

Alstom's CCS Demonstration Projects

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ALSTOM - Core competencies

- **Power Systems**

- *25% of the World's installed capacity*

- **Power Service**



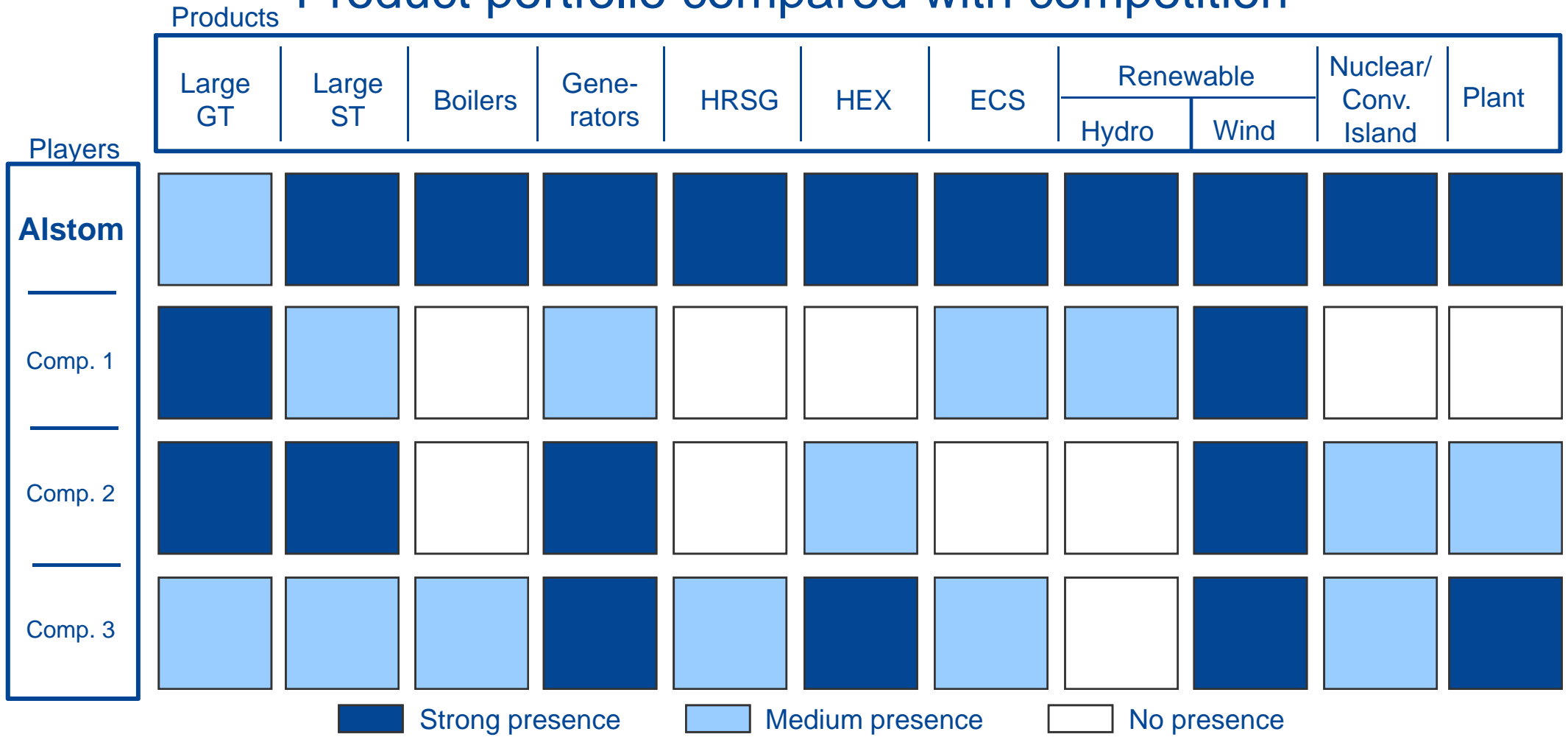
- **Rail Transport**

- *World Rail Speed Record*



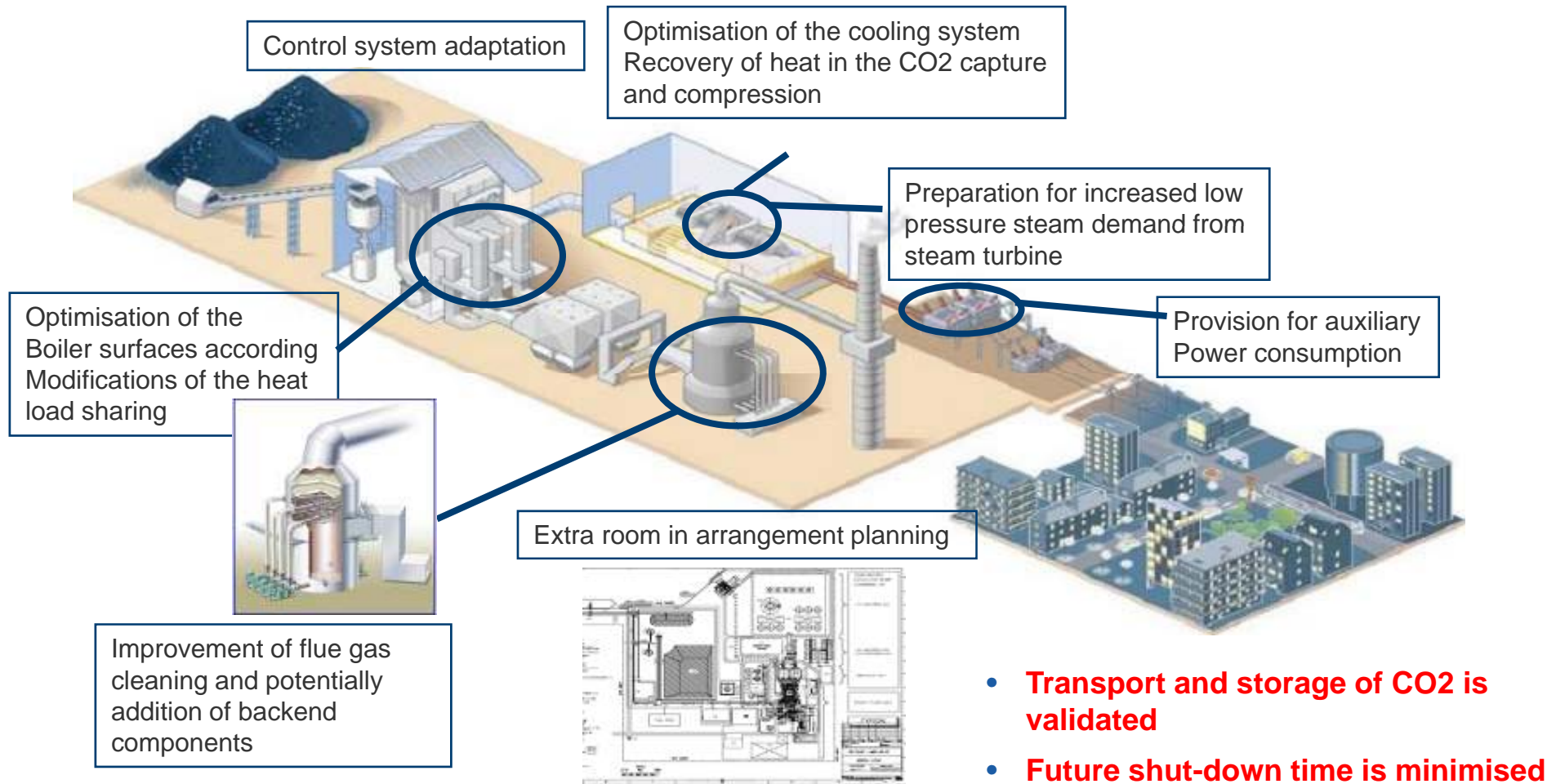
Alstom has the most Extensive Product Offering - ie Alstom's CO₂ response not technology limited

Product portfolio compared with competition



“CAPTURE READY” PLANT CONCEPT











CO₂ “Capture Ready” concept for a Coal Power Plant



- **Transport and storage of CO₂ is validated**
- **Future shut-down time is minimised**

Plant designed for future CO₂ capture addition with minimal plant performance and cost impact

Main Alstom PCC Demonstration Partnerships/Projects Announced to Date

CHILLED AMMONIA	Stanford (US) - Gas and Coal	0.25 MWt	  StatoilHydro ALSTOM
	Pleasant Prairie (US) - Coal	5 MWt	 we energies.  ALSTOM
	Mountaineer (US) - Coal Northeastern (US) - Coal	30 MWt >200 MWt	 ALSTOM
	Karlshamn (Sweden) - Gas	5 MWt	 ALSTOM
	Mongstad (Norway) - Gas	40 MWt	StatoilHydro ALSTOM
ADVANCED AMINES	Joint Development Partnership		 ALSTOM
OXY-COMB	Schwarze Pumpe (Germany) - Coal	30 MWt	VATTENFALL  ALSTOM
	Lacq (France) - Gas	30 MWt	 ALSTOM
Lignite Drying	Hazelwood 2030 (Australia)	330 MWt	 ALSTOM

