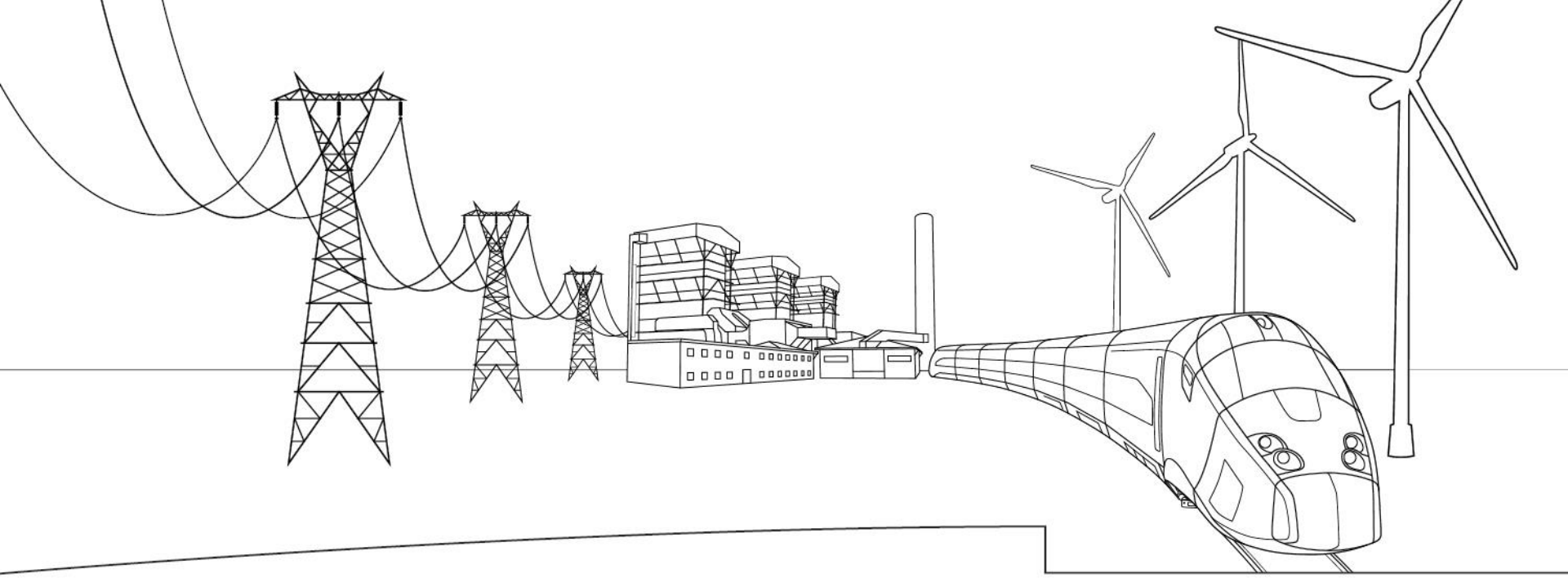


Alstom Environmental Control Solutions

An Overview

Dr. Magnus MÖRTBERG

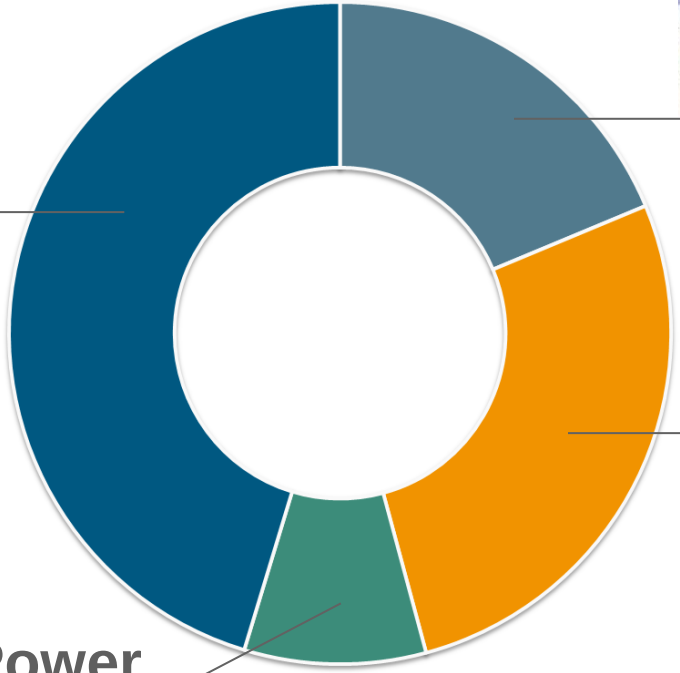
25/06/2015

ALSTOM

Shaping the future

Three main activities in four Sectors

Group sales



Thermal Power

8.8 €bn

Transport

5.9 €bn

Renewable Power

1.8 €bn

3.8 €bn

- Total sales 2013/14 = 20.3 billion
- Total orders 2013/14 = 21.5 billion

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Alstom Thermal Power Organisation

Thermal Power
Philippe Cochet
President

Gas

Steam

Nuclear

Power Automation & Controls

Thermal Services

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Historical Background
Air Pollution Control Since 1920

Svenska Fläktfabriken 1920

Fläkt 1974

ABB 1988

ABB ALSTOM POWER 1999

ALSTOM 2000

- **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)

1942 Start selling ESP worldwide

1957 Start of the Växjö activities

1981 Delivers first SDA to Igelsta, Sweden

1983 Opening of the Technical Center in Växjö

1986 Acquires Peabody Process Systems (USA) for WFGD technology

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

Fläktfabrikens first workshop at the old hospital mill in Jönköping, Sweden.

Large fans were delivered at an early stage of the history

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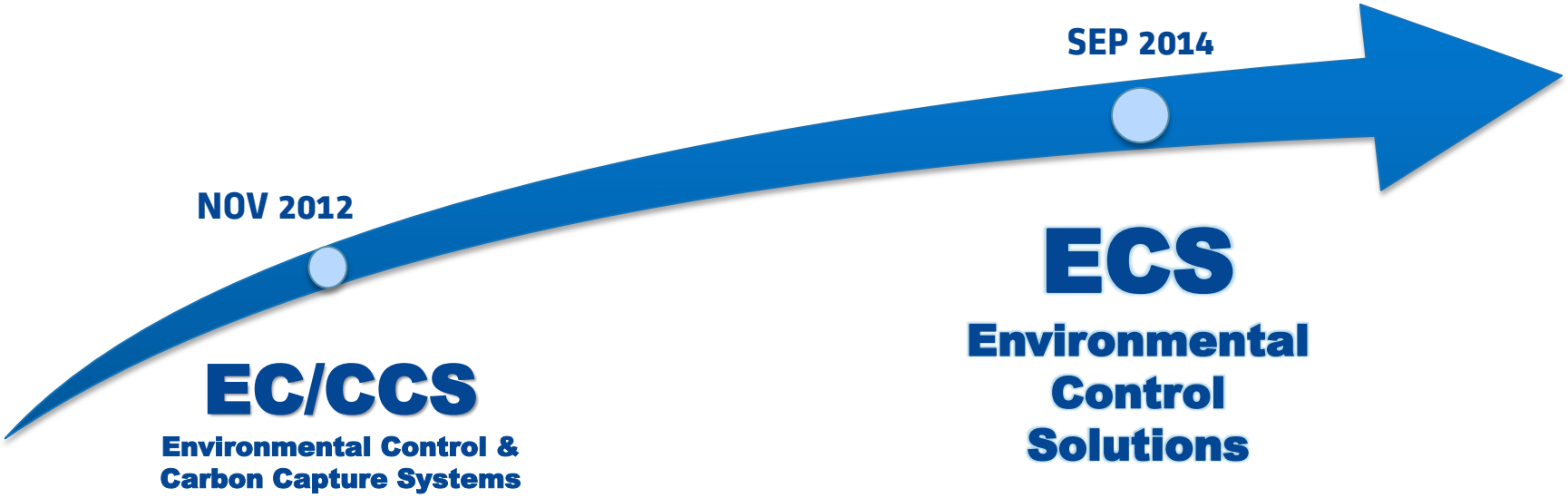
ECS Today – Environmental Control Solutions



ECS Environmental Control Systems + **CCS** Carbon Capture Systems

EC/CCS Environmental Control & Carbon Capture Systems + **TS AQCS** Thermal Service AQCS

