



ACCELERATING SMART POWER AND RENEWABLE ENERGY IN INDIA (ASPIRE)¹

Policy Roundtable on Enabling Circular Economy & Resource Efficiency in Aluminium & Cement Sectors: Utilizing Spent Pot Lining (SPL) and other waste products of Aluminium Sector

June 2023

¹ASPIRE is a bilateral program implemented by Foreign Commonwealth and Development Office, Government of UK in association with Ministry of Power, Government of India. KPMG is the lead delivery partner for the ASPIRE programme. Idam Infrastructure Advisory Private Limited (India) and Carbon Trust (UK) are the key consortium members





**Circular Economy - Aluminium
Waste (SPL) as Input Raw
Material and Energy to Cement**

Linear Economy vs Recycling Economy vs Circular Economy



Raw Material

Production

Use

Waste

Linear Economy



Raw Material

Production

Use

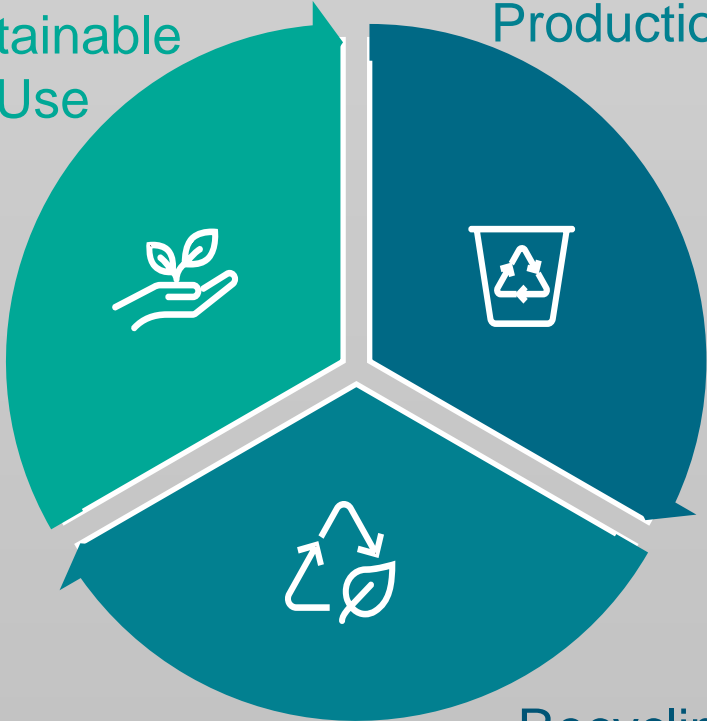
Waste

Recycle

Recycling Economy

Sustainable
Use

Sustainable
Production



Recycling

Circular Economy

Waste From Aluminium Sector – Spent Pot Lining (SPL) (1/3)

SPL is a solid waste generated during the production of primary Aluminium.

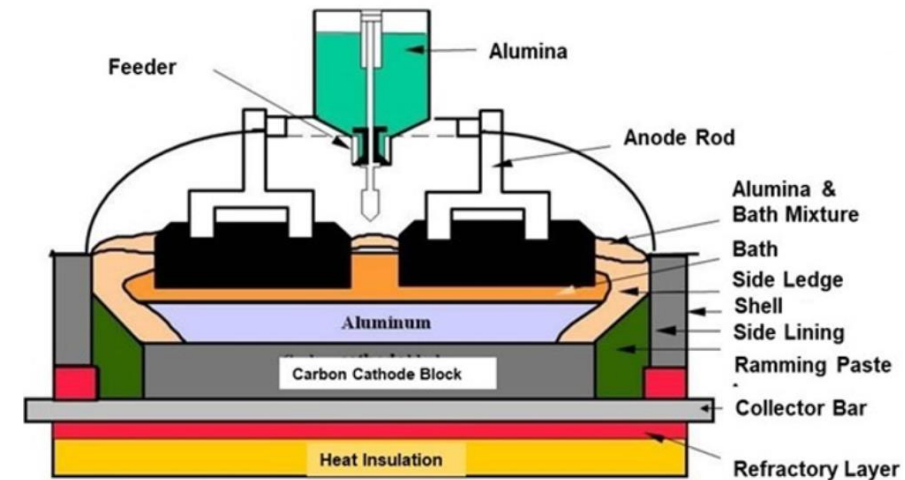
SPL is an unavoidable by-product of Aluminium smelting.

