
Presentation to SO₂ Control Workshop

Hosted by

***US DOE Office of Fossil Energy
& Chinese Ministry of Science &
Technology***

***Wet, Semi-Dry & Ammonia FGD Technologies
July, 2003***



Presentation Contents

- ***Marsulex Formation Overview***
- ***FGD Experience & Licensing Strategy***
- ***Coventional FGD Technologies***
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- ***Advanced Ammonia Based FGD***



Marsulex Power Group 2003 – Formation History

GE Environmental Services

- Component of GE Power Systems Division (1981-1997)
- Predominant market segments were utilities and refineries
- Global market leader in wet FGD
- Market co-leader in refinery FCCU cyclones
- Developed & commercialized ammonium sulfate process in USA

Marsulex 1997

- Publicly traded company (TSE)
- \$400 million (Cdn) revenue
- Served refinery, smelting & industrial clients in N. America, Europe & Asia
- Creates value from sulfur byproducts
- Experienced in plant asset ownership, O&M, “fee for service” contracts

Marsulex Power Group 2003

- Developer of advanced air pollution control technologies – ammonium sulfate, potassium sulfate, liquid re-dist tech, and sulfur trioxide mitigation;
- Provider of environmental compliance solutions focused on opportunities where customers can lower operating and/or power generation costs using an advanced Marsulex technology;
- Leader in global applications of calcium-based technologies through extensive licensee network;

