



Training Handbook: Building Material Cleaner Production Auditing and Green Building Material Evaluation

For MSMEs



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1. Introduction of Cleaner Production Audit

1.1 Concept of Cleaner Production

1.1.1 Basic Concept

The *UNEPIE/PAC* defines: cleaner production is a new way of creative thinking, which persistently applies an integrated preventive environmental strategy to production processes, products and services in order to increase eco-efficiency and minimize human and environmental risks. For production processes, it requires to save raw materials and energy, eliminate toxic raw materials, reduce the amount and toxicity of all wastes. For products, it requires to minimize the negative impacts of the whole life cycle from raw material extraction to final disposal of products.

The *Administrative Center for China's Agenda:21* defines: cleaner production is a practical production method and measure, which could both fulfill human needs and rationally utilize natural resources and energy, as well as protect environment. Its essence is to plan and manage human production activity in the least material and energy consumption way. Reduce, reutilization and detoxicate wastes, or eliminate during production. Meanwhile, as the sustainable development process goes further, the production of green products that are harmless to human and environment will become the predominant direction of future production.

Cleaner Production Promotion Law defines: cleaner production implies the application of improved design and advanced technology and equipment, the usage of clean energy and clean raw materials, and the improvement of management and utilization. Moreover, it includes the prevention of pollution, enhancement of resource utilization efficiency reduction/avoidance of waste generation and emission during the production process and product usage. Finally, both human health and environmental harm is to be minimized/eliminated.

1.1.2 Basic Contents

(1)Process

The definition of cleaner production includes two clean process controls: the whole production process and the whole product cycle.

For production process, cleaner production involves saving raw material and energy, eliminating toxic and harmful raw material, and minimizing to the greatest extent the discharge and toxicity of emissions and wastes before leaving their production process. For products, cleaner production aims at decreasing the impacts on human and environment during the whole product life cycle from raw material extraction to final disposal.

The innovative idea of clean production: In the past, the focus was on removing contaminants after their production, while the idea of cleaner production implies the elimination of contaminants right from the start.

(2)Goals

According to the requirements of sustainable economic development on resources and environment, cleaner production includes two goals: First, to rationally utilize natural resources and alleviate resource depletion through integrated resource utilization, scarce resources substitution, secondary energy utilization, energy saving, consumption reduction and water conservation; Second, to reduce the emission of wastes and contaminants, to insure that industrial production and consumption are compatible with environment and to reduce the risks of industrial activities for human health and environment.

1.1.3 Measures

(1)Implement Green Product Design

During the product design process of enterprises implementing cleaner production, first take into account environmental protection, reduce resource consumption, achieve sustainable development strategy; second, consider commercial profit, cost reduction, decrease potential liability risk and enhance competition. Practical measures are: take into account the future modifiability at the beginning of product design, easy to upgrade and basic design that can be used to produce several products, offer substantial opportunity to reduce solid waste contamination. Product design needs to be able to simply upgrade products by redesigning some components, in order to reduce the generation of solid waste. It should also be considered to use less material or more energy saving components during production, give preference to nontoxic, low toxic, low pollution raw and auxiliary material to substitute the high toxic materials, and to prevent human and environmental harm imposed by raw material and products.

(2)Implement Whole Production Process Control

Cleaner production process requires enterprises to use less or no wastes production technology and high efficiency production equipment; use less or no toxic/hazardous raw material; reduce hazards and toxic/hazardous intermediate products during production process; use simple and reliable operation and control; establish good hygienic practices, sanitation standard operation procedure, hazard analysis and key control point; organize the recycling of material; establish comprehensive quality management system, optimize production organization; conduct necessary contamination treatment, achieve a clean and efficient utilization and production.

(3)Implement Material Optimization Management

Material optimization management is a key step of implementing cleaner production. Choosing the material, evaluating chemical usage and estimating lifecycle are all crucial aspects of enhancing material management. During the implementation of cleaner production, enterprises need to consider the reusability and recyclability when

choosing the material, those materials have economic and environmental profits through improving environmental quality and reducing production cost; implement proper closed circle flow of material, including material flow during raw material and products recycling process, material flow during products usage process and during production process.

The raw material processing cycle refers to the flow process of natural resources to finished products, as well as a closed process composed of the recycling of wastes generated from exploitation and processing. Material flow during production process is a cyclic process composed by the flowing of materials in the entire production system, and the recycling and processing of wastes generated during this process. All aspects of the production process affect material consumption either directly or indirectly. Material flow during product usage process refers to product usage, maintenance and service processes within the product lifecycle, and the recycling of wastes generated during these processes. Material flow during product recycling process refers to the processing process after product usage, including: reusable components, renewable components and non-renewable wastes. In the four aspects of material consumption, we should reduce the amount of wastes or eliminate it completely during the production process. Besides the establishment of a production process which is free from pollution and contamination, also the final products need to be clean.

1.1.4 Implement Procedure

Specific implementation procedures of cleaner production audit include:

- (1) Planning and organizing, including getting official support, setting up cleaner production audit team, developing cleaner production audit working plan, launching publicity and education, etc.
- (2) Pre-assessment, including enterprises profiles, on-site investigation, main contaminants and their treatment measures, establish audit focuses, set cleaner production goals, propose and implement no-cost / low-cost programs, etc.
- (3) Assessment, including audit focus review, check the input, output, and cleaner production potential analysis of key materials, etc.
- (4) Program generation and screening, including program summarizing and screening.
- (5) Feasibility analysis, including the necessity of investing in measures, modification programs, technology assessment, economic assessment and environmental assessment, etc.
- (6) Implementation of the program, including program implementation overview, no-cost/ low-cost programs implementation and results summary, medium-cost/ high-cost programs implementation and results summary, assessment score of cleaner production evaluation indicators.
- (7) Sustainable cleaner production, including promote sustainable implementation of cleaner production through organizations and establishing management system, etc.

1.2 Developing History of Cleaner Production

China's cleaner production related activities have a long history. In 1973, the *Environment Protection and Improvement and a Number of Provisions* stated the pollution control guideline "prevention first and prevention & treatment combination", it states the ideology of cleaner production. Since then, the implementation of cleaner production in China has undergone the following five stages of development.

1.2.1 Preliminary Preparation Stage (1973-1988)

In 1973, China formulated the *Environment Protection and Improvement and a Number of Provisions*, which proposed the pollution control guideline "prevention first, prevention & treatment combination". This is the earliest law on cleaner production in China. Since the late 1970s, some enterprises such as Jilin Chemical Corporation carried out a series of technology reformation including "no waste technology", "less waste technology" and "whole production process pollution control". It resulted in many successful cases-this was the preparatory stage of implementing cleaner production in China. In the 1980s, as environmental problems were getting more serious, it was proposed that the fundamental way to eliminate the "three wastes" is technological transformation. The idea of cleaner production is occasionally mentioned in the environmental management policy documents. However, due to the lack of comprehensive regulations, systems and operating guidelines, cleaner production has not become a solution to environmental and development issues.

1.2.2 Introducing and Digesting Stage (1989-1992)

After the UNEP put forward the action plan of implementing cleaner production in 1989, the idea and methods of cleaner production were introduced to China. The governments responded with positivity and the concerned departments and units started to study how to implement cleaner production. In August 1992, the State Council formulated the *Ten Major Measures for Environment and Development*, which suggested that "when starting, rebuilding and expanding projects, the technical level should be advanced, adopt the cleaner production technology with small energy/material consumption and less contamination emission." Cleaner production has become one of the solutions to China's environmental and development issues. Although the importance of cleaner production for environmental protection been recognized during that period, its role was limited by the technical level and capital conditions at that time, coupled with its original irrational industrial structure constraints.

1.2.3 Legislation and Pilot Program Verification Stage (1993-2002)

This stage is where cleaner production developed from a spontaneous stage into the government-organized promotion stage. The basic characteristics of this stage are: establishing cleaner production in legal policy, introducing cleaner production concepts and methodologies, and its promotion and practice in China. During this 10 years, cleaner production has made significant progress. Depended on a variety of

international cooperation projects and domestic demonstration projects, conducting cleaner production verification pilot demonstration projects at the enterprise level, nearly a thousand enterprises carried out cleaner production verification. In the *Energy Conservation Law*, *Air Pollution Prevention Law*, *Environmental Noise Pollution Prevention Law* and *Solid Waste Pollution Prevention Law*, etc., the content of cleaner production was added in all of them. On the basis of these laws, the *Law of the People's Republic of China on the Promotion of Cleaner Production* (hereinafter referred to as the "Promotion Law") was passed at the 28th Sessions of Standing Committee of the 9th National People's Congress on June 29, 2002. This was the first special law that regarding pollution prevention as the main content, it's the new milestone of implementing cleaner production in China, marking the legislation of cleaner production.

1.2.4 Establishment and Implementation of Cleaner Production Audit System (2003-2005)

On August 16, 2004 the National Development and Reform Commission, the Ministry of Environmental Protection (formerly the State Environmental Protection Administration) formulated, deliberated and approved the *Interim Measures for Cleaner Production Audit*, put forward the "mandatory cleaner production audit" and gave a clear definition to "cleaner production audit" for the first time. The issue and implementation of *Interim Measures for Cleaner Production Audit* became the milestone for establishing cleaner production audit system. On December 13, 2005 the Ministry of Environmental Protection issued the *Regulations on Key Enterprises Cleaner Production Audit Procedure*, stressed the need for mandatory cleaner production audit procedures and requirements, marking that mandatory cleaner production audit has become regulated.

Promoted by laws and regulations, cleaner production audit has developed from local area and local industry pilot demonstration into rapid full roll-out in all national sectors. Provinces that launched cleaner production audit also expanded from less than 10 into almost 30 nation-wide, including autonomous regions and direct-controlled municipalities. Industry involved expanded from limited industries such as chemical, paper-making, electroplating, construction, etc. into more than 20 including thermal power, mechanical processing, automobiles, construction, steel and pharmacy, etc. According to incomplete statistics, there are more than 17,800 enterprises that pass cleaner production audit in China.

1.2.5 Audit System Developing and Refining Phase (2006-present)

To encourage and guide enterprises to effectively carry out cleaner production, regulate cleaner production audit actions and ensure the effectiveness of energy-saving and emission reduction, the Ministry of Environmental Protection published *Notice on Further Strengthening Key Enterprises Cleaner Production Audit* ((2008) No. 60) on 1st July, 2008. *Key Enterprises Cleaner Production Audit Assessment and Acceptance Implementing Guideline* and *List of Toxic and Hazardous Substances Requiring Major Audit (2nd)* are issued to implement at the

same time as complementary documents, marking the establishment of key enterprises cleaner production audit assessment and acceptance system.

Establishing key enterprises, the *Cleaner Production Audit* assessment and acceptance system is an important part of cleaner production policy. It is an innovation and perfection of the cleaner production audit system and of great importance to guarantee industrial enterprises cleaner production audit quality as well as raising the implementation rate of medium/high-cost cleaner production plan. It solves the long-standing issues of lacking governmental supervision and lacking safeguard measures for cleaner production audit quality during the implementation of national cleaner production process.

1.3 Legislation and Policy relevant to Cleaner Production Audit

1.3.1 Cleaner Production Promotion Law of the People's Republic of China

On June 29 2002, the 28th Meeting of the Standing Committee of the 9th NPC passed the *Cleaner Production Law* and amended in the 25th Meeting of the Standing Committee of the 11th NPC on February 29, 2012. This is the first special law concerning cleaner production, as well as the world's first law formulated for the purpose of promoting cleaner production. It is formulated to promote governments and enterprises to actively conduct cleaner production. This law summarizes relevant foreign experiences in implementing cleaner production and pollution prevention, makes a series of regulations and measures based on China's cleaner production current status. It is adapted to production and service fields.

The amended *Cleaner Production Promotion Law* has 6 chapters with 40 articles in total.

The first chapter deals with the general principles. It introduces the purpose of legislation, the definition of cleaner production, the scope of application, the management department of cleaner production and the basic policies of implementing cleaner production in China. The purpose of this legislation is mainly to improve the utilization of resources and energy, prevent pollution and promote cleaner production, so as to protect the environment and human health and ultimately achieve sustainable development. The amended *Cleaner Production Promotion Law* provides that the coordination of national cleaner production management department changes from the original administrative department of economy and trade under the State Council to comprehensive coordination departments of cleaner production. Local governments at the country level or above shall be responsible for the promotion of cleaner production.

The second chapter is about the promotion of cleaner production. This chapter mainly introduces the relevant policies and plans formulated by the government and its administrative departments on the implementation of cleaner production, including taxation policy, industrial policy and promotion policy. The relevant departments of the State Council shall implement the promotion plan for cleaner production in the key areas and industries. The people's governments at or above the county level shall carry out cleaner production promotion plan to the key projects under its

administrative jurisdiction, striving for low consumption and low pollution. The relevant departments should make necessary capital investment in carrying out cleaner production projects, and provide information and services on cleaner production, including cleaner production methods and technologies, etc., formulate and publish guidelines and catalogs of cleaner production, as well as product labels, national standards and industrial standards. It states that relevant departments of the State Council should eliminate technology and equipment that are not eligible for cleaner production within prescribed time periods, e.g. high consumption or heavy pollution technology and equipment that are lagged behind. In addition, cleaner production information and technology should be heavily publicized, including technical training, vocational education, media publicity, etc. This chapter also provides the importance of energy saving and emission reduction in the implementation of cleaner production, and requires governments at all levels to lead the public to pay attention to energy conservation and emission reduction, and purchase products that can contribute to environmental and resource protection.

The third chapter is about the implementation of cleaner production. It mainly regulates on the requirements of specific implementation of cleaner production in production sector, agricultural and service sector. The instructive provisions are:

(1) Instructive provisions on industrial production sectors. Conduct Environmental impact assessment to construction projects, select cleaner production technology that contributes to pollution prevention and raising resources utilization; during technological transformation, enterprises should choose cleaner production technology and equipment to replace the high pollution and high consumption lagged-behind technology and equipment, raw materials used need to be innocuous and harmless or slightly noxious and harmful, reduce the generation of hazardous waste, formulate energy saving and emission reduction measures; products produced need to be healthy and safe, packaging need to be easily degrading and recycling, avoid excessive packaging; make recycling use of the wastes and waste water generated in production process; solid wastes are categorized storage and reasonably disposed; conducting cleaner production audit on wastes generated during production and resource consumption; Involved person in the energy-using entities should timely report energy usage performance.

(2) Instructive provisions on agricultural and service sectors. Agricultural producers should improve the planting technology, reasonably use innocuous and harmless chemical fertilizer, reduce agricultural waste produced, improve the quality of agricultural products, use degradable agricultural films, prevent soil and crop pollution; mining of mineral resources should be uniformly planned, prevent pollution and waste, reasonably exploitation and comprehensively utilization; in terms of transportation, produce and use energy-saving environmental friendly motor vehicles, those high-fuel consumption and high pollution motor vehicles and ships that are unqualified should be eliminated in time; the state encourages the installation of solar energy systems. In addition to these instructive provisions, this chapter also includes relevant voluntary and mandatory provisions. Voluntary provisions include enterprises

to apply for environmental management system certification, signing relevant pollution emission agreements, etc. Mandatory provision refers to that producers are mandatory to fulfill their obligations and undertake legal responsibilities. It mainly regulates on actives including excessive pollution emission that surpasses standards, usage of noxious and harmful substances surpasses standards, products produced or for sale contain noxious and harmful substances that surpasses standards, etc.

The fourth chapter is incentive measures. As the 4th and 6th article in general principles have already pointed out, the state encourages and promotes cleaner production. This chapter mainly introduces the specific incentives to carry out cleaner production, including commendation and reward, financial support, tax preference, etc., mainly to give entities and individuals who actively conduct cleaner production with rewards and preferential policies, and give energy saving emission reduction entities financial subsidies and preferential prices, etc.

The fifth chapter is legal liabilities. It mainly provides to those activities that violate the mandatory rules of this law, are subject to administrative, civil or criminal liabilities.

The sixth chapter is supplementary provision, with one article stating the effective date of this law.

Cleaner Production Promotion Law is “the intensive representative of achievements on implementing cleaner production for over 10 years, the new milestone of comprehensive implementation of cleaner production, the inevitable choice of taking the new industrialization path and sustainable development strategy”.

1.3.2 Policies Relevant to Cleaner Production

In order to implement the cleaner production special law and achieve goals posed by the *Cleaner Production Promotion Law*, the *State Council*, the *Ministry of Environmental Protection* and other government departments have issued corresponding supporting policies, guidance, regulations and management methods, etc. and thus formulate a regulatory policy system to promote cleaner production. The introduction and implementation of these documents provide a solid foundation for the promotion and implementation of cleaner production.

Table 1: Policies for Cleaner Production

Time	Government Department	Policy Document	Contribution
2003	Ministry of Environmental Protection	Several Suggestions on Implementing <i>Cleaner Production Promotion Law</i>	
	The State Council	The State Council Forwarding 11 Commissions Joint Document <i>Suggestions on Cleaner Production</i>	Propose overall work planning for promoting cleaner production.

		<i>Promotion</i>	
	Ministry of Environmental Protection	Issued 3 industrial cleaner production standards	
2004	Ministry of Environmental Protection; National Development and Reform Commission	Jointly issued <i>Cleaner Production Audit Interim Measures</i> (order 16)	Specify that cleaner production audit includes voluntary and compulsory audit for the first time.
2005	The State Council	<i>Decisions on Implementing Scientific Outlook on Development and Enhancing Environmental Sustainability</i>	Encourage energy saving and consumption reducing, implement cleaner production and compulsory audit by law.
	Ministry of Environmental Protection	<i>Regulations on Key Enterprises Cleaner Production Audit Process</i>	Specifically answers “what to audit”, “who to audit” and “to what extent” for the first time, provides substantial regulatory and legal basis for compulsory cleaner production audit. Marking the legalization of compulsory cleaner production
	Ministry of Environmental Protection; National Development and Reform Commission	Jointly issued 3 industrial cleaner production assessment index systems	
2006	Ministry of Environmental Protection	Issued 17 industrial cleaner production standards	
	National Development and Reform Commission	Issued 7 industrial cleaner production assessment index systems	
2007	The State Council	<i>Energy Saving and Emission Reduction Integrated Working Plan</i>	Specifically proposed “Comprehensively Promote Cleaner Production”
	National	Issued 14 industrial cleaner	

	Development and Reform Commission	production assessment index systems	
2008	Environmental Protection Department	Issued 15 cleaner production standards	
	Environmental Protection Department	<i>Notice on Further Enhancing Key Enterprises Cleaner Production Audit Work</i>	Specify new requirements to key enterprises cleaner production audit work in the new situation of energy saving and emission reduction, raised key enterprises cleaner production audit assessment acceptance check
2009	Environmental Protection Department	Issued 12 cleaner production standards	
	National Development and Reform Commission; Ministry of Industry and Information Technology	Jointly issued 6 industrial cleaner production assessment index system	
	Ministry of Industry and Information Technology	Issued <i>Notice on Enhancing Cleaner Production Promotion Work in Industry and Communication Sectors</i>	Specify the working focus and tasks of promoting cleaner production in industry and communication sectors.
	Ministry of Finance; Ministry of Industry and Information Technology	Jointly issued <i>Central Finance Cleaner Production Special Funds Management Interim Measures</i>	Further regulated the usage and management of central financial cleaner production special funds, clarify applied demonstration project, promotion demonstration project applying for special funds report summary
2010	Environmental Protection Department	<i>Notice on Further Promoting Key Enterprises Cleaner Production</i>	Closely combined with the prevention and control of heavy metal pollution, restrain overcapacity and

			redundant construction in some industries, specify the objectives, tasks and requirements for key enterprises cleaner production in the near future. Innovatively combine key enterprises cleaner production systems and current environmental management systems in China.
2011	Ministry of Industry and Information Technology	<i>Notice on Application for 2012 Industrial Cleaner Production Demonstration Projects</i>	
2013	National Development and Reform Commission; Environmental Protection Department Ministry of Industry and Information Technology	<i>General Rules for Cleaner Production Assessment Index System (trial)</i>	
2014	National Development and Reform Commission; Environmental Protection Department Ministry of Industry and Information Technology	<i>Revise Cleaner Production Assessment Index System for Iron and Steel Industry, and Cleaner Production Assessment Index System for Cement Industry</i>	

2. Index Systems of Evaluation of Building Material Cleaner

Production

The National Development and Reform Commission issued *Evaluation Index System of Aluminum Cleaner Production Industry* on 1st December, 2006, *Evaluation Index System of Ceramics Cleaner Production Industry* and *Evaluation Index System of Coating Cleaner Production Industry* on 23th April, 2007, the National Development and Reform Commission, Environmental Protection Department and Ministry of Industry and Information Technology jointly issued *Evaluation Index System of Plate Glass Production Industry* on 28th October, 2015. Each evaluation index system will be explained in the following:

2.1 Evaluation Index System of Aluminum Cleaner Production Industry

This index system is used to evaluate the cleaner production level of electrolytic aluminum enterprises, as the main basis for establishing cleaner production advanced enterprises and also provide technical guidance for enterprises to implement cleaner production. This system classifies enterprises cleaner production level into two categories based on the score of a comprehensive evaluation, namely the “Cleaner Production Advanced Enterprise” representing domestic advanced level, and “Cleaner Production Enterprise” representing domestic average level.

Table 2: Quantitative Rating System of Electrolytic Aluminum Production Enterprises

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value ¹
(1)Energy Index	35	Primary aluminum direct current consumption	kw·h/t.Al	15	13300
		Aluminum ingot comprehensive AC electricity consumption	kw·h/t.Al	10	14500
		Current efficiency	%	10	93.5
(2)Resource Index	20	Alumina unit consumption	kg/t.Al	3	1920
		Carbon anode (net consumption) unit consumption	kg/t.Al	2	420
		Carbon anode (gross consumption) unit consumption	kg/t.Al	2	540

		Fluorinated salt unit consumption	kg/t.Al	3	22
		Enterprise new water unit consumption	m ³ /t.Al	5	4.5
		Enterprise industrial water reusage rate	%	5	95
(3)Production Technology Index	10	Aluminum ingot qualification rate	%	2	100
		Average voltage of electrolyzer	V	4	4.13
		Anode effect coefficient	Time/machine*day	4	0.2
(4)Comprehensive Utilization Index	15	Electrolyzer gas collection efficiency	%	8	98.5
		Dry purification of fluorine purification efficiency	%	4	99
		Dry purification of dust purification efficiency	%	3	99.2
(5)Pollution Index	20	Waste water external emission	m ³ /t.Al	3	1.6
		SO ₂ emission	kg/t.Al	2	5
		Dust emission	kg/t.Al	5	1.3
		Fluorine emission	kg/t.Al	10	0.8
Note: 1. Evaluation reference value has the same unit as its corresponding index.					

Table 3: Qualitative Rating System of Electrolytic Aluminum Production Enterprises

Primary Index	Index Value	Secondary Index	Index Value	Note
(1)Compliance to implement the nationally encouraged development of production capacity,	30	280kA and above large-scale pre-baked anode electrolyzer	10	Qualitative rating index has no evaluation preference value, the assessment is scored based on its implementation.
		Alumina transport using dense or	5	

processing equipment and products		super-dense phase technology		All the secondary indexes of primary index (1), give credits to the adopted ones according to their index score, and no credit to non-adopted ones. All the secondary indexes of primary index (2), give credits to the non-exist or eliminated ones according to their index score, no credits to the existed ones. All the secondary indexes of primary index (3), give 10 credits to established and verified environmental management systems, give 5 credits to established but unverified systems; give 10 credits to implemented cleaner production audit and no/low cost plans, additional 5 credits to implemented medium/high cost plans.
		Computer Controlled Alumina Concentration Feeding Technology	5	
		The cathode of the electrolyzer uses semi-graphitized or graphitized carbon block	5	
		Waste water treatment (secondary) and recycling	5	
(2)Compliance to implement the nationally required elimination of obsolete production capacity, processing equipment and products.	10	Self-baking anode electrolyzer	10	
(3)Establishment of environmental management system and cleaner production audit	20	Establish environmental management system and certified	10	All the secondary indexes of primary index (4), give credits to those comply to regulations according to index score, no credit to those who failed to comply to “three simultaneous” construction projects, environmental impact assessment construction projects or old pollution
		Conduct cleaner production audit	10	
(4)Compliance to implement environmental protection regulations	20	Implementation of environmental production “three simultaneous” in construction projects	5	
		Implementation of environmental impact assessment system in	5	

		construction projects		resources time-limit treatment; no credit to failing to comply to pollution emission control requirement, water pollution or air pollution beyond requirement amount.
		Completion of old pollution source limited-time treatment projects	5	
		Control of pollution discharge	5	
(5)Compliance to implement labor safety regulations	10	Implementation of labor safety “three simultaneous” in construction projects	5	All secondary indexes of primary index (5) and (6), give credits to complied entities according to index score.
		Implementation of safety pre-evaluation system in construction projects	5	
(6)Compliance to implement occupational health regulations	10	Implementation of occupational health “three simultaneous” in construction projects	5	
		Implementation of occupational hazard pre-evaluation system in construction projects	5	

2.2 Evaluation Index System of Ceramics Cleaner Production Industry

This index system is used to evaluate the cleaner production level of ceramics enterprises, as the main basis for establishing cleaner production advanced enterprises and also provides technical guidance for enterprises to implement cleaner production. This system classifies enterprises cleaner production level into two categories based on the score of a comprehensive evaluation, namely the “Cleaner Production Advanced Enterprise” representing domestic advanced level, and “Cleaner Production Enterprise” representing domestic average level.

