TCC Group Holdings Global Cement & Concrete Business Units Net-Zero Pathway Formulate Steps (Version 1, 2024)

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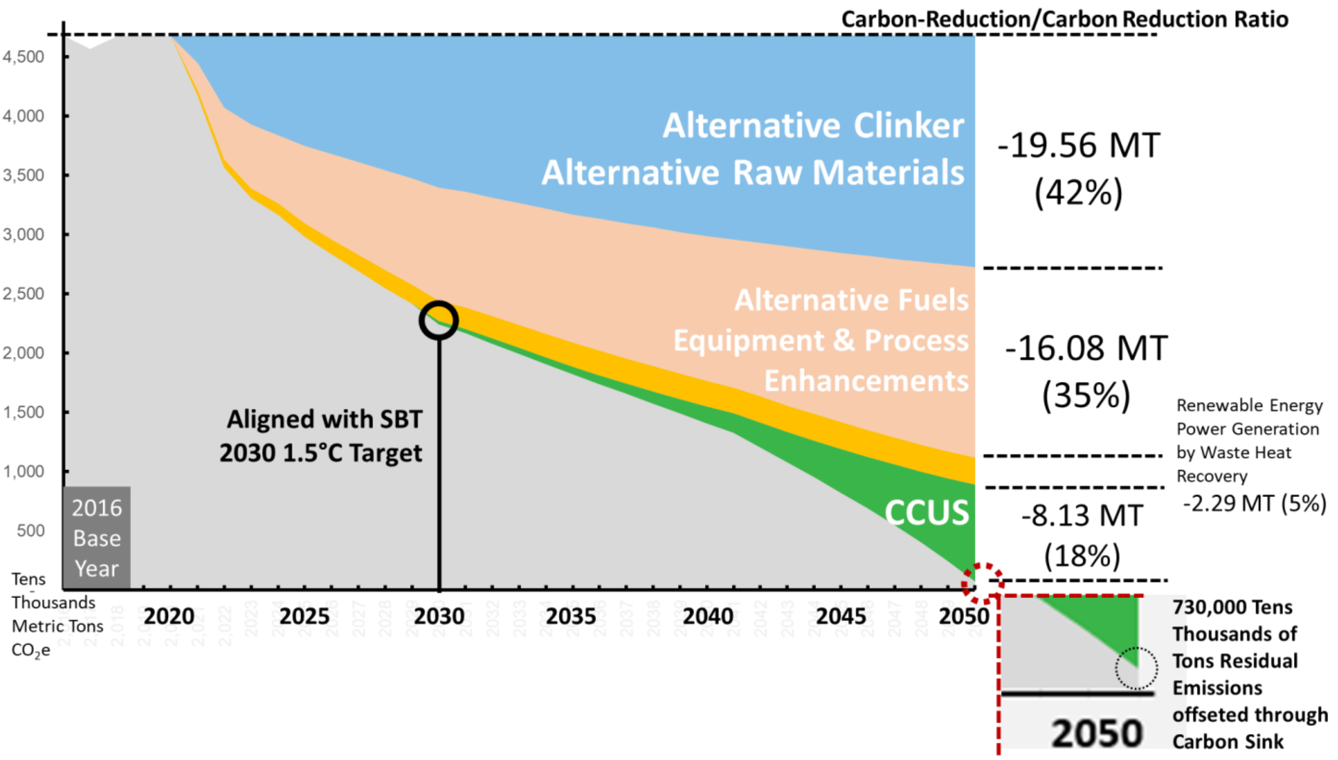

Summary of Pathway Formulate Steps

<u>Basis for TCC Group Holdings Global Cement & Concrete Business Units Net-Zero Pathway</u>

The Net-Zero Pathway for TCC Group Holdings Global Cement & Concrete Business Units is responding to the ISO IWA 42 Net Zero Guidelines by establishing a Science-Based Pathway. It refers to the Open-Source equations of the En-ROADS Climate Solutions Simulator developed by the Climate Interactive, MIT Sloan Sustainability Initiative, coupled with the logic of the International Energy Agency's (IEA) Global Energy and Climate Model. The company's greenhouse gas factors are broken down based on TCC's ISO 14064-1 inventory results.

