

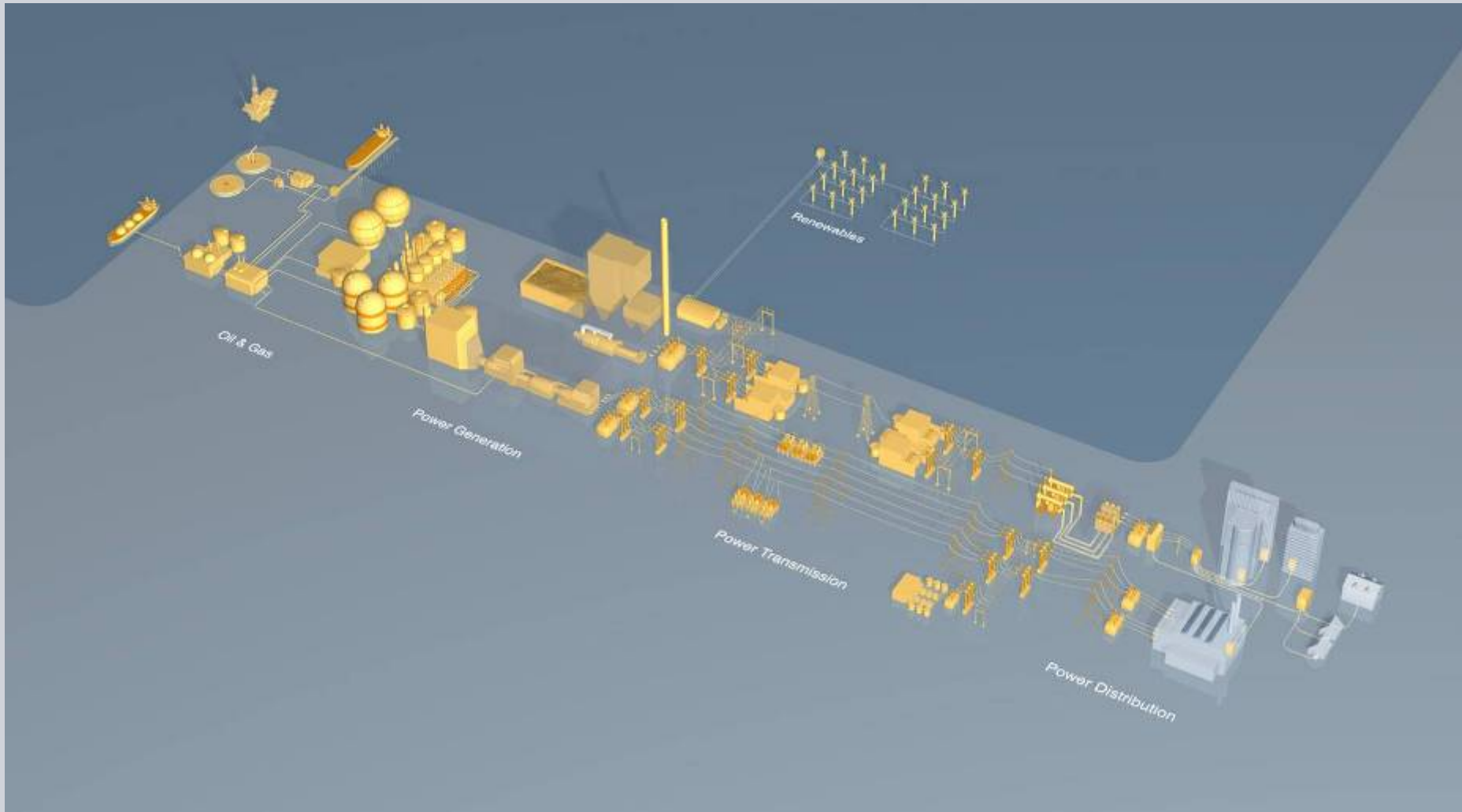
# Siemens Energy Product Portfolio and Post-Combustion CO<sub>2</sub> Capture Technology

