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Air Quality Control
Siemens Carbon Capture Technology

Tony DoVale
President - Environmental Systems & Services

Basis: Amino Acid Salt Formulations

Environmental Systems & Services Business Model

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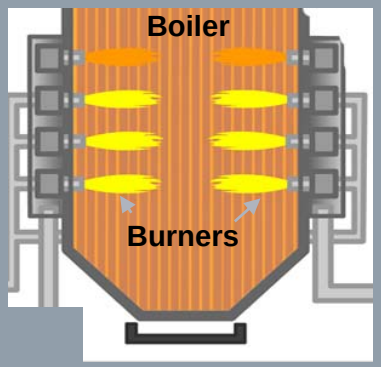
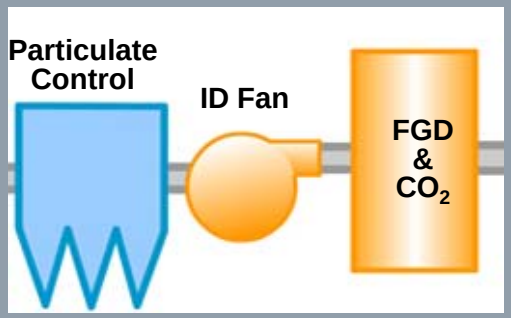
Provide One Stop Combustion/Gas Path Optimization, Equipment and Service

A cleaner burn results in less clean-up

Combustion Performance + **Air Pollution Control Equipment** = Lower Emissions





Combustion Process =	ABT Product Line ESS Service Steinmuller Engineering	Lower NO_X Increase Efficiency Enhance Reliability
Flue Gas Clean-up =	ESS Systems (former Wheelabrator)	Full Range of Products Experienced Team

Environmental Systems & Services
Expanded Products for Global Markets

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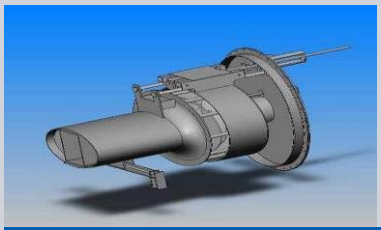

- **Carbon Capture Technology (CC)**
  - Siemens PostCap Process
- **Flue Gas Desulfurization (FGD)**
  - Dry FGD
  - Mercury Control
  - Wet FGD
  - Wet ESP
- **Electrostatic Precipitators (ESP)**
  - HaRDE
  - VIGR
- **Fabric Filters (FF)**
  - Pulse Jet
  - Cartridge
  - Reverse Air
- **NO_X and Ancillary Products**
  - Low NO_X Burners
  - Overfire Air
  - SNCR/SCR
  - Boiler Design Upgrades

