Alstom Environmental Control Solutions
An Overview

Dr. Magnus MÖRTBERG
25/06/2015
Three main activities in four Sectors

- **Thermal Power**: 8.8 €bn
- **Renewable Power**: 1.8 €bn
- **Transport**: 5.9 €bn

- Total sales 2013/14 = 20.3 billion
- Total orders 2013/14 = 21.5 billion
Alstom Thermal Power Organisation

Thermal Power
Philippe Cochet
President

Gas
Steam
Nuclear
Power Automation & Controls
Thermal Services
Historical Background
Air Pollution Control Since 1920

• **1920**: AB Svenska Fläktfabriken established in Jönköping
  • Manufacturing of fans, duct work, ventilation systems, etc.
  • No. of employees: 20
  • Share capital of SEK 175,000 (€ 19,000)

The heritage from ASEA, STAL and AB Svenska Fläktfabriken (Fläkt) have later been transferred through ABB to the Alstom of today.

Fläktfabriken’s first workshop at the old hospital mill in Jönköping, Sweden.

Large fans were delivered at an early stage of the history.
ECS Today – Environmental Control Solutions

NOV 2012

EC/CCS
Environmental Control & Carbon Capture Systems

SEP 2014

ECS
Environmental Control Solutions

ECS
Environmental Control Systems

CCS
Carbon Capture Systems

EC/CCS
Environmental Control & Carbon Capture Systems

TS
AQCS
Thermal Service AQCS
ECS
Footprint – Key Locations

Levallois, FR
Mgt Office
Headcount: 8+1*

Wiesbaden, DE
Execution/R&D
Headcount: 101

Oslo, NO
Front Office
Headcount: 53

Vaxjo, SE
Front Office, R&D
Headcount: 135+72*

Moscow, RU
Front Office
Headcount: 54

Kobe, JP
Front Office
Headcount: 33

Beijing, CN
Execution Centre
Headcount: 197+25*

Kolkata, IN
Execution Centre
Headcount: 189+40*

Knoxville, US
Execution Centre
Headcount: 208+49*

Milan, IT
Front Office
Headcount: 47+15*

Global knowledge and resources, local presence and insight

1,200+ dedicated professionals across:

4 Execution Centres
5 Front Offices
6 Project Offices
1 R&D Centres

Headcount: ECS @ Mar-14 Actual (Perm + FTC)
* Employees from TS-AQCS @ 1-Sep

© ALSTOM 2013. All rights reserved. Information contained in this document is indicative only. No representation or warranty is given or should be relied on that it is complete or correct or will apply to any particular project. This will depend on the technical and commercial circumstances. It is provided without liability and is subject to change without notice. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.
ECS
World’s No.1 AQCS Supplier

Over 480 GW supplied for power & 2,800 systems for industry globally

North America
- Power: 148+ GW
- Industry: 200+ Systems

Latin America
- Power: 6+ GW
- Industry: 200+ Systems

Europe
- Power: 115+ GW
- Industry: 1,000+ Systems

Russia & CIS
- Power: 11+ GW
- Industry: 55+ Systems

Middle East & Africa
- Power: 35+ GW
- Industry: 100+ Systems

India
- Power: 50+ GW
- Industry: 700+ Systems

Asia
- Power: 95+ GW
- Industry: 400+ Systems

Oceania
- Power: 20+ GW
- Industry: 90+ Systems
Agenda

• Introduction

• **Product Portfolio**

• Key Features and Customer Benefits
  – Power
  – Industry

• Retrofit

• Conclusions
ECS
Product Portfolio for Power and service

NOx Control
- Selective Catalytic Reduction Systems
- Combustion Modification

Mercury Control
- Mer-Cure™
- Filsorption™

Particulate Control
- Fabric Filter
- Electrostatic Precipitator
- Wet Electrostatic Precipitator

Integrated Systems
- NID™
- Spray Dryer Absorber

Flue Gas Desulphurisation
- Wet FGD
- Seawater FGD
## Product Portfolio for Industry

### Air Quality Control Systems

<table>
<thead>
<tr>
<th>Industry Specific</th>
<th>I &amp;S</th>
<th>WtE</th>
<th>Alu</th>
<th>Oil &amp; Gas</th>
<th>P&amp;P</th>
<th>Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFGD (NID and SDA)</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>SWFGD</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>ESP (Wet and Dry)</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>FF (high ratio and low ratio)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>SCR</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>ACI (Hg)</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>

