White Book of Low Carbon Emission Development of Huaxin Cement Co., Ltd

As a fundamental building material of national economy, cement is hard to be replaced. Huaxin Cement is one of the oldest cement enterprises in China. To respond to the call of “Carbon Peak, Carbon Neutrality” of national government and actively cope with the climate change, Huaxin made the strategy of sustainable development. Huaxin will research on the technology breakthrough in the field of alternative fuels, alternative raw materials, clinker factor optimization, fuel efficiency, low carbon clinker development, energy utilization, green mining, new energy development, carbon capture, utilization and storage, contributing to the sustainable growth of the cement industry and striving to be the frontrunner in “carbon neutrality” of China.

I. The history of carbon emission and current situations of Huaxin

(I) Review of the history of carbon emission

The main products of the Company are clinker, cement, ready-mixed concrete and others. The production process of clinker and cement brings about the main energy consumption and carbon dioxide emission. Concrete is the finished product and the most important application of cement. Cement, aggregate, mineral powder or fly ash, water, admixtures are mixed to produce concrete to provide strength protection for buildings. The Company mainly focuses on the carbon emissions of clinker, cement and concrete (see Figure 1).

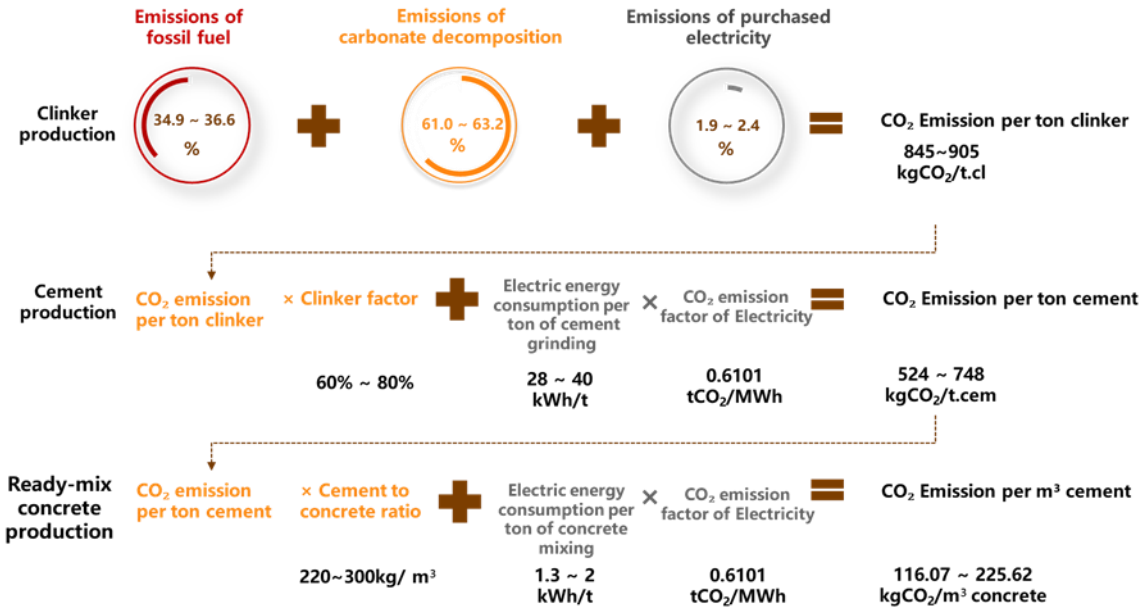

Figure 1 Main Source of Carbon Emission of Huaxin

The company reviewed the production and energy consumption data of the cement business in key years of 1990, 2000, 2005, 2010, 2015 and 2020. The review of carbon emissions of the company's clinker kiln lines as follows (see Figure 2). Since 1990, the company's cement business has continued to grow. The carbon emission intensity per unit product output value has shown a downward trend, and the carbon emission intensity of cement and clinker has decreased overall.

