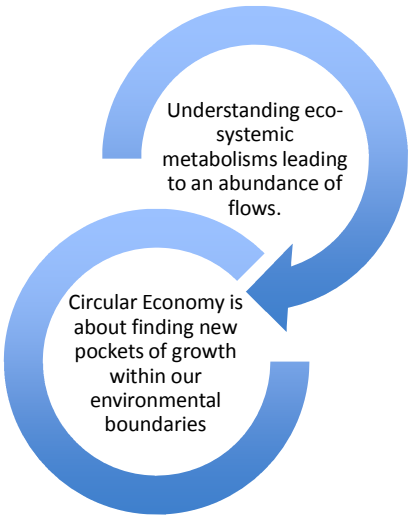
Coal Combustion Products and the Circular Economy

David Harris

Asian Coal Ash Association
Optimus Management Limited

The Circular Economy



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

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 (eg. Material Circularity Index)
- Design of materials and products to flow in effective cycles
- Other regions
- Other concepts?

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Global resource consumption: Reaching crisis levels

	China (2014)	Europe 28 (2012)
Waste Generated (Industrial Solid Waste)	3.2 Billion mT	2.5 Billion mT
Waste Recovered (Recycling, composting, incineration or reuse)	2.0 Billion mT	1.0 Billion mT
Net Surplus	1.2 Billion mT	1.5 Billion mT
Population	1.5 Billion	0.5 Billion
Net Waste Intensity	0.8mT/person	3mT/person

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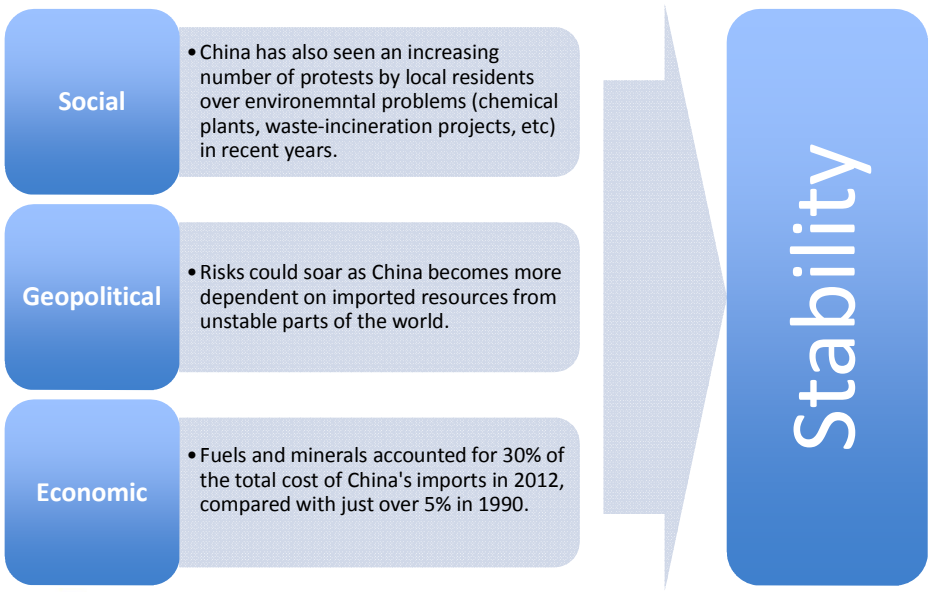
Circular Economy and Stability



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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

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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.

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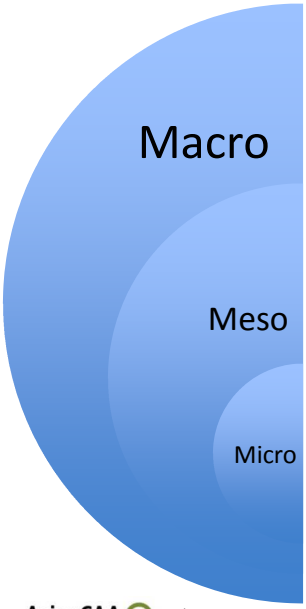
Levels of circular economies



- **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.