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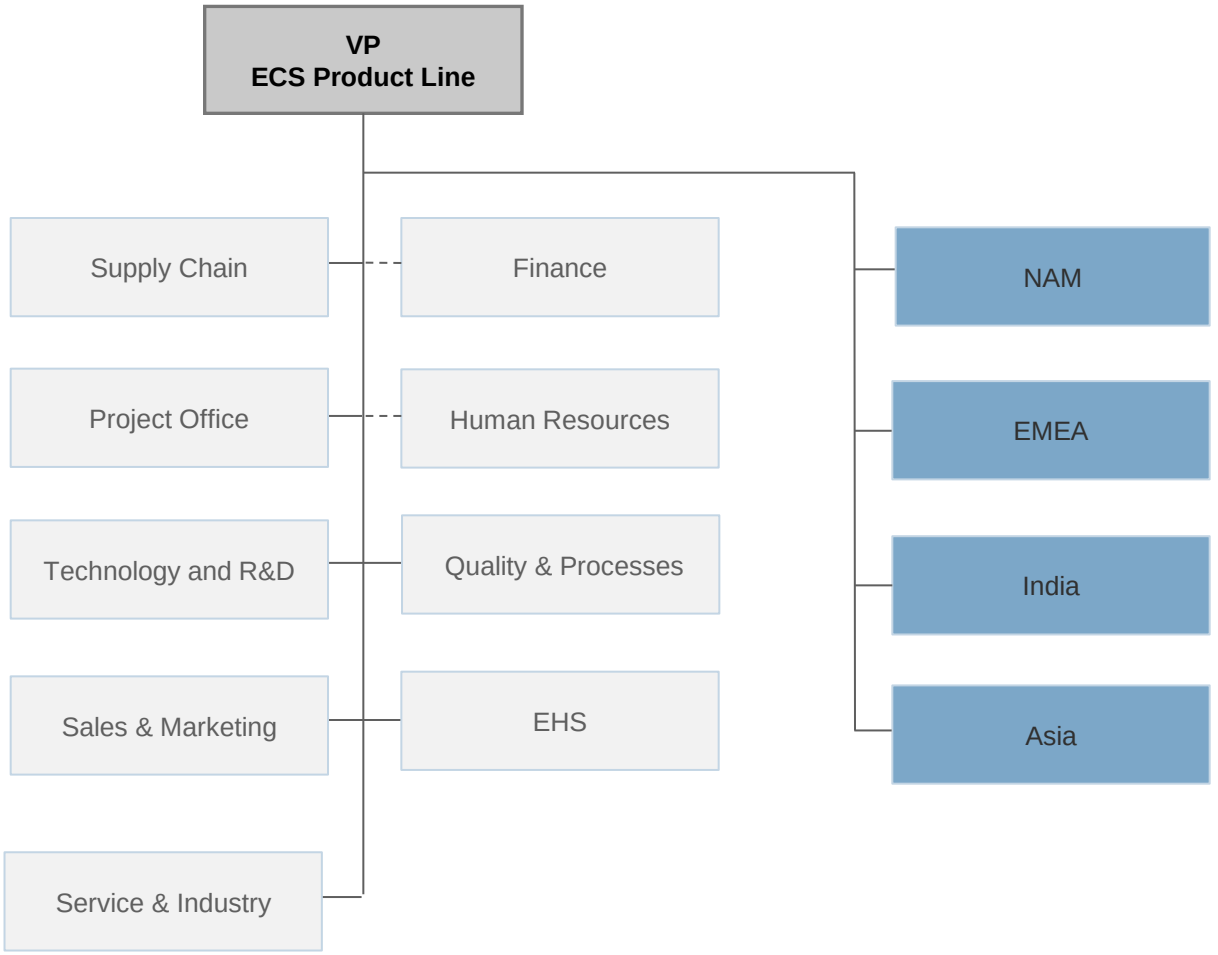
ECS
Organization Chart



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ECS
Footprint – Key Locations

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

Global knowledge and resources, local presence and insight

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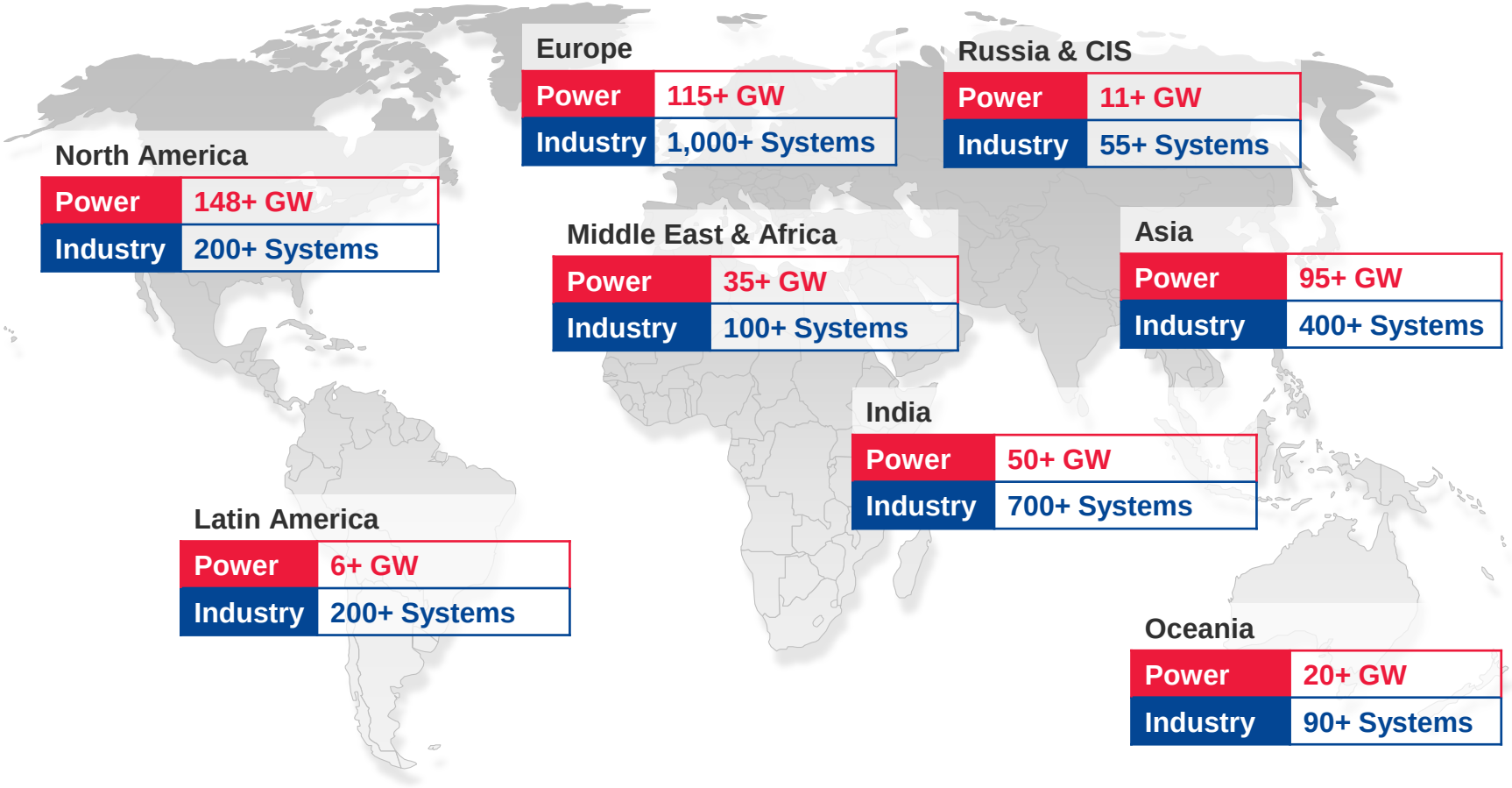
ECS
World's No.1 AQCS Supplier



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

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Agenda

- Introduction
- **Product Portfolio**
- Key Features and Customer Benefits
  - Power
  - Industry
- Retrofit
- Conclusions

