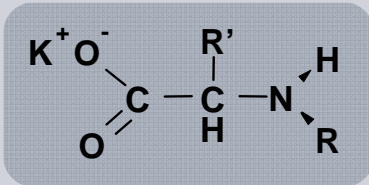
Synthetic gas flue gas mixtures

Absorption column with operating pressure up to 10 bar

Fully automated DCS system  
NDIR CO<sub>2</sub> analytic

Siemens Energy runs a fully automated lab plant for CO<sub>2</sub> capture for 24/7 test operation.

# Siemens CO<sub>2</sub> Capture Process Based on Amino Acid Salts

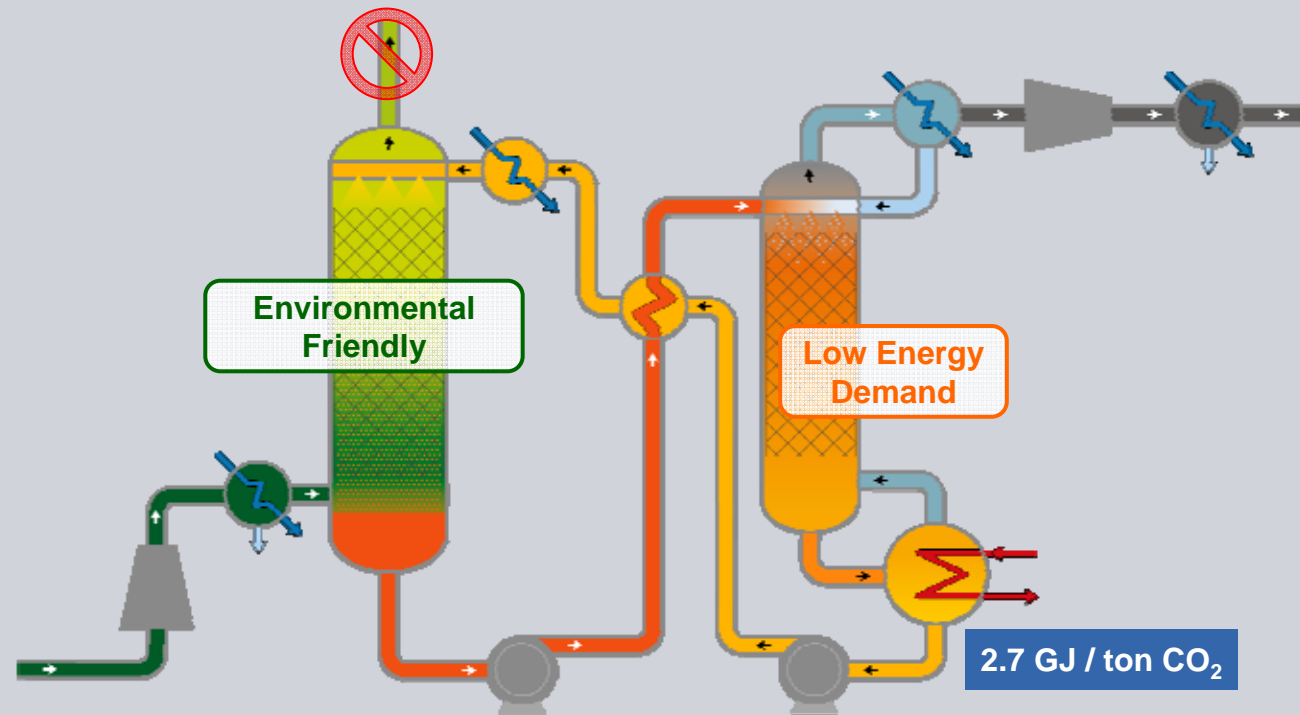


Amino acid salt

## Salts have no vapor pressure

- No thermodynamic solvent emissions
- Not flammable
- Not explosive
- Odorless
- No inhalation risk
- Chemically stable, low degradation (O<sub>2</sub>)
- Naturally occurring