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Key Mechanism: Eco-Industrial Park

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.

-The Eco-industrial Park Handbook

- 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.

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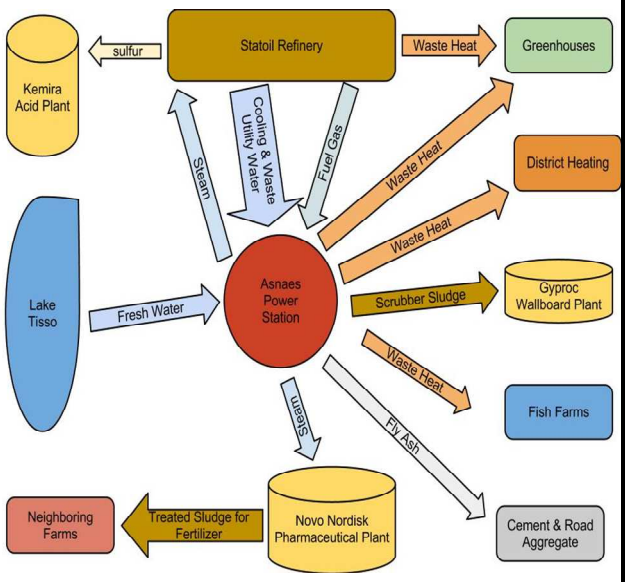
Kalundborg Eco-Industrial Park