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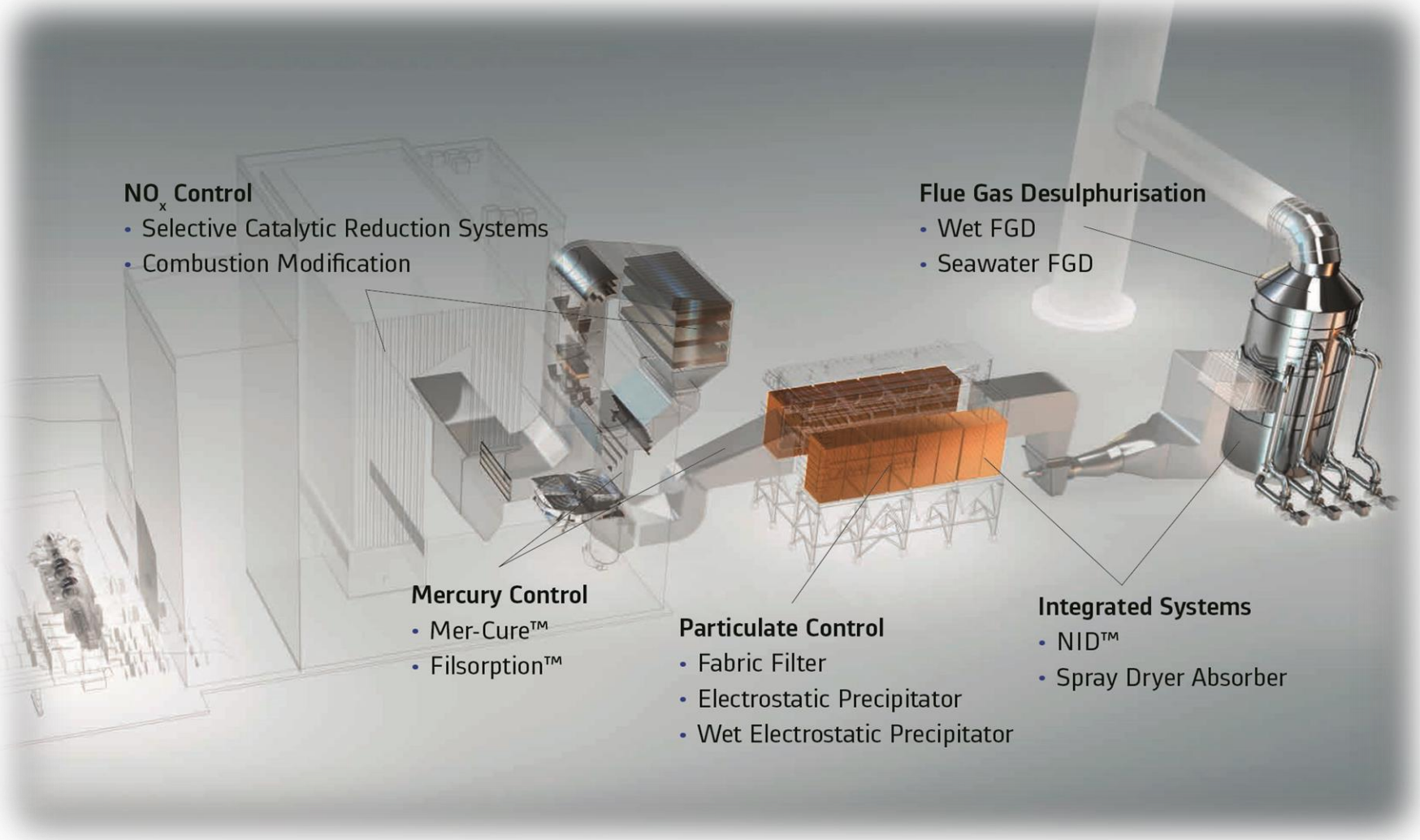
ECS
Product Portfolio for Power and service



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Product Portfolio for Industry
Air Quality Control Systems

		I &S	WtE	Alu	Oil & Gas	P&P	Cement
DFGD (NID and SDA)		✓	✓		✓		
SWFGD				✓	✓		
ESP (Wet and Dry)		✓	✓		✓	✓	✓
FF (high ratio and low ratio)		✓	✓	✓	✓	✓	✓
SCR		✓	✓		✓	✓	✓
ACI (Hg)		✓	✓				

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

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

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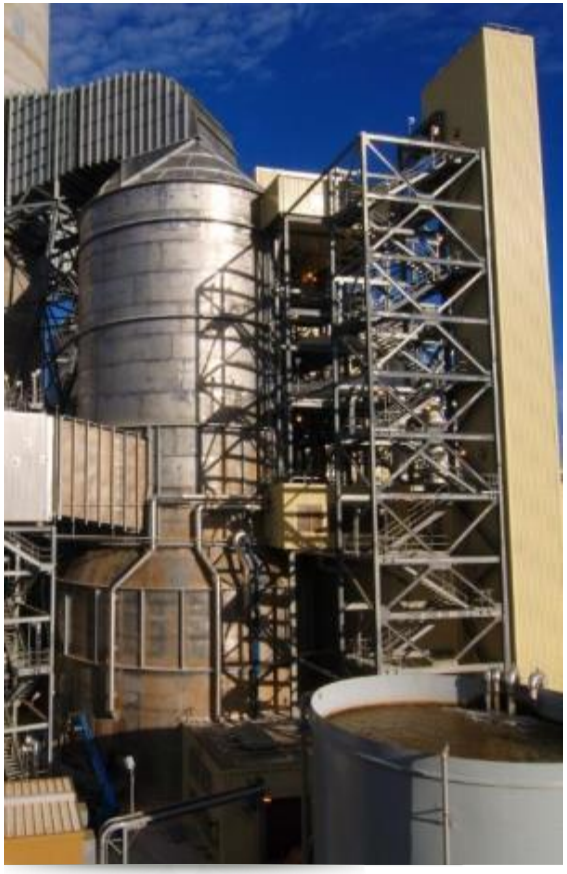
Wet FGD – Open Spray Tower (OST)



- 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

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

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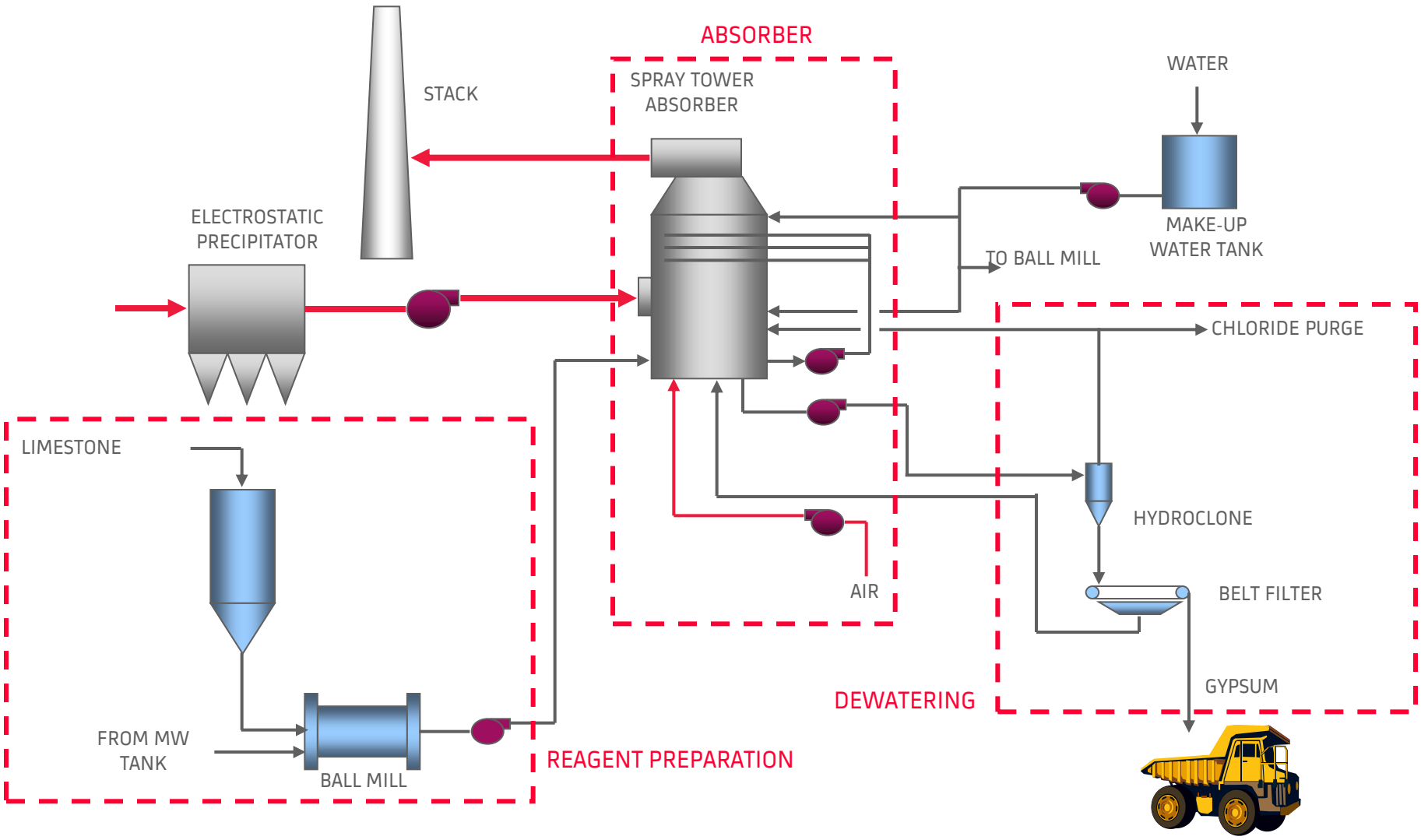
Limestone WFGD Process Diagram



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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

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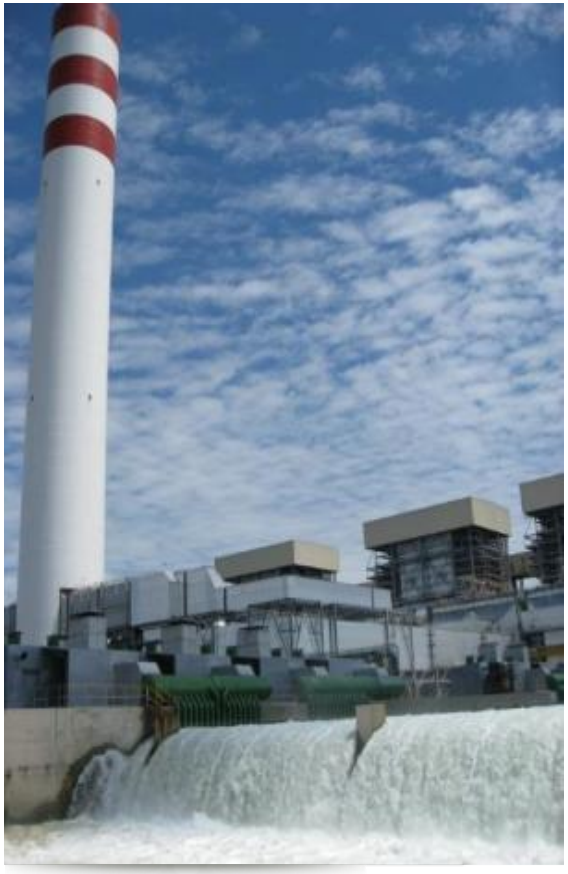
Seawater Flue Gas Desulphurisation – (SWFGD)