Siemens Solutions for Post-Combustion  
Carbon Capture

- Siemens Energy Sector at a Glance
- Solutions and Competencies for Clean Coal
- Post-Combustion Carbon Capture
- CO<sub>2</sub> Compression
- Capture-Ready / Retrofit Solutions for SPP

# Comprehensive Portfolio and Services: from Primary Energy to Power Distribution

**SIEMENS**





# Siemens Energy Sector – Answers for Energy Supply

**SIEMENS**

## Energy Products and Solutions - in 6 Divisions

**Oil & Gas**



**Fossil  
Power  
Generation**



**Renewable  
Energy**



**Energy  
Service**



**Power  
Transmission**



**Power  
Distribution**



# Siemens Preferred Solutions for CO<sub>2</sub> Capture

## IGCC / Pre-Combustion Carbon Capture

Gasification technology with multi-fuel capability for new power plants

- Technology “ready for implementation”
- Alternative route for chemical / fuel production, hydrogen economy
- Mastering higher technological and contractual complexity with “Siemens phased project execution offer”

## Post-Combustion Carbon Capture

Scalable market introduction, Demo plants with slipstreams, minimize upgrade risk in process trains

- Enhancement potential for solvents, scrubbing process and for integration into the power plants
- For retrofit and new fossil fired power plants
- Siemens develops process based on amino acid salt formulations and has established partnership for aqueous ammonia process



Siemens Fuel Gasifier



Siemens IGCC in Puertollano (E)



Siemens Scrubbing Process Test Lab



Post-Combustion Carbon Capture Plant Design

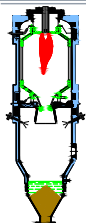
Siemens solutions ready for implementation in upcoming CCS demonstration projects



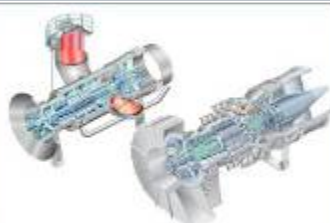
# Siemens Competencies for Fossil Power Generation with Carbon Capture

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Gasifiers



Gas Turbine Generators



Steam Turbine Generators



Chemical Engineering



Environmental Services



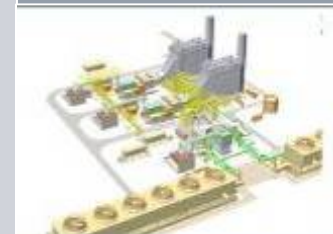
Air / N<sub>2</sub> / O<sub>2</sub> / CO<sub>2</sub> / Syngas Compressor Trains



Instrumentation & Control Systems



Reference Power Plants



O & M Services



Siemens provides key components and systems

# Siemens Environmental Systems & Services Products Cover Most Types of Flue Gas Emissions

**SIEMENS**



- **Flue Gas Desulfurization (FGD)**
  - Dry FGD
  - Mercury Control
  - Wet FGD
  - Wet ESP
- **Electrostatic Precipitators (ESP)**
  - HaRDE
  - VIGR
- **Fabric Filters (FF)**
  - Pulse Jet
  - Cartridge
  - Reverse Air
- **NO<sub>x</sub> and Ancillary Products**
  - SNCR
  - SCR Services



Siemens is already a strong partner for flue gas cleaning  
and now widens the scope with CO<sub>2</sub> capture