Steel Pots are Lined. This lining is made up of two layers:

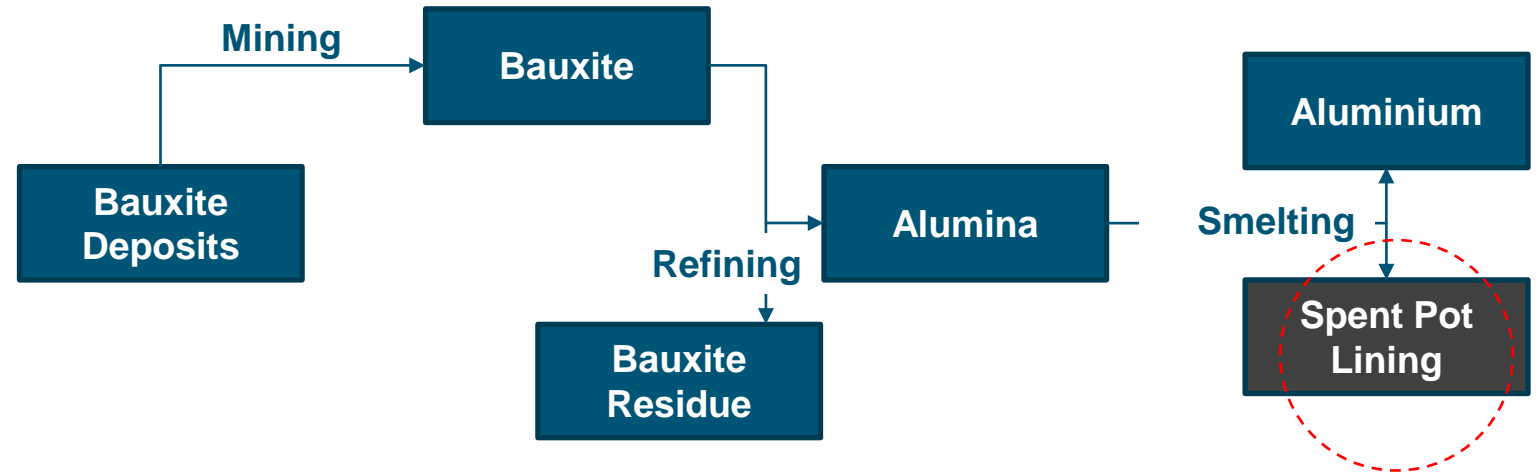
- an insulating refractory lining
- an interior carbon lining

Over a period of typically between **4–7 years***, the pot lining wears and comes to the end of its life, when it is classified as Spent Pot Lining.

SPL Generation Quantity typically : 22 kg SPL/t Al[#]



Waste From Aluminium Sector - SPENT POT LINING (SPL) (2/2)



- ❖ SPL is classified as a hazardous waste due to its potential toxicity and corrosiveness as mentioned below:
 - ✓ Contains toxic fluoride and cyanide compounds that can leach into water sources.
 - ✓ Exhibits high pH levels, making it corrosive due to the presence of alkali metals and oxides.
 - ✓ Reactive with water, producing flammable, toxic, and explosive gases.
- ❖ Typically, SPL comprises ~60%* **carbon** and ~40%* **refractory** by weight.