**Industry Specific**

- HQT, WCD, FDC, HPC; Drypac DAS/DSI
- Polishing & condensing scrubber; DAS
- GTC FTC Alfeed HEX

**Definitions**

- **HQT**: Hot Quenching Tower
- **WCD**: Water Cooled Ducts
- **FDC**: Forced Draft Cooler
- **HPC**: Hair Pin Cooler
- **DAS**: Dry Absorption System
- **HEX**: Heat Exchanger

© ALSTOM 2013. All rights reserved. Information contained in this document is indicative only. No representation or warranty is given or should be relied on that it is complete or correct or will apply to any particular project. This will depend on the technical and commercial circumstances. It is provided without liability and is subject to change without notice. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.
Agenda

• Introduction

• Product Portfolio

• Key Features and Customer Benefits
  – Power
  – Industry

• Retrofit

• Conclusions
Reduce Cost of Electricity
- Lower power consumption by sulphite sensor control
- Lower lime consumption using unique egg-crate nozzles & Performance Enhancement Plate

Lower Environmental Footprint
- > 99% SO2 removal
- Up to 6.0% Sulphur in coal

Increase Flexibility & Reliability
- Largest fuel flexibility, including various types of coals and oil
- Can successfully and economically follow all boiler load changes

The best just got better: Alstom latest 3rd generation WFGD-OST

- 40+ years of continuous innovation, with latest 3rd Generation WFGD-OST
- 60+ GW installed in Power
- Up to 1,300 MW unit size
- Highly efficient absorber design with less spraying banks and power & reagent consumption

© ALSTOM 2013. All rights reserved. Information contained in this document is indicative only. No representation or warranty is given or should be relied on that it is complete or correct or will apply to any particular project. This willdepend on the technical and commercial circumstances. It is provided without liability and is subject to change without notice. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.
Present Design Practice of WFGD

- Single vessel, 100% scrubbing, up to 99% SO2 removal.
- Larger pumps, higher nozzle density
- Forced Oxidation to improve dewatering and enable byproduct utilization/disposal
- PEPs/flow distribution trays for better gas/slurry distribution across
- Lower flow, lower pressure nozzles
- Smart nozzle placement
Seawater Flue Gas Desulphurisation – (SWFGD)

• Pioneer in SWFGD with 1st installation in 1968
• 50+ GW in Power alone
• Proven experience with 1,000 MW unit
• Unique packed tower design
• No reagent and no by-product, with superior restoration quality of discharged seawater

Reduce Cost of Electricity
• Lower power consumption resulting from packed tower design
• No additional cost for reagent and end-product disposal
• Lower maintenance cost

Lower Environmental Footprint
• > 98% SO2 removal demonstrated
• Up to 4.5% Sulphur in Heavy Fuel Oil (HFO)

Increase Flexibility & Reliability
• Largest fuel flexibility, including coal, HFO and industrial flue gas
• Robust design without nozzles, leading to high reliability

NO.1 in SWFGD with ~60% of installed base globally
SWFGD Chemical Process

- Recycles sulfur back to its original location in its original form
- Only seawater and air are used
- No waste handling is needed

From Seawater

\[ \text{SO}_2 + \text{H}_2\text{O} \leftrightarrow \text{SO}_3^{2-} + 2\text{H}^+ \] (absorption)

\[ \text{H}^+ + \text{HCO}_3^- \leftrightarrow \text{CO}_2 + \text{H}_2\text{O} \] (neutralisation)

\[ \text{SO}_3^{2-} + \frac{1}{2}\text{O}_2 \rightarrow \text{SO}_4^{2-} \] (oxidation)

From Air

\[ \text{CO}_2 \]
\[ \text{H}_2\text{O} \]
\[ \text{SO}_4^{2-} \]

\[ \text{SO}_4^{2-} \text{ (Sulfate), already present in Seawater (typical 2.7kg/m}^3) \]

\[ \text{CO}_2 \text{ emissions negligible vs stack emissions} \]
SWFGD Process Flow

- **Flue Gas Path:**
  - De-dusted flue gas pass through booster fan (if required) before entering into GGH
  - Flue gas cooled down by GGH is scrubbed with counter-current seawater in absorber
  - Clean flue gas is reheated by GGH before exhausted through the stack

- **Seawater Path:**
  - Part of the spent cooling water is pumped into the top of the absorber
  - Effluent seawater is mixed with the remaining fresh spent cooling seawater and treated in Seawater treatment Plant

