SUSTAINABLE WAY OF HANDLING ALUMINIUM PLANT HAZARDOUS WASTE IN CEMENT & STEEL INDUSTRIES

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Presenter's Bio

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- **Present position: Chief Operating Officer (COO), Metal**
- **Work experience: 20 Years**

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Introduction

- **Effective and sustainable management of Spent Pot Lining (SPL) has been a major challenge for the aluminium industry for many years.**
- **An estimated 1.6 million tonnes of SPL is generated globally on annual basis from the primary aluminum production process, and this is expected to increase over the next 20 years to 2.3 million tonnes.**
- **This work is about the collaboration for co processing of 2nd cut SPL with one of the leading cement industry in creating a blueprint for sustainable development of aluminium industries.**

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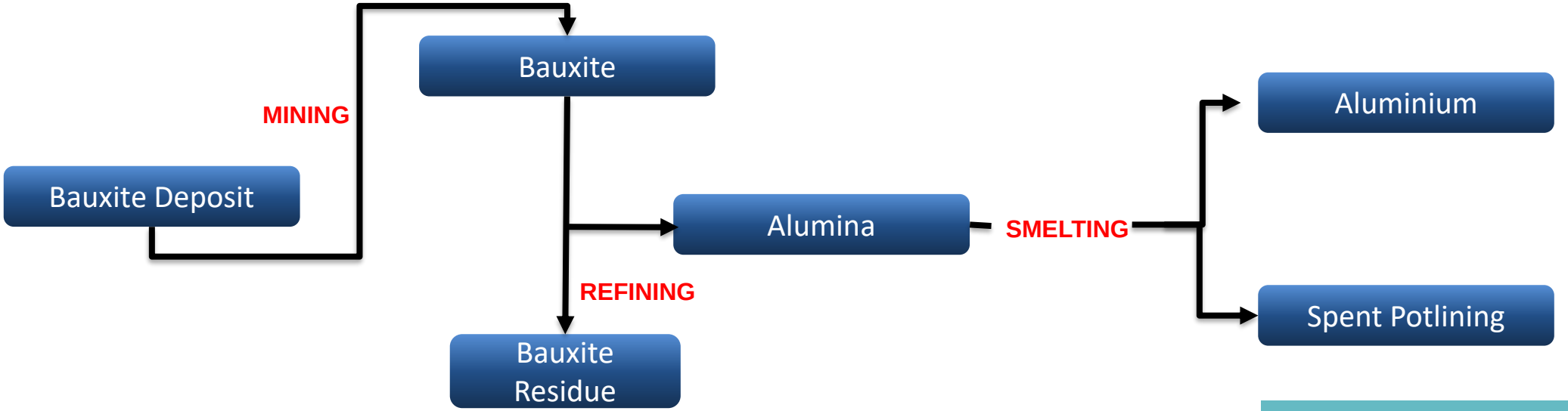
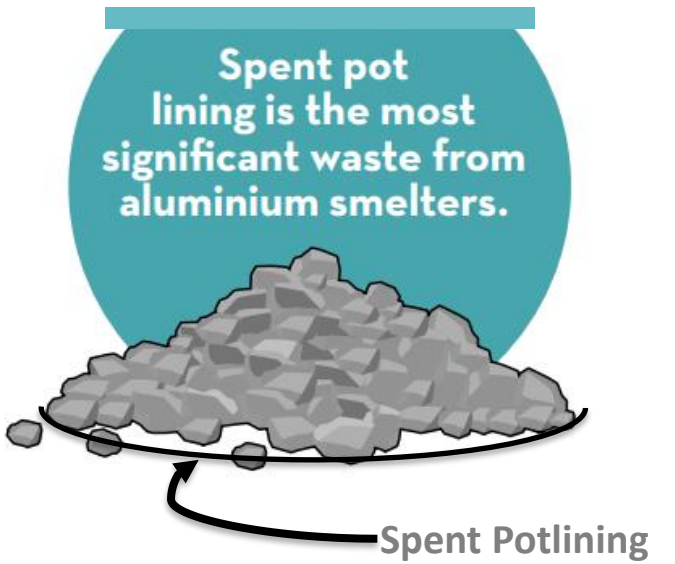
What Is Spent Pot Lining (SPL)?