Waste From Aluminium Sector - Spent Pot Lining (SPL) (3/3)

Chemical Composition of SPL First and Second Cut*

Compound	Carbon lining 1st cut range wt %	Refractory lining 2nd cut range wt %
Al ₂ O ₃	0 – 10	10 – 50
C	40 – 75	0 – 20
Na	8 – 17	6 – 14
F	10 – 20	4 – 10
CaO ₂	1 – 6	1 – 8
SiO ₂	0 – 6	10 – 50
Metallic Al	0 – 5	0
CN Total	0.01 – 0.5	0 – 0.1
CN Free	0 – 0.2	0 – 0.05

SPL as Hazardous Waste

- ❖ Can be treated and deposited in specially designed and closely monitored landfills
- ❖ SPL can be used in Cement Industries after processing it into Carbon mineral fuel as Input Raw Material/Energy.

Challenges in Disposal of SPL

Hardness and Crushability



Very hard to crush. Bond index of lime stone is 13-15 and of SPL is around 40-45

Hazardous hence proper disposal of SPL is challenge



Proper disposal of SPL

Process and maintenance impact



Abrasive, high and variable content of sodium and fluorine and high ignition temperature of the carbon fraction.

Continuous availability of raw material is an issue.



Continuous availability

Outbound Logistics



Possibility of the formation of toxic and inflammable gases in contact with moisture

Need to find a permanent solution for the safe and environment friendly disposal of SPL.



Disposal through Un-organized sector

Chemical Properties and Handling



Essential to ensure homogenization of the material before use

Not have a reliable quantification of the total amount of SPL which is available for disposal



Waste Quantification and National Database for SPL

Storage



Any storage under open sky or without sealed paved ground is prohibited

Opportunity: Utilisation of SPL in Cement Sector

SPL or its derivatives can be introduced into a cement kiln via either of the following.

1

Injected as a powder alongside pulverized coal via the Kiln burner (first cut SPL only)

2

Injected pneumatically into the pre-heater end of the Kiln (both first and second cut SPL).

The benefits of using SPL or SPL derivatives in cement kilns as an alternate fuel and raw material (AFR) have been well documented and essentially consist of the following:

1

First cut SPL burnt as fuel and therefore reduce the consumption of primary fuel in the kiln.

2

Fluoride is beneficial for reducing clinkering temperature by fluxing action (from 1450°C to 1350°C).

3

Ammonia and cyanide from the SPL act to reduce nitrous oxide (NOX) emissions from the cement kiln by up to one-third.

Summary of SPL Utilization Options at Global level




Industrial use	First / second / both	Pre-treatment	Use/impact	Fluorides	Cyanides
Cement	Both	Crushing	Energy & Raw Material	Fluxing Effect	Destroyed

*Source: International Aluminium


Case Study - Star Cement & Emirates Global Aluminium (EGA)

- ❖ Since 2010, Emirates Global Aluminium (EGA) has been working with cement companies in the United Arab Emirates to explore the potential use of spent pot lining (SPL) in the cement manufacturing process.
- ❖ EGA embarked on a study in 2019 to quantify the environmental benefits of adding SPL to the cement manufacturing process.

0.6% The study focused on using 0.6% SPL in feedstock and found that, as a result of this addition, fuel consumption and emissions were notably reduced.

 **3.5%** Coal consumption was estimated to reduce by 3.5%.

 **0.74%** CO₂ emissions were down 0.74%.

 **3.75%** NO_x emissions were down 3.75%

SPL Utilization – Initiatives by Indian Industries

- ❖ **Vedanta Aluminium** announced a long-term agreement with **Dalmia Cement** to supply industrial wastes such as fly ash and **spent pot lining** for the production of low-carbon cement.[#]
- ❖ An SPL co-processing trial was completed at the **ACL Bhatapara Cement Plant** completed in 2016 as per an **MOU signed between Holcim and Bharat Aluminium Company Ltd. (BALCO)**, part of Vedanta. ACL received permission to process 3,200 tpa of SPL.
- ❖ **Ultratech Hirmi Cement** got permission to co-process 2,880 tpa of SPL from **BALCO for five years in 2016**, with execution starting soon after.
- ❖ A quantity of SPL is being converted to mineral fuel by **Green Energy Sambalpur and Subhra Chemicals**, who are authorized reprocessors at a smelter in Odisha.