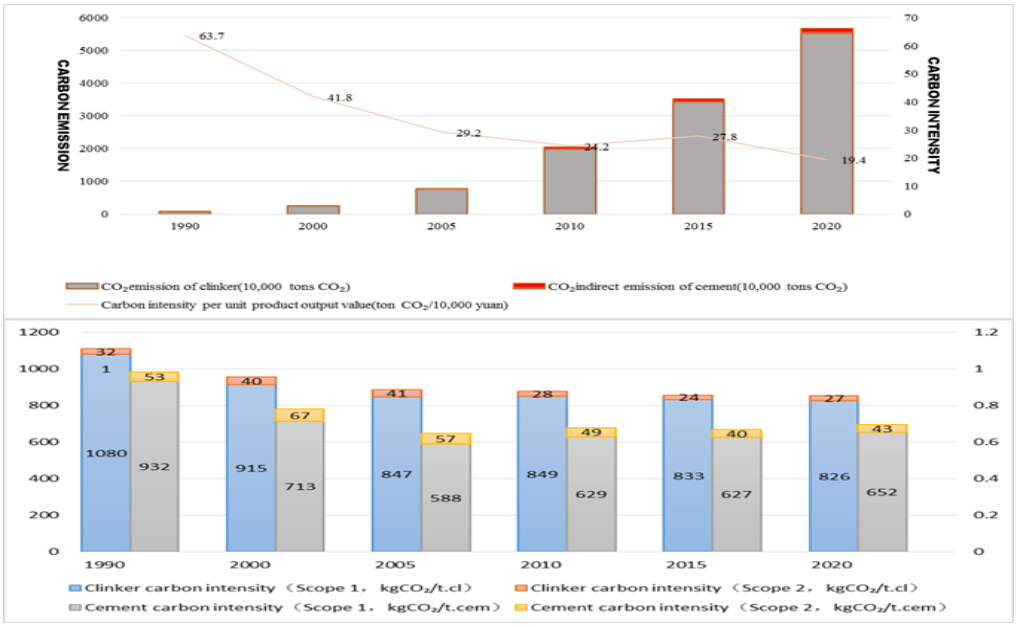

Figure 2 Review of the History of Carbon Emission of Huaxin

For the definition of scope 1, please refer to the below.

(II) Current situation of carbon emission

1. Scope of carbon emission

We refer to the GHG Protocol calculation system to categorize the carbon emission into Scope 1, Scope 2, Scope 3.

Scope 1 refers to direct emission including decomposition of carbonate in raw materials, fossil fuel consumption during cement production, on-site power generation, etc.; Scope 2 refers to indirect emissions of energy converted from purchased electricity, heat, and steam; Scope 3 refers to other indirect emissions, such as refinement and production of purchased materials and fuels, vehicle transportation, employee commuting, etc.

2. Clinker carbon emission

As of June 30, 2021, the company has 58 new dry-process clinker production lines in 9 provinces and cities and 5 overseas countries. Based on the current calculation method of carbon emissions per unit of clinker in the cement industry*, and calculating the CO_2 emissions per ton of clinker, the company's carbon emissions in the past three years are as follows(see Table 1):

Table 1 Carbon emission of clinker line（unit：kgCO_2/t.cl）

Year		2018	2019	2020
Emission intensity		860.52	852.46	853.63
Direct emission(Scope 1)	Fossil fuel	302.87	295.97	295.86
	Technique process	530.57	529.58	530.66
Indirect emission(Scope 2)	Power	27.08	26.91	27.11

* ***Calculation Method and Report Guidance of Green House Gas Emission for Chinese Cement Enterprises (complementary data tables),*** **excluding altitude correction**

3. Cement carbon emission

In 2020, Huaxin's CO_2 emission per unit of cement was 695kg, 419kg of process emissions and 233kg of fossil fuel combustion in direct emissions (Scope 1), and 43kg of indirect emissions (Scope 2). The company will take 2020 as the base year for Scope 1 and Scope

2 cement carbon emissions to formulate low-carbon development goals.

4. Concrete carbon emission

In 2020, the output of concrete of Huaxin was 4.61 million m^3. The direct emission of CO_2 per unit concrete (Scope 1) was 196kg, calculated by the direct emission of cement carbon emission intensity.

(III) Current technologies of carbon emission and measures in practice

1. Roadmap of overseas carbon emission reduction technologies

(1) International Energy Agency (IEA)

In the *2050 Cement Industry Low-Carbon Transition Technology Roadmap*, the IEA clarified that the main carbon emission reduction measures of the cement industry are: improving energy efficiency, developing co-processing technologies, reducing clinker factor, and applying new technologies including carbon capture and other alternative cementitious materials.