- 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

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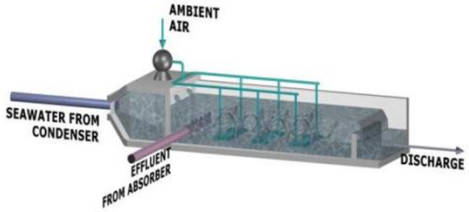
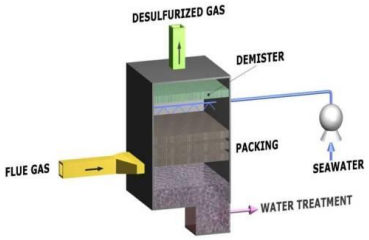
SWFGD Chemical Process

From Seawater

$H^+ + HCO_3^- \leftrightarrow CO_2 + H_2O$
(neutralisation)

$SO_2 + H_2O \leftrightarrow SO_3^{2-} + 2H^+$
(absorption)





(oxidation)
$SO_3^{2-} + \frac{1}{2}O_2 \rightarrow SO_4^{2-}$

From Air

CO_2
H_2O
SO_4^{2-}

SO_4^{2-} (Sulfate), already present in Seawater (typical 2.7kg/m3)

CO_2 emissions negligible vs stack emissions

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

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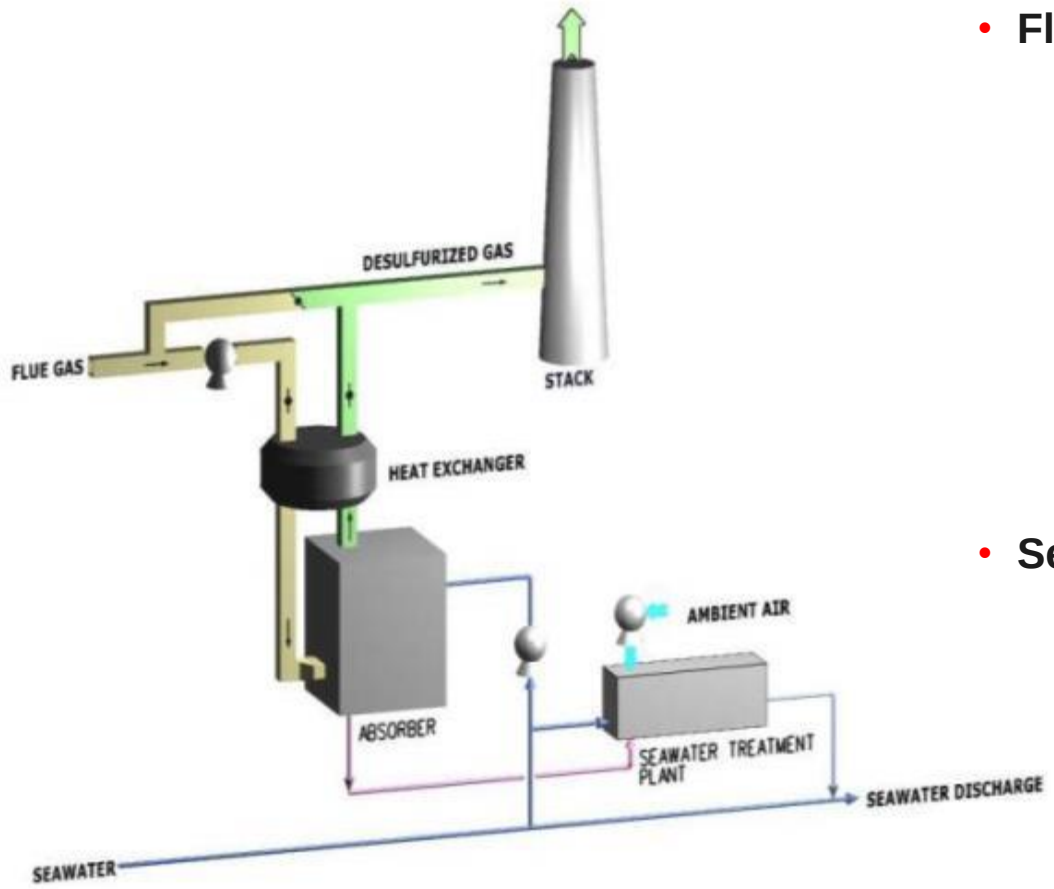
SWFGD Process Flow



- **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 sea water and treated in Seawater treatment Plant

Simple & Efficient System

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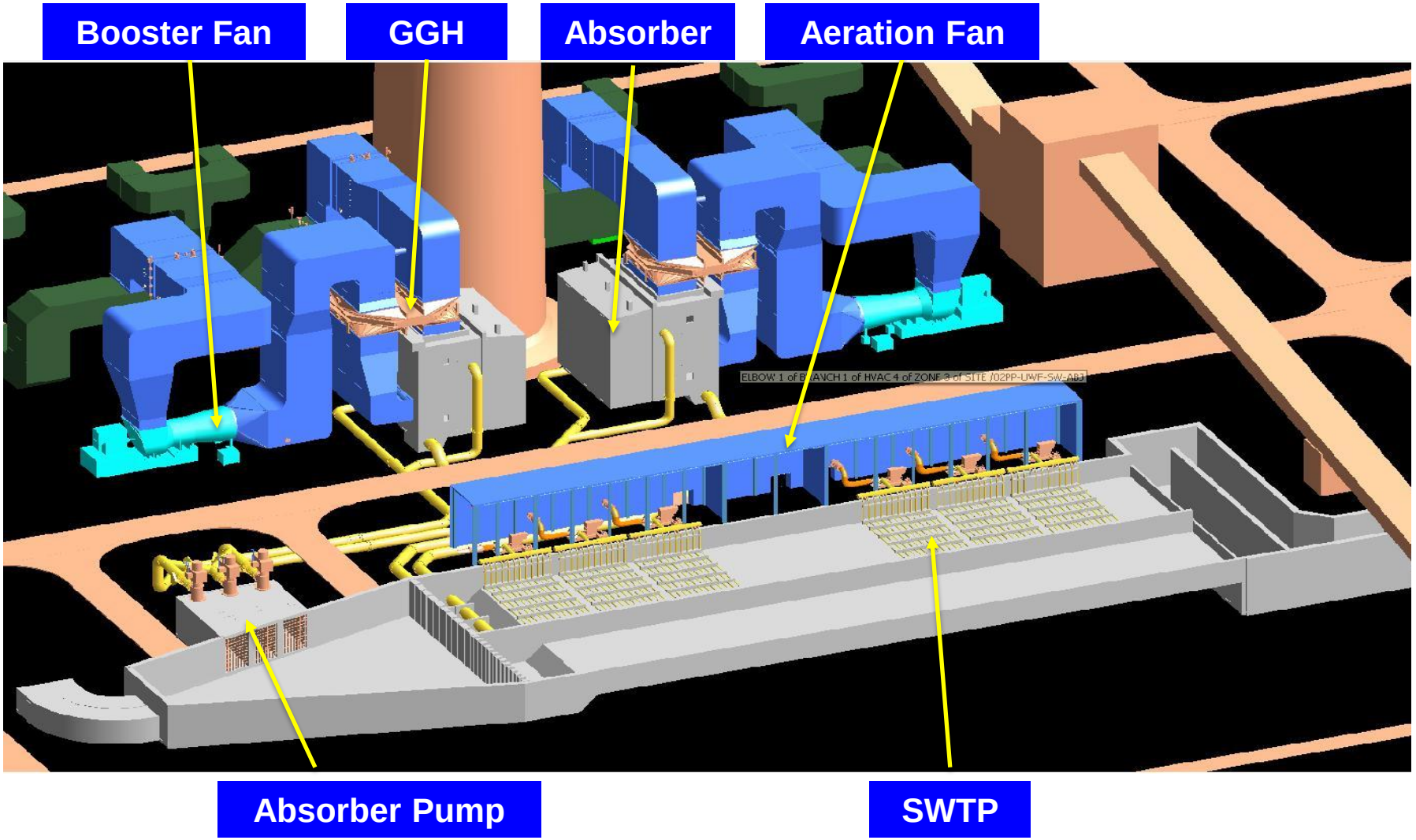
Alstom SWFGD 3D Layout



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Absorber
Concrete Work and Packing