- 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



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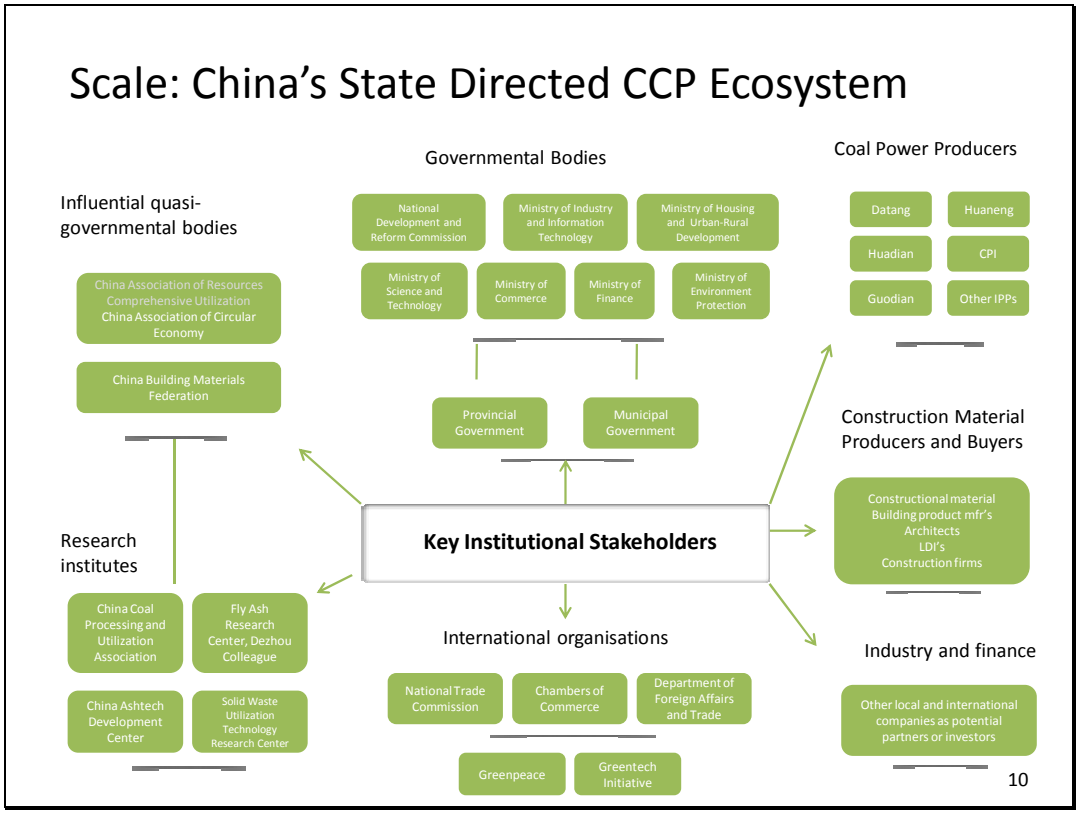
Scale: China's State Directed CCP Ecosystem
Governmental Bodies
Coal Power Producers
Influential quasi-governmental bodies
National Development and Reform Commission
Ministry of Industry and Information Technology
Ministry of Housing and Urban-Rural Development
Ministry of Science and Technology
Ministry of Commerce
Ministry of Finance
Ministry of Environment Protection
Datang
Huaneng
Huadian
CPI
Guodian
Other IPPs
China Association of Resources Comprehensive Utilization
China Association of Circular Economy
China Building Materials Federation
Provincial Government