(2) Cembureau

Cembureau highlighted in the *2050 Cement Industry and Low Carbon Economy* that European cement industry will achieve the 2025 net zero emission target through the value chain of cement and concrete and 5 technology roadmaps. (see Figure 3)

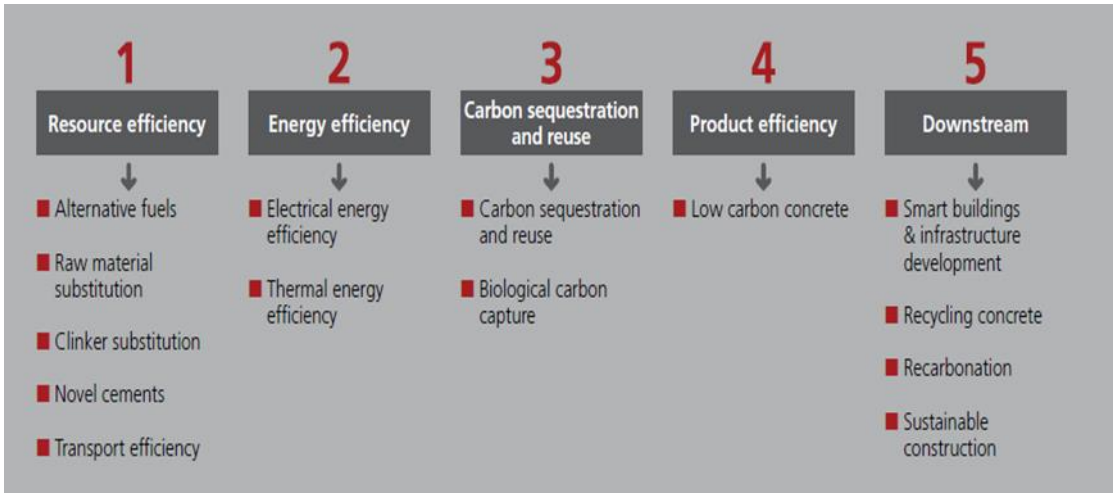

Figure 3 Carbon Emission Technologies of Cembureau

2. Current technologies of carbon emission and measures in practice of Huaxin

(1) Lower emission through alternative fuels

The company has fully studied the characteristics of waste, combined with the technological advantages of the clinker kiln system, and used the clinker kiln to carry out co-processing. "Clinker Kiln Efficient Ecological Co-processing of Solid Waste Technology and Application" was awarded the Second Prize of National Science and Technology Progress Award in 2016. "Ecological Pre-treatment of Household Waste and Clinker kiln Co-processing Technology" was listed in the 2019 National Industrial Energy-saving Technology and Equipment Recommendation Directory. In 2020, seven cement clinker plants of Huaxin were selected as energy efficiency “leaders” in the key energy consumption industries of the Ministry of Industry and Information Technology. Among them, Xinyang plant's comprehensive energy consumption of clinker at comparable unit 91.75kgce/t, and thermal substitution rate of clinker at 31%, the heat consumption of fossil fuels per unit clinker is as low as 590kcal/kg, ranking first among the front runners.

In the second-generation new dry-process cement technology and equipment innovation research and development project, the company undertook the research and development projects of Safe and Harmless Waste disposal and Resource Utilization Technology and Application. The demonstration plant of Huangshi 10,000 tons/d line was put into operation at the end of 2020. It can absorb 900,000 tons of pretreated combustible municipal wastes (CMSW) per year (equivalent to 1.5 million tons/y of raw refuse), save 200,000 tons of standard coal per year, and reduce CO_2 emission 540,000 tons/year. At present, the Huangshi 10,000 tons/d line has achieved more than 40% thermal substitution rate of fuel derived from domestic wastes.

In 2020, Huaxin disposed of 2.06 million tons of domestic waste. Compared with landfills, net CO_2 emissions were reduced by more than 2.4 million tons; 450,000 tons of standard coal was saved, and carbon emissions were cut by 1.2 million tons. From the perspective of

utilization efficiency of wastes, refuse burning is less than 20% while co-processing in the clinker kiln is about 70%. The company's efforts in the field of alternative fuels have accumulated experience and established a demonstration for carbon emission reduction in the domestic cement industry.