- **Spent pot lining is a solid waste generated during the production of primary aluminium.**
- **Primary aluminium is produced in steel pots which are lined with broad category materials:**
  - **an insulating refractory lining**
  - **an interior carbon lining.**
- **During the handling of SPL significant amount of fines are generated called as "SPL Refractory Fines".**



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SPL Classification & Generation Details

Major toxic contaminants in SPL are fluoride & cyanide; hence classified as hazardous waste as per CPCB guidelines and category 11.2 of schedule I of HOWM rules, 2016.

Chemical reactions

Formation of cyanide & fluoride compounds:

$$2Na + 2C + N_2 = 2NaCN$$

$$4Na_3AlF_6 + 12Na + 3C = Al_4C_3 + 24NaF$$

$$4Na_3AlF_6 + 12Na + 3O_2 = 2Al_2O_3 + 24NaF$$

Annual SPL Generation Details

India's Contribution in Primary Aluminium Production (FY'23):

~4.3 Million Metric Tonnes

Spent Potlining Generation in India (FY'23):

~77 Kilo Metric Tonnes

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SPL Material Constituents

Material	% Wt.
Waste Carbon Block	47%
Paste	7%
Insulating Brick	4%
Refractory Particle	2%
Firebrick	6%
DBM	6%
Rest	28%

Table 1

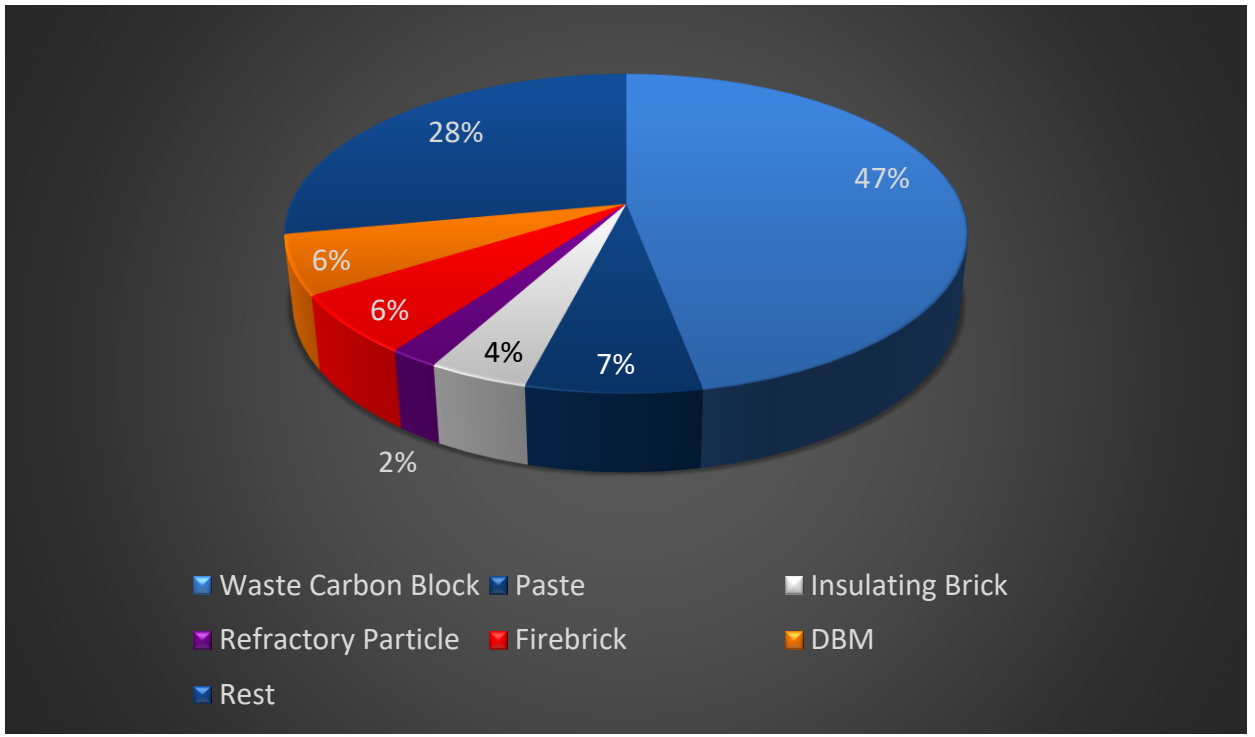

Fig. SPL Constituents

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SPL Categorization

- SPL is stored in covered storage sheds for further processing and disposal.
- **Typical material constituents of SPL is shown in Table 1**.
- **Typical chemical analysis of SPL is shown in Table 2.**
- SPL is categorized in 2 parts **– 1st cut or Carbon part and 2nd cut or Refractory part.**
- **1st Cut of SPL** post detoxification can be used as raw material **(Carbon Mineral Fuel) in ferro-alloy or cement industries.**
- **SPL 2nd cut** is stored in storage buildings and **no viable options for reuse in this form.**

