

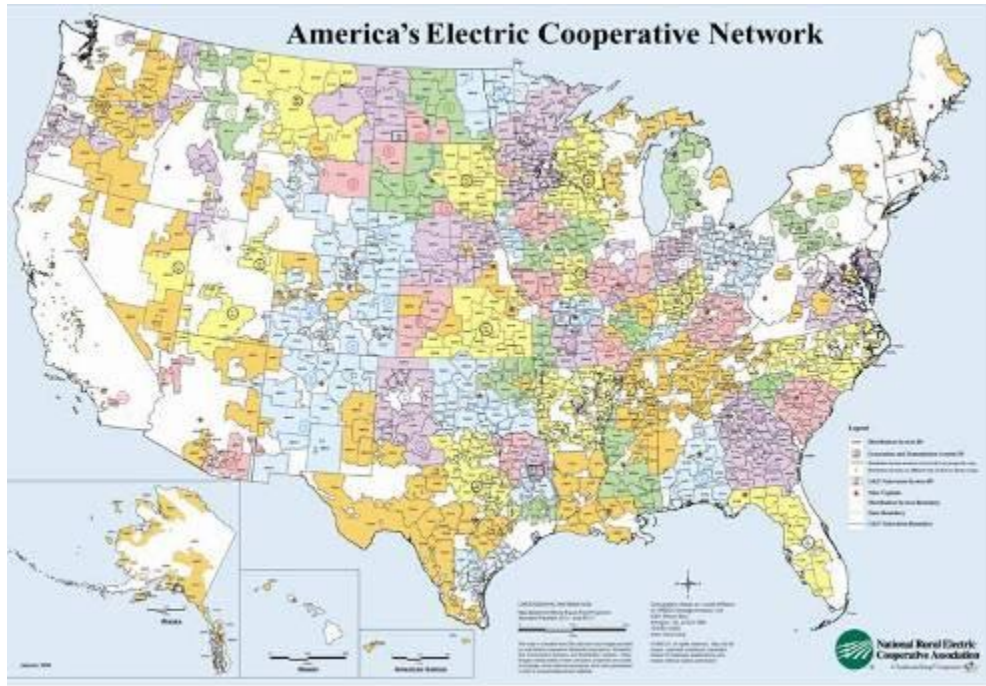
Coal Ash Beneficiation and Refining Options

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Technology and Innovation Dept
Arizona Public service

National Rural Electric Cooperative Association (NRECA) Electric Cooperatives



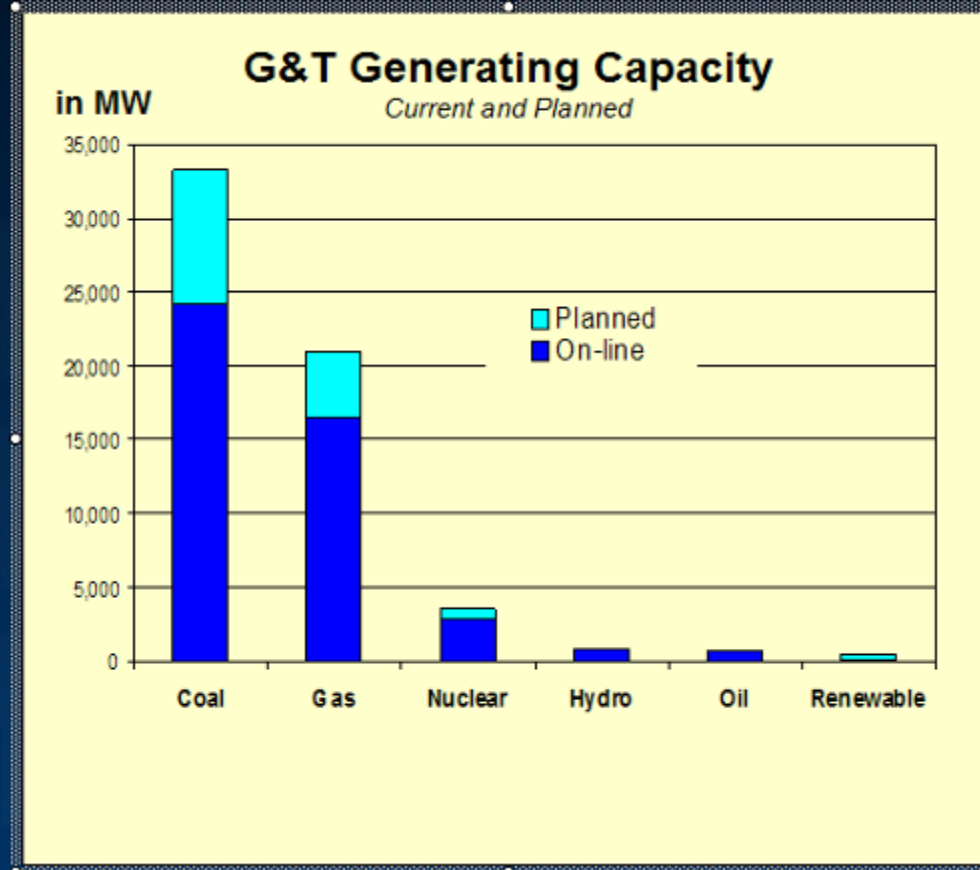
- Over 900 co-ops
- 42 million in 47 states
- 75 percent of land area
- 83 percent of counties fully or partially served
- 42 percent of nation's distribution lines
- 7 customers/line mile
- 50% Suburban and 25% micro urban
- Largest aggregation of coal power plants