Oxy-Combustion

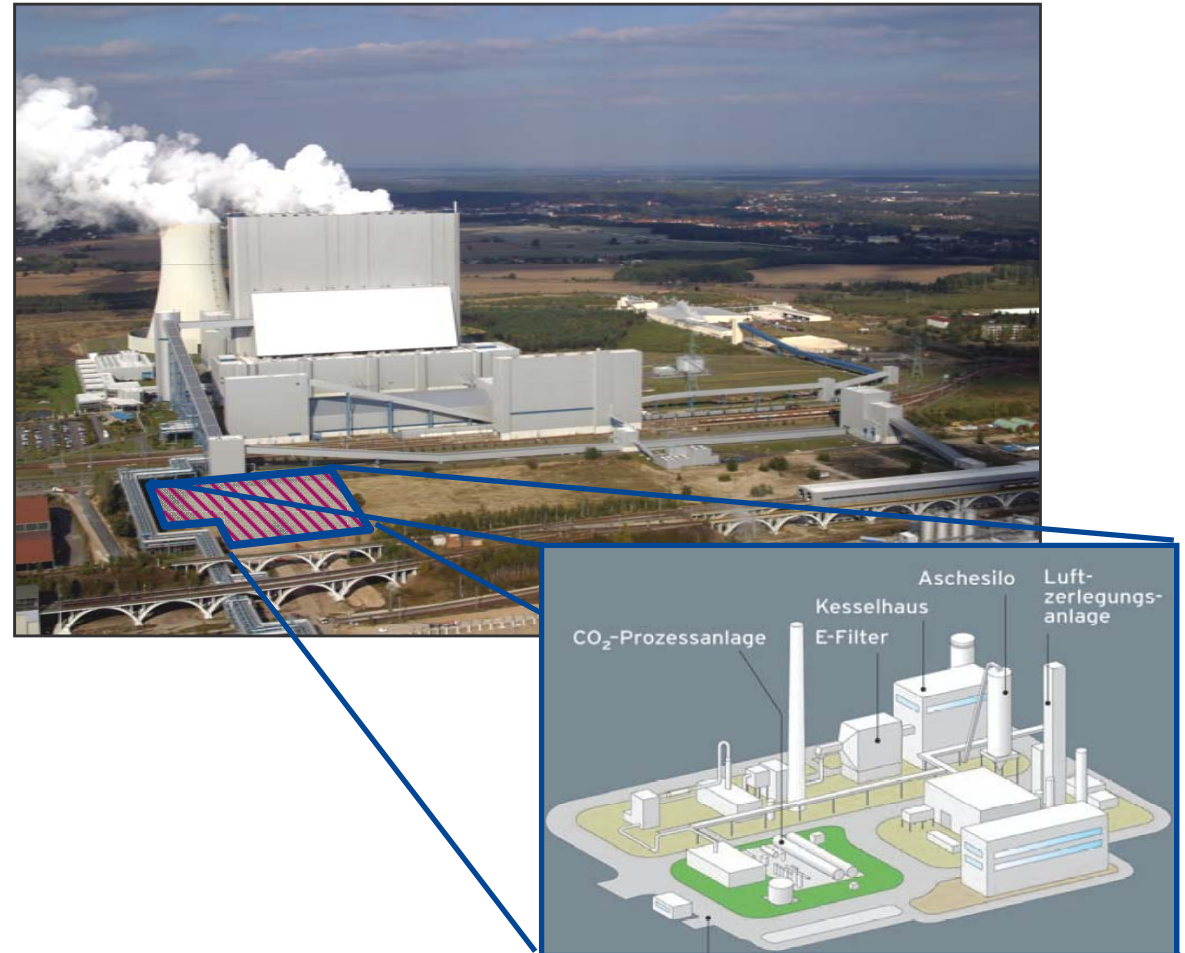
Oxy-PC: Demonstration 30 MW_{th}: Vattenfall



