Initiatives for Optimum Utilization of Fly Ash

Fly Ash: A Material Resource for Value Addition

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Office of the Principal Scientific Adviser to the Government of India

Bhubaneswar City Knowledge Innovation Cluster (BCKIC)

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Science and Technology Clusters

Office of the Principal Scientific Adviser to the Government of India

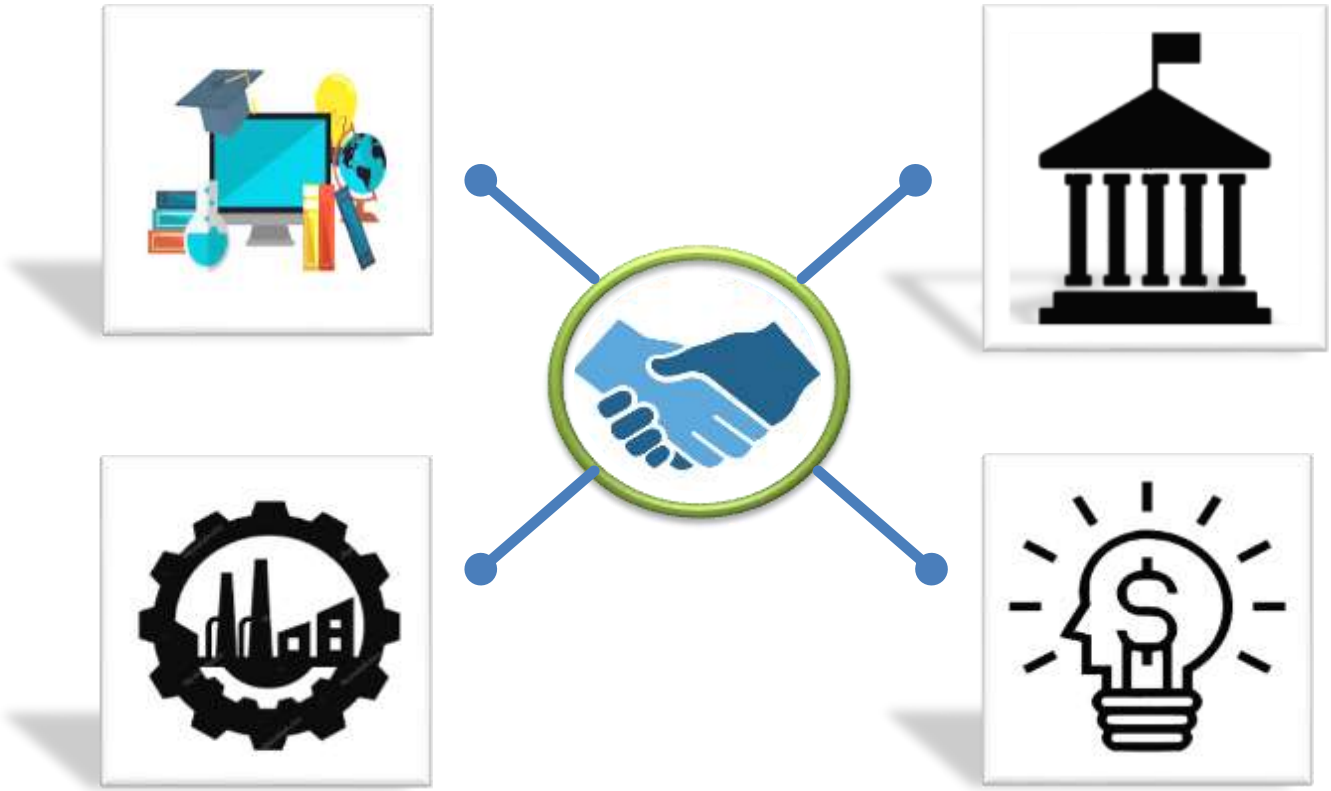
SCIENCE & TECHNOLOGY CLUSTER

Prime Minister Science, technology & innovation advisory council (PM-STIAC)