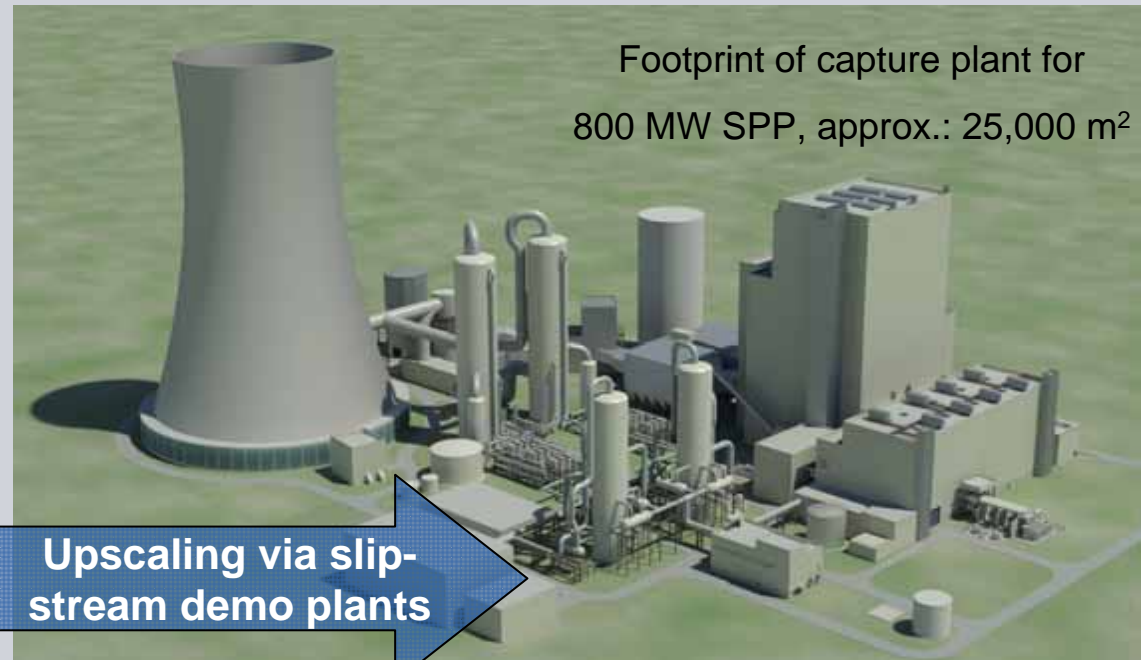
Solvent slip nearly zero, no additional washing unit required



The efficiency is < 6 %-pts. lower than the reference hard-coal fired power plant\*, w/o CO<sub>2</sub> compression.

\*SSP5-6000 (800 MWeI.net, 600°C/610°C/270bar)

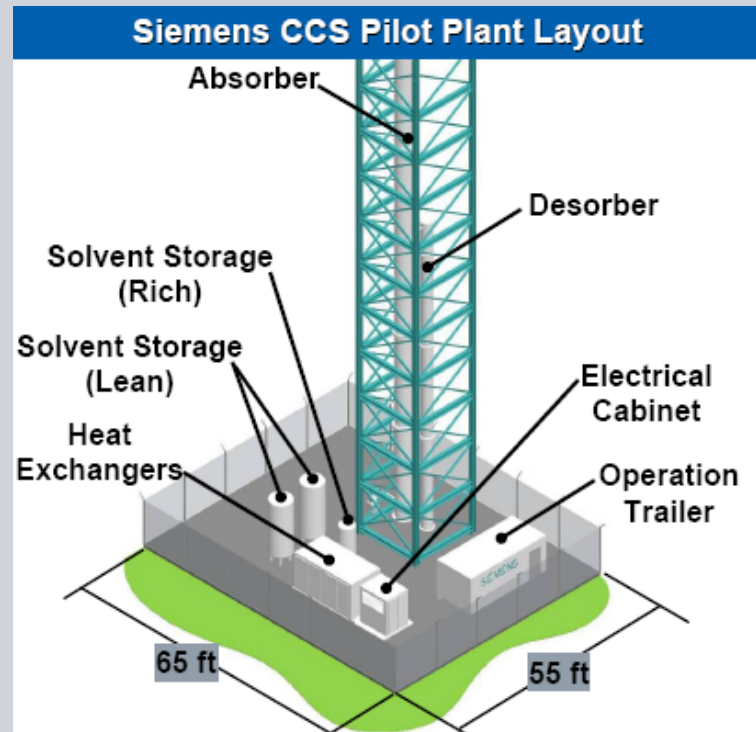
# Upscaling: Lab to Pilot Plant Carbon Capture Pilot Plant at E.ON SPP „Staudinger“