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

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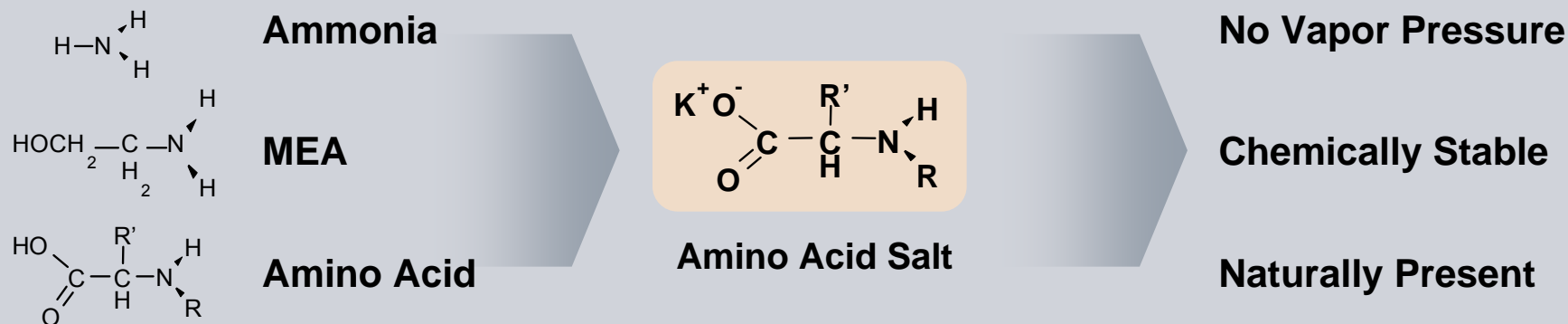
**Siemens Post-Combustion  
Technology Development**

**Basis: Amino Acid Salt  
Formulations**





# Amino Acid Salt is the Basis of Our Solvent



Salts have no vapor pressure

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



Negative ion is less sensitive to O<sub>2</sub>

- Low degradation

Amino acids are naturally present

- Biodegradable
- Nontoxic
- Environmentally friendly



Solvents based on amino acid salts are economic, have low environmental impact and are easy to handle