(2) Lower emission through alternative raw materials

Huaxin actively searched for alternative raw materials, using various industrial by-products such as fly ash, slag, coal gangue, sulfuric acid slag, phosphorous slag, and municipal sludge to reduce the consumption of natural raw materials and effectively reduced process emissions. In 2020, the company's clinker kiln lines comprehensively utilized 3,185,400 tons of various industrial by-product residues as alternative raw materials, reducing carbon emissions by a total of 345,900 tons.

(3) Lower emission through decreasing clinker factor

The company's "Key Technologies and Engineering Demonstration Projects for Cement Low Environmental Load" won the second prize of National Science and Technology Progress Award in 2009. The project overcame the technical problems of industrial by-products activation and cement high-performance, realizing efficient utilization of industrial by-products and substantial improvement of cement performance. Applying the complementary effects of hydration control, physical and chemical activation, and different waste residues, using 53% of mineral components to prepare 42.5 grade high-performance composite cement and functional cementing materials, Huaxin realized the industrialization of a cement production line with an annual output of 1.2 million tons, reduced CO_2 emissions by 240,000 tons/year. The company has promoted the technology in plants with abundant mineral components to reduce the clinker factor and reduce carbon.

In the meantime, with the superfine grinding process of clinker, namely by adjusting the fineness of the cement, increasing the specific surface area of the powder, and improving

the performance of the strength of cement in the early phase, the efficiency of clinker utilization and the reduction of clinker consumption can be achieved, and the overall carbon emissions of cement production can be reduced.

(4) Lower emission through cogeneration of cement, wall material and other integrated projects

Through independent research and development, the company uses waste heat steam and hydrothermal reaction technology to produce high-performance wall materials by large-scale utilization of mine waste residues, so as to fully utilize mine resources. It not only reduces carbon but also improves the recovery efficiency of clinker kiln waste heat. As a result, waste materials stripped from the exploitation and production of mines are fully utilized to the greatest extent. And logistics is relatively concentrated, reducing carbon emissions in the process of transportation. Huaxin Wuxue pilot project with an annual production capacity of 240 million standard bricks directly reduces CO_2 emissions by 11,885 tons per year by improving the efficiency of waste heat steam recovery; compared with traditional bricks and blocks, it can reduce CO_2 emissions by 15,800 to 47,100 tons of CO_2/100 million standard brick.

(5)The application of "separate grinding" of cement in the lower stream of low carbon concrete

Separate grinding can greatly improve the working performance of cement, ultimately reduce the amount of clinker in the concrete, and reduce CO_2 emissions during the life cycle of the building. Huaxin Dongjun plant uses separate grinding process to produce cement. In the concrete of the same grade using this cement, the clinker amount is reduced by 10%~15% compared with the traditional mixed grinding process.

(IV) Carbon market and carbon trade trial

Since 2013, in pilot cities of Hubei province, Guangdong province and Chongqing, Huaxin

has been actively engaged in carbon trading and fulfilled all carbon quota contracts. Meanwhile, Huaxin explored quota trusteeship, CCER (forwards) swap and fulfilled the social responsibility of coping with climate change.

II. Carbon reduction roadmap and goal of Huaxin

(I) Technology measures of carbon emission in cement industry

Huaxin reviewed each link's carbon emission from mining exploitation, raw material, clinker production, waste disposal, waste heat recovery to cement production, deliberated the practice adopted by domestic and overseas leading enterprises as well as other carbon reduction technology implemented and predicted by the Company. Hereby Huaxin analyzed the potential of each technology:

Table 2 Carbon reduction technology and potential in cement industry ***

No	Technology roadmap	Remarks	Potential of carbon reduction（$kgCO_2/t.cl$）	
			low	high
1	Green mining	Part of the carbon sink is realized through afforestation, forest management, vegetation restoration, etc.	0.1	0.3
2	Alternative raw material	The non-carbonate industrial by-productss that replace natural carbonate ore raw materials are mainly industrial by-products residues, high-temperature calcination waste residues, or raw materials that clearly do not contain calcium carbonate or magnesium carbonate.	4	7
3	Alternative fuel	Domestic waste, sludge cake, industrial and biomass, the current industry heat replacement rate is less than 2%.	140	285
4	Efficiency of fuel	Six-stage preheater, low-resistance high-efficiency decomposition pre-heater, high-efficiency clinker grate cooler, multi-channel high-efficiency burner, oxygen-enriched combustion, new thermal insulation materials and other combustion system improvement technologies.	20	50

