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Towards Closed-Loop System in the Steel Industry

worldsteel Conference on Circular Economy Impact on the Steel Industry

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Contents

Circular economy is being accelerated as the 4th industrial revolution progresses, along with the energy transition and resource revolution

Energy Transition


Coal


Electricity, oil & gas


Solar & wind power

Industrial Revolution


1st

- Steam power, spinning machine

→ Mechanization


2nd

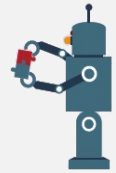
- Electricity, conveyor belt

→ Mass production


3rd

- Computer, ICT

→ Automation

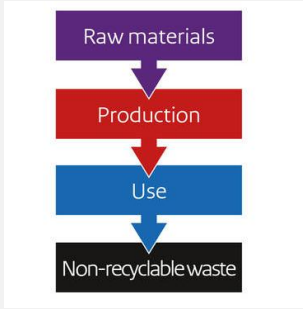

4th

- Big Data, AI, Smart manufacturing

→ Smartization

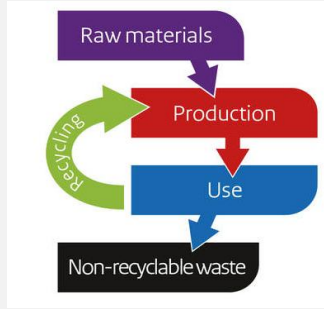
Resource Revolution

Linear



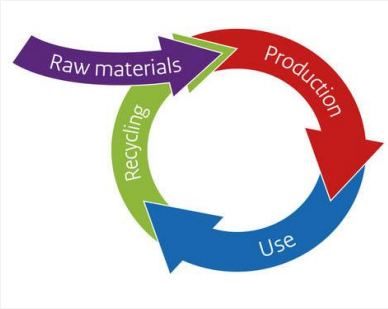
- Reduce materials consumption & waste

Partially -recycle



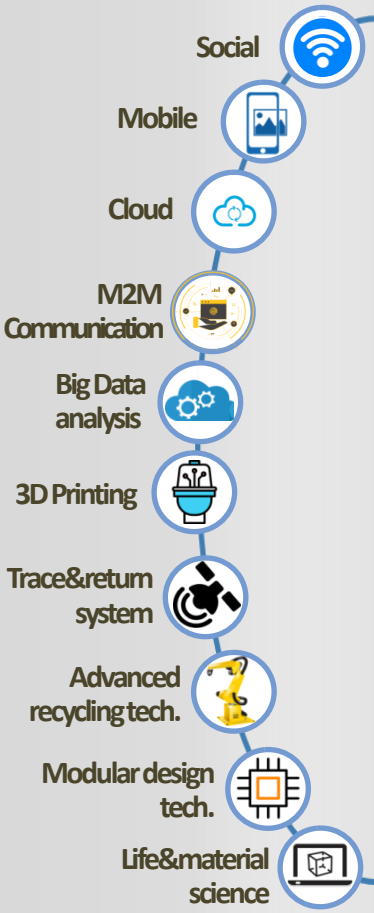
- Some level of product recycling
- Improve resource productivity

Circular Economy



- Focus on full life cycle resource productivity

New technologies and data platform enabled by the 4th industrial revolution will expedite the transition to a circular economy



1 Advanced collection, sorting and recycling technologies

- **Advanced recycling tech** for effective separation and recycling
- **Trace and return system** for cost effective collection and sorting of used goods at a scale

2 Efficient material processing technologies

- **M2M tech** to provide real-time insight of assets' status and automatically manage them
- **Big data analytics and AI** to optimize the assets' performance based on complex data analysis

