Updates on Alstom’s Clean Coal Technologies For Power Generation

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9/15/2014
Updates on Alstom’s Clean Coal Technologies For Power Generation

• Alstom and its power business at a glance

• Alstom presence in China

• Alstom’s approach to CO2 challenge

• A-USC boiler technology development update

• Oxy-Combustion technology update

• Chemical-Looping technology update
Group – Power, Grid, Renewable, Transport

Thermal Power
9.2 €bn

Renewable Power
1.8 €bn

Grid
3.8 €bn

Transport
5.5 €bn

• Total sales 2012/13 = 20.3 €bn
• Total orders 2012/13 = 23.8 €bn

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Alstom’s Position in Global Power Industry

• Alstom equipment in >50% of U.S. Power Plants
• Alstom supplies major equipment for 25% of the worldwide installed power generation capacity
• Broad portfolio of power generation technologies: fossil, renewable, nuclear
• Leader in CCS with extensive R&D and pilot testing experience
  ➢ First generation technologies – advanced amines, chilled ammonia post capture, and oxy-combustion
  ➢ Second generation technology – chemical looping
• Alstom’s US boiler operation (former C-E) is best known by the Chinese power industry as the inventor of tangential firing system
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- **Alstom presence in China**
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Alstom Presence in China

Over 20 legal entities
9,000 employees

As of 31 March 2014
截止至2014年3月31日
China Presence is Important to Alstom’s Clean Coal Strategy

- Alstom is committed to develop its branches into competitive Chinese companies that can combine local talents with Alstom’s global know-how
- Emission control and carbon capture engineering execution center in Beijing
- Steam turbine engineering center and manufacturing facility in Beijing
- Boiler engineering center and manufacturing facility in Wuhan
  - Alstom’s most advanced and largest boiler manufacturing facility
  - World class material lab and growing R&D capability
  - Able to offer 1000MW class ultra-supercritical boiler products
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Alstom’s Approach to CO2 Challenge

- **Technology mix and decarbonized power** –
  - Example: hydro, solar thermal, wind, geothermal, nuclear and biomass (CO2 neutral)

- **Plant efficiency improvement** –
  - Example: Advanced Ultra-supercritical (A-USC) cycle, heat recovery and plant optimization

- **CO2 capture, utilization and storage** –
  - Example: Post combustion capture, oxy-combustion

Clean Coal Technologies
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Pulverized Coal Boilers Steam Parameters - Jumping to A-USC

- A-USC refers to steam cycles with steam temps of 700°C - 760°C
- A-USC steam cycles increase net plant efficiency by ~ +9% vs. USC (600°C)
- A-USC reduces emissions (including CO₂) and flue gas volumes making equipment smaller
- Need development work on materials as well as boiler design
A-USC – USA (760°C) – Alabama Power Barry Station Steam Loop

Highest condition steam loop in the World

- Under US DOE AUSC Materials program, Alstom has participated high Nickel alloy qualification, welding and fabrication studies and testing in the past 14 years
- Alstom also designed A-USC boiler for 760°C steam condition
- The ongoing activity is Barry station high temperature corrosion test where candidate materials have been installed in an operating coal fired boiler.
- Field exposure testing at A-USC steam temperature (760°C) will validate laboratory corrosion and oxidation testing
- Super304H, HR3C, HR6W, Haynes 230 & 282, Inconel 617 and Inconel 740 etc.
- Alstom also participated European AUSC material and boiler program
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CCS Technologies Developed by Alstom

CO₂ capture technologies pursued by Alstom

- Post-combustion (New + retrofit)
- Oxy-combustion (New + retrofit)

Alstom’s activities on CCS address

- all fossil fuels, i.e. Hard Coal, Lignite, Natural gas
- Installed Base, New Built for Power
- Industrial CCS
Oxy-Combustion Overview

- Reliable: main components exist; drawing on high degree of conventional technology
- Flexibility: applicable for all types of boilers, firing systems and fuels and flexible operation
- Scale-up: no constraints anticipated for commercial units based on pilot experience
- Emissions: No new chemicals introduced to the power plant for CO2 capture