The Net-Zero Pathway scope covers TCC Group Holdings Global Cement Business, including cement and RMC plants across Taiwan, Mainland China, Turkey, Portugal, Low-carbon R&D Centers, and TCC Headquarters in Taiwan. It aligns with the UN report "Integrity Matters: Net Zero Commitments by Businesses, Financial Institutions, Cities and Regions," recommended in line with IPCC or IEA net zero GHG emissions modelled pathways, referring to IEA 2023 updated Net-Zero Roadmap Report and World Energy Outlook 2023, and input past activity data and carbon reduction performance to simulate the Net-Zero Pathway to 2050 for the Cement & Concrete Business.

Upon reviewing the Net-Zero Pathway for the TCC Group Holdings Global Cement & Concrete Business Units, achieving the SBTi Interim 1.5°C target that the company plans to submit in 2024 is feasible in the context of existing regulations, permissions for alternative raw materials and fuels, and market demand.

1. <u>Processes Emissions</u>

The main factors to process emissions include cement production, clinker-to-cement ratio, proportion of alternative raw materials, and the CaO and MgO content in alternative raw materials. *(For detailed carbon reduction measures, refer to the 2023 TCC Group Holdings Sustainability Report, pp. 63-85)*

Cement production projections for Taiwan, Turkey, and Portugal plants are based on the IEA NZE Scenario. In contrast, those for Mainland China are based on predictions from the Institute of Technical Information for Building Materials Industry of China and the China Cement Association. The clinker-to-cement ratio and the proportion of alternative raw materials consider the alternative raw materials and clinker plan of the group for carbon reduction, as well as IEA recommendations for the cement industry's Net-Zero Pathway, sustainability report targets, and data from the Carbon Reduction Management Platform.

The carbon reduction measures for alternative clinker and raw materials are estimated to reduce emissions by approximately 19.56 million tons by 2050, contributing about 42% to the Net-Zero Pathway.

2. Combustion Emissions

The main factors for fuel combustion emissions include clinker production, energy consumption per unit of clinker produced, proportion of alternative fuels, and biomass contained in biofuels. *(For detailed carbon reduction measures, refer to the 2023 TCC Group Holdings Sustainability Report, pp. 63-85)*

These parameters are drawn from past production data, sustainability report targets, and the IEA's recommended proportion of low-carbon fuels in the cement industry's Net-Zero Pathway.

Carbon reduction measures for alternative fuels and process improvements are estimated to reduce emissions by approximately 16.08 million tons by 2050, contributing about 35% to the overall Net-Zero Pathway.

3. Indirect Emissions from Imported Energy

The main factors of indirect emissions from electricity consumption include cement production, electricity consumption per unit of cement produced, renewable energy usage, power generation by waste heat recovery, and the emission factors from the local grid's electricity. *(For detailed carbon reduction measures, refer to the 2023 TCC Group Holdings Sustainability Report, pp. 63-85)*

These parameters are based on past production data and sustainability report targets. To conservatively estimate the corporate Net-Zero Pathway, scenarios in which some countries do not achieve an electricity emissions factor of zero by 2050 should be considered.

Therefore, the estimates are based on the IEA model's APS Scenario and the Ministry of Environment of Taiwan's Low Emission Analysis Platform model's Policy Scenario for grid electricity carbon emission factors.

The carbon reduction measures for renewable energy and power generation by waste heat are estimated to reduce emissions by approximately 2.29 million tons by 2050, contributing about 5% to the Net-Zero Pathway.