steinmüller engineering

Steinmüller Addition Expands Environmental Solutions

Environmental Technology Update
Post Combustion Air Pollution Control

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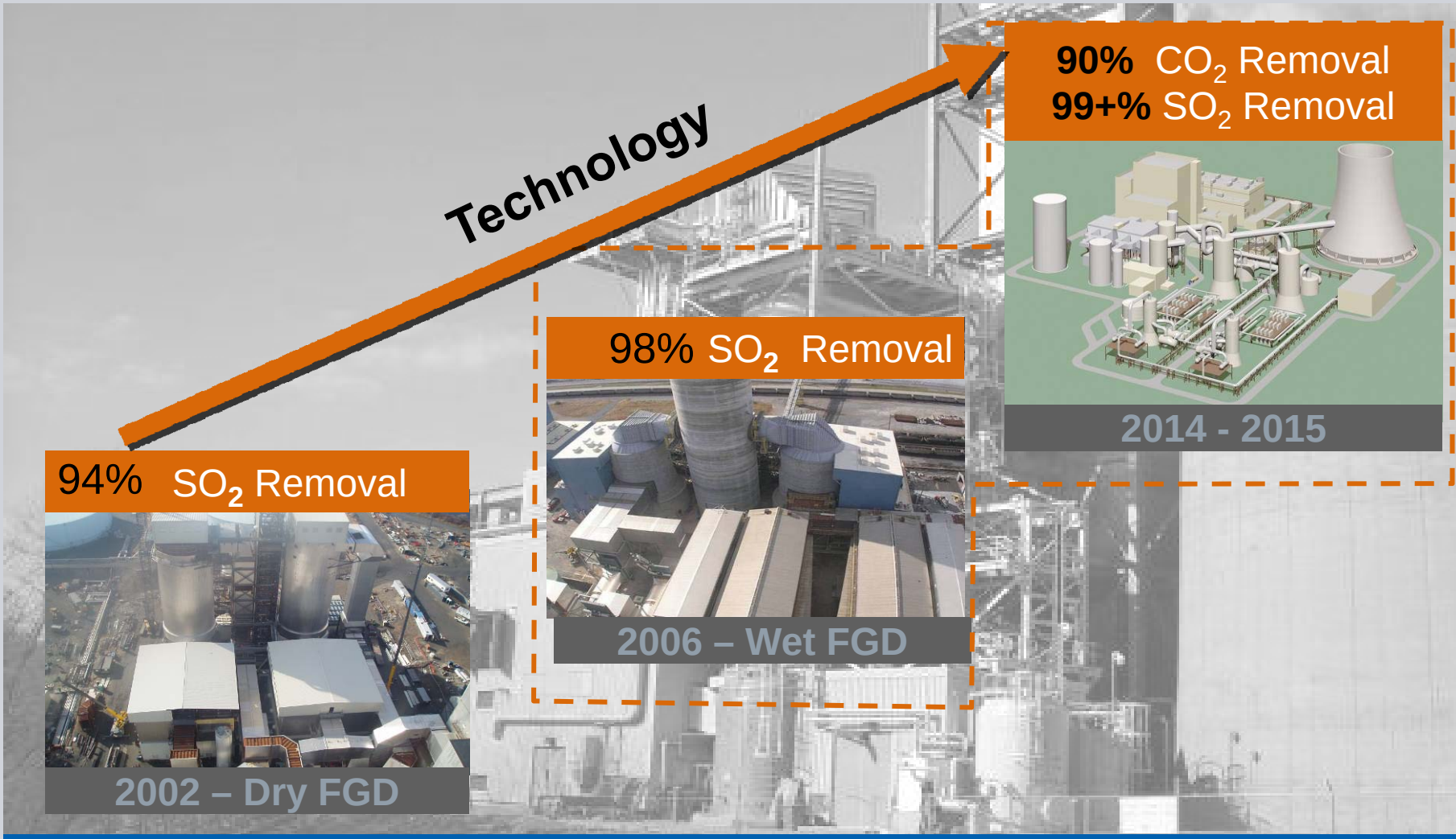

Enhanced FGD Technology Critical to Carbon Capture Technology

Siemens Preferred Solutions for CO_2 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

Oxyfuel Combustion Burners

Post-Combustion Carbon Capture

- Scalable market introduction, Slipstream Demo plants will minimize scale up 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 process based on amino acid salt formulations

Siemens Fuel Gasifier

Siemens IGCC in Puertollano (E)

Siemens scrubbing process test lab

Post-Combustion carbon capture plant design

Siemens Solutions Available for Implementation in CCS Demonstration Projects

Amino Acid Salt (Environmentally Safe) is the Basis of our Process

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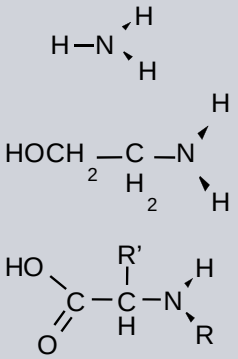
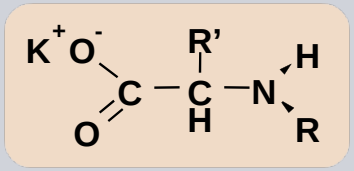