Simple & Efficient System
Absorber Concrete Work and Packing

- Seawater piping inlet
- Absorber inlet
- Structured Packing
- Radom Packing

Compact design, easy construction and maintenance
Key Benefits of Alstom SWFGD

1. Up to 99% removal efficiency
2. Superior restoration quality of seawater for discharge
3. Low consumption of power
4. No chemicals or additives needed for pH recovery
5. No by-product
6. Optimized footprint
7. Reliable and easy operation
8. Simple and low maintenance
9. Global market leader with >40 years experience

Meeting most stringent regulations with minimized cost
Dry FGD NID™

- 20+ years of successful commercial operation
- 15+ GW installed for Power
- Compact footprint: <50% footprint compared to SDA
- Modular scalable design
- Water, flyash, reagent are blended outside the flue gas stream.
- Low construction costs

Reduce Cost of Electricity
- Lower lime consumption with optimized hydrator/mixer design
- Local Construction
- Zero Liquid Discharge, low water consumption

Lower Environmental Footprint
- > 98% SO2 removal
- Up to 4% Sulphur in coal
- Multi-pollutant control: SO2, SO3, HCL, HF, PM, Hg (with ACI)

Increase Flexibility & Reliability
- Largest fuel flexibility, including heavy fuel oils and petcoke
- Suitable for PC and CFB boilers
- Can successfully and economically follow all boiler load swings

Alstom patented technology, No.1 in Dry FGD globally
NID Process

- Compact footprint
- Gas cooling by thin film evaporation
- Very high solids recirculation
- Fluid bed / dust recirculated continuously
- No external hydrator
- No external dust recycle
- No slurry handling
- Free flowing dry end product
Key Benefits of NID

• Multi-pollutant control: High efficiency removal of SO$_2$, SO$_3$, PM, HCl, HF and Hg
  - SO$_2$ removal: ≤ 98%
  - SO$_3$ emissions: < 1 ppm
  - PM (filterable): < 15 mg / Nm$^3$

• Lime-based semi-dry FGD technology
  - Patented, integrated hydrator/mixer – no slurry handling
  - Zero liquid discharge – no waste water/treatment
  - Low water consumption; ability to use low quality water: CTB, WFGD purge

• Simple, compact design
  - Small footprint offers retrofit advantage
  - Low capital cost
  - Low BOP/construction cost
  - Low O&M cost

• Modular design
  - High reliability
  - Good turndown
  - No scale-up issues

Meeting Most Stringent Regulations at Minimized Cost
Integration of Fabric Filter with DFGD

FF is an integral part of dry FGD
FGD Technology Selection

Lifecycle cost and reliability are critical. Key drivers are……

- Fuel sulfur
- Unit size, capacity factor, service life
- Redundancy
- Emission limits
  - Criteria pollutants
  - Multi-pollutant considerations
- Site issues
- Other
  - Reagent cost, quality, availability
  - Byproduct sale/disposal
Life cycle cost of a SWFGD is lower than other FGD technologies driven by lower OPEX

- Based on 2x600MW PC boiler PP in Turkey.
- CaO price in Turkey is very high which results in high OPEX for DFGD.
- For CFB boiler, DFGD life cycle cost will lower than WFGD.
Selective Catalytic Reduction – (SCR)

- 30+ years of experience
- 46+ GW installation
- 80+ successful installations worldwide
- Catalyst expertise through partnerships with leading catalyst suppliers
- EPC capabilities with design tailored to existing site conditions and optimized outage time

Reduce Cost of Electricity
- Ammonia injection grid allows very precise ammonia dosage to ensure optimal system efficiency and performance.
- ADIS for aqueous ammonia

Lower Environmental Footprint
- Up to 95% NOx removal
- < 2ppm ammonia slip
- New IsoSwirl™ mixing technology improves flue gas-ammonia contact for better performance

Increase Flexibility & Reliability
- Large portfolio with high dust, low dust, and tail-end configurations to adapt to the most stringent plant conditions and environmental legislations

Large portfolio of configurations with high NOx removal efficiency
High Efficiency Ammonia Injection + IsoSwirl™ Mixer

- Proprietary in-duct mixers.
- Advantages:
  - Excellent ammonia distributions
  - Best for challenging applications
  - Robust to operation variations
  - Avoids grid re-tuning
  - Flexibility
  - Much less tuning