4. Carbon Capture, Utilization, and Storage (CCUS)

TCC prioritises the measures above to reduce carbon emissions, with CCUS as a last resort for reducing CO2 emissions. Considering the sustainability report targets, the IEA's Net Zero Roadmap, and the simulation results of the above-mentioned carbon reduction measures, the CCUS targets for each year are set accordingly. **Annual CO_2 capture capacity for the group by 2050 will be 8.13 million tons, contributing about 18% to the Net-Zero Pathway.** **Compared to the GCCA's estimate of 36%, the IEA's 48%, TCC's Net-Zero Pathway CCUS proportion of 18% is more realistic.**

5. Counterbalance Residual Emissions in 2050 To achieve the SBT 2050 Net-Zero Target, TCC Group Holdings Global Cement & Concrete Business Units will have a residual CO_2e volume of 730,000 tons that needs to be counterbalanced. According to the SBT's Cement Science Based Target Setting Guidance, after achieving the long-term SBT Target, any residual emissions must be permanently removed and stored to achieve Net-Zero emissions. Methods that may be adopted include improved soil management, improved forest management, and land restoration, e.g., of forest and mangroves. Residual emissions can be handled following the ISO IWA 42 Net-Zero Guidelines "Counterbalancing Residual Emissions."

Detailed Explanation	
Basic Definition and Coverage of the Net-Zero Pathway	
Definition	The Net-Zero Pathway is based on scientific evidence and aims to achieve Net-Zero greenhouse gas emissions in alignment to limit global warming to 1.5 degrees Celsius (1.5°C). This definition refers to the ISO IWA 42:2022 Net-Zero Guidelines.
Scope	This Net-Zero Pathway chart pertains to TCC Group Holdings Global Cement & Concrete Business Units. The Coverage includes TCC Headquarters, a Low-carbon R&D Center, Cement Plants in Taiwan, Cement Plants in Mainland China, Turkey and Portugal, RMC Plants in Taiwan, Turkey and Portugal, and Grinding Stations in Turkey and Portugal.
	Emissions Sources included in this Net-Zero Pathway Are: ■ Category 1: Stationary Combustion, Mobile Combustion, Process Emissions, and Fugitive Emissions ■ Category 2: Indirect Emissions From Imported Energy
Base Year	2016

Formulate the Net-Zero Pathway Process	
Step 1 Greenhouse Gas Inventory	According to the ISO 14064-1:2018 standard, a greenhouse gas inventory for Category 1 and 2 emissions was conducted. BSI verified the results as the corporate Net-Zero Pathway data foundation. This version adopts the 2023 inventory results.
Step 2 Decomposing influencing factors of greenhouse gas	**Step 2-1:** Based on the Technical Reference of the En-ROADS, developed by the MIT Sloan School of Management, apply the Kaya identity to decompose greenhouse gas emissions into four influencing factors: *Greenhouse Gas Emissions = Population × GDP per capita × Energy intensity of GDP × Carbon intensity of Energy* 1. Population (Unit: People) 2. GDP Per Capita (Unit: GDP/Per capita) 3. Energy Intensity (Unit: Energy Use/GDP) 4. Carbon Intensity (Unit: Greenhouse Gas Emissions/Energy Use)
	Step 2-2: **Since En-ROADS is a global climate simulator, the decomposition formula must be adapted for industry scales. Therefore, the International Energy Agency's (IEA) Global Energy and Climate Model must also be used, which applies the Kaya equation to decompose greenhouse gas emissions on an industry scale into four influencing factors:** *Greenhouse Gas Emissions = Industry Activity Data × Industry Structural Changes × Energy Intensity ×* CO_2 *Intensity*

Step 2-3:

Refer to the Open-Source equations of En-ROADS and the IEA's Global Energy and Climate Model calculation logic; decompose the factors for various emission sources based on the characteristics of the cement industry. The primary emission sources analyzed are stationary combustion, process emissions, and indirect emissions from electricity. For analysis of Taiwan plants, these sources account for 99.99% of the total emissions. Fugitive emissions are excluded due to their minimal contribution (e.g., methane from septic tanks, refrigerants from air conditioners, spot welding equipment, and fire extinguishers), for which no individual reduction measures have been planned. To achieve Net-Zero goals, these will be addressed according to ISO IWA 42 standards by 2050, along with other remaining residual emissions.