A near term CCS coal power generation solution
Alstom Oxy-Combustion Pilot Testing Achievements – Boiler, AQCS, FGC, and GPU
Update on Alstom Oxy-Combustion Roadmap

- **1990’s**
  - Laboratory Scale
  - 15-30 MWth

- **2008**
  - Large Pilot Plant
  - 30 MWth

- **2012**
  - Demonstration Plant
  - 150-450 MWe

- **2017**
  - White Rose, UK
  - 450 MWel,gross

- **2020 & Beyond**
  - Commercial Plant
  - 600-1000 MWe
White Rose Project - Largest Oxy-Combustion CCS Project

OXY-POWER PLANT

- Delivery of Oxy-PP
- Integration of Oxy-PP
- O&M of Oxy-PP
- Trading Services
- Site and Site Services
- Fuel Supply
- Electrical Connection

CO₂ TRANSPORT & STORAGE

- Full-Chain Integration
- Delivery of Oxy-PP
- Integration of Oxy-PP
- Delivery of ASU
- O&M of ASU
- Delivery of Transport & Storage network
- O&M of Transport & Storage network

Courtesy of © Capture Power Ltd 2014
White Rose Project Overview & Status

- A new modern ultra-supercritical 450 MW_{el gross} Oxy-Combustion Power Plant
- 100% of flue gas treated, 90% CO\textsubscript{2} capture rate → 2 million tonnes CO\textsubscript{2}/year
- Biomass co-firing up to 15% (by heat) leading to zero - or negative - CO\textsubscript{2} emissions
- CO\textsubscript{2} to be permanently stored in a deep saline formation off-shore beneath the North Sea
- FEED is underway after FEED contract signed in December 2013 with the UK Government under the CCS Commercialization Programme
- In July 2014, EU “NER300” programme awarded another funding for up to €300M towards White Rose project
- On track for a final investment decision end 2015

Largest Oxy-combustion CCS Commercialisation Project Worldwide
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Chemical Looping Process – a Transformational CCS Technology

- An innovative oxy-combustion process where oxygen is transported by solids oxygen carrier
- No cryogenic Air Separation Unit
- Low conventional air pollutant emission: NOx, SOx, Mercury

A transformational CCS technology with low cost and low energy penalty
Chemical Looping Process Overview
Alstom’s Chemical Looping Development, Since Late 1990’s

**Limestone Based (LCL™)**

US-DOE funded

Main Features:

- Low cost limestone based oxygen carrier – CaS, CaSO₄
- Process based on two “Fast” beds
- Flue gas contains high concentration CO₂
- Option is available to generate syngas for Coal-to-Liquid fuel conversion w/o using gasifier

**Metal Oxide Based (MeOx)**

ÉCLAIR/ACCLAIM Programs – EU RFCS funded

Main Features:

- Metal-based oxygen carriers such as Fe, Mn, Cu... ores, ilmenite (FeTiO₃), or on substrates
- Process based on CFB solids transport
- Carbon stripper for minimizing UBC

Alstom is executing two chemical looping programs
Limestone-based Chemical Looping (LCL™) Process
Managed Development and Scale-up Steps

World’s first “autothermal” operation in 2012 in the largest CLC facility

1996-2000
Bench Tests

2000-2008
Pilot Plant
65 kWth

2008-2015
Prototype
3 MWth

2016-2020
Demonstration
10 - 50 MWe

2020-2025
Commercial Scale
>100 MWe

- Cold Flow Models
- Managed Development and Scale-up
- 1996-2000
- 2000-2008
- 2008-2015
- 2016-2020
- 2020-2025
- Bench Tests
- Pilot Plant
- Prototype
- Demonstration
- Commercial Scale
- World’s first “autothermal” operation in 2012 in the largest CLC facility
Shaping The Future With Alstom

- Shaping leading expertise
- the future vision
- with Alstom long-term collaboration
Thank You!
Any Question?

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