G&T Cooperatives

The Largest Domestic Coal Based System

- **Total G&T Generating Capacity**

- On-line = 45,243 MW
- Proposed ~ 15,000 MW
- Total ~ 60,000 MW



Co-op Principal Mission

*Keeping electricity reliable
and the rates affordable*

Co-op Business Realities

Innovation—a result of unique circumstances

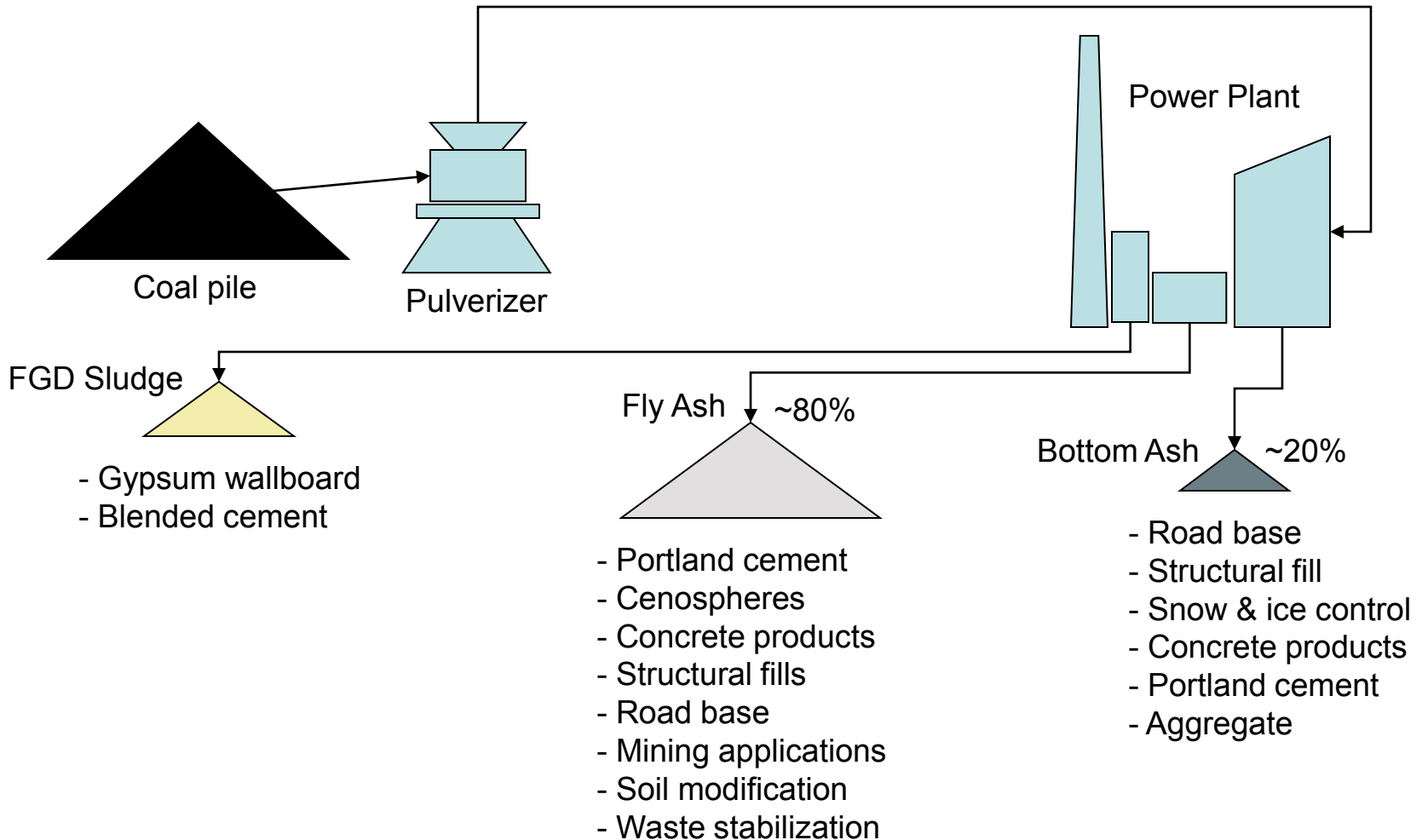
- Sparse service territories
- Not for profit
- Consumer-owned & consumer-governed
- Overwhelmingly residential and farms
- Household incomes below national average
- Federally set construction standards, technical specifications, augmented by industry best practices

