Waste and By-Product Management Programs

1. Background information

The steel industry is the cornerstone of industrial development and the core of economic development. Its extensive industrial linkages can stimulate the upstream and downstream industrial chains, thereby fostering the development of various sectors and creating opportunities for a circular economy. Therefore, China Steel Corporation (CSC) focuses on the recycling and reuse of waste and by-products. Utilizing the integrated characteristics of its steel manufacturing processes and its innovative research and development capabilities, CSC evaluates the physical and chemical properties, substitutability, and usage benefits of resources. It develops various resource utilization pathways that integrate with steelmaking and rolling processes to reduce the use of natural raw materials, thereby achieving carbon reduction.

(1) Waste

Wastes include general industrial waste and hazardous industrial waste. CSC's waste mainly consists of dust ash, sludge, and refractories, all treated as resources for recycling. All dust ash is recycled within the ironmaking plant, while efforts continue to reduce the amount of sludge and refractories and integrate recycling programs to achieve the “zero landfill target”.

(2) By-products

By-products include blast furnace slag (BF slag), basic oxygen furnace slag (BOF slag), desulfurization slag, iron oxide fines, mill scale, coal tar, etc., treated through resource processing and supplied to chemical, construction, civil engineering, electrical, and consumer industries. This enables effective reuse of resource and expands into a resource recycling industrial ecology network, not only increasing resource utilization efficiency but also reducing environmental impact from long-distance transportation, thereby achieving carbon reduction benefits.

2. Targets

(1) Continue to achieve the goal of “zero waste solidification to landfill”.

(2) The annual waste production is below 800,000 metric tonnes, of which the waste reuse rate is above 90% and the waste disposal rate is below 10%. By 2030, the annual waste production will be reduced by 10%, and the waste reuse rate will be increased to above 94 %, while the waste disposal rate will be reduced to below 6%.

(3) The resource recovery rate of by-products is 100%.

3. Audits

(1) Autonomous management and audit by CSC

To ensure that the recycling and reusing process of various wastes and by-products complies with environmental regulations, CSC annually establishes audit plans with varying frequencies for different types of waste and by-products. Relevant internal departments collaborate on these audits, examining the classification, storage, transportation, and handling operations of waste and by-products, as well as the operation of treatment facilities and on-site environmental management from their respective professional perspectives. Following the audits, audit reports are compiled, and responsible departments are requested to implement improvements within a specified timeframe. After confirmation through follow-up reviews that improvements have been completed, subsequent reviews continue to assess ongoing performance.

Category	Frequency
Sludge	Quarterly
Used Refractory Materials	Quarterly
Scrap Steel	Quarterly
Waste Wood	Annually
Other General Industrial Waste	Irregularly
Hazardous Industrial Waste	Annually
Recyclable Products	Annually
BOF Slag	Quarterly
Desulfurization Slag	Annually

(2) Third-Party independent verification

I. CSC discloses the waste diversion rate from landfill in the sustainability report and engages a third-party independent accreditation with AA1000 Type 2 high level assurance.

II. For wastes and by-products with significant output, CSC annually commissions third-party verification from independent entities (such as ITRI) to conduct environmental audits of the factory and third-party inspections of the self-management plans. The third-party entities audit the management systems, production, application sites, corrective improvements, and other aspects of the wastes and by-products from both a systems and operational perspective, assessing the integrity of the system, document records, standardized processes, product quality, storage methods, sales records, quantity balance, flow tracking, anomaly management, contingency measures, risk analysis, and improvement measures. This ensures that wastes and by-products are appropriately managed and utilized both internally and externally within the CSC Group, complying with environmental regulations and continually being improved and revised.

III. For by-products and products with excellent circular economy benefits, CSC Group also commissions independent third-party entities to conduct verification processes. For example, applications of BOF slag in asphalt concrete pavement and land reclamation, granulated blast furnace slag in construction materials, and desulfurization slag and coal ash mixed with sludge (iron slag) in cement raw materials are verified through the BS 8001 circular economy standard by British Standards Institution (BSI). Additionally, galvanized steel products (SGCC) with added recycled materials have obtained UL 2809 validation for recycled content.