5	Waste heat recovery	The existing waste heat recovery technology has low thermal efficiency, the steam produced by high-temperature smoke can steam integrated high-performance wall materials to improve the waste heat thermal efficiency.	30	45
6	Clinker factor （$kgCO_2$/t.cem）	Superfine grinding + separate grinding, using natural/industrial active waste slag as a mixture, LC3-calcined clay, etc. instead of cement clinker.	120	170
7	Low carbon clinker development	Alite-sulfoaluminate clinker, silicate clinker for carbonization reaction, etc.	40	70
8	Energy utilization rate	Process pipeline design with low wind resistance, high-efficiency fan motor, energy-saving grinding technology.	6	10
9	Intelligent industry system	Expert operation optimization system; energy efficiency management system, etc.	5	10
10	Development and utilization of new energy	Photovoltaic power generation, wind power generation, hydrogen energy, etc.	30	60
11	Carbon capture and utilization	Without emerging technologies to replace clinker on a large scale, carbon capture and storage (CCS) is an important way for the cement industry to achieve carbon neutrality.	160	350

*****the potential of carbon reduction is based on 860kg CO_2/t.cl**

(II)Plan for carbon reduction

Huaxin pays great attention to the reduction of CO_2 in the integrated industry of clinker, cement and concrete. The existing cement industry emission reduction technologies, clean energy, forest carbon sinks, and industrial electrification cannot achieve carbon neutrality in terms of investment economy and emission reduction volume. In the medium and long term, to a certain extent, it is necessary to rely on CCUS (carbon capture, utilization and storage) and BECCS (bioenergy carbon capture and storage) technologies to achieve carbon neutrality throughout the system. With mature CCUS and other innovative technologies, the company will achieve its net zero emission target in 2060.

Currently, the company focused on the application of alternative fuel technologies with great

carbon reduction potential and lowering the utilization coefficient of clinker; stepped efforts in improving energy efficiency, clinker kiln waste heat utilization technology, alternative raw material technology, and intelligent manufacturing technology, and actively developed low carbon clinker.

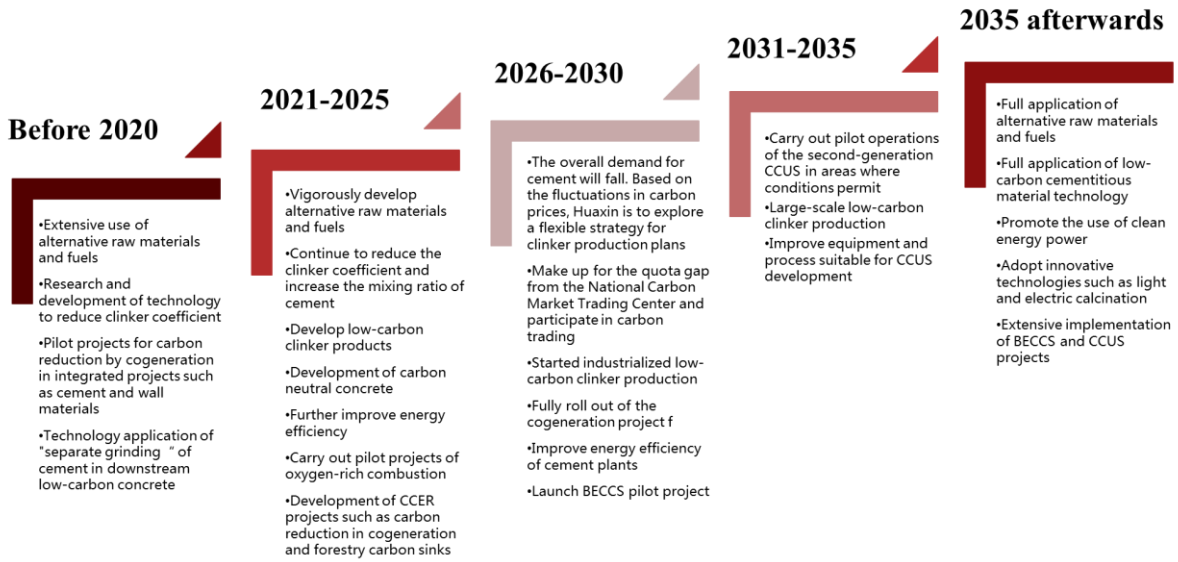

Figure 4 Future Roadmap of Huaxin Carbon Reduction

For the carbon reduction technologies emphasized currently, Huaxin proposes the following short-term quantitative targets, and at the same time the proposed emission reduction measures for Scope 3 carbon emissions:

1. Vigorously develop clinker kiln co-processing technology. The company's alternative fuel energy will account for more than 25% of primary energy in 2030, reducing 60kg CO_2/t.cl per unit of clinker; the number will reach 30% in 2035, reducing 75kg CO2/t.cl per unit of clinker.

2. Extensive use of active industrial solid waste and natural materials as mineral components and the application of superfine grinding technology to reduce the clinker factor. In 2025, the company's clinker factor of the same grade cement will drop by at least 5 percentage points.

3. Actively promote low-carbon concrete application technologies, such as "separate

grinding" in cement preparation, digital support system for concrete business, new admixtures, and materials from industrial solid waste processing. In 2030, the cement amount of the same grade concrete will reduce by 10-15%.

4. Use Carbon Capture, Utilization and Storage (CCUS) as basic technology to test the carbon reduction effect of cement. The company will develop O_2/CO_2 oxygen rich combustion + CCUS for the whole clinker kiln system; carry out CO_2 capture and utilization projects in 2025; in 2030, develop in Sichuan, Chongqing, Guangdong, Western Hubei and other regions with geological and ocean storage potential (all oxygen combustion +) CCUS pilot project; after the second-generation CCUS technology gradually matures in 2035, CCUS will be gradually promoted in the company's suitable clinker kiln lines.

5. The company plans to reduce Scope 3 emissions through measures such as optimizing transportation networks, improving logistics conditions, green driving, and purchasing low-carbon materials. The evaluation and assessment of Scope 3 will be introduced in due course.

(III) Quantitative goals of low carbon development

President Xi Jinping announced in the United Nation’s Climate Summit in December 12, 2020 that in 2030, China’s CO_2 emission per capita GDP will reduce 65% against 2005, non-fossil fuels will account for 25% in primary energy consumption.

Huaxin regards green and low carbon as one of the strategies for sustainable development. Through forward integration into concrete and other building materials related to cement, continuing to lower the carbon emission intensity of main products, by 2030, Huaxin CO_2 emission per unit product will drop over 70% against 2005, alternative fuel will account for over 25% in primary energy consumption. (see Figure 5)

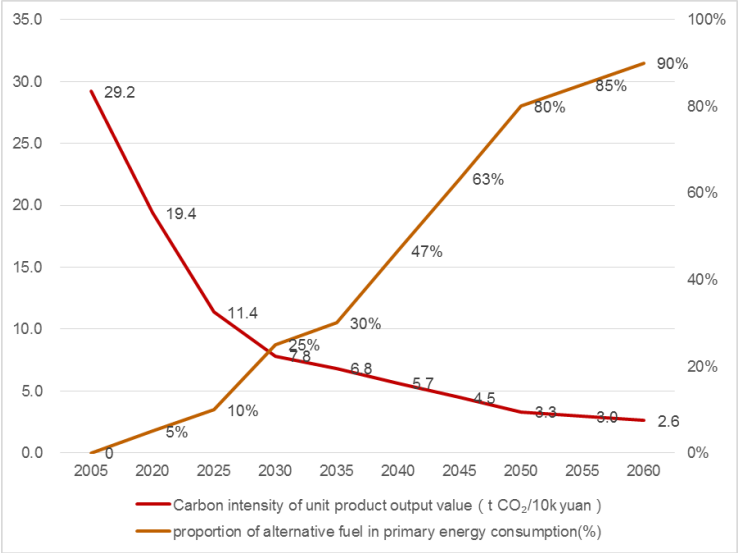

Figure 5 Goal of Carbon Intensity Output Value Per Unit Product and Alternative Energy Consumption