# Siemens Lab Plant for CO<sub>2</sub> Capture Tests at Frankfurt Hoechst Industrial Park

**SIEMENS**

Desorption column

Synthetic gas flue gas mixtures

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

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 operation

# Siemens Post-Combustion Capture Process

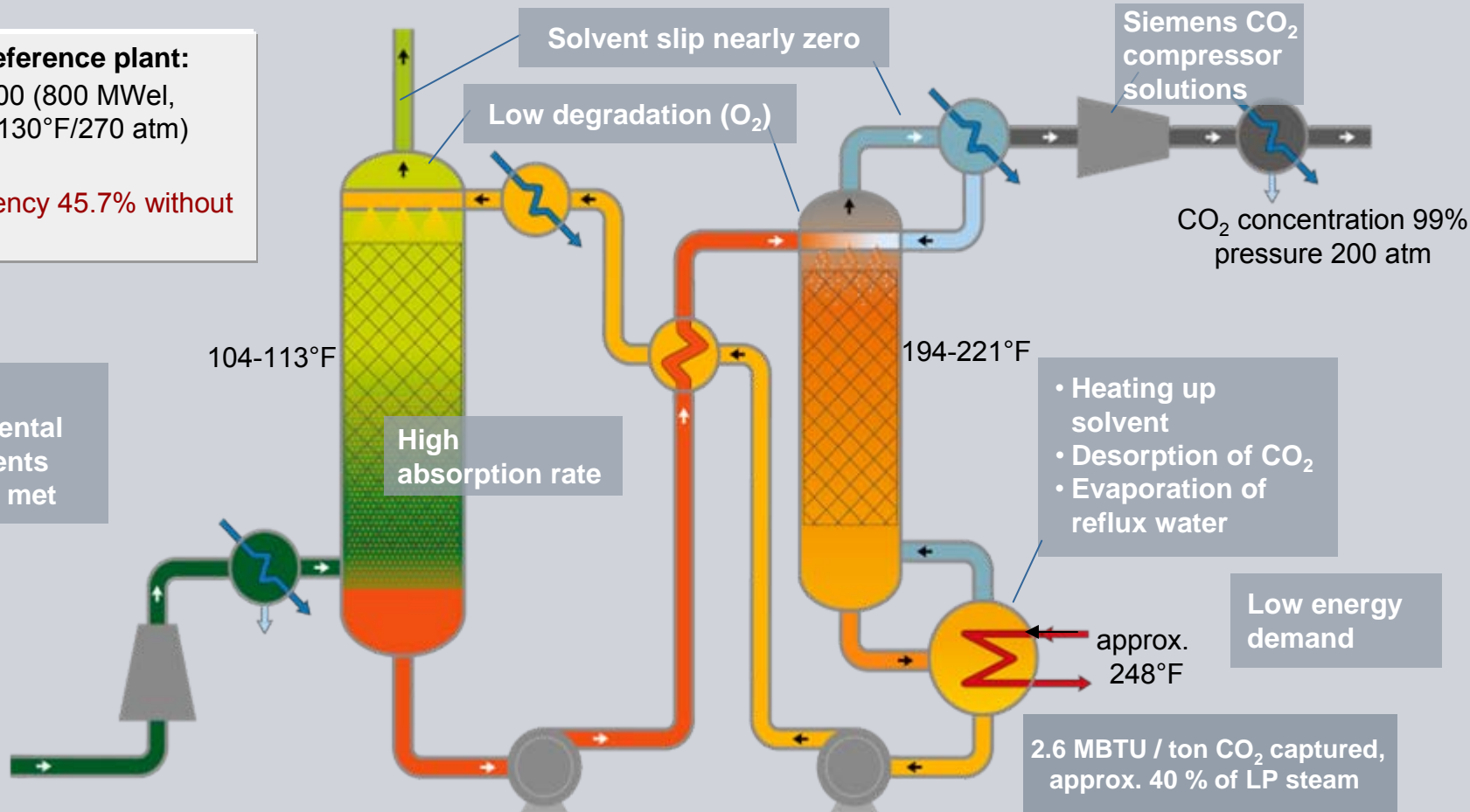
## Current Development Status

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### Non-CCS reference plant:

- SSP5-6000 (800 MWeI, 1112°F/1130°F/270 atm)
- Hard coal
- **Net efficiency 45.7% without CCS**