3 Production technologies that support design for circularity

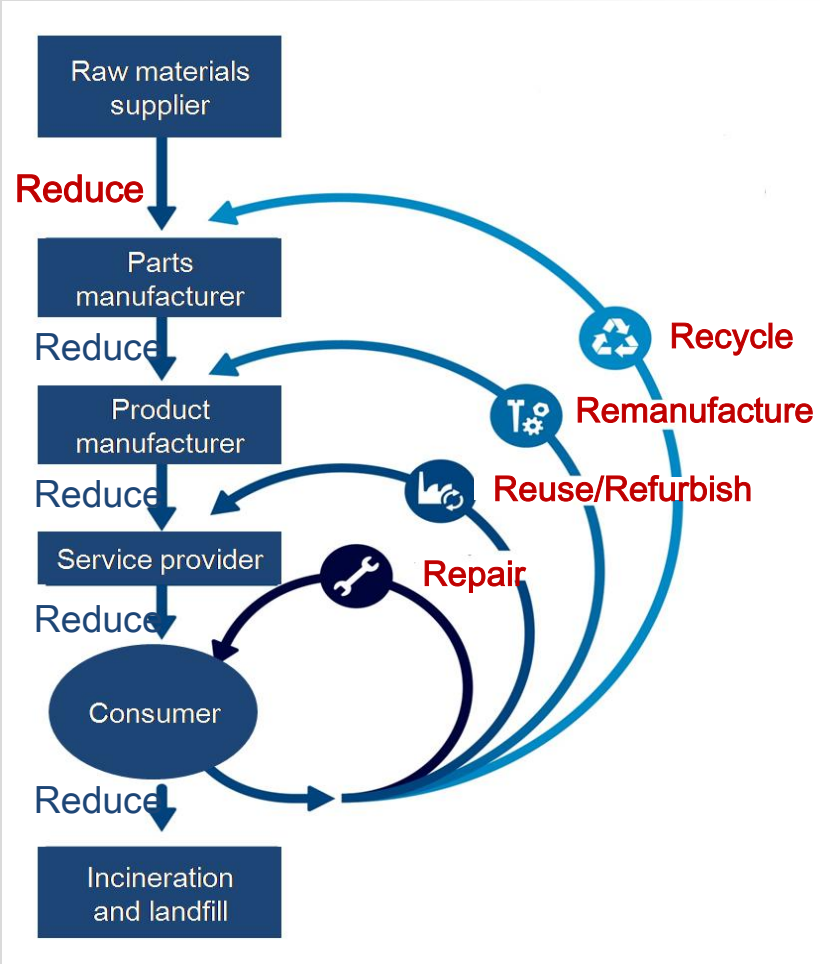
- **3D printing** which enables local, customized and resource efficient production on demand
- **Modular design** for easy upgrade and repairs, quick and cost-effective reuse of components

4 Interactive platform for enhanced connectivity

- **Mobile tech** for easy access to good and services everywhere and any time
- **Cloud** for easy access to large database and powerful applications

Source: Complied by POSRI, based on Accenture's 10 technologies for disruption

Circular economy is based on 'closing the loop' through 6Rs of products and materials which link to circular business models



6R	Description
Recycle	The series of activities by which discarded materials are collected, sorted, processed, and used in the production of new products
Remanu -facture	Returning a used product to its original performance with a warranty that is equivalent to better than that of the newly manufactured product
Reuse	Using product multiple times within its functional life by different end users
Refurbish	Bringing product back to required aesthetic specifications
Repair	Fixing faults or damage bringing product back to required functioning order
Reduce	Decreasing the amount of material, energy and other resources used to create the product

Source: Compiled by POSRI based on EMF, McKinsey and Philips

Steel has many circular advantages such as infinite recycling without loss of properties, permanent material, and easy separation and recovery

Manu-facturing

Efforts to reduce weight and emissions

Weight reduction of auto sheet (e.g. AHSS) → Weight reduction of vehicle

If the vehicle weight is reduced 10kg,

- Fuel Effiency 2.8%↑
- CO_2 emissions 4.5% ↓
- Nox emissions 8.8% ↓

Use

Long service life of steel applications

Steel use('16) & Service Life (Year)	Buidlings and Infra.	Mechanical equipments	Automobile
	50%	16%	13%
	50~100 yrs	10~20 yrs	15 yrs

Disposal/ Recycling

Recycling advantages both in terms of quantity & quality

High recycling rate	70~90% (Al 42~79,% Mg 39%), 650 Mt recycled annually
Infinite recycling	Without loss of properties
Impurities ↓	Easier to remove impurities than other materials

Source: UNEP('11), worldsteel('15), KISTI(Korea Institute of Science and Technology Information) etc.

