Coal Combustion By-Products
Opportunities in fly ash trade and utilisation

- Coal miners
- Coal power producers
- Shipping firms
- Construction material manufacturers
- Policy makers – Environment, Land Use, Infrastructure, Housing
## Contents

**Introduction**
- Optimus Management Limited
- Asian Coal Ash Association

**Fly ash: Pollution**

**Fly ash: Resource**
- Commoditisation
- Utilisation

**Supply and Demand vs Geography**
- China
- USA

**International Trade**
- Supply/Demand vs Cost
- Logistics
- Quality

**Emerging higher-value technologies**
- Vecor Limited
- CeraTech Inc.
**Optimus Management**

**www.optimusml.com**

- Private firm based in Hong Kong, incorporated in 2008
- Offices in Beijing, Sydney and Hong Kong

**Clients**
- Coal power stations
- Technology developers
- Construction material manufacturers
- Governments

**Services**
- Procurement of raw materials and equipment
- Technology development and commercialisation
- Financial advisory
- Strategy and Policy Advisory
Asian Coal Ash Association
www.asiancoalash.org

Mission:
- To facilitate academic and commercial knowledge, collaboration through research, events and media.

Incorporated
- Founded in 2010 as a not-for-profit trade association
- Australia, ACN 147031230

Offices and Operations
- Sydney, Australia
- Beijing, China
- Indonesia: PT. Tirta Samudera Caraka
  - Cato.Nordskog@tirtasamudera.com

Member of the World Wide Coal Combustion Products Network
- 11 countries/regions
- www.wwccpn.net
FLY ASH: Pollution

Soil, Water and Air

- Fly ash >75% of CCP’s
- One of the largest sources of solid waste globally
- Leaching of heavy metals into soil and water
- Particulate matter in Beijing/Shanghai PM 2.5 (15 – 35% fly ash)

Fly ash landfill per year (2015)

<table>
<thead>
<tr>
<th>Country</th>
<th>Tons per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>300 million</td>
</tr>
<tr>
<td>USA</td>
<td>70 million</td>
</tr>
<tr>
<td>India</td>
<td>100 million</td>
</tr>
<tr>
<td>Europe</td>
<td>100 million</td>
</tr>
</tbody>
</table>

Adding >600 million tons per year
FLY ASH: A RESOURCE

- **Abundant**
  - >600 million tons of surplus globally each year
  - ~3 billion tons stockpiled in landfill

- **Versatile**
  - Similar to a once-fired ceramic powder, fine (D50 <45um)
  - Useful in a broad range of high volume and high value applications

- **Safe when used responsibly – US, Europe, Australia**
  - Humans
    - US Geological Survey
    - US Environmental Protection Agency
  - Ecosystems
    - European Comm’s Scientific Committee on Toxicology, Ecotoxicology
    - Australian Government agencies

- **Superior**
  - Technical Performance
  - Environmental impact (lower energy, less virgin materials)
  - Improved profitability for producers and users

Collection is >99.8% efficient when used properly
Commoditisation

- Not all ash is equal
  - As with coal, chemistry and ‘quality’ vary
  - ‘Quality’ depends on application

- HS Code:
  - Fly ash HS 26219000
  - Fly ash bricks and blocks, ceramic articles HS 6902

- Standards for use of fly ash in construction materials (cement)
  - US – ASTM C618
  - Europe – EN 197, EN 450
  - Australia/NZ – AS/NZS 3582
  - India – IS 3812
  - China – GB/T 1596
  - Japan – JIS A 6201
  - Thailand- EIT 1014
  - Proposed global system
Mature fly ash utilisation

- Cement
  - About 20% fly ash can be used as replacement for Portland cement
  - Cost and environmental benefits
  - Better early strength
- Concrete bricks and blocks
  - Aerated Autoclave Concrete
- Road fill, mine fill
- Agriculture
  - Soil stabiliser
  - Barrier against desertification
Aerated Autoclave Concrete

- Low cost, low energy
- 20% weight of concrete, insulating and versatile
- Widely used in China, India, Australia and Europe (<50% market share)
- Global market potential 100’s of millions of tons, growing 7%/yr
Autoclave

Technology since 1930’s

Portland cement, lime and fly ash

Contains 30 - 70% fly ash

Lower energy bricks and blocks vs. brick kiln @1150C

Cured in autoclaves at 50 - 190C
International trade

Currently
- Cross border trade >100 million USD per year
- Est. 5-10 million tons per year