Municipal Government
Construction Material Producers and Buyers
Constructional material
Building product mfr's
Architects
LDI's
Construction firms
Key Institutional Stakeholders
Research institutes
China Coal Processing and Utilization Association
Fly Ash Research Center, Dezhou Colleague
China Ashtech Development Center
Solid Waste Utilization Technology Research Center
International organisations
National Trade Commission
Chambers of Commerce
Department of Foreign Affairs and Trade
Greenpeace
Greentech Initiative
Industry and finance
Other local and international companies as potential partners or investors
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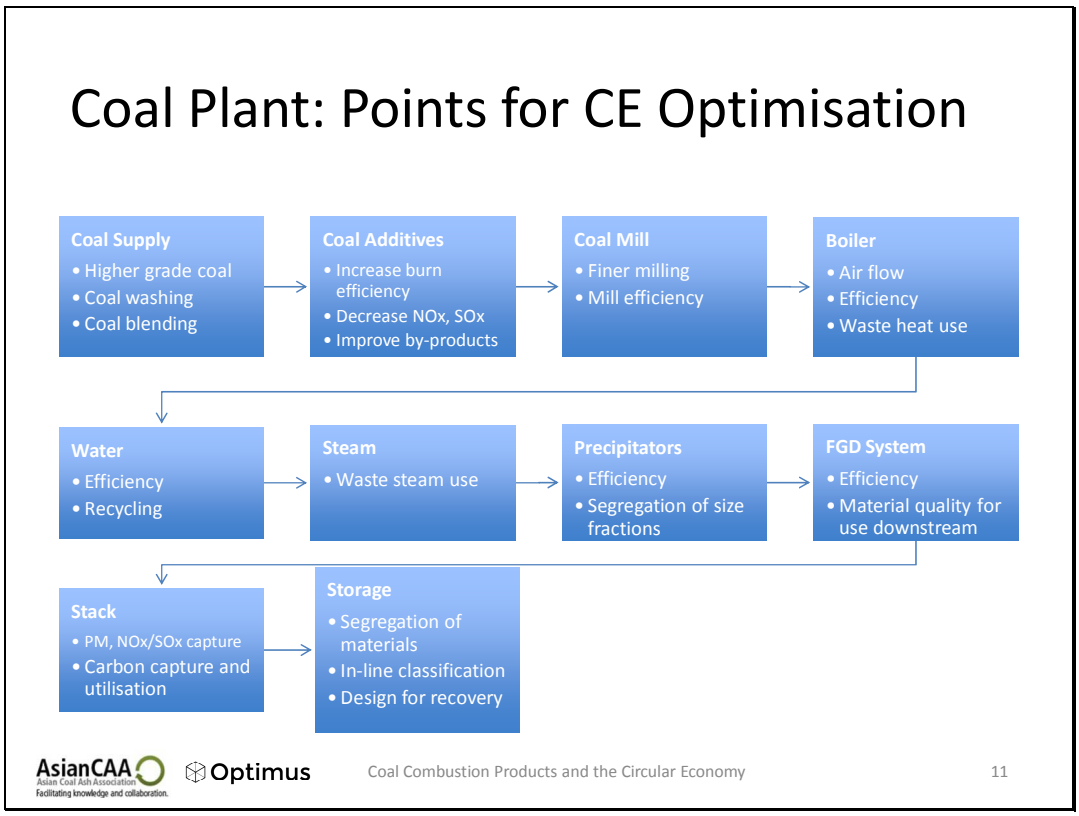