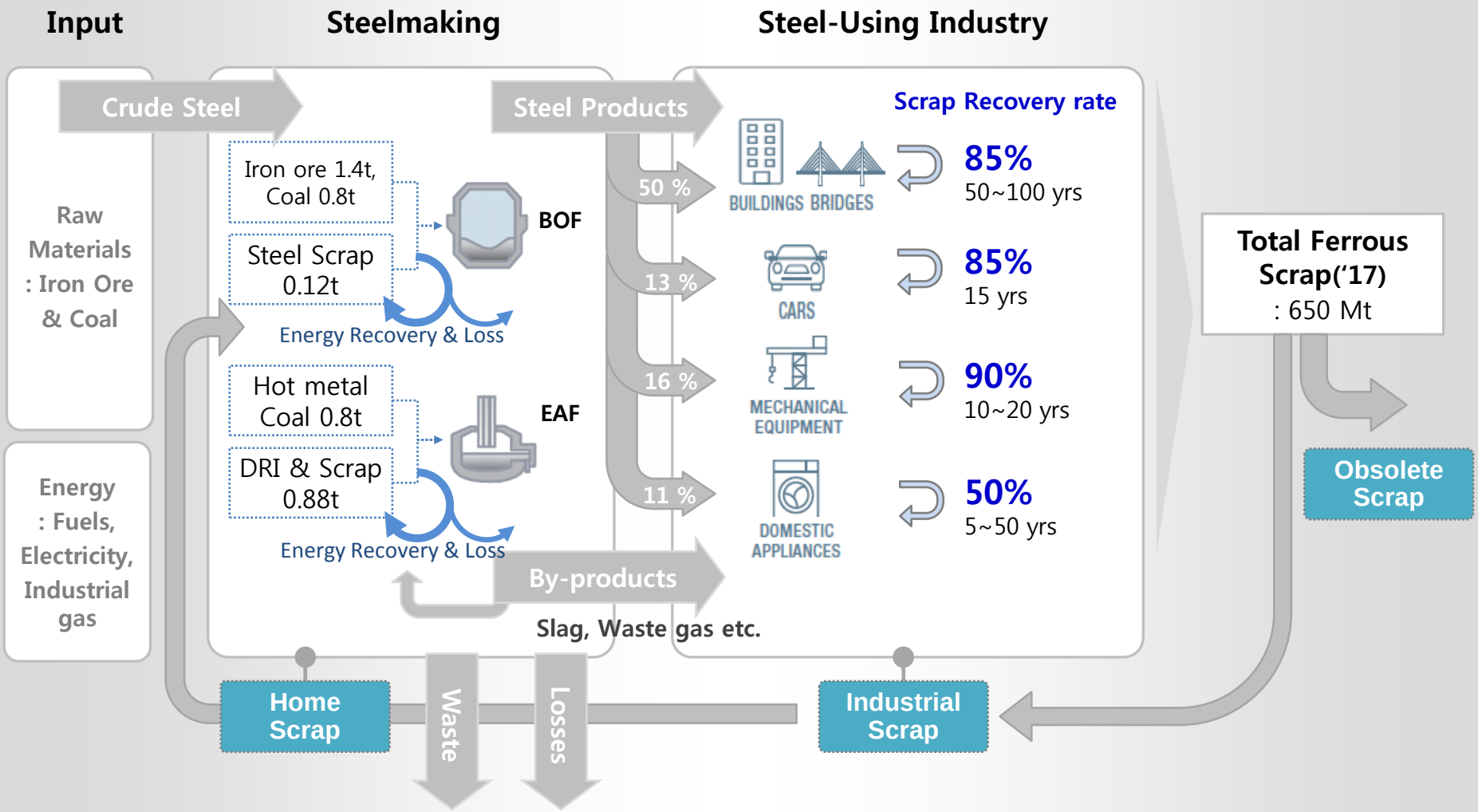
However, steel has relatively high environmental impact in its production phase compared to other key materials

[Overview of eight key materials and their environmental impacts (relative)]

Material	Production Volumes (tons)	Greenhouse gas emissions	Water consumption	Land use
Steel	9%	23%	2%	0%
Aluminium	0%	1%	0%	0%
Plastic	2%	3%	1%	0%
Cement	21%	30%	0%	0%
Glass	1%	2%	0%	0%
Wood	14%	1%	0%	52%
Primary Crops	47%	14%	96%	22%
Cattle	6%	26%	2%	27%

Source: 'Circular economy and environmental priorities for business', Ecofys and WBCSD, May 2017