Stringent environmental requirements are easily met

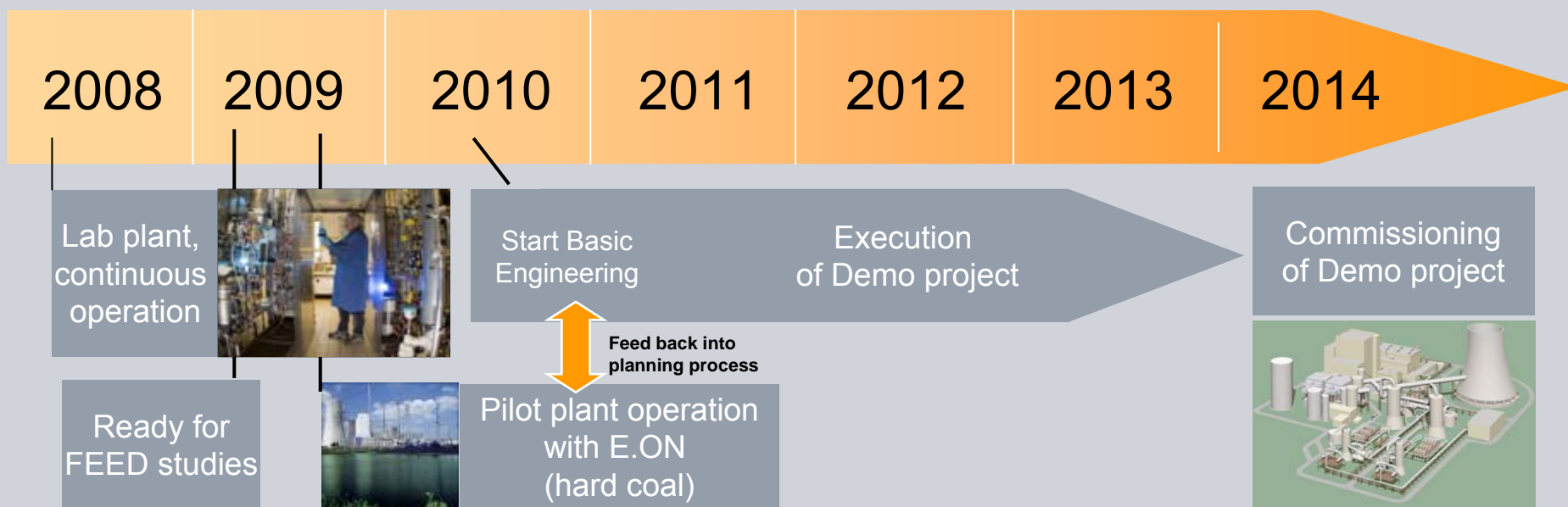


The efficiency is approx. 9.2%-pts. lower than the reference hard-coal fired power plant, including CO<sub>2</sub> compression (200 atm)



# Major Next Steps on the Way to a Full Scale Post-Combustion Demo Plant

- Post-combustion capture is preferred solution for retrofits of coal fired power plants, application for CCPPs under development
- Scalable market introduction with “slipstream demo projects”, one train up to 130 MW (absorber diameter approx. 12 m)
- Multi-train concepts for full scale post-combustion capture plants



Siemens Post-Combustion Technology ready for implementation in demonstration projects

# ECO<sub>2</sub> Carbon Capture Solution

## Collaboration between Powerspan and Siemens

**SIEMENS**



**Powerspan Alliance**  
**Burger Commercial Unit - 50 MW (Feb 04)**

- ▶ **Siemens Scope**
  - Absorber Design/Supply
  - Process Mechanical Scope
  - Detail Design/Purchase/Supply
  
- ▶ **Powerspan Processes**
  - ECO-SO<sub>2</sub> Only
  - ECO for NO<sub>x</sub>, SO<sub>2</sub> & Hg
  - ECO<sub>2</sub> for CO<sub>2</sub> Capture Process
  
- ▶ **Powerspan Status**
  - ECO Ready for Commercial Awards
    - AMP Ohio to utilize
  - ECO<sub>2</sub> – Pilot Unit operational Summer 2008
  - Feed Studies
    - First Energy Burger
    - NRG Indian River
    - Basin Antelope Valley
    - Basin NextGen
  - CO<sub>2</sub> Demo MOU's
    - 125 MW Size
    - NRG Texas
    - Basin Antelope Valley

# Siemens CO<sub>2</sub> Compression Solutions: Machine and Drive Combinations



Steam Turbine



Gas Turbine



Electric Motor



Gear-type  
- Up to 200 atm  
- 8 Compression Stages



+



Gear-type +  
Vertical Split Single Shaft  
- Up to 300 atm



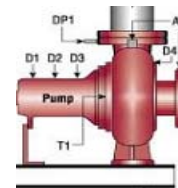
+



Horizontal +  
Vertical Split Single Shaft  
- Up to 305 atm



+



Gear-type + Pump  
- Up to 305 atm



# Capture Ready Requirements

## Exhaust ducts

- consider  $\Delta p$  from CO<sub>2</sub> absorption unit
- later flue gas connection to capture unit (T-branch)

## Flue gas fan

- upgradeable design
- or additional space for installation of second fan downstream of FGD

## Steam turbine building

- sufficient space/foundation for:
- modification of turbines
  - steam and condensate pipes
  - installation of heat exchangers

## Steam turbines

- extraction of approx. 40 % of LP cross over steam
- options for modification of turbines depend on operation modes (part load, full load capability w/o CO<sub>2</sub> capture, other plant and site conditions)

## Electrical auxiliary load

- sufficient space for:
- additional auxiliary transformer(s)
  - switchyard
  - cable routes

## Cooling system

- sufficient space for:
- additional circulation pumps
  - service water system
  - sufficient cooling capacity of cooling tower

## Condensate system,

- sufficient space for:
- heat exchangers for low grade heat utilization
  - additional piping routes with supporting structure / racks

## Raw water & cooling water supply / Waste water treatment

- sufficient space for enlargement
- secure water utilization rights

## FGD

- either consider capacity extension in column design
- or provide space for enlarged FGD unit