^{*}[The SPL Waste Management Challenge in Primary Aluminum - Light Metal Age Magazine](#)

[#][Vedanta Aluminium pact with Dalmia cement to supply industrial wastes - Indian Cement Review](#)

Way Forward

- ❖ Deliberate and explore the potential of utilizing SPL from the Aluminium sector in the context of the circular economy including
 - ✓ identification and evaluation of suitable approaches
 - ✓ technologies required to facilitate safe and environmentally friendly disposal or reprocessing of SPL.
- ❖ Seek to address challenges related to SPL management, such as its hazardous nature, proper handling, homogenization, storage, and regulatory directives.
- ❖ Accelerate the utilization of SPL in Cement Industries

Estimated that around 77000 Ton SPL generated from Indian Aluminum Industries in FY 23. SPL Management is challenge for Aluminium Industries but Opportunity for Cement Industries.

Thank You

SPL Detoxification Technology Provider: Ultromex, UK

❖ **Issue: Storage, Landfilling, and transport of SPL**

- ❖ SPL contains toxic compounds including leachable fluorides and cyanides, plus it reacts with water; hydrolysing to produce explosive gas mixtures of hydrogen and methane.
- ❖ Landfill can cause serious environmental damage
- ❖ Transporting untreated Spent Pot Liner is dangerous and expensive and requires to follow regulations

❖ **Technology Solution: CARBOMEX**

A low-cost plant and process to treat and fully recycle spent pot liners so that they can be transported safely and disposed of permanently & sustainably.

SPL Detoxification Technology Provider: Ultramex, UK

❖ **Technology Solution: CARBOMEX**

- ❖ Recovers any trapped aluminium and salts
- ❖ Eliminates cyanides, fluorides & other toxic contaminants
- ❖ All effluents made safe and compliant for disposal
- ❖ Treats both the CARBON and the REFRACTORY layer individually or mixed
- ❖ Treated refractory becomes useful construction material
- ❖ Treated carbon can be re-used in many industries

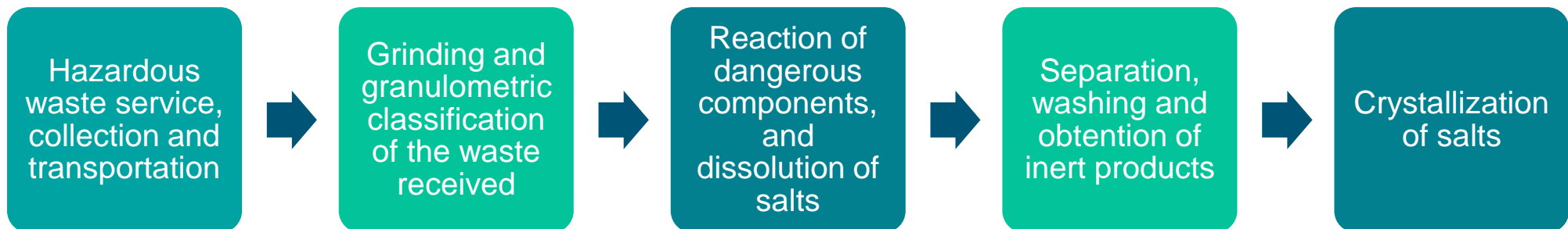
❖ **Benefits/Advantages:**

- ❖ Removes the need for storing or landfilling spent pot lines by being the first commercially attractive process for the treatment of spent pot lining so that it is no longer hazardous.
- ❖ Can be safely transported around the world for use as a secondary resource and feedstock for other industries.