NRECA CRN Generation, Fuels & Environment

MISSION

**Ensuring cost-effective power supply for
electric cooperatives while facilitating
compliance with environmental
regulations**

Current Coal Combustion By-Products (CCB) examples



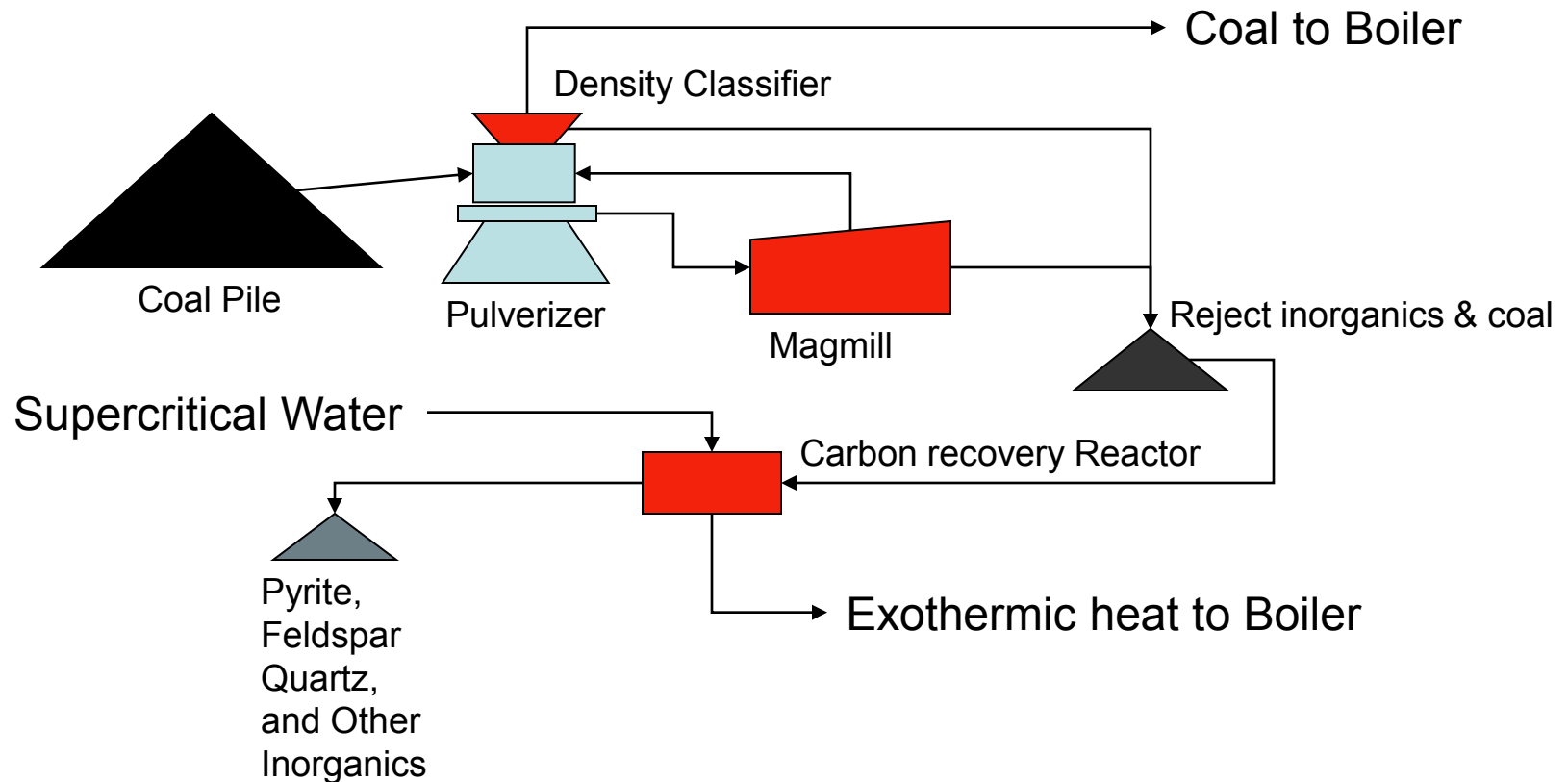
CCB Utilization

- 71.7 million tons fly ash produced nationally (2007 data)
- 18.1 Mtons bottom ash and 12.3 Mtons FGD gypsum
- 47% of ash and gypsum used in construction
- Dependent on local markets, hauling costs, economy