Unique Strategic Initiative by the Office of the PSA to Government of India

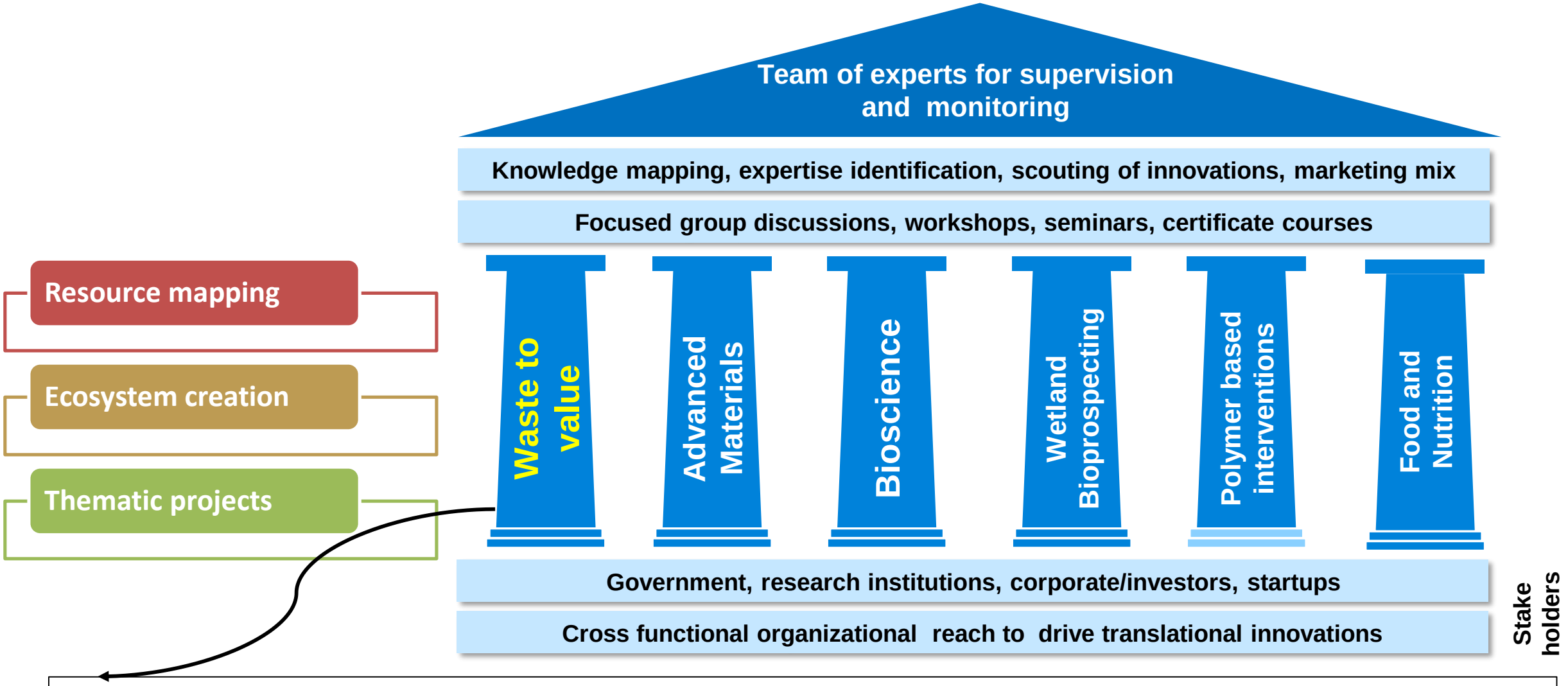
Shared Ecosystem & Cluster Partners

- Academia
- Industry
- Government
- Startups



Conversance of sectors and ideas with directional solutions

BCKIC Overview



Fly Ash: A Material Resource for Value Addition addresses the 1st Verticals

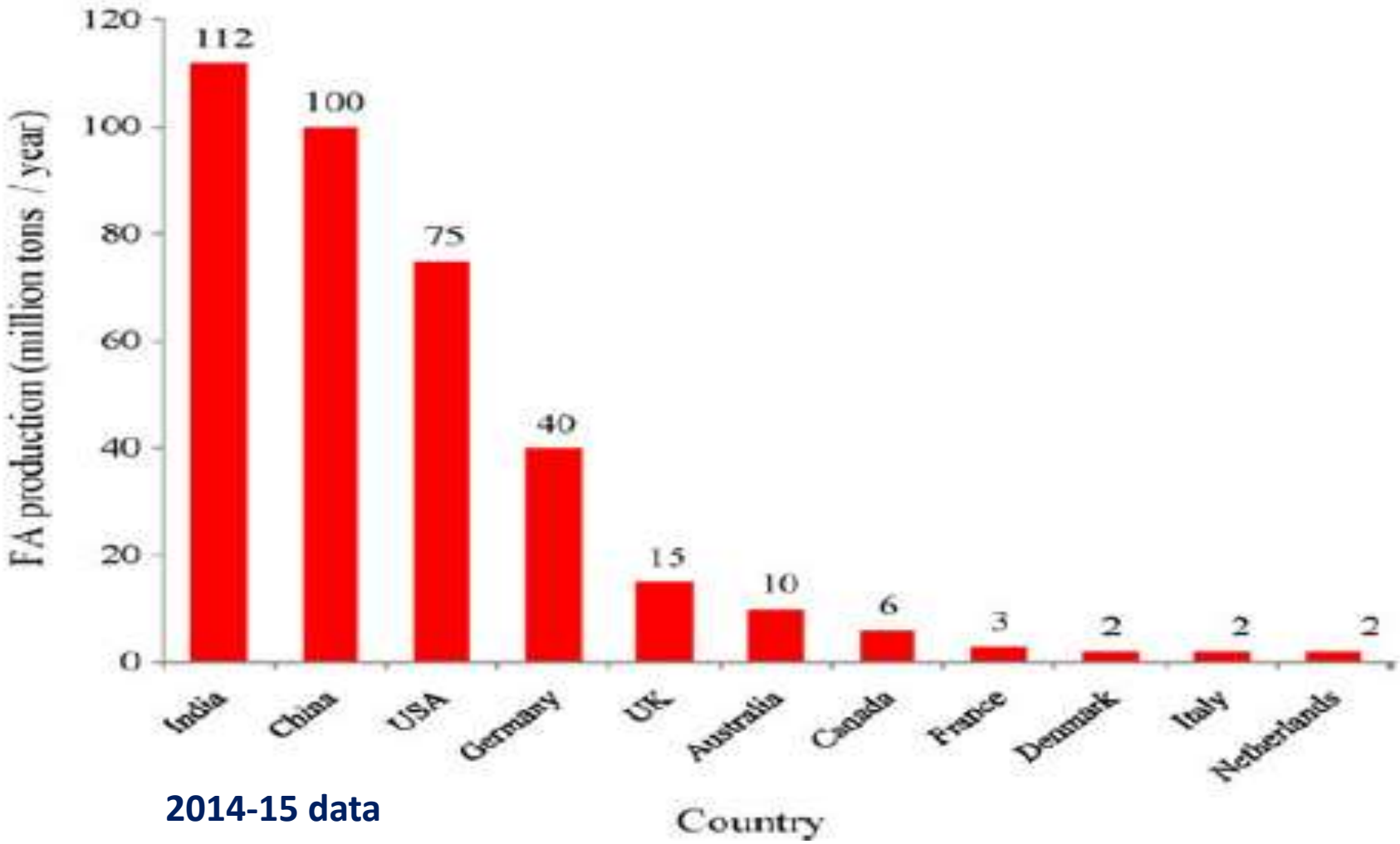
Initiatives for Optimum Utilization of Fly Ash

Fly Ash: A Material Resource for Value Addition

Content of Presentation

- Introduction
- Fly Ash- A Potential Resource
- Initiatives
- Opportunities for Optimum Utilization
- Way forward

