Sustainability in Action: Recovery of Zinc from EAF Dust in the Steel Industry

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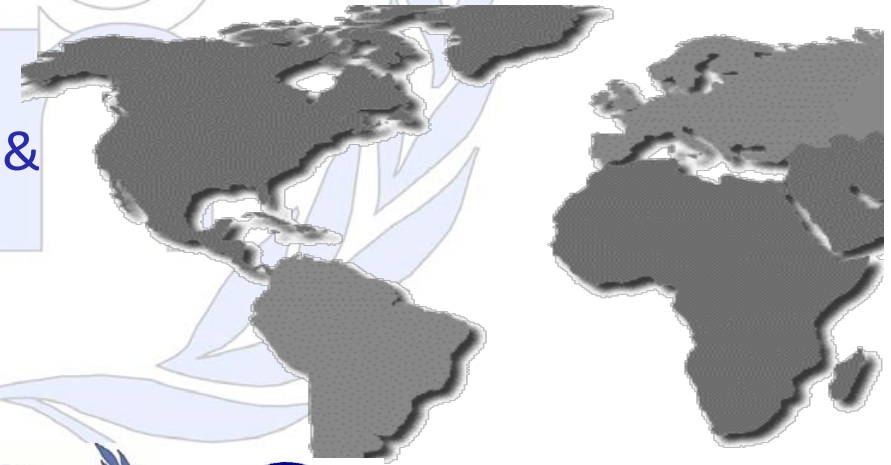
Presentation outline

- Introduction – ILZSG and its role
- Zinc Recycling - Background
- EAF Steel Production
- EAF Dust
- EAF Dust Processing – Technology, Plants
- Waelz Zinc Oxide
- Regulations
- Summary and Future developments

ILZSG Overview

- Intergovernmental organization set up within the UN system
- Significant level of industry representation
- Established by UN in 1959 in New York
- Moved to London in 1977
- From start of 2006 ILZSG, ICSG & INSG co-located in Lisbon, Portugal



www.icsg.org

ILZSG

www.insg.org

ILZSG Membership

- Membership open to any country involved in lead and/or zinc production, usage, or trade
- 30 members (>85% of global lead/zinc industry):

Australia
Belgium
Brazil
Bulgaria
Canada
China
Finland
France
Germany
India
Iran
Ireland
Italy
Japan
Korea Rep.
Mexico
Morocco
Namibia
Netherlands
Norway
Peru
Poland
Portugal
Russian Fed.
Serbia
Sweden
Thailand
Turkey
United States
European Community