- Revised EPA rules for coal combustion byproducts (CCB) expected in 2012
- CCB stigma if regulated as “special waste”
- EPRI estimates NPV cost impact of \$50 billion to \$75 billion with impact to G&T cooperatives of \$5 billion to \$7 billion
- Beyond just utilization – must consider ash material Reduction, Conversion and Reclamation options

Methods to Reduce Coal Ash

Coal Processing

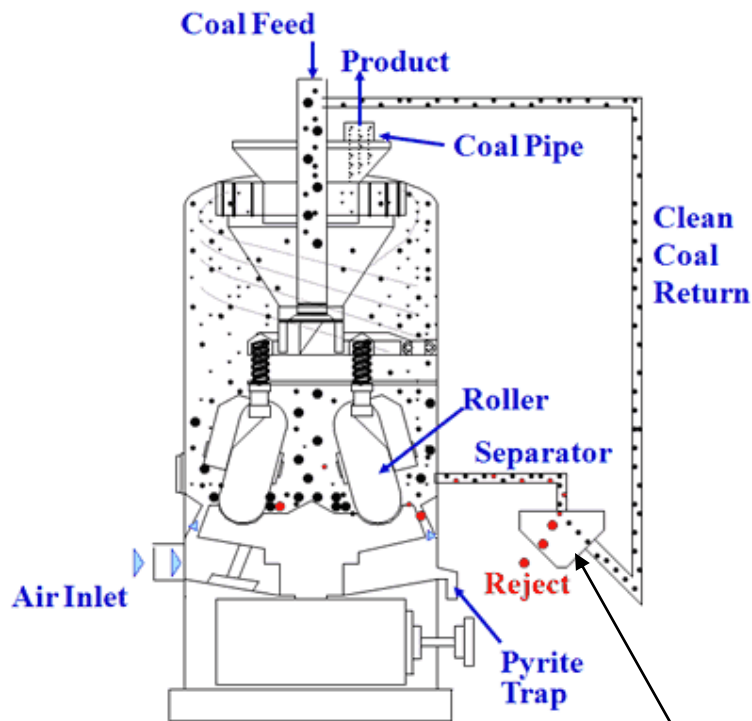
(RED = New Equipment)