Chemical Analysis	
LOI	10-12%
SiO_2	30-50%
Al_2O_3	20-35%
Fluorides	15-20%
Fe_2O_3	2-5%
CaO	2-6%
MgO	3-6%
K_2O	1-4%
Na_2O	2-6%
SO_2	0.1- 1.0 %

Table 2

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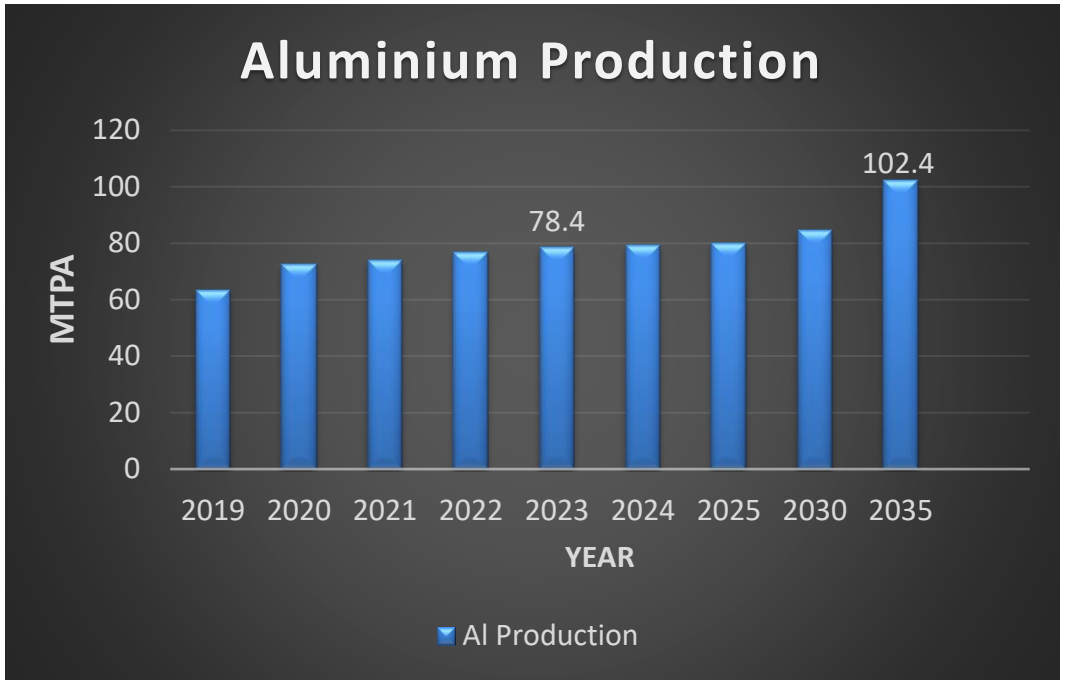
Global Scenario: Al Production and SPL Generation