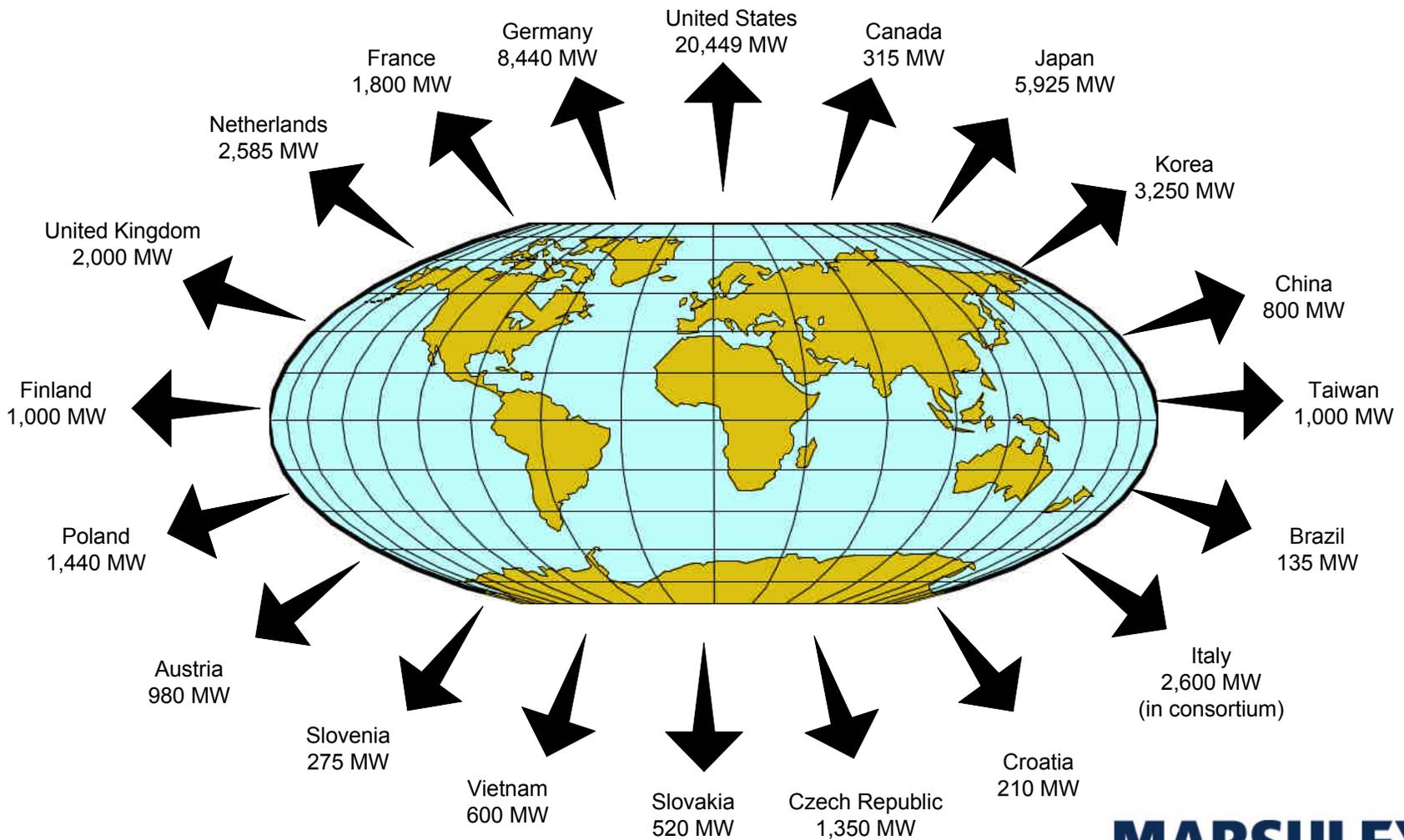


FGD Design Experience Summary

- **Marsulex has 55,674 MWe of FGD technology experience in 20 countries**
- **Technology Base includes conventional & advanced systems:**
 - **limestone with usable gypsum by-product**
 - **lime with disposable by-product**
 - **soda ash with usable by-product**
 - **ammonia with ammonium sulfate fertilizer by-product**
- **Experience base includes wide range of fuel characteristics, system configurations and materials of construction**
 - **low sulfur (<0.5% wt) to high sulfur (>5.0% equivalent) fuels**
 - **worldwide leader in single absorber per boiler installations**
 - **various reheat schemes, reagent preparation and dewatering options**
 - **“multiple boilers into single vessel” experience**
 - **vessel construction using carbon steel, alloys, fiberglass and concrete substrates**
 - **corrosion protection using FRP/GRP & rubber linings, alloys and tiles linings**
- **Experienced in applying various business models**
 - **Lump sum, firm price (historic)**
 - **Cost reimbursable with fixed fee**
 - **Build, own, operation & maintain (BOOM)**
 - **Technology Licensing**



Marsulex Worldwide WFGD Awards of 55,674 MWe



MLX leads in Worldwide Experience



Global Technology Base

Marsulex's technology licensing strategy has resulted in global leadership in the application of FGD technology – over 30 years of experience;

| | |
|---------------------------------------|-------------------|
| Total FGD Awards: | 55,674 MWe |
| • United States | 20,449 MWe |
| • International Total | 35,225 MWe |
| ➤ W. Europe | 18,405 MWe |
| ➤ Asia | 11,575 MWe |
| ➤ E. Europe | 3,795 MWe |
| ➤ Other (Can, SA, Scandanavia) | 1,450 MWe |

***Marsulex has Extensive Experience -
USA & Around the World***



Marsulex Technology Licensing

Marsulex's technology licensing strategy:

- **Develop highly effective technologies for flue gas desulfurization recognizing the complex forces which influence markets;**
- **Continuously improve the technologies through R&D, both basic and applied, to ensure competitiveness in a "globalized" market;**
- **Seek strong, local firms who are skilled in the fabrication, procurement, installation & BOP design of thermal power plant equipment/systems;**
- **Transfer basic technology to enable licensees to become self sufficient;**

Marsulex licensees have become highly respected as independent entities:

- **L.C. Steinmueller (currently part of Fisia BBP Environmental)**
- **IHI**
- **Austrian Energy & Environment**
- **Doosan**
- **Hoogovens (currently Corus)**