Huaxin will take an open and forward look at carbon reduction technologies, exploring the potentials of various technologies and laying out and reserving leading edge carbon reduction technologies. Huaxin looks forward to the pilot and industrialized application of carbon reduction technologies to drive the low carbon growth of the company. By 2030, direct CO2 emission intensity per ton cement (Scope 1) will be reduced to 475 kg, direct CO2 emission intensity per m^3 concrete (product carbon footprint, Scope 1) will be reduced to 124 kg. Huaxin plans to invest 10.5 billion Yuan between 2020 and 2030 for the technology research and productions system upgrade of carbon reduction emission. By 2060, CCUS and other innovative technologies will guarantee the net zero emission target of Huaxin, neutralize remaining carbon emission. Carbon reduction brought by BECCUS/CCUS will not be included into carbon intensity goal. (see Figure 6, Figure 7)

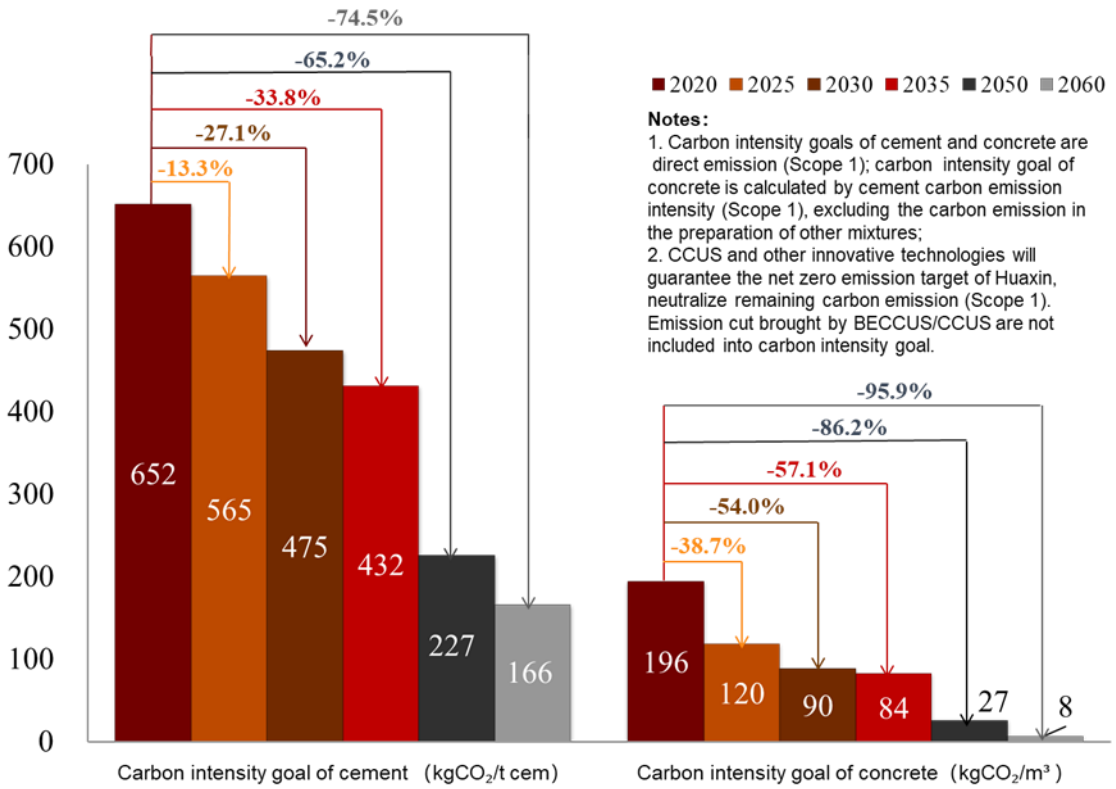

Figure 6 Carbon Intensity Goals of Cement and Concrete of Huaxin

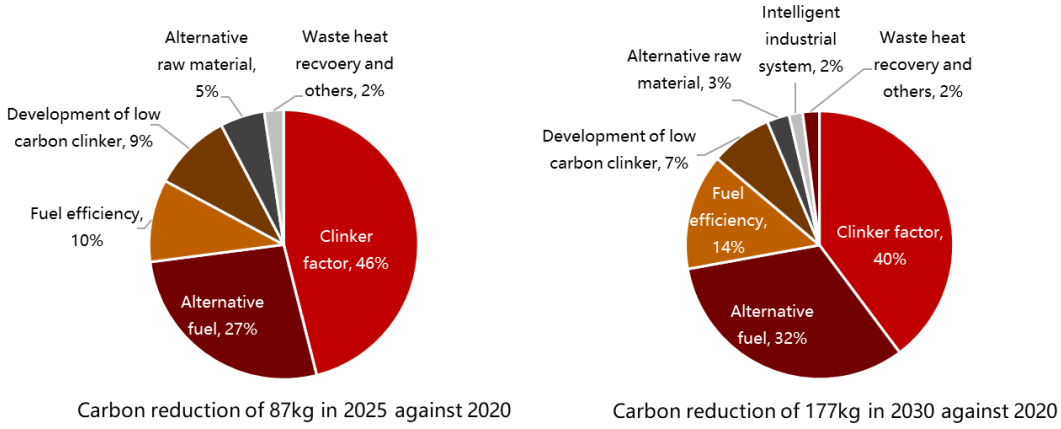

Figure 7 Contributions to the Goals of Carbon Intensity Reduction of Cement in 2025, 2030 (%)

Huaxin follows closely on the formulation and publication of Carbon Emission Policy and Standard by national government and building material industry, actively promotes the establishment of low carbon standard, and consistently to promote the third party audit for carbon emission and will launch the certification of carbon targets in due time. Huaxin will regularly update and improve its white book of low carbon development based on the

roadmap of “carbon peak, carbon neutrality”, the latest carbon emission calculation method of the industry and research progress of carbon reduction technology. Huaxin will make low carbon plan for each plant. The White Book took Wuxue plant as the example and made the 2021-2030 carbon reduction plan.

Attachment:

Carbon Reduction Plan of Wuxue Plant (2021-2025)

Unit: kg CO_2/ t.cem