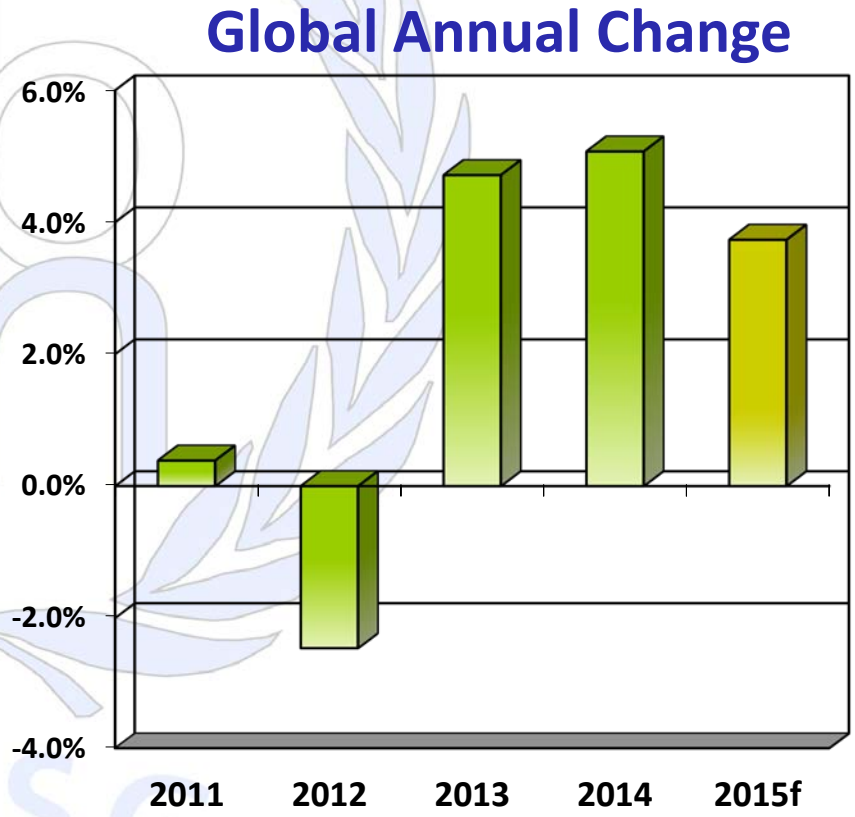
ILZSG Overview – Work of the Group

- **Facilitate Co-operation Between Government and Industry**
  - ✓ Twice yearly meetings
  - ✓ Special conferences/seminars
- **Conduct In-depth Research into Other Issues of Interest or Concern to Members**
  - ✓ Economic developments
  - ✓ Environmental legislation
- **Promote Transparency in the Lead and Zinc Markets**
  - ✓ Closely monitor production, consumption, prices, stocks, trade flows and market balances
  - ✓ Reports and directories

World Zinc Metal Demand Forecast

ILZSG Forecast

- **2015 - Global 3.7%**
  - China 4.8%
  - Ex China 2.8%



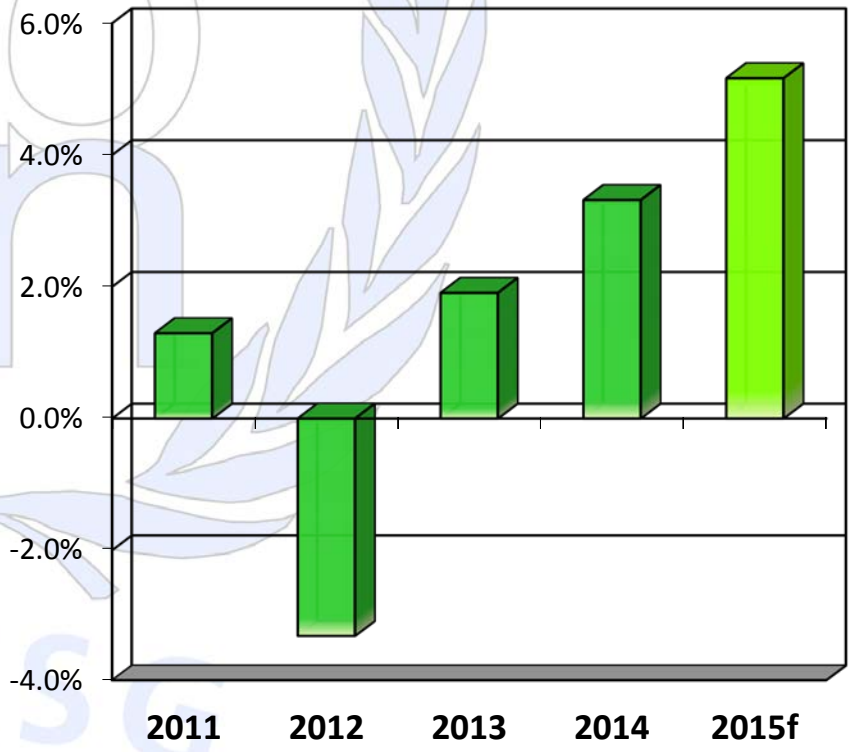
Source: ILZSG

World Zinc Metal Supply Forecast

ILZSG Forecast

- **2015 - Global 5.2%**
  - China 8.9%
  - Ex China 2.4%

Global Annual Change



Source: ILZSG

Zinc Recycling - Background

- Zinc recycling has social, environmental and economic benefits e.g. reductions in emissions, energy use and solid wastes
- Reduces dependence on the supply of zinc concentrates by the mining sector, reduces risks associated with price fluctuations, supply disruptions, etc.
- Zinc is a valuable commodity the recovery of metal at products' end of life – which would be wasted otherwise –avoids economic loss

Zinc Recycling - Background

- International Zinc Association (IZA) estimates that secondary zinc represents 25% of total refined output
- "Recycled Content" is the fraction of recycled zinc contained in overall refined metal production
- According to IZA about 60% of zinc in old scrap (end of life) is ultimately recycled