Taking into account that the production process and technology are different for domestic ceramics, dry-pressed ceramics tile and sanitary ceramics, this index system has some differences in the contents of secondary indexes and settings of their evaluation preference value and weighted score, based on the actual production characteristics of the three industries. So it is more targeted and operable.

Considering that production process and technology are quite different among dry-pressed ceramics tile, according to the actual production of dry-pressed ceramics tile enterprises and in order to make this index system more operable and corresponding to GB/T4100-2006 *Ceramic Tile*, divide dry-pressed ceramics tile into three types based on water absorption $E \leq 0.5\%$ 、 $0.5\% < E \leq 10\%$ 、 $E > 10\%$. The quantitative evaluation, including secondary index references and value settings, are different for these three types of enterprises.

Table 4: Quantitive Evaluation and Rating System of Domestic Ceramics Production Enterprise

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value	
(1)Energy Index	25	Comprehensive energy consumption	kgce/t ceramics	15	1240	
		① Biscuit firing process consumption	kgce/t ceramics	②10/n	520	
		Glaze firing process consumption	kgce/t ceramics	③10/n	450	
(2)Resource Index	15	Enterprise plaster consumption	t/t ceramics	3	0.20	
		Enterprise raw material consumption	t/t ceramics	4	1.20	
		Enterprise tons of ceramic consumption of fresh water	t/t ceramics	5	Ordinary ceramic	22
					Bone ceramic	60
		Industrial water recycling rate	%	3	70	
(3)Production Technology Index	15	Plaster model usage times	time	2	Olling	150
				2	Grouting	80
		Product lead release	mg/l	3	④Comply with international	

					standards	
		Product cadmium release	mg/l	3	⑤Comply with international standards	
		Decal paper utilization	%	1	99	
		Glaze slip utilization	%	1	99	
		Product qualification rate	%	3	99	
(4)Comprehensive Utilization Index	20	Waste ceramic utilization	%	3	95	
		Waste plaster utilization	%	2	98	
		Waste base utilization	%	2	99	
		Waste glaze slip recycling rate	%	2	99	
		Fettling clay recycling rate	%	2	98	
		Exhaust heat utilization of kiln	%	5	70	
		Comprehensive utilization product value	yuan/t ceramics	4	150	
(5)Pollution Index	25	Waste water external emission	m ³ /t ceramics	4	Bone ceramic	50
					Ordinary ceramic	0.5
		Waste water PH value		1	6-9	
		total lead	mg/l	3	1.0	
		total cadmium	mg/l	3	0.1	
		COD	mg/l	3	150	
		SS	mg/l	3	200	
		SO ₂ Emission concentration	mg/m ³	3	1430	
		Enterprise boundary noise (day)	Leq[dB(A)]	1	65	
		Enterprise boundary noise (night)	Leq[dB(A)]	1	55	

		Smoke (dust) concentration	mg/m ³	3	400
<p>Note: 1. Evaluation reference value has the same unit as its corresponding index. 2. ①Only assessed with twice firing 3 ②③The value of n: n=1 when once firing, n=2 when twice firing 4 ④⑤Has the same limit value as GB12651—2003 <i>Contact-Food Ceramic Lead and Cadmium Release Limit</i></p>					

Table 5: Quantitive Rating System of Dry-Pressed Ceramic Tiles ($E \leq 0.5\%$)
Enterprise

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value	
(1)Energy Index	25	Comprehensive energy consumption	kgce/t ceramics	6	400	
		Spray granulation process consumption	kgce/t ceramics	4	80	
		Drying process consumption	kgce/t ceramics	7	20	
		Firing process consumption	kgce/t ceramics	8	180	
(2)Resource Index	22	Enterprise raw material consumption	t/t ceramics	8	1.1	
		Enterprise tons of ceramic consumption of fresh water	t/t ceramics	8	Polished	30
					Unpolished	0.64
Industrial water recycling rate	%	6	97			
(3)Production Technology Index	10	Glaze slip utilization	%	2	98	
		Radioactivity level		6	A	
					B	
C						
Product qualification rate	%	2	98			
(4)Comprehen	20	Waste ceramic	%	4	87	

-sive Utilization Index		utilization			
		Waste base utilization	%	4	99
		Waste glaze slip recycling rate	%	2	90
		Exhaust heat utilization of kiln	%	5	80
		Comprehensiv e utilization product value	yuan/t ceramics	5	160
(5)Pollution Index	23	Waste water external emission	m ³ /t ceramics	4	0.30
		Waste water PH value		1	6-9
		COD	mg/l	3	150
		SS	mg/l	3	200
		SO ₂ Emission concentration	mg/m ³	4	1430
		Enterprise boundary noise (day)	Leq[dB(A)]	2	65
		Enterprise boundary noise (night)	Leq[dB(A)]	2	55
		Smoke (dust) concentration	mg/m ³	4	400
<p>Note: 1 Evaluation reference value has the same unit as its corresponding index. 2 Radioactivity level is implemented according to GB6566-2001 <i>Construction Material Radionuclide Limit</i></p>					

Table 6: Quantitive Rating System of Dry-Pressed Ceramic Tiles (0.5% < E ≤ 10%)
Enterprise

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value
(1)Energy Index	25	Comprehensive energy consumption	kgce/t ceramics	6	220
		Spray granulation	kgce/t ceramics	4	80

		process consumption			
		Drying process consumption	kgce/t ceramics	7	15
		Firing process consumption	kgce/t ceramics	8	150
(2)Resource Index	22	Enterprise raw material consumption	t/t ceramics	8	0.64
		Enterprise tons of ceramic consumption of fresh water	t/t ceramics	8	0.64
		Industrial water recycling rate	%	6	97
(3)Production Technology Index	10	Glaze slip utilization	%	2	98
		Radioactivity level		6	A
					B
					C
Product qualification rate	%	2	98		
(4)Comprehensive Utilization Index	20	Waste ceramic utilization	%	4	87
		Waste base utilization	%	4	99
		Waste glaze slip recycling rate	%	2	90
		Exhaust heat utilization of kiln	%	5	80
		Comprehensive utilization product value	yuan/t ceramics	5	160
(5)Pollution Index	23	Waste water external emission	m ³ /t ceramics	4	0.30
		Waste water PH value		1	6-9
		COD	mg/l	3	150
		SS	mg/l	3	200
		SO ₂ Emission concentration	mg/m ³	4	1430
		Enterprise boundary noise (day)	Leq[dB(A)]	2	65

		Enterprise boundary noise (night)	Leq[dB(A)]	2	55
		Smoke (dust) concentration	mg/m ³	4	400
<p>Note: 1. Evaluation reference value has the same unit as its corresponding index. 2. Radioactivity level is implemented according to GB6566-2001 <i>Construction Material Radionuclide Limit</i></p>					

Table 7: Quantitative Rating System of Dry-Pressed Ceramic Tiles (E > 10%)
Enterprise

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value
(1)Energy Index	25	Comprehensive energy consumption	kgce/t ceramics	6	180
		spray granulation process consumption	kgce/t ceramics	4	80
		Drying process consumption	kgce/t ceramics	7	15
		Firing process consumption	kgce/t ceramics	8	85
(2)Resource Index	22	Enterprise raw material consumption	t/t ceramics	5	1.3
		Enterprise plaster consumption	t/t ceramics	6	0.28
		Enterprise tons of ceramic consumption of fresh water	t/t ceramics	6	14
		Industrial water recycling rate	%	5	60
(3)Production Technology Index	10	Plaster model usage times	times	5	90
		Glaze slip utilization	%	2	100
		Product qualification rate	%	3	95
(4)Comprehensive	20	Waste ceramic utilization	%	5	98

Utilization Index		Waste plaster utilization	%	3	97
		Waste base utilization	%	2	99
		Waste glaze slip recycling rate	%	3	99
		Exhaust heat utilization of kiln	%	4	97
		Comprehensive utilization product value	yuan/t ceramics	3	180
(5)Pollution Index	23	Waste water external emission	m ³ /t ceramics	4	6.45
		Waste water PH value		3	6-9
		COD	mg/l	3	400
		SS	mg/l	3	500
		SO ₂ Emission concentration	mg/m ³	3	1430
		Enterprise boundary noise (day)	Leq[dB(A)]	2	65
		Enterprise boundary noise (night)	Leq[dB(A)]	2	55
		Smoke (dust) concentration	mg/m ³	4	400
<p>Note: 1 Evaluation reference value has the same unit as its corresponding index. 2. Radioactivity level is implemented according to GB6566-2001 <i>Construction Material Radionuclide Limit</i></p>					

Table 8: Quantitive Evaluation and Rating System of Sanitary Ceramics Production Enterprise

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value
(1)Energy Index	25	Comprehensive energy consumption	kgce/t ceramics	15	350
		Firing process consumption	kgce/t ceramics	10	190
(2)Resource Index	22	Enterprise raw material	t/t ceramics	8	0.64

		consumption			
		Enterprise tons of ceramic consumption of fresh water	t/t ceramics	8	0.64
		Industrial water recycling rate	%	6	97
(3)Production Technology Index	10	Glaze slip utilization	%	2	98
		Radioactivity level		6	A
					B
					C
Product qualification rate	%	2	98		
(4)Comprehensive Utilization Index	20	Waste ceramic utilization	%	4	87
		Waste base utilization	%	4	99
		Waste glaze slip recycling rate	%	2	90
		Exhaust heat utilization of kiln	%	5	80
		Comprehensive utilization product value	yuan/t ceramics	5	160
(5)Pollution Index	23	Waste water external emission	m ³ /t ceramics	4	0.30
		Waste water PH value		1	6-9
		COD	mg/l	3	150
		SS	mg/l	3	200
		SO ₂ Emission concentration	mg/m ³	4	1430
		Enterprise boundary noise (day)	Leq[dB(A)]	2	65
		Enterprise boundary noise (night)	Leq[dB(A)]	2	55
		Smoke (dust) concentration	mg/m ³	4	400
Note: Evaluation reference value has the same unit as its corresponding index.					

Table 9: Qualitative Evaluation and Rating System of Domestic Ceramics Production Enterprise

Primary Index	Index Value	Secondary Index	Index Value
(1)Compliance to implement the nationally encouraged development of technology (including ceramics cleaner production)	50	More than 70% enterprise products export	5
		Lead-free	9
		Low-temperature fast-firing	8
		Provincial or above level engineering (technology) center, pilot base	3
		Exhaust gas comprehensive utilization	8
		All factory sewage treatment (secondary) and recycling	8
		Comprehensive utilization (or digest) of social wastes	9
(2)Establishment of environmental management system and cleaner production audit	25	Establish and certified environmental management system	10
		Conduct cleaner production audit	15
(3)Compliance to implement environmental protection regulations	25	Implement of environmental “three simultaneous” in construction projects	5
		Implementation of environmental impact assessment system in construction plans	5
		Completion of old pollution source limited-time treatment projects	6
		Control of pollution discharge	9

Note:

1. Qualitative rating index has no evaluation preference value, the assessment is scored based on its implementation;
2. All the secondary indexes of primary index (1), give credits to the adopted ones according to their index value, and no credit to non-adopted ones;
3. All the secondary indexes of primary index (2), give 10 credits to established and verified environmental management systems, give 5 credits to established but unverified systems; give 15 credits to implemented cleaner production audit;
4. All the secondary indexes of primary index (3), give credits to those comply to regulations according to index value;
5. No credit to those who failed to comply to “three simultaneous” construction projects, environmental impact assessment construction projects or old pollution resources

time-limit treatment;

6. For pollution emission total amount requirement, no credit to those both water and air pollution exceeds requirement amount; give 4 credits to either water or air pollution exceeds requirement amount.

2.3 Evaluation Index System of Coating Cleaner Production Industry

This index system is used to evaluate the cleaner production level of ceramics enterprises, as the main basis for establishing cleaner production advanced enterprises and also provide technical guidance for enterprises to implement cleaner production. This system classifies enterprises cleaner production level into two categories based on the score of a comprehensive evaluation, namely the “Cleaner Production Advanced Enterprise” representing domestic advanced level, and “Cleaner Production Enterprise” representing domestic average level.

Cleaner production quantitative and qualitative evaluation index system, index weighted value and evaluation reference value of solvent-based paint enterprises using natural resin or synthetic resin as raw material, are shown in Table 10.

Cleaner production quantitative and qualitative evaluation index system, index weighted value and evaluation reference value of water-based paint enterprises using natural resin or synthetic resin as raw material, are shown in Table 11.

Cleaner production quantitative and qualitative evaluation index system, index weighted value and evaluation reference value of powder-based paint enterprises using natural resin or synthetic resin as raw material, are shown in Table 12.

Table 10: Rating Table of Solvent-Based Paint Cleaner Production

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value	
Quantitative evaluation index						
(1)Resource and energy consumption index	21	Raw material consumption	t/t product	11	1.015	
		Product comprehensive energy consumption	tce/t product	6	0.17	
		Fresh water consumption	t/t product	4	0.20	
(2)Pollution index	12	Waste water	t/t product	2	0.15	
		COD in waste water	mg/l	3	40	
		Exhaust gas concentration	Xylene	mg/m ³	3	5.0
			Toluene	mg/m ³	2	5.0
			Dust	mg/m ³	2	4.0
(3)Resource	8	Water recycling rate	%	8	95.0	

comprehensive utilization index						
Qualitative evaluation index						
(4)Product feature index	21	One-time pass rate		%	5	$\geq e-ti$
		Implement national mandatory standard		(yes or no)	2	yes
		1Pass ISO9001 series quality system certification		(yes or no)	2	yes
		Pass Environmental product certification		(yes or no)	2	yes
		Standad adopting	Adopt foreign standard	%	10	≥ 25
			Adopt national standard	%	8	≥ 30
(5)Environmental management and occupational safety and health index	38	Acquire hazardous chemicals safety production license		(yes or no)	3	yes
		Acquire fire-control safety production license		(yes or no)	3	yes
		Pass ISO14001 certification		(yes or no)	5	yes
		Number of occupation disease		Number/ thousand* year	5	≤ 0.001
		No fire or explosion accidents in 3 years		(yes or no)	13	yes
		Injury rate per thousand people		Number/ thousand *year	9	0
					6	≤ 0.001
<p>Note:</p> <ol style="list-style-type: none"> 1. Evaluation reference value has the same unit as its corresponding index. 2. If the enterprise simultaneously produce several products in solvent-based painting, then the value of each index depends on the production weighted average of its products. 3. Fresh water consumption refers to production process water consumption (including fresh supplementary water to the recirculating cooling water) and workshop cleaning water consumption (excluding domestic water consumption). 4. Waste water related indexes in pollution index refers to waste water external emission data after end-of-pipe treatment, exhaust gas index refers to production site environmental-related data. 						

5. The proportion of products adopting foreign standards in the product feature indexes refers to the ratio of product output that directly adopts foreign advanced standards or equivalent foreign advanced standards to the total product output; the proportion of products adopting domestic standards refers to the ratio of product output that adopts higher-than-domestic standards to total product output.

6. Number of occupation disease and injury rate per thousand people are taken as the average of relevant data in 5 years.

Table 11: Rating Table of Water-Based Paint Cleaner Production

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value	
Quantitative evaluation index						
(1)Resource and energy consumption index	35	Raw material consumption		t/t product	20	1.015
		Electricity consumption		kWh/t product	10	80
		Fresh water consumption	Constructi- on latex paint	t/t product	5	0.25
			Water based industrial painting			0.35
(2)Pollution index	12	Waste water		t/t product	10	0.2
		COD in waste water		mg/l	5	40.0
		Dust in exhaust gas		mg/m ³	5	4.0
(3)Resource comprehensive utilization index	8	Water recycling rate		%	10	80.0
Qualitative evaluation index						
(4) Product feature index	25	One-time pass rate		%	6	≥99.0
		Implement national mandatory standard		(yes or no)	3	yes
		Pass ISO9001 series quality system certification		(yes or no)	3	yes
		Pass Environmental product certification		(yes or no)	3	yes
		Standard adoption	Adopt foreign standard	%	10	≥25
			Adopt national	%	8	≥30

		standard			
(5)Environmental management and occupational safety and health index	38	Acquire hazardous chemicals safety production license	(yes or no)	1	yes
		Acquire fire-control safety production license	(yes or no)	1	yes
		Pass ISO14001 certification	(yes or no)	5	yes
		Number of occupation disease	Number/thousand *year	1	≤0.001
		No fire or explosion accidents in 3 years	(yes or no)	1	yes
		Injury rate per thousand people	Number/thousand *year	1	≤0.001

Note:

1.If the enterprise simultaneously produce several products in water-based painting, then the value of each index depends on the production weighted average of its products.

2. Fresh water consumption refers to production process water consumption and workshop cleaning water consumption, excluding raw material and domestic water consumption data.

3. Waste water related indexes in pollution index refers to waste water external emission data after end-of-pipe treatment, exhaust gas index refers to production site environmental-related data.

4. The proportion of products adopting foreign standards in the product feature indexes refers to the ratio of product output that directly adopts foreign advanced standards or equivalent foreign advanced standards to the total product output; the proportion of products adopting domestic standards refers to the ratio of product output that adopts higher-than-domestic standards to total product output.

5. Number of occupation disease and injury rate per thousand people are taken as the average of relevant data in 5 years.

Table 12: Rating Table of Powdered Paint Cleaner Production

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value
Quantitive evaluation index					
(1)Resource and energy consumption index	35	Raw material consumption	t/t product	15	1.015
		Product comprehensive energy consumption	tce/t product	15	0.17
		Fresh water consumption	t/t product	5	0.20

(2)Pollution index	15	Waste water	t/t product	3	0.15	
		Dust in waste water	mg/m ³	12	4.0	
(3)Resource comprehensive utilization index	10	Water recycling rate	%	10	95.0	
Qualitative evaluation index						
(4)Product feature index	25	One-time pass rate		%	6	≥99.0
		Implement national mandatory standard		(yes or no)	3	yes
		Pass ISO9001 series quality system certification		(yes or no)	3	yes
		Pass Environmental product certification		(yes or no)	3	yes
		Standard adoption	Adopt foreign standard	%	10	≥25
			Adopt national standard	%	8	≥30
(5)Environmental management and occupational safety and health index	15	Acquire hazardous chemicals safety production license		(yes or no)	1	yes
		Acquire fire-control safety production license		(yes or no)	1	yes
		Pass ISO14001 certification		(yes or no)	3	yes
		Number of occupation disease		Number/ thousand *year	5	≤0.001
		No fire or explosion accidents in 3 years		(yes or no)	2	yes
		Injury rate per thousand people		Number/ thousand *year	3	≤0.001
<p>Note:</p> <p>1.If the enterprise simultaneously produce several products in powdered painting, then the value of each index depends on the production weighted average of its products.</p> <p>2. Fresh water consumption refers to production process water consumption (including fresh supplementary water to the recirculating cooling water) and workshop cleaning water consumption (excluding domestic water consumption).</p>						

3. Waste water related indexes in pollution index refers to waste water external emission data after end-of-pipe treatment, exhaust gas index refers to production site environmental-related data.
4. The proportion of products adopting foreign standards in the product feature indexes refers to the ratio of product output that directly adopts foreign advanced standards or equivalent foreign advanced standards to the total product output; the proportion of products adopting domestic standards refers to the ratio of product output that adopts higher-than-domestic standards to total product output.
5. Number of occupation disease and injury rate per thousand people are taken as the average of relevant data in 5 years.

2.4 Evaluation Index System of Cement Cleaner Production Industry

This index system regulates cement industry enterprises on cleaner production requirements. It consists of six types including production process and equipment index, resource and energy consumption index, resource comprehensive utilization index, pollution generation index, product feature index and cleaner production management index, etc.

This index system is applicable to the general cement production enterprises, including cement (clinker) production enterprise, cement grinding station cleaner production audit, cleaner production potential and opportunity judgement, cleaner production performance evaluation and cleaner production performance announcement system. It also applies to resource/energy consumption cleaner production management requirements, including cement industry environmental impact evaluation, environmental check, sewage discharge permit and industry access, etc.

Table 13: Quantitive Rating System of Cement Production Enterprises

No.	Primary Index	Primary Weighted Value	Secondary Index		Unit	Secondary Weighted Value	Level 1 Reference Value	Level II Reference Value	Level III Reference Value	
1	Production process and equipment index	0.3	Limestone mining and crushing	Mining technology	—	0.15	Use top-down leveled mining technology; medium-depth holes millisecond blasting technology; Self-contained or mobile air compressor drilling equipment or hydraulic perforating machine, hydraulic excavators, wheeled or crawler loader.			
2				Crushing	—	0.05	One stage crushing system	Two stage crushing system		
3			Cement production	Technology		—	0.08	New type of dry process		
4				Scale	Single-line cement clinker production	t/d	0.15	≥4000	2000~4000	≥1500
5					Cement grinding system	10 ⁴ t/d		≥100	≥60	≥30
6				*Equipment	Raw material grinding system	—	0.08	Vertical Grinding or Roller Press Finish Grinding	Mill diameter ≥ 4.6m circle grinding ball mill	Mill diameter ≥ 3.0m

							System		
7				Coal powder making system	—	0.08	Vertical mill or air-swept mill		
8				Cement grinding system (including grinding station ^a)	—	0.08	Mill diameter \geq 4.2m Roller mill and ball mill combined grinding system or vertical mill	Mill diameter \geq 3.8m Roller mill and ball mill combined grinding system or circle grinding ball mill with high-efficiency powder concentrator	Mill diameter \geq 3m Circle grinding ball mill or high-fine grinding mill
9				Production process control level ^a	—	0.05	Use field bus, DCS or PLC control system, raw material quality control system, production management information analysis system.		
10				Cement bulk capacity ^a	%	0.05	≥ 70		≥ 50
11				*Environmental protection facilities		0.06	Gas collection system and purification treatment device ^a		
12						0.05	Unorganized emission control		
							According to HJ 434 and GB 4915, set up local or integrated gas collection system and purification treatment device to all production process and equipment that generate air pollutants, emission up to standards.		
							Dust effusion equipment and workplaces, such as material treatment, transportation, loading and storing, etc. should implement control measures, use measures such as containment, coverage, reduce		

							material gap and negative pressure operation, etc. to prevent dust effusion, or negative pressure collecting dusty gas and discharge after purification treatment. Use reasonable process layout, closed in-plant transportation, road hardening, cleaning and watering measures to reduce traffic road dust. Ensure unorganized emission limit complies with GB4915 regulation.	
13					Denitrification facility	—	0.04	Use appropriate denitrification facilities to ensure that oxynitride missions is up to standard.
14					Automatic monitoring device	—	0.04	Install smoke PM, sulfur dioxide and oxynitride automatic monitoring devices on exhaust funnels of cement kiln and kiln-grinding machine, install smoke PM automatic monitoring devices on exhaust funnels of cooling machine, and checked by environmental protection department for normal operation.
15					Noise prevention and control measures ^a	—	0.02	Encourage the use of low-noise equipment, and have sound insulation, sound absorption, and sound proofing and vibration isolation measures to equipment or production workshop, to reduce noise emission. It is advised to reduce impact on external noise sensitive targets through reasonable production layout, construction building obstruction and greening measures.
16					Solid waste incinera-	—	0.02	The treatment of solid wastes using cement production facilities shall be based on the nature of

					tion control			wastes, in accordance with GB50634 requirements and the environmental protection technical standards related to coordination with cement kiln on hazardous waste disposal. Take relevant measures and pollution monitoring, to prevent environmental risks.	
17	Resource consumption	0.2	*Fresh water consumption per unit clinker		t/t	0.15	≤0.3	≤0.5	≤0.75
18			*Comparable clinker comprehensive coal consumption (amounts to standard coal)		kgc e/t	0.17	≤103	≤108	≤112
19			* Comparable clinker comprehensive energy consumption (amounts to standard coal)		kgc e/t	0.17	≤110	≤115	≤120
20			* Cement (clinker) production enterprise comparable cement comprehensive energy consumption (amounts to standard coal) ^b		kgc e/t	0.17	≤88	≤93	≤98
21			*Cement grinding station comparable cement comprehensive energy consumption (amounts to standard coal) ^a		kgc e/t		≤7	≤7.5	≤8
22			*Comparable clinker comprehensive electricity consumption		kW·h/t	0.17	≤56	≤60	≤64
23			*Comparable cement comprehensive electricity consumption	Cement (clinker) production enterprise	kW·h/t	0.17	≤85	≤88	≤90
24				Cement grinding station	kW·h/t		≤32	≤36	≤40
25	Resour-ce	0.1	Industrial waste used in raw material proportioning		%	0.1	≥10	≥5	≥2
26	compre-		Substitution rate of using combustible waste fuel		%	0.13	≥10	≥5	<5

27	hensive utiliza- tion index		Low grade coal utilization	%	0.02	≥30	≥20	<20	
28			*Circulating water utilization ^a	%	0.15	≥95	≥90	≥85	
29			* Kiln system exhaust gas exhaust heat utilization	%	0.15	≥70	≥50	≥30	
30			Kiln dust and dust collector recycling rate ^a	%	0.1	100			
31			Mine resources Comprehensive utilization	%	0.15	≥90	≥50	<50	
32			Waste and sewage water treatment and recycling rate ^a	%	0.1	Set up sewage treatment station, after treatment 100% reuse	Set up sewage treatment station, after treatment partially discharge		
33	Solid waste used in cement mixture ^a	%	0.1	Confirm to relevant product standards					
34	Pollution genera- tion index	0.2	*Sulfur dioxide Production	kg/t	0.3	≤0.15	≤0.3	≤0.6	
35			* Oxynitride (as in NO ₂) production	kg/t	0.5	≤1.8	≤2.4		
36			*Fluoride (as in total fluorine) production	kg/t	0.2	≤0.006	≤0.008	≤0.01	
37	Product feature index	0.1	*product percent of pass ^a	%	0.5	Cement and clinker product quality should comply with the relevant requirements of GB175, GB 13590, GB/T21372, JC600 and <i>Cement Enterprises Quality Management Regulation</i> , product manufactured pass rate should be 100%.			
38			Product environmental quality	—	0.3	Co-processing the contained pollutants from cement products generated by solid waste should meet the relevant pollution control standards of cement kiln co-processing solid waste.			
39			* Radioactivity	—	0.2	The internal and external exposure index of natural radioactivity specific activity should meet GB6566 standard.			