Ammonia

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

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

Siemens Post-Combustion Capture Process Current Status

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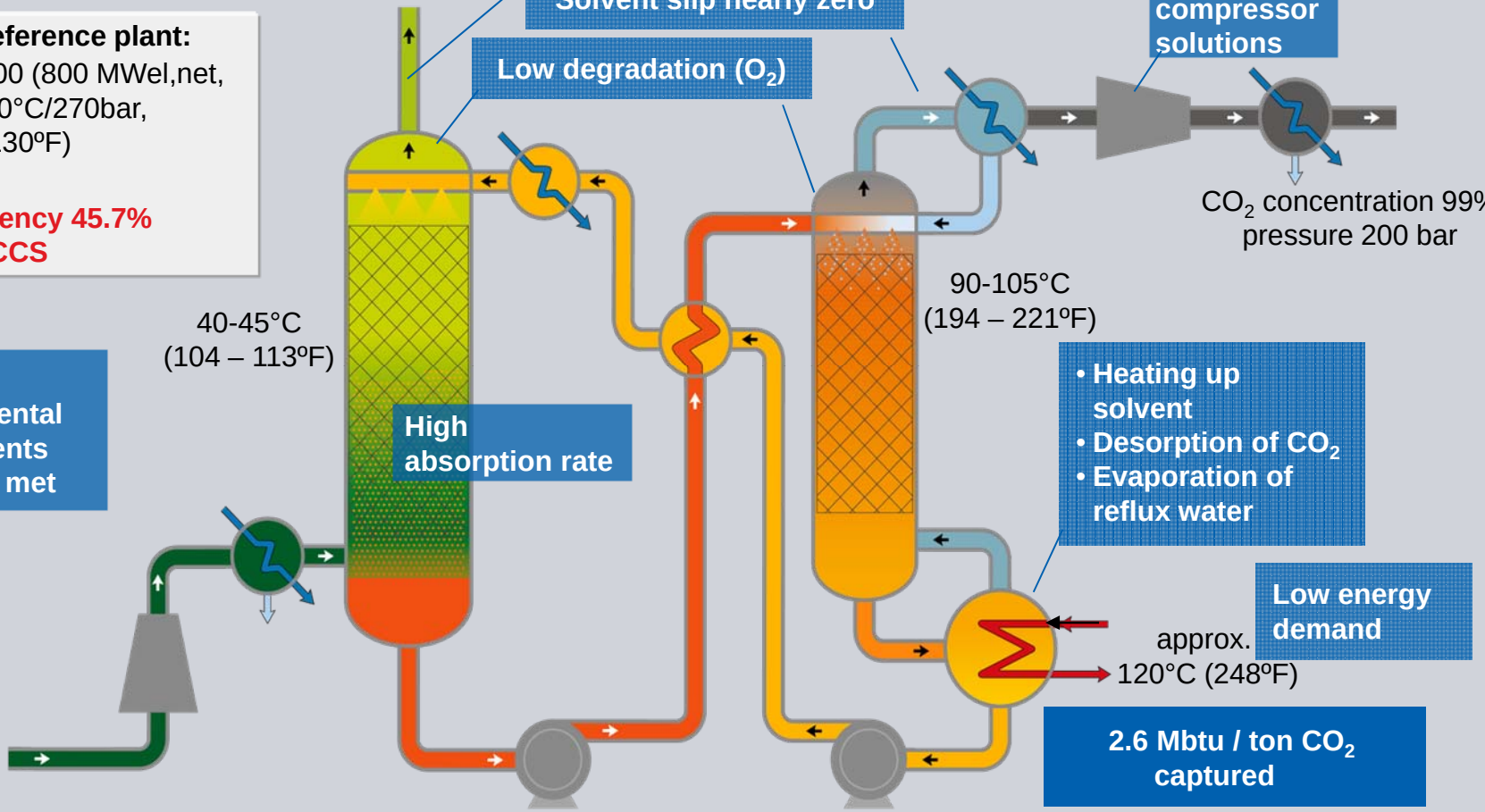
Non-CCS reference plant:

- SSP5-6000 (800 MWel,net, 600°C/610°C/270bar, 1112ºF/1130ºF)
- Hard coal
- **Net efficiency 45.7% without CCS**



The efficiency is ~ 8,5 %- pts. lower than the reference hard-coal fired power plant, CO_2 compression (200 bar) included

European POSTCAP Projects

E.On Staudinger Pilot Plant, Online Sept-09

Specifications
- 0.1 MWe scale
- Industrial packing
- Standard process layout

Results
- Long-term experience
  - Stability, Emissions, Corrosion
- Operating parameters
  - Start-up, Part load
  - Exceeding 90% Capture
- Further model validation

Fortum Meri-Pori Demonstration Plant, Online 2015

- 565 MW Plant in Finland
- Specification for CO_2 Capture on 50% of Plant Capacity
  - FEED Study culminating priced proposal
  - Full EPC contract
- Evaluated 7 Post-Combustion and 3 Oxyfuel Providers
  - Included both Ammonia and Amine based post combustion technologies
  - 3 Suppliers included in the short list for final negotiations
  - Fortum partnered with Siemens POSTCAP Technology exclusively in June 2009
- Current Schedule: begin FEED in June 2010

Most critical step: Validation of the process under real flue gas conditions

Carbon Capture Pilot Plant at E.ON SPP„Staudinger“, Pilot to Demo plant

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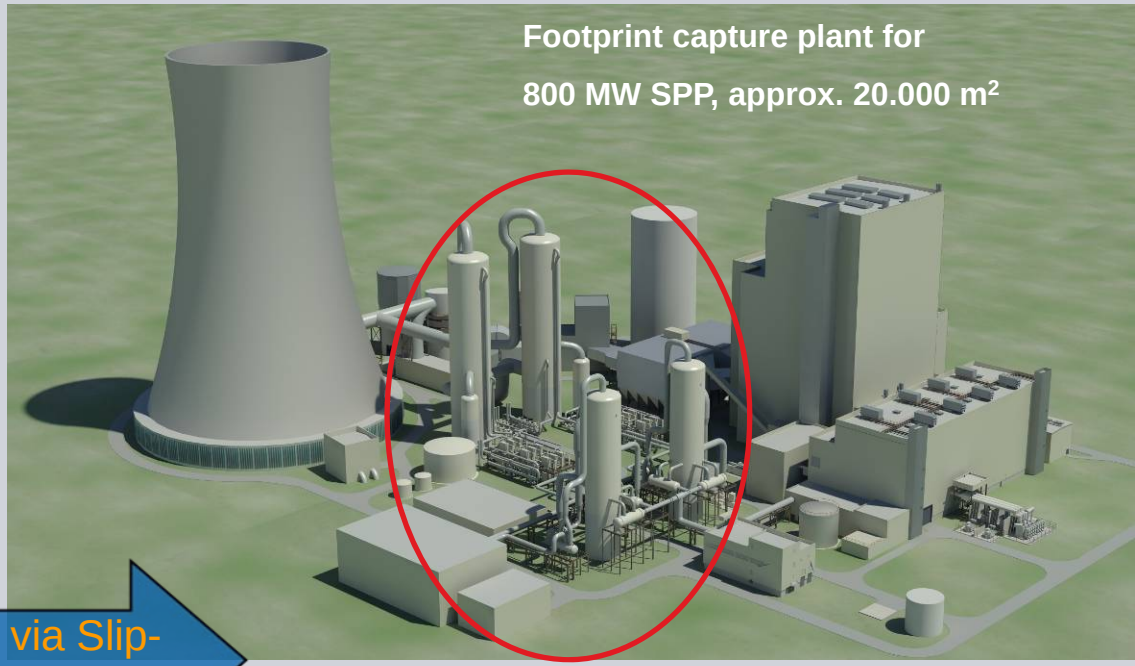
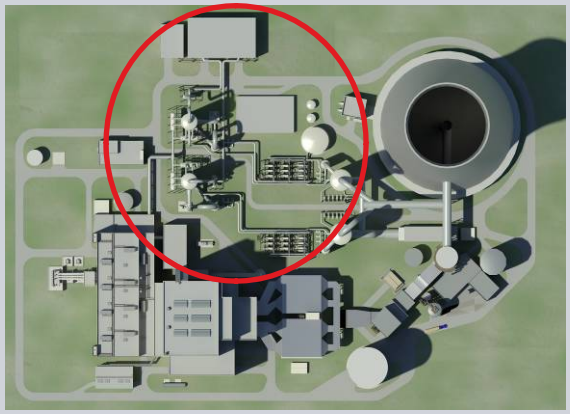
Start Operation September 2009