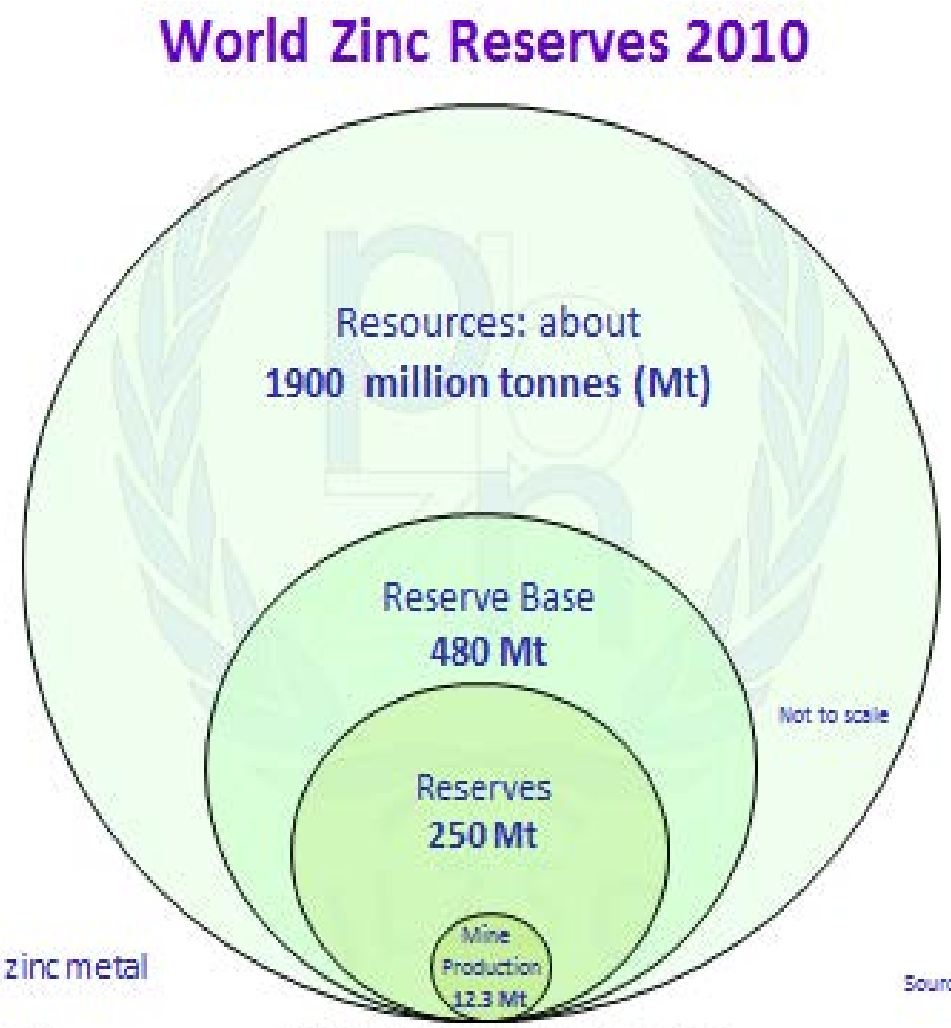
The World Is Not Running Out Of Zinc – Despite the Occassional Headlines

ZINC: WORLD RUNNING OUT AND SHORTAGE HITS -

It's used in everything from steel-making to sunscreen, but the world is rapidly running out of zinc.