40	Cleaner production management index	0.1	Laws and regulations ^a	*Implementation of environmental laws, regulations and standards	—	0.15	In line with national and local relevant environmental laws and regulations, pollutant discharge should reach national or local discharge standards, total amount control and sewage discharge permit management requirement.	
41				*Implementation of environmental impact assessment, “three simultaneous” system	—	0.15	Set up project EIA, “three simultaneous” system implementation rate should reach 100%	
42			*Implementation of industry policies ^a		—	0.15	Confirm to national and domestic relevant industry policies, do not use outdated technology and equipment that are eliminated or prohibited by national and local official orders	
43			Implementation of cleaner production audit system ^a		—	0.10	Carry out audit according to <i>Cleaner Production Promotion Law</i> and <i>Cleaner Production Audit Interim Measure</i>	
44			Production process control	Cleaner production department setting and personnel allocation ^a		—	0.03	Equipped with cleaner production management department and full-time management staff
45				Job training ^a		—	0.02	All job position has regular training
46				Cleaner Production Management System ^a		%	0.02	Well-establish management system and strictly implement
47				Stable operation rate of environmental protection facilities ^a		%	0.07	Purification treatment device and its corresponding production device synchronous running rate reaches 100%, ensure that air pollutants such as PM are discharged in compliance with standards
48				Raw material and fuel		—	0.04	Establish raw material and fuel quality control

				consumption and quality inspection ^a			system, raw material and fuel consumption quota management system, install measuring devices or meters, to strictly quantitatively inspect energy consumption, material consumption and water consumption		
49				Energy-saving management ^a	—	0.05	Conduct low-temperature exhaust heat power generation, high-voltage inverter, energy management center construction, etc.; equipped with full-time management staff; set up third-degree energy measuring system.		
50				Standardized management of sewage draining exit ^a	—	0.05	Conduct low-temperature exhaust heat power generation, high-voltage inverter, energy management center construction, etc.; equipped with full-time management staff; set up third-degree energy measuring system.		
51				Ecological restoration	—	0.07	<table border="1"> <tr> <td>Has an integrated ecological restoration plan, include ecological restoration management into daily production management.</td> <td>Has an integrated ecological restoration plan, include ecological restoration management into daily production management. After final slope angle of mining is formulated, ecological restoration of land destruction reaches at least 75%</td> </tr> </table>	Has an integrated ecological restoration plan, include ecological restoration management into daily production management.	Has an integrated ecological restoration plan, include ecological restoration management into daily production management. After final slope angle of mining is formulated, ecological restoration of land destruction reaches at least 75%
Has an integrated ecological restoration plan, include ecological restoration management into daily production management.	Has an integrated ecological restoration plan, include ecological restoration management into daily production management. After final slope angle of mining is formulated, ecological restoration of land destruction reaches at least 75%								

						After final slope angle of mining is formulated, ecological restoration of land destruction reaches at least 85%	
52			Effective environmental contingency plans	—	0.06	Formulate environmental contingency plan and regularly conduct environmental contingency drill	
53			Environmental information disclosure ^a	—	0.02	Disclose environmental information according to article 19 of <i>Measures for the Disclosure of Environmental Information (Trial Implementation)</i>	
54				—	0.02	Compile enterprises environmental report according to <i>Enterprises Environmental Report Compiling Guideline (HJ 617)</i>	

Note:1. Uninvolved index of cement (clinker) production enterprises are scored as full mark;
2. Cement grinding station only evaluate on indexes labelled with ^a;
3. Indexes labelled with ^b: if percentage of clinker in cement is higher than or lower than 75%, every 1% increase or decrease, comparable cement comprehensive energy consumption increases or decreases according to GB16780 *Cement Energy Consumption Quota per Unit Product*, limit value increases/decreases 1.2kg/t, access value 1.15 kg/t and advanced value 1.0 kg/t;
4. Indexes labelled with * are restrictive index;
5. Enterprises co-processing solid waste with cement kiln, give 3 additional credits to the above score, and then evaluate on cleaner production level.

2.5 Evaluation Index System of Steel Cleaner Production Industry

This index system classifies the enterprise's cleaner production level into three categories based on the score of a comprehensive evaluation - level one represents the domestic cleaner production leading level, level two represents the domestic advanced level and level three represents the domestic average level.

This system classifies cleaner production indexes into 6 categories, namely production technology equipment index, energy-saving and emission-reduction equipment index, resource and energy utilization index, product feature index, pollutant emission control index, and cleaner production management index.

This system is applicable to iron and steel enterprises (with long process flow) cleaner production level evaluation, cleaner production audit; newly expanded reconstruction project environmental impact evaluation, new project audit and approval; enterprises environmental inspection, energy-saving evaluation, etc.

Table 14: Evaluation Index of Cleaner Production of Iron and Steel Production Enterprise

Primary Index		Secondary Index					
Index	Weighted Value	No.	Index	Weighted Value	Level 1 Reference Value	Level II Reference Value	Level III Reference Value
Production technology equipment and technology	15	1	Distribution rate of coke oven equipment	3	Top mounting coke oven chamber height $\geq 7\text{m}$ or tamping coke oven chamber $\geq 5.5\text{m}$, distribution rate $\geq 60\%$	Top mounting coke oven chamber height $\geq 6\text{m}$ or tamping coke oven chamber $\geq 5\text{m}$, distribution rate $\geq 60\%$	Top mounting coke oven chamber height $\geq 6\text{m}$ or tamping coke oven chamber $\geq 5\text{m}$, distribution rate $\geq 30\%$
		2	Distribution rate of sintering machine equipment	3	Sintering machine larger than 300 m^2 , distribution rate $\geq 60\%$	Sintering machine larger than 200 m^2 , distribution rate $\geq 60\%$	Sintering machine larger than 180 m^2 , distribution rate $\geq 60\%$
		3	Distribution rate of pelletizing equipment	2	Equipped with belt roaster device or grate-kiln grate rotary kiln device, single-unit equipment pelletizing production scale $\geq 3,000,000\text{t}$	Equipped with belt roaster device or grate-kiln grate rotary kiln device, single-unit equipment pelletizing production scale $\geq 2,000,000\text{t}$	Single-unit equipment pelletizing production scale $\geq 1,200,000\text{t}$
		4	Distribution rate of blast furnace equipment	3	Blas furnace over 3000m^3 , distribution rate $\geq 60\%$	Blas furnace over 2000m^3 , distribution rate $\geq 60\%$	Blas furnace over 1000m^3 , distribution rate 100%
		5	Distribution rate of converter equipment	2	Converter over 200t , distribution rate $\geq 60\%$	Converter over 150t , distribution rate $\geq 60\%$	Converter over 120t , distribution rate 100%

		6	Iron-steel high efficiency connecting technology	1	Using this technology, hot metal temperature drop $\leq 80^{\circ}\text{C}$	Using this technology, hot metal temperature drop $\leq 100^{\circ}\text{C}$	Using this technology, hot metal temperature drop $\leq 130^{\circ}\text{C}$
		7	Hot-charging and hot-transportation of continuous casting slabs technology	1	Hot charging temperature $\geq 600^{\circ}\text{C}$, hot charging rate $\geq 60\%$	Hot charging temperature $\geq 500^{\circ}\text{C}$, hot charging rate $\geq 50\%$	Hot charging temperature $\geq 400^{\circ}\text{C}$, hot charging rate $\geq 40\%$
Energy-saving and emission-reduction equipment and technology	20	1	Raw material plant pollution control technology	2	Raw material plant achieves full-closed, large-scale mechanized technology	Raw material plant achieves dust screen, large-scale mechanized technology	
		2	Coke quenching equipment	1.5	High temperature high pressure dry-quenching device, quenching amount $\geq 60\%$		
		3	Coke oven gas desulfurization and decyanation equipment	2	$\text{H}_2\text{S} \leq 150\text{mg}/\text{m}^3$, $\text{HCN} \leq 150\text{mg}/\text{m}^3$	$\text{H}_2\text{S} \leq 200\text{mg}/\text{m}^3$, $\text{HCN} \leq 180\text{mg}/\text{m}^3$	$\text{H}_2\text{S} \leq 250\text{mg}/\text{m}^3$, $\text{HCN} \leq 200\text{mg}/\text{m}^3$
		4	Coal moisture control technology	1.5	Using this technology, fired coal material $\geq 60\%$	Using this technology, fired coal material $\geq 40\%$	
		5	Minipellet sintering technology and deep-bed sintering operation	1.5	Use minipellet sintering technology and deep-bed sintering operation (deep-bed sintering $\geq 600\text{mm}$)	Use minipellet sintering technology and deep-bed sintering operation (deep-bed sintering \geq	Use minipellet sintering technology and deep-bed sintering operation (deep-bed sintering \geq

					500mm)	400mm)
6	Sintering exhaust heat recycling equipment	1.5	Equipped with Sintering exhaust heat recycling equipment, recycled exhaust heat $\geq 10\text{kgce/t}$ mine		Quipped with Sintering exhaust heat recycling equipment, recycled exhaust heat $\geq 8\text{kgce/t}$ mine	Use minipellet sintering technology and deep-bed sintering operation (deep-bed sintering $\geq 400\text{mm}$)
7	Sintering smoke comprehensive purification technology	1.5	Use comprehensive fuel gas purification technology with sintering machine desulfurization, denitration, dedioxin and heavy metal dust		Use comprehensive fuel gas purification technology with sintering machine desulfurization and denitration,	Use fuel gas purification technology with sintering machine desulfurization
8	Blast furnace gas dry dedusting device distribution rate %	1.5	100		≥ 80	≥ 50
9	Equipped with blast furnace top gas exhaust heat (TRT or BPRT) utilization device	2	TRT device distribution rate 100%, electricity generation $\geq 40\text{kWh/t}$ iron; or BPRT device distribution rate $\geq 50\%$, electricity saving $\geq 40\%$		TRT device distribution rate 100%, electricity generation $\geq 30\text{kWh/t}$ iron; or BPRT device distribution rate $\geq 30\%$, electricity saving $\geq 30\%$	TRT device distribution rate 100%, electricity generation $\geq 26\text{kWh/t}$ iron; or BPRT device distribution rate $\geq 30\%$, electricity saving $\geq 20\%$
10	Equipped with converter gas dry deducting device	1.5	Device distribution rate 100%, PM concentration at exit $< 20\text{mg/Nm}^3$		Device distribution rate $\geq 60\%$, PM concentration at exit $< 30\text{mg/Nm}^3$	Device distribution rate $\geq 30\%$, PM concentration at exit $< 50\text{mg/Nm}^3$
11	Regenerative	1.5	Use all ironmaking,		Use ironmaking and steel	Use steel rolling process

			combustion technology		steelmaking and steel rolling process	rolling process	
		12	Centralized treatment facility for sewage water of whole plant	2	Set up with centralized treatment facility for sewage water of the whole plant, total water recycling $\geq 80\%$, of which deep processing water is no less than 50% of total recycling	Set up with centralized treatment facility for sewage water of the whole plant, total water recycling $\geq 80\%$, of which deep processing water is no less than 30% of total recycling	Set up with centralized treatment facility for sewage water of the whole plant, total water recycling $\geq 80\%$
Resource and energy consumption	20	1	Coking process energy consumption kgce/t coke	3	≤ 115	≤ 125	≤ 155
		2	Sintering process energy consumption kgce/t mine	2	≤ 50	≤ 53	≤ 56
		3	P process energy consumption kgce/t mine	1	≤ 21	≤ 26	≤ 36
		4	Ironmaking process energy consumption kgce/t iron*	3.5	≤ 390	≤ 417	≤ 446
		5	Blast furnace fuel ratio kg/t iron	2	≤ 490	≤ 520	≤ 540

		6	Hot-blast stove blast temperature °C	1	≥1240	≥1200	≥1180
		7	C technology energy consumption kgce/t steel	2	≤-20	≤-8	≤0
		8	Converter steelmaking steel consumption kg/t	1	≤1080	≤1090	≤1100
		9	Production use fresh waster m3 water/t steel*	2	≤3.5	≤3.8	≤4.1
		10	Proportion of secondary energy electricity generation to total electricity consumption %	1.5	≥45	≥35	≥25
		Product features	5	11	Steel material yield (hot padding/hot and cold padding/hot padding, cold padding and	2	≥99/≥98/≥96

			coating) %				
		2	Steel quality pass rate %	1	≥ 99.8	≥ 99.5	≥ 99
		3	Steel quality superior rate %	2	≥ 50	≥ 30	≥ 20
Pollutant emission control	15	1	Waste water emission m ³ /t steel	1.5	≤ 1.4	≤ 1.6	≤ 1.8
		2	COD emission kg/steel	3	≤ 0.06	≤ 0.08	≤ 0.10
		3	Ammonia nitrogen emission kg/t steel	3	≤ 0.006	≤ 0.010	≤ 0.013
		4	PM emission kg/t steel		≤ 0.60	≤ 0.80	≤ 1.0
		5	SO ₂ emission kg/t steel		≤ 0.80	≤ 1.2	≤ 1.6
		6	NOx emission (as in NO ₂) kg/t steel	3	≤ 0.9	≤ 1.2	≤ 1.8
Resource comprehensive utilization	15	1	Production water recycling rate %	3	≥ 97	≥ 96	≥ 95
		2	Blast furnace gas utilization %	2	≥ 98	≥ 97	≥ 95
		3	Coke oven gas utilization %	2	≥ 99	≥ 97	≥ 95
		4	Converter gas recycled heat	2	≥ 28	≥ 23	≥ 18

			kgce/t steel				
		5	Iron-containing dust (slime) recycling rate %	1	100	≥ 98	≥ 95
		6	Blast furnace slagutilization %	1	100	≥ 98	≥ 95
		7	Converter slag utilization %	1	100	≥ 95	≥ 90
		8	Liquid iron pre-treatment, refine equipment, steel ladle, etc. scrap iron utilization %	1	≥ 98	≥ 90	≥ 80
		9	Desulfurization by-product utilization%	1	≥ 90	≥ 70	≥ 50
		10	Absorb municipal sewage	1	Absorb and utilize municipal sewage or utilized water accounted for $\geq 30\%$ of enterprise water intake		
Cleaner production management	10	1	*Compliance of product policy	1.5	Did not use production technology or devices that are officially prohibited or eliminated by the state, did not produce officially prohibited products.		
		2	Emission up to standard*	1	Enterprise pollutant emission concentration complies with the national and local relevant requirements		
		3	Total volume control*	1.5	Enterprise pollutant emission volume and total energy consumption complies with the national and local relevant requirements		
		4	Environmental	1.5	In accordance with national relevant requirements, establish sound environmental		

			pollution accident prevention*		management system and pollution accident prevention measures, prevent the occurrence of major environmental pollution accidents		
		5	Establish a sound environmental management system	0.5	Establish GB/T24001 environmental management system, and obtain certification, effectively functioning; completely fulfill annual environmental targets, indexes and environmental management plans, reach the requirements of continually improvement of environment; environmental management manual, procedure document and working document are complete and valid	Establish GB/T24001 environmental management system, and effectively functioning; fulfill annual environmental targets, indexes and environmental management plans $\geq 80\%$, reach the requirements of continually improvement of environment; environmental management manual, procedure document and working document are complete and valid	Establish GB/T24001 environmental management system, and effectively functioning; fulfill annual environmental targets, indexes and environmental management plans $\geq 60\%$, partially reach the requirements of continually improvement of environment; environmental management manual, procedure document and working document are complete
		6	Hazardous waste safe disposal	1	Establish relevant management system, ledger booking, transfer manifest are complete. After hazard-free treatment comprehensive utilization $\geq 80\%$	Establish relevant management system, ledger booking, transfer manifest are complete. After hazard-free treatment comprehensive utilization \geq	Establish relevant management system, ledger booking, transfer manifest are complete. After hazard-free treatment comprehensive

					70%	utilization \geq 50%
	7	Cleaner production organization institution and management system	1	Establish full-time leading institution for cleaner production, all member units and personnel in-charge have clear job division; has sound cleaner production management system and incentive management measure, implementation performance check record; formulate cleaner production work planning and annual work planning, organized and implement the targets, indexes and cleaner production plans raised in planning; targets, indexes and plans implementation rate \geq 80%	Establish full-time leading institution for cleaner production, all member units and personnel in-charge have clear job division; has sound cleaner production management system and incentive management measure, implementation performance check record; formulate cleaner production work planning and annual work planning, organized and implement the targets, indexes and cleaner production plans raised in planning; targets, indexes and plans implementation rate \geq 70%	Establish part-time leading institution for cleaner production, all member units and personnel in-charge have clear job division; has cleaner production management system and incentive management measure, implementation performance check record; formulate cleaner production work planning and annual work planning, organized and implement the targets, indexes and cleaner production plans raised in planning; targets, indexes and plans implementation rate \geq 60%
	8	Cleaner production audit	0.5	In accordance with government requirements, establish cleaner production	In accordance with government requirements, establish cleaner production	In accordance with government requirements, establish

				audit working plan, regularly carry out cleaner production audit activities to the whole process of steel production, high/medium-cost plan implementation rate $\geq 80\%$, achieve significant result of energy saving, consumption reduction and pollution reduction	audit working plan, regularly carry out cleaner production audit activities to the whole process of steel production, high/medium-cost plan implementation rate $\geq 60\%$, achieve significant result of energy saving, consumption reduction and pollution reduction	cleaner production audit working plan, regularly carry out cleaner production audit activities to partial process of steel production, high/medium-cost plan implementation rate $\geq 50\%$, achieve significant result of energy saving, consumption reduction and pollution reduction	
		9	Energy management institution, management system, energy management and control center	1	Has sound energy management institution and management system, all member units and personnel in-charge have clear job division, and play their role effectively; establish energy management institution and effectively functioning; has energy management control center, formulate enterprise energy using and energy saving development planning, annual controlled target	Has sound energy management institution and management system, all member units and personnel in-charge have clear job division, and play their role effectively; establish energy management planning and annual working plan, and organizing implementation; has energy management control center, formulate enterprise energy using and	Has energy management institution and management system, all member units and personnel in-charge have clear job division, and play their role effectively; establish energy management annual working plan; formulate enterprise energy using and energy saving development planning, annual controlled target

					completion $\geq 90\%$	energy saving development planning, annual controlled target completion $\geq 80\%$	completion $\geq 70\%$
		10	Carry out energy-saving activities	0.5	In accordance to national requirements, organizing energy saving evaluation and energy audit work, discover energy saving potential from three aspects, structure energy saving, management energy saving and technology energy saving; implement energy saving reconstruction project completion 100%, annual energy saving task reaches national requirement.	In accordance to national requirements, organizing energy saving evaluation and energy audit work, discover energy saving potential from three aspects, structure energy saving, management energy saving and technology energy saving; implement energy saving reconstruction project completion $\geq 70\%$, annual energy saving task reaches national requirement.	In accordance to national requirements, organizing energy saving evaluation and energy audit work, discover energy saving potential from management energy saving; implement energy saving reconstruction project completion $\geq 50\%$, annual energy saving task reaches national requirement.
	Total			100			

2.6 Evaluation Index System of Plate Glass Production Industry

This index system regulates the general requirements of plate glass industrial enterprises cleaner production. It is not applicable to electronics industry ultra-thin glasses under 1.1mm, automobile front windshield glasses under 2mm, ultra-clear plate glasses produced using calendaring technology and other special glasses with non-soda-lime-silica as main component. This system classifies cleaner production indexes into 6 categories, namely production technology and equipment index, resource and energy consumption index, resource comprehensive utilization index, pollution generation index, product feature index, and cleaner production management index.

This system is applicable to plate glass enterprises in cleaner production audit, cleaner production potential and opportunity estimation, cleaner production performance evaluation and cleaner production performance announcement, environmental impact evaluation, pollution emission permit, environmental leader and management system.