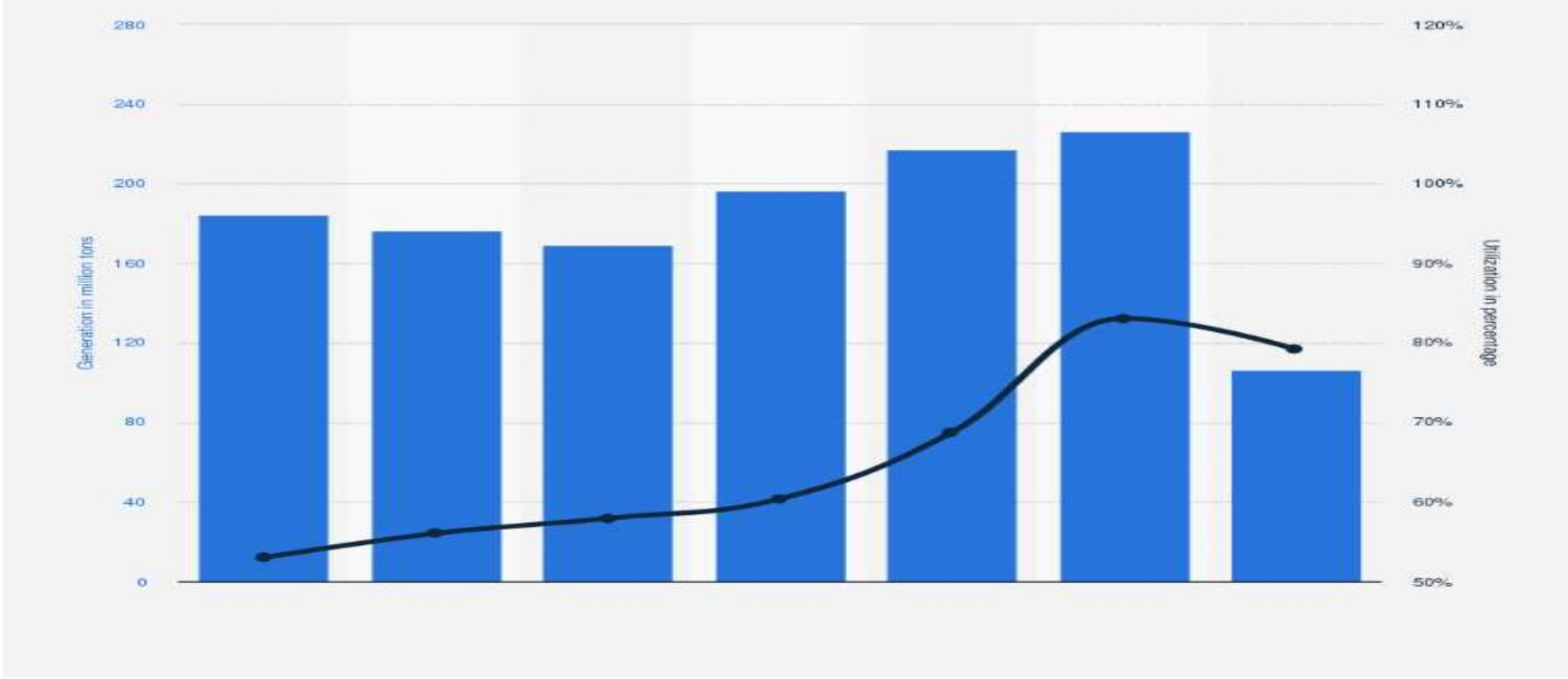
Major Fly Ash Producing Countries



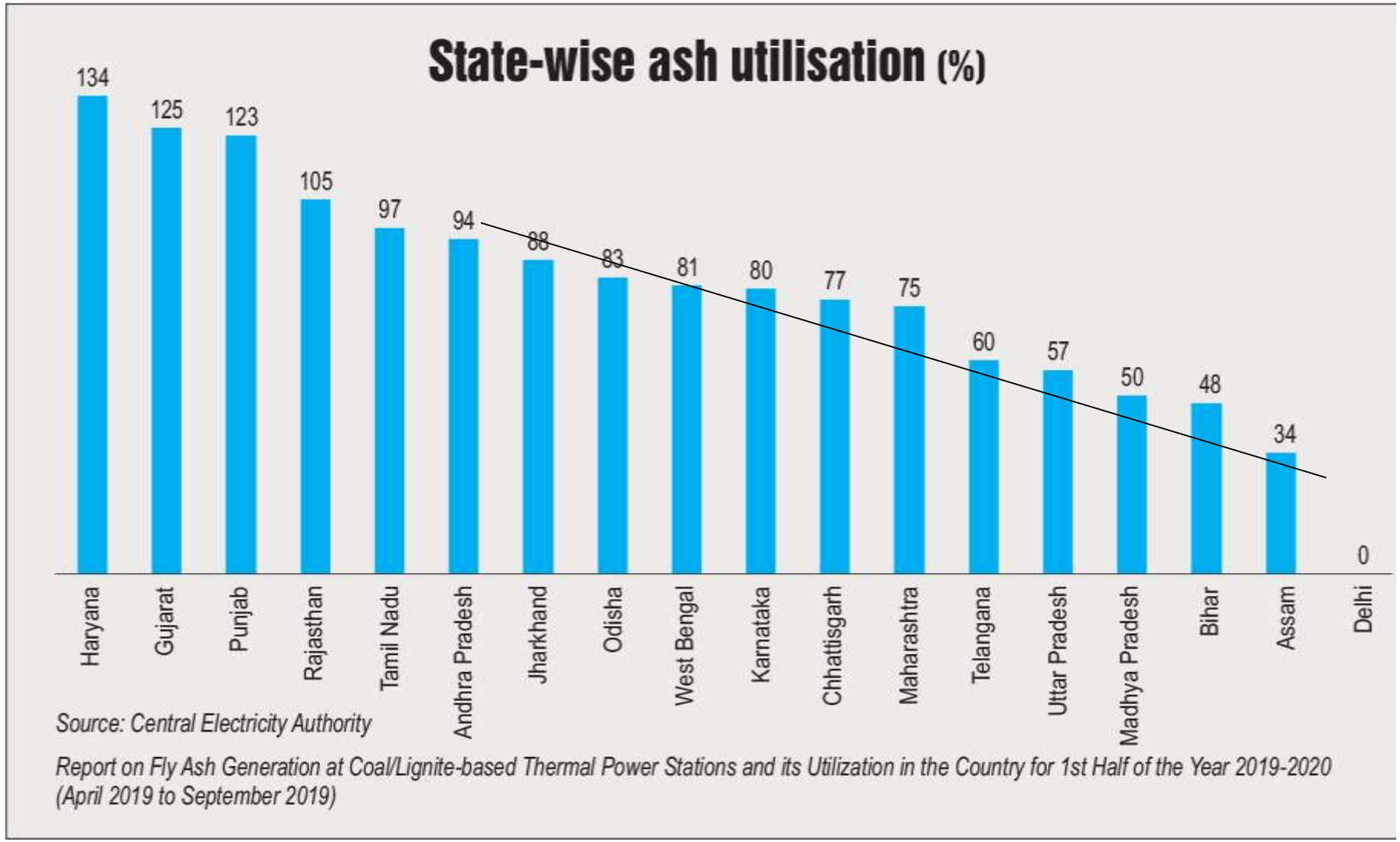
2014-15 data

Fly Ash Production & Utilization

- Over 200 million tons of Fly ash generated in India
- Utilization is about 80%
- State wise utilizations are different
- **Generation and utilization of fly ash from power stations in India (2015-2021):**