Independent 14 September 2014

http://www.independent.co.uk/news/uk/home-news/zinc-world-running-out



Zinc Recovery from EAF Dust Trends

Growing rates of zinc recovery from products at end of life

New more efficient technologies and methods to improve results

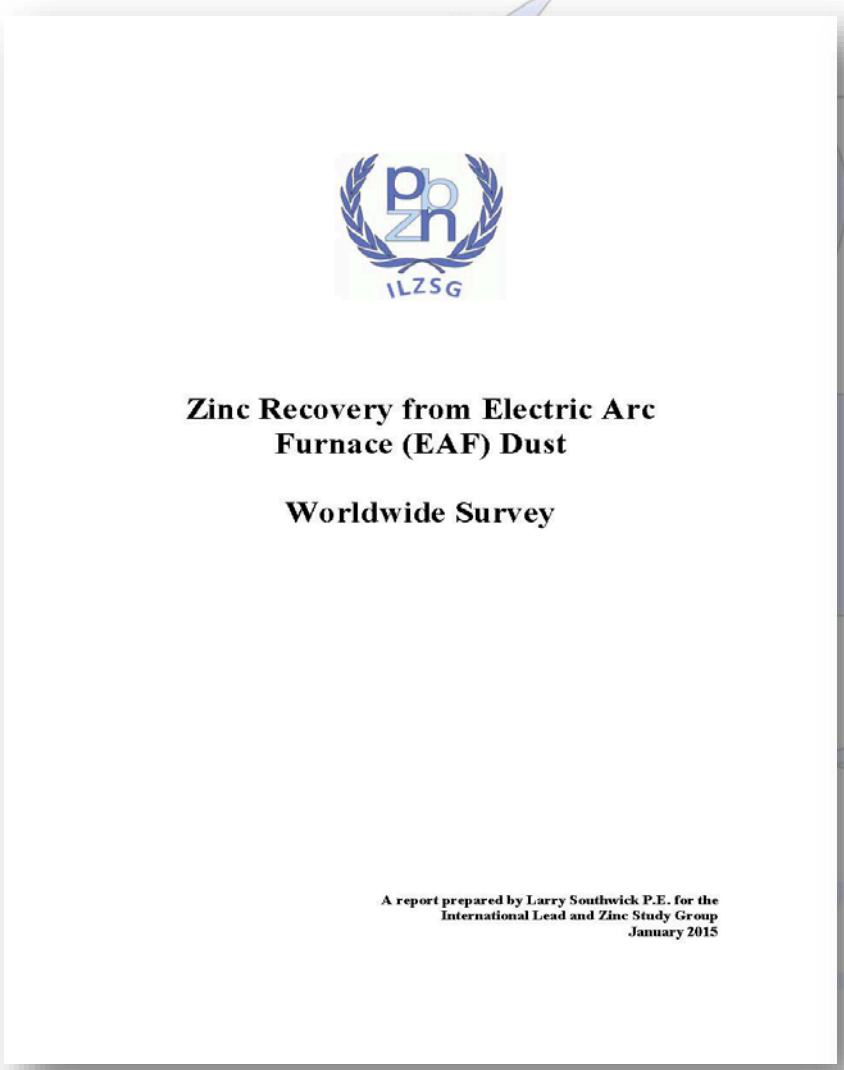
In recent years, one of the most dynamic areas has been

Zinc Recovery From Electric Arc Furnace (EAF) Dust

ILZSG has recently published a 60 page report on this topic:

Zinc Recovery from Electric Arc Furnace (EAF) Dust – Worldwide Survey

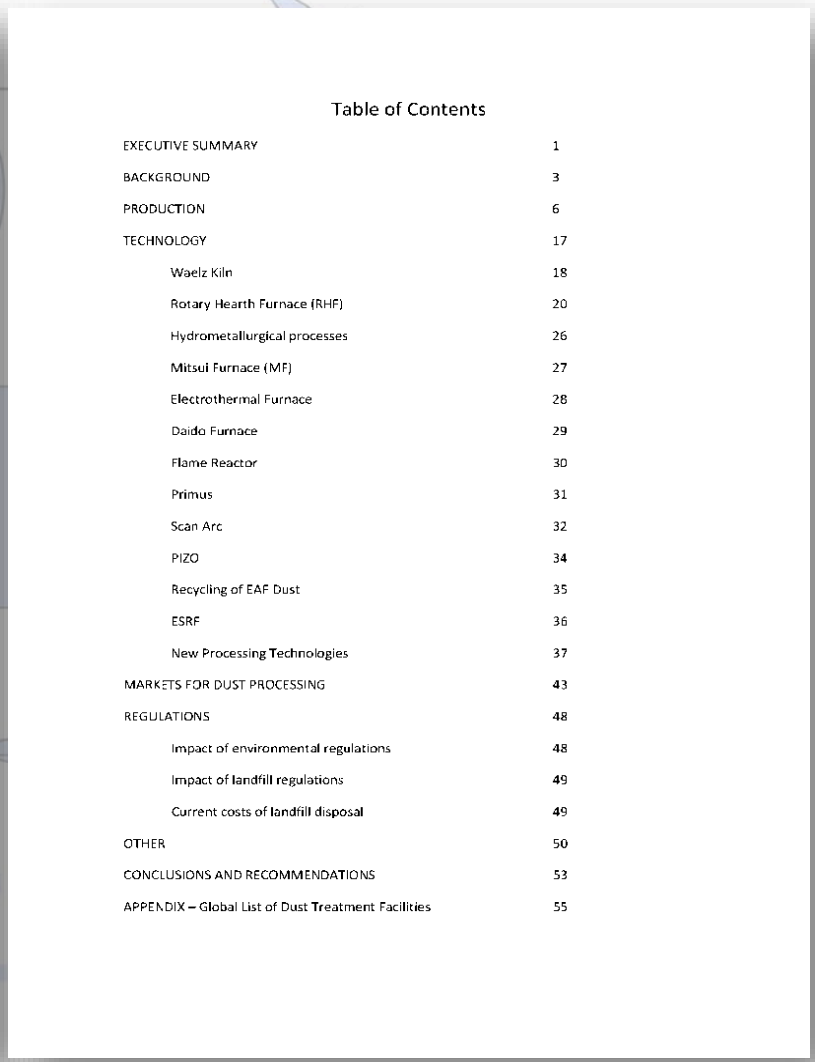
Zinc Recovery Electric Arc Furnace (EAF) Dust Worldwide Survey



Zinc Recovery from Electric Arc Furnace (EAF) Dust

Worldwide Survey

A report prepared by Larry Southwick P.E. for the International Lead and Zinc Study Group
January 2015



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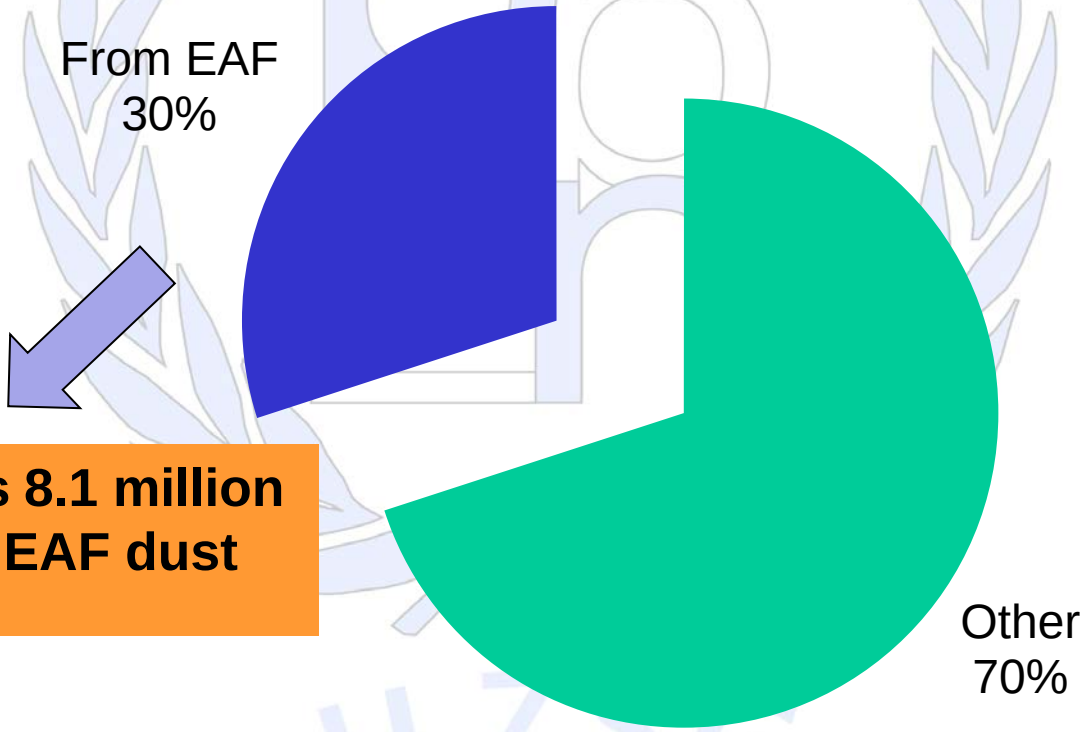
Zinc Recovery from EAF Dust
EAF Steel Production