The following explains the decomposition results for process emissions, stationary combustion (hereinafter referred to as fuel combustion), and indirect emissions from electricity.

■ **Process Emissions Decomposition Formula:**

The main factors for process emissions include cement production, clinker-to-cement ratio, proportion of alternative raw materials, CaO and MgO content in alternative raw materials, and moisture in alternative raw materials. The formula is detailed below:

Process Emissions (Tons of CO2e) = (A) – (B) (A), (B) = Activity Data × Carbon Intensity		
Emission	Activity Data (Tons)	Carbon Intensity (Ton CO2e/Ton Clinker)
(A) Process Emission	Total Clinker Production=(1)+(2) (1) Amount of clinker used for cement (Tons)= Amount of Cement (Tons) × Clinker-To-Cement Ratio (%) (2) Amount of Clinker Sold Directly (Tons)	CaO% × 44/56 + MgO% × 44/40
Emission	Activity Data (Tons)	Carbon Intensity (Ton CO2e/Ton Clinker)
(B) Carbon Reduction by Alternative Raw Materials	Total Amount of Raw Materials × Proportion of Alternative Raw Materials (%) = Amount of Alternative Raw Materials (Tons)	(CaO × 44/56/100) × ((100-H_2O)/100) (MgO × 44/40/100) × (100-H_2O)/100)

※ Note: In this document, the clinker-to-cement ratio is the amount of clinker used in cement production divided by the total cement production.

※ Note: The proportion of alternative raw materials is the amount of alternative raw materials used divided by the total amount of raw materials plus alternative raw materials. Alternative raw materials are those with carbon reduction benefits containing CaO and MgO.

※ The total clinker amount does not consider stock changes.

■ **Stationary Combustion Emissions Decomposition Formula:**

The main factors for fuel combustion emissions include clinker production, energy consumption per unit of clinker produced (energy intensity), coal consumption, diesel consumption, various alternative fuels consumption, the proportion of alternative fuels, biomass fuels, non-biomass fuels, and biomass content. The formula is detailed below:

Emissions = Activity Data × Energy Intensity × Emission Structure Ratio × Carbon Intensity				
Emissions	**Activity Data (Tons)**	**Energy Intensity**	**Emission Structure Ratio**	**Carbon Intensity**

<table>
<tr><td rowspan="3">Fuel Combustion Emissions (Tons CO2e)</td><td rowspan="3">Total Clinker Production = (1)+(2)
(1) Amount of clinker used for cement (Tons)
= Amount of cement (Tons) × clinker-to-cement ratio (%)
(2) Amount of Clinker Sold Directly</td><td rowspan="3">Total Heating Value (Kcal) / Amount of Clinker (Tons)</td><td>Heating Value of Coal /Total Heating Value (%)</td><td>Kg CO2e of Coal/Kcal</td></tr>
<tr><td>Heating Value of Diesel / Total Heating Value (%)</td><td>Kg CO2e of Diesel/Kcal</td></tr>
<tr><td>Heating Value of Non-Biomass Alternative Fuel/ Total Heating Value (%)</td><td>Kg CO2e of Non-Biomass Alternative Fuel/Kcal</td></tr>
</table>