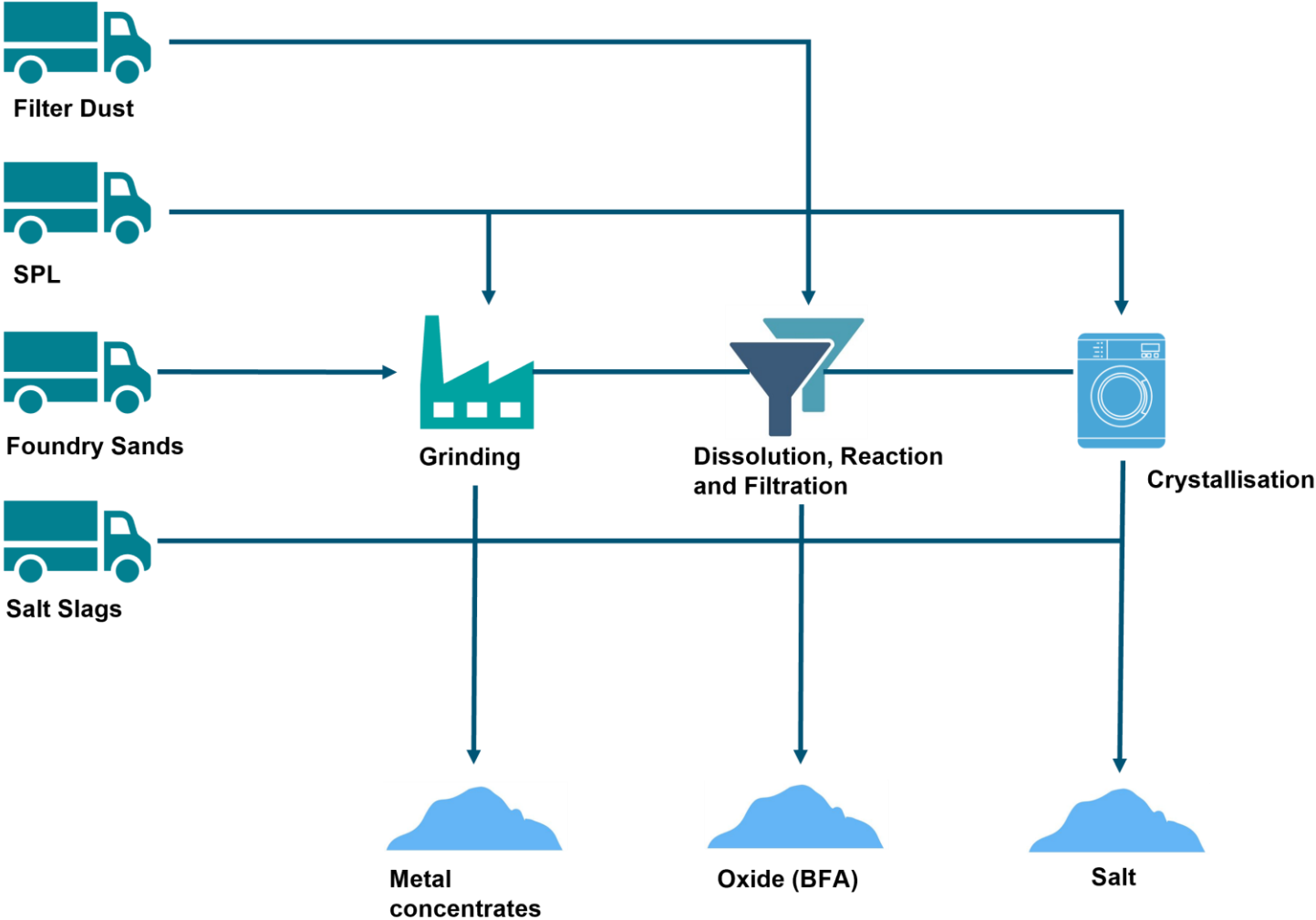
Aluminium Recycling Industry, Befesa, UK

- ❖ Befesa provides innovative and sustainable technological solutions for the aluminium recycling industry.
- ❖ Befesa Aluminium Salt Slags Recycling Services is divided into 3 separate but complementary areas
 - ❖ Salt slag, Spent Pot Lining (SPL) and refractory lining recycling services
 - ❖ Secondary processing of aluminium scraps, drosses and other aluminium containing residues to produce custom aluminium alloys
 - ❖ Technology and specialized equipment sales

Salt/SPL Recycling Five Stage Process :



Aluminium Recycling Industry, Befesa, UK



Final Products:

- 1 Metal concentrates ready to be used as raw material in foundries
- 2 Metallic oxides, ready to be used as a source of aluminium oxide in different industrial activities
- 3 Salts that can be used as fluxes in metallurgical processes or as agricultural fertilizers

Points for Discussions on Policy/Regulations Intervention

SPL – Waste from AI Industries as Energy /Input Raw Material to Cement Industries - Such an approach can serve as an excellent example of a circular economy, where waste materials are effectively repurposed.