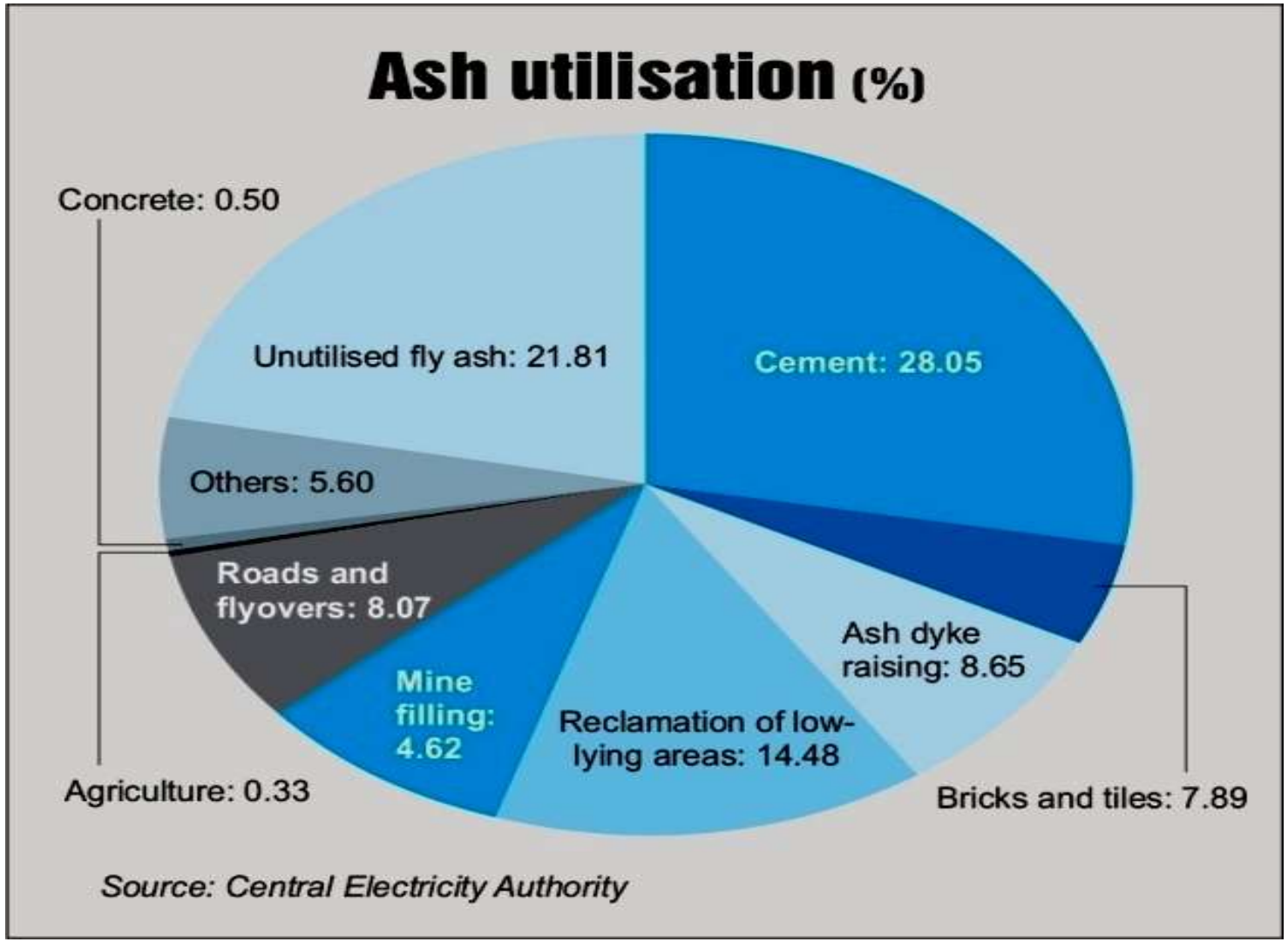
Fly Ash Utilization Logistic Dependents



Source: Central Electricity Authority

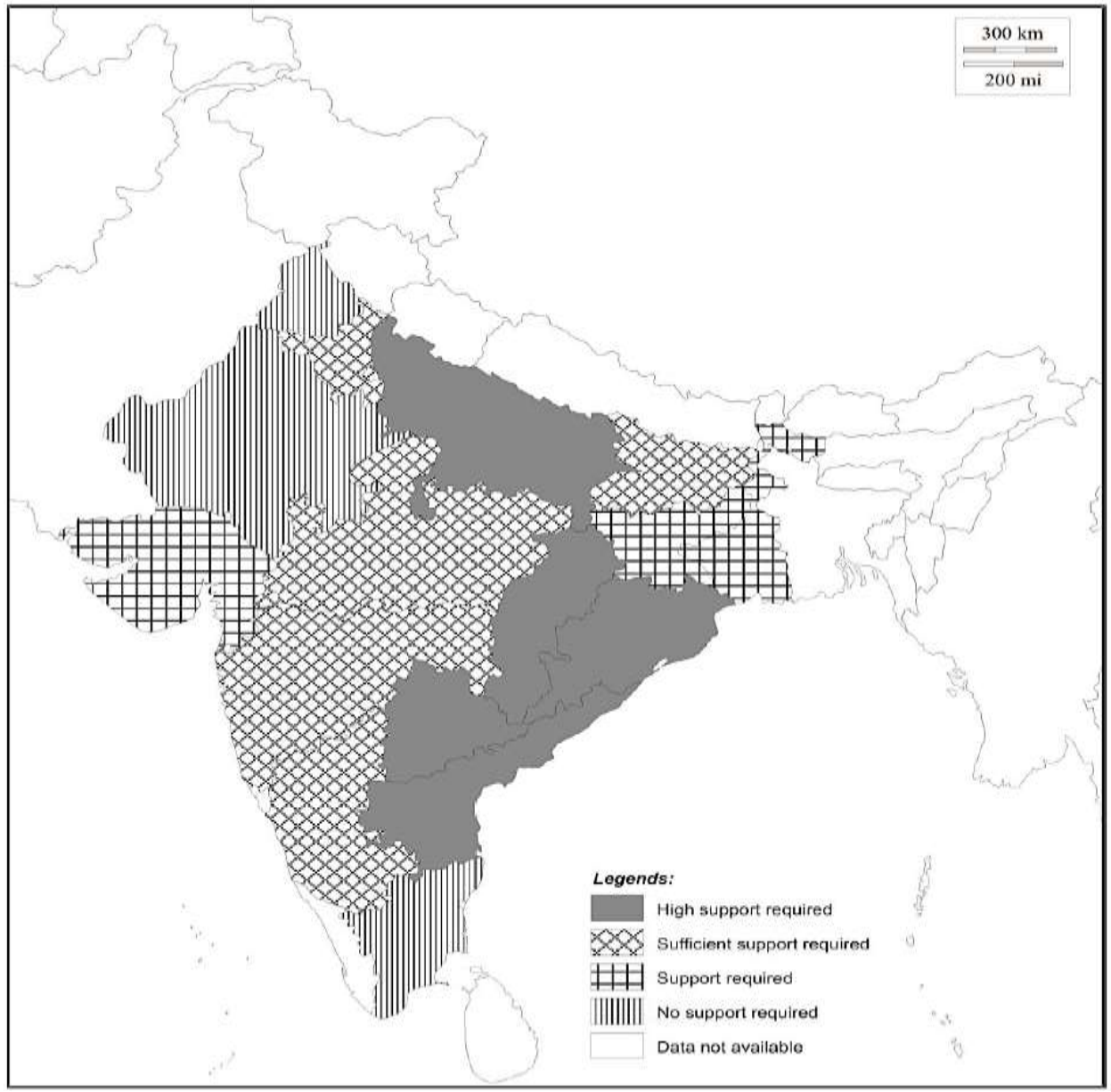
Report on Fly Ash Generation at Coal/Lignite-based Thermal Power Stations and its Utilization in the Country for 1st Half of the Year 2019-2020 (April 2019 to September 2019)

FA in Cement Industries – A Value Utilization



2020-2021

Logistics an Important Factor for Optimum Utilization



Support Required For Value based Applications

Source: International Journal of Innovative Research and Review ISSN: 2347 – 4424 (Online)

Fly ash, a Potential Resource !!!

- As of now about 20% of fly ash remains unutilized
- Out of 80% utilization, value and essential utilization is only about 35% (Cement: 28, Bricks: 7)
- It is time to work on **Value addition** & Support low utilizing states
- Need several technologies to fill in the gap!!!