- Goal: validation and improvement of oxyfuel process starting summer 2008

Main features

- 5,2 t/h solid fuel
- 10t/h oxygen
- 40 t/h steam
- 9 t/h CO₂
- ALSTOM supplies the oxy-boiler and ESP



30 MW_{th} Demonstration – Schwarze Pumpe, Germany

Source: Vattenfall

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Oxy-Combustion

Oxy-PC: Demonstration 30 MW_{th}: TOTAL Lacq



- Goal: validation and improvement of oxyfuel process starting 2008

Main features

- 40 t/h steam,
240 t/day Oxygen
- 150,000 tons CO₂ will be stored in a depleted gas field



30 MWt demonstration – Lacq, France

Source: TOTAL

Example of Oxy-fire CO₂ Capture Plant Layout



CO₂ CAPTURE SOLUTIONS

Post Combustion Solutions for New Plants and Retrofit

CO₂ absorption processes (MEA, MDEA)



PP Esbjerg (DK)

- Available in commercial scale
- Retrofittable and flexible
- High energy demand for regeneration of solvents



1 t CO₂/h pilot plant (CASTOR EU-FP6)

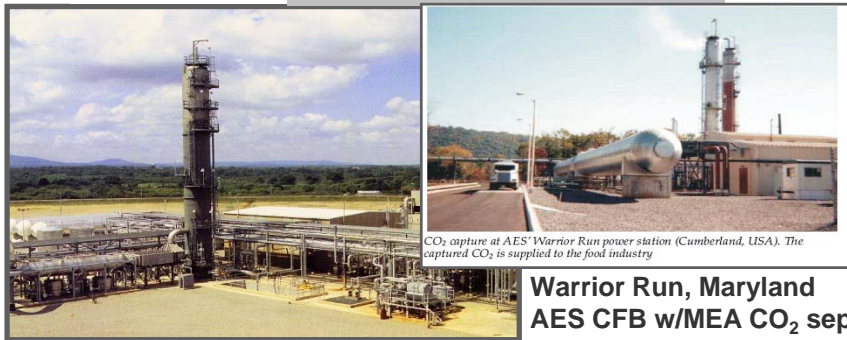
Post Combustion Capture Partnership with DOW



PP Esbjerg
Denmark



1 t CO₂/h pilot plant (CASTOR
EU-FP6)



Warrior Run, Maryland
AES CFB w/MEA CO₂ separation

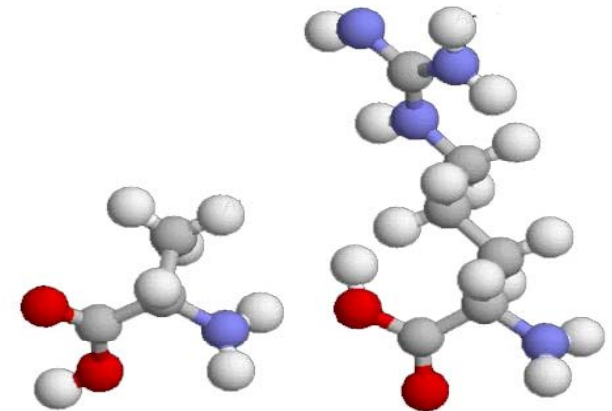
SHADY POINT, OKLAHOMA, USA
AES CFB w/ MEA CO₂ separation

Amine CO₂ capture is proven

- Retrofittable
- Installed on a few plants burning coal
- High energy demand for regeneration