Coal Processing Details

- Magmill – dry magnetic cleaning of pulverized coal w/ maximized removal of pyrite and other minerals including mercury
- Technomics Inc. - density classifier to remove ash
- Magmill and/or classifier will need carbon recovery
- Carbon Recovery Alternatives:
 - Supercritical water conversion of carbon w/ heat recovery
 - Separation Technologies (ST) Inc. extraction process
 - Electrostatic concentration and recovery of carbon from ash
 - Concentrated carbon recycled as boiler fuel input
 - PMI Ash Technologies LLC carbon burn-out technology
 - Eliminate carbon in remaining inorganic ash material
 - Cleaned ash / ore suitable for “refining”
 - Exothermic heat recovery to plant
 - SEFA Group Stage Turbulent Reactor (STAR)
 - Eliminate carbon in remaining inorganic ash material
 - Cleaned ash / ore suitable for “refining”
 - Exothermic heat recovery to plant
- Carbon recovery may be required with either coal cleaning technology as appropriate. Both cleaning technologies may be required to maximize this ash Reduction option.

Magmill



Magmill System

- Dry magnetic cleaning of pulverized coal
- APS power plant coal tested at Magmill pilot site
- Reduce Ash, SO₂, Hg
- Improve power plant performance & reliability
- Carbon recovery to plant
- “Mining” ash concentrate
- Any Demonstrations yet?

Technomics Density Classifier

- Rotating throat-ledge cover system
- Demonstration at Gavin power plant – AEP
- Pyretic rock is efficiently removed from pulverizer
- Increased primary air velocity but not flow mass
- Improved coal fineness and boiler combustion