**Marsulex Licensees' Success Reflects
Effective Technology Transfer**

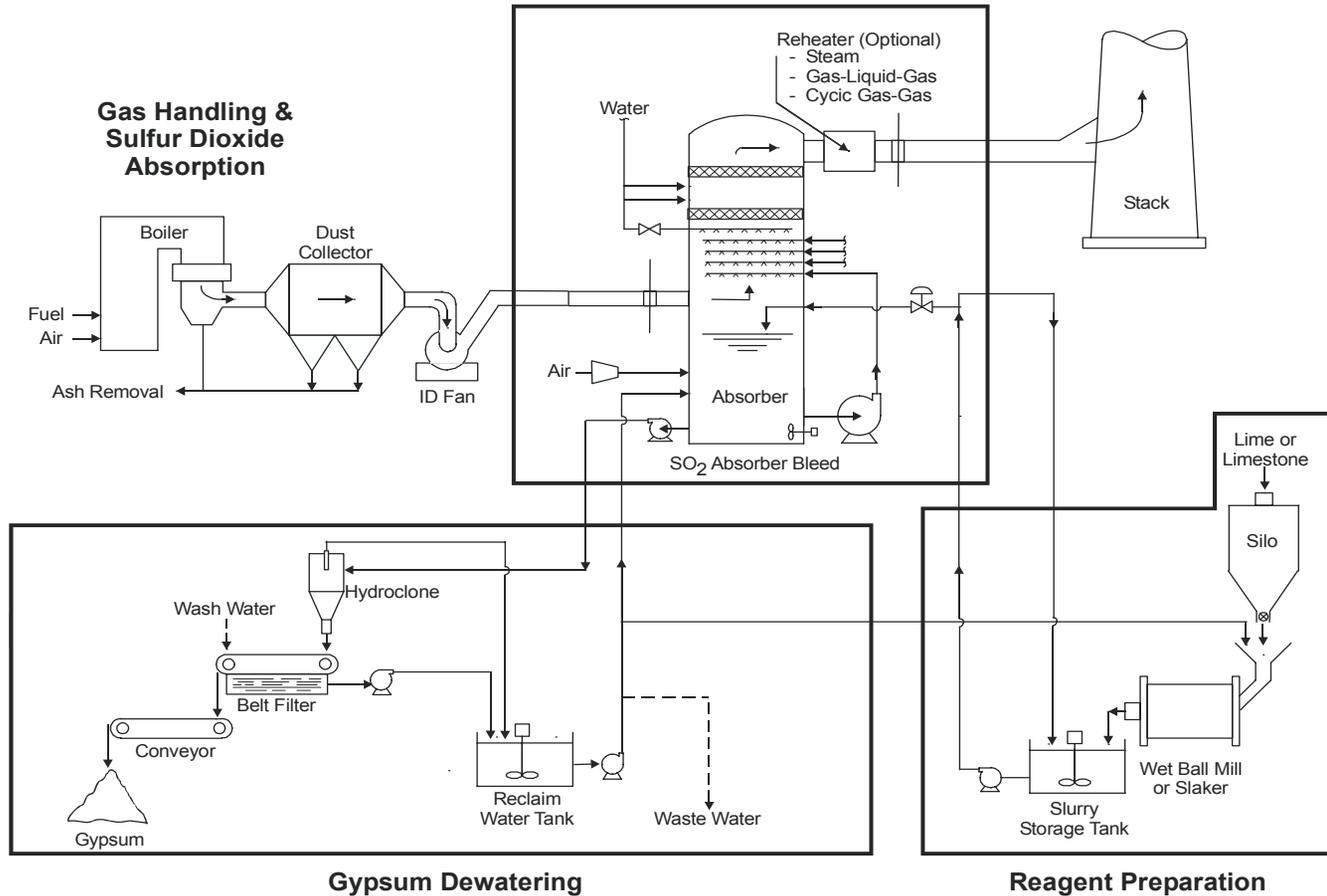


***Wet FGD Technology
Lime & Limestone/Gypsum***



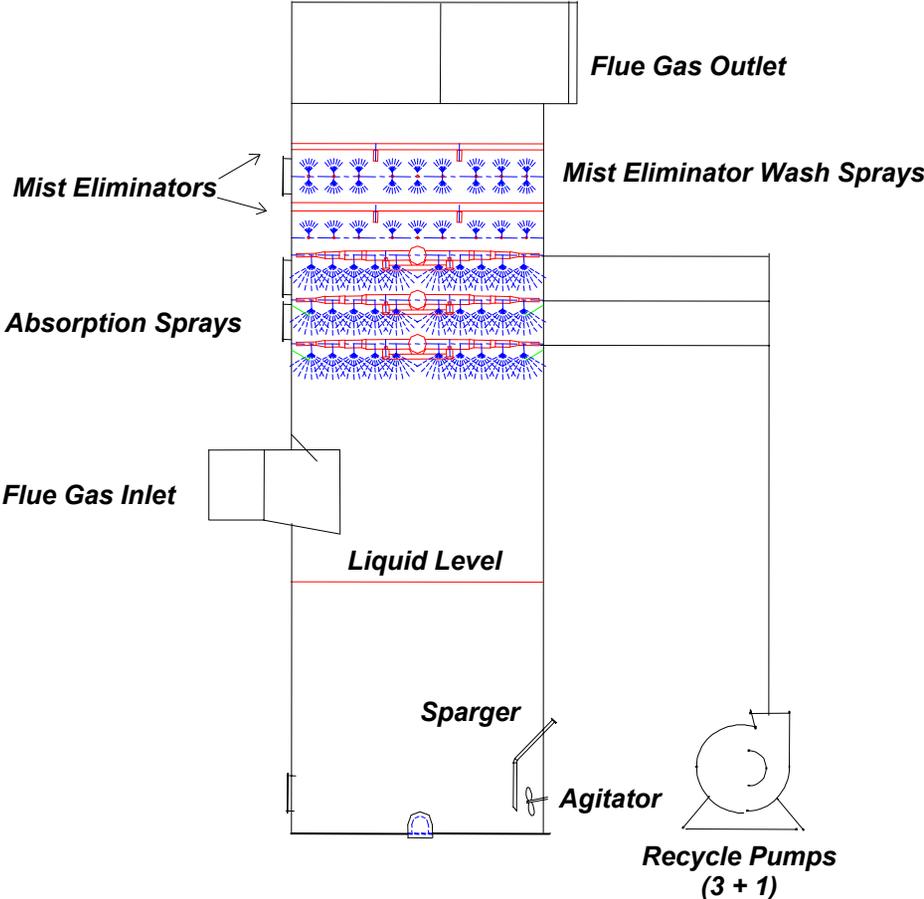
Lime & Limestone/Gypsum Process Flow Diagram - General