Seawater piping inlet

Absorber inlet

Compact design, easy construction and maintenance

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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

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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

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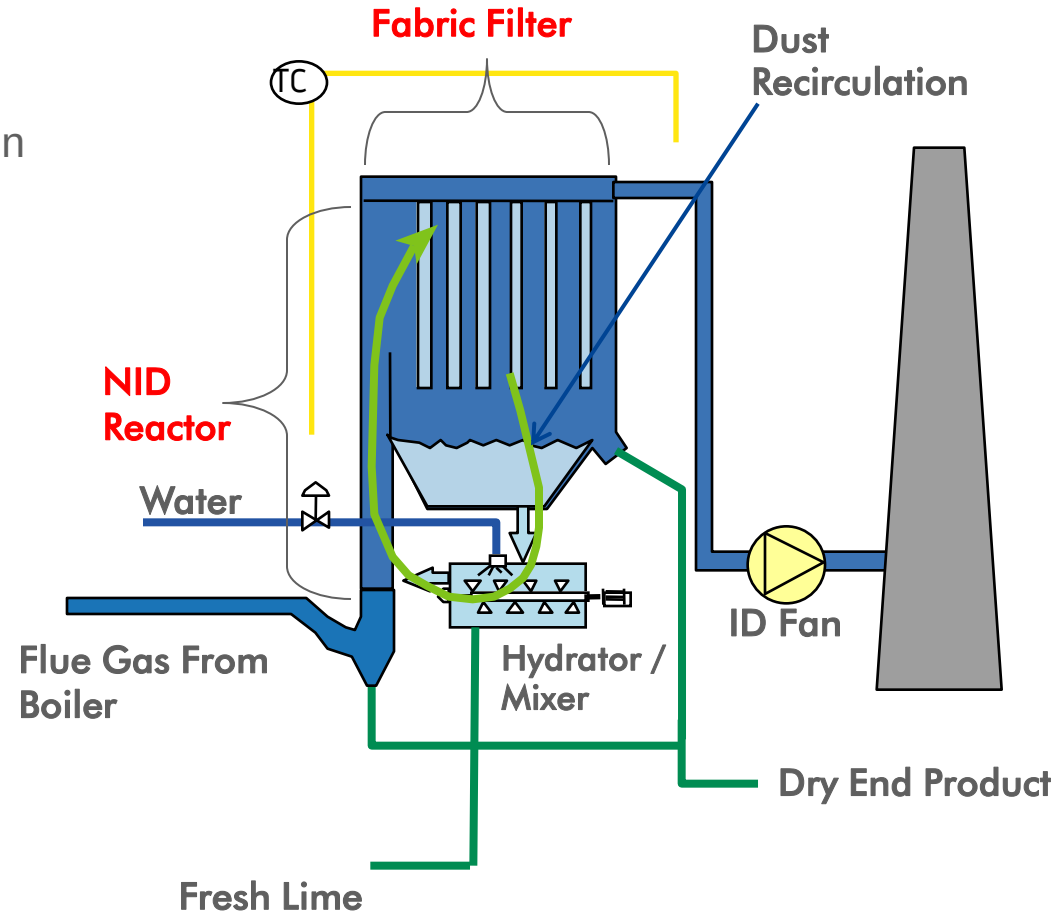
NID Process

- 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



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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

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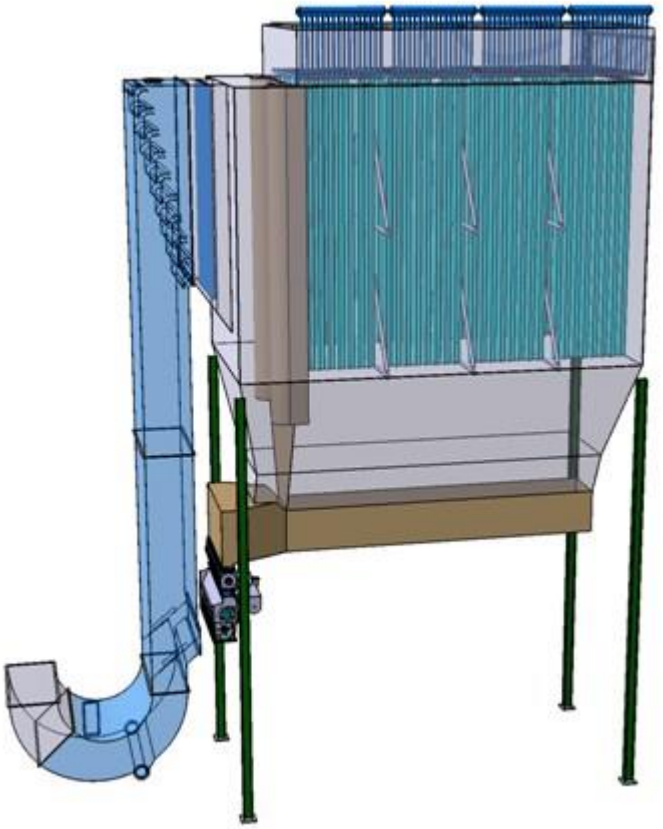
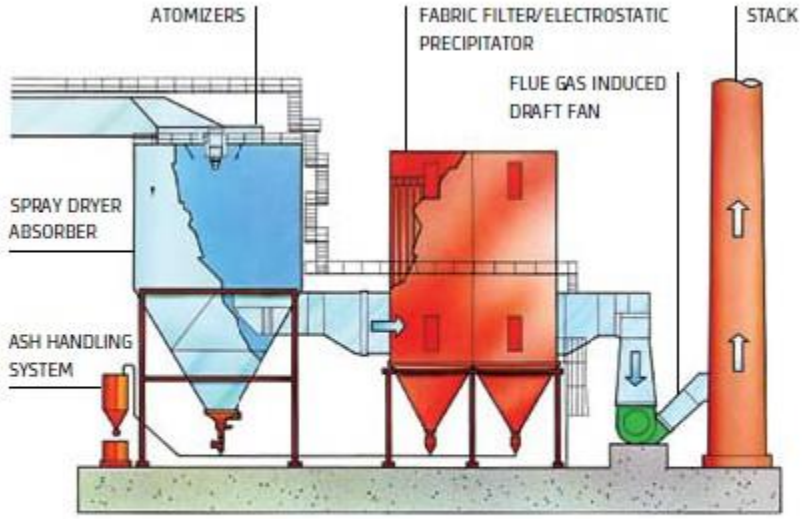
Integration of Fabric Filter with DFGD



NID



THE SDA PROCESS

SDA

FF is an integral part of dry FGD

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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

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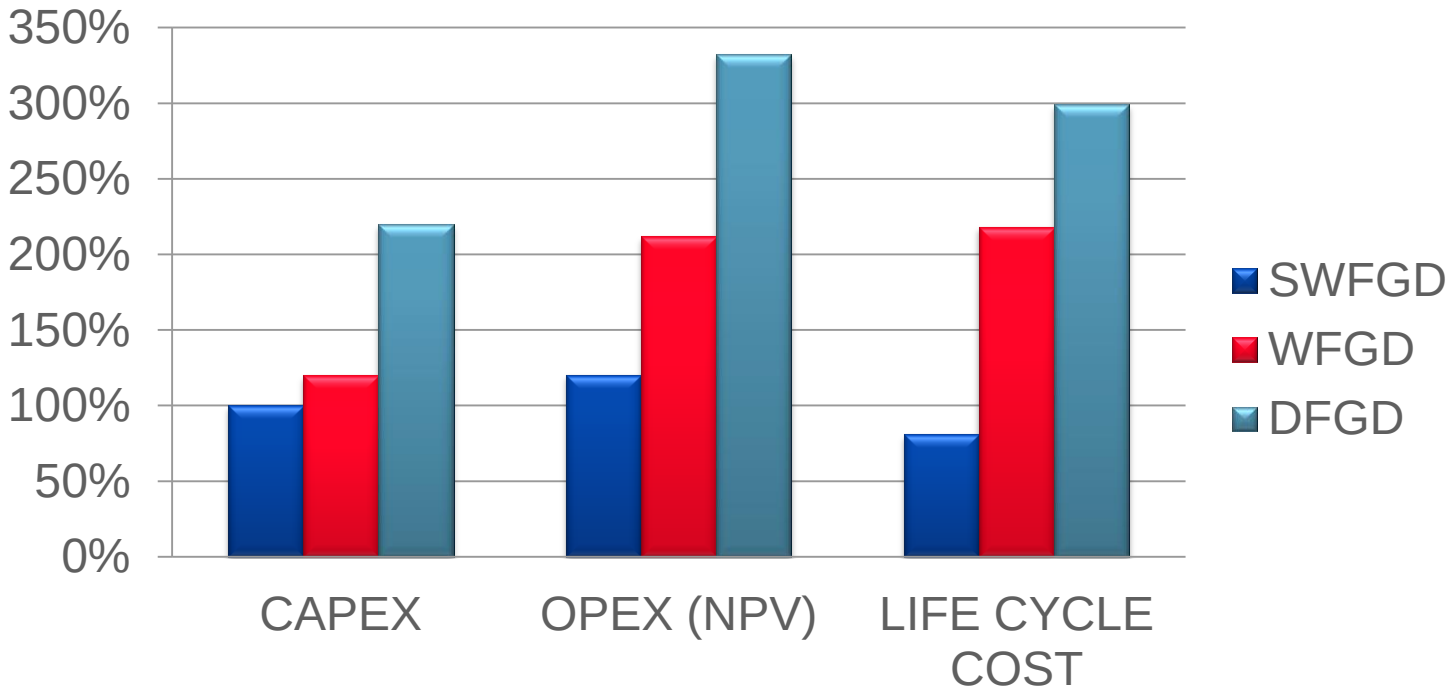
FGD Economic Comparison