(3) Supervisory authority inspections

The Ministry of the Environment, the Ministry of Economic Affairs, and local environmental protection bureaus conduct unscheduled on-site inspections of

relevant wastes and by-products at CSC every year. These inspections ensure that CSC properly executes the classification, storage, transportation, and operational management of waste in accordance with the law.

4. Action plans and R&D

Before planning the production process, CSC conducts feasibility studies on the process, by-product applications, and waste recycling design, incorporating potential impacts on the natural environment into relevant assessments and completing risk identification. To reduce the environmental burden during operations, CSC follows the concept of the steel life cycle, dedicating efforts to developing various recycling technologies and reusing process waste. Additionally, CSC integrates internal and external resource links within the coastal industrial zone, incorporating usable resources into production planning. This not only ensures the proper recycling and application of industrial by-products and waste within the plant, reducing the risks of outsourcing disposal, but also lowers production costs and achieves circular economy benefits.

In addition to researching and producing low-carbon steel, CSC has also invested considerable technical research and funds towards effectively circular reusing and recycling the raw materials used in the processes and the wastes generated from them. Currently, over 100 personnel are dedicated to research and development in resource recycling. By the end of 2023, CSC's cumulative investment in various environmental protection facilities reached NT$91.2 billion, with waste pollution prevention accounting for 7% of this total. To date, CSC has achieved substantial results in resource recycling and reuse, as demonstrated by the following cases:

(1) Cyclical use of waste pickling acid

Cold-rolled coil is a major product of CSC. Prior to entering the cold-rolling process, hot-rolled coils at the frontend must undergo acid pickling to remove surface rust. The residual acid after pickling remains corrosive and contains various alloy elements, which may potentially lead to environmental pollution due to improper treatment. Adhering to the government's “circular economy” policy, CSC has established an acid regeneration plant (ARP) to purify and

recycle the waste acid following the examples of advanced countries, such as Japan, European countries, and the United States. The products from the ARP are mainly regenerated hydrochloric acid (HCl) and iron oxide powder (Fe_2O_3). The regenerated hydrochloric acid is reintroduced into the pickling process, while iron oxide powder serves as an industrial raw material for soft and hard ferrite used in various electronic and electrical applications, including inductor components, transformers, motors, and so on. This successful example of resource reutilization can be considered as a good model of circular economy.

(2) Cyclical use of sludge

More than 98% of industrial water used in CSC is re-cooled, filtered, dispersed, and coagulated to produce “sludge.” Sludge has great economic value because it contains various types of raw materials such as rust, iron ore, coke, and fluxes. Therefore, CSC recycles and reuses sludge upon dehydration to reduce the use of natural minerals, as well as sells the remaining iron-containing sludge to cement plants after processing and mixing them, thereby reducing the need for cement plants to purchase import iron slags from abroad. In 2023, CSC sold 44,000 tonnes of sludge-coal fly ash mixture in total.

(3) Cyclical use of used refractory materials

In order to protect high-temperature equipment in steel smelting and rolling processes (such as blast furnaces, basic oxygen furnaces, hot stoves, and reheating furnaces), CSC regularly replaces refractory materials in such equipment during the production process. Since refractory materials are mainly composed of aluminum, silicon, carbon, and magnesium, and meet the requirements of additional materials to be added to the smelting process, CSC sorts and processes used refractory materials based on their characteristics before recycling them into excipients for steelmaking and ironmaking at its plants. Used refractory materials are also recycled by suppliers or used as raw materials for cement outside CSC plants. In 2023, CSC recycled about 88,000 tonnes of used refractory materials, of which 79% were recycled within its

plants and 21% were used outside its plants, thereby minimizing the impact of these materials on the environment.