Exclusive partnership with DOW

- Advanced Amines
- Improved Process
- Plant Integration

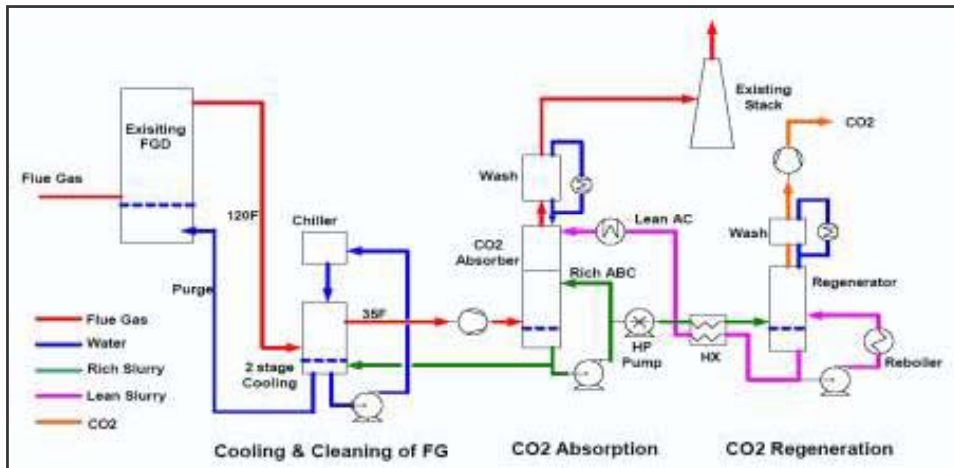


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CO2 CAPTURE SOLUTIONS

Chilled Ammonia Process

A promising technology for post combustion carbon capture



Advantages

- High efficiency capture of CO₂ and low heat of reaction
- Low cost reagent
- No degradation during absorption-regeneration
- Tolerance to oxygen and contaminations in flue gas

Principle

- Ammonia (NH₃) reacts with CO₂ and water. It forms ammonia carbonate or bicarbonate
- Moderately raising the temperatures reverses the above reactions – releasing CO₂



5 MW Pilot Plant (USA)

Start-up anticipated for 2007

Post-Combustion Chilled Ammonia - Field Pilot at WE Energies



Pleasant Prairie Power Plant (US)



Test Bench 5 MW, start up in February 2008

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Industrial pilot program

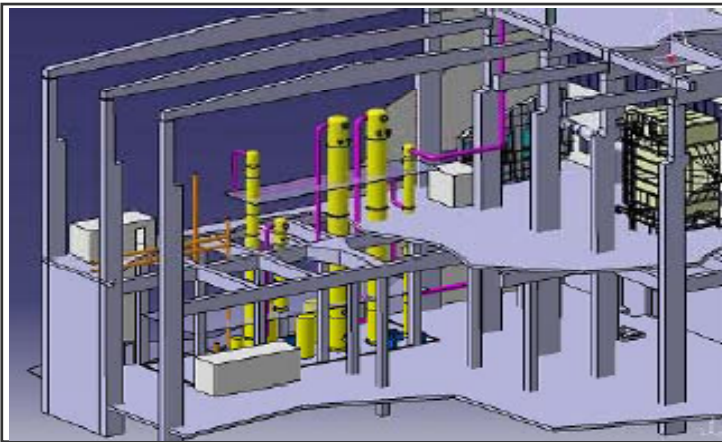
- Project participation through EPRI by over 30 US and international utilities
- Designed to capture up around 15,000 tons/year of CO2 at full capacity
- Absorber and cooling systems commissioned
- Erection of regenerator system in completion
- Parametric testing to commence March 2008
- Will provide data necessary to establish “proof of concept”

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Post-Combustion Chilled Ammonia - Field Pilot at E.ON Karlshamn



Karlshamn Power Plant (Sweden)



Test bench 3D schematic



Industrial pilot program

- Designed to capture up around 15,000 tons/year of CO₂ at full capacity
- Project schedule:
 - Commissioning July 08
 - Testing Fall 2008
- Testing to continue into late 2009

Post-Combustion Chilled Ammonia - Demonstrations: AEP & STATOIL



Industrial demonstrator 30 MWt,
Mountaineer (US)



Industrial demonstrator 40 MWt,
Mongstad (Norway)



- Designed to capture up around 100,000 tons/year of CO₂ at full capacity
- Saline aquifers storage
- Commenced engineering Oct 07
- Project commissioning 09

StatoilHydro

- European Test Centre Mongstad for flue gases from natural gas CHP plant and a refinery
- Designed to capture 100,000 tons/year

Capture and Storage Deployment time-line

Roadmap

	2007	2010	2015	2020	2025	2030
<i>Capture</i>						
Post-comb.	Pilot / Demo		Pre-commercial	Commercialization		
Oxy-comb.	Pilot / Demo		Pre-commercial	Commercialization		
Pre-comb.	Pilot / Demo		Pre-commercial	Commercialization		
<i>Transport</i>						
EU,US Australia	Local, limited EOR projects + Demo			Progressive pipeline deployment, depending on validated storage sites		
<i>Storage</i>						
EU,US Australia	EOR + validation of storage sites			Ramp-up to full scale saline aquifer storage		

Source : Alstom Analysis

Ample storage available but its timely deployment is the likely bottleneck

4. CO2 CAPTURE SOLUTIONS

Technology comparison – 2015 Design – 650 Mwe (net)

Cost of electricity comparison