- EAF production of steel is fed by steel scrap
- Of 1.56 billion tons of steel generated in 2014, almost 30% is secondary steel produced in Electric Arc Furnaces
- Environmental regulations drive recycling of steel
- EAF Steel production generates zinc-rich **EAF Dust**
- **Around 15 to 22kg of zinc-rich dust is generated per ton of steel**

Electric Arc Furnace Steel Production

2014 Global Steel Production
1.56 Billion tonnes



Generates 8.1 million tonnes of EAF dust

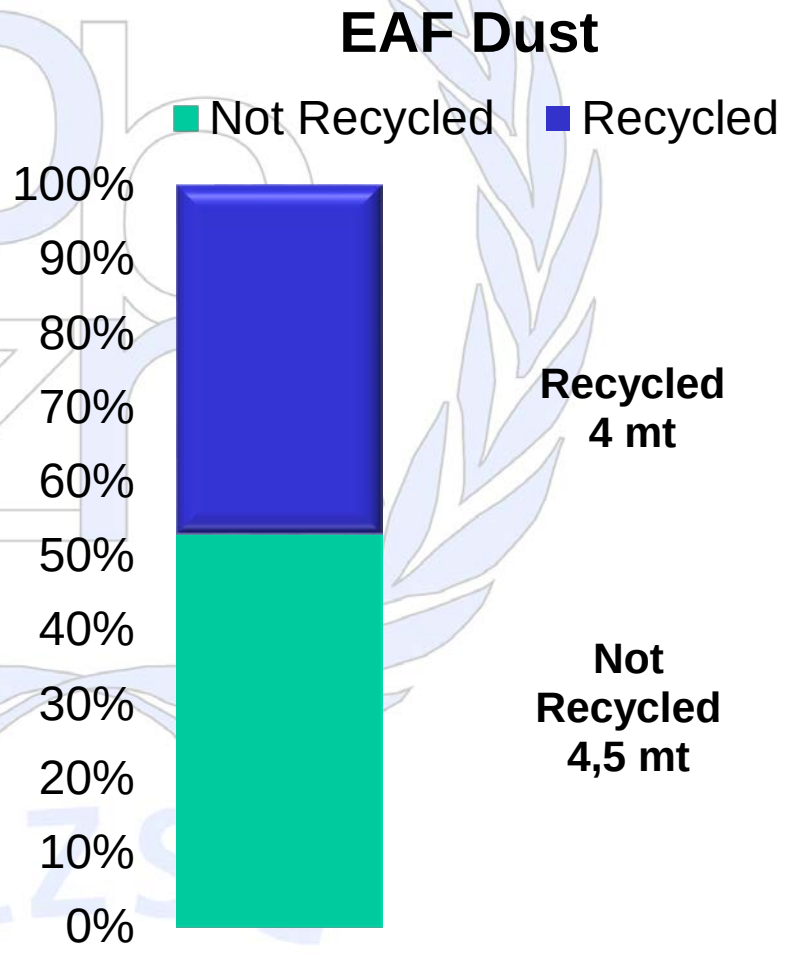
Zinc Recovery from EAF Dust – EAF Dust

- The zinc content of EAF dusts from around the world show a wide variation, reflecting the composition of the scrap used in the furnaces
- Data cited in ILZSG's report show **Zn contents** of 31%, 28.5%, 29.1%, 8%, 18%, 18.9%
- In the US, analysis of dust generated in 11 mills showed an average 25% zinc content (max: 41.8% / min:17.3%)
- A variety of residual metals (such as Cr, Mn, Ni and Cu) are also found in the dusts

Zinc Recovery from EAF Dust – EAF Dust

Globally, around 8.5 mt of dust containing 1.7mt of zinc is generated annually

- ✓ **4.0mt of dust containing 0.8mt of zinc is recycled**
- ✓ **4.5mt of dust containing 0.9mt of zinc is not recycled, most of it going to land fill**