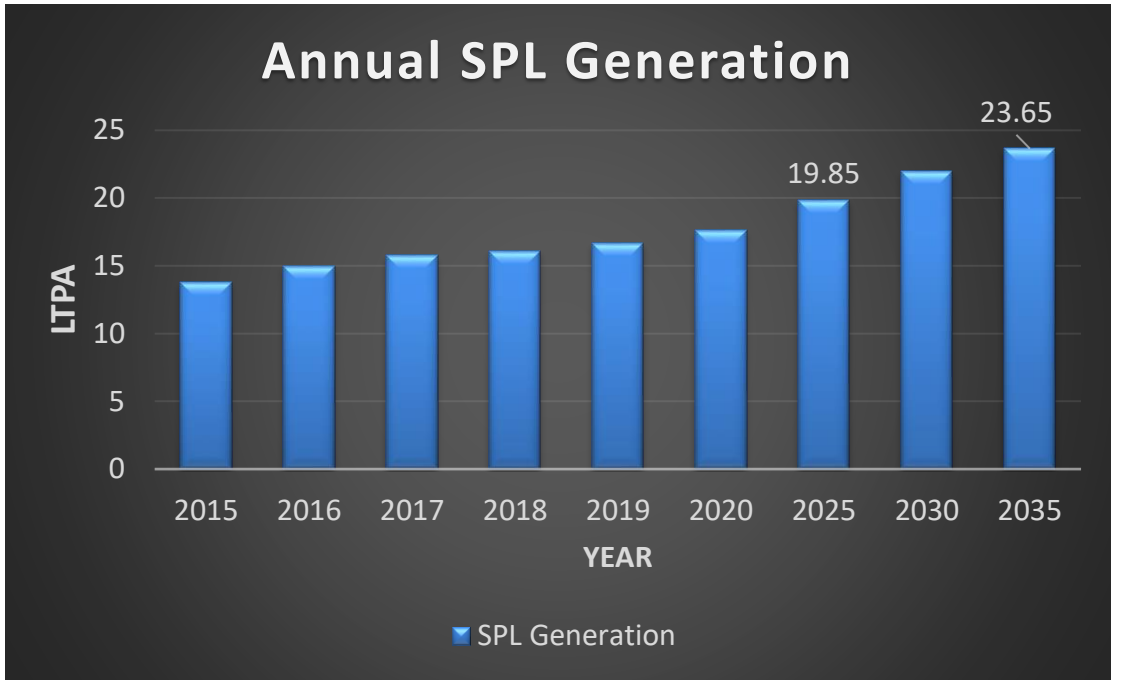


Fig. Estimate of primary aluminum production & SPL generation to 2035

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Role Of Cement Industry In Sustainable Waste Management

- **Cement plants have lion's share in creating a blueprint for sustainable development in India's bright future through co-processing.**
- **Co-Processing of Hazardous Wastes in Cement industry will have far-reaching effects:**
  - For efficient and secure form of waste processing, recovering energy and mineral content from wastes
  - As Alternate Fuel or Raw Material
  - For conservation of natural resources, reduction in land filling
- **Co-Processing will enable "Circularity" and "zero waste" in primary aluminium industry and reduce the environmental impact .**

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SPL Co-Processing in Cement Industry

- **Co-processing in cement production is defined as the reuse or recovery of mineral or energy content of waste materials.**
- SPL can be a substitute fuel as well as primary raw material in cement manufacturing
- **High temperature conditions of cement kiln decompose hazardous fractions** without any residue generation
- **SPL 1st Cut** can act as **an alternate fuel replacing conventional coke**
- **SPL 2nd Cut**: **Fluorides present in SPL lowers melting point of clinker, saves input of fuel** as well as certain fractions contributing to clinker process

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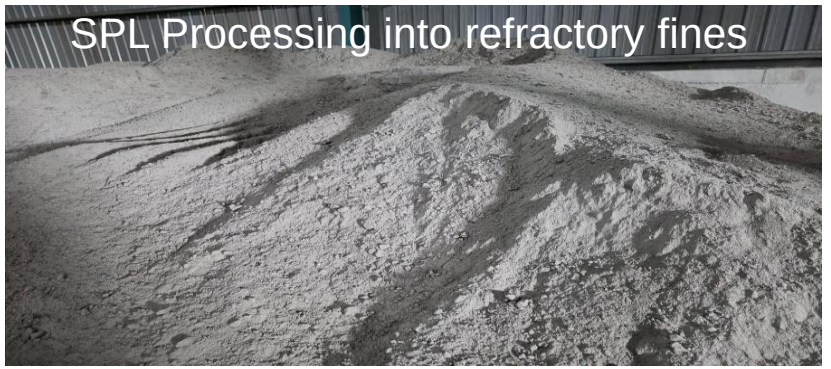
SPL Co-Processing Trials

- **Vedanta collaborated with two of the major cement units in India.**
- **SPL in form of refractory fines (<10 mm)** was required by Cement units for co-processing



- **Material transportation** done in authorized and dedicated Vehicles with requisite safeguards **as per provisions stipulated under HOWM Rules, 2016.**
- **Multiple samples of SPL refractory fines were tested in lab** with sophisticated equipment in laboratory.

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SPL Co-Processing Trials

- **Tests of composite sample, have been conducted in NABL accredited lab and test results were well within the recommended limit** (Table-2).