(4) Utilization of slag

I. Application of granulated blast furnace slag in construction materials

Granulated blast furnace slag powder produced from the blast furnace ironmaking process can be used to replace cement clinker. Its components undergo a pozzolanic reaction, promoting late-stage strength growth in concrete, thereby enhancing concrete strength and engineering quality. In 2022, it passed the BS 8001 circular economy audit by the British Standards Institution (BSI), achieving Level 4 (Optimizing) maturity in its business model for the application of granulated blast furnace slag in construction materials. It serves as an indispensable green material for the cement industry.

II. Application of BOF slag in asphalt concrete pavement

The hydrophobic nature of BOF slag allows asphalt to envelop it more easily, preventing it from stripping off due to water infiltration. Incorporating porous asphalt concrete with BOF slag aggregates increases its continuous porosity and permeability, prolonging the drainage function of asphalt pavements. This application also addresses road flooding and urban cooling, enhancing road safety and comfort for drivers. The hard and wear-resistant characteristics of BOF slag aggregates significantly improve the overall resistance to rutting on roads, further reducing the frequency of pavement damage and saving on labor and materials during maintenance. This application achieved Level 4 (Optimizing) maturity in its business model for the application of BOF slag in asphalt concrete pavement, as verified by the BS 8001 circular economy audit conducted by the BSI in 2019.

III. Application of BOF Slag in land reclamation

Using BOF slag as material for land reclamation projects in ports enhances land creation efficiency and maximizes land resource

utilization. This application reduces the need for natural resource extraction, lowers construction costs, minimizes environmental impact, and generates carbon reduction benefits. In 2022, it achieved Level 4 (Optimizing) maturity in its business model for the use of BOF slag in land reclamation, as verified by the BS 8001 circular economy audit conducted by the BSI.

IV. Application of BOF slag and desulfurization slag in cement raw materials

BOF slag produced from the steelmaking process shares mineral similarities with cement minerals, allowing it to replace natural materials such as limestone, silica, and iron ore in cement production. Additionally, desulfurization slag produced from desulfurization processes is processed into mineral fine aggregate through wet ball milling and magnetic separation, serving as a substitute for secondary limestone. By applying these materials in cement plants as cement raw materials, both economic and environmental benefits are achieved. These applications respectively passed the BS 8001 circular economy audit conducted by the BSI in the years 2021 and 2022, attaining Level 4 (Optimizing) maturity in their business models for the use of BOF slag and desulfurization slag in cement raw materials.

(5) Development of Recycled Steel Products

In 2021, CSC initiated research and development into advanced recycled material smelting technologies, aiming to increase the proportion of recycled materials. The percentage of recycled materials, specifically in the production of galvanized steel SGCC, was successfully raised from 8% to 12%. This achievement was validated through rigorous production processes and recycled material management reviews conducted under the environmental declaration verification of UL 2809 by the well-known American verification organization, Underwriter Laboratories (UL). This made CSC the world's first steel mill to obtain UL 2809 recycled content validation, ensuring the credibility of its recycled material products. In 2022, certifications were obtained for hot-dip galvanized SGCC RC20 and electro-galvanized SECD

RC12 products, anticipating expanded supply of diverse recycled steel products to downstream customers. Future efforts will focus on further research and development in steelmaking technologies for recycled steel materials, establishing a new paradigm in circular economy practices.

5. **Training:**

In addition to the monthly pre-meetings and meetings to review the production and application progress of various waste and by-products, CSC also organizes at least two group-wide seminars annually. These seminars are conducted by colleagues from the Environmental Protection Department of CSC or external experts and scholars. They provide updates and information to supervisors and staff across the CSC group on domestic and international regulations and standards for waste and by-products, management practices, waste reduction measures, application methods, and research and development technologies. This effort aims to strengthen environmental management knowledge within the group and ensure its implementation throughout CSC. Additionally, CSC periodically sends representatives to attend professional training courses on waste clearance and treatment organized by the National Environmental Research Academy, enhancing departmental expertise to continually improve waste management practices.