Scrap recovery rate varies from 50~90%. There are still considerable losses of material and energy with each stage of production and use



Source: worldsteel factsheet: steel and raw materials, world steel outlook(2017-2018), world steel recycling in figures (2013-2017)

What causes circular leakages in the steel industry

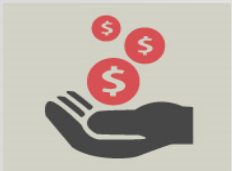
Losses and waste are coming from material complexity, geographic dispersion, lack of incentives and infrastructure

Material complexity

- Mixed streams of products from different industries
- High level of material variation and complexity
- Difficulty in identifying, separating and recycling materials

Geographic dispersion

- Recovery/recycling system mostly localized and fragmented
  - scrap collection rate, recovering/recycling technologies and costs
- Disjoint supply chains



Lack of Incentives

- Low intrinsic value of products/material per unit
- Lack of markets at scale and 'right' policies

Lack of infrastructure

- Lack of data and infrastructure to support closed-loop system
  - global material flows, life cycle environmental impacts
- Need for greater digitalization of the recycling chain

Understanding the value chain impact

Circular economy will affect not only steel making processes but also the entire value chain of the steel industry

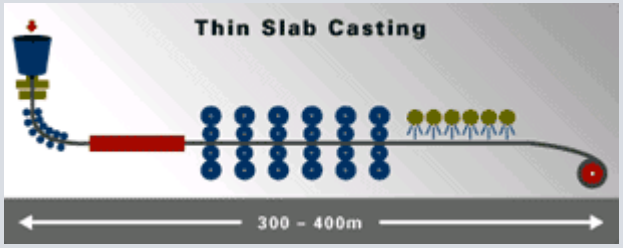
Circular Economy

	R&D	Raw Materials	Manufacturing /Process	Product	Logistics & Service
Changes	• Product develop-ment & design based on life cycle analysis • Process innovation with carbon free and zero waste	• Enhanced recycling of resources • Substitutable renewables, eco-friendly raw materials	• Minimize losses and improve environmental impacts • Smart tech-based management of resources and waste streams	• Ultra light, high strength & high performance • longer service-life, recyclable steel • By-products as a source of revenue stream	• Reverse logistics for wider range of product categories • Circular economy data platform and e-marketplace
Case examples	thyssenkrupp	NUCOR		posco	mjunction

[Nucor] Advanced scrap-based steel production mills

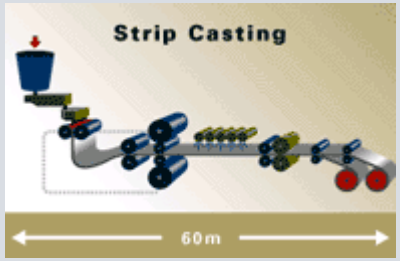
Innovations

Minimill



- Thin slab(50mm)
- Faster casting speed & less energy consumption
- Dust & water recycling

Micromill



- Thin strip steel(0.7~2mm)
- Faster production and more responsive order and timeline
- Much less energy consumption and CO_2 emission
- More adaptable and applicable to install nearby scrap production sites or customers

Values

- **Reduce energy intensity and carbon emission**
- **Reduce the cost of input raw materials, inc. scraps**
- **decentralized recycling among scrap sites and customers**
- **Enable to produce ultra-thin cast strip and increase the productivity**

Source: 'The Castrip® Advantage', Castrip LLC, 2018

[POSCO] Product innovation from a circular perspective: *PosMAC, GIGA Steel*

“ Eco-friendliness, recyclability in particular, will become a key to product quality.”

GIGA Steel

≈ 1,000MPa
(mega pascal tensile strength)

- High performance and easy fabrication
- High durability and longer life cycle
- Life cycle impact reduction - roughly 10% in vehicle

PosMent

CO_2 60% ↓
Compared to conventional cement

- Higher slag contents replacing cement clinker - Max. 5% → 40~60%
- Improved physical properties e.g. pressure resistance and strength

- Establishment of LCI(Life Cycle Inventory) DB for POSCO WP(World Premium) Products
- Promotion of EPD(Environmental Product Declaration) Certification