- Value of metals is estimated to be of **US $ 4,500 to 46,500 per tonne of Fly Ash** at current market prices (significant value derivation from Scandium, Dysprosium, Yttrium & Aluminium etc)

**Based on analysis of ~11 global fly ash samples – Ref: Lucinda Tolhurst, Commercial Recovery of Metals from Coal Ash, 2015 World of Coal Ash (WOCA) Conference in Nashville, TN, May 5-7, 2015,www.flyash.info*

R&D Efforts for Fly Ash - Value Utilization

Many R&D Projects have been conducted on Fly Ash Utilization, Some of these are:

- Fly Ash bricks and shapes (Already commercialised)
- Fly Ash as an Admix to Cement (Already Commercialized)
- Fly Ash as a Filler in Synthetic wood (could not take-off)
- Fly Ash as an Admix to Soil for better Agriculture Products (Social issues)
- Fly Ash as a Geopolymer (Partly Commercialized has Potential)

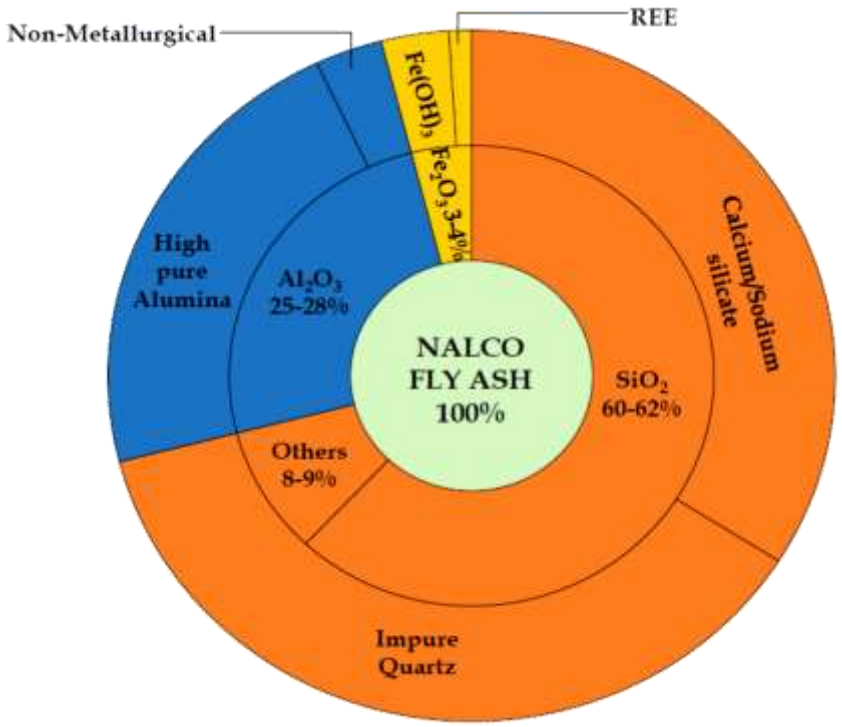
- Fly ash – as a Metallurgical Resource for Metal & Material Values
  - CSIR-IMMT & NALCO (R&D Stage)