2020 cement emission base (Scope 1)：623.10 kgCO_2/ t.cem

2025 cement carbon emission target (Scope 1)：539.27kgCO_2/ t.cem

Technology	Carbon cut realized	Potential of carbon cut	Target of carbon cut	Carbon cut for the period	Planned carbon cut projects	Investment (10,000 yuan)
Clinker factor	/	92.8-131.47	38.01	83.83	Extensive use of active industrial solid waste and natural materials as mixed materials; Superfine grinding project; Separate grinding items;	9000
Alternative fuel	30.19	108.3-220.4	66.58		RDF quality improvement project; New biomass fuel utilization project (100,000 tons/year) TSR reached more than 30%	
Fuel efficiency	/	15.47-38.67	3.96		Preheater resistance reduction project	
Alternative raw material	3.93	3.09-5.41	5.30		Exploit the potential of alternative raw materials around the Wuxue factory	
Intelligent industry system	/	3.87-7.73	4		Kiln operation optimization and energy efficiency management system	
Green mining	0.03	0.08-0.23	0.12		Mine reclamation (estimated 1,360 mu) project	

Carbon Reduction Plan of Wuxue Plant (2025-2030)

Unit: kg CO_2/ t.cem

2025 cement carbon emission target (Scope 1)：539.27 kgCO_2/ t.cem

2030 cement carbon emission target (Scope 1)：471.37 kgCO_2/ t.cem

Technology	Carbon cut realized	Potential of carbon cut	Carbon cut for the period	Planned carbon cut projects	Investment (10,000 yuan)
Clinker factor	92.8-131.47	37.25	67.9	LC3- Calcined clay project (1 million tons/y)	25000
Alternative fuel	108.3-220.4	22.19		Biomass utilization project; High heat value waste disposal project TSR reaches more than 40%	
Fuel efficiency	15.47-38.67	7.38		Six-stage preheater transformation project, oxygen-enriched combustion project	
Waste heat recovery	23.2-34.8	1.04		Waste heat recovery project (expansion of 120 million standard bricks/year)	
Green mining	0.08-0.23	0.05		Mine reclamation (an increase of 640 mu compared to 2025) project	
BECCUS/CCUS*	123.73-270.66	/		BECCUS/CCUS trail project (100, 000 tons CO_2/)	

*** BECCUS/CCUS are not calculated into carbon reduction emission**