What is FGD Gypsum?

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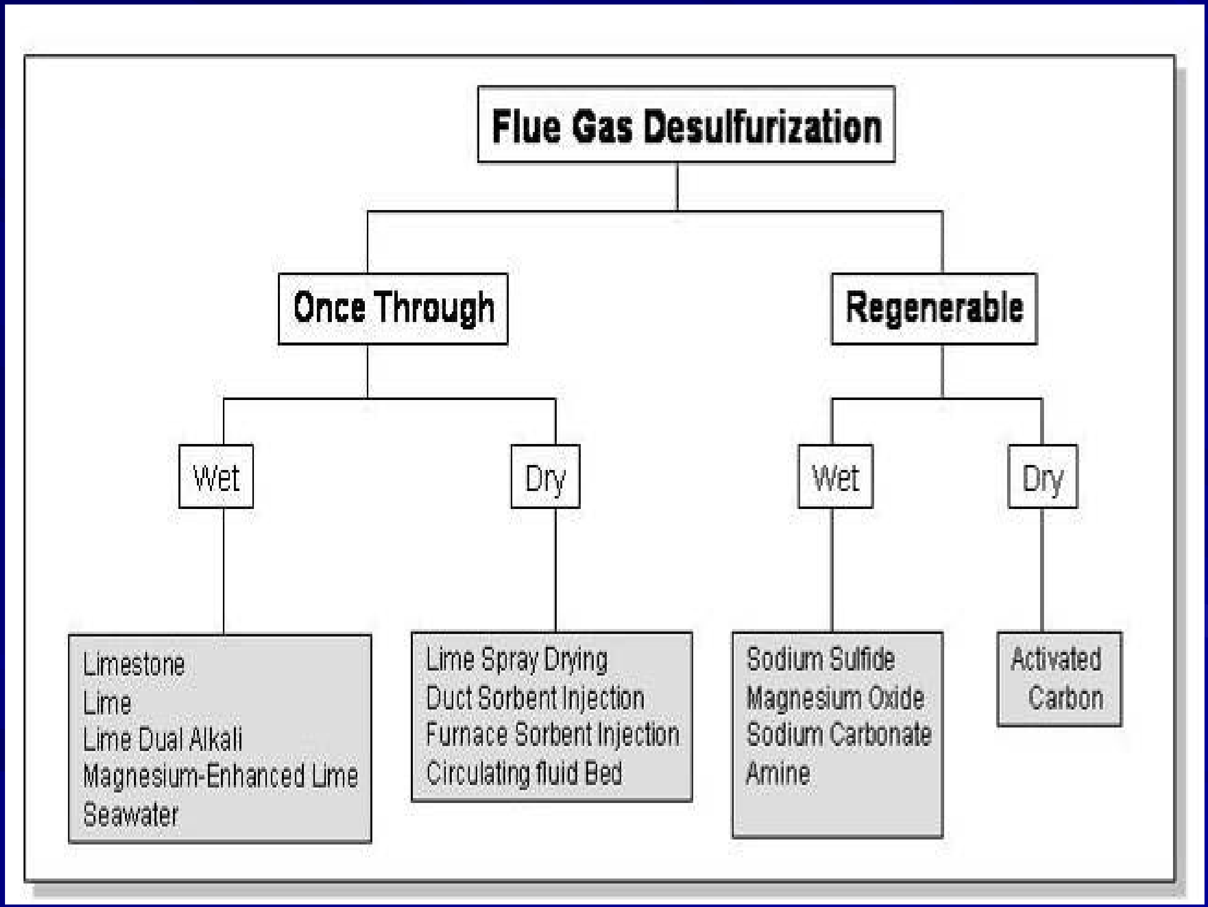
Flue Gas Desulfurization (FGD) Gypsum

- Production
- Processing
- Disposal
- Markets

WHAT ARE FGD SCRUBBERS?