Table 15: Quantitive Rating System of Cleaner Production of Plate Glass

No.	Primary index	Primary weight	Secondary index	Unit	Secondary weight	Level I reference value	Level II reference value	Level III reference value
1	Production technology and equipment index	0.2	Plate glass manufacturing technology*		0.1	Float glass process		
2			Glass production single line melting capacity	t/d	0.2	900	700	500
3			Design kiln age	a	0.15	12	10	8
4			All fuel variety*	0.3	Natural gas		Heavy oil, Coal gas (caloricity \geq 10454kJ/Nm ³)	
5			Heating and burning method	0.25	Oxygen-fuel combustion	Use residual oxygen utilization measures and electric boosting, e.g. oxygen-enriched combustion, O# port xygen lance, etc.	Air fuel combustion	
6	Resource and energy consumption index	0.25	*comprehensive energy consumption per unit plate glass product ^a	kgce/weight case	0.3	12	13.5	14.0
7			*Plate glass melting furnace heat consumption ^a	kJ/kg glass liquid	0.3	5650	6400	6700

			(do not corrected for kiln age coefficient and fuel effect coefficient)					
8			Tin consumption	g/ weight case	0.1	0.7	1.5	2.0
9			Mirabilite content rate	%	0.1	2.0	3.0	3.5
10			Water intake	m ³ / weight case	0.2	0.002	0.005	0.008
11	Resource comprehensive utilization index	0.15	*Self-produced waste glass recycling rate	%	0.2	100		
12			Industrial waste water recycling rate	%	0.2	100	95	90
13			Glass melting furnace exhaust heat recycling		0.2	Dust exhaust heat electricity generation technology		Dust exhaust heat used to batch pre-heating, heavy oil heating or set up exhaust heat boiler
14			Raw material workshop dust recycling rate	%	0.2	100		
15			Magnesite-chrome brick recycling rate	%	0.2	100		
16	Pollution generation index	0.2	Waste water generation	m ³ / weight case	0.1	0.001	0.0025	0.004
17			CODcr generation	g/weight case	0.1	0.04	0.12	0.4

18			SS generation	g/ weight case	0.05	0.06	0.2	0.4
19			*SO ₂ generation	kg/ weight case	0.3	0.1	0.2	0.37
20			*NO _x generation	kg/ weight case	0.3	0.1	0.25	0.35
21			* PM generation	kg/weight case	0.15	0.015	0.025	0.035
22	Product feature index	0.1	Product quality		0.4	Superior quality rate 80%		Meet the GB11614 standard
23			Product application field		0.3	Glass making and automobile front windshield	Deep processing	Other uses
24			Production energy-saving and solar energy applied products		0.3	On-line TCO, on-line LOW-E or solar control coated glass		others
25	Cleaner production management index	0.1	*Implementation performance of environmental laws and regulations		0.14	Comply with national and local relevant environmental laws, regulations, waste water, waste gas, noises, etc. pollutant emission, solid waste treatment and disposal complies with national and local emission (control) standard; pollutant emission should meet national and local pollution emission volume control index and pollution discharge management requirement.		
26			*Implementation performance of industry policies		0.14	Production scale complies with national and local relevant industry policies, do not use national and local official prohibited or eliminated technology and		

					equipment	
27			*Cleaner production audit performance	0.08	In accordance with national and local requirement, conduct cleaner production audit	
28			Environmental management system	0.08	In accordance with GB/T 24001, set up and run environmental management system, environmental management system document and working document are complete	Well-established environmental management system and complete management documents
29			Waste gas treatment facility operation management	0.08	Establish pollution treatment facility operation ledger	
30			Pollutant emission monitoring	0.08	In accordance to the requirements of Pollution Source Automatic Monitoring Management Measures, install smoke pollutants emission automatic monitoring devices, and networking with monitoring device of environmental protection department, and ensure the well-functioning of devices.	
31			Energy management system	0.08	In accordance with GB/T 23331 requirement, establish and run energy management system, energy measuring devices are equipped in compliance with GB 17167 requirement	Energy measuring devices are equipped in compliance with GB 17167 requirement
32			Environmental management system and	0.08	Has well-established environmental management	

			institution		system; set up specialized environmental management institution and specialized management personnel.	
33			Environmental contingency	0.08	Establish contingency plan to environmental accidents in the system, filling and conduct emergency drill in accordance with regulations.	
34			Environmental information disclosure	0.08	Disclose environmental information in accordance with <i>Measures for the Disclosure of Environmental Information (Trial Implementation)</i> the 19th article	Disclose environmental information in accordance with <i>Measures for the Disclosure of Environmental Information (Trial Implementation)</i> the 20th article
35					0.08	Compile enterprises environmental report book in accordance with HJ 617
<p>Note 1. For glass enterprises that produce thin plate under 4mm and thick plate above 12mm, use data from 5mm transparent plate glasses produced by melting furnace to compare with this table.</p> <p>Note 2. indexes with * are definitive index</p> <p>a. In accordance with GB 21340-2013 regulations, the evaluation object of this index excludes oxygen-fuel combustion glass melting furnace. The index of this type of melting furnace equates fulfilling level I reference value requirement.</p>						

3. Case Analysis of Cleaner Production of China Building

Material Industry

Until now China has carried out 5 cleaner production audits, in total 17862 enterprises passed the audit. Then take examples as plate glass enterprises, cement enterprises and ceramics enterprises in construction industry, according to the operation procedure, introduce how they conduct cleaner production audit from simple to complex.

3.1 Case Analysis of Plate Glass Cleaner Production Industry

China is a big plate glass production country, the scale of production has ranked top 1 worldwide for 20 consecutive years. In 2012, the annual plate glass production reached 760 million weight case with a total sale of 722 million weight case. It is estimated that, flat glass industry production capacity has exceeded the market demand for nearly 40%, while capacity utilization only accounts for 63%. SO, redundant construction and over capacity problems in the industry are quite severe. Meanwhile, plate glass industry is a high energy consumption and resource intensive industry, the Ministry of Environmental Protection issued *Notice on Advancing Key Enterprises Cleaner Production* (EL No. [2010]54) and Notice of the General Office of the State Council on Implementing Suppressing Overcapacity and Redundant Construction in Some Industries for the Division of Work for Key Departments (General Office of the State Council No. [2009]116), etc. It refers to public steel, cement and glass products and takes seven over capacity major industries as the focus of implementing cleaner production audit in accordance with the laws, and actively guide and supervise key enterprises to conduct cleaner production. Cleaner Production for plate glass industry fundamentally contributes to reduce resource and energy consumption, mitigate environmental pollution and ensure continuous improvement of environmental quality.

3.1.1 Enterprise Cases

(1) Enterprise Introduction

A plate glass production enterprise is an integrated enterprise that combines glass, coke and fine coal. Its main products are plate glasses of all sizes and according by-products are coke, coke gas and coking tar. The coke furnace production line produces coke gas and coking tar as main fuels for sheet glass production. The produced coke is supplied to the market. So, gas production and coal production lines are combined, both ensuring clean coal for coke production and also reducing coal production costs. Moreover, waste coal, middling coal and drystone can be used by paper mill.

(2) Main Technological Process and Pollution Generation Link

During the production process, pollution is mainly caused by gas emissions. In addition, there is waste water and domestic sewage, generated during production and maintenance processes. Solid wastes mainly come from raw material workshop wastes, glass falling out during transportation and disposal, and waste material from cold repair process, etc. The block diagram of main pollution factors generated during process flow and production process see Figure 1.

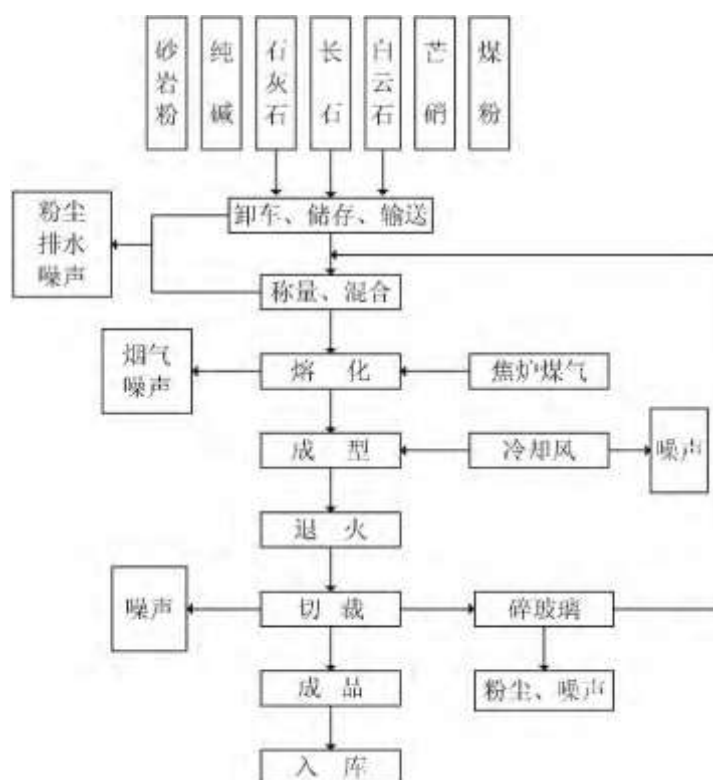


Figure 1: Plate Glass Enterprises Process Flow Diagram

(3) Enterprises Cleaner Production Status Quo and Existing Major Problems

Through an investigation and analysis to the whole plant it is shown that, although the enterprise adopted the improved sheet production technology, there are still some cleaner production indexes failing to meet domestic basic level requirement. From the aspect of key indexes composition, in some definable targets, especially indexes concern material consumption, energy consumption and pollution emission, there are still some gaps. This is mainly due to some problems during production process, that the current cleaner production level can be improved. The comparison with plate glass industry cleaner production indexes see Table 16.

Table 16: Index Value Comparison between One Plate Glass Enterprise and Requirements

Project	Level I	Level II	Level III	Comparison Level
1.Resource and Energy Utilization Index				
(1).Plate glass comprehensive energy consumption per unit	≤13	≤18.5	≤20	Level 3
(2).Electricity consumption (kW.h/weight case)	≤6.5	≤7.5	≤8.6	Level 2
(6) Mirabilite containment rate %	≤2.0	≤3.5	≤5.0	Level 3
2.Product Index				
(1).Total yield %	≥88	≥85	≥75	Level 2
No. of glass bubble per m ²	0.3mm≤L≤0.5mm:2			Level 1
3.Waste recycling index				
(1).Glass recycling rate%	100			Level 1
(2).Industrial waste water recycling rate%	100	≥90	≥80	Level 3
(3).Raw material workshop dust recycling rate%	100			Level 1
(4).Magnesium and cadmium recycling rate	100			Level 1
4.Pollution generation index				
(1).Waste water generation (m ³ / weight case)	≤0.05	≤0.10	≤0.16	Level 3
(2).COD generation (g/weight case)	≤2	≤5	≤16	Level 2
(3).SS generation (g/weight case)	≤3	≤8	≤15	Level 3
(4).SO ₂ generation (g/weight case)	≤0.11	≤0.44	≤0.61	Level 2
(5).NO _x generation (kg/weight case)	≤0.4	≤0.6	≤0.8	Level 3
(6).PM generation (kg/weight case)	≤0.072	≤0.096	≤0.120	Level 3
5.Environmental Management Requirements				

(1).Cleaner Production Audit	Carry out audit in accordance with enterprises cleaner production audit guideline compiled by State Environmental Protection Administration	Level 1
(2).Environmental Management System	Establish and operate environmental management system in accordance with ISO14001, environmental management manual, procedure document and working document are complete, environmental management system is sound, raw record and statistical data are complete and valid.	Level 2

It is shown from Table 16 that there are 5 indexes reaching Level 1, which is 25% of total indexes; 5 reaching level 2, 25% of total indexes; 7 reaching Level 3, 35% of total indexes

(4) Existing Major Problems for Enterprises

Currently, some major problems for enterprises exist: firstly, the reservoir water is not recycled. During the melting procedure, large amounts of cooling water and high temperature water enter the reservoir, mostly directly discharged into the trench. This does not only waste huge water resource but also causes thermal pollution. Secondly, the idling of themotor. Some motors in the melting furnace workshop often operates idling, it is non-economical operation and sever waste of electricity energy. Thirdly, gas generator furnace has huge energy consumption and low efficiency. Coal-based gas generator furnace provides fuel to the combustion of glass melting furnace. It not only severely wastes huge energy resources but also discharge a large amount of hazardous gas into the atmosphere including CO、CO₂、SO₂ and NO_x, etc. Severely damages the environment and cause huge pollution. Lastly, the furnace kiln has poor heat preservation and heat loss is severe. High energy consumption of glass production is a major common fault of domestic plate glass industry. Around 30% heat is diffused into the air from the kiln surface. It's not only a waste of energy but also deteriorates production operation environment; around 40% heat enters the funnel along with waste gas, wastes huge amount of coal every year.

3.1.2 Cleaner Production Scheme

(1) The Formulation and Screening of Cleaner Production Scheme

On the existing enterprises problems, cleaner production scheme is formulated after an evaluation and analysis on the overall production of enterprises, the usage of material and energy and all kinds of balances. The relevant enterprises leaders, technician and on-site operator and technical experts inside and outside plant together prioritize and screen out no cost/low cost scheme and medium/high cost scheme, based on technical feasibility, environmental effect, investment funds and benefit. Then cleaner production audit team, industry experts and cleaner production audit experts' three-party discussion on the proposed cleaner production scheme, from three aspects of environment, technology and economic condition. Finally

establish 11 cleaner production audit implementation schemes, including 8 no/low cost ones and 3 medium/high cost ones. The specific cleaner production scheme and progress see Table 17.

Table 17: Overview of Cleaner Production Plans

NO.	Plan	Completion	
No/low cost plan	LF1	Cooling water reservoir pipeline reform	Completed
	LF2	Electricity technology reform	Completed
	LF3	Gas pressing machine and cooling machine improvement	Completed
	LF4	Install automatic watering system to water tower	Completed
	LF5	Melting furnace workshop and horizontal drawing workshop green lighting	Completed
	LF6	Raw material dust recycling	Completed
	LF7	Raw coal and powdered coal recycling and cleansing	Completed
	LF8	Enhance material management	Completed
Medium/high cost plan	HF1	Gas generator furnace turning into coke oven gas production line	Completed
	HF2	Furnace all-around thermal insulation and energy saving	Completed
	HF3	Install cooling tower, build reservoir to reduce water temperature	Completed

(2) Cleaner Production Three-Benefits Analysis

With the implementation of enterprise cleaner production scheme, all cleaner production indicators have been improved, and achieved significant social, economic and environmental benefits. This round of cleaner production generated 11 feasible cleaner production schemes with a total investment of 20,997,900 yuan. After the scheme implementation is complete, the total annual operational costs are reduced by 36,608,300 yuan compared to pre-audit years. After all schemes are implemented, the annual saving is 887,300kW·h, waster saving 1,100t, coal saving 47,300t, SO₂ reduction 1052.66t/year.

3.2 Case Analysis of Cement Cleaner Production Industry

3.2.1 Introduction of Cleaner Production Program

The cement industry is illustrated using this cement enterprise as an example. Enhancing environmental awareness, improving resource and energy utilization, fulfilling the comprehensive recycling and utilization of production “three wastes”, eliminating pollution hazard, have always been the works for this enterprise. With the continuously deepening of “create a conservation-oriented society” and enterprise’s own need for development, enterprises are paying more and more attention to cleaner production. In the beginning of 2011, the enterprise hired cleaner production experts

for facilitation and guidance for multiple times. Held “cleaner production” symposium, “cleaner production knowledge” tutorial lecture to above enterprise-manager staff, and held in-depth discussion with enterprise leaders. The enterprise set up a sound audit team and had comprehensive staff training in different forms. Long-term cleaner production audit team is formulated under the leadership of chief responsible person, to be responsible for the cleaner production work within the enterprise, and make cleaner production a powerful management measure for the enterprise. Include continuous improvement of cleaner production into enterprise development planning, to further promote the rapid, sustained and stable development of the enterprise, to improve overall quality, enhance competitive advantage, development advantage and benefit advantage.

3.2.2 Planning and Organizing

(1) Gain Leaders’ Support

This cement enterprise has adhered to the “three simultaneous” strategy of environmental protection and enterprise development to be simultaneously planned, simultaneously constructed and simultaneously operated since plant establishment. The enterprise has always attached great importance to the win-win of environmental benefit and economic benefit, especially the top-level leaders pay great attention to conducting cleaner production audit to the enterprise, and also invite cleaner production audit experts for training and inspection, to understand the details of production process, explore cleaner production opportunity and potential. It laid a good foundation for the implementation of cleaner production work.

(2) Establish Cleaner Production Audit Team

To ensure the smooth and organized conduct of audit work, set up a cleaner production audit team with enterprise plant director as team leader, enterprise chief engineer as deputy team leader. On the basis of taking experts’ opinions and consulting institution’s guidance, achieved a clear work division among team members.

(3) Formulate Audit Work Plan

In order to achieve a satisfactory result from the audit, the audit team formulate an audit work plan in accordance with manual requirements in combination with the audit working performance. See Table 18.

Table 18: Plan of Cleaner Production Implementation

Phase	Work Content	Completion Time	Department	Results
1. Planning and Organizing	1. Carry out publicity and education, organize learning	2010.12-2011.1		
	Acquire top leader support		External audit institution	1. Acquire top leader support

	2. Form enterprise audit team		Department leaders	2. Form enterprise audit team, make audit work Plan
	3. Make audit work Plan			
2.Pre-evaluation	1. Conduct status survey; enterprise profile	2011.1-2011.3	Department heads	
	Production status, environmental protection status		Professionals & technician	
	2. Analyze pollution generation cause, draw conclusions		Audit team	
	3. Determine audit focus			1. Determine audit focus
	4. Propose cleaner production targets			2. Implement no/low cost plan
3.Evaluation	1. Determine material input, output and pollution emission status	2011.3-2011.4	Department heads	
	2. Form material equilibrium diagram, water equilibrium diagram		Technical heads	1. Material and water equilibrium diagram
	3. Analyze waste generation cause		Audit team	2. Waste generation cause, analysis result
	4. Propose and implement no/low cost plans			3. No/low cost plans implementation
4. Plan Formulation and Screening	1. Backup plan	2011.4-2011.6	Department heads	Cleaner production scheme list
	2. Plan classification and screening		Professionals & technician	
	3. Interim report, no/low cost plan		Audit team	
5. Feasibility Analysis	1. Conduct technology feasibility analysis	2011.6-2011.7	Audit team	Implemented plan feasibility
	2. Environmental, economic and social benefit			Analysis report

	evaluation			
	3.Recommend enforceable plan			
6.Plan Implementation	1.Organize the implementation of plan	2011.7	Relevant technician	1. Implemented plans
	2.Assessment on the implemented plan results		Audit team	2.Implemented result
7.Continuous Cleaner Production	1.Establish sound cleaner production organization	2011.7-2011.8	Branch leaders	Continuous cleaner production plan
	2. Establish sound management scheme		Audit team	
	3.Form continuous cleaner production plan			
8.Audit Report	1.Compile audit report for expert inspection	2011.8	Branch leaders	Cleaner production audit report
	2.Complete audit report		Audit team	

(4) Publicity Education

In order to smoothly deploy cleaner production audit work, it is necessary to educate all the leaders and employees about the current environmental protection awareness and significance of conducting cleaner production work, through publicity education and relevant training. Furthermore, it is important to eliminate ideological obstacles and create a favorable public atmosphere. On 13th January 2011, the enterprise invited experts for cleaner production training and ideological mobilization. There were 37 participants including audit team members and other responsible persons. The content included social background of cleaner production, domestic and foreign status quo, the significance and relevant cases of enterprises deploying cleaner production. With the training, audit team members got a better understanding of cleaner production and realized the significance of deploying cleaner production on enterprise energy saving, consumption reducing, pollution reducing and efficiency enhancing. Predictions and analyzes concerning the possible obstacles that encounter during cleaner production audit work were also discussed and participants come up with according solutions. Moreover, the trainings provided basic knowledge, organizational, technical and material support. See Table 19 for cleaner production audit barriers and solutions.

Table 19: Barriers and Solutions of Cleaner Production Audit

No.	Barrier	Cause	Solution
1	Idea barrier	Some employees consider clean audit to be a few people's work, themselves not included.	Use a variety of publicity channels, promote the purpose, significance of cleaner production, and explain cleaner production potential benefits using the results of cleaner production from domestic and foreign peer
2	Organization Barrier	The ideological conflict between current management system and cleaner production	Enhance training, establish the ideology of cleaner production and pollution prevention, establish examination scheme for performance assessment
3	Production barrier	Lack of basic data; lack of cleaner production technology	Collect sufficient information, enhance research and test
4	Economic barrier	Concerned about expense and no actual return	Carry out audit work as soon as possible, and implement no/low cost plans to gain actual benefits.

With publicity education the education rate of all enterprise employees reached over 90%, most of them have a clear understanding of the concept of cleaner production and cleaner production audit content and measures within a short period of time. So as to achieve the goals of correct ideology, realize and do the best to reduce waste generation and energy consumption to the largest extent.

3.2.3 Pre-audit of Cleaner Production

(1) Enterprise Introduction

This cement enterprise is a limited liability company, its business scope includes: cement production and sales, wear-resistant material casting, new construction material sales and limestone mining. The company currently has 294 employees in total, including 21 technicians. Production-site staff has a three-shift system, management staff above group leader level has day-time shift system, and there are 310 working days annually. The enterprise was established in August 2004, by 2010 the gross annual output value is 1.5 billion yuan, annual profits and taxes is 69 million yuan.

This cement enterprise has 180,000m² floor area. Currently, it has one new cement production facility, with an annual output of 1200t clinker and a 0*10⁴t cement production capacity. The production line was officially put into operation in November 2004. Using the world's most advanced ABB company's AC800F and DCS (distributed control system). Inspection machine is at the advanced level in the cement industry. The main products are: P.O42.5R、P.O42.5、P.C32.5、P.C32.5R, etc.

cement varieties. It passed ISO9001:2000 quality management system certification in 2002, its products have features such as high strength, high extra coefficient, low alkali content, intensive paste structure, high penetration resistance and frost resistance, good abrasive resistance and corrosion resistance, etc. The key markets are Yinchuan, northern Shaanxi, Bayannur, Alxa League and Erdos, etc. Extensively used in industrial and civil building, highway, bridge construction and airport, etc.

(2) Field Investigation

A Field investigation to the production site of the cement enterprise was organized. Seminars and consulting dialogues were conducted to further understand the current cleaner production status. Moreover, no/low cost plans were proposed and collected and the feasible ones were summarized, respectively. Lay the foundation of determining audit focus through field investigation.

1) Key Production Process Flow Chart

- ① 1200T/D clinker production line, limestone crushing and delivering--- limestone prehomogenization---raw material storage and allocation---raw material grinding and waste gas treatment---raw material homogenization and feeding--- clinker sintering---clinker cooling---clinker storage and delivering, clinker bulk coal crushing and prehomogenization--- coal dust preparation---clinker sintering.
- ② 500,000T/A cement production line, plaster crushing and delivering---cement batching---cement grinding---cement storage, bulk transportation, and detailed production process see Figure 2.

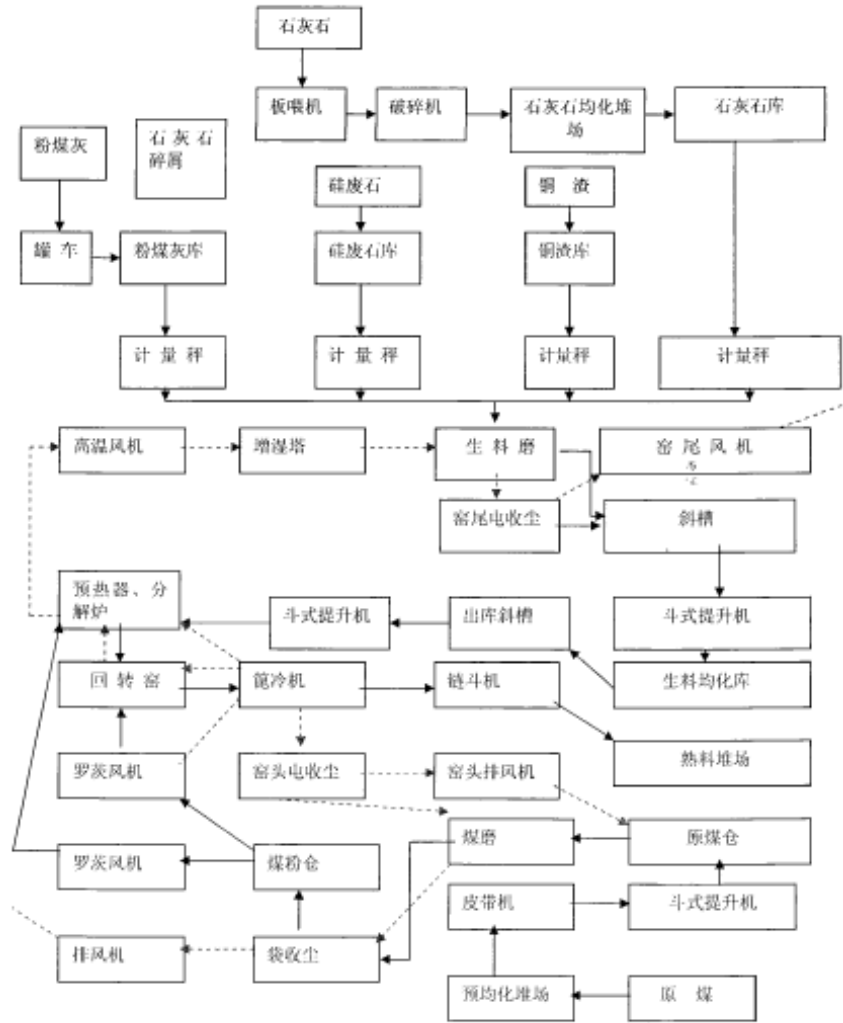


Figure 2: Clinker Production Process Flow Chart

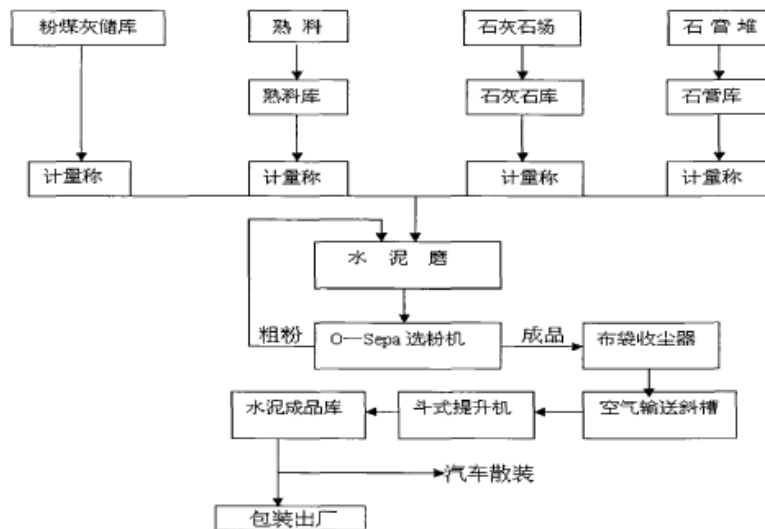


Figure 3: Cement Grinding Technology Flow Chart

The raw materials consumed in the sintering process are limestone (lump), limestone chippings, coal ash, pyrite residue, copper residue, raw coal, middling coal and silicon waste rock. Raw materials consumed in the manufacturing process are cinder, plaster, silica powder, desulfurization plaster and limestone chippings. Raw material annual consumption and source see Table 20.