Energy Saving — Optimize resources & energy in the entire life cycle

Recycle — Re-use or recycling options are available at the end of the life cycle

Environmental Impact — Enhanced environmental & qualitative credentials

[Tata Steel] Sharing platform for scrap and by-products (e.g. secondary steel)

mjunction
innovating for outcomes

- Established in 2001 by Tata Steel and SAIL
- Transaction value: $13.8M in 2002 → $9.45B in 2016

14M
tonnes of steel sold

300M
tonnes of coal sold

6,000CR = 60 bil. rupee
worth idle asset sold

"The world's largest e-market for steel, India's biggest e-commerce company"

metaljunction
- Bid for secondary, over-rolled, scrap, by-products
- Buying from 12,000 registered bidders & 10 Plants

valuejunction
- Sale of idle assets, which include industrial assets, stressed assets and retail surplus

for Seller,

Efficiency improved
- Reduced time, cost, inventory

Better Price & Revenues

Transparency

for Bidder,

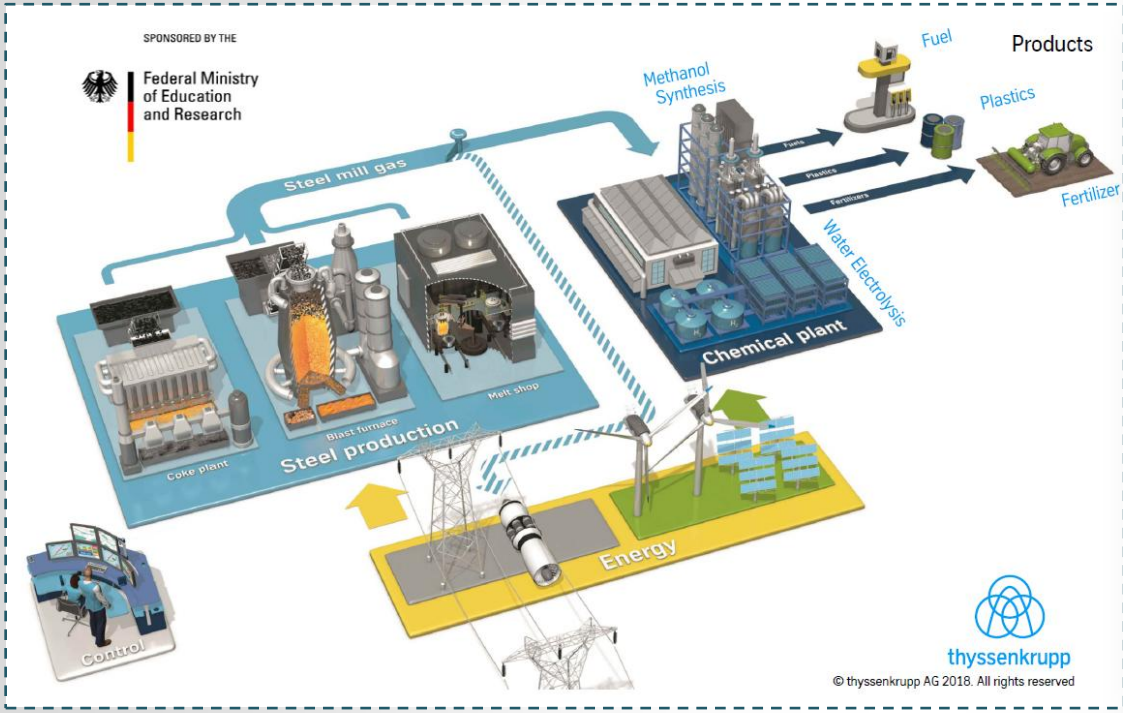
Reliable transparent transaction

Logistics & inspection

Convenience & Service

[ThyssenKrupp] Cross-industry utilization of CO_2 as a valuable raw material

The Carbon2Chem® project



Carbon2Chem® Project

- **Goal:** Using emissions from steel production as raw material for chemicals
- **Status:** Pilot plant (in Duisburg) construction completed, start operation in the 2nd half of 2018
- **Values**: ① Cost-effectiveness and fossil fuels savings, ② CO_2 reduction, ③ Jobs and growth