IsoSwirl™ mixers can achieve up to 95% NOx removal
Electrostatic Precipitators – (ESP)

- 233+ GW installed in power generation
- Effective Cleaning System design with robust tumbling hammer
- Best-in-Class Integrated ESP Control systems: 3rd Generation Intelligent Controller (EPIC III)
- Switch Integrated Rectifiers (SIR) for increasing power input into ESPs

Reduce Cost of Electricity
- Lower capital cost through more compact sizing
- Lower power consumption by minimum 5% thanks to best-in-class controllers

Lower Environmental Footprint
- > 99.95% removal efficiency
- <10 mg/Nm3 emissions

Increase Flexibility & Reliability
- Largest fuel flexibility, including heavy fuel oils
- Constant efficiency for varying boiler load conditions

Largest reference base on a variety of fuels
Operating Principles & Performance

- Dust particles carried by the gas stream through the gas passages become charged while passing through the charged field.

- The negatively charged dust particles migrate to the Collecting Plates.

- On reaching the neutral Collecting Plates the dust loses the charge and is ready for removal.

- The collected dust is removed from the Collecting plate by knocking with Hammers.

**Uniform charging of dust gives best removal efficiency**
Why Alstom ESP?

1. **High Particulate removal efficiency** – can achieve emission levels < 10 mg/Nm³

2. **Variety of Discharge Electrode** designs to choose from based on application specific requirements ensures most optimized Corona power distribution

3. **State-of-the-art ESP Control System** allows optimization of Power input based on emission level required – resulting in low power consumption

4. **Robust Tumbling Hammer type Rapping** arrangement ensure efficient cleaning of the Electrodes. Electric Impact Rapping design also available

Meeting most stringent regulations with minimized cost
Fabric Filters – (FF)

- 46+ GW (standalone) installed in Power
- Up to 12m tall filters for reduced footprint & operational costs
- Renowned Optipulse® filtration technology with gravimetric flow & Optipow® plunger valves for efficient bag cleaning
- Standalone applications or integrated at the down stream of SDA, NID™, Abart™, Mer-Cure™, Filsorption™

Reduce Cost of Electricity
- Lower Capital Cost with tall bag designs of up to 12 m
- Lower auxiliary consumption like compressed air

Lower Environmental Footprint
- > 99.97% removal efficiency
- High PM10 & PM 2.5 removal efficiency
- < 5 mg/Nm3 emissions

Increase Flexibility & Reliability
- Largest fuel flexibility and ability to handle varying boiler loads
- Bag life of 5+ years achieved

Consistent lower compliant costs for dynamic process requirements
Operating Principles & Performance

1. Dust particles are captured on Filter media surface - inside for Low Ratio and outside for High Ratio

2. Accumulated dust layer on fabric surface assists in fine filtration

3. Dust removed from fabric surface by Reverse Gas flow or Compressed Air pulse

4. Discharge of the dust from FF Hoppers
Key Benefits of Alstom HRFF Design

1. **High Particulate removal efficiency** – can achieve emission levels < 5 mg/Nm3 opacity < 10%

2. **Offers both High and Low Ratio Designs** to suit the application specific requirements ensures most optimized performance

3. **Compact Design – small Foot print**
   Mega FF design achieves the smallest footprint with up to 12 m bags and 30 bags /row.

4. **Optipulse R Pulse Cleaning System**
   The proprietary Alstom Pulse Cleaning System ensures effective cleaning

Meeting most stringent Regulations at minimum cost
# ECS Performance in Power

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Alstom Process</th>
<th>References</th>
<th>Removal Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_x$</td>
<td>Selective Catalytic Reduction</td>
<td>46GW</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>SO$_x$</td>
<td>Open Spray Tower</td>
<td>60GW</td>
<td>&gt;99%</td>
</tr>
<tr>
<td></td>
<td>Flowpac™ Absorber</td>
<td>1GW</td>
<td>&gt;99%</td>
</tr>
<tr>
<td></td>
<td>Dry Flue Gas Desulphurisation</td>
<td>30GW</td>
<td>&gt;98%</td>
</tr>
<tr>
<td></td>
<td>Seawater Desulphurisation</td>
<td>50GW</td>
<td>&gt;98%</td>
</tr>
<tr>
<td>Particulates</td>
<td>Dry Electrostatic Precipitators</td>
<td>233GW</td>
<td>&lt;10mg/Nm$^3$</td>
</tr>
<tr>
<td></td>
<td>Wet Electrostatic Precipitators</td>
<td>2GW</td>
<td>&lt;10mg/Nm$^3$</td>
</tr>
<tr>
<td></td>
<td>Fabric Filters (standalone)</td>
<td>46GW</td>
<td>&lt;5mg/Nm$^3$</td>
</tr>
<tr>
<td>SO$_x$/HCl/HF/Hg</td>
<td>NID &amp; Spray Dryer Absorber</td>
<td>136 installations</td>
<td>≥98% for SO$_2$</td>
</tr>
<tr>
<td>Mercury</td>
<td>Mer-Cure™/Filsorption™</td>
<td>8GW</td>
<td>&gt;90%</td>
</tr>
</tbody>
</table>