FGD PRODUCTS

- Many different products from the various FGD processes, primarily:
  - Lime/limestone force oxidized (LSFO) = Calcium sulfate dihydrate (gypsum)
  - Lime/limestone unoxidized = Calcium sulfite
  - Fluidized bed ash and dry scrubbers = mixtures of char/fly ash and spent bed material or sorbent containing CaO, $CaSO_4$, $CaSO_3$ and ash
  - Wet ammonia = ammonium sulfate

FGD PROCESS SELECTION

Individual utilities are selecting FGD processes based on a number of criteria including:

- **SO_2 removal efficiencies—generally 92-95% plus**
- **Availability of resources / reagents—i.e. water, limestone, lime**
- **Byproduct handling requirements—storage / disposal availability**
- **Marketability of byproduct**
- **Cost**
- **Cost**
- **Cost!**

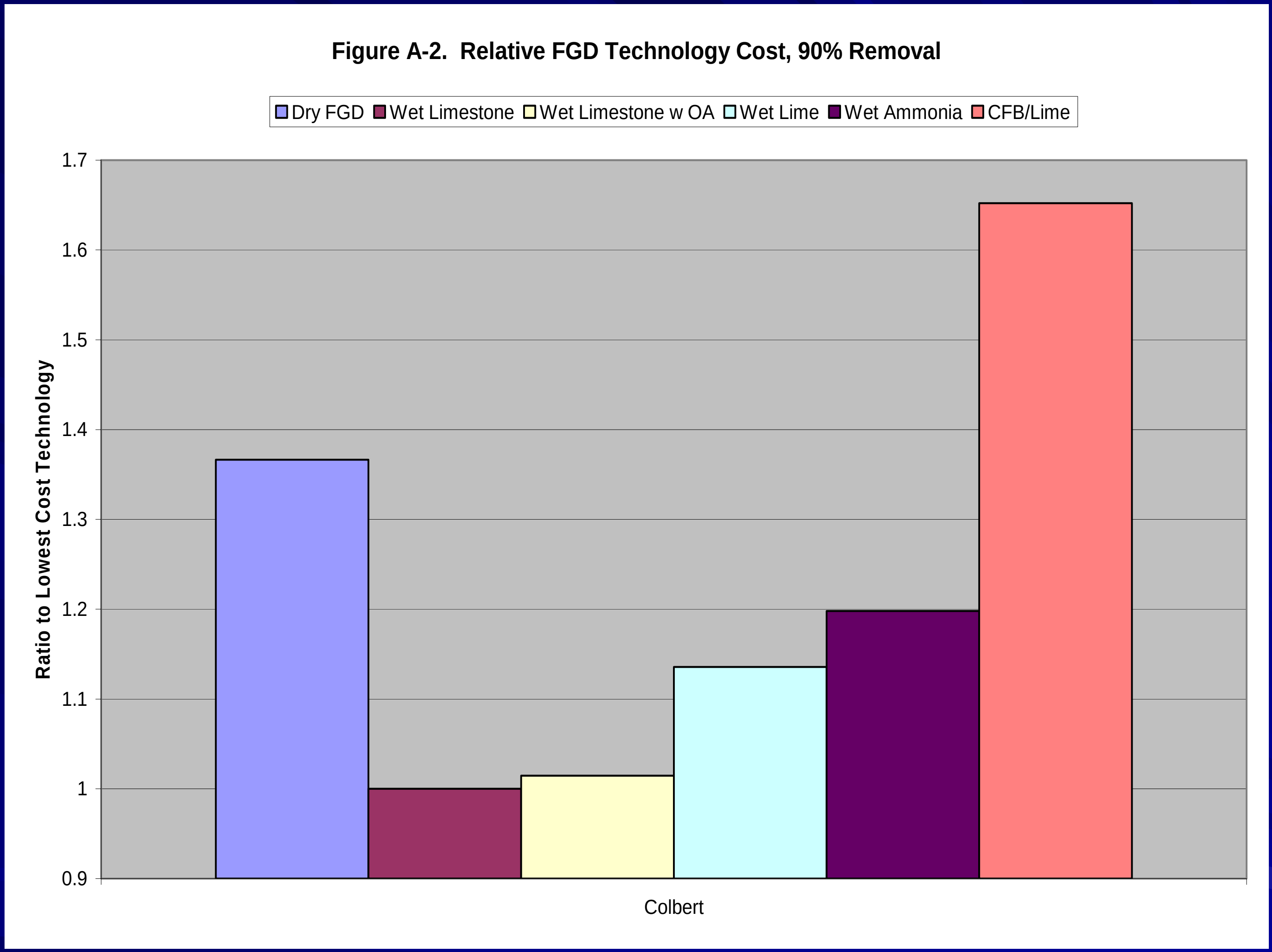


Figure A-2. Relative FGD Technology Cost, 90% Removal
Dry FGD
Wet Limestone
Wet Limestone w OA
Wet Lime
Wet Ammonia
CFB/Lime
Ratio to Lowest Cost Technology
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Colbert