Table 20: Supply and Consumption of Source Material (Year 2010)

Workshop	Material	Consumption t/a	Indicator	Source
Sintering Workshop	Limestone	390,728.60	CaO \geq 49%	Otog banner Zhongkai Mining Development Co., Ltd.
	Coal ash	87,067.52	Al ₂ O ₃ \geq 30.0%	Erdos Inner Mongolia Electricity Co., Ltd.
	Pyrite residue	9,265.28	Fe ₂ O ₃ \geq 45%, 55%、75%	Qingtongxia Liyuan Trading Co., Ltd.
	Copper residue	10,697.16	Fe ₂ O ₃ \geq 55%	Bayannur Feishang Copper Industry Co., Ltd.
	Raw coal	50,967.10	Heat generation \geq 4800Kcal/kg	Otog Banner Dongchen Coal Mining
	Middling coal	19,606.80	Heat generation \geq 4700Kcal/kg	Shenhua Coal Transportation and Marketing Company Wuhai Branch Company
	Silicon waste stone	33,983.74	SiO ₂ \geq 82%	Otog banner Zhixinggui Limestone
Manufacturing Workshop	Plaster	5,599.45	SO ₃ \geq 35%	Co., Ltd. Otog banner Mengxing Plaster Co., Ltd.
	Cinder	33,096.43	Loss on ignition \leq 5%	Individual household
	Desulfurization plaster	17,769.09	SO ₃ \geq 40%	Erdos Inner Mongolia Electricity Co., Ltd.
	Silica powder	20,822.44	SiO ₂ \geq 65%	Erdos Xijin mining and metallurgy Co., Ltd.
	Limestone chippings	148,977.96	CaO \geq 47%	Individual household

2) Enterprise Electricity Utilization

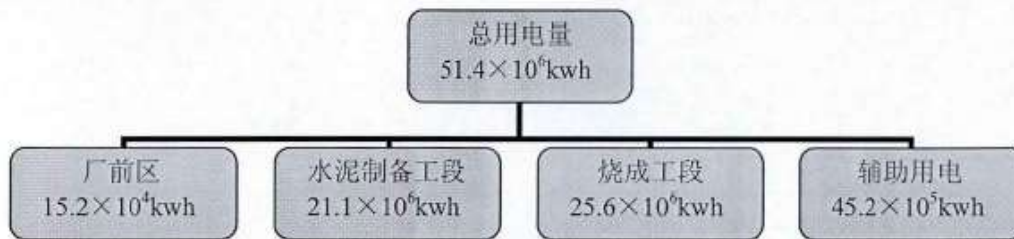


Figure 4: Enterprise Electricity Consumption

3) Enterprise Heat Supply

This plant belongs to a central heating area, adopting the domestic advanced RB-SM-4T hot water boiler and setting the exit power at 240×10^4 kcal/hr, using low quality bituminous coal with daily consumption 6t/d and annual consumption 1080t. Indoor calculated temperature of heating design is implemented based on the *Cement Industry Labor Safety and Health Design Regulation*.

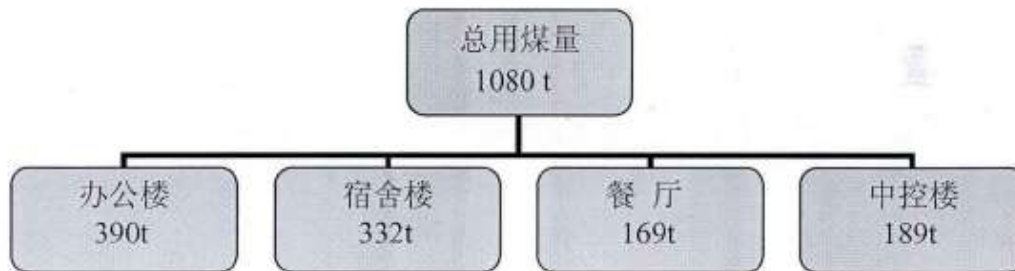


Figure 5: Pleat Heating Supply

4) Enterprise Water Usage

Drainage system including production circulating cooling water and subsidiary water consuming system, domestic water. The producing water usage are all circulating cooling water and domestic water, the total circulating water amount is $319.2 \text{ m}^3/\text{d}$, among which circulating water supplementary amount is $247.2 \text{ m}^3/\text{d}$, domestic water usage is $47.04 \text{ m}^3/\text{d}$, fresh water is $366.24 \text{ m}^3/\text{d}$. For the annual water usage see Figure 6

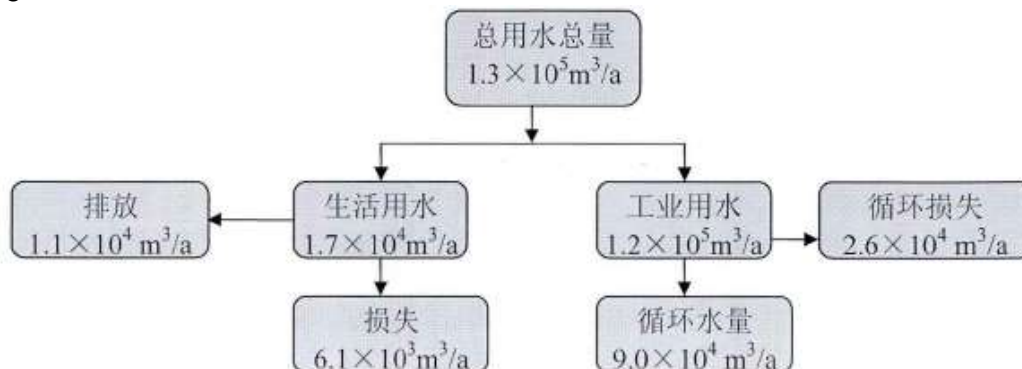


Figure 6: Plant Water Supply/Discharge

(3) Main Pollutants and Treatment Measures

1) Waste Gas

Enterprise waste gas mainly comes from rotary kiln. Rotary kiln produces waste gas after the clinker firing process. The main waste gas generation parts are at kiln head and kiln tail. The main pollutants are dust, SO₂、NO_x、CO, etc.

Kiln head waste gas goes through kiln head static dust collection, then the falling dust arrived at storage yard through conveyor, waste gas discharges into the atmosphere through exhaust fan after reaching standards. Kiln tail waste gas cools down through kiln end humidifier tower, after static dust collection at the kiln tail the falling dust arrived at homogenization silo through conveyor, waste gas discharges into the atmosphere through tail exhaust fan after reaching standards. All of the production steps are reaching the cement industry enterprise pollutant emission standards under the monitoring of Erdos Environmental Protection Department.

Table 21: Smoke and Dust Emission Results of Each Outfall

No	Name	Air Capacity (Nm ³ /h)	Discharge Temperature (°C)	Dedusting Equipment	Entrance Concentration (g/Nm ³)	Qualified Concentration (g/Nm ³)	Emission (t/a)
1	Limestone crushing	13390	Room temperature	Bag dust collector	200	30	0.22
2	Ras material station Roof	5200-7000	Room temperature	Bag dust collector	100	30	0.66
3	Coal mill	40100	Room temperature	Bag dust collector	100	50	2.3
4	Homogenization silo roof	8930	Room temperature	Bag dust collector	20	30	0.44
5	Sintered kiln tail	30000	150	Electric dust collector	500	50	15.56
6	Clinker tower roof	6000	80	Bag dust collector	200	30	0.17
7	Clinker cooling	230000	250	Electric dust collector	200	50	20.2
8	Cement	158000	90	Bag dust	100	30	17.5

	mill			collector			
9	Cement silo roof	5200-7000	60	Bag dust collector	100	30	0.2
10	Bulk silo roof	22500	Room temperature	Bag dust collector	100	30	0.2
11	Packaging workshop	26700	Room temperature	Bag dust collector	100	30	2.56

2) Waste Water

The main source of waste water discharge: domestic water. Domestic water around 17169.6m³/a, production workshop washing water and circulating cooling water are all utilized, domestic sewage round 6132m³/a. Main pollutants are COD、BOD、SS, etc. Waste water treatment process of the plant: production waste water is recycled and not discharged externally, daily domestic sewage discharge amount is 16.8t/d, laboratory acid and alkali-contained sewage converges into septic tank after neutralization and dilution. Collected and treated every day by the Inner Mongolia Mengcheng city Economic Development Zone Management Committee Bureau for Environmental Health. Domestic sewage treatment schematic is shown in Figure 7.

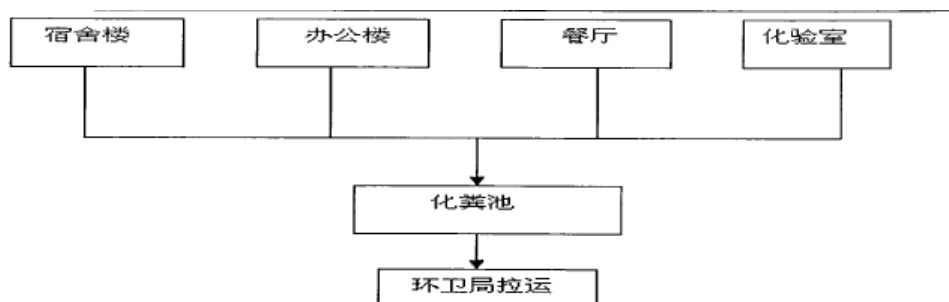


Figure 7: Domestic Sewage Treatment Schematic

3) Solid Waste

Solid waste is not generally produced during the enterprise production process, but is mainly generated from household garbage. The total household garbage output accounts for 300kg/d. The environmental sanitation collects and processes all of them.

4) Noise

There is many noise generation equipment in this project, as the sound level is high. Noises mainly come from shredding, raw material grinding machine, coal grinding, air compressor and fan, etc. All noise sources have been taken relevant shielding measures to reduce noise impact on environment. Detailed measures see Table 22:

Table 22: Generation and Treatment of Noise

Process	Main Noise Source	Control Measures
Raw Material Workshop	Limestone Crushing Machine	Soundproof wall
Raw Material Workshop	Raw Material Grinding Machine	Soundproof wall, silencer
Furnace Workshop	Raw Material Homogenization Roots Blower	Silencer
Furnace Workshop	Clinker Cooling, crushing	Soundproof wall, silencer
Furnace Workshop	Raw Material Grinding Machine	Soundproof door
Furnace Workshop	Raw Material Grinding Machine	Soundproof door
Manufacturing Workshop	Cement Grinding Machine	Soundproof door

(4) Determine Audit Focus

Through the investigation of whole plant's status quo, onsite inspection, pollution generation and emission analysis, to combine with practice. The clinker burning section and cement manufacturing section of enterprise cement production are the alternative audit focus, analyze and summarize on three aspects of production process main consumption, waste generation and environmental cost, that is the clinker burning and cement manufacturing are the alternative audit summary of key cases. After summarizing, determine the 6 factors influencing enterprise cleaner production, namely waste output, main consumption, environmental protection cost, waste toxicity, cleaner production potential and workshop initiative, as the basis of evaluation. Grading using the weighted ranking method that is the weighted ranking of clinker burning and cement manufacturing sections. Lastly determined, the audit focus of this round of cleaner production is clinker burning section.

Table 23: Goal of Cleaner Production of Enterprises

No.	Project	Unit	Status 2010	Short-term Target End of 2011		Long-term Target 2013	
				Indicator	Relative Quantity (%)	Indicator	Relative Quantity (%)
1	Heat material comprehensive energy consumption	kg/t	118	116.5	Decrease 1.27	115.5	Decrease 0.8
2	Recycling water utilization	%	90%	95%	Increase 5%	97%	Increase 2%

(5) Present and Implement No/Low Cost Plans

On the basis of extensively collected reasonable proposals, present and implement a number of simple no/low cost plans, which receive environmental benefit and economic benefit to some extent.

Table 24: Summary of Plans of No Charges/Low Charges

No.	Name	Introduction	Investment (10 ⁴ yuan)	Anticipated Benefit
F1	Reform the air cylinder of coal mill dust collector	Use ribbon heater to twine the dust collecting air cylinder from top to down, then covered with quilt to prevent air cylinder from freezing and malfunctioning	0.09	Reduce main engine shut down time, increase equipment efficient operation rate, decrease the energy consumption caused by device malfunctioning shut down
F2	Reform the cement grinding mill reduction gears of oil leak	Reform on the sever oil leak of cement grinding mill main reduction gear, reseal using new seal gum, re-fix the cover-end bolt to achieve the desired effect	No cost	No-cost investment, after reform the main reduction gear has a good leakproofness. Calculated by 0.625kg leak/hour, annually saved machine oil 3870.27kg, saved cost 57600yuan.
F3	Reform of new packing machine line	Move forward the top-hung bridge originally at the open flashboard by 60mm, move backward the red pipe instrument controller originally at the close flashboard by 20mm. The purpose is to open the flashboard in advance when canning, and postpone the closing, prolong canning time, fulfill bag weight requirement, decrease bag per round, increase production and reduce electricity consumption	No cost	No-cost investment, after reform production increase by 0.06t/hour, reduce electricity consumption
F4	Install bulk	Install one air conveyor at the	2	Increase cement

	cement system on #2 and 3 cement bunker	bottom of cement bunker, one steel cable tray, use cement bunker #2 and 3 for direct bulk packing, increase truck loading rate		bulk packaging rate, annually increase 30%
F5	Replace the operation computers in central control room	The operation computers in the central control room are the lowest configuration computers since plant establishment and have low speed, affecting normal operation. Therefore replace with computers with high configuration	0.96	Enhance central control room working efficiency, reduce all the energy consumption due to computer malfunctioning leading to main engine shut down
F6	Double use office papers	All office papers are replaced with double-side papers excluding a few documents. Improve office supplies effective utilization	No cost	Office papers are replaced with double-side papers, reduce office costs and enhance enterprise management and working performance
F7	Collect obsolete cotton yarn	Collect all the obsolete cotton yarn used to wipe equipment in a designed bucket, reutilize for rotary kiln firing. Save cost and reduce waste	No cost	No-cost investment, use in rotary kiln firing after recycling. Annually save 160kg and cost 1228yuan.
F8	Reform deironing roller installed to new cement grinding mill line	Install the obsolete magnet roller at cement grinding enter long belt, then driven to run by the belt and absorb waste iron contained in material. Good for cement grinding blocking the slot.	No cost	Use waste reforming to improve operating rate and output for cement grinding main engine equipment

3.2.4 Cleaner Production Evaluation

(1) Audit Focus Overview

1) Clinker Sintering Section

The raw material has four groups of burdening, namely limestone, silicon waste stone, copper residue and coal ash. Raw materials entering the plant arrived at corresponding storage by conveyor (in-plant limestone enters limestone prehomogenization yard after grinding, and then enters limestone storage), then after

bottom reservoir burdening, feed into raw material mill for grinding through belt conveyor, drying hot wind is provided by hot winder exits the preheater machine. Grinding qualified raw material are collected through electric dust collector carrying by wind, the collected raw material dust then enters raw material prehomogenization yard through conveyor for prehomogenize. The prehomogenized raw material then enters preheater machine for heat exchange decomposition through feeding and metering devices. Then, in-window calcination follows. Heat source for calcination and decomposition comes from coal burning. After homogenization and grinding, the in-plant raw coal arrives at head coal and tail coal pulverized coal bunkers, for raw material prehomogenization and sintering. After sintering, the clinker goes through the grate cooler for cooling down, and is then delivered to clinker storage yard or stored through conveyor.

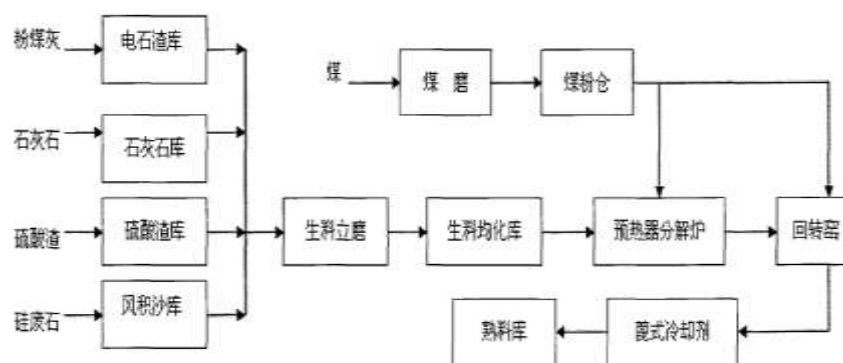


Figure 8: Clinker Sintering Section Technological Process

2) Function Description of Unit Operation

Table 25: Function Description of Unit Operations of Fired Station

Sintering Section	Function Description
Raw material grinding	After calculating grind the material through ball mill
Raw material prehomogenizing	Prehomogenization silo prehomogenize raw material with wind power, so as the production zone burdening is stable
Coal dust production	Grind raw coal into coal dust, and fineness reaches rotary kiln clinker sintering requirement
Pre-heater	Put prehomogenized raw material through pre heater for decomposition, decomposition rate reaches 90%
Rotary kiln	Decomposed raw material enters rotary kiln for sintering
Grate cooler	Clinker enters grate cooler for cooling down then arrives at clinker storage yard through conveyor.

(2) The Input and Output of Audit Key Materials

In order to conduct a more in-depth and detailed analysis of the reasoning of material balance and waste generation on the audit key materials at this phase, the audit team

makes full use of current testing equipment, and with the help of testing equipment and manpower from assistance units, under the condition of normal production, using on-site inspection for further testing the input and output material.

1) Clinker sintering section Material Balance

Table 26: Summary of Input/output Data of Clinker Station

Input		Quantity (t/d)	Output	
Input			Output	Quantity (t/d)
Raw Material	Limestone	2241.5	Clinker	1244
	Silicon Waste Stone	156.2		
	Coal Dust	47	Ignition loss, homogenization remaining raw material, dust, CO ₂	1489.6
	Coal Ash	62.4		
Coal Grinding	Raw Coal	226.5		
Total		2733.6		2733.6

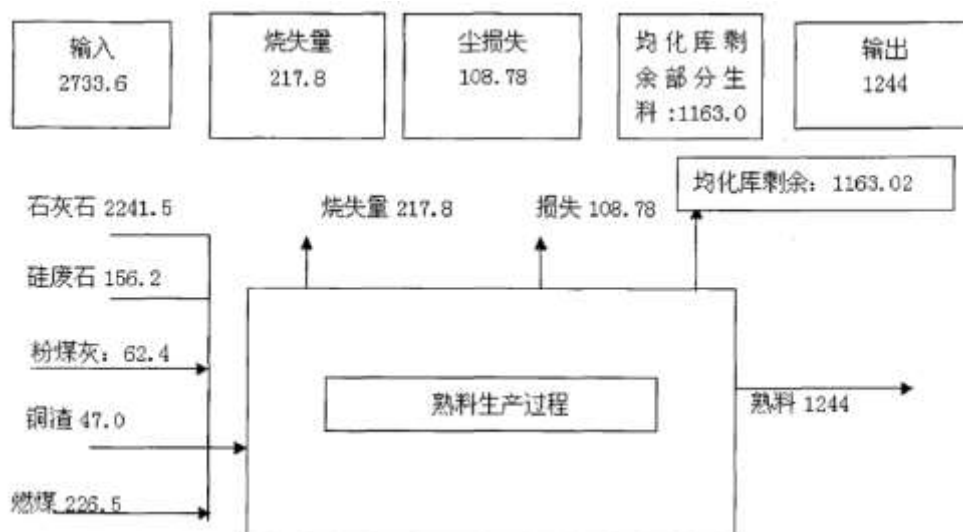


Figure 9: Clinker Sintering Section Material Balance Unit: t/d

2) Clinker Sintering Section Water Balance

Table 27: Water Balance of Clinker Station

Water Usage (m ³ /d)		Drainage and Water Consumption (m ³ /d)	
Name	Quantity (d)	Name	Quantity (d)
Water Supply	364.01	Production Device Water usage	247.2
Device circulating	145.4	Device circulating	145.4

cooling water		cooling water	
		Unforeseen water usage	44.81
		Evaporation Loss	62.4
		Wind Loss	9.6

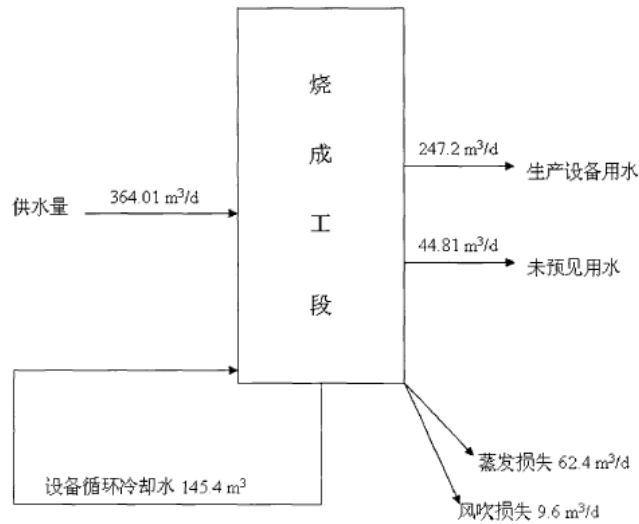


Figure 10: Clinker Sintering Section Water Balance

2) Clinker Sintering Section Heat Balance

Table 28: Heat Balance of Clinker Station

Income Heat			Expense Heat		
Item	KJ/Kg	%	Item	KJ/Kg	%
Fuel burning heat	4886.38	93.78	Clinker formation heat	2958.1	56.77
Fuel sensible heat	9.90	0.19	Clinker exiting cooling machine sensible heat	95.37	1.83
Raw material sensible heat	109.96	2.11	Pre-heater exhaust steam sensible heat	1222.11	23.45
Feed back dust kiln sensible heat	14.59	0.28	Cooling machine exhaust air sensible heat	384.06	7.37
Primary air sensible heat	8.86	0.17	System surface heat dissipation	335.1	6.43
Raw material brought into air sensible heat	1.56	0.03	Cooling water brings heat	153.74	2.95
System wind leakage sensible heat	21.89	0.42	Pre-heater flying ash sensible heat	63.06	1.21
Entering cooling	158.40	3.04			

machine air sensible heat			Total	11.54	00
Total	5211.54	100			

(3) Cleaner Production Potential Analysis

The sintering section is a typical cement clinker sintering unit operation, the technique is more mature. Cement industry is an important high energy-consuming industry in China, the total energy consumption is huge. Combining with the technology innovation needs of this year, it is finally determined that the main cleaner production potential of sintering section lies in energy consumption. Although the current technology level and consumption indicators are at middle level in this industry, but since they are put into use, with technical analysis and comparison it is shown that there are still possibilities to further reduce energy consumption in clinker sintering system. There is great potential for cleaner production. The analysis are:

- 1) When the rotary kiln was in preparation phase, the cement clinker dry production line was still at its initial development stage and there were some drawbacks in the selection of rotary kiln coal-injection duct. The designing met the requirements of rotary kiln clinker sintering, but it caused energy waste. After a demonstration by the enterprise energy group, low-quality coal was tried out. It was decided to adjust raw coal proportion, matching the original raw coal proportion with 1:1 low-quality coal. During the trial period the heating value of coal was within the required range of use, and since the ash contents of coal and SO₂ were low, it is good for the normal operation of rotary kiln system. Less crusting of kiln-end smoke chamber and decomposing furnace occurred, and moreover there was less shutdown due to process incidents, greatly reducing the labor intensity for employees. Meanwhile it saves energy, reduces energy consumption and clinker cost. Therefore it is quite necessary to innovate the technology of rotary kiln coal-injection duct in the sintering section.
- 2) Since plant construction, the circulating water branch pipeline in the sintering section uses regular steel pipes with diameter 50mm. The steel pipes are prone to oxidize and leak, therefore circulating effective water utilization is lower than 90%. In 2010, there was an incident for over 100 hours due to circulation water shut down, and it was difficult to repair which lead to increased energy cost such as electricity consumption.
- 3) Due to the large fluctuation in the raw material composition, the rotary window clinker sintering process is instable. Frequent kiln-ringing and kiln-knotting incidents are leading to blockage at crushing exit, which are difficult to manage, have a low safety coefficient and huge labor intensity for employees. In 2010, there was an incident for over 100 hours.
- 4) With the analysis above, finally it is determined to conduct energy saving modification to sintering section. Contributing to fulfill cleaner production goals of

energy saving, consumption reducing, pollution reducing and efficiency enhancing.