NO$_x$: Nitrogen Oxides  
SO$_x$: Sulphur Oxides  
HF: Hydrogen Fluoride  
HCl: Hydrogen Chloride  
Hg: Mercury

Alstom ECS is a world leading supplier of AQCS
Agenda

• Introduction

• Product Portfolio

• Key Features and Customer Benefits
  – Power
  – Industry

• Retrofit

• Conclusions
## Major applications for:

- Potline Gas Treatment Centre (GTC)
- Anode Baking Furnace Fume Treatment Centre (FTC)
- Hot Bath Fume Treatment integration into GTC
- Alumina enrichment, recovery, storage, transportation, distribution and pot feeding
- Heat Energy Recovery from potline gases or anode baking oven fumes

## Products and Processes:

- The ABART™ system: for HF recovery & recycling in electrolysis
- Advanced Heat Exchanger (AHEX) with FTC
- Heat Exchanger (HEX)
- SO₂ Abatement
- ALFEED: Alumina transportation, distribution and feeding for electrolysis pots
- Abart-C: Integrated ABART dry HF scrubbing, HEX, SO₂ wet scrubbing & ALFEED

## Key Customer Benefits:

- 50+ years of experience from 200+ successful installations worldwide
- Innovative and well proven best-in-class technologies
- Patented AHEX FTC delivers 1 MWth energy per compartment, removes 50% more condensed tars, 20% more PAH and 50% more HF than conventional FTC
- Abart-C reduce 75% footprint on top of CAPEX & OPEX reductions
Primary Aluminium Production – ALSTOM AQCS

Key Drivers

Unique Industrial Gas Cleaning Process

- Keep good working atmosphere inside the plant
- Clean flue gases of multiple pollutants
- Recovery of valuable material in the flue gases
- Enrich recovered flue gas material
- Recycle recovered flue gas material to the smelting process

Results:

- Dry process with no secondary discharge
- No waste products
- Totally integrated Dry Scrubbing with the Electrolysis Pot Process by returning Alumina to pots by tanker or other means
- Optional heat/energy recovery by HEX

Unlike Other AQCS, These Add Value To The Process & Product Through Recycling
**Iron & Steel**

Major applications for:

- Melt shop dedusting and ventilation systems (EAF, AOD, Induction Furnace)
- Sinter plants primary & secondary gas treatment systems
- Cast house and stock house ventilation for blast furnaces
- BOF secondary system dedusting and ventilation systems
- Pelletizing plant flue gas cleaning systems

Products and Processes:

- Particulate removal - ESP, FF
- Desulphurisation - NID or DRYPAC
- DeNOx - SCR
- Water cooled ducts for EAFs
- Hot quenching towers
- Force draft coolers
- Canopy hoods for collection of fumes

Key customer Benefits:

- 50+ years of experience to supply solutions for I&S
- 700+ plants installed worldwide including FGD for sinter & pelletizing plants
- Complete product portfolio to cover various gas cleaning requirements
- R&D support to develop customer specific solutions

**World Leader in Process Technology and Applications**
Waste to Energy - (WtE)

Products and Processes:

- NID™ for removal of SOx, HCl, HF, heavy metals and dioxin
- WETPAC open spray tower for acid gas removal
- SCR catalytic NOx emission abatement system
- Condensing scrubber for simultaneous heat recovery and removal of acid gas components
- Filsorption™ for dry polishing
- ESP for dedusting

Key Customer Benefits:

- +35 years experience with +350 plants installed worldwide
- The patented NID™ technology provides gas cleaning of multiple pollutants in one unit
- Small footprint required for NID installations
- Comprehensive engineering capabilities to deliver systems for ultra-low emissions and heat recovery
Combined Systems - process layout (1)