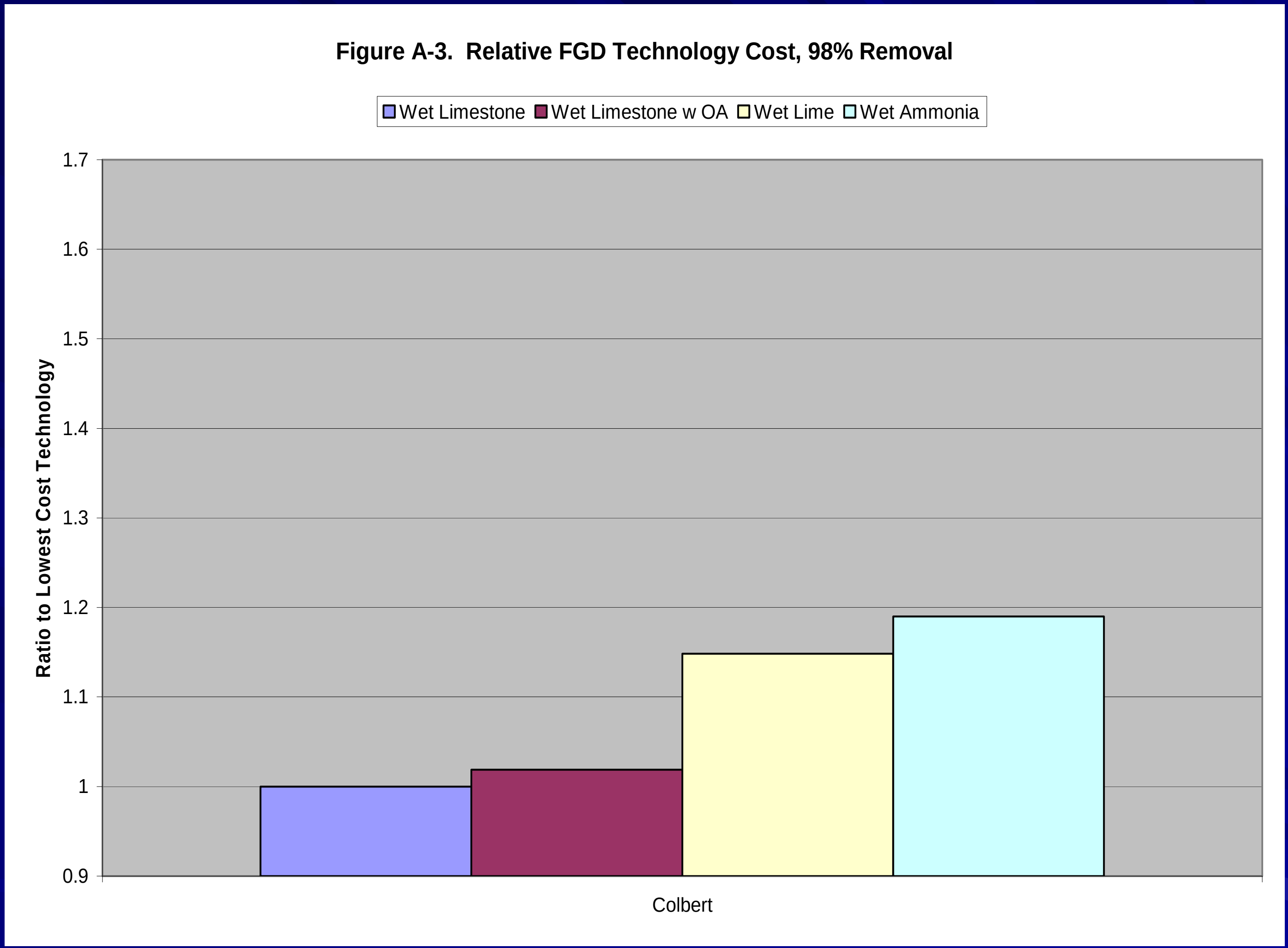


Figure A-3. Relative FGD Technology Cost, 98% Removal
Wet Limestone
Wet Limestone w OA
Wet Lime
Wet Ammonia
Ratio to Lowest Cost Technology
1.7
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Colbert

Scrubber Installations

- Over 160,000 MW of electrical generation capacity in North America has installed or plans to install scrubbers
- Of some 368 coal-fired units surveyed*, at least 316 will be lime or limestone-based, with up to 225 of those slated to be either wet lime or limestone forced oxidation systems and the rest some form of dry lime or limestone system
- Of the remainder only two dual alkali, three magnesium oxide, one sodium based, and the rest identified as “other”

*Included the U.S. and Canada

FGD PRODUCTS (cont.)