(4) The Formation and Selection of Plans

The working focus of this phase is to formulate a cleaner production plan based on previous audit results. The cleaner production audit group analyses the results based on material balance, water balance and pollutant generation. Starting with actual condition at the site, mobilize and encourage all staff to propose cleaner production plans or reasonable suggestions. Extensively learning from domestic and foreign industry advance technology and organizing experts for technical consulting, finally formulate a number of cleaner production plans.

1) Plan Summary

Cleaner production plan is jointly discussed and formulated by the audit team, enterprise employee and experts. Firstly, cleaner production audit team collects suggestions from all sections. The motivated front-line employees actively respond and propose many reasonable suggestions and clues for the plan based on their practical production experiences. Secondly, organizing relevant technicians and experts to inspect and analyze on the whole production technology and production process. Come up with a plan from 8 aspects: raw material and energy, technology process renovation, equipment maintenance and update, process optimized control, products update or improvement, waste recycling, enhancing management and improving staff quality. Then experts and enterprise employees have seminars, verify actual production scenario, inspire each other and resulting in an alternative plan. Summarize all the collected suggestions, and produce 8 no/low cost plans, 3 medium/high cost plans. Table 29 shows no/low cost plans and medium/high cost plans.

Table 29: Summary of Cleaner Production Plans

Type	No.	Name	Investment estimate (10 ⁴ yuan)	Economic Benefit	Environmental Benefit
Equipment	F9	Circulating water renovation and replace cooling tower	29	Circulating water utilization increases to 95%, annually increase main engine equipment operation rate by 1%. Calculated by 86% annual operation rate, it reduces loss of 1.8 million yuan.	Effectively reduce fresh water usage
	F10	Add a high pressure water gun at crushing	6	Annually increase main engine equipment operation rate by 1%. Calculated by 86% annual	After implementation it reduces equipment

	exit		operation rate, it reduces loss of 1.65 million yuan.	idling, saves rotary kiln firing used diesel, coal dust, etc.
F11	Replace coal injection duct at rotary kiln	21	Calculated by 70000t raw coal per year, it saves 1.4 million yuan.	After implementation effectively reduce energy consumption
F1	Renovate the air cylinder of goal mill dust-collector	0.09	Enhance equipment operation rate and reduce energy loss	Reduce pollution
F2	Renovate the oil leaking of main reduction gear of new line cement grinding mill	no cost	No-cost investment. After renovation the main reduction gear has a good leakproofness, by 0.625kg/hour, it saves 57600yuan of oils per year	Save energy consumption
F3	Renovate the new line packaging machine	no cost	No-cost investment, after renovation production per machine increases 10.06t/h	Save energy consumption
F4	Install cement bulk packing system to #2 and 3 cement bunker	2	Increase bulk cement rate	Reduce energy consumption
F5	Replace central control room computers	0.96	Enhance working efficiency	
F6	Suggestion on using double size office paper	no cost	Replace office papers to double size, reduce office costs	Save resources
F7	Collect	no cost	No-cost investment,	

		waste cotton yarn		recycled cotton yarn are used for rotary kiln firing, annually recycles 160kg and saves 1280yuan.	
	F8	Renovate deironing roller installed to new line cement grinding mill	no cost	Use wastes renovation to increase cement grinding mill output	Reduce energy consumption

2) Plan Selection

The enterprise leader, technicians, managers, internal and external experts consider from the aspects of technical feasibility, environmental feasibility, economical feasibility and enforceability, a simple screening method which is adopted for the no/low cost plans. The weighted ranking method is used for medium/high cost plans. Finally the audit team screened and selected 11 feasible plans from aspects of technical feasibility, environmental feasibility, economic benefit, ease of implementation and impacts on production and products. Of the selected plans, there are 8 no/low cost plans and 3 medium/high cost plans. The selection of feasible no/low cost plans and preliminary feasible medium/high cost plans are shown in Table 30.

Table 30: Selection of Cleaner Production Plans

Result	No.	Name	Note
Feasible no/low cost plans	F1	Coal mill dust collector air cylinder	Sintering section
	F2	Renovation on oil leaking of New Line cement grinding mill main reduction gears	Cement manufacturing section
	F3	Renovation on New Line packing machine	Cement manufacturing section
	F4	Install cement bulk packing system to #2,3 cement bunker	Cement manufacturing section
	F5	Replace central control room computers	Central control room
	F6	Suggestion of using double size paper in office	General affairs department
	F7	Collect waste cotton yarn	Sintering section
	F8	Renovate deironing roller installed to new line cement grinding mill	Cement manufacturing section

Preliminary feasible medium/high cost plans	F9	Circulating water renovation and replace cooling tower	Sintering section
	F10	Add a high pressure water gun at crushing exit	Sintering section
	F11	Replace coal-injection duct at rotary kiln	Sintering section

(5) Feasibility Analysis

1) Feasibility analysis on circulating water renovation and replacing cooling tower

① The necessity of project investment

When enterprise 1200t/d put into use clinker production line in August 2004, there were many drawbacks in the initial circulating water system design. Before the reform, the recharge well circulating pool had a length of around 500m, and 7.5kW deep-well pumps were used for water recharging., The water recharging pipes were regularly made of seamless steel which uses direct buried pipe. A part of the steel pipes was oxidized and water was leaking since plant establishment; Circulating water, flowing into all equipment also used regular steel pipes, and again they were partly oxidized with water leaking. The effective utilization of circulating water was less than 90%.

② Energy-saving Reform Plan

Replace the original water recharging well with recharging well closer to circulating water pool of 200m, using PPR pipes with 75mm diameter, deep-well pump changes to 5.5kW power deep-well pump, saving pipe material around 300m. Replace the original cooling tower with new industrial circular counter flowing fiberglass cooling water tower.

③ Technology Evaluation

First, after renovation it could effectively increase circulating water utilization and ensure the well-functioning of rotary kiln.

Second, replace all the circulating water pipes into fiberglass pipes, which is a one-time investment and has low maintenance cost.

Third, the replaced cooling tower is the general model in the industry, with mature technology.

④ Economic Evaluation

Comparing the situation before and after the circulating water establishment, since there are less shut down incidents, and circulating water temperature reduces to around 10°C, the well-functioning of the equipment is ensured.

The circulating water recharging well reduces power by 2kW compared to the initial state; the daily saving electricity cost are by 24yuan, and hence by $2 \times 24 \times 0.5 \times 365 = 8760$ yuan for the total year. In total 8760yuan are saved on electricity.

As an effect, there is reduced water resource waste, reduced energy consumption and effectively and reasonably reduced clinker sintering cost. After reform, the effective utilization of circulating water reaches 95%, achieving the expected goals.

For example: before reform, the actual circulating water usage accounted for 30.3m³/h while after reform, the actual circulating water usage was 14.4m³/h. Indicating: circulating water usage is 280t/hr and the supplement with fresh water is 14.4m³/h. So, the effective utilization of circulating water can be calculated as followed: (280/280+14.4)*100%=95.1% with annual water savings of (30.3-14.4)*24*365=13.9*104m³ and total saving in water costs of 13.9*0.5 yuan=69500yuan.

Project	Formula	Result	Unit
Project investment I	/	10.8	10 ⁴ yuan
Annual operational cost-saving P	/	7.75	10 ⁴ yuan
Equipment annual depreciation cost D	I/5	2.16	10 ⁴ yuan
Annual incremental cash flow F	P-0.33*(P-D)	5.90	10 ⁴ yuan
Pay Back Period N	I/F	1.9	Year
Net present value NPV	$\sum_{j=1}^n \frac{F}{(1+i)^j} - I$ (i=12%)	10.46	10 ⁴ yuan
Internal rate of return IRR	$i1 + \frac{NPV1 * (i2 - i1)}{NPV1 + NPV2 }$	46.6	%

⑤ Environmental Evaluation

During the implementation of plans, do not affect the normal functioning of equipment. Except for laying circulating water pipe and digging foundation, there is no adverse factor on environment.

⑥ Conclusion

The circulating water reform plan includes advanced technology which is safe, reliable, mature, beneficial for reducing the current water resource waste, improving circulating water utilization factor and also fulfills some economic benefits. There is enough room to install new equipment under current condition. From the technical perspective, it is a feasible plan.

After implementing the plan, the new circulating water pipe saves 381.6t of water per day, circulating water effective utilization reaches over 95%. Comply with the fundamental concepts of cleaner production energy saving, consumption reducing, pollution reducing and efficiency enhancing. From the environmental perspective it is a feasible plan.

According to the relevant economic indicators of this plan, it can recover the cost in about 2 years, and internal yield is far more than industry benchmark yield. From economic perspective it is a feasible plan.

In summary, Circulating water reform plan is a feasible plan. The implementation of this plan saves 730kW·h electricity per year and water resource costs of 69500yuan

per year. Provide technical support for the enterprise to achieve energy saving and consumption reducing.

2) Feasibility analysis of adding high pressure water gun at crushing exit

①The Necessity of Project Investment

Before reform the rotary window gets knotting due to frequent technology incident, which leads to a blocked and shut down grate cooler crushing exit , affecting the function of main engine. The blockage is difficult to handle and requires many manpower and material resources, and low safety coefficient. Each time the incident takes more than 12 hours to handle, during this time the grate cooler and fan are doing useless power, consuming huge electricity resource. In addition diesel (around 1000L) is being used during kiln which creates invisible waste. In 2010, main engine shut down takes 49.5hr due to grate cooler knotting, with a total direct loss of 386800yuan.

②Energy-saving Reform Plan

Install the high pressure water gun type TJ02-S at the crushing exit of rotary kiln grate cooler, with an instantaneous pressure reaching 50MPa at exit and a water consumption of 50L/min. It takes only 15min to handle everything when the crushing exit gets blocked again. Its working principle is the following: When spraying water contacts high temperature material using a high pressure water gun, the material and water instantaneously explode and smash the bulk material. In the normal treatment process, if the treatment time of grate cooler is within 30min, it does not influence the functioning of main engine and auxiliary engine. It only takes 2-3 people to handle it with high safety coefficient. Avoid the shutdown incident due to crushing exit blockage, increase the effective operation rate of main engine equipment.

③Technology Evaluation

First, the implemented plan can effectively reduce cleaning time for crushing exit blockage and increase the main engine function rate.

Second, the adopted high pressure water gun can be operated by one person and is easy to install and maintain.

④Economic Evaluation

After finishing the reform in April, the blockage shut down incident of crushing exit is restrained effectively, the equipment operational costs are greatly reduced and the emission of dust is decreased. By calculating, the annual decrease of losses is 658500yuan:

Annual shut down time is 49.5hr, rotary kiln production 51.57t/h* annual operational rate 86%* clinker price 176.22yuan=386800yuan.

Project	Formula	Result	Unit
Project investment I	/	6.8	10 ⁴ yuan
Annual operational cost-saving P	/	38.68	10 ⁴ yuan
Equipment annual	I/5	2.26	10 ⁴ yuan

depreciation cost D			
Annual incremental cash flow F	$P-0.33*(P-D)$	26.66	10 ⁴ yuan
Pay Back Period N	I/F	0.26	year
Net present value NPV	$\sum_{j=1}^n \frac{F}{(1+i)^j} - I$ (i=12%)	57.3	10 ⁴ yuan
Internal rate of return IRR	$i1 + \frac{NPV1 * (i2 - i1)}{NPV1 + NPV2 }$	> 100%	%

⑤ Environmental Evaluation

During the project implementation process the functioning of equipment is not affected. In addition, it could reduce the environmental pollution caused by technology shut down and unorganized dust emission.

⑥ Conclusion

The plan of adding a high pressure water gun at the crushing exit with advanced, safe, reliable and mature technology leads to effectively improved main engine equipment operation rates, reduced technology incident shut down, reduced clinker production cost and reduced economic loss. There is enough room to install new equipment under current condition. So, from the technical aspect this plan is feasible.

With the plan implemented, it reduces main engine equipment shut down, stabilizes the technical factor, effectively ensures the functioning of rotary kiln, contributes to an annual operation rate increased by 1%, and in total reduces financial loss of 386800yuan. The plan is in accordance with cleaner production fundamental concepts of energy saving, consumption reducing, pollution reducing and efficiency enhancing. So, from the environmental aspect ,the plan is feasible, as well.

According to the relevant economic indicators of this plan, it can recover the cost in about four months, and internal yield is far more than industry benchmark yield. From economic perspective it is a feasible plan.

In summary, the reform plan of adding a high pressure water gun at the crushing exit is a feasible one. With its implementation it could save losses of 186800yuan/a. It provides technology support for the enterprise to achieving the goals of energy saving and consumption reducing.

3) Feasibility Analysis of replacing rotary kiln coal-injection pipe.

① The Necessity of Project Investment

For the rotary kiln coal-injection pipes that use raw coal type before reform, it requires a relatively high proportion of all ingredients in the raw coal, among which the coal ash content is within 31.33, sulfur-containing ingredient within 1.8, volatility within 21.55, and heat generation around 5200kcal, which goes beyond the design scope (normally

application range 4800-5000kcal). It imperceptibly increases clinker production cost and creating unnecessary energy waste.

② Energy-saving Reform Plan

Replace to a new type of four-channel burner which has relatively low requirement on coal quality, generally requires coal-fired heat generation of 4700kcal. Therefore use low quality coal 1:1 to raw coal, effectively reduce clinker production cost and reduce energy waste.

③ Technical Evaluation

First, replace to a set of four-channel burner HP-II(B), finished product purchase and can be installed and applied directly afterwards;

Second, the technician can be replaced, operation is easier;

Third, after replacement effectively reduce raw coal usage amount.

④ Economic Evaluation

Before reform the 2010 annual usage amount is raw coal 702791t*350yuan/t=24,597,600yuan; coal-injection duct usage amount after reform is: raw coal 47087*350yuan=16,480,400yuan, middling coal 23192*300yuan=6,957,600yuan. In total it saves energy 1,159,600yuan/a.

Project	Formula	Result	Unit
Project investment I	/	21.3	10 ⁴ yuan
Annual operational cost-saving P	/	115.96	10 ⁴ yuan
Equipment annual depreciation cost D	I/5	10.65	10 ⁴ yuan
Annual incremental cash flow F	P-0.33*(P-D)	81.2	10 ⁴ yuan
Pay Back Period N	I/F	0.27	year
Net present value NPV	$\sum_{j=1}^n \frac{F}{(1+i)^j} - I$ (i=12%)	115.93	10 ⁴ yuan
Internal rate of return IRR	$i1 + \frac{NPV1 * (i2 - i1)}{NPV1 + NPV2 }$	> 100%	%

⑤ Environmental Evaluation

During project implementation process it does not affect the normal functioning of equipment. Reducing energy operation cost, reducing energy waste and therefore reduce clinker production cost.

⑥ Conclusion

The plan of replacing the rotary kiln coal-injection pipe where the technology is advanced, safe, reliable and mature, effectively ensures the stability of rotary kiln technological parameter. Meanwhile, clinker energy consumption and production costs are reduced, and energy waste is minimized, as well. Under current condition,

there is enough room to install new equipment. From technical aspect this plan is feasible.

After implementing the plan, it could stabilize rotary kiln technological parameter and reduce clinker production cost. Annually, a saving of raw coal worth 1,159,600yuan can be achieved. Comply with the fundamental concepts of cleaner production energy saving, consumption reducing, pollution reducing and efficiency enhancing. From the environmental perspective it is a feasible plan.

According to the relevant economic indicators of this plan, it can recover the cost in about 2.7 months, and internal yield is far more than industry benchmark yield. From economic perspective it is a feasible plan.

In summary, the reform plan of replacing rotary kiln coal-injection pipe is a feasible one. With its implementation it could save raw coal resource worth 1,159,600yuan; it provides technology support for the enterprise to achieving the goals of energy saving and consumption reducing.

4) Overall Evaluation

$$I_{11} > I_9 > I_{10}$$

$$P_{11} > P_{10} > P_9$$

$$N_9 > N_{11} > N_{10}$$

$$D_{11} > P_{10} > P_9$$

$$NPV_{11} > NPV_{10} > NPV_9$$

$$IRR_{11} > IRR_{10} > IRR_9$$

Table 31: Comparison of Plans on Techniques, Environment and Economic Aspects

Plan Content	F9 Circulating water reform and replacing cooling tower	F10 Adding a high pressure water gun at the crushing exit	F11 Replacing rotary kiln coal-injection pipe
Technical evaluation result	Effectively ensure the smooth functioning of rotary kiln	Enhance main engine equipment operating rate	2.Stabilize smooth operation of kiln technology, reduce technical incident such as ringing and knotting, crusting, etc.
	Replace all circulating water pipes into fiberglass pipes, one-time investment and low maintenance cost	3.Energy saving and emission reducing, decrease technical incident	Effectively reduce clinker cost, reduce resource waste
Environmental evaluation	Annually saving water resource 13.9*104t, electricity cost 8760 yuan.		
Economic evaluation			

I(10 ⁴ yuan)	10.8	6.8	21.3
P(10 ⁴ yuan)	7.75	36.68	115.96
F(10 ⁴ yuan)	5.9	26.66	81.2
N(year)	1.9	0.26	0.27
VPV (10 ⁴ yuan)	10.46	57.3	115.93
IRR (%)	46.6	>100	>100

From the comparison of these 3 plans, in terms of environmental benefit: F9 could significantly reduce water resource usage, and the other two are slightly inadequate in quantitatively reducing environmental load; in terms of economic benefit, F10 and F11 have an obvious advance, Pay Back Period N, net present value NPV and internal rate of return IRR are all much higher than F9. Although F11 has a slightly higher investment, the reform to rotary kiln coal-injection pipe could fundamentally solve the problem of high energy consumption. Therefore, this investment is worthy; in terms of technical perspective, all three plans have mature technology. Overall, these three plans are in line with requirements in terms of technology, environmental benefit and economic benefit.

(7) The Plan Implementation

1) Plan Implementation Overview

Only by actually implementing cleaner production plans practical results can be generated, and all the previous works are preparation for plan implementation. The significant environmental and economic benefits resulted from implementing cleaner production plans and are motivation for enterprises to continuously carry out cleaner production. Therefore, implementing cleaner production plans is the most important process and phase of cleaner production, which requires active participation from all enterprise departments and collaboration of all employees. After the cleaner production plans are discussed and passed by the audit team, the break down and narrow down of all schemes should be started according to plan, actively pushing forward the implementation. Until July 2011, all the 8 no/low cost plans were implemented, all 3 medium/high cost plans are implemented as well, achieved satisfactory environmental and economic benefits.

2) No/low Cost Plans Implementation and Outcome Overview

Table 32: Implementation and Outcomes of No/Low Cost Plans

No.	Name	Investment Estimation (10 ⁴ yuan)	Economic Benefit	Environmental Benefit
F1	Coal mill dust collector air	0.09	Main engines shut down due to coal	Reduce the unorganized dust

	cylinder		mill dust collector air cylinder freezing, annually increase main engine operation rate 1%	emission after shut down incident and energy consumption
F2	Renovation on oil leaking of New Line cement grinding mill main reduction gears	no cost	Annually save oil production cost 5.76*10 ⁴ yuan	Reduce energy loss
F3	Renovation on New Line packing machine	no cost	Unit production increases 10.06t/h	Energy saving
F4	Install cement bulk packing system to #2,3 cement bunker	2	Cement production bulk packaging rate 30%	Reduce cement production cost and energy consumption
F5	Replace central control room computers	0.96	After replacing operation computers there are no incidents and shut down incident.	Reduce equipment shut down incident and energy consumption
F6	Suggestion of using double size paper in office	no cost	Replacing office papers into double sided, reduce office cost	Reduce pollution and waste
F7	Collect waste cotton yarn	no cost	Annual recycling 160kg, annual saving cost 1280 yuan	Reduce environment pollution
F8	Renovate deironing roller installed to new line cement grinding mill	no cost	Enhance cement grinding mill output and main engine operation rate	Reduce energy consumption

3) Medium/high Cost Plans Implementation and Outcome Overview

Table 33: Implementation and Outcomes of Medium/High Cost Plans

No.	Name	Investment	Economic benefit	Environmental benefit
F9	Circulating water	10.8	Circulating water	Reduce water resource

	renovation and replace cooling tower		effective utilization reaches 95%, Annually increases main engine equipment operation rate by 1%, annually saves water 13.9*10 ⁴ t	waste, reduce energy consumption, annually saves electricity cost 8760yuan, saves water cost 6.95*10 ⁴ yuan
F10	Add a high pressure water gun at crushing exit	6.8	Annually increase main engine equipment operation rate by 1%, reduces loss 36.68*10 ⁴ yuan	Have some effect on controlling dust unorganized emission
F11	Replace coal-injection duct at rotary kiln	21.3	Effectively control clinker production cost, annually saves raw coal 3300t, saves energy cost 115.96*10 ⁴ yuan	Have some effect on reducing pollutant emission

Scoring of Cement Enterprises Cleaner Production Evaluation Index

The scoring of Enterprises Cleaner Production Quantitative Evaluation Index, formula is:

$$P_i = S_{ij} * K_i / 100$$

In which

P_i -Score of the i^{th} secondary evaluation index

K_i -Final weighted value of the i^{th} secondary evaluation index

S_{ij} -The score corresponding to different level in the i^{th} secondary evaluation index (j corresponds to level A\B\C)

Level A index corresponds to score $S_{iA}=100$; Level B index corresponds to score $80 \leq S_{iB} < 100$; Level C index corresponds to score $60 \leq S_{iC} < 80$

Corresponding level B forward index: $S_{iB} = 80 + 20(X_i - X_{\min(i)}) / (X_{\max(i)} - X_{\min(i)})$

Corresponding level C forward index: $S_{iC} = 80 + 20(X_i - X_{\min(i)}) / (X_{\max(i)} - X_{\min(i)})$

Corresponding level B reverse index: $S_{iB} = 80 + 20(X_{\max(i)} - X_i) / (X_{\max(i)} - X_{\min(i)})$

Corresponding level C reverse index: $S_{iC} = 80 + 20(X_{\max(i)} - X_i) / (X_{\max(i)} - X_{\min(i)})$

In the formula: X_i is the actual value of the i^{th} evaluation index

$X_{\max(i)}$ is the maximum of the i^{th} index; $X_{\min(i)}$ is the minimum of the i^{th} index

The scoring of Enterprises Cleaner Production Qualitative Evaluation Index, formula is:

$$P_i = S_{ij} * K_i / 100$$

In which:

P_i —Score of the i^{th} secondary evaluation index

K_i — Final weighted value of the i^{th} secondary evaluation index

S_{ij} —The score corresponding to different level in the i^{th} secondary evaluation index (j corresponds to level A\B\C)

For the qualitative evaluation indexes that don't distinct amount level A,B and C, the index has no value if not qualified for evaluation equipment, that is $S_{iA}=0$. Maximum score is 100 if qualified for evaluation requirement, that is $S_{iA}=100$

When qualitative indexes have level A,B and C, level A index corresponds to score $S_{iA}=100$; Level B index corresponds to score $80 \leq S_{iB} < 100$; Level C index corresponds to score $60 \leq S_{iB} < 80$. Failing to reach level C has a value of 0 for that evaluation index. Scores corresponding to level B and C in the secondary index are graded by experts.

The calculation formula for comprehensive evaluation index:

$$P = \sum_{i=1}^n P_i$$

In which:

P- Comprehensive evaluation index of the enterprise cleaner production, generally between 0-100.