MET IFO Flue Gas Desulfurization Process

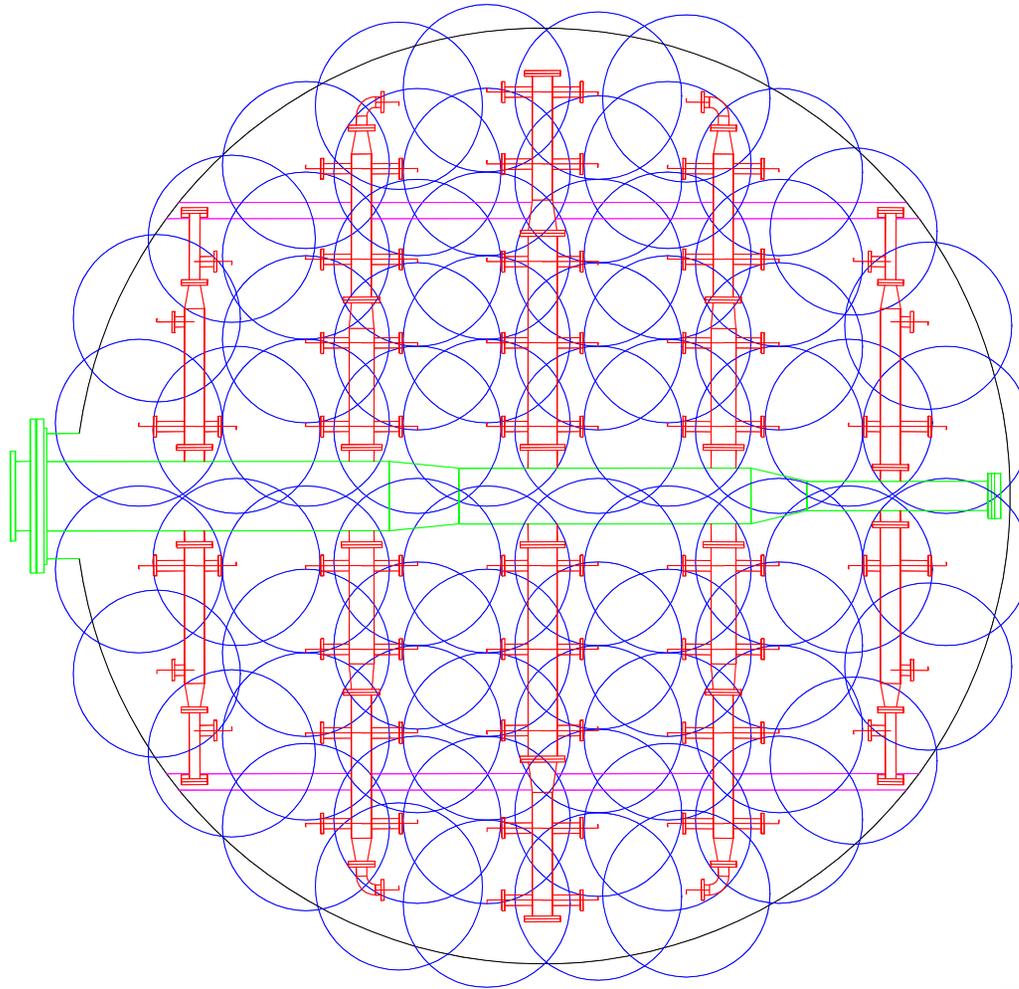


Wet Flue Gas Desulfurization Process

Conventional Absorber (Spray Tower Design)