Coal Plant: Points for CE Optimisation
Coal Supply
• Higher grade coal
• Coal washing
• Coal blending
Coal Additives
• Increase burn efficiency
• Decrease NOx, SOx
• Improve by-products
Coal Mill
• Finer milling
• Mill efficiency
Boiler
• Air flow
• Efficiency
• Waste heat use
Water
• Efficiency
• Recycling
Steam
• Waste steam use
Precipitators
• Efficiency
• Segregation of size fractions
FGD System
• Efficiency
• Material quality for use downstream
Stack
• PM, NOx/SOx capture
• Carbon capture and utilisation
Storage
• Segregation of materials
• In-line classification
• Design for recovery
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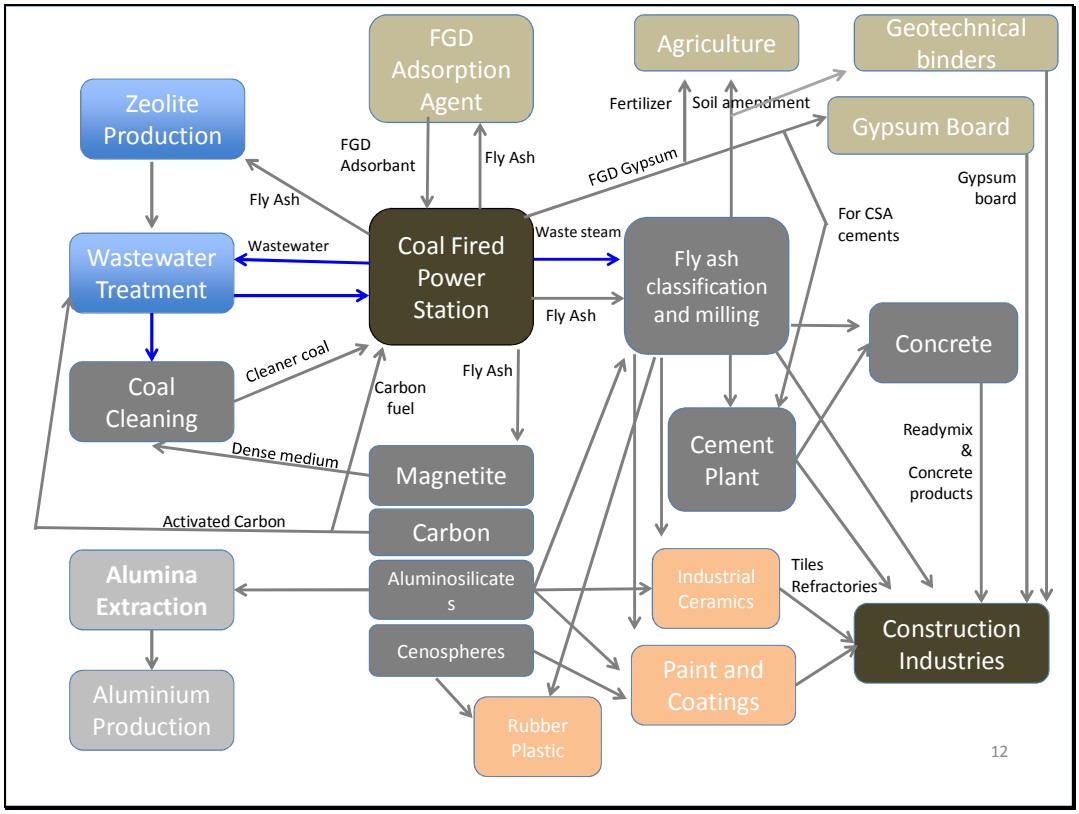
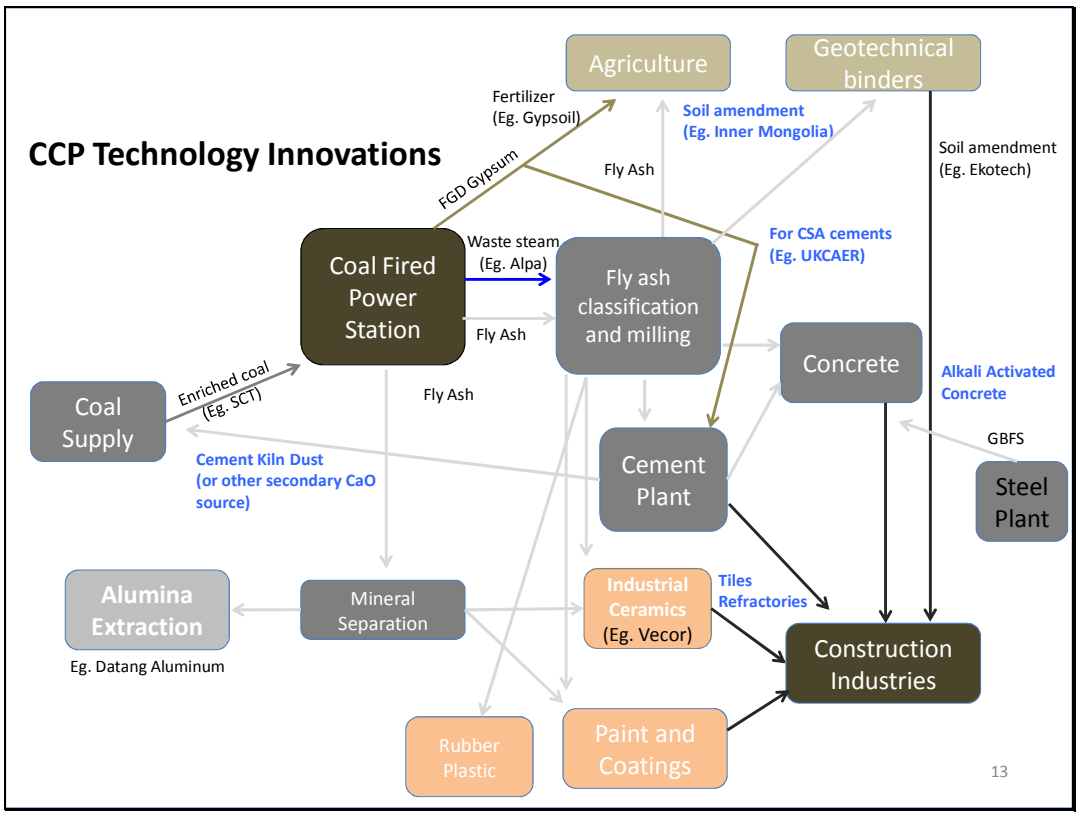