## Air heating

- Optional: space for installation of heat exchanger(s) for lowest grade heat utilization

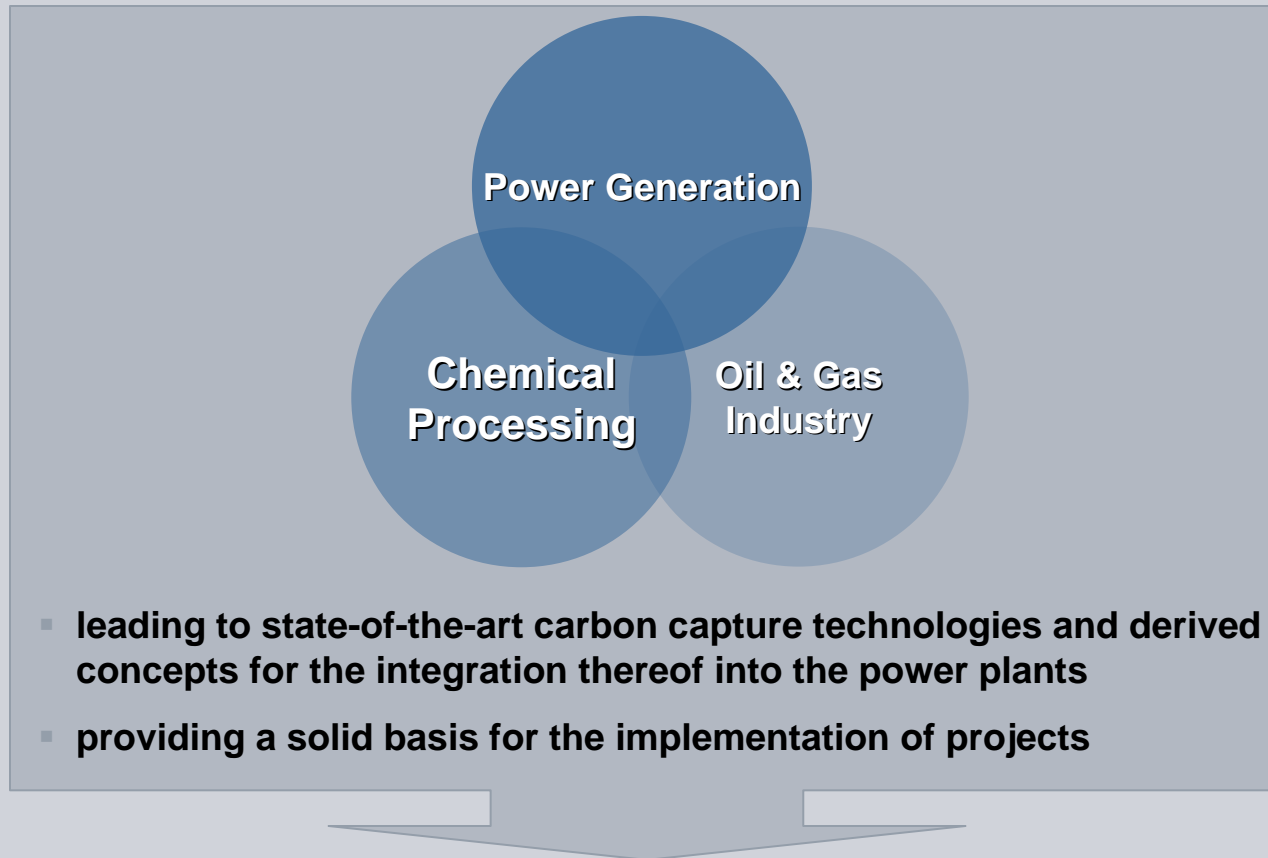
Our offer proposal:  
Integration of carbon capture unit into the power plant  
"Capture Ready / Retrofit Solutions"

All measures defined - reference Siemens steam power plant layout SSP5-6000

# Siemens CCS Solutions

## Combining Know-How and Experiences

**SIEMENS**



**Siemens, your partner,  
from process development to implementation of CCS projects**

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