Coal Combustion Products and the Circular Economy

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The Circular Economy

- Continual re-valuation of already extracted resource chains
- Rethinking value
  - unlocking synergies
  - comprehensive accounting
- Imitate natural cycles as closely as possible

Understanding eco-systemic metabolisms leading to an abundance of flows.

Circular Economy is about finding new pockets of growth within our environmental boundaries.
Scope/Limitations

This talk focuses on:

- Coal Combustion Products
- Material flows
- Eco-Industrial Parks
- Industrial synergies and new technologies
- China
- India

Important but under-represented herein:

- Energy, Water, Social aspects of CE
- Measurement (e.g., Material Circularity Index)
- Design of materials and products to flow in effective cycles
- Other regions
- Other concepts?

Global resource consumption: Reaching crisis levels

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Waste Generated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Industrial Solid Waste)</td>
<td>3.2 Billion mT</td>
<td>2.5 Billion mT</td>
</tr>
<tr>
<td><strong>Waste Recovered</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Recycling, composting, incineration or reuse)</td>
<td>2.0 Billion mT</td>
<td>1.0 Billion mT</td>
</tr>
<tr>
<td><strong>Net Surplus</strong></td>
<td>1.2 Billion mT</td>
<td>1.5 Billion mT</td>
</tr>
<tr>
<td><strong>Population</strong></td>
<td>1.5 Billion</td>
<td>0.5 Billion</td>
</tr>
<tr>
<td><strong>Net Waste Intensity</strong></td>
<td>0.8mT/person</td>
<td>3mT/person</td>
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</tbody>
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Coal Combustion Products and the Circular Economy

Circular Economy and Stability

Social
- China has also seen an increasing number of protests by local residents over environmental problems (chemical plants, waste-incineration projects, etc) in recent years.

Geopolitical
- Risks could soar as China becomes more dependent on imported resources from unstable parts of the world.

Economic
- Fuels and minerals accounted for 30% of the total cost of China’s imports in 2012, compared with just over 5% in 1990.

Brief History of CE in China

1990’s
- China followed Germany & Japan in adopting circular economy concept

2002
- ‘Circular economy’ formally legislated as national endeavour in 2002 (16th People’s Congress)

2013
- Circular Economy Development Strategies Action Plan
  - Outlines targets meant to address both industrial and social sectors.

Present
- Leading the world in cleantech investment and promoting the recirculation of waste materials through:
  - Setting clear targets
  - Adopting policies and financial measures:
    - In 2008 the Standing Committee of the 11th National People’s Congress (NPC) formalized aspects of the Circular Economy concept in a Circular Economy Promotion Law.
    - Under the law any new industrial policies created by the Government must meet the criteria for promoting a circular economy. Industries must implement management systems that reduce resource usage and waste generation, while improving resource recovery and recycling.
  - Enacting legislation
Stated Circular Economy Goals

2015 goals:
- having a widely used resource recycling technology that is advanced, re-using 72% of industrial solid waste
- a modern system for recovering at least 70% of waste products
- improving the recovery of important resources.
  - raising energy productivity by 18.5%
  - increasing water productivity by 43%
- aiding the recycling industry to reach US $276 billion of output
- re-using 70% of some minerals that are heavy pollutants.

2020 goals:
- having an innovative industrial technological system that can efficiently re-use and recycle material
- creation of a new industry related to the manufacturing of innovative technical equipment that promotes competitive advantages.
- The advanced industrial technological systems should be able to address the waste management concerns of rural and urban areas by 2020.

Levels of circular economies

- **Societal level initiatives**
  - Development of Eco-cities and Eco-provinces
  - Aims to address social concerns with both production and consumption of products that pollute.

- **Inter-firm initiatives**
  - Eco-industrial parks (EIPs), where industrial plants are constructed in close proximity and capitalize on the trading of industrial by-products, ultimately reducing waste.

- **Corporate level implementation**
  - Refers to initiatives related to the Eco-design of manufacturing plants, such as cleaner production and Environmental Management Systems (EMS) that are meant to reduce the production of harmful by-products.
Key Mechanism: Eco-Industrial Park

- Collaborative strategies include:
  - by-product synergy ("waste-to-feed" exchanges)
  - wastewater cascading
  - shared logistics, shipping & receiving facilities
  - shared parking
  - green technology purchasing blocks
  - multi-partner green building retrofit
  - district energy systems
  - local education & resource centres.
- Systems approach
  - designs and processes/activities are integrated to address multiple objectives.

Eco-Industrial Park
A community of manufacturing and service businesses, located together on a common property where members seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues.