FGD Adsorption Agent
Agriculture
Geotechnical binders
Zeolite Production
Fertilizer
Soil amendment
Gypsum Board
FGD Adsorbant
Fly Ash
FGD Gypsum
Gypsum board
Fly Ash
For CSA cements
Wastewater
Waste steam
Coal Fired Power Station
Fly ash classification and milling
Wastewater Treatment
Fly Ash
Concrete
Cleaner coal
Carbon fuel
Fly Ash
Coal Cleaning
Cement Plant
Readymix & Concrete products
Dense medium
Magnetite
Activated Carbon
Carbon
Alumina Extraction
Aluminosilicates
Industrial Ceramics
Tiles Refractories
Construction Industries
Cenospheres
Paint and Coatings
Aluminium Production
Rubber Plastic
12


CCP Technology Innovations
Agriculture
Geotechnical binders
Fertilizer (Eg. Gypsoil)
Soil amendment (Eg. Inner Mongolia)
Soil amendment (Eg. Ekotech)
FGD Gypsum
Fly Ash
For CSA cements (Eg. UKCAER)
Waste steam (Eg. Alpa)
Coal Fired Power Station
Fly ash classification and milling
Fly Ash
Concrete
Alkali Activated Concrete
Enriched coal (Eg. SCT)
Coal Supply
Fly Ash
GBFS
Cement Kiln Dust (or other secondary CaO source)
Cement Plant
Steel Plant
Alumina Extraction
Mineral Separation
Industrial Ceramics (Eg. Vecor)
Tiles Refractories
Eg. Datang Aluminum
Construction Industries
Rubber Plastic
Paint and Coatings
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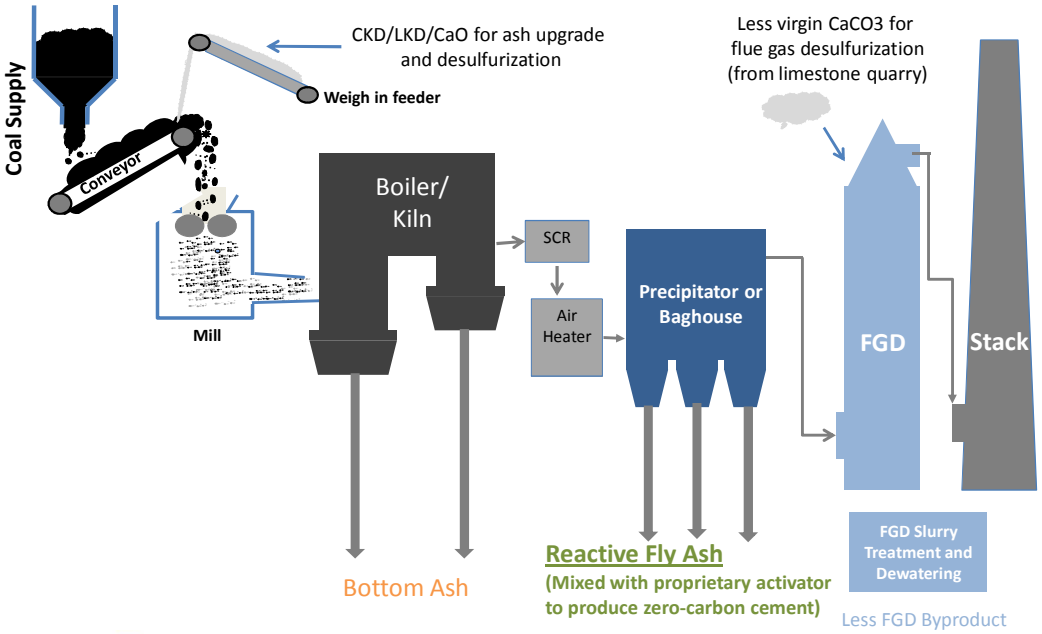
Boiler as Cement Kiln