Upscaling via Slip-Stream Demo plants





Fortum and Teollisuuden Voima (TVO) plan to retro-fit Meri-Pori 565 MW coal-fired power plant

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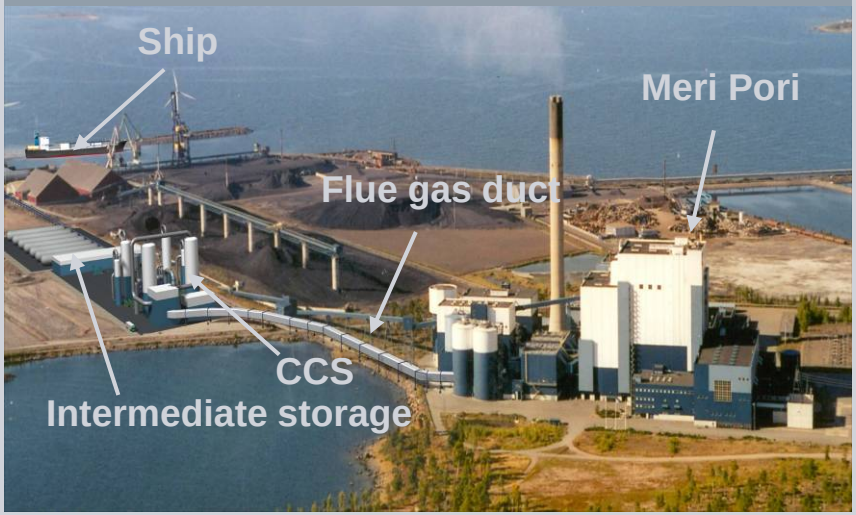
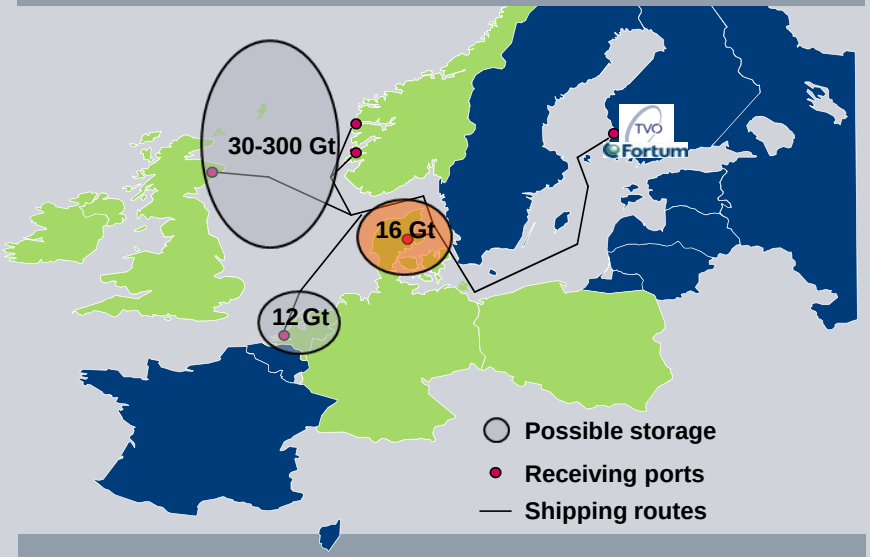
Retrofit project



- 50% Slip stream
- Aim to reduce CO_2 emissions by ~1,25 million tons/a, as well as NOx and SOx emissions
- Siemens Post-Combustion Technology selected