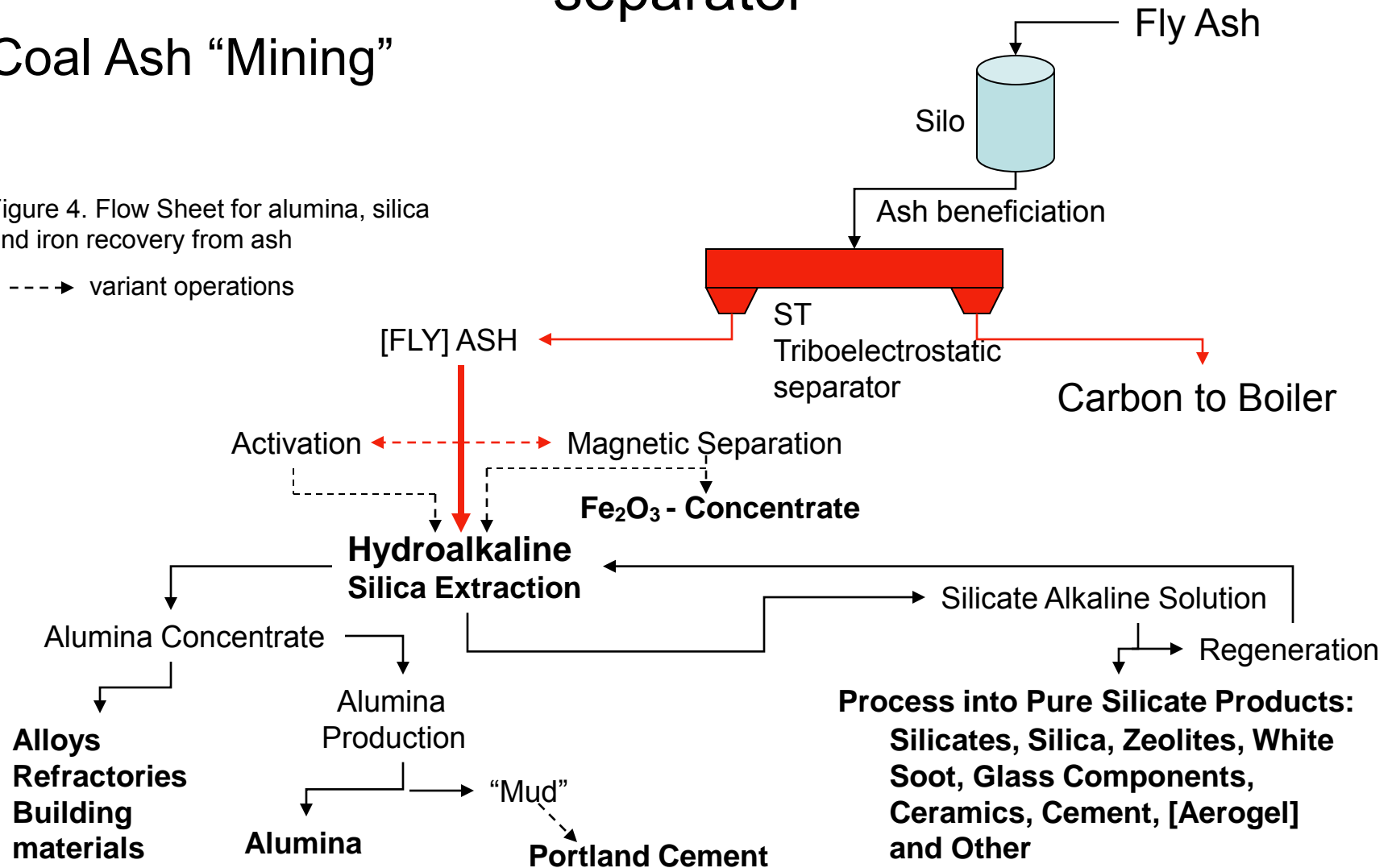


Coal Ash Conversion Option Using Russian Hydroalkaline process with ST Triboelectrostatic separator

Coal Ash "Mining"

Figure 4. Flow Sheet for alumina, silica and iron recovery from ash

----> variant operations



Coal Ash “Mining” and Refining

Coal Fly Ash Processing into Metallurgical and Silicate Chemical Products:

- Russian HYDROALKALINE pilot process w/ magnetic recovery of concentrated Fe_2O_3
- Ferric-oxide recovery approx 50%
- Hydroalkaline silica extraction approx 60%-77%
- Bauxite quality Alumina ash remaining for processing
- Alumina production residue “mud” is considered a valuable Portland cement additive

Ash Beneficiation Alternatives: (see Coal Processing)

- Separation Technologies (ST) process separates carbon from fly ash w/ carbon recycled back to boiler
- PMI Ash Technologies carbon burn-out technology w/ heat recovery back to boiler
- SEFA Group Stage Turbulent Reactor (STAR) w/heat recovery back to boiler

RockTron Eco-Minerals

- RockTron is a UK company; <http://rktron.com>
- Fiddler's Ferry eco-mineral processing plant is on-line
- Designed to process 800,000 tons of fly ash per year
- Processes both fresh and stockpiled ash
- RockTron eco-mineral coal-ash products
 1. CenTron™ - hollow alumino-silicate spheres for coatings and composites.
 2. MinTron™ - solid alumino-silicate spheres
 3. MagTron™ - spherical magnetite / iron
 4. Recovers 98% of the carbon for use as fuel, reductant, or activated carbon

Keystone Metals Recovery, Inc

Process for recovering Metals from Coal Ash

- The coal ash is heated in a CFBC using coal and the carbon in the ash (LOI) to break the physical bonds of the metals in the ash with the waste heat used for a small T/G or used to by-pass feedwater heaters in the plant.
- The ash is chlorinated with the metal chloride (Al, Ti, Fe, and others) removed from the remaining solids (Silicon oxide) in cyclone separators. Coal ash has the following:
 - 50% to 55% sand
 - 22% to 35% Al
 - 3% to 10% Fe
 - 1% to 1.5% Ti
 - Trace quantities of germanium, gallium, Hg, etc.
- The metal chlorides are reduced to molten metals and formed into ingots for sale. (electricity used to produce the Al from the chloride is 65% less than production from bauxite).