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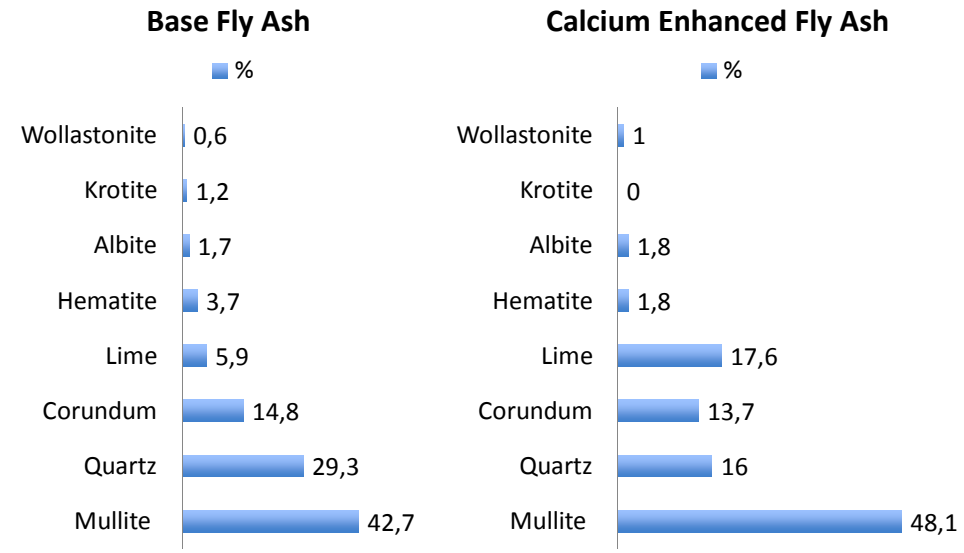
Mineral Composition



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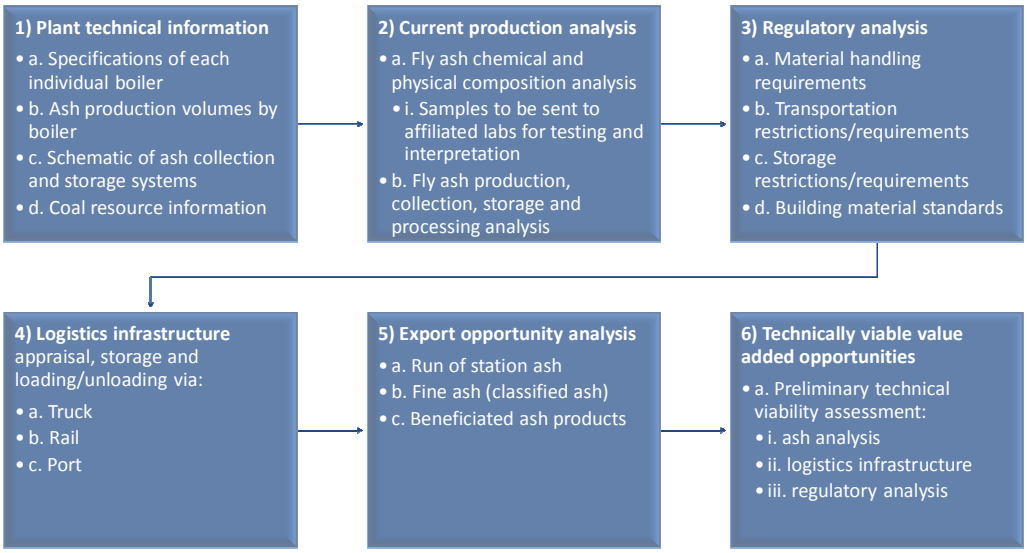
Designing CCP Eco-industrial Park
Stage 1: Technical/Operational Overview