Use of CO2 for EOR



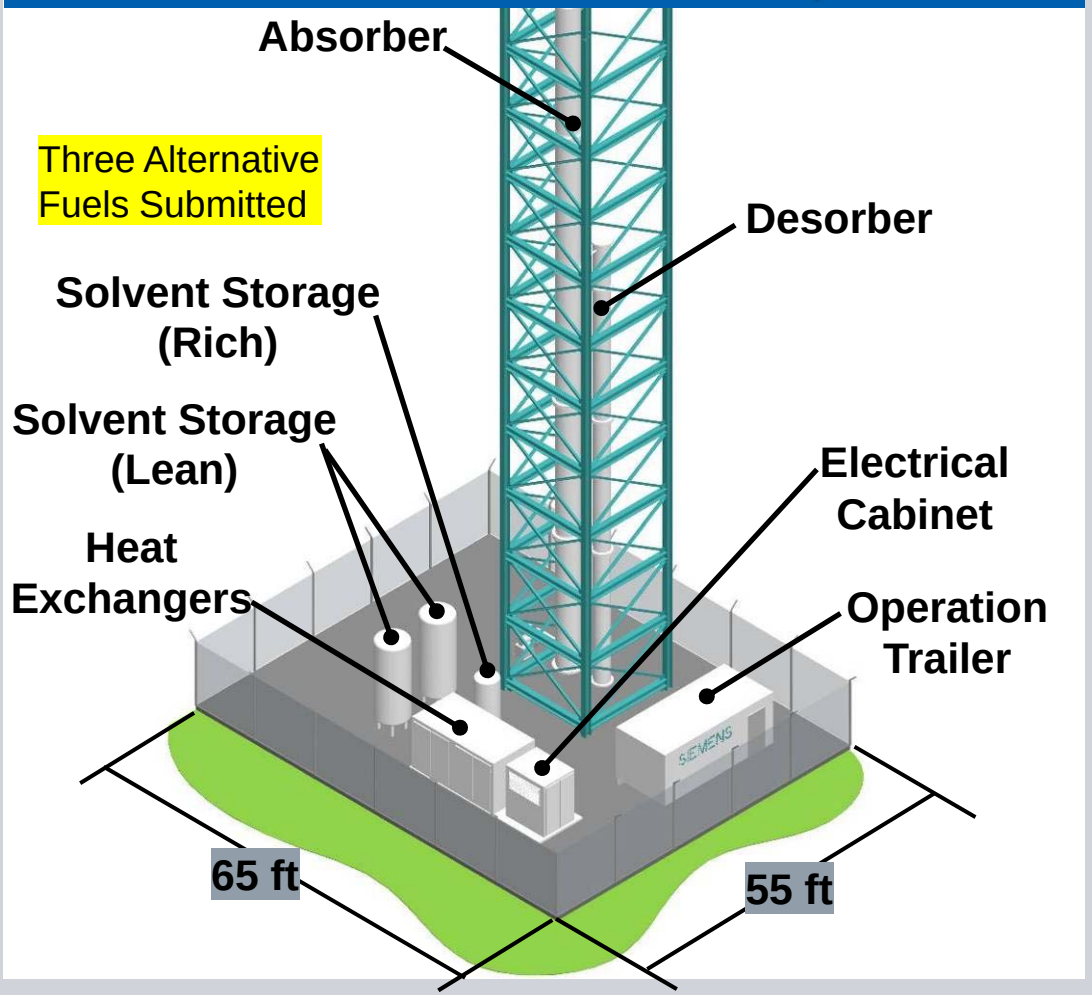
- CO_2 will be captured in Meri-Pori, transported abroad for storage and sequestered in geological formations
- FINCAP commissioning 2015

POSTCAP – U.S. Pilot Applications

DOE CCS Tech Solicitation

- Applications submitted in last round
  - Approx 1 MWe Pilot
- Planned DOE Awards
  - Bench Scale: 3 - 8
  - Slipstream: 1 - 3
- Award Timing
  - Summer 2010
- Performance Period (years)
  - Bench Scale: Up to 3
  - Slipstream: Up to 4