- Wear Resistant Ceramic Tiles – Using high percentage of Fly Ash
  - IIT Kharagpur, NALCO & CSIR-IMMT(Advance Stage of R&D)

FA Based Geopolymer Concrete (GPC)

Trial Mix Geo Polymer Mortar Specimens Using Fly Ash

Extraction of Metal Values from Fly Ash



Fly ash as potential resource for Alumina & REEs (Other Products)
NALCO-CSIR-IMMT Initiatives

A pyro-hydrometallurgical process for the recovery of alumina and calcium silicate from fly ash, Indian patent: 344358; August 2020

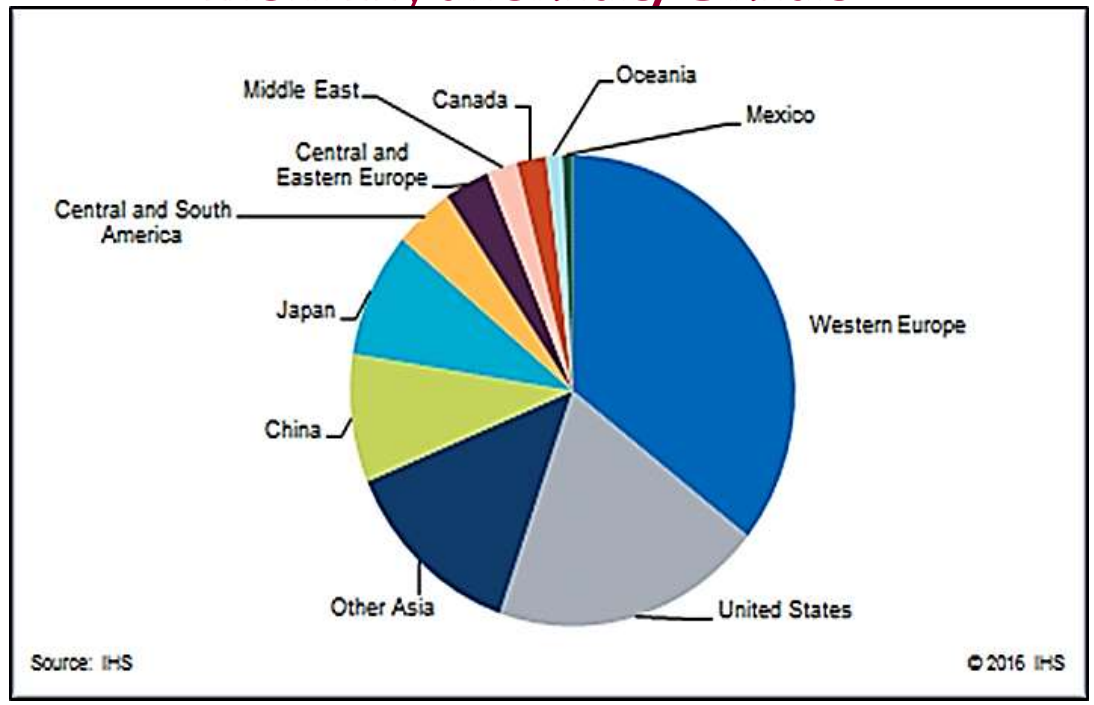
A process modification in the downstream was developed to produce metallurgical grade alumina

Metal & Material Values from Fly Ash

Alumina and ATH

Grade	Usage	Price (Rs/ton)
Metallurgical Grade	Aluminium production	25,000-30,000
Chemical Grade (ATH)	Water treatment, flame retardant, chemicals	35,000-50,000
Refractory grade	Refractory for metal and cement industry, abrasives etc	35,000-60,000

Iron Hydroxide/Oxide



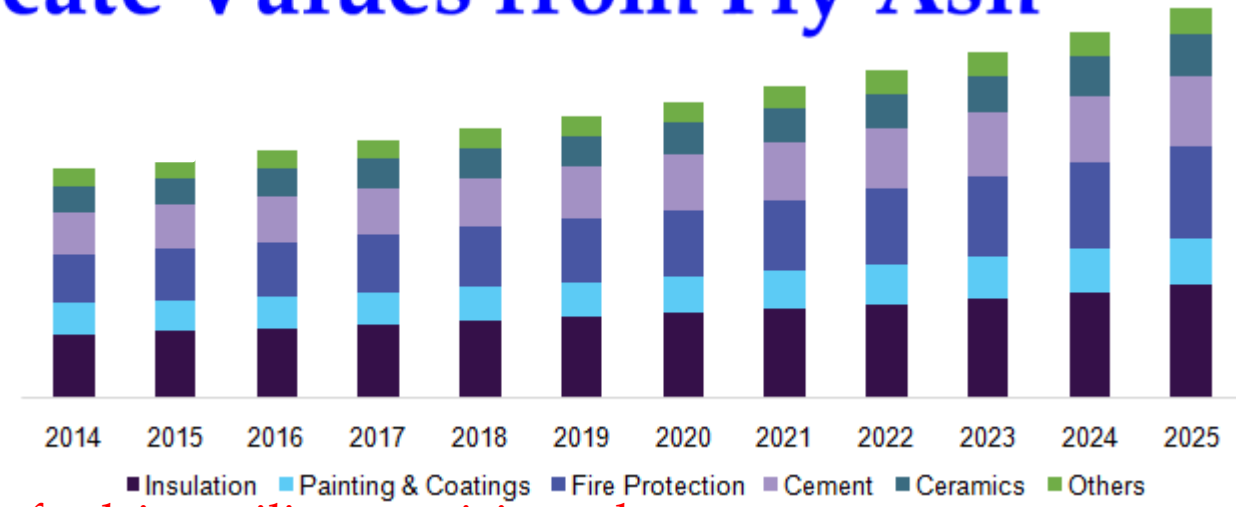
- Uses
  - Water treatment, Pharmaceutical
  - Pigments
- Consumption
  - Global consumption of iron oxide pigments: 800 kilo tons
  - Price: 50-100 Rs/kg