Trends
- Growing demand for Supplementary cementitious materials
  - Less carbon
  - Less capex
  - Greater performance benefits
- Fall in local supply in high demand, strong growth markets
- Unable to use local supply in regions of high production
- Est international trade opportunity
  - 50 - 100 million tons/year (2015-2020 outlook)

Importers in:
- US, Oceania, Middle East, UK
CHINA
Supply and Demand vs Geography

- East coast urban development
  - Beijing, Shanghai, Guangzhou, Shenzhen
- Production shifted further west:
  - Closer to coal resources
  - Further from key metropolitan centers
- Fall in domestic import demand
  - Slow down in construction
  - Some additional supply (BJ)
- Increasing cost of landfill
  - Greater scrutiny
  - ~4USD per ton

Utilisation rates (2014):
- <30%
- 40-80%
- >80%
- >100%

Maps showing locations of Beijing, Shanghai, Guangzhou, Shenzhen, Yangtze River Delta, Pearl River Delta, Bohai Rim, Tianjin, Chengdu, Chongqing, Wuhan, and Shuozhou.
USA
Supply and Demand vs Geography

West coast
• Few power plants
• Distance from east
• Rocky mountains

California
• No power plants
• 5 million tpa demand for fly ash

Imports
• From China/India
• Indonesia?
Challenges: Infrastructure capacity and ROI

Origin
- Transportation method available/compliant?
  - Covered truck
  - Tanker truck
  - Rail tanker

Export
- Capacity to load 10K – 50K ton ships
- Investment required?
- ROI

Import
- Capacity to unload 10K – 50K ton ships
- Investment required?
- ROI
Logistics Costs and Viability

- **Distance covered**
  - By truck, rail, ship

- **Number of transfers**
  - From truck to rail, etc.

- **Volumes shipped**
  - 10K, 30K bulk vessel
  - Frequency of shipment

- **Value of Cargo**
  - Ash characteristics of particular value
  - High aluminum
  - High calcium (CeraTech)

- **Shipping prices**
  - Currently 10 yr low
  - Opportunity to lock in low prices
Resource-efficient minerals

- Substitute for virgin minerals
  - Replaces intensive extraction processes
  - Enables more energy efficient production process

- Similar in chemistry to clay
  - Aluminum, Si, Fe, CaO, MgO, TiO₂
  - Rare Earth Elements

Game changing technologies

www.ceratechinc.com
Zero carbon high performance cement

www.vecor.com
High performance ceramics
CERATECH Inc

- ‘Zero carbon’ cement
  - No cement kiln required
  - Just fly ash (95%) and organic additives (5%)

- Very durable concrete:
  - Lasts 2-4 times longer than portland
  - Uses half the water

- Customers since 2007 include:
  - Port of Savannah
  - Shell Oil
  - US Military
  - Chemical processing
  - Wastewater infrastructure
  - Departments of Transport
Key Performance Attributes & Benefits

- Exceptionally dense, crystalline matrix
  - Inhibits transportation of liquids
  - Reduced chloride penetration
  - Reduced steel rebar corrosion

- Very low water to cement ratio (0.18 - 0.22)
  - Lower permeability = Enhanced durability
  - Reduced propensity for cracking

- Low vapor transmission
  - Allows for expedited placement of flooring systems
Utilizes existing infrastructure

The CERATECH cement system utilizes existing ready mix infrastructure

- **Batching**
- **Delivery**
- **Pumping**
- **Placement**
- **Finishing**
Vecor Limited

Industrial grade ceramics
- Sintered bricks and pavers
- Aggregates
- Engineered sands
- Refractories

Ceramic tiles
- 20% less production cost
- 40-80% recycled content
- 30-40% less energy
- 80% less water
- Very strong and durable

Pilot commercial factory in China
6 patent families developed in-house, in collaboration with universities, engineering firms and industrial partners.
Emerging Applications

- Polymer matrix
  - Flooring
  - Furniture
- Metal matrix
  - Aluminium and Magnesium
  - Automotive components
- Geopolymers
  - Low carbon cements
  - Alkali activated cements
  - Blocks, pre-fab, road construction
Summary
Fly ash: A global opportunity

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- Ecosystems
- US, Europe, Australia

Superior alternative
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- Environmental
- Profitability

Global Demand for recycled materials
- USA
- China
- India
- Middle East
- Australia
- Europe

Summary
Fly ash: A global opportunity