- Products of Lime/Limestone Forced Oxidation processes are most often sought for agricultural use
  - Readily dewater to 7-12% moisture even without mechanical dewatering equipment
  - Are easily reclaimed from ponds, stored, transported and spread using conventional equipment

FGD PRODUCTS (cont.)

- Unoxidized Lime/Limestone FGD products are thixotropic sludges (consistency of toothpaste—may liquefy when shaken)
  - Difficult to dewater
  - Require some sort of processing or admixture such as fly ash or lime to achieve moisture levels that can be handled
  - Cannot be easily stored, transported or spread with conventional agricultural equipment

FGD Gypsum Management

- In “once-through” systems, bleed stream from the scrubber absorber tank is usually at 12-30% solids and low chloride levels. Filtrate from gypsum dewatering is not recycled

- In “closed loop” systems, absorber tank will concentrate chloride levels to very high levels (20,000 ppm or more) as filtrate from gypsum dewatering is recycled back into the scrubber cycle

Limestone Forced Oxidation Process

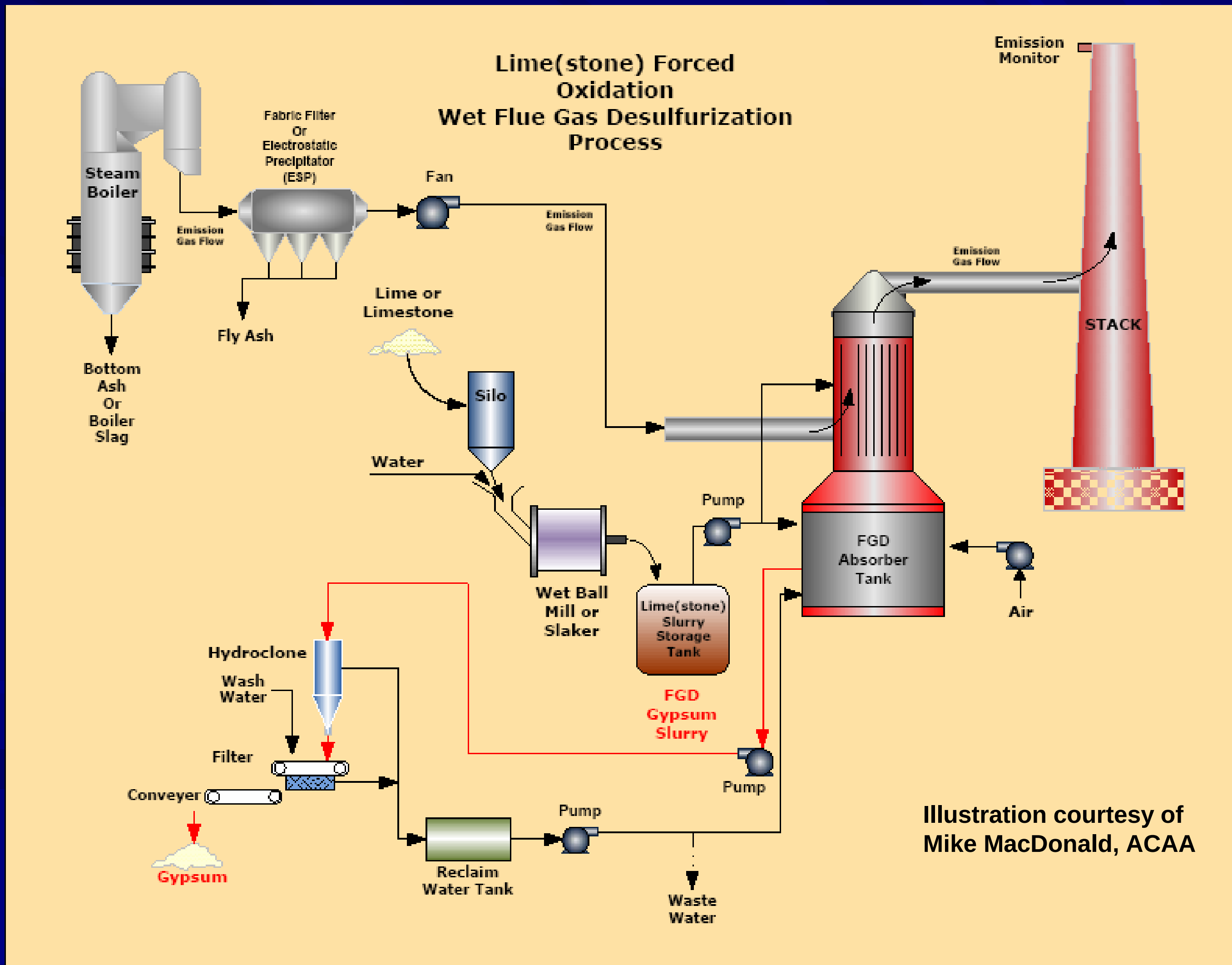


Illustration courtesy of Mike MacDonald, ACAA

FGD Gypsum Management (cont.)