Kalundborg Eco-Industrial Park

- One of the best known examples of industrial ecology.
- Inspiration for China EIP's
- 7 key partners
- CO2 reduction 275,000 tpa
- 20-60 million euros pa
- Payback on capital in ~7 years

CHINA SCALE
Suzhou Industrial Park
- 288 square kilometers
- 25,000 companies
- 91 Fortune 500 companies
- GDP of ~US$35 Billion
- From eco-park to eco-city
Coal Plant: Points for CE Optimisation

- **Coal Supply**
  - Higher grade coal
  - Coal washing
  - Coal blending

- **Coal Additives**
  - Increase burn efficiency
  - Decrease NOx, SOx
  - Improve by-products

- **Coal Mill**
  - Finer milling
  - Mill efficiency

- **Boiler**
  - Air flow
  - Efficiency
  - Waste heat use

- **Water**
  - Efficiency
  - Recycling

- **Steam**
  - Waste steam use

- **Precipitators**
  - Efficiency
  - Segregation of size fractions

- **Stack**
  - PM, NOx/SOx capture
  - Carbon capture and utilisation

- **Storage**
  - Segregation of materials
  - In-line classification
  - Design for recovery

- **FGD System**
  - Efficiency
  - Material quality for use downstream
**Mineral Composition**

<table>
<thead>
<tr>
<th>Base Fly Ash</th>
<th>Calcium Enhanced Fly Ash</th>
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<tbody>
<tr>
<td>Wollastonite</td>
<td>0,6%</td>
</tr>
<tr>
<td>Krotite</td>
<td>1,2%</td>
</tr>
<tr>
<td>Albite</td>
<td>1,7%</td>
</tr>
<tr>
<td>Hematite</td>
<td>3,7%</td>
</tr>
<tr>
<td>Lime</td>
<td>5,9%</td>
</tr>
<tr>
<td>Corundum</td>
<td>14,8%</td>
</tr>
<tr>
<td>Quartz</td>
<td>29,3%</td>
</tr>
<tr>
<td>Mullite</td>
<td>42,7%</td>
</tr>
</tbody>
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Designing CCP Eco-industrial Park
Stage 1: Technical/Operational Overview

1) Plant technical information
   • a. Specifications of each individual boiler
   • b. Ash production volumes by boiler
   • c. Schematic of ash collection and storage systems
   • d. Coal resource information

2) Current production analysis
   • a. Fly ash chemical and physical composition analysis
     • i. Samples to be sent to affiliated labs for testing and interpretation
     • b. Fly ash production, collection, storage and processing analysis

3) Regulatory analysis
   • a. Material handling requirements
   • b. Transportation restrictions/requirements
   • c. Storage requirements/standards
   • d. Building material standards

4) Logistics infrastructure appraisal, storage and loading/unloading via:
   • a. Truck
   • b. Rail
   • c. Port

5) Export opportunity analysis
   • a. Run of station ash
   • b. Fine ash (classified ash)
   • c. Beneficiated ash products

6) Technically viable value added opportunities
   • a. Preliminary technical viability assessment:
     • i. ash analysis
     • ii. logistics infrastructure
     • iii. regulatory analysis

Designing CCP Eco-industrial Park
Stage 2: Commercial/Technical Feasibility

1) Financial overview
   • a. Capital requirements/availability
   • b. Financial performance targets

2) Resource overview
   • a. Land requirements/availability
   • b. Equipment inputs
   • c. Raw material inputs
   • d. Skilled labor

3) Industrial ecosystem analysis
   • a. Other local producers or users whose products or by-products (waste streams) may have synergy with prospective technologies.

4) Addressable market analysis
   • a. Study of addressable markets (domestic and export) for specific products/price points.
   • b. Get real market feedback from potential customers, samples, trial orders, etc.

5) Shortlist of technologies/opportunities that correlate with parameters
Barriers to CE adoption

**Financial**
- Motivating producers and downstream industries to support the circular economy

**Regulatory**
- Supporting “materials management” and monitoring

**Markets**
- Improving commodity markets for secondary raw materials

**Information**
- Data & information systems
- Models and algorithms

**Knowledge**
- Best practice and skills exchange

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**New Frontier: India**

**Supply**
- CCP’s to reach between 150 million and 900 million tpa by 2040

**Demand**
- Indian construction sector poised to become 3rd largest globally.
- Already > 8% of GDP, construction accounts for about 20% of total material demand.
- Affordable housing shortage to reach 38 million units by 2030.
- To meet needs of rapidly urbanising population, India must build 700-900 million square metres of new commercial and residential space every year.

**Challenges**
- Highly fragmented, largely informal construction sector
- Underdeveloped downstream industries
- (Ready mix concrete uses <1% of fly ash produced in India)
- Administrative barriers and ‘red-tape’
India CCP and CE: Opportunity

Government initiatives suggest that the time is ripe for Indian cities to embrace circular economy approaches.

Government initiatives

- Accelerating investment in construction of urban infrastructure:
  - Smart Cities Mission
  - Development of industrial corridors
  - Swachh Bharat Mission
  - City renewal schemes eg. 500 AMRUT cities

US$ 1.2 trillion

- Research by the McKinsey Global Institute indicates that India needs to invest ₹77 lakh crore (US$ 1.2 trillion) in city infrastructure by 2030.
- New materials that offer economic advantages can support the provision of affordable housing, while reducing the environmental impact of extracting and processing materials, such as sand and aggregates.

Coal Combustion Products, Infrastructure & the Circular Economy

Developing infrastructure following circular economy principles can avoid getting locked into resource-ineffective systems in the long term.

As new building technologies and business models emerge and reach scale, urban planning should embrace circular economy approaches.

Circular economy opportunities will help China, India and other nations create high-quality spaces where people would live, work, and thrive.
Thank You!

Any questions or comments are welcome.

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