<table>
<tr><th colspan="3">Total Heating Value (Kcal) = (A) + (B) + (C) + (D)
(A), (B), (C),(D) = Activity Data × Unit Heating Value</th></tr>
<tr><th>Heat Value</th><th>Activity Data (Tons)</th><th>Unit Heating Value</th></tr>
<tr><td>(A)</td><td>Coal Consumption (Metric Tons) × 1,000 (kg/Metric Ton)</td><td>Kcal/Kg</td></tr>
<tr><td>(B)</td><td>Diesel Consumption (kiloliter) × 1,000 (liters/kiloliter)</td><td>Kcal/L</td></tr>
<tr><td>(C)</td><td>Non-Biomass Alternative Fuel Consumption (Tons) × 1,000 (kg/Ton)</td><td>Kcal/Kg</td></tr>
<tr><td>(D)</td><td>Biomass Alternative Fuel Consumption (Tons) × 1,000 (kg/ Ton)</td><td>Kcal/Kg</td></tr>
</table>

※ Note: According to the Taiwan Ministry of Environment's 2022 greenhouse gas emissions inventory guidelines, CO2 emissions from biomass fuel combustion are part of the natural cycle and do not increase atmospheric CO2 concentration. According to ISO 14064-1 Annex, biogenic CO2 emissions will be separately quantified and reported. Thus, it is not included in Category 1.

※ Note: Coal is measured on a wet basis, and the heating value is reported as the lower heating value.

■ **Indirect Emissions from Electricity Decomposition Formula:**

The main factors for indirect emissions from electricity include clinker production, cement production, electricity consumption for raw material grinding, rotary kiln electricity consumption, power generation by waste heat, electricity consumption for cement grinding, renewable energy usage, and emission factors from the local grid's electricity. The formula is detailed below:

<table>
<tr><th colspan="4">Indirect Emissions from Electricity (Tons CO2e) = (A) + (B) + (C) + (D)</th></tr>
<tr><th>Heat Value</th><th>Activity Data (Tons)</th><th>Energy Intensity (1,000 Kwh/Ton)</th><th>Carbon Intensity (Ton CO2e/1000 Kwh)</th></tr>
<tr><td>(A)</td><td>Total Clinker Production = (1)+(2)
(1)Amount of clinker used for cement (Tons)
= Amount of cement (Tons) × clinker-to-cement ratio (%)
(2)Amount of Clinker Sold Directly</td><td>(Electricity consumption of raw material mill + Electricity consumption of rotary kiln) / Amount of clinker</td><td rowspan="3">Emission Factors from Electricity</td></tr>
<tr><td>(B)</td><td>Cement Production (Tons)</td><td>Cement Grinding Electricity Consumption / Cement Production</td></tr>
<tr><td>(C)</td><td colspan="2">Other Electricity Consumed (MWh)</td></tr>
<tr><td>(D)</td><td colspan="2">Power Generation by Waste Heat (MWh) + Renewable Energy Usage (MWh)</td><td>0</td></tr>
</table>

<table>
<tr><td rowspan="2">Step 3
Input Net-Zero Scenario Variables</td><td>Step 3-1: Input Initial Variables
After decomposing the factors for greenhouse gases according to the above process, compile the important initial variables affecting future emissions. Data come from various plants of the TCC group.</td></tr>
<tr><td>Step 3-2: Input Net-Zero Scenario Variables
Process Emissions:
■ Reference sources of change rate of cement production and amount of clinker sold directly:
  ■ TCC Sustainability Report
  ■ IEA 2023 updated Net-Zero Roadmap for the cement industry
  ■ Institute of Technical Information for Building Materials Industry of China
  ■ China Cement Association
■ Reference sources of clinker-to-cement ratio (clinker substitutes):
  ■ TCC Sustainability Report
  ■ Plant Set Targets
  ■ IEA 2023 updated Net-Zero Roadmap for the cement industry
■ Proportion of alternative raw materials:
  ■ TCC Sustainability Report
  ■ Plant Set Targets

Fuel Combustion Emissions
■ Heating Value required per ton of clinker (GJ/ton of clinker) and energy efficiency improvement rate (process improvement):
  ■ TCC Sustainability Report
  ■ Plant Set Targets
  ■ IEA 2023 updated Net-Zero Roadmap for the cement industry
■ The proportion of alternative fuels (Biomass Fuels, Hydrogen, Electricity, Non-Biomass Fuels):
  ■ TCC Sustainability Report
  ■ Plant Set Targets
  ■ IEA 2023 updated Net-Zero Roadmap for the cement industry