What are the primary challenges faced in the disposal of SPL for the aluminum industries?

What are challenges (Operational and regulatory) in Consuming SPL in Cement Plants? – Dedicated facility need to be developed for converting SPL into Carbon Mineral Fuel

What Regulatory changes and policy changes from Central/State level will boost the circular economy efforts by Industries?

What are the challenges related to storage and handling of SPL in terms of safety and regulatory compliance? Specifically, what difficulties are being encountered by the aluminum/cement sector in addressing these challenges?

Snapshot of CPCB guidelines on SOP for Utilization of SPL (1/2)

SOP for utilization of SPL

Transport - SPL in size 200-500 mm must be covered containers

SPL transportation requires sender and receiver authorization from State Pollution Control Board (SPCB)

SPL storage requires a cool, dry, well-ventilated covered shed with impervious RCC flooring, as authorized by SPCB/Pollution Committee to prevent rainwater intrusion

Designated space for unloading of SPL within the covered storage shed

The crushing and screening system will operate in a closed environment. Under negative suction, connected to a cyclone, pulse jet bag filter, and ID fan.

The screened SPL (less than 30 mm) will be heat treated in the rotary kiln at a minimum temperature of 430°C.

Snapshot of CPCB guidelines on SOP for Utilization of SPL (2/2)

SOP for utilization of SPL

Proper ventilation will be maintained in the work zone and process areas. Mandatory personal protective equipment (PPE)

The unit shall provide suitable fire safety arrangements and flame proof electrical fittings

SPL will be sourced only from industries with valid authorization for its generation and storage, as mandated by Rules and Regulations

The unit is liable for addressing environmental damages caused by improper handling of hazardous waste, including spillage.

The unit must comply with the requirements of the Public Liability Insurance Act, 1991, as amended, during the utilization and handling of hazardous waste, wherever applicable.

Fuel Savings In Cement Plant – By Using SPL

1 **5%** Approximately 5%* saving by reducing energy input from primary fuel by 160 MJ/tonne* of clinker

2 **5%** Approximately 5% saving by lowering the clinker temperature by 100°C.

However, this effect is dependent on the sodium content of the clinker raw materials and how much additional sodium can be tolerated with the SPL addition. The sodium limit may prevent addition of sufficient fluoride to see this fluxing effect.

3 The intake of spent anode butts will result in further, considerable savings on the energy input from primary fuel.

Seven Principles of Circular Economy

What is Circular Economy?

- ❖ The circular economy is a system where waste and resources are reused instead of being sent to the landfill or incinerated.
- ❖ Instead, resources are kept in use for as long as possible, and when they're no longer needed, they're recycled or reused.
- ❖ In a circular economy, there is no waste.
- ❖ The Circular Economy is built on Seven Principles as shown in adjacent figure.