- 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

Life cycle cost of a SWFGD is lower than other FGD technologies driven by lower OPEX

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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

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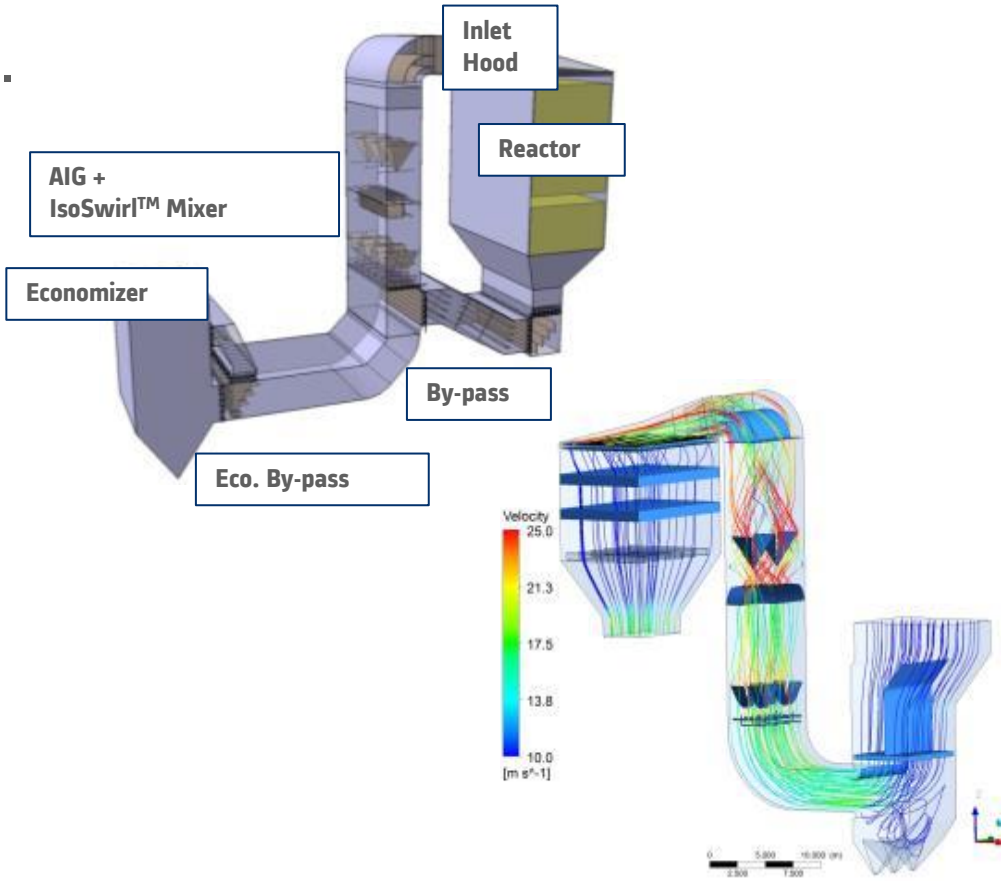
SCR Design

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

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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

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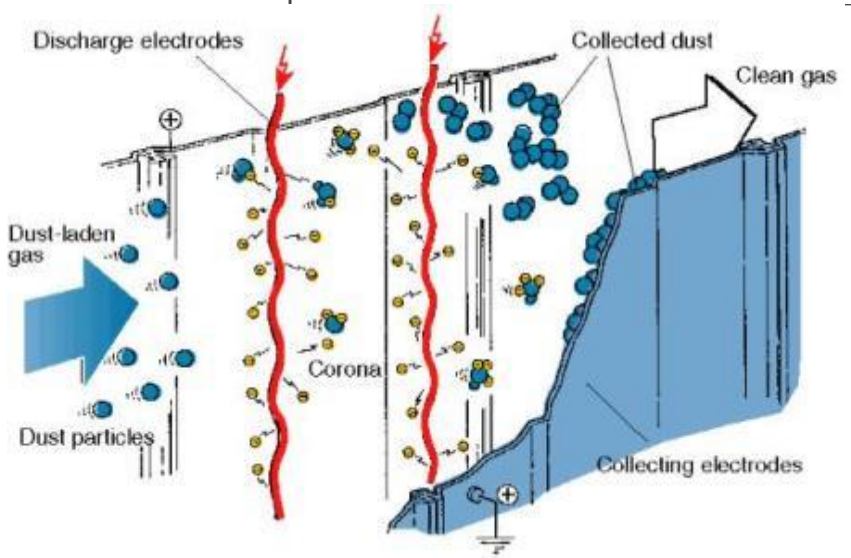
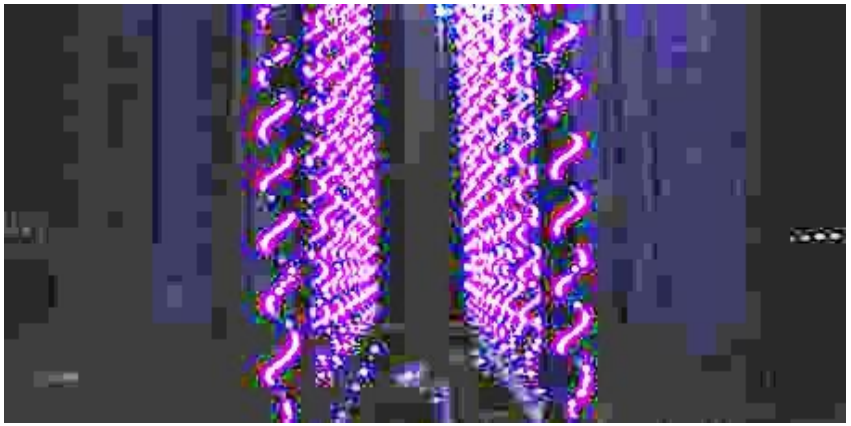
Operating Principles & Performance

- 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

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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

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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

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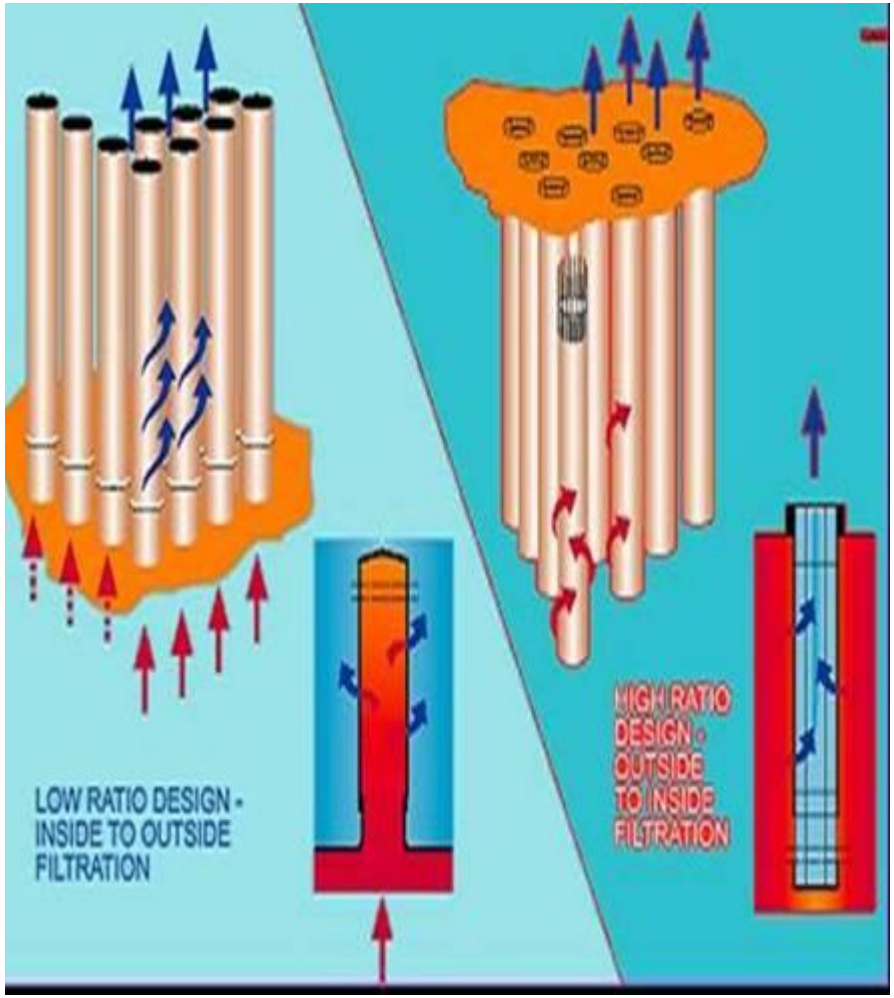
Operating Principles & Performance