- Gypsum can be mechanically dewatered using vacuum filters, rotary drum filters or centrifuges
- Mechanical dewatering results in a gypsum cake product which can have moisture levels as low as 5%
- Mechanical dewatering also allows for control of particle size, chloride content and removal of impurities

Vacuum Filter Belt

FGD Gypsum Management (cont.)

- Gypsum can also be dewatered in ponds managed as “rim ditch stacks”
- The large size of FGD gypsum particles (average 45 microns) allows the material to readily dewater in ponds
- Gypsum ponds/stacks can dewater product to 7-12% moisture by natural gravity drainage and drying depending on temperature and rainfall

Overview of LSFO Operation—Gypsum Pond with Fly Ash Silos in Foreground

Rim Ditch Stacking

Rim Ditch Stacking (cont.)

- FGD Gypsum which has been deposited in a pond or stack is easily reclaimed for marketing using either conventional earth moving equipment, or
- Can be reclaimed using a hydraulic dredge and re-slurried back through the mechanical dewatering system

Hydraulic Dredging from Gypsum Stack

Mining Gypsum from Rim Ditch Stack Using Earthmoving Equipment

FGD Gypsum Handling Issues

- Dewatered gypsum is usually stored in a roofed storage shed to avoid accumulating additional moisture from precipitation and to provide wind screens to prevent dusting
- Reclaimed gypsum on ponds will form a crust which helps shed water and prevents dusting so long as it is undisturbed. If the crust is broken it can cause a dusting problem

Loading Trucks with Gypsum Inside Covered Storage Shed

FGD Gypsum Handling Issues

- Even at moisture contents as low as 5% loading does not usually cause a dust problem
- Covered conveyors help prevent dust problems at transfer points

Gypsum Truck Dump-Covered Conveyor

Loading Barge

Aerial View of Barge Loadout

Potential Markets for FGD Gypsum

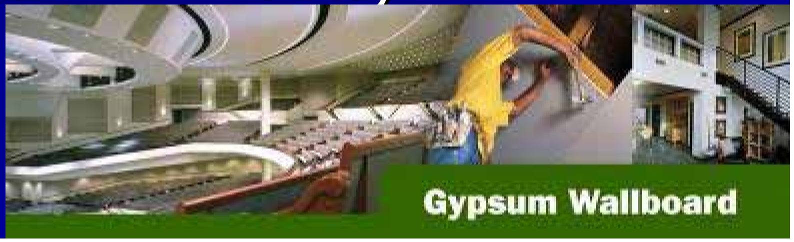
- North American Production – 2005/2006* = 12 M tons

  ***ACAA 2005/2006 CCP Production and Use Surveys**

Use 2005 (tons)	Use 2006 (tons)
-wallboard=8.2M	-wallboard=7.6M
-cement=0.74M	-cement=1.8M
-agriculture=0.4M	-agriculture=0.2M
-other=0.021M	-other=0.008M

Potential Markets for FGD Gypsum

- Future North American Production – 2015 = over 20 million tons
  - –Wallboard
    - At least 20 wallboard plants are operating or have been announced which will run on FGD Gypsum
    - Total usage in these plants will approach 3-5 M tons/yr accounting for a total of 12 M tons/yr