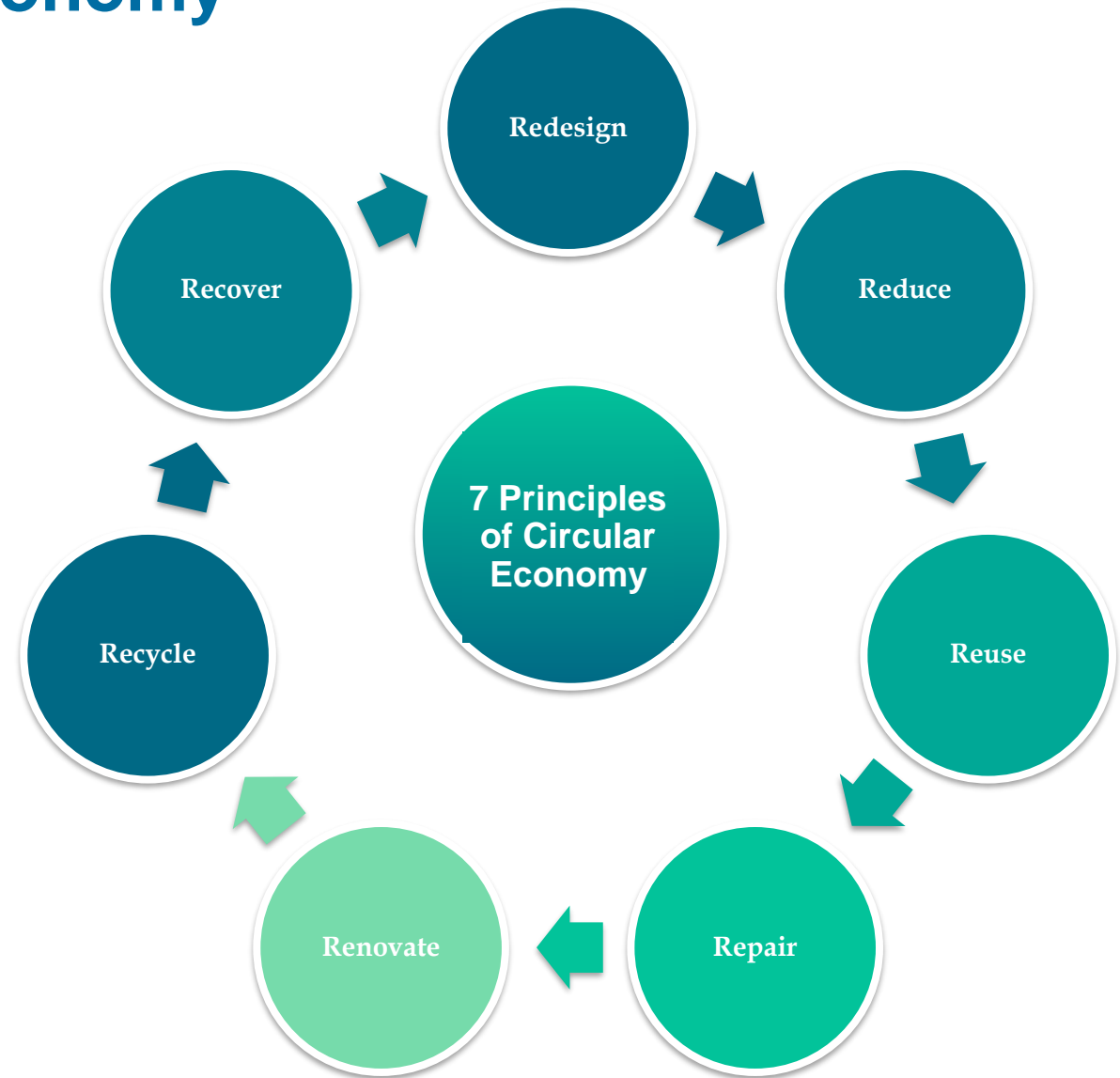


Fig: Seven Principles of Circular Economy

Opportunities for SPL Co-processing in India

Opportunities for SPL Co- Processing

India is the second largest Cement producer in the world after China with a targeted production of 356 Million MT in year FT 22.

Opportunities and availability of Cement Kilns for SPL disposal through co-processing is not a constraint.

SPL (1st cut and 2nd cut) to be used as fuel supplement with raw materials additives properties.

SPL contain ~ 15%* fluoride, fluoride is mineralizer and substitute fluorspar.

SPL contain ~ 30%* carbon, calorific value ranges 3200 – 4500 kCal (First Cut).

SPL contains ~ 15%* sodium, can be beneficial if operating with high sulfur containing fuels.

Recycling is an attractive and proven option; Best may be Cement Industry