Zinc Recovery from EAF Dust – EAF Dust

- Improvements in efficiency have allowed ever lower zinc grades of dust (below 15%) to be processed
- Within the next five years new electric furnace steel production could rise by at least 50 million mt per year, which would produce roughly 1 mt of new dust

Zinc Recovery from EAF Dust – Dust Processing

- EAF dust is considered a hazardous waste, thus treatment or disposal is closely regulated
- Increasing regulations and higher landfill costs (and high zinc prices) are incentives to process EAF dust
- EAF dust is recognized as a potential source of recycled zinc, but the technical problems of extracting the zinc present challenges

Zinc Recovery from EAF Dust – Technology

- Under the 1980 regulations, the US EPA(Environmental Protection Agency) had to designate a specific technology to treat EAF dust.
- The reference process was the **Waelz kiln**
- Waelz kilns are most economical when operating on a large scale (serving several mills), and much of the new technology development focused on in-house processing for a single mill.
- However, that effort overall has not been successful

Waelz kilns remain the predominant method of processing dust, with over 85 % of the market

Zinc Recovery from EAF Dust – Technology

- Alternative technologies include:
  - Rotary hearth furnace
  - Hydrometallurgical processes
  - Mitsui Furnace
  - Electrothermal Furnace
  - Daido Furnace
  - Flame Reactor
  - Primus process
  - Scan Arc process
  - PIZO process
  - ERSF process

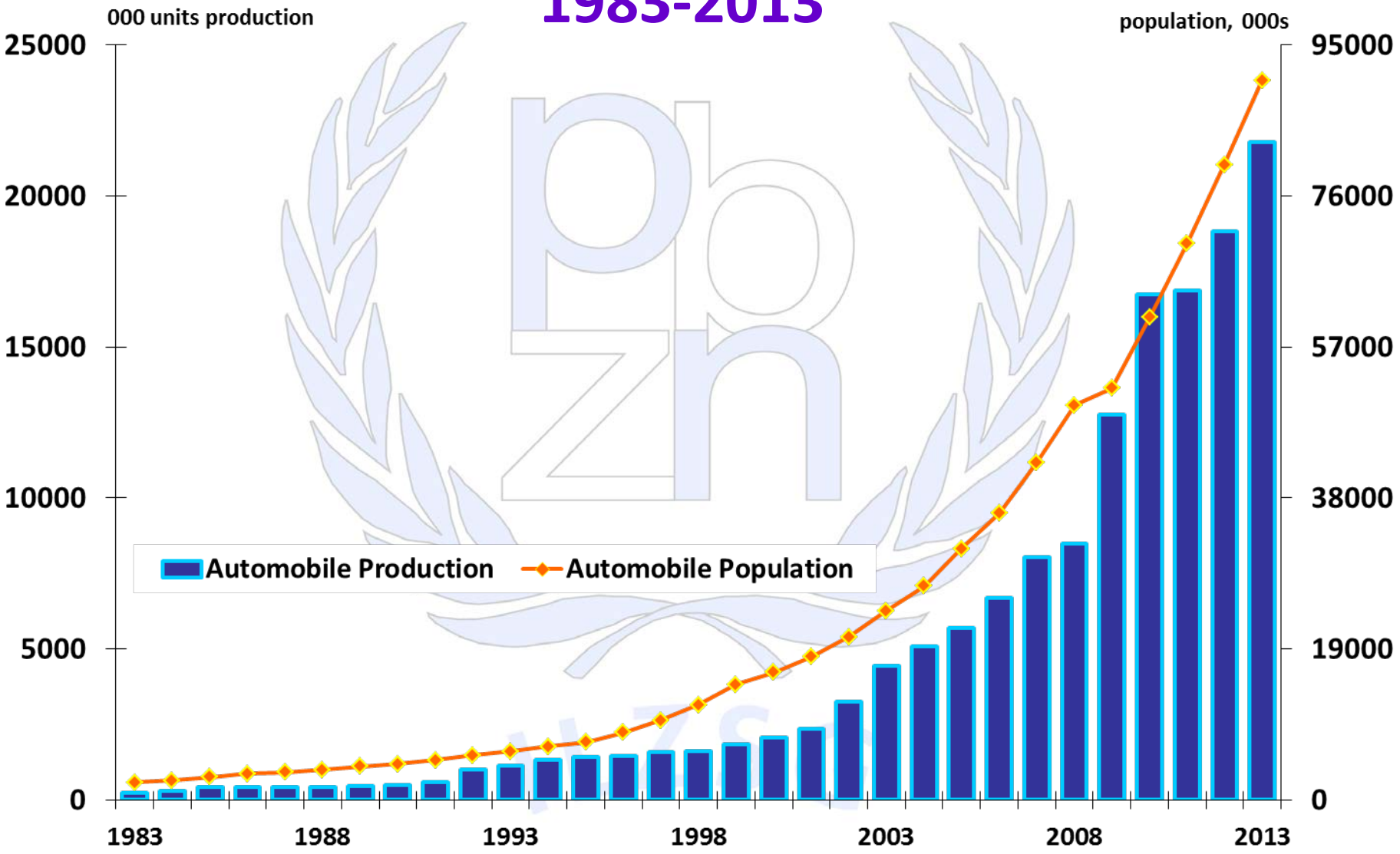
- Compared to alternatives, the Waelz kiln is a proven technology with lower energy consumption. Currently there do not appear to be any new processes that can exceed its efficiency, reliability, economics or regulatory compliance