Mandatory Requirement (mg/l)		Value	Method of Analysis
Cyanide (TCPL)	20 (max)	< 3.5 mg/l	EPA 1311, APHA 23 Rd edn. 4500-CN: C/D
Fluoride (STLC)	180 (max)	< 5.5 mg/l	EPA 1311, APHA 23 Rd edn. 4500, F:D

- **SPL refractory fines was used mainly to compensate the silica and alumina deficiency in cement raw mix.**
- **As raw mix component, better control obtained due to improved homogenization & more dilution also.**

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SPL Co-Processing Trials

- A **separate controlled feeding system was used to feed into kiln inlet.**
- The **addition of SPL refractory fines was started from 0.25% with gradual addition up to 1.5%.**
- **Various aspects were streamlined during the trial** such as
  - SPL material transportation
  - Storage at processing facility
  - Handling of material and
  - controlled feeding

The trials conduct shown good results with utilization of SPL as fines in cement production process

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SPL Co-Processing in Steel Industry

- **Co-processing of Spent Pot Lining in steel production is another viable scope for sustainable reuse of waste materials.**
- **SPL 1st cut** can be a competent alternate to coal as an auxiliary fuel for blast furnace in ironmaking sector and it can also be treated as flux in making alloy steel in electric arc furnace.
- SPL contains fluorspar (CaF_2), therefore it can serve as an additive in steelmaking due to its ability to enhance slag formation by fluoride addition.
- **Like cement kiln, high temperature conditions inside the furnace decomposes hazardous fractions** without any residue generation.

SPL 1st Cut

Steel Making in Furnace

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SPL Co-Processing in Steel Industry

- Characteristics of SPL 1st cut that makes it a suitable substitute of conventional fuels used in furnace-
  - **High Carbon content** : Can be used as secondary fuel source or reducing agent
  - **Low Sulfur content**: The brittleness and weldability of steel remain intact
  - **Fluorspar content**: Aids in the liquefication of the slag and facilitates the slag removal

SPL Cut	Pre-treatment	Use case	Carbon	Fluoride	Cyanide
1st	Ground to fines (~50-80mm)	Fuel Source	Combustion releases heat	Helps in fluxing effect	Destroyed in high temperature

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Major Challenges in SPL Disposal through Co-processing

- **Hardness and Crushability** : Very hard to crush. Bond index of lime stone is 13-15 and of SPL is around 39-42 BHI (lime crusher not feasible).
- **Homogenization**: Essential to ensure homogenization of the material before use. Mainly the alkali and fluoride content can vary strongly. Segregation of aluminium metal, carbon material and refractory material needs to be done.
- **Segregation of SPL:** Separation of lumps and fines with dedicated storage facilities.
- **Pre-processing of SPL:** Segregation of contaminants and to reduce size <10 mm.
- **Feeding system in Cement Kilns:** Controlled feeding at kiln inlet to maintain quality of cement and maintain right mix.