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



The 4 important stages of FF Operation

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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

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ECS Performance in Power

Pollutant	Alstom Process	References	Removal Performance
NO_x	Selective Catalytic Reduction	46GW	>95%
SO_x	Open Spray Tower	60GW	>99%
	Flowpac™ Absorber	1GW	>99%
	Dry Flue Gas Desulphurisation	30GW	>98%
	Seawater Desulphurisation	50GW	>98%
Particulates	Dry Electrostatic Precipitators	233GW	<10mg/Nm^3
	Wet Electrostatic Precipitators	2GW	<10mg/Nm^3
	Fabric Filters (standalone)	46GW	<5mg/Nm^3
SO_x/HCl/HF/Hg	NID & Spray Dryer Absorber	136 installations	≥98% for SO_2
Mercury	Mer-Cure™ /Filsorption™	8GW	>90%

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

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ALSTOM

Agenda

- Introduction
- Product Portfolio
- **Key Features and Customer Benefits**
  - Power
  - **Industry**
- Retrofit
- Conclusions

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Aluminium

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, SO_2 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

Global No. 1 in Aluminium

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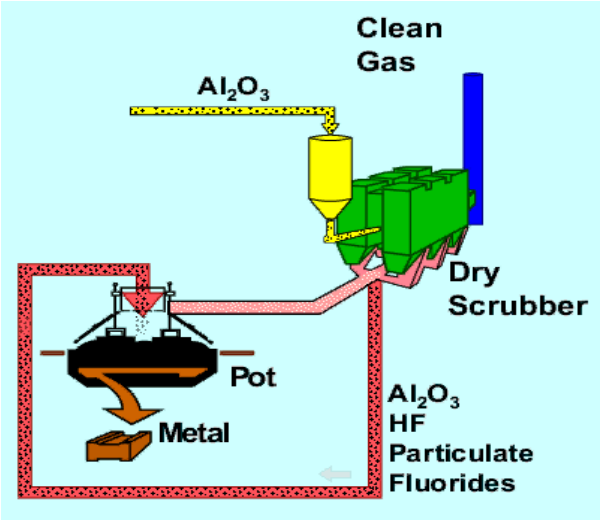
Primary Aluminium Production – ALSTOM AQCS Key Drivers

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

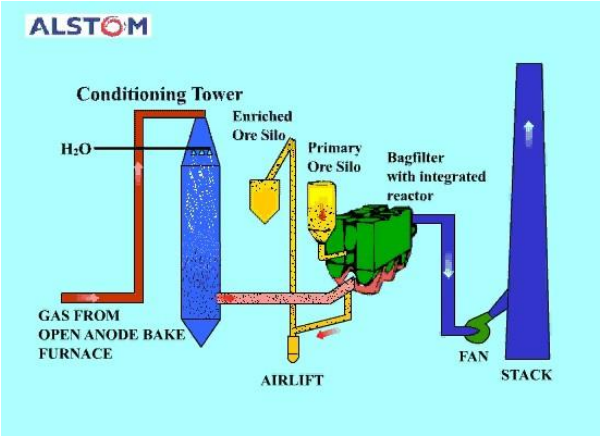
For Electrolysis
The ABART System



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

For Anode Bake
Conditioning +
ABART System



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

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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

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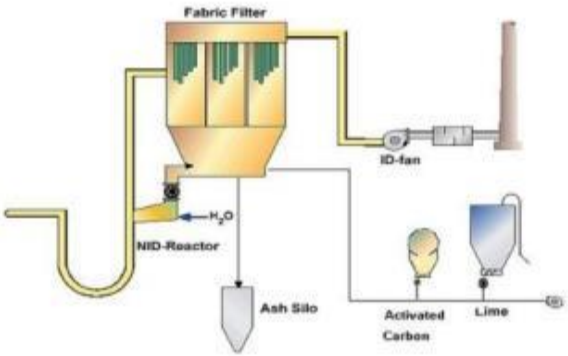
Waste to Energy - (WtE)



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

World Leader in Process Technology and Applications

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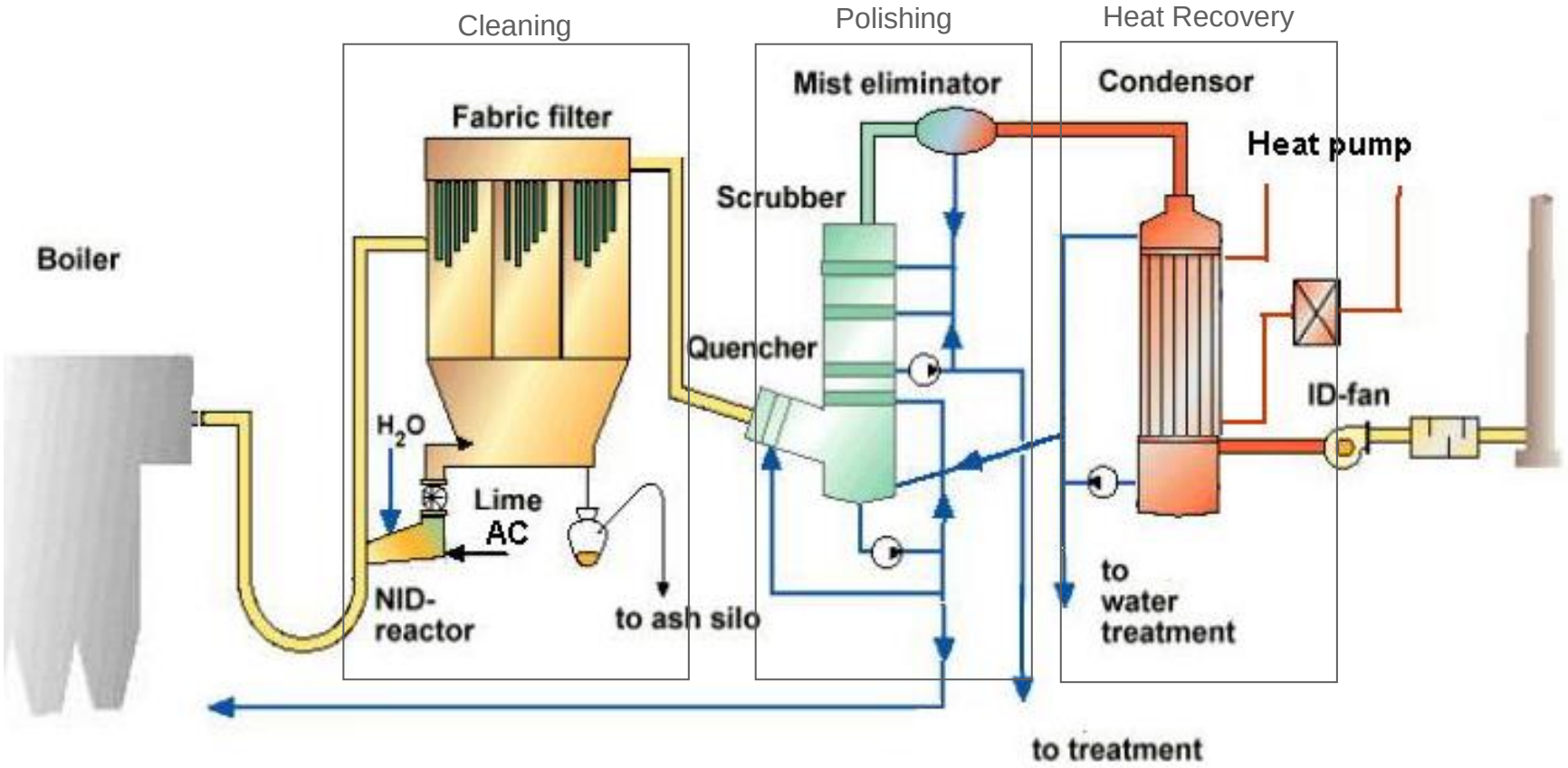
Combined Systems - process layout (1)



Example #1: Jönköping, Sweden

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Pulp & Paper

Applications:

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

Products:

- Electrostatic Precipitators
- Fabric Filters

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

Vast and successful references globally

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Cement

Applications:	Products:	Key Customer Benefits:

• Raw mill & kiln
• Clinker cooler
• Coal mill
• Alkali bypass
• Cement mill
• Other de-dusting
	• Fabric Filters
	  • Low Ratio Reverse Air
	  • High Ratio Pulse Jet
	• Electrostatic Precipitators
	• Gas Conditioning Towers
	• Heat Exchangers
		• 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