Typical Absorption Zone Spray Nozzle Configuration



Marsulex WFGD Experience Characteristics

Over 55,000 MWe of Wet FGD installed base:

- ***20 countries***
- ***111 single vessel units***
- ***195 total vessels on 152 boilers***
- ***80 installations utilizing limestone reagent producing gypsum***
- ***30 installations rated at 500 MW or larger***
- ***6 installations rated at 700 MW or larger***
- ***2 vessels installed within the base of the chimney***

Global Market Leader in Limestone Based FGD Systems



Demonstrated WFGD Technology Enhancements

High Velocity Operation

- ***Operation of several Phase 1 FGD systems above design has verified gas velocity impact on absorber design***
 - Santee Cooper, Cross Unit #1 - 550 MW – 3.7 mps
 - APS Harrison, Units 1-3 - 3 x 650 MW – 3.7 mps
 - AEC, BL England Station, Unit #2 - 170 MW – 3.4 mps
 - IP&L Petersburg Units 1&2 - 278 MW & 438 MW – 3.4 mps design
- ***Exceptional results from Phase 1 resulted in several designs above 3 mps***
 - KDHC - 2 x 50 MW – >4.0 mps
 - DGC (ammonium sulfate) 1 x 300 MW – 3.4 mps
 - KEPCO - Yosu Units 1&2 250 MW & 400 MW – 4.0 mps
- ***All units have met SO₂ removal performance and verified design equations for SO₂ removal and pressure drop***
- ***Advantages of higher gas velocity is improved mass transfer resulting in lower cost designs***

***Marsulex's extensive high velocity experience
results in standard designs up to 4.0 mps***



Demonstrated WFGD Technology Enhancements

Tower Dimension Optimization

- ***Independent verification of reaction zone height impact on model performed by Dr. Gary Rochelle of University of Texas for Marsulex***
- ***Optimum absorber dimensions result in similar reaction zone:***
 - Inlet stub to first spray level
 - Distance between sprays
- ***Recent units have used optimum dimensions to balance SO₂ removal with pressure drop to optimize capital and operating cost***

Marsulex's extensive experience results in optimized design to minimize capital and operating costs



Demonstrated WFGD Technology Enhancements

High Velocity Mist Eliminators

- ***Standard chevron mist eliminators demonstrated successfully at high velocity:***
 - Santee Cooper, Cross Unit #1 - 550 MW
 - APS Harrison, Units 1-3 - 3 x 650 MW
 - AEC, BL England Station, Unit #2 - 170 MW
- ***Exceptional results from high velocity mist eliminators at DGC:***
 - Approximately 60 mg/Nm³ at velocities exceeding breakthrough
 - At velocities of > 4.1 mps, small amounts of breakthrough measured

MLX's extensive high velocity experience employs state of the art mist elimination devices for high velocity applications



Demonstrated WFGD Technology Enhancements

Absorber Liquid Re-Distribution Device

- ***Flue gas contact with recycle liquid along wall results in phenomenon known as wall slip***
- ***Several Phase 1 units tested for wall slip phenomenon:***
 - ***AEC BL England Unit #2, 1 x 170 MW***
 - ***IP&L Petersburg, Units 1&2; 278 MW & 438 MW***
- ***Most units show 99-100% SO₂ removal in center center area of tower***
- ***Absorber Liquid Distribution (ALRD) device installed commercially demonstrated in several units at over 300 MW with outstanding results;***
 - ***2-5% SO₂ efficiency improvements on 90% “baseline” efficiencies;***
 - ***In some cases, ALRD will enable the reduction of one recycle pump while maintaining constant or improved SO₂ efficiency;***
- ***ALRD patent has been awarded to Marsulex in USA; other countries in process;***

Application of MLX ALRD Technology Offers Economical Efficiency Upgrades or Power Savings



Demonstrated WFGD Technology Enhancements

Example: Dakota Gasification ALRD Performance

- ***Ammonia absorber, 13.3 m diameter***
- ***Four (4) operating recycle spray levels***
- ***93% SO₂ removal initially (design value)***
- ***Three (3) ALRD units installed***
- ***Improvement to 96% - 97.7% SO₂ removal with ALRD units***
- ***Enables lower operating pH or saving of recycle pump power***