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SPL Management Hierarchy

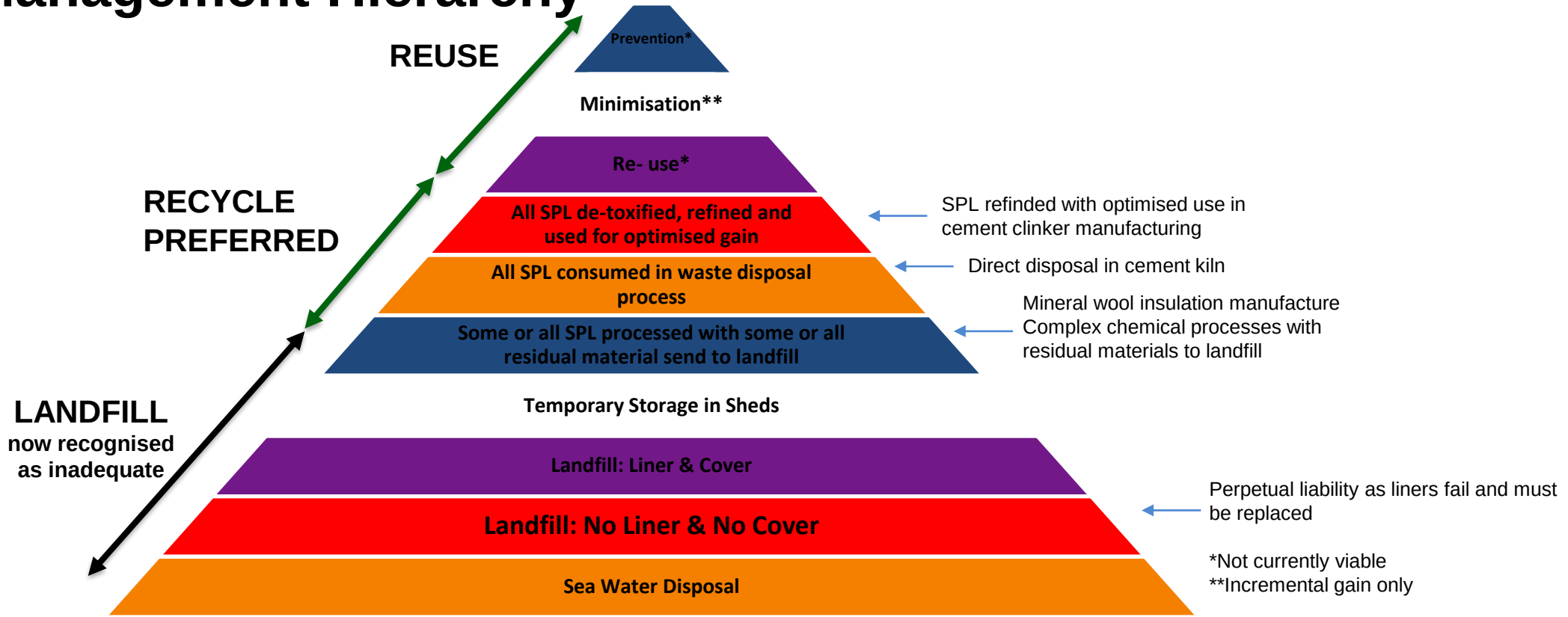

Fig. SPL management practices and the waste management hierarchy

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Global Overview of SPL Processing

Fig. General overview of current global SPL activities (Ref. IAI)

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Sustainable SPL Management

Fig. Key areas identified for AI sustainable SPL management guidance (Ref. IAI)

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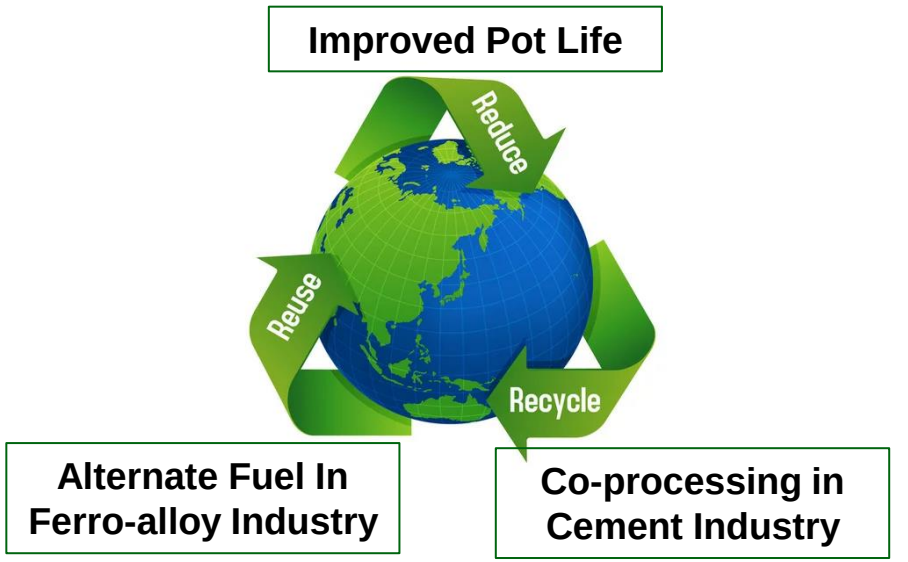
Conclusions

- **As nation is poised for inclusive growth, industries should work together for efficient use of natural resources by promoting *"Reuse – Recycle – Reduce"* philosophy.**
- **Government should encourage through some incentive scheme to evacuate legacy hazardous waste stock from each plant as one of the "RESULT" line item for upcoming carbon credit calculation.**
- **Strategic collaboration between aluminium, steel & cement industry for hazardous waste management will create scope for circular economy and will re-emphasize ESG commitments laid down across industry.**



- **The Glasgow vision emphasizes the need to minimize waste generation, promote circularity, and mitigate climate change.**
- ***SPL usage can be a promising proposal for reduction in SPL stockpiles of cut 2 SPL at aluminium smelter and cut 1 SPL as an AFR across industries.***
- **Cement, steel and Aluminium industry should join hands and work out a 'win – win' solution.**
- **State and central Government should create an ecosystem for seamless transboundary hazardous waste movement.**

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Thank you very much for kind attention !!!

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