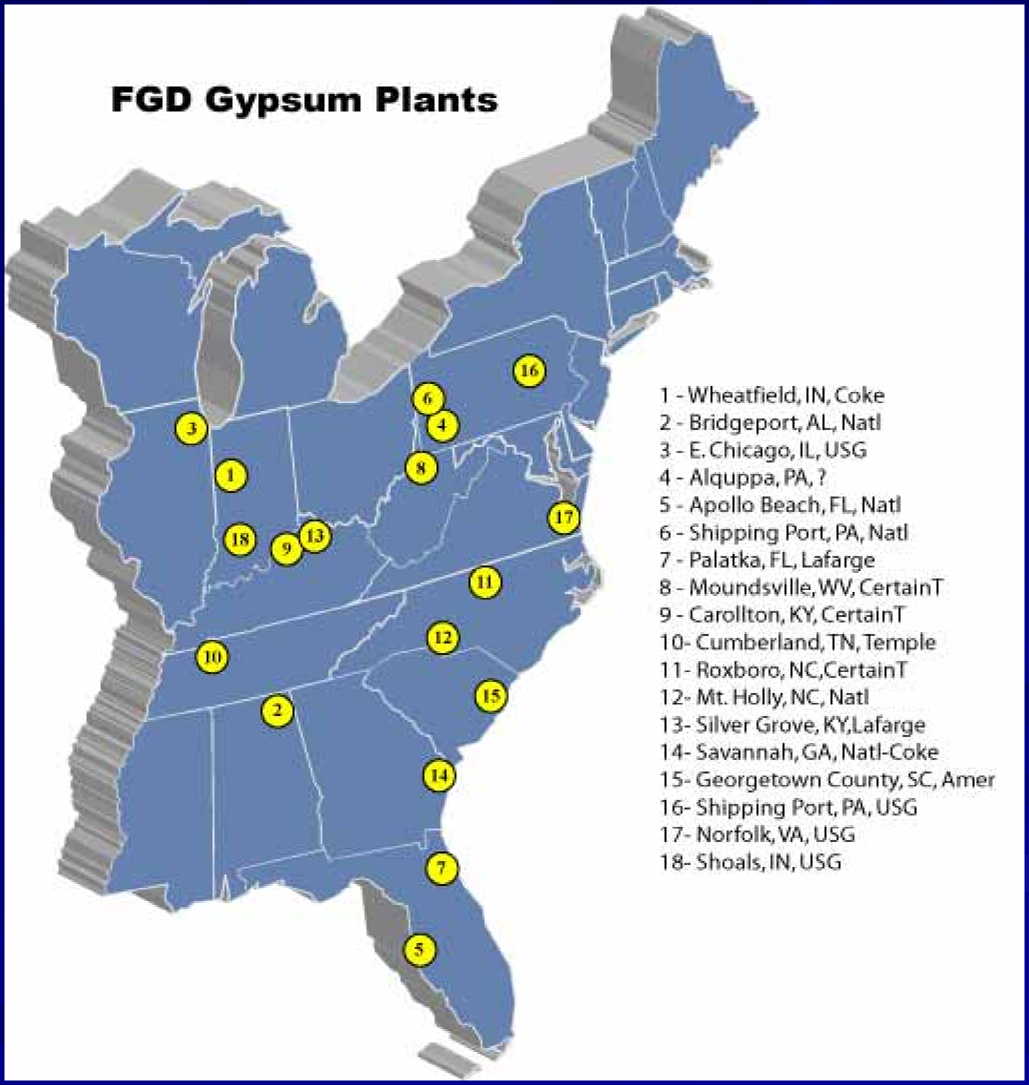


Illustration courtesy of Mike MacDonald, ACAA

Potential Markets for FGD Gypsum

– Cement

- Although several new cement kilns are planned for North America, use in cement (as a set retardant and grinding aid) will not significantly increase FGD Gypsum use

Potential Markets for FGD Gypsum

– Agriculture

- Use of FGD Gypsum in agriculture is the market with the greatest potential for expanding gypsum use
- Application rates will average 1-5 tons/acre
- Concerns about heavy metals in FGD Gypsum may dampen acceptance in this market

Summary

- Total amount of FGD gypsum available for agricultural use will be ~ 7-8 million tons/year by 2015
- Not all FGD gypsum will be acceptable for agricultural use because of high chloride content and potential perception issues associated with heavy metals
- Many FGD gypsum sources will not be located in areas where the cost/benefit of using FGD gypsum for soil amendment will justify the cost of transporting and handling the material
- Agricultural use of FGD gypsum will probably be opportunistic, developing primarily in agricultural areas very close to sources of material, or at sites where the utility has disposal costs that are very high
- At power plants where the FGD gypsum cannot be diverted prior to disposal and/or where significant quantities cannot be marketed, the utility will not be able to justify paying subsidies to market FGD gypsum
- If FGD gypsum is to be accepted as a *bona fide* commodity, the cost of utilizing the material should be borne by the end user—payment of subsidies for use of byproduct materials is usually viewed with suspicion by regulators

Questions?

Gypsum Parameters