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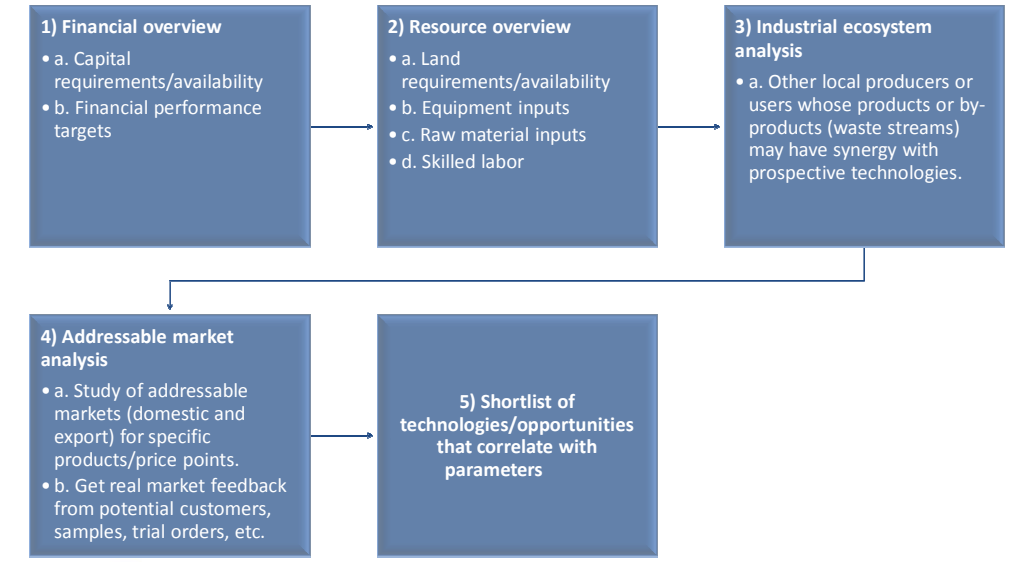
Designing CCP Eco-industrial Park
Stage 2: Commercial/Technical Feasibility



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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
  - (Readymix concrete uses <1% of fly ash produced in India)
- Administrative barriers and ‘red-tape’

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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.

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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.

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Thank You!

Any questions or comments are welcome.

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www.optimusml.com

David Harris
d.harris@asiancoalash.org

TABLE 1: METRICS IN THE STANDARD FOR SECTOR-INTEGRATED ECO-INDUSTRIAL PARKS (HJ 274-2009) AS AMENDED IN 2012

CATEGORY	METRICS		UNIT	VALUE
Economic development	1.1	IAV per capita	10⁴ RMB/P	≥ 15
Material reduction and recycling	2.1	IAV per industrial land occupancy	100 million/km²	≥ 9
	2.2	Energy consumption per IAV	tce/10⁴ RMB	≤ 0.5
	2.3	Coefficient of elasticity on energy consumption	--	< 0.6
	2.4	Fresh water consumption per IAV	m³/10⁴ RMB	≤ 9
	2.5	Coefficient of elasticity on fresh water consumption	--	< 0.55
	2.6	Industrial wastewater generation per IAV	ton/10⁴ RMB	≤ 8
	2.7	Solid waste generation per IAV	ton/10⁴ RMB	≤ 0.1
	2.8	Industrial water reuse ratio	%	≥ 75
	2.9	Solid waste reuse ratio	%	≥ 85
Pollution control	3.1	Chemical Oxygen Demand (COD) emission per IAV	kg/10⁴ yuan	≤ 1
	3.2	Coefficient of elasticity on COD emission	--	< 0.3
	3.3	Sulphur dioxide (SO_2) emission per IAV	kg/10⁴ yuan	≤ 1
	3.4	Coefficient of elasticity on SO_2 emission	--	< 0.2
	3.5	Disposal rate of hazard solid waste	%	100
	3.6	Centrally provided treatment rate of domestic wastewater	%	≥ 85
	3.7	Safe treatment rate of domestic rubbish	%	100
	3.8	Waste collection and disposal system	--	available
Administration and management	4.0	Extent of establishment of information platform	--	established
	4.1	Extent of establishment of eco-industrial information platform	%	100
	4.2	Environmental report release per year	issue/year	1
	4.3	Implementation of cleaner production audit in heavy pollution enterprises	%	100
	4.4	Extent of public satisfaction with local environmental quality	%	≥ 90
	4.5	Extent of public awareness degree with eco-industrial development	%	≥ 90