P_i- evaluation score of the i^{th} secondary index.

n- Number of secondary indexes participated in the evaluation, n=40

Table 34: Index Comparison before/after Audit

Index	Unit	Before Audit	After Audit
Cement kiln PM emission limit	mg/m ³	37.6	30.4
Crusher PM emission limit	mg/m ³	27.6	24.6
Crusher PM emission limit	mg/m ³	23.2	20.2
Cement kiln SO ₂ emission limit	mg/m ³	85	80
Cement kiln NOx emission limit	mg/m ³	371	359
Cement kiln fluoride emission limit	mg/m ³	0.395	0.376
Cement clinker heat consumption	kg standard coal/t clinker	127	125
Cement comprehensive electricity consumption	kWh/t cement	103	101
Low-quality coal usage	%	0	50
Industrial waste used in the ingredient	%	30	34

Recycled water utilization	%	90	95
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Table 35: Score before/after Cleaner Production Audit

Secondary Index		Evaluation Index Preference			Before Audit Pi	After Audit Pi
		Value				
		A	B	C		
1	Quarry dust removal requirement: implement water spraying dedusting to open cast mining, spray water to mass pile, mining work site, transportation road and other dust source. Barren stone treatment: mine overburden material, barren stone, surface soil and tailings, etc. must use waste-rock yard	100%	> 50% < 100 %	30%-50%	0.6890	0.6890
2	Harmless piling and use comprehensive utilization measures (e.g. greening), not allow to dump into other channels beside rivers, lakes, reservoir and waste rock yard	100%	>70% <100%	50%-70%	1.1642	1.1642
3	Mine waste water treatment	Reference to quantitative required secondary index			1.1642	1.1642
4	Mine crushing PM emission limit, mg/m ³	<20	20-30	>30-50	2.0451	2.4051
5	Cement PM emission limit value mg/m ³	<30	30-40	>40-80	4.1568	4.8627
6	Crusher PM emission limit, mg/m ³	<20	20-30	>30-50	1.7342	1.857
7	Crusher PM emission limit, mg/m ³	<20	20-30	>30-50	1.0897	1.1595
8	Cement kiln SO ₂ emission limit, mg/m ³	<200	200-300	> 300-400	4.9020	4.9020
9	Cement kiln NOx emission limit, mg/m ³	<400	400-600	> 600-800	1.1642	1.1642
10	Cement kiln fluoride emission limit, mg/m ³	<3	3-5	>5-10	0.6890	0.6890

11	Dust unorganized emission, mg/m ³	<0.8	0.8-0.9	>0.9-1.0	2.0451	2.0451
12	Production line material dust prevention	Reference to quantitative required secondary index			3.3581	3.3581
13	Exhaust funnel minimum allowed limit	Reference to quantitative required secondary index			0.6890	0.6890
14	Boiler emission limit and chimney height	Reference to quantitative required secondary index			0.6890	0.6890
15	Water pollutant emission (in-plant)	Reference to quantitative required secondary index			3.3581	3.3581
16	Oil-contained waste water emission	Reference to quantitative required secondary index			2.0451	2.0451
17	Laboratory waste liquid treatment	Reference to quantitative required secondary index			1.1642	1.1642
18	Plant noise limit, dB	<45	45~55	>55~60	2.0451	2.0451
19	High-intensity noise source index	Reference to quantitative required secondary index			2.0451	2.0451
20	General waste residue treatment	Reference to quantitative required secondary index			1.1642	1.1642
21	In-plant sewage sludge treatment	Reference to quantitative required secondary index			0.6890	0.6890
22	Fire proof material qualification requirement	Reference to quantitative required secondary index			0.6890	0.6890
23	Hazardous waste sintering control index	Reference to quantitative required secondary index			2.0451	2.0451
24	Household garbage sintering control index	Reference to quantitative required secondary index			2.0451	2.0451
25	Cement clinker heat consumption, kg standard coal/t clinker	<106	106-114	>114-121	0	0
26	Cement comprehensive electricity consumption, kW·h/t cement	<98	98-105	>105-115	8.732	10.384
27	Kiln system exhaust heat utilization, %	<80	50-80	30~<50	0	0
28	Adopted <48%CaO limestone, %	>10	5-10	<5	3.9552	3.9552
29	Using salic to replace raw material, %	>50	30-50	<30	0.7762	0.7762
30	Use low-quality coal, %	>30	20-30	<20	0	1.2938
31	(1) Burning substitution rate of using flammable wastes, %	>25	10-25	<10	0.7762	0.7762

	2) Wastes as cement mixture material, %					
32	Slag cement Pozzolan cement Flyash cement	>40-70 >40-50 >30-40	>30-40 >30-40 >25-30	≥20-30 ≥20-30 ≥20-25	1.2938	1.2938
33	Industrial wastes in ingredient, %	>15	10-15	<10	0.7214	0.7214
34	Fresh water usage, t/t clinker	<0.3	0.3-0.6	>0.6-1	2.4273	2.4273
35	Recycled water utilization, %	>95	85-95	65-<85	1.2938	1.2938
36	Ex-plant cement bulk rate, %	>60	40-60	30-<40	2.4273	2.4273
37	Cement and clinker quality	Reference to quantitative required secondary index			7.1475	7.1475
38	Cement radioactivity	Reference to quantitative required secondary index			2.3825	2.3825
39	Cleaner production management	Reference to quantitative required secondary index			3.6080	3.6080
40	Use automatic control and monitoring system	Pollutant emission achieves automatic control and monitoring			0.9020	0.9020
P	$P = \sum_{i=1}^n P_i$				78.9	82.7

According to the Cement Industry Cleaner Production Evaluation Index (trial), issued by national Development and Reform Commission, cleaner production comprehensive evaluation index increases from pre-audit 78.9 to post-audit 82.7. Hence, the cleaner production level has increased.

To analyze the before and after audit environmental performance using single evaluation index, cement clinker heat consumption has been improved after audit. It reduces from pre-audit 127 standard coal kg/t product to 125 standard coal kg/t product. But it is still below the third level of the industry; Kiln system waste gas/heat utilization is 0 before and after audit, meaning that no measures have been taken to utilize kiln system waste gas/heat. This indicates that for the next round of cleaner production audit, the focus should be reducing energy consumption and kiln system waste gas/heat. For the other resource indexes, low-quality coal usage and recycled water utilization are greatly improved. For pollutant emission indexes, the improved ones are dust emission and unorganized emission.

(8) Continuous Cleaner Production

1) Improve cleaner production organization

Cleaner production is a process continuously improving enterprise management, enhancing technology process, reducing cost, improving product quality and reducing environmental pollution. Therefore, it requires a cleaner production office to take charge of organizing and coordinating all departments. This office is directly managed by enterprise manager, specifically responsible for the following works: Organizing coordination and monitoring the implementation of cleaner production plans raised by this audit;

First, generate a cleaner production training plan: frequently educate employees on cleaner production; Second, be responsible for daily management job of cleaner production and formulate new cleaner production audit plans. Cleaner production office needs 2-3 full-time (or part-time) management staff, who need the following skills: familiar with cleaner production audit knowledge, acquainted with enterprise environmental protection performance, familiar with enterprise production and technology condition, good coordination ability and strong work responsibility.

2) Improve cleaner production reward system

Formulate cleaner production audit method, incorporate cleaner production departments and employees' bonus, salary composition, promotion and demotion, in order to trigger the enthusiasm of all employees to participate in cleaner production.

3) Ensure a Stable Cleaner Production Financial Source

Actively and Initiatively strive for all kinds of cleaner production financial source, such as taking full advantage of national cleaner production promoting polices to get bank loan, cleaner production subsidiaries, interest subsidy, etc. external funding. Meanwhile it is suggested for enterprise finance to set up a separate bookkeeping for cleaner production investments and benefits, ensure that the benefits generated from implementing cleaner production are fully or partly used in cleaner production audit, continuously advance cleaer production.

3.3 Case analysis of Ceramics Cleaner Production industry

3.3.1 Planning and Organizing

In May 2011, a ceramics enterprise established a cleaner production audit leading team and cleaner production audit working team on the basis of its original management organizing structure and system and under the guidance of Hunan cleaner production audit center experts. Established working plan for this cleaner production audit, proceed strictly according to cleaner production steps until completion in mid-August 2011. According to the production performance of this ceramics enterprise, organizational structure and surroundings environmental impact, the range of this cleaner production audit is: daily-used stoneware, packaging bottle (wine bottle), and special porcelain production line.

On 16th March 2011, the enterprise cleaner production knowledge publicity and education seminar is held, enabling the employees to better understand cleaner production, its significance as a new concept for the enterprise, in social and environmental terms. So that top down enterprise can understanding the importance of cleaner production audit, and also lay a good foundation for implementing cleaner

production audit in the next phase. On this basis the audit working team carries out the pre-audit work in the second phase.

3.3.2 Pre-audit of Cleaner Production

(1) Enterprise Basic Information

1) Enterprise Overview

The ceramics enterprise is a private-run technology oriented enterprise that integrates production, research, development and trade. Founded in July 2000, the enterprise is located in Zhuzhou Liling city, Hunan province. The enterprise has one province level technology center, one high-tech ceramics branch company, one brand factory specializes in high-end ceramics wine bottle manufacturing, two export stoneware branch factories, one fine porcelain branch company. In 2009 the brand “Taixin” daily ceramics was rated as the “International Famous Brand” of Hunan province by Hunan Department of Commerce. The main products are: daily stoneware, packaging bottle (wine bottle), and special ceramics. In 2010 the production output is 14744t of ceramics. Until the end of 2010 the enterprise has total assets 97,640,000yuan and 1400 employees.

2) Products and production process

The main products are: daily stoneware, packaging bottle (wine bottle) and special ceramics.

Production process of daily stoneware and packaging bottle (wine bottle) is briefly summarized as: base and glaze raw material enters the plant and after some time of storage and homogenization, ingredients are weighted the based on a production formula, then they are fine grinded by ball-milling until they are reaching the required fineness, deironing and screening. Then based on a different molding method, roller forming and mud are used to press filter dewater, then a multiple vacuum pugmill is put in reserve; for slip forming, mud is used for vacuum treatment, and after becoming finished mud, it is put in reserve. Molding process mainly uses roller forming and slip forming, then dry out, fettling, glazing and then reserving. Meanwhile, the sintering process uses natural gas sintering for the modern colored glaze stoneware, inspecting the stoneware exiting kiln and collecting the qualified colored stoneware. Applique and gold inlay to the qualified stoneware that needs color decoration, to the decorating firing kiln for sintering, inspection, and storage.

All processes are:

- ① Base glaze material manufacture: use kaolin, quartz and feldspar, etc. as raw material, use dry mixing, large ball mill and wet ball grinding, double screening to deironing. Plastic forming blank filter pressing, primary smelting and double refining. Grout material uses vacuum defoamation treatment. Glaze material uses dry mixing, wet ball grinding, double screening to deironing.
- ② Molding: plate, glass, bowl and tray products, use plastic rolling forming; special-shaped products like wine bottle use slip forming, in which hollow

products use centrifugal casting, special-shaped large products like fish plate use high-pressure grouting.

- ③ Glazing: plate, glass, bowl and tray products mainly use manual glazing.
- ④ Sintering: For large piece products, use single sintering technique. To increase product quality and qualification rate, some vessel shaped complicated and ductile products use double sintering. Use pure natural gas for sintering.
- ⑤ Inspection: inspect the sintered ceramics and pick out the unqualified products, and classify qualified ceramics.
- ⑥ Packaging: load the qualified ceramics according to order requirement.

The main production process for special ceramics is: the out-purchased ingredient mud goes through pugmill, chipping, molding, drying, sintering, inspection and packaging steps. The ceramics enterprise will generate some waste water, waste gas, noises and solid wastes during production process. Daily stoneware, packaging ceramics (wine bottle), special ceramics production process and product location is shown in Figure 11 and Figure 12.

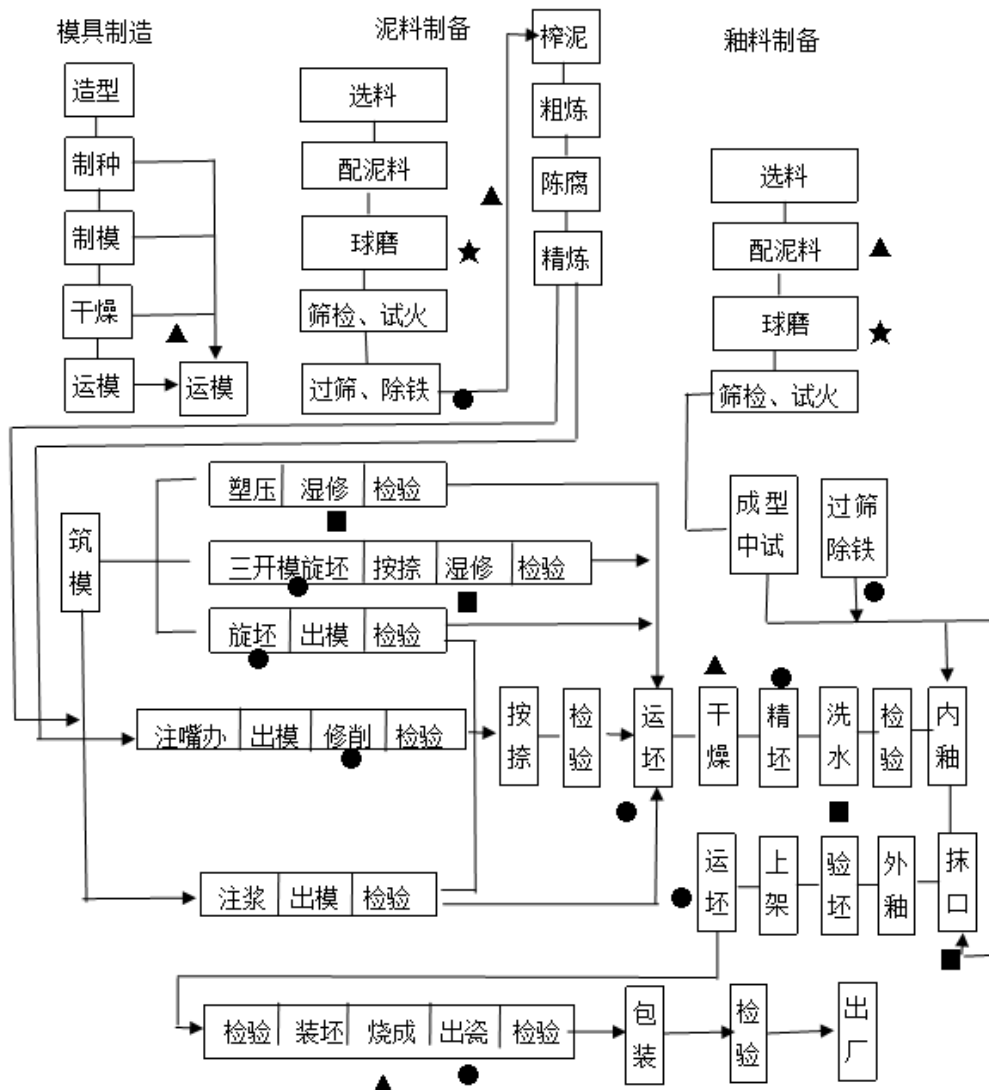


Figure 11: Daily Stoneware and Packaging Ceramics Production Process and Pollution Emission Point

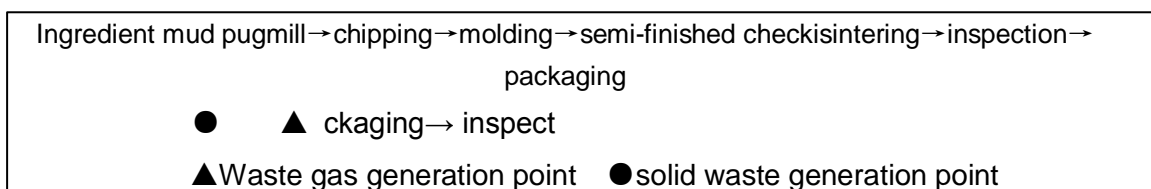


Figure 12:Special Ceramics Production Process and Pollution Emission Point

3) Major equipment and facilities

The ceramics enterprise production line has the following major production equipment in Table 36.

Table 36: Overview of Major Equipment Audit

Branch factory #1 major equipment				
No.	Name	Model and Specification	Quantity	Operation Performance
1	Ball mill	3T、5T、15T	6	Roller belt is scaling, uneven belt, vibrating
2	Ball mill	0.5T、0.3T、0.15T、1T	15	Roller belt is scaling, uneven belt, vibrating
3	Plunger pump	TCB140 250	2	Normal operation
4	Double cylinder slip pump	TCBQ125 180	3	Normal operation
5	Stirrer	300、400、630	10	Normal operation
6	Circular vibrating screen	TZS-80	3	Screening net is pierced, need repair
7	Pugmill	TCN23-33A	2	Normal operation
8	Vacuum pump	W3	2	Engine oil leaking
9	Hydraulic pressure filter	TCIF-750 60B	3	Normal operation
10	Chain dryer	TCG200-300	12	Normal operation
11	Roller mill	TC200 120 (175D)	7	Normal operation
12	Plastic mill	TC2Y-30A	6	Normal operation
13	Single template jigger	204	9	Normal operation
14	Glazing machine	204	35	Normal operation
15	Air compressor		7	Normal operation
16	Draught fan	Y4-73-1044WW	1	Normal operation
17	Chain Lifting		1	Normal operation

	machine			
18	Air heating furnace		1	Normal operation
19	Generating set	6160-Z 250kW	1	Normal operation
20	Glazing Iron absorption machine		4	Normal operation
21	Circular vibrating sieve	TCG200-300	1	Screening net is pierced, need repair
22	Fine base machine	B665	18	Normal operation
23	Mechanical filter press		1	Normal operation
24	Double-cylinder membrane filter press	40B	1	Normal operation
25	Roller kiln	80m	1	Equipment ageing, low heat utilization, need renovation
26	Refining machine	6170Z	1	Normal operation
27	Afterheat draught	45kW	1	Normal operation
28	Vibrating screen	800*600	1	Normal operation
29	Drawer kiln	6M3	1	Equipment ageing, low heat utilization, need renovation
30	Drying room		12	Normal operation
31	Jigger		288	Normal operation
32	Tipper		55	Normal operation

Branch factory #1 major equipment

No	Name	Model and Specification	Quantity	Operation Performance
1	Ball mill	3T	8	Feed belt is broken, need repair
2	Plunger pump	TCB140 250	2	Normal operation
3	Double cylinder slip pump	TCBQ125 180	1	Normal operation
4	Stirrer	630	2	Normal operation
5	Pulp stirrer	TCJJ2600	2	Normal operation
6	Circular vibrating	TZS-80	3	Screening net is pierced, need repair

	screen			
7	Pugmill	TCIL-250	2	Normal operation
8	Vacuum pump	2X-4	3	Normal operation
9	Vacuum slurry preparing system		2	Normal operation
10	Semi-automatic vacuum slurry preparing line		1	Normal operation
11	Roller mill	TC200 120(175D)	3	Normal operation
12	Plastic mill	TC2Y-30A	3	Normal operation
13	Glazing machine	204	12	Normal operation
14	Air compressor		1	Motor damaged, need replace
15	Refining machine	B665	4	Normal operation
16	Edging machine	204	1	Normal operation
17	Roller kiln	40m、60m	2	Normal operation
18	Small generator	TEGP1	2	Normal operation
19	Drying room		2	Normal operation
20	Hydraulic Fork Lift		226	Normal operation
21	Jigger		12	Normal operation
22	Tipper		300	Normal operation
Special Ceramics Plant Major Equipment				
No	Name	Model and Specification	Quantity	Operation Performance
1	Vacuum Pugmill	250	1	Normal operation
2	Vacuum Pugmill	120	1	Normal operation
3	Vacuum pump	H-25	1	Normal operation
4	Small Pressing machine		1	Normal operation
5	Dimpling machine		1	Normal operation
6	Magnet ring machine	Φ25、Φ38、Φ50	3	Normal operation
7	Template	Φ1000	1	Normal operation

	jigger			
8	30 lathe	CWW6163	1	Normal operation
9	Bench drilling machine	SI-13	1	Normal operation
10	Cutting machine	J3G3-400	1	Normal operation
11	Liquefied gas drawer kiln	SC-02、03、04、05	3	Normal operation

From the equipment inspection, enterprise production equipment has the following features:

- ① According to Catalogue for Guiding Industry Restructuring (2011 Version) (National Development and Reform Commission No.9 Order, 2011), Catalogue of Eliminated Obsolete Production Capacity, Technique and Products, High Energy Consumption Machinery and Electrical Equipment (Product) Elimination Catalogue (First Group), the major production equipment and energy reform equipment are not included in the elimination list; the enterprise has maintained, updated and reformed the equipment during development process, gradually eliminate high energy consumption, production obsolete equipment.
- ② The enterprise notices with the inspection that equipment has the following cleaner production potential: a. branch plant #1 ball mill roller belt is scaling, uneven belt creates vibrating, should be cleaned and descaled in time; b. branch plant #1 circulating vibrating screening net is pierced, need repair; c. branch plant #1 roller kiln and drawer kiln equipment is ageing, low heat utilization, need renovation d. branch plant #2 ball mill feed belt is broken, need repair; e. branch plant #2 circulating vibrating screening net is pierced, need repair; f. branch plant #2 air compressor motor damaged, need replacement.

4) Raw and auxiliary materials, energy consumption and production analysis

The raw materials for making ceramic base are mud, grit, Limestone including clay and quartz; Chemicals including feldspar, stone, aluminium oxide, kaolin, calcite, zinc oxide, etc. for glaze processing; plaster mainly used for making molds. In the recent 3 years the enterprise uses the following raw and auxiliary materials as in Table 37:

Table 37: Overview of Consumption of Raw and Auxiliary Materials in Last 3 Years

Category	2008		2009		2010	
	Usage	T ceramics consumption	Usage	T ceramics consumption	Usage	T ceramics consumption
	t	t/t	t	t/t	t	t/t

Pug	18513	1.563	19006	1.527	21941	1.488
Ceramic glaze	1156.84 8	0.098	1086.276	0.087	1207.756	0.082
Plaster	1733	0.147	1168	0.093	1341.7	0.091

Note: pug consumption is calculated as wet weight with 23% moisture content, excludes wastes recycled from production workshop.

The enterprise reinforces management on raw and auxiliary material transportation, storage and utilization; reinforces employee management on job skills and responsibility, so that the product qualification rate increases from 64% in 2008 to 67.2% in 2010. It can be seen from Table 37 that the raw and auxiliary material consumption is showing a downtrend in the past 3 years.

① Produce output

Production output, output value and transformation is shown in Table 38 and 39:

Table 38: Overview of Production in Last 3 Years

Product	Unit	2008	2009	2010
Daily stoneware	10 ⁴	2585	1871	2195
Packaging bottle (wine bottle)	10 ⁴	10	29	102
Special ceramics	m ³	783	913	744

Table 39: Overview of Output Value in Last 3 Years

Name	Unit	2008	2009	2010
Industrial output value	10 ⁴	9091.4	9399.3	15026

It can be seen from Table 38 and 39 that in addition to continuously produced daily stoneware, the enterprise also adds new economic growth projects-such as high-end wine bottle production. The enterprise therefore shows an upstream in the last 3 years.

② Water Resource Consumption Analysis

This ceramics enterprise water usage includes tap water and circulating water, circulating water is waste water used by production process and then being treated and recycled back to production. Tap water is pumped from the district and then put into a clean water reservoir build by the enterprise, and enterprise usage does not have a water meter for metering. With on-site investigation the cleaner production audit team discovers that the enterprise has two deep well water pumps, each has a water flow of 20m³/h. The water pump operates 9h per day and fresh water usage is:

$20 \times 2 \times 9 = 360 \text{m}^3/\text{d}$. Annual working days are 350 and annual fresh water usage is: $360 \times 350 = 126000 \text{m}^3/\text{a}$.

Enterprise ton ceramics new water consumption (t/t ceramics) is the fresh water consumption for producing 1t of qualified ceramics, it calculates as:

Enterprise ton ceramics new water consumption (t/t ceramics) = enterprise annual fresh water usage (t)/annual output of qualified ceramics (t)

This enterprise has 8.55t/t ceramics of ton ceramics new water consumption in 2010, lower than ceramics cleaner production standard of 22t/t ceramics.

According to investigation, currently the enterprise only recycles part of water and the majority of waste water is discharged after treatment. Recycled water is mainly used for ball mill process, recycling rate is 58.1%, failing to achieve the ceramics cleaner production standard of $\geq 70\%$.

4) Major energy consumption analysis

The ceramics enterprise has the following energy consumption and unit product consumption in the past 3 years:

Table 40: Overview of Energy Consumption in Last 3 Years

Category	2008		2009		2010	
	Usage	Standard coal	Usage	Standard coal	Usage	Standard coal
Natural gas /m ³	2836691	3602597.57	2611587	3316715.49	2749668	3492078.36
Electricity /kW·h	2350032	822511.2	2202875	771006.25	2978760	1042566
Total standard coal /kgce	—	442510.77	—	4087721.74		4534644.36
Unit consumption /(kgce/t)		373.48		328.36		307.55

Note: natural gas average Lower heating value is 3893kJ/m³, standard coal coefficient is 1.214kgce/m³, electricity average Lower heating value is 3600kJ/(kW·h).

According to requirements of Evaluation Index System of Ceramics Cleaner Production Industry (for trial implementation), when evaluating energy consumption index of ceramics industry, comprehensive energy consumption (kgce/t ceramics) refers to the sum of all energy converses into kg of standard coal, to produce 1t of qualified ceramics (coal, coal gas, electricity, Liquefied gas and compressed air, etc.). In 2010, comprehensive energy consumption is 307.55kgce/t ceramics, lower than cleaner production evaluation index of 1240kgce/t, achieves cleaner production requirement.

(2) Pollution Generation Analysis

1) Waste Water Generation Source

Enterprise waste consuming points are: a. glaze making ball mill ingredients and equipment/floor cleaning; b. molding workshop plaster and equipment/floor cleaning; c. mudding workshop ball mill ingredients and equipment/floor cleaning; d. forming workshop waste washing water, external washing water, tool washing and floor cleaning; e. canteen, office space domestic water.