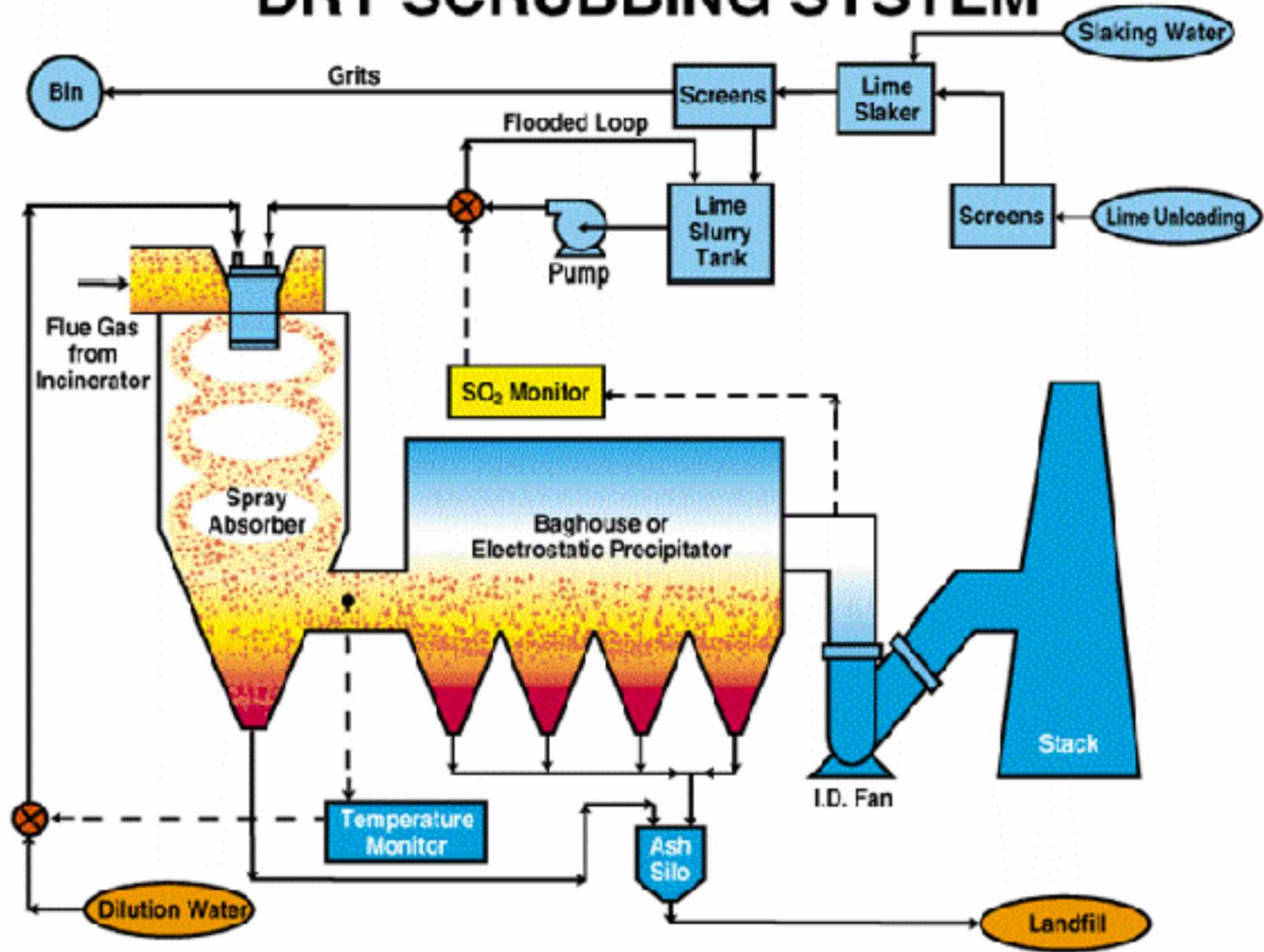
***ALRD Technology Can Improve Efficiency
& Reduce Power Consumption***



Semi-Dry FGD Technology



DRY SCRUBBING SYSTEM



Marsulex DFGD System Differentiators

Direct Drive Atomizer



- ***Minimized atomizer maintenance***
- ***Operating speed flexibility***
- ***Lowest power consumption***

Two Loop Control



- ***Independent slurry supply lines***
- ***Most responsive to load swings***
- ***Optimum lime utilization***

Single Top Inlet Design



- ***Maximum control for turndown***
- ***Optimum gas/slurry mixing***
- ***Elimination of wall buildup***

***System Differentiators Ensure Meeting
Availability & Performance Requirements***