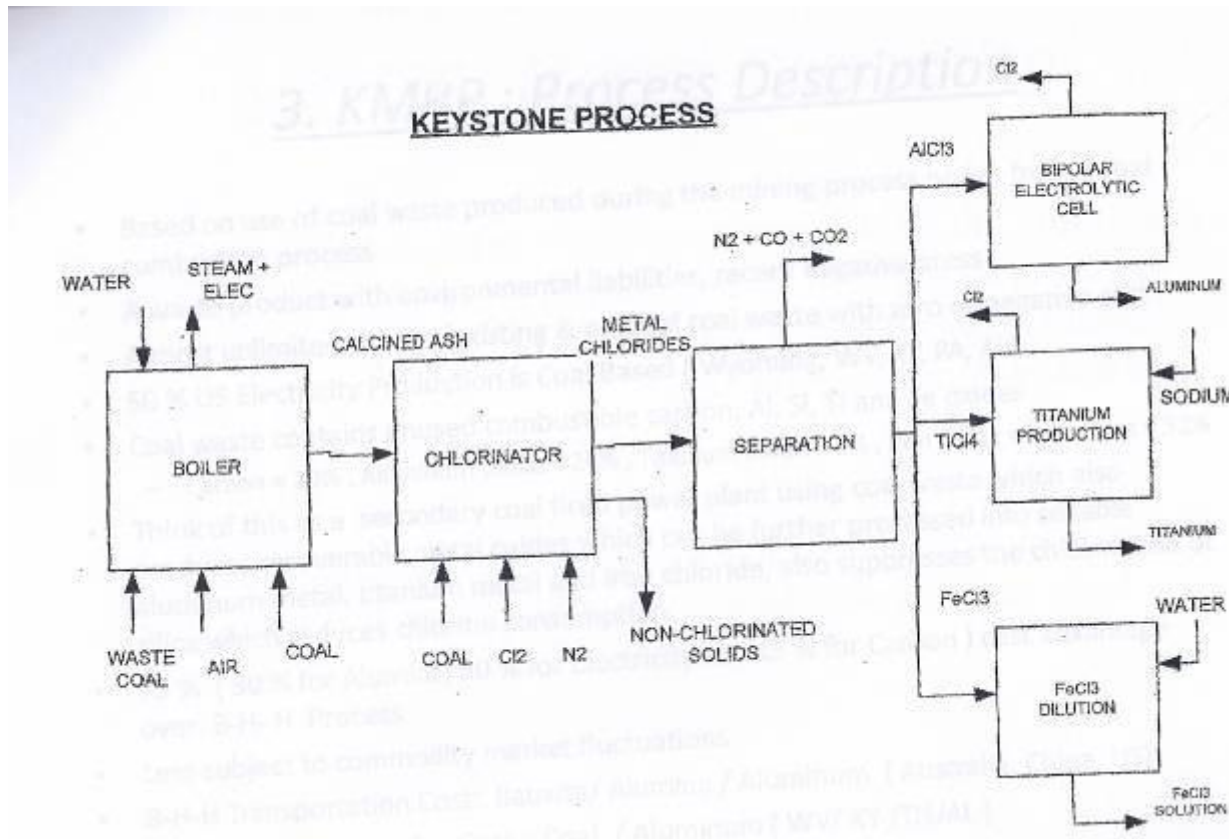
Keystone Metals Recovery, Inc

Process for recovering Metals from Coal Ash

- Keystone has successfully tested the chlorination and recovery steps in the lab
- Keystone is attempting to secure funding for a 50 tpd pilot plant which will generate excess electricity for the grid and have a profit of \$2 million per year.
- Keystone would then scale up to a 1,000 tpd plant with a three year payback from the Al and the Ti sales only.

Keystone Metals Recovery

to chlorinate ash and recover valuable AL, Ti, Fe, and other heavy metals.



Elixsys



Patented and patent pending hydrometallurgical process using a chloride leach solution on fly ash to produce

- Zeolites
- Slow release fertilizers
- concentrated metal chloride solution that can be sent off-site for further extraction of high value metals.

“The Time has come to Mine and Refine Coal Ash”

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KEYWORDS: coal ash refining, aluminum, bauxite,

ABSTRACT

Under pressure from the EPA to classify coal combustion residuals (CCR) as a “special waste”, it may finally be time to refine and mine coal ash for the valuable minerals in the coal like Aluminum, titanium, iron, pyrite, feldspar, quartz, pozzolanic glass spheres, Cenospheres, spherical magnetite, etc. Processes that use hydroalkaline, chlorine, etc. extraction methods are reviewed discussed as possible coal ash mining and refining process.

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