Source: https://international-aluminium.org/statistics/alumina-production/

Calcium Silicate Values from Fly Ash

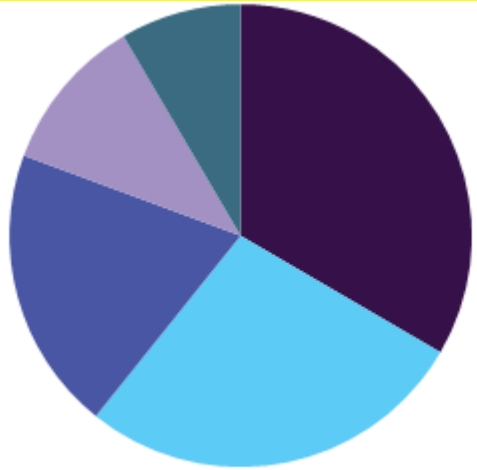
Uses

- Insulation, Paints
- Fire protection
- Cement, Ceramics



- Consumption
  - Global consumption of calcium silicate anticipated: 115 kilo tons by 2024
  - Calcium silicate price: 50-100 Rs/kg
  - Sodium silicate consumption: 2-3 million TPA

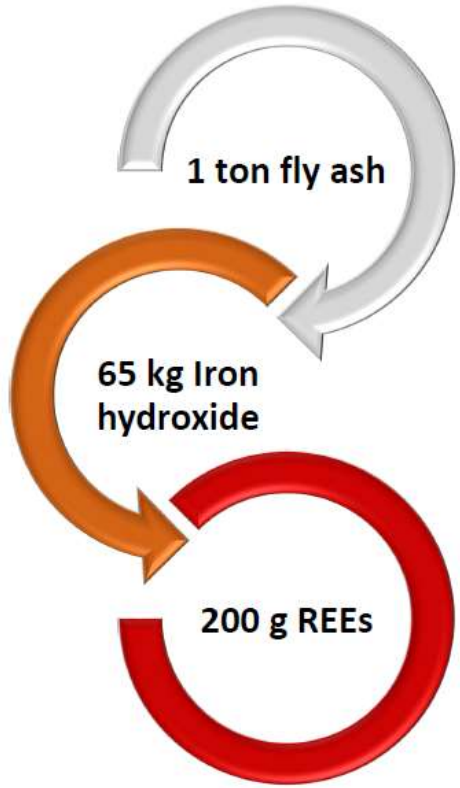
Calcium Silicate Global Demand



Scandium & Other REEs Values in Fly Ash

Typical composition

Element	NALCO Fly Ash	Hydroxide residue	Rs/g
	ppm	ppm	
Sc	15	111.4	345
Y	51	377.2	2.5
La	100	593.6	0.2
Ce	155	997	0.2
Pr	18	127.6	3.9
Nd	66	466.2	3.5
Sm	13	93.4	0.13
Eu	2.3	16.4	0.21
Gd	10	71.4	1.7
Tb	1.7	11.6	57.3
Dy	9.2	65.8	26.25
Ho	1.9	13.6	2.8
Er	5.1	36.2	
Yb	4.8	34.4	
Total	**453**	**3015.8**	



**based on 2016 feasibility report by Scandium International Mining Corp for Nyngan Sc project, Australia, with average 409 ppm Sc grade from lateritic ore including mining, high pressure leaching and other process costs which are not considered here*

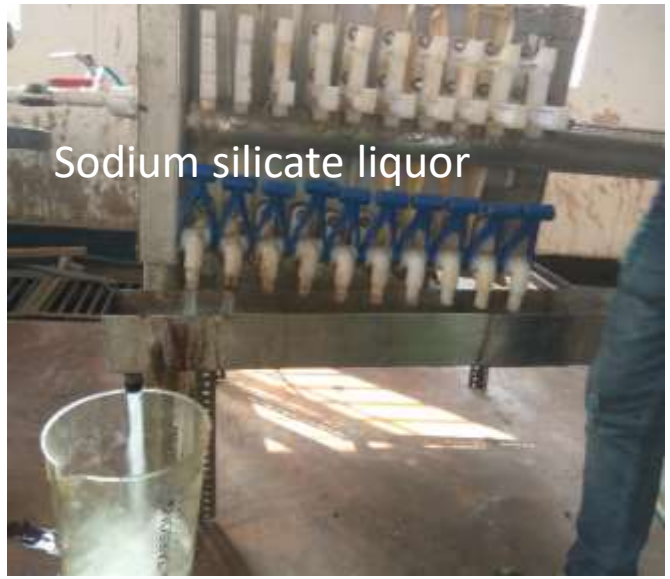
REEs in Fly Ash from different Power Plants in India

Name of thermal power station	Power generation (MWe)	Coal type	Total REE in fly ash (ppm)
Neyveli Lignite Corporation India 1	600	Lignite	1188
Neyveli Lignite Corporation India 2	1470	Lignite	2161
NTPC Ramagundam	2600	Bituminous	403
Singaneri power plant	18	Bituminous	726
Farakka Super power plant	200 x 3, 500 x 3	Bituminous	450
Heavy Water Plant - Manuguru	30 x 3	Bituminous	417
Surat Lignite Power Plant	250 x 4	Lignite	245
NALCO fly ash		Bituminous	453

