

Environmental Control Solutions GE Power

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Imagination at work

A DIGITAL INDUSTRIAL COMPANY

With more than 300,000 people operating in 175 countries, GE is the world's Digital Industrial Company, transforming industry with software-defined machines and solutions that are connected, responsive and predictive. GE is organized around a global exchange of knowledge that we call the GE Store. It's through the GE Store that each business shares and accesses the same technology, markets, structure and intellect. At GE, each invention further fuels innovation and application across our industrial sectors. With people, services, technology and scale, GE delivers better outcomes for customers by speaking the language of industry.



POWER

~\$30B



ENERGY

MANAGEME

~\$11B

RENEWABLE

ENERGY

~\$9B



OIL & GAS

\$18.7B





TRANSPORTATI

ON

\$5.7B



HEALTHCAR

F

\$18.3B

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PPLIANCES	
& LIGHTING	

\$8.4B



AVIATION

\$24B





GE POWER

~\$28B '14 revenue ~65,000 employees >120



Steve Bolze, CEO Schenectady, NY

countries

Gas Power Systems

High Efficiency, Scale Power

- Power Plants (combined & simple cycle)
- Gas Turbines
- Steam Turbines
- Generators & Controls
- Heat Recovery
 Steam Generators



Power Services

Optimizing Plant Performance

- Installation planning/execution
- Maintenance, repairs & outage solutions
- Multi-year service agreements
- Hardware/software blended upgrades
- Data-driven
 software solutions



Steam Power Systems

Advanced Steam Power Expertise

- Complete portfolio, turnkey power plants
- Widest range of generators
 & Steam Turbines
- Air Quality Control Systems (AQCS) including CCS
- Turbine Island
 Solutions for Nuclear



Distributed Power

Broad, Efficient Portfolio

- Reciprocating engines (0.1 to 10 MW)
- Jenbacher engines, power equip. & servicer
- High efficiency & fuel flexibility: Natural gas, CHP, oilfield power, diesel & special gas applications



GE Hitachi Nuclear

Advanced Reactor Technologies

- ESBWR, ABWR, PRISM
- Outage & Asset Optimization Services
- Fuels & Engineering Services



Digital Capabilities – Building for the Future



Water & Process

Energy Efficient Water Solutions

- Chemical &
- Monitoring Solutions
- Engineered Systems
- Mobile Water
- Build-OwnOperate Services







Air Quality Control Solutions: Overview





Particulate Control

Electrostatic Precipitators





- Extensive experience in various industries
- Multiple designs of dry & wet ESPs
- Removal efficiencies up to 99.99 %

Fabric Filters (FF)



- Higher performance than ESP
- Lower capital cost than ESP
- Higher operating costs than ESP
- Emissions down to 1 mg/Nm³



Wet Desulfurization

Open Spray Tower



- Up to 1,300MW
- Up to 6% sulphur
- Removal efficiency > 99%

Flowpac[™] Absorber



- High availability
- Low maintenance
- Compact design
- Removal efficiency: 99%

Seawater FGD



- Discharged seawater exceeds environmental standards
- Removal efficiency > 98%



De-SO_x and De-NO_x

Spray Dryer Absorber

NID

SCR



- Up to 900 MW and 2.5% sulphur coal
- Online atomizer
 maintenance
- Multi-pollutants SO₃, HCl, HF and Hg



- Removal rate up to 98%
- Fuel flexibility up to 4.5% sulphur coal
- Smaller foot print, lower construction cost
- Multi-pollutants SO₃, HCI, HF and Hg



- NO_x converted into N₂ & H₂O by injecting NH₃
- Low ammonium slippage
- NOx reduction exceeding 95%



Our Worldwide References





Air Quality Control Solutions: Applications





CO₂ capture technologies

- Initially developed for CCS on Power Generation
- Focus on post and oxy to address new installations as well as existing installed base





Chilled Ammonia Process Technology Overview

Principle

- Cooled flue gas is treated with ammonium carbonate in solution, which reacts with CO₂ to form ammonium bicarbonate
- Raising the temperatures reverses the above reactions – releasing pressurized CO₂

Advantages

- Energy-efficient CO₂ capture (90% rate)
- High CO₂ purity + High CO₂ pressure
- Tolerant to oxygen and flue gas impurities
- Stable reagent, no degradation possible
- No emission of trace contaminants
- ow-cost, globally available reagent

VENT TO ATMOSPHERE

 $2NH_{3} (aq) + H_{2}O (I) + CO_{2} (aq) \iff I = I \Rightarrow (NH_{4})_{2}CO_{3} (aq)$ $(NH_{4})_{2}CO_{3} (aq) + CO_{2} (aq) + H_{2}O (I) \iff I \Rightarrow 2(NH_{4})HCO_{3} (aq)$ $(NH_{4})_{2}CO_{3} (aq) \iff I \Rightarrow (NH_{4})NH_{2}CO_{2} (aq) + H_{2}O (I)$

Mongstad – Refinery and TCM Site





Offering - Scope of Services from Conceptual Studies to Plant Commissioning





Application of CO₂ Capture in the Methanol Industry



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Methanol Production – the role of CO₂





Flue gas CO₂ Recovery





Benefits with Ammonia as solvent

Benefits of Ammonia solvent:

- Ammonia solvent cost is estimated to be lower than 1% of OPEX for CAP
- Solvent is readily available as a commodity chemical with no single supplier or producer
- No solvent degradation and no additional processing costs
- No special need for degradation products to handle or destroy

Solvent Cost (NH3)

Solvent make-up= $0,7 \text{ kg/t}_{CO2}$ recoveredSolvent Cost= 300-600 USD/tonAnnual Cost=<1 % of total OPEX</td>Nodegradationproducthandlingcosts(CAPEX or OPEX)



For some amine-based processes, typical solvent cost can reach approx 10% of OPEX (ref. US) , excl. disposal costs.



CAP implementation case study

Reduced NG feed with maintained product yield through CO_2 recovery

- Typical process parameters for CO₂ recovery
- Steam consumption: 1,72 t/t_{CO2}
- Electricity: 142 kWh/t_{CO2} (P_{CO2} 27 bara)
- Cooling Water: 151 t/t_{CO₂} (25°C Δ T=10°C)
- NH₃ make up: 0,7 t/t_{CO2}
- By adjusting the Stoichiometric Ratio to the optimum by using CO₂ recovery via CAP
- Reduction of natural gas consumption of about 500 kWh/t_{CH₃OH} for maintained methanol output
- In addition, equipment sizing (incl. compressor) on the syngas stream will be smaller due to the reduced natural gas flow to be processed.





Why GE...

- Leader in ECS and CCS engineering, from design to construction, operation and maintenance
- Comprehensive portfolio that covers a complete range of systems, components and services for gas treatment
- Reliable partner with established processes to deliver consistently, on budget and on time
- Customer support with tailored solutions ensuring maximum efficiency and flexibility
- Helps customers be compliant and costeffective in a rapidly changing environment





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<u>Statement</u>

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