*20mtCO_2/y reduction from steel industry if fully implemented

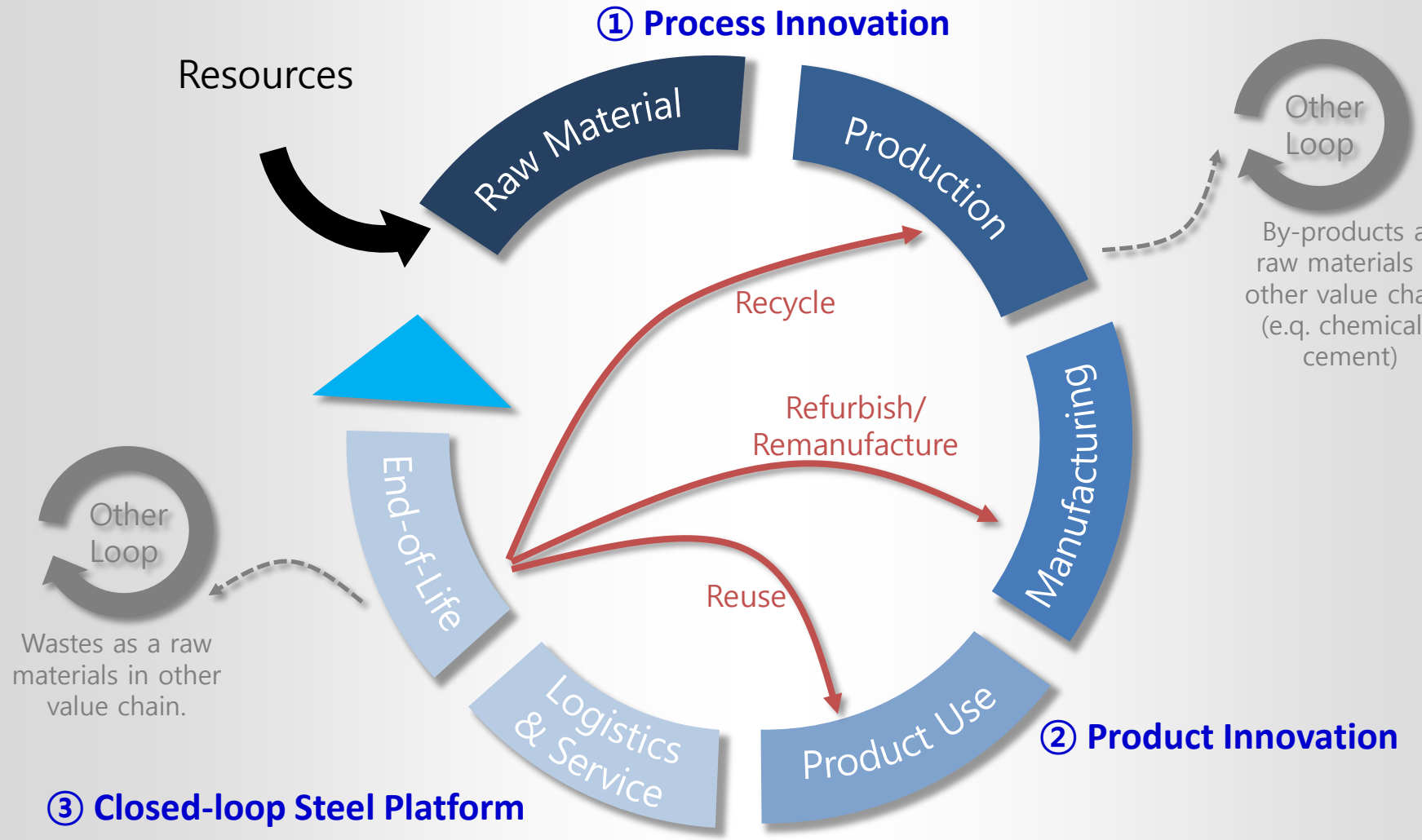
Large amount of waste gas from steel process (about 300,000m3/day)