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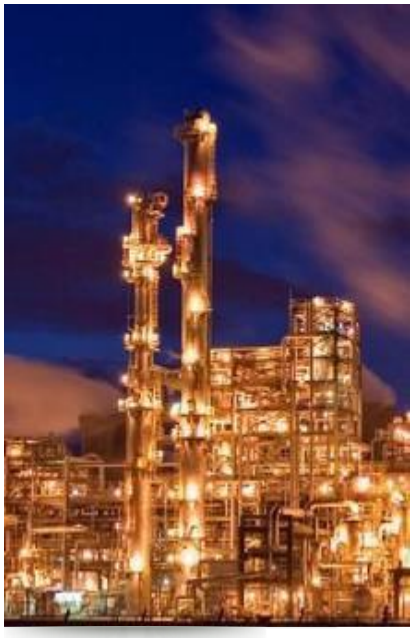
Oil & Gas



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

Full range of products to comply with the strictest international standards

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ALSTOM

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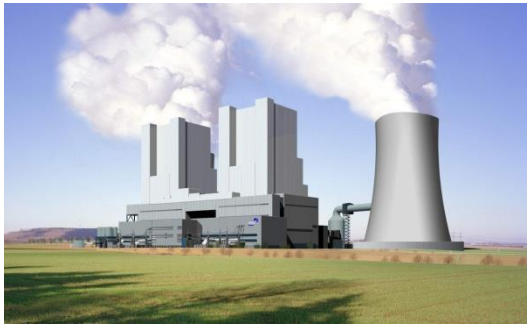
Efficiency and Environmental Impact of Power Plants

Less CO2 = higher power plant efficiency

New Plants

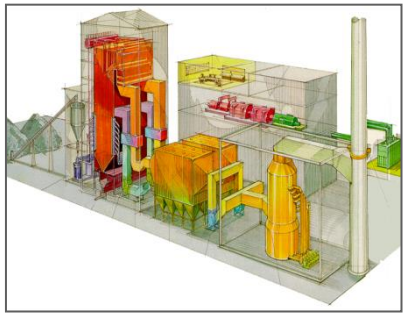


Coal: +15 p.p in efficiency saves 30% CO_2 emissions

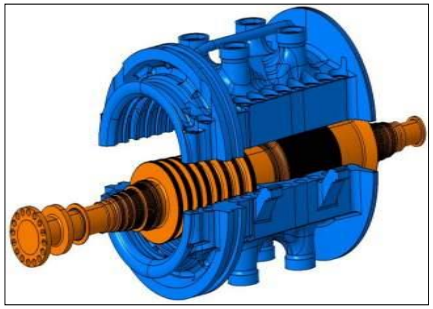
Gas: +20 p.p in efficiency saves 33% CO_2 emissions

60% of the 2030 installed base still to be built

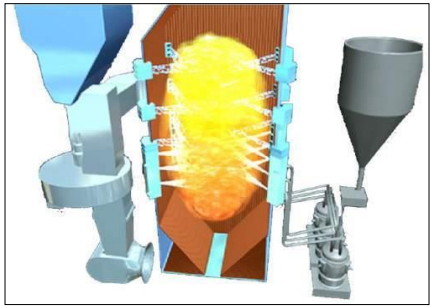
Retrofit



Plant Optimisation: -5% CO_2



Turbine retrofit: -5% CO_2



Boiler retrofit: -3% CO_2

60% of carbon emitted in 2030 will come from today's plants

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Alstom Boilers

Expert is a broad range of fuel

Specialist experience	World Class Products	Specialist experience

Fiddlers' Ferry
Drax (co firing)
Narva*

Niederaussem K
Patnow II
Maritza East
Belchatow II
Neurath F/G
Can
Kaiyuan

Waigaoqiao II and III
Karlsruhe 8
Westfalen D/E
Iatan
Comanche 3
Manjung
RDK 8

Chalkpoint
Ravens Wood 3
Pittsburgh 7
La Spezia 4
Shoaiba
Yanbu 3

Tonghae,
Luohuang

Tamuin
Mailiao

Expertise & world class products for a broad fuel spectrum

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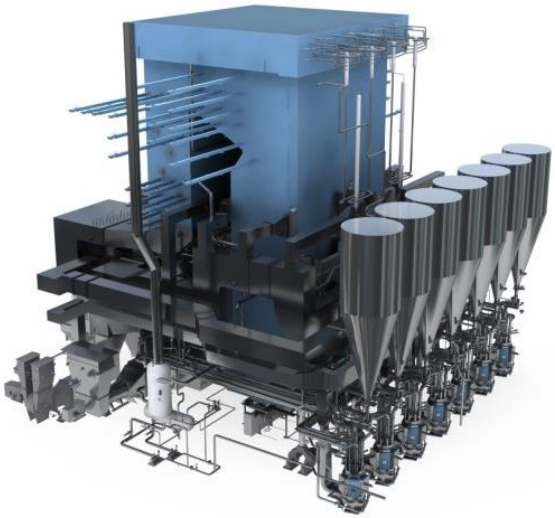
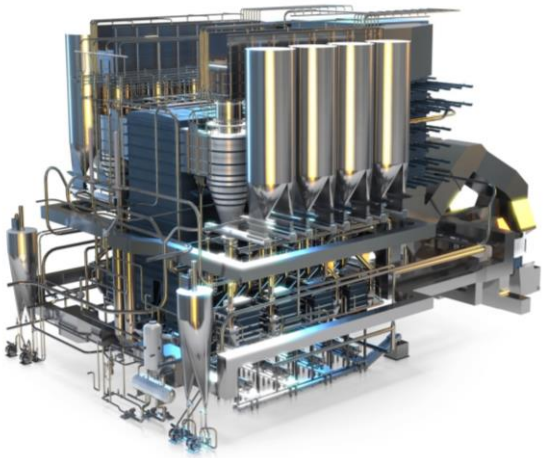
Efficiency and Environmental Impact of Power Plants
Alstom Technology for Combustion

Two Pass Boiler	Tower Boiler	CFB Boiler
		

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

World-class Technology and Product to meet Customer's requirement

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Product offering to meet customer new challenges

DRIVERS

→ Fuel Flexibility

→ Availability

→ Reliability

→ Efficiency

→ Capacity

→ Emissions

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

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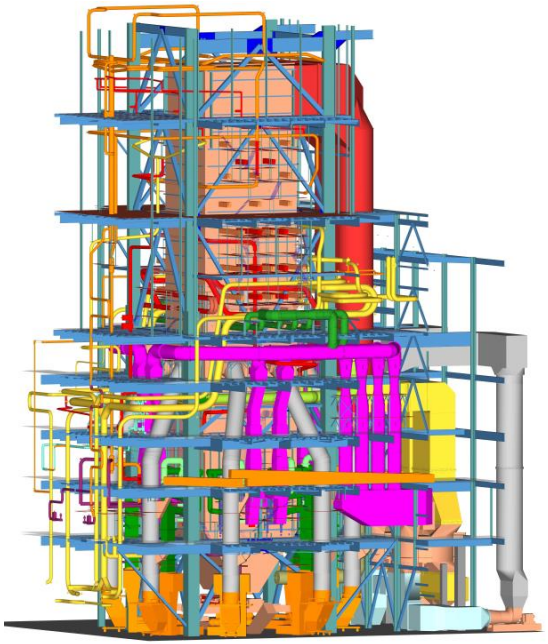
Efficiency and Environmental Impact of Power Plants
Case Study for Retrofit – Belchatow 6

- Superheaters & Reheaters
  - Performance Adjustments
  - Material Upgrades
  - Cleanability
- Economizer
  - Performance Improvem.
  - 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

	Before retrofit	After retrofit
NOX	<400 mg/Nm3	**<200 mg/Nm3**
MW Output	370MW	**<394MW**
Cycle efficiency	>38%	**>41,3%**
Feedwater temp	255°C	**275°C**
Live Steam / RH	540°C / 540°C	**570°C / 570°C**

STG + BOP Retrofit

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ALSTOM WFGD Upgrade Reference List

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

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ALSTOM WFGD Upgrade Reference List Cont.

Customer / Unit	Type Upgrade	Date	Comments
AEC / Lowman Unit 3	Performance Enhancing Plates, Flow Distribution Trays, Oxidation Air Sparger, Recycle Spray Nozzles	2007-2008	Converted two absorbers.
SIPC / Marion Unit 4	Gypsum Dewatering and Handling System, Forced Oxidation System	2007-2008	Added underflow pumps, horizontal belt filters, and conveyors as well as oxidation air compressors and air spargers.
CPS / J.K. Spruce Unit 1	Performance Enhancing Plates, Flow Distribution Trays, Spray Nozzles, Forced Oxidation System, Ductwork Modifications	2008-2009	Upgraded all three absorbers.
Westar / Lawrence Units 4 & 5	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	2009-2012	Upgraded all four absorbers. (two for Unit 4 and two for Unit 5)
ENEL / Brindisi Sud	New agitators (side entry) in palce of existing top entry, new oxidation air injection lance in place of the original air grid	2010	Revamping of agitation and oxidation air systems in a suared tower
EDF / Le Havre & Cordemais	Absorber relining, new spary banks and nozzles, Performance Enhancement Plates, new absorber recycle pumps and piping	2015	Revamping and performance enhancement
ENDESA / Litoral 2	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	2016	Revamping and performance enhancement

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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

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

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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

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