EAF Dust Processing Plants

	Number of Plants	Estimated Capacity (Tonnes/year)
Japan	7	400,000
Republic of Korea and Taiwan	5	600,000
Europe	8	>1,000,000
North and South America	8	>1,200,000
China	1	200,000
Saudi Arabia (2015)	1	110,000

Production of Galvanized Steel in China

Chinese Vehicle Population and Production 1983-2013



Zinc Recovery from EAF Dust
Waelz Zinc Oxide

- EAF processors convert dust to **Waelz oxide (WZO)**. The WZO is sent to zinc refiners for recovery of metallic zinc and the production of high grade zinc oxides. Current alternatives include making ferroconcrete or fertilizer and nutrients in the agricultural industry
- An analysis of sampling of data on WZO produced from several dust processing facilities returned an average content of:
  - **61.4% zinc (min: 56 / max 66)**
  - 7.2% lead
  - 4.2% Chlorine
  - 2.3% Iron
  - Traces of Cd, F, Na, K, Si and Ca
- Zinc recovery out of the dust should be on the order of 95% or more

Zinc Recovery from EAF Dust Regulations

- Regulations to eliminate landfilling of EAF dust or its residues
- Tends to encourage steel making (and especially new mills) to move to countries with less restrictive regulations
- Tightening limits on gas emissions generated by the major processing technology, Waelz kilns - there have been significant advances here
- The industry that generates the waste is also recycling another major waste (scrap steel), which allows cheaper steel, higher productivity and lower energy consumption levels

Zinc Recovery from EAF Dust
Summary and Future Developments

- According to IZA and considering the end of life efficiencies, about 60% of the zinc contained in old scrap coming to end of life is ultimately recycled
- Zinc can be recycled without harming its metallurgical characteristics, there are **numerous advantages in recycling**: reducing emissions, energy use and solid wastes, reducing risks associated with concentrate price's fluctuations and supply disruptions and finally re-capturing the metal's value
- In recent years, one of the most dynamic areas has been the **zinc recovery from electric arc furnace (EAF) dust**
- EAF dust results from steel recycling in Electric Arc Furnaces. This activity is now 30% of total steel production and increasing

Zinc recovery from EAF Dust
Summary and Future Developments

- **Waelz kilns** are a proven technology and remain the predominant method of processing dust, with **over 85 % of the zinc processing market**
- EAF processors first convert dust to **Waelz oxide (WZO)** containing an average of **around 60% zinc** sent mostly to zinc refiners for recovery of metallic zinc and the production of high grade zinc oxides
- **Solvent Extraction** combines Waelz kilns technology, leaching, solvent extraction and electrowinning, allowing direct production of high grade metallic zinc independently from energy intensive primary zinc smelters
- With only one EAF dust plant operating, **China** the most likely country to offer new opportunities for dust processing and Zn recycling

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