For energy efficiency,
Waste gas → power plant → CO_2+power

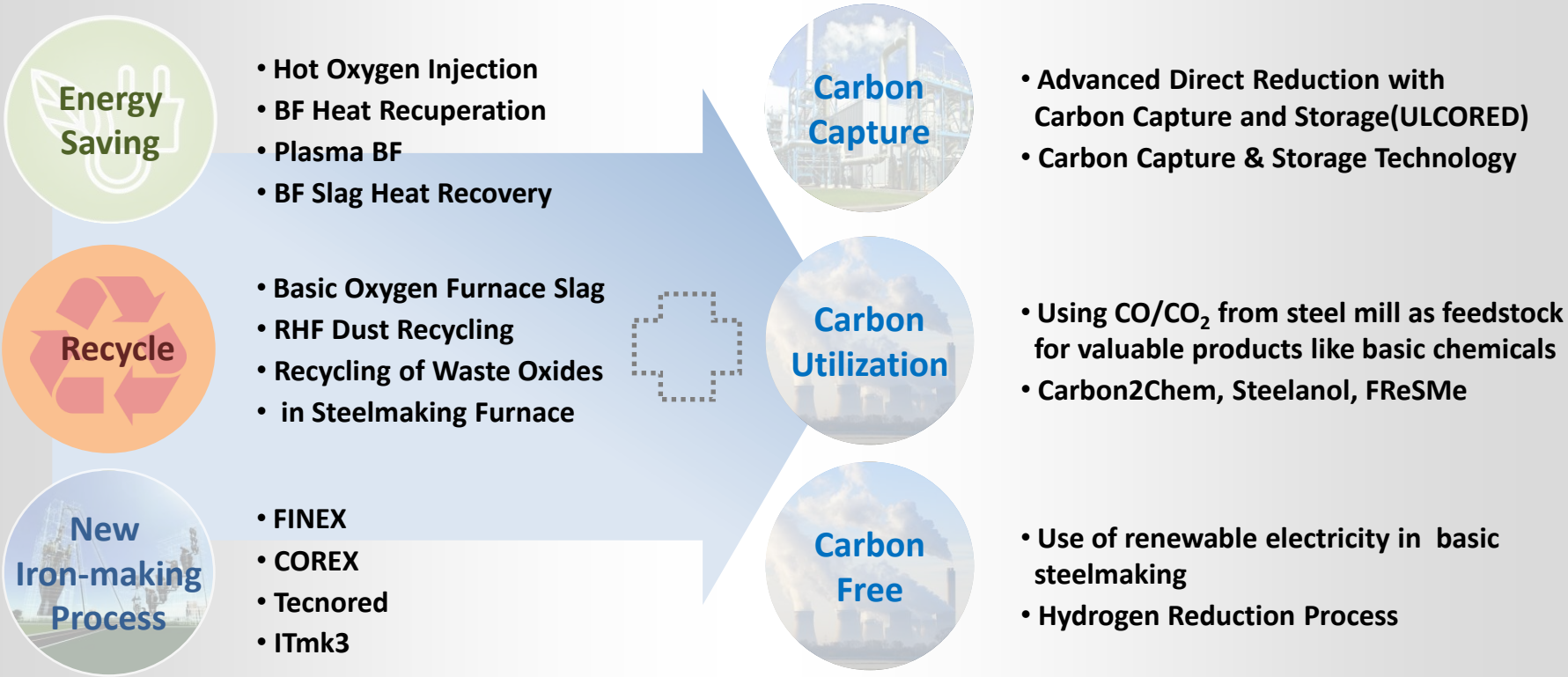
Applying CCU
Waste gas → synthesis → chemical products (methanol, polymer, etc.)

Value creation in a circular economy

Circular economy model for the steel industry



❶ Process innovation – Circular economy and global climate action with the 4th industrial revolution will lead to eco-friendly steel making processes



❷ Product innovation – Maximize the product's circularity (e.g. longevity and recyclability) and minimize the life cycle impact of products

Design for closed-loop product

- Products are designed to minimize the resource and energy intensity across the life cycle
- Design for long service life, efficient reuse and remanufacture
  - e.g. modular steel buildings

Explore life cycle implications

- Assess the product's life cycle impact or environmental footprint to identify strengths and weaknesses
- Review current and emerging customer requirements and understand their life cycle implications