Siemens CCS Pilot Plant Layout



GenPower Longview Facility
CCS 375 MW Demo Unit

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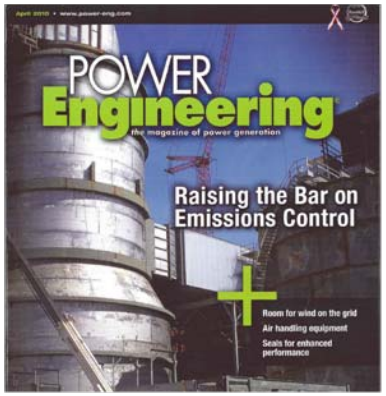
- Siemens selected by GenPower to conduct a Feasibility Study
  - Completed March 2010
- New 695 MW supercritical pulverized coal power plant
  - Maidsville, WV
- SESS supplying state-of-the-art pollution control system
- Ready to build on the study with government incentives to capture 90% CO_2 from 50% of the Unit



CO_2 Compression Integration

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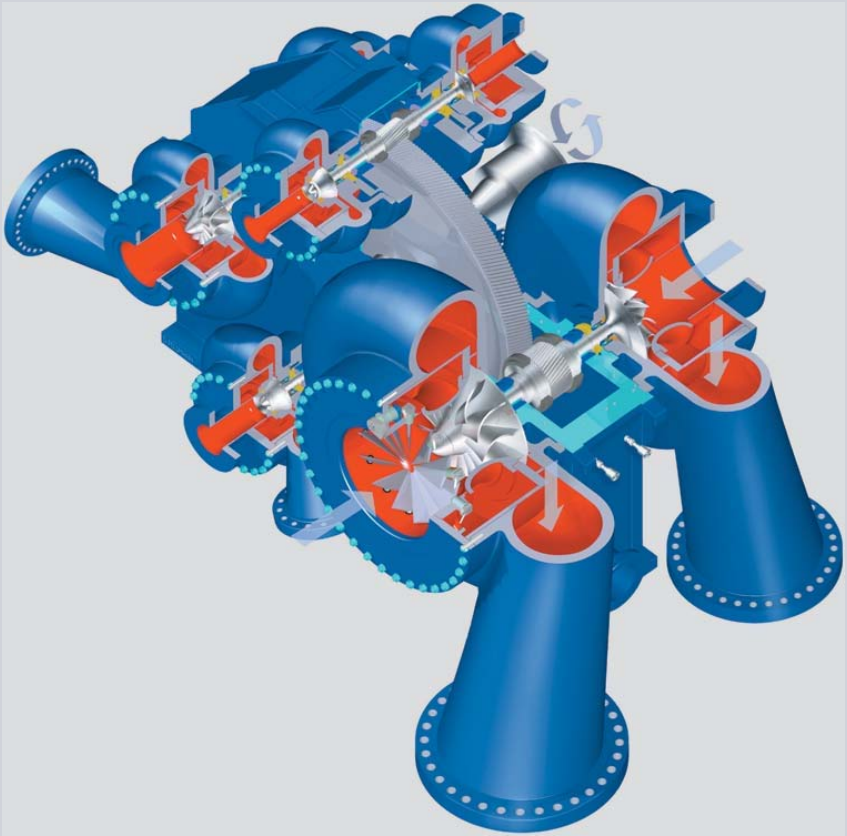
Siemens CCS Compression Module

- Intercooled gear-type compressor
- Dedicated cooler for changing CO_2 fluid density
- Pump or high density compressor

Heat Recovery Impacts

- Compressor Design
- Rotor Dynamics
- Material Selection



CO_2 compressor development coordinated with CO_2 capture process development and Power Plant Integration for optimal solution

Post-Combustion for Combined Cycle Power Plant

Main driver for Natural Gas CCS

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

Post-Combustion Development Challenges

- Low 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 pursues the development
of a dedicated capture process for combined cycle power plants

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