Example #1: Jönköping, Sweden
Pulp & Paper

Applications:
- Recovery boilers
- Lime sludge kilns
- Power boilers - coal & biomass fired

Key Customer Benefits:
- 70+ years of experience
- 600+ successful installations worldwide
- Experience of working with various P&P equipment technologies and OEMs
- Lowest & consistent emissions guaranteed even for difficult applications like recovery boiler

Products:
- Electrostatic Precipitators
- Fabric Filters

Vast and successful references globally
## Cement

### Applications:
- Raw mill & kiln
- Clinker cooler
- Coal mill
- Alkali bypass
- Cement mill
- Other de-dusting

### Products:
- Fabric Filters
  - Low Ratio Reverse Air
  - High Ratio Pulse Jet
- Electrostatic Precipitators
- Gas Conditioning Towers
- Heat Exchangers

### Key Customer Benefits:
- 60+ years of experience
- 1000+ successful installations worldwide
- Lowest emissions guaranteed
- Robust equipment designs with minimum maintenance requirements
- Competitive Capex & Opex

---

Successful installations across all the critical applications in cement

**Note:** Any information contained in this document is indicative only. No representation or warranty is given or should be relied on that it is complete or correct or will apply to any particular project. This will depend on the technical and commercial circumstances. It is provided without liability and is subject to change without notice. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.
Oil & Gas

Full range of products to comply with the strictest international standards

### Major applications for:

- Fluidized Catalytic Cracking Units
- Sulphur Recovery Units
- Refinery Heater/Boiler Fumes
- Oil Platforms
- Refinery/Petrochem Captive Power Generation Units
- Tank Farms

### Products and Processes:

- ESP/FF: for de-dusting/particulate removal from gas streams
- FGD/SWFGD: for SO2 removal
- The SCR System: for NOx abatement
- TO/RTO: for VOC & Odour removal

### Key Customer Benefits:

- Well proven state-of-the-art solutions
- Unique Seawater FGD solution for FCCU and oil platforms
- Dedicated Competence Centres supplemented by global footprint
- Delivering solutions with CAPEX, OPEX, performance, support & longevity in mind
Agenda

• Introduction

• Product Portfolio

• Key Features and Customer Benefits
  – Power
  – Industry

• Retrofit

• Conclusions
Efficiency and Environmental Impact of Power Plants

Less CO2 = higher power plant efficiency

New Plants

Coal: +15 p.p in efficiency saves 30% CO2 emissions

Gas: +20 p.p in efficiency saves 33% CO2 emissions

60% of the 2030 installed base still to be built

Retrofit

Plant Optimisation: -5% CO2

Turbine retrofit: -5% CO2

Boiler retrofit: -3% CO2

60% of carbon emitted in 2030 will come from today’s plants
Alstom Boilers
Expert is a broad range of fuel

Specialist experience
- Fiddlers’ Ferry
- Drax (co firing)
- Narva*
- Niederassem K
- Patnow II
- Maritza East
- Belchatow II
- Neurath F/G
- Can
- Kaiyuan

World Class Products
- Waigaoqiao II and III
- Karlsruhe 8
- Westfalen D/E
- Iatan
- Comanche 3
- Manjung
- RDK 8
- Chalkpoint
- Ravens Wood 3
- Pittsburgh 7
- La Spezia 4
- Shoalba
- Yanbu 3

Specialist experience
- Tamuin
- Mailiao

Fiddlers’ Ferry
- Oil Shale*
- Lignite
- Bituminous
- Sub-bituminous
- Oil
- Anthracite
- Petcoke

Pulverized Coal
Circulating Fluidized Bed

Expertise & world class products for a broad fuel spectrum

© ALSTOM 2013. All rights reserved. Information contained in this document is indicative only. No representation or warranty is given or should be relied on that it is complete or correct or will apply to any particular project. This will depend on the technical and commercial circumstances. It is provided without liability and is subject to change without notice. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.
### Efficiency and Environmental Impact of Power Plants

**Alstom Technology for Combustion**

<table>
<thead>
<tr>
<th>Two Pass Boiler</th>
<th>Tower Boiler</th>
<th>CFB Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Two Pass Boiler" /></td>
<td><img src="image2" alt="Tower Boiler" /></td>
<td><img src="image3" alt="CFB Boiler" /></td>
</tr>
</tbody>
</table>