Create value from by-product

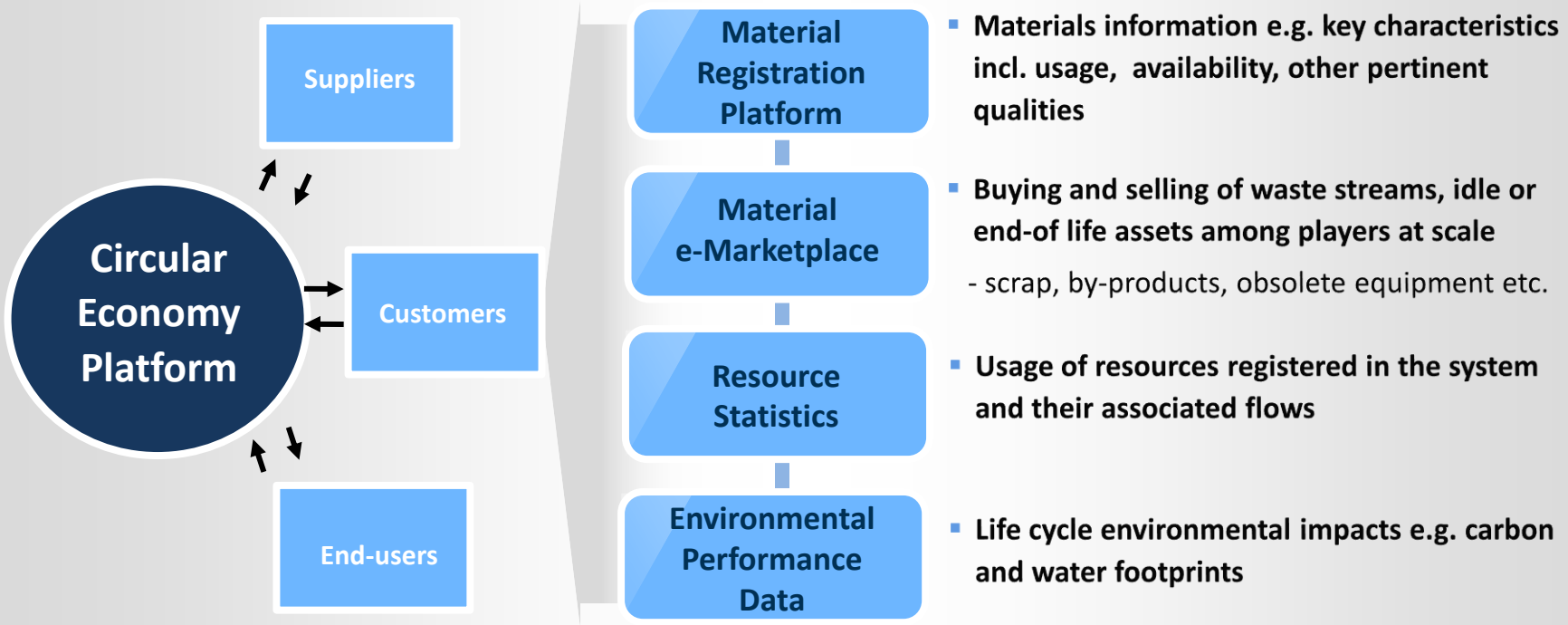
- Further improve by-product recovery rates and expand its use by improving the quality of the materials recovered
- Channelize by-products for commercial applications like slag being used in concrete and road construction

Image credit: worldsteel

❸ Closed-loop Steel Platform – Data/digital infrastructure for increased resource flow efficiency

"Information is at the heart of ensuring that business around the world can make the right decisions to eradicate waste and use resources efficiently"

EMF, Intelligent Assets: Unlocking The Circular Economy Potential, 2016



Source: Complied by POSRI, based on EMF, Accenture and District0x reports

The steel industry will face many stumbling blocks in order to achieve a closed-loop system which will bring enormous changes in its value chain

- ✓ **Steel has many circular advantages in recycle, reuse and remanufacture, however there is considerable potential for improvement**

- ✓ **To respond to circular economy challenges and opportunities, there are three key areas of focus:**
  - Process innovation for reducing energy and resource intensity, and eco-friendly steelmaking processes with CCUS(Carbon Capture, Utilization & Storage)
  - Product innovation for maximizing the circularity and minimize the life cycle impacts
  - Create a 'Closed-loop platform' across the supply chain for the steel industry to increase resource flow efficiency

Deeper collaboration across the supply chain is needed based on a closed-loop, circular economy platform in order to stay competitive and capture circular biz. opportunities

Thank you!

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If you have any comment and suggestion on this presentation, please feel free to send an e-mail to ‘jgoh@posri.re.kr’.