Indirect Emissions from Electricity:
■ Annual energy efficiency improvement rate:
  ■ Plant Set Targets
■ Electricity carbon emission factors:
  ■ Ministry of Environment of Taiwan’s Low Emission Analysis Platform model’s Policy Scenario for grid electricity carbon emission factors
  ■ China Emission Factors from Local Grid’s Electricity Research Report
  ■ IEA 2023 updated Net-Zero Roadmap for the cement industry
■ Power generation by waste heat.
■ Share of energy consumption from renewable energy:
  ■ TCC Sustainability Report
  ■ Plant Set Targets

Process CCUS
  ■ TCC Sustainability Report</td></tr>
</table>

	■ Plant-Set Targets ■ IEA 2023 updated Net-Zero Roadmap for the cement industry
	Step 3-3: Calculation Method for Future Emissions of Various Sources **Process Emissions** ■ Using the Net-Zero Scenario variables for cement production and amount of clinker sold directly change rate, clinker-to-cement ratio, proportion of alternative raw materials, and the 2023 initial values, calculate the annual process emissions for each plant from 2024 to 2050. **Fuel Combustion Emissions** ■ Using the Net-Zero Scenario variables for heating value required per ton of clinker (GJ/ton of clinker), energy efficiency improvement rate, proportion of alternative fuels (biomass fuels, hydrogen, electricity, non-biomass alternative fuels), biomass content, and the 2023 initial values, calculate the annual fuel emissions for each plant from 2024 to 2050. **Indirect Emissions from Electricity** ■ Using the Net-Zero Scenario variables for annual improvement rate in energy efficiency, emission factors from electricity, power generation by waste heat, share of energy consumption from renewable energy, and the 2023 initial values, calculate the annual indirect emissions from electricity for each plant from 2024 to 2050. **CCUS** ■ Insert the Net-Zero Scenario variables into the formula.
	Step 3-4: Calculation Results **Process Emissions** ■ Carbon reduction measures for alternative clinker and raw materials can reduce approximately 19.56 million tons of emissions by 2050, contributing about 42% to the overall Net-Zero Pathway. **Fuel Combustion Emissions** ■ Carbon reduction measures for alternative fuels and process improvements can reduce approximately 16.08 million tons of emissions by 2050, contributing about 35% to the overall Net-Zero Pathway. **Indirect Emissions from Electricity** ■ Measures for renewable energy, waste heat power generation, and energy efficiency can reduce approximately 2.29 million tons of emissions by 2050, contributing about 5% to the Net-Zero Pathway. **CCUS** ■ The annual CO2 capture capacity for the group by 2050 is 8.13 million tons, which will contribute about 18% to the Net-Zero Pathway.
	Step 3-5: Verify if the SBT 1.5°C Target for 2030 and 2050 is Achieved ■ Upon reviewing the Net-Zero Pathway for the TCC Group Holdings Global Cement & Concrete Business Units, comparing to the data of 2016 as the base year and taking into consideration the emission intensity targets of cementitious material for 2030 and 2050, the SBT 1.5°C target expected to be submitted by the corporate group in 2024 is considered achievable. ■ To achieve the SBT 2050 Net-Zero Target, TCC Group Holdings Global Cement & Concrete Business Units will estimate a residual CO_2e volume of 730,000 tons that needs to be counterbalanced.

	■ According to the SBT's Cement Science Based Target Setting Guidance, after achieving the long-term SBT Target, any residual emissions released into the atmosphere must be permanently removed and stored to achieve Net-Zero emissions. Methods that may be adopted include improved soil management, improved forest management, and land restoration, e.g., of forest and mangroves. ■ Residual emissions will be handled following the ISO IWA 42 Net-Zero Guidelines, "Counterbalancing Residual Emissions."

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