For a full range of solid fuel from anthracite to lignite and biomass

World-class Technology and Product to meet Customer’s requirement
Product offering to meet customer new challenges

DRIVERS

Fuel Flexibility

SOLUTIONS

Fuel Switch

- Oil → Coal or Gas switch
- Coal → Oil or Gas switch
- Gas → Coal or Oil switch

Coal to Biomass (conversion)
Coal and Biomass (co-firing)

Boiler Upgrade

Performance Improvement incl. Integrated Boiler + Turbine

Pressure Parts Condition Assessment and Re-design

Enviromental Compliance

- NOx Reduction
- Biomass Co-firing
- Boiler + Enviromental Control Systems

- Alstom Boiler Retrofit offer solutions all along the value chain
Efficiency and Environmental Impact of Power Plants
Case Study for Retrofit – Belchatow 6

- Superheaters & Reheaters
  - Performance Adjustments
  - Material Upgrades
  - Cleanability
- Economizer
  - Performance Improvement
  - Cleanability
  - Erosion Protection
- Ducts & expan. joints
  - Material Upgrades
  - Repairs
- Air heater
  - High Efficiency Heating Elements
  - Air Leakage reduction
  - Cleanability

- Waterwalls
  - Cleanability
  - New Burner openings
- Overfire air (OFA)
  - Two stage OFA
- Burners
  - Low NOx burners
- Bottom ash handling
  - Modified After Burning Grate
- Coal pulverizers
  - Improved classifiers
  - Advanced wear parts

<table>
<thead>
<tr>
<th></th>
<th>Before retrofit</th>
<th>After retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOX</td>
<td>&lt;400 mg/Nm3</td>
<td>&lt;200 mg/Nm3</td>
</tr>
<tr>
<td>MW Output</td>
<td>370MW</td>
<td>&lt;394MW</td>
</tr>
<tr>
<td>Cycle efficiency</td>
<td>&gt;38%</td>
<td>&gt;41.3%</td>
</tr>
<tr>
<td>Feedwater temp</td>
<td>255°C</td>
<td>275°C</td>
</tr>
<tr>
<td>Live Steam / RH</td>
<td>540°C / 540°C</td>
<td>570°C / 570°C</td>
</tr>
</tbody>
</table>

© ALSTOM 2013. All rights reserved. Information contained in this document is indicative only. No representation or warranty is given or should be relied on that it is complete or correct or will apply to any particular project. This will depend on the technical and commercial circumstances. It is provided without liability and is subject to change without notice. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.
## ALSTOM WFGD Upgrade Reference List

<table>
<thead>
<tr>
<th>Customer / Unit</th>
<th>Type Upgrade</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRE / Coal Creek Units 1 &amp; 2</td>
<td>Mist Eliminators and Fixed Grid Mist Eliminator Wash</td>
<td>1996-1998</td>
<td>Converted all eight absorbers to the Alstom 2 x 2+ design</td>
</tr>
<tr>
<td>Abitibi / Snowflake, AZ</td>
<td>Mist Eliminators and Fixed Grid Mist Eliminator Wash</td>
<td>1999</td>
<td></td>
</tr>
<tr>
<td>GRE / Coal Creek Units 1 &amp; 2</td>
<td>Recycle Spray Headers and Spray Nozzle Performance Upgrade</td>
<td>1999</td>
<td>FRP Headers converted in all eight absorbers.</td>
</tr>
<tr>
<td>Tri-State / Escalante</td>
<td>Scrubber Inlet Rain Hood Modifications</td>
<td>2001</td>
<td>Extended Inlet Rain Hood in all three absorbers to reduce build-up.</td>
</tr>
<tr>
<td>Dominion / Clover Units 1 &amp; 2</td>
<td>Performance Enhancing Plates</td>
<td>1998-2000</td>
<td>Installed three levels of PEPs in A and C absorbers of both units.</td>
</tr>
<tr>
<td>OUC / Stanton Unit 1</td>
<td>Mist Eliminators and Fixed Grid Mist Eliminator Wash</td>
<td>1999</td>
<td>Chevron type Mist eliminators for absorbers 1A, 1B, and 1C.</td>
</tr>
<tr>
<td>Dominion / Clover Units 1 &amp; 2</td>
<td>Forced Oxidation System</td>
<td>2001</td>
<td>Oxidation Air Compressors and Lances.</td>
</tr>
<tr>
<td>Reliant / WA Parrish Unit 8</td>
<td>Performance Enhancing Plates</td>
<td>2001</td>
<td>PEPs for three levels of each module. (GE WFGD)</td>
</tr>
<tr>
<td>Tri-State / Escalante Unit 1</td>
<td>Mist Eliminators and Fixed Grid Mist Eliminator Wash</td>
<td>2000</td>
<td>Converted all three absorbers to the Alstom 2 x 2+ design (Plastic).</td>
</tr>
<tr>
<td>TUSI / Sandow Unit 4</td>
<td>Mist Eliminators and Fixed Grid Mist Eliminator Wash</td>
<td>2000</td>
<td>Converted one of three absorbers to the Alstom 2 x 2+ design.</td>
</tr>
<tr>
<td>Reliant / Niles Station</td>
<td>Mist Eliminators</td>
<td>2003</td>
<td>Replaced first section of original style 2 x 2+ with upgraded version. (Plastic)</td>
</tr>
<tr>
<td>Tri-State / Escalante Unit 1</td>
<td>Performance Enhancing Plates</td>
<td>2002/03</td>
<td>PEPS for two levels in all three absorbers.</td>
</tr>
<tr>
<td>TXU / Sandow Unit 4</td>
<td>Mist Eliminators and Fixed Grid Mist Eliminator Wash, Performance Enhancing Plates, Recycle Spray Headers, Rain Hood, Turning Vanes</td>
<td>Fall 2006</td>
<td>Converted all three absorbers.</td>
</tr>
</tbody>
</table>
## ALSTOM WFGD Upgrade Reference List Cont.