Status March 2011:  
> 3,500 operating hours

## DOE-funded Pilot Plant in the USA Operation start planned mid 2012

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### CCS Pilot Plant Information and Timing

- Flue gas from a coal-fired power plant
- Pilot plant size: approx. 2.5 MW<sub>el</sub> slip stream
- Funding by DoE: 15 million US\$
- DOE award: September 2010
- Project start: October 2010
- Operation: mid 2012 - mid 2013

## Post-Combustion Capture for Combined Cycles



### Main driver for Natural Gas CCS

- EU legislation calls for capture ready feature for new plants with an output  $> 300 \text{ MW}_{el}$
- Enhanced Oil Recovery (EOR)

### Post-Combustion Development Challenges

- Low  $\text{CO}_2$  concentration in flue gas (3.8v-%)
- High oxygen content in flue gas (12.6v-%)
- High flue gas flow rate
- Operation with frequent load changes
- Little integration options for low temperature heat from the capture plant

**Siemens has adapted the PostCap process for combined cycle power plants**

# Siemens Power Plant and CCS Solutions

Partner from process development to EPC supply



## Strengths

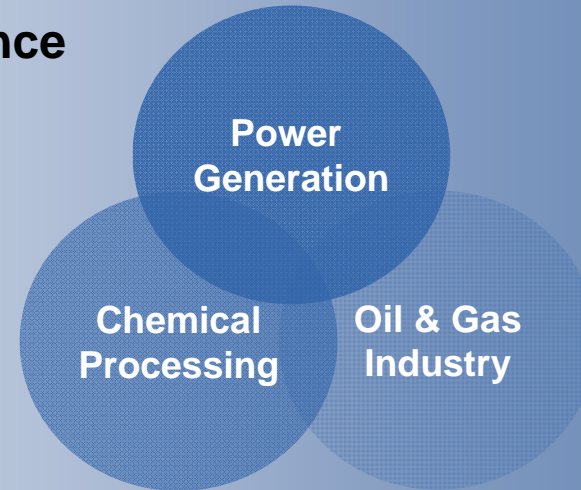
Environmentally friendly solvent

Integration into power plant and system optimizations

Minimizing solvent losses and emissions

- Efficient “Green Power Plant”

## Experience



- is state-of-the-art power plant and CCS technology provider
- Project execution from a single point of responsibility

Carbon Capture Process Development

Process- and Modell-Development

Piloting and Optimization

FEED / Basic eng.

Licensing

Detail eng.

Construction & Installation

Comis-sioning

Plant support

Engineering & Construction of Post-combustion Carbon Capture Demo Plant

## Summary

**Fossil fuels will maintain a big share in global electricity production and carbon capture is one important and necessary measure to cope with climate change**

**Siemens offers an unique portfolio of high efficient power plants as well as pre- and post-combustion carbon capture solutions to reduce and/or avoid CO<sub>2</sub> release**

**Post-combustion capture technology comprises a proprietary chemical absorption process which is retrofittable to coal- and gas-fired power stations**

**The PostCap process exhibits an outstanding environmentally friendly character and is very energy efficient.**

**The advantages of the PostCap process have successfully been verified in the Staudinger pilot plant. Siemens' technology is ready to be applied in large-scale demonstration projects.**

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