Fly ash as Potential Resource for REEs

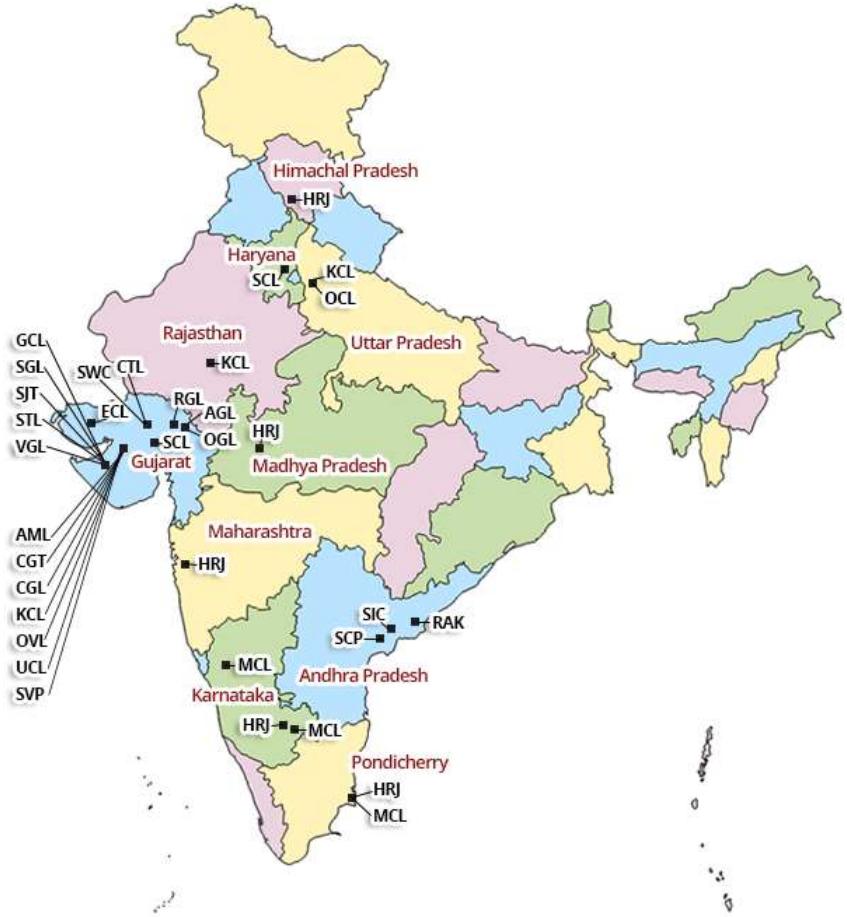
REEs demand in India 2016-17	1.86 kT
REEs unused in Fly Ash 2019-20	7.6 kT

Rao et al., Separation Science and Technology (2020)



NALCO-IMMT Process tested at Bench scale for complete Fly Ash utilization

Fly Ash Tiles Industry in India



Geographical Presence of Ceramic Tile Industries in India

State-wise production of China clay (In tonnes)

State	Year		
	2015-16	2016-17	2017-18
Gujarat	55833145	3928033	5363418
Rajasthan	2060437	2855198	2287080
Andhra Pradesh	19670	84210	107855
Telangana	90663	65149	57465
Kerala	585965	-	-
Odisha	6	-	-

Source: Indian Minerals Yearbook 2018

- Ceramic tiles industry in India: 16 - 20 million tons per annum
- Most of the tile industries are located in western India owing to availability of clay with high plasticity
- Presently, the tiles in Eastern India are being sourced from Gujarat that adds to transportation cost.
- Fly Ash attempted as a major raw material with suitable binder.

Tiles using Fly Ash – NALCO-IMMT-IIT Initiatives

Unglazed fly ash tiles – dry process

- IIT-Kharagpur, has developed a process for production of wear resistant ceramic/glazed tiles from fly ash/pond ash funded by NALCO and patent has been obtained (IN253/KOL/2012, Grant No: 287533)
- The process is dry process while standard tiles making use wet process
- Raw materials used for wall tiles: fly ash (60%), local clay (15-20%), pyrophyllite (20-25%)

Fly Ash Wall Tiles Benchmarking

The tiles produced using the NALCO fly ash through the dry process was tested through standard methods and compared with tiles available in the market

Sr. No	Property	ISO 13006/EN 14411 Group Bill	Johnson Wall Tile Value	Fly ash based tile (dry process)
1	Surface flatness	+- 0.5%	+-0.3%	+-0.25%
2	Water absorption	>10%	14-19%	14-17%
3	Flexural Strength (MOR)	> 15 N/mm^2	> 15 N/mm^2	> 15 N/mm^2
4	Crazing resistance	Required	2 cycles	4 cycles
5	Thermal shock resistance	No damage	No damage	No damage

Quality of tiles made using fly ash qualify the bench mark

FA Tiles Trial Manufacturing

Dry Pressing

Conveyor to firing

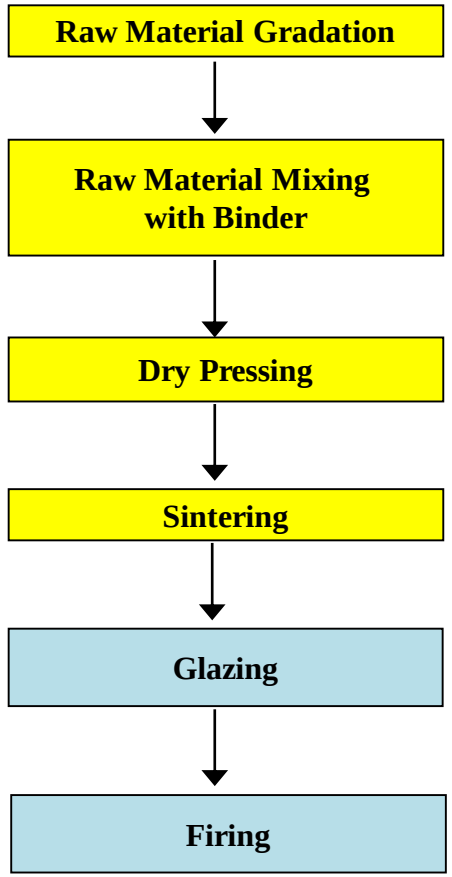
Glazing

Firing

FA based Wear Resistant Ceramic Tiles/Glazed Tiles

Dry Process

Process Flow Diagram



Advantages

- 60% mass in the tiles
- Less number of unit operations

Challenges

- Low green strength
- Needs engineering to handle low green strength tiles

Wet Process

Incorporating Spray Dryer/suitable binders for Wet Process to improve the green strength

Advantages

- Can have almost equivalent green strength with suitable binder
- Can use standard equipment
- Possibly increase the fly ash mass above 60%

Challenges

- Achieving green strength using fly ash as of clay tiles
- More unit operations than dry process. However, the decrease in number of rejects can off-set this cost

Developing wet process which used few unit operations in the upstream can enable use of standard equipment

Ceramic Tiles from Fly Ash

Way Forward

- No stand-alone technology or process can address total utilization of fly ash generated. Alternate uses and processes are required to minimize the gap between generation and utilization.
- Fly ash can be a good alternate material resource for alumina and REEs to address the Optimum utilization with value addition.
- Fly ash can also be used for establishing the Tiles industry in Eastern India by Piloting the technology developed
- Process Technology developed to be take forward to the next level

Thank you