<table>
<thead>
<tr>
<th>Customer / Unit</th>
<th>Type Upgrade</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIPC / Marion Unit 4</td>
<td>Gypsum Dewatering and Handling System, Forced Oxidation System</td>
<td>2007-2008</td>
<td>Added underflow pumps, horizontal belt filters, and conveyors as well as oxidation air compressors and air spargers.</td>
</tr>
<tr>
<td>Westar / Lawrence Units 4 &amp; 5</td>
<td>Performance Enhancing Plates, Flow Distribution Trays, Recycle Spray Headers / Spray Nozzles, Forced Oxidation System, Mist Eliminators and Fixed Grid Mist Eliminator Wash, Inlet Duct / Absorber Modifications</td>
<td>2009-2012</td>
<td>Upgraded all four absorbers. (two for Unit 4 and two for Unit 5)</td>
</tr>
<tr>
<td>ENEL / Brindisi Sud</td>
<td>New agitators (side entry) in palce of existing top entry, new oxidation air injection lance in place of the original air grid</td>
<td>2010</td>
<td>Revamping of agitation and oxidation air systems in a squared tower</td>
</tr>
<tr>
<td>EDF / Le Havre &amp; Cordemais</td>
<td>Absorber relining, new spary banks and nozzles, Performance Enhancement Plates, new absorber recycle pumps and piping</td>
<td>2015</td>
<td>Revamping and performance enhancement</td>
</tr>
<tr>
<td>ENDESA / Litoral 2</td>
<td>Absorber relining, new spary banks and nozzles, Performance Enhancement Plates, new mist eliminator, new absorber recycle pumps and piping, new agitators and oxidation air system</td>
<td>2016</td>
<td>Revamping and performance enhancement</td>
</tr>
</tbody>
</table>
Litoral U2 WFGD revamping project

- Original design only to treat part of the flue gas for < 700 mg/Nm$^3$ dry 6% $O_2$ emissions at the stack

- Original design to operate at full load with 35% by-pass in operation with worst S fuel

- Revamping project now requiring treatment of flue gas to emit $SO_2$ concentration of less than 160 mg/Nm$^3$ dry 6% $O_2$ $SO_2$ at Stack

- Full treatment of flue gas required (no by-pass) to meet stack emissions

Key project milestones

- Pre-engineering (LNTP): Feb 2014
- Contract award (NTP): Apr 2014
- Start of erection activities: Sep 2015
- First gas-in: Apr 2016
- PAC: Nov 2016
Conclusion

No. 1
Suppliers in AQCS Worldwide

• 80+ years of experience in AQCS technologies
• 480 GW for Power and 2800 systems for Industry globally
• Largest AQCS business with global footprint
• Broadest portfolio of technologies
• Extensive R&D for continuous development
• Strong commitment to customer requirements and interests