2) Industrial waste water

Waste water mostly comes from domestic industrial consumption; Industrial waste water can be categorized based on production source: mudding workshop waste water, glaze making workshop waste water, forming workshop waste water, etc. see Table 41.

Table 41: Generation and Treatment of Wasted Water

Workshop	Waste water Type	Contained Pollutant Category	Current treatment/utilization measure
Mudding workshop	Press machine filter pressing water	Mud suspended solids	Discharge into in-plant sedimentation tank, reused in ball mill machine
	Bar magnet washing water	Mud suspended solids; Fine iron powder	Discharge into sewage treatment plant #1
Molding workshop	Size mixing kettle cleaning water	Plaster suspended solids	Discharge into sewage treatment plant #1
Glaze making workshop	Glaze mixing cleaning water	Glazing suspended solids	Discharge into sewage treatment plant #1
Branch plant #1	Base washing water kiln cooling water	Mud suspended solids; Glazing suspended solids Heat	Discharge into sewage treatment plant #1
Branch plant #2	Base washing water kiln cooling water	Mud suspended solids; Glazing suspended solids; Heat	Discharge into sewage treatment plant #2
Special ceramics branch company	Kiln cooling water	Heat	Discharge into sewage treatment plant #2

The enterprise has set up sewage treatment plant in branch plant #1 and #2, its treatment technology is: waste water-grilling well- regulating reservoir- dosing coagulating basin- multiple layer sedimentation tank- disinfection tank-recycling. Partly used for mudding workshop ball mill and floor cleaning, mostly discharged after treatment. Domestic waste water discharged after treating with grease trap and septic tank, partly used in surrounding farm irrigation.

The current waste water monitoring is shown in Table 42:

Table 42: Overview of Wasted Water

Monitoring program	pH	Suspended solids / (mg/L)	Chemical requirement (mg/L)	Animal or vegetable butter (mg/L)
Monitoring result	6.5-7.5	59	37	3.02
Standard limit value	6-9	50	50	3.0
Meet standard	Yes	No	Yes	No

Note: data comes from Liling city environmental monitoring station, monitoring report on 27th April 2010, monitor location is at discharging outlet for glazing waste water after treatment, water contained heavy metal is shown in Table 43.

Table 43: Overview of Wasted Water

Monitoring program	Pb(mg/L)	Cd(mg/L)	Hg(mg/L)	As(mg/L)
Monitoring result	0.007	0.002	0.0005	Not detected
Standard limit value	0.3	0.07	0.1	-
Meet standard	Yes	Yes	Yes	Yes

Note: monitoring data comes from Liling city environmental monitoring station monitoring report on 06th September, 2011, monitor location is the discharge outlet. According to Ceramics industry enterprise pollutant emission standards, suspended solids and animal and vegetable oil are unqualified according to waste water discharge standards, therefore suggesting to renovate the current waste water treatment station.

2) Waste gas treatment and utilization

Waste gas can be classified into two categories: the first category is industrial waste gas containing mainly industrial dust; this type of waste gas usually has low temperature, mainly from mudding and glazing ball mill, base dry finishing process, ceramics rubbing process; the second category is smoke mainly containing SO₂、NO₂ smoke, mostly coming from kiln sintering process. Detailed production and treatment is shown in Table 44:

Table 44: Generation and Treatment of Wasted Gas

Workshop	Waste Gas Type	Contained Pollutants	Current treatment/utilization measure
Raw material storage	Dust	Dust	Unorganized emission
Mudding Workshop	Ingredient Dust	Dust	Clean, partially unorganized emission
Glaze making workshop	Ingredient Dust	Dust	Clean, partially unorganized emission
Forming Workshop	Fine base dust	Dust	Unorganized emission
Inspection, packaging workshop	Mill bottom dust	Dust	Aspirator coefficient
Kiln workshop	Natural gas combustion	Dust, SO ₂ , NO _x	Direct emission

According to *Ceramics industry enterprise pollutant emission standards*, when sintering oil or gas, roller kiln and tunnel kiln SO₂ (standard state) emission concentration is 300mg/m³, smoke (standard state) emission concentration is 50 mg/m³, NO₂ emission concentration is 400mg/m³. Liling city environment monitoring station monitored the smoke exit of roller kiln on 27th April 2010, smoke blackness is Ringelmann level 1, SO₂、NO₂ smoke concentration is not monitored. According to “daily ceramics products pollution emission coefficient” in the *Industry Pollution Source Pollutant Emission Coefficient Manual*, calculating SO₂ and NO_x in the kiln workshop: industrial waste gas is 5791.814m³/t product, smoke is 0.145kg/t product, SO is 0.038kg/t product, NO₂ is 0.579kg/t product, all direct emission. Getting: smoke (standard state) concentration is 25.08mg/m³, SO₂ (standard state) emission concentration is 65.7mg/m³, NO₂ (standard state) emission concentration is 100.1mg/m³. In summary, enterprise SO₂ and NO₂ emission are within limit.

3) Solid Waste Treatment and Resource Utilization

Enterprise solid wastes are mostly industrial solid waste and household garbage. The industrial solid wastes are general industrial solid waste, including screening deironing process produced waste residue containing iron, waste molds, waste kiln furniture, waste kiln base, waste ceramics, sludge and waste water treatment sludge, etc. Solid wastes generation of 2010 is shown in Table 45.

Table 45: Generation of Solid Waste

No.	Solid Waste	Output (t/a)	Current treatment measure	Note
1	Iron containing waste residue	79.8	no	Landfill with household garbage

2	Waste molds, molding pollution	1341.7	no	Cement plant recycle
3	Waste kiln base, mudding sludge	4443.2	no	Recycle
4	Waste ceramics	4814.95	no	Recycling
5	Waste kiln furniture	24	no	Plant recycle
6	Waste water treatment station sludge	168.9	no	Landfill with household garbage
7	Employee household garbage	245	no	Landfill
8	Total	11117.55		

Note: solid wastes cannot be accurately calculated. Therefore, data in the table is a calculation based on theory or estimation of actual usage data.

Table 46: Identification of Hazardous Waste of Sludge from Waste Water Treatment Plant

Category	Cu	Zn	Pb	Cd	Cr	Cr ⁶⁺
Waste Water Treatment Plant Sludge	0.046	0.079	0.117	0.0006	0.235	0.037
Standard (GB5085.3-2007)	50	50	3	0.3	10	1.5

Note: monitor data comes from Liling city environment monitoring report, 14th October 2011.

① Waste Residue Containing Iron

Mainly generated from glazing, mudding workshop iron screening process, little generation. Calculated as containing 0.5% of Fe₂O₃ in the raw sludge, generally landfill in domestic garbage dump together with waste glaze sludge.

② Waste Molds

The main ingredient is CaCO₃, which is delivered to ceramics plant as raw material. The annual plaster usage is 1341.7t, and waste molds account for 1341.7t

③ Waste Blank

Including waste blank generated in forming workshop, residue mud from repairing the blank and waste mud returns to mud making workshop ball mill to recycle, do not discharge externally. Waste blank is calculated as 0.233t of recycled waste blank per 1t of ceramics production.

④ Waste kiln furniture

The company adopts the advanced roller kiln, kiln furniture using cordierite, mullite and silicon carbide made deck and holder, with a service life of 100-400 times. The little waste produced with kiln furniture goes to a kiln furniture plant or fireproofing material plant, being used as raw material for fireproofing material.

⑤ Waste Ceramics

Ceramics products have a qualification rate of around 70%, which means annually there are 4814.95t of waste ceramics generated and they are all crushed and reused in ball mill process.

⑥ Mud making Sludge

Generated in waste water sedimentation tank of raw material workshop, generally sludge generation is about 3% of production output, annually 506.8t. Back to mud making workshop ball mill process for recycling, does not externally discharge.

⑦ Waste water treatment sludge

Sludge generated from waste water treatment station branch plant #1 and #2, sludge generation is 1% of production output, annually 168.9t. Regularly cleaned and transported out of plant by Liling city sanitation department into landfill.

According to Liling city environment monitoring station on the waste water treatment station sludge, its leach liquor contains far less heavy metal than GB5085.3-2007 *Identification Standards for Hazardous Wastes- Identification for Extraction Toxicity* standard requirement. It is general industrial solid waste.

The enterprise should further enhance management, reduce waste ceramics generation or make it recycled, reduce the amount of mud entering into water. Therefore, it is considered that this enterprise has great cleaner production potential in waste management.

4) Noise treatment Performance

The main noise source of the enterprise is ball mill, vibrating screen, pugmill, forming machine, magnetic separator and all kinds of fans and pumps mechanical equipment. Noise source is shown in Table 47:

Table 47: Intensity of Major Noise Source

No.	Noise Source	Intensity	Location	Treatment	Discharge Intensity
1	Ball mill	85-95	Mud making workshop, glaze making workshop	Basic vibration reduction, plant sound insulation	75-85
2	Vibrating screen	85-95	Mud making workshop, glaze making workshop	Basic vibration reduction, plant sound insulation	75-85
3	Magnetic separator	85-95	Mud making workshop	Basic vibration reduction, plant sound insulation	75-80
4	Plunger pump	75-85	Mud making workshop	Basic vibration reduction, plant sound insulation	64-75
5	Pugmill	80-85	Mud making workshop	Basic vibration reduction, plant sound insulation	70-75
6	Sole	65-75	Forming	Basic vibration reduction,	60-70

	Rubbing		workshop	plant sound insulation, sound proof door & window	
7	Induced draft fan	80-90	Forming workshop	Vibration reduction device, acoustic hood	70-80
8	Forming machine	80-90	Forming workshop	Vibration reduction device	75-85

Currently using workshop soundproof wall, sound attenuation, vibration reduction, range attenuation and enhancing equipment maintenance management, etc. to achieve sound insulation. Furnace induced draft fan has sealing treatment, large mechanical equipment like ball mill adopts rubber sheet as base to reduce vibration, reduce vibrating noise impact on surrounding environment.

Circadian Plant Boundary Noise Monitoring Result is shown in Table 48:

Table 48: Circadian Plant Boundary Noise Monitoring

Monitoring Location	Daytime			Nighttime		
	Data/d B(A)	Standard Limit Value/dB (A)	Meet standard	Data/d B(A)	Standard Limit Value/dB(A)	Meet standard
Outside plant gate 1m	53.6-58.9	65	yes	47.6-54.3	55	yes
Outside furnace workshop wall 1m of plant #2	57.2-59.8		yes	52.5-55		yes
Outside forming workshop wall 1m of plant #1	64.7-66.0		yes	49.3-54.2		yes
Outside mud making workshop wall 1m of plant #1	65.3-66.9		no	54.7-55.7		yes
Outside molding workshop wall 1m of plant #1	51.3-56.8		yes	47.6-54.3		yes

Note: monitoring data comes from Liling city environment monitoring station monitor report on 27th April 2010.

With monitoring, except circadian noise of mud making, workshop plant #1 does not meet the requirements of *Boundary Noise Emission Standard for Industrial Enterprises*, while all the other boundary circadian noises meet the GB12348-2008 requirements. Therefore, the management on plant #1 should be improved so that enterprise noise meets the standard requirements.

(3) Cleaner Production Level Analysis

Cleaner production level is evaluated based on National Development and Reform Commission issued *Evaluation Index System of Ceramics Cleaner Production Industry (for trial implementation)*. According to cleaner production principal requirements and indexes measurability, ceramics industry indexes are two parts: quantitative index and qualitative index. See Table 49 and 50.

Table 49: Qualitative Evaluation and Rating System of Domestic Ceramics Production Enterprise

Primary Index	Index Value	Secondary Index	Index Value	Enterprise Performance	Score
Compliance with implementing national focus encouraging technology development (including ceramics cleaner production technology)	50	Over 70% products are exported	5	90%	5
		Lead-free	9	Lead release < 0.1mg/L	9
		Low temperature and fast firing	8	yes	8
		Above province level engineering (technology) center, testing base	3	yes	3
		Wastes comprehensive utilization	8	Furnace exhaust heat recycle	8
		All plant sewage treatment (second) and recycle	8	Built and used two sewage treatment systems, but waste water recycling rate is low	3
		Comprehensive use (or absorb) social wastes	9	Cannot absorb social wastes	0
Establish environmental management system and cleaner production audit	25	Establish environmental management system and certified	10	Didn't establish environmental management system	0
		Conduct cleaner production audit	15	Conducting cleaner production audit, unfinished	10
Compliance	25	Construction projects	5	Pass	5

with implementing environmental protection regulations	environmental production “three simultaneous” implementation performance			
	Construction projects environmental impact evaluation system implementing performance	5	Complete	5
	Old pollution source limit-time treatment project completion performance	6	Finish changing coal to gas	6
	Pollutant total emission control performance	9	Reach total amount requirement	9
Total		100		71

Table 50: Quantitive Evaluation and Rating System of Domestic Ceramics Production Enterprise

Primary Index	Weighted Value	Secondary Index	Unit	Weighted Value	Evaluation Reference Value	Actuality value	Score
(1)Energy Index	25	Comprehensive energy consumption	kgce/t ceramics	15	1240	307.55	15
		①Biscuiting Process energy consumption	kgce/t ceramics	② 10/n	520	265	5
		Glaze firing process energy consumption	kgce/t ceramics	10/n	450	244.9	5
(2)Resource Index	15	Plaster consumption	t/t ceramics	3	0.20	0.091	3
		Raw material consumption	t/t ceramics	4	1.20	1.488	3.04
		Fresh water consumption per ton of ceramics	t/t ceramics	5	22 Normal ceramics	8.55	5

		Industrial water recycling rate	%	3	70	58.1		
(3)Production Technology Feature Index	15	Plaster model usage time	times	2	Roll-ing	150	100	1.33
				2	slip cast-ing	80	60	1.5
		Product lead release	mg/l	3	Compliance with international I④	<0.1	3	
		Product cadmium release	mg/l	3	Compliance with international I⑤	<0.01	3	
		Stained paper utilization	%	1	99	>99	1	
		Glaze slip utilization	%	1	99	>99	1	
		Product qualification rate	%	3	99	67.2	2.04	
	(4)Comprehensive Utilization Index	20	Waste ceramics utilization	%	3	95	95	3
Waste plaster utilization			%	2	98	98	2	
Waste base utilization			%	2	99	90	1.8	
Waste glaze slip recycling rate			%	2	99	99	2	
Unfired bricks recycling rate			%	2	98	98	2	
Furnace exhaust heat utilization			%	5	70	70	5	
Comprehensive utilization product value			yuan/t ceramics	4	150	70	1.5	
(5)Pollutant Index	25	External emission	m ³ /t ceramics	4	0.5 Normal ceramics	6.26	0.5	

	waste water					
	Waste water PH value		1	6-9	pass	1
	Total lead	mg/l	3	1.0	pass	3
	Total cadmium	mg/l	3	0.1	pass	3
	COD	mg/l	3	150	pass	3
	SS	mg/l	3	200	pass	3
	SO ₂ Emission concentration	mg/m ³	3	1430	pass	3
	Boundary noise (daytime)	Leq[dB(A)]	1	65	pass	1
	Boundary noise(nighttime)	Leq[dB(A)]	1	55	pass	1
	Smoke (dust) concentration	mg/m ³	3	400	pass	3
Total						88.7 1

① Only check when twice sintering

②③ The value of n: n=1 when once sintering, n=2 when twice sintering

① The same as GB12651—2003 *Contact-Food Ceramic Lead and Cadmium Release Limit*

Note: evaluation reference value has the same unit as its corresponding index.

Comprehensive evaluation index is an index describing and evaluating the enterprise's overall cleaner production level in the audit year. The difference of cleaner production comprehensive evaluation scores of domestic large and mediums-size ceramics enterprises can reflect the gap between cleaner production levels.

Comprehensive evaluation index has the following calculation formula:

$$P=0.7P_1+0.3P_2$$

In which,

P-clean production comprehensive evaluation index of enterprises

P₁, **P₂**- sum of all secondary indexes evaluation scores in quantitative evaluation, and sum of all secondary indexes evaluation scores in qualitative evaluation.

According to current domestic ceramics industry actual performance, *Evaluation Index System of Ceramics Cleaner Production Industry (for trial implementation)* comprehensive evaluation index of different levels of cleaner production enterprises is shown in Table 51

Table 51: Evaluation Index of Enterprises of Different Level in Ceramic Industry

Cleaner production enterprise level	Cleaner production comprehensive evaluation index
	Daily ceramics production enterprise
Advanced cleaner production enterprise	Pdva
Cleaner production enterprise	70an<80

It is shown from Table 74 and 75 that this enterprise has a qualitative evaluation score of 71 and a quantitative evaluation score of 88.71, and after calculation its comprehensive index is 83.4. Hence, this enterprise is an advanced cleaner production enterprise.

The unmet standards are mostly raw material consumption, water recycling, plaster model usage times, product qualification rate and external water emission, etc. It has certain cleaner production potential.

(4) Industry Policy Analysis

Catalogue for Guiding Industry Restructuring (2011 Version) encourages: production and technology/equipment development for special designed ceramics, including industry, medical, electronics and aerospace, etc.; ceramics cleaner production and comprehensive utilization technology development.

Catalogue for Guiding Partial Industry Industries on the Elimination of Outdated Production Process Equipment and Products (2010 Version) regulates to eliminate: building sanitary ceramic kiln, down-draft kiln, multi-passage kiln, coal burning Open flame tunnel kiln, muffle tunnel kiln and sagger-installed sanitary ceramics tunnel kiln

Catalogue for Guiding National Key Industries on Cleaner Production Technology (third group) recommends: little air fast drying technology. Using low temperature and high humidity method, wet body in the low temperature section the body surface vapor pressure keeps increasing, prevent external diffusion, the absorbed heat is used to increase body internal temperature, increase internal diffusion speed, so that the pre-heating period is shortened.

Policy Research on Ceramics Industry Resource Consumption and Industry Restructuring points out:

First, continue to guide ceramics industry, especially daily ceramics to develop towards “5 changes”, to achieve raw material standardized, fuel purified, auxiliary material professionalized, production process modernized, products upgraded.

Second, enhance product added value, in addition to improve product quality, more importantly improve product design level, decoration level, product design has the courage to innovate and diversified development. Daily ceramics can boldly use art ceramics decoration method.

Third, the specific policy requirement on ceramics industry development is to adjust partial products structure, priority to the development of daily ceramics and sanitary ware, environmental ceramics, micro ceramic tile, glazed tile; prohibit the usage of

solid liquid fuel on limited time, encourage the use of natural gas, hydraulic energy and solar energy. This is the key to promote cleaner production.

This ceramics enterprise has roller kiln sintering production technology, and use afterheat to dry; the enterprise produces special kind ceramics, all belong to the encouraged category of *Catalogue for Guiding Industry Restructuring (2011 Version)* ; and contains no products or technology and equipment that belong to limited category or elimination category of *Catalogue for Guiding Industry Restructuring (2011 Version)* or *Catalogue for Guiding Partial Industries Elimination Outdated Production Technology and Equipment (2011 Version)*. The enterprise is now striving to develop high added value daily ceramics such as high-end wine bottle to comply with the requirements from *Policy Research on Ceramics Industry Resource Consumption and Industry Restructuring*

(5) Cleaner Production Potential.

Based on the current production status of this enterprise, combining industrial technology development and national industrial policy requirements, the enterprise has potential to improve cleaner production in the following aspects:

First, raw and auxiliary material aspect: the storage and management of raw material need to be further regulated. The enterprise has a common phenomenon of fresh water “run, emerge, drip or leak”, some sections use fresh water instead of recycled water which leads to over consumption of fresh water, does not comply with cleaner production requirement. The enterprise should reduce fresh water usage by enhancing management, change to water saving equipment, improve equipment maintenance, etc. In addition, there commonly exists the problem of weak energy saving awareness and sever water resource waste.

Second, technology aspect: ceramics industry is mainly an artisan craftsmanship. However as the society develops should develop and utilize automated process.

Third, equipment aspect: there are breakdowns in equipment, should enhance equipment maintenance and repair, reduce equipment failure rate.

Forth, process control aspect: enhance operation post motivation and punishment scheme, improve staff activity to further increase product qualification rate.

Fifth, product aspect: product qualification rate needs to be improved.

Sixth, waste aspect: water is not fully utilized; waste storage is in disorder without setting a uniform storage site. It is suggested for this enterprise to improve on waste management.

Seventh, management aspect: pulverizer and air compressor have strong noise, need to enhance equipment maintenance and repair.

Eighth, staff quality aspect: ceramics is a typical labor intensive industry, the enterprise should regularly educate its staff on cleaner production relevant knowledge, and coming with the post feature to conduct post cleaner production competition, improve staff post operation skill.

(6) Cleaner Production Targets

Based on enterprise development planning, cleaner production index evaluation goals and key improvement potentials, the cleaner production audit targets are set. See Table 52:

Table 52: Overview of Targets of Cleaner Production Audit

No.	Secondary Index	Current Status		Short-term targets (2011-12)		Medium/long-term targets (2013-9)	
				Absolute value	Relative value	Absolute quantity	Relative value
1	Comprehensive energy consumption (kgce/t ceramics)	307.55		292.2	Decrease by 5%	271.3	Decrease by 7.2%
2	Industrial fresh water (t/t ceramics)	8.55		5.8	Decrease by 32.2%	2.8	Decrease by 51.7%
3	Raw material consumption (t/t ceramics)	1.488		1.25	Decrease by 16%	1.11	Decrease by 11.2%
4	Plaster model usage times	Rolling	100	150	Increase by 50%	150	Increase by 0%
		Hydraulic pressure	60	80	Increase by 33.3%	80	Increase by 0%
5	Product qualification rate (%)	67.2		85	Increase by 26.5%	90	Increase by 5.88%
6	Water recycling rate (%)	15.6		70	Increase by 348.7%	90	Increase by 28.6%
7	External sewage emission (m ³ /t ceramics)	6.26		3.5	Decrease by 44.1%	0.5	Decrease by 85.7%
8	Comprehensive utilize (or absorb) social wastes	Unutilized		By 2013 comprehensively utilize enterprise waste ceramics, waste sludge and part of ceramics enterprises' waste ceramics of Liling city.			

(7) Formulate Audit Focus

The audit group based on cleaner production audit methodology, integrating this ceramics enterprise's actual performance, environmental monitor reports data of environmental protection department and national industry policy requirements, comparing with ceramics industry cleaner production index system, formulate that the alternative audit focus are bran plant #1 and 2, special ceramics branch company during production process.

Audit working group adopts the weighted scoring method, scores based on the coefficients of weighted factors and formulate the audit focus of this cleaner production work:

Table 53: Determining the Focus of Audit via Weighted Scoring Method

Factor	Weighting 1-10	Alternative Audit Focus Score					
		Branch Plant #1		Branch Plant #2		Special Ceramics Plant	
		R	RW	R	RW	R	RW
Raw material and energy consumption	10	10	100	7	70	6	60
Pollutant Generation	9	7	63	7	63	6	54
Cleaner Production Potential	7	8	56	7	49	6	42
Staff Cooperation	3	8	24	7	21	8	24
Total Score		243		203		180	
Rank		1		2		3	

With the analysis of weighted scoring method, bran plant #1 is the audit focus of this round of cleaner production.

(8) Pre-audit Stage Cleaner Production Plan

In the pre-audit phase, researching the overall production performance of this enterprise from 8 aspects of the production process (raw/auxiliary material and energy, technology process, equipment, product, process control, staff, management and wastes generation/emission). According to the current problems and cleaner production potential the audit working group formulates cleaner production potential of this stage, in total 21 items. See Table 54:

Table 54: Overview of Cleaner Production Potential on Pre-Audit Stage

No.	Current Problem	Improvement Measure	Improvement Result	Investment/10 ⁴ yuan
F1-1	Vacuum pump oil leakage	Oil seal is damaged, need to be replaced in time	Reduce oil leaking, save resources	0.1
F1-2	Too much dust in raw material storage, goods are randomly storage and lead to waste	Timely clean raw material storage dust	Raw material recycle, reduce material consumption	0
F1-3	Belt roller is scaling and result in uneven belt shaking and material drop	Timely clean belt roller	Save raw material, save cleaning time	0
F1-4	Rain leakage in the raw material storage and cause raw material loss	Repair raw material storage roof, effectively prevent water contamination	Save raw material, prevent water contamination	1(estimation)
F1-5	Mud-making and glaze making workshops have running water, severe waste of water	Turn off water in time	Save water	0
F1-6	Vacuum equipment has unrecycled cooling water, huge waste	Cooling water recycling	Recycle and utilize cooling water, save water resource	3(estimation)
F1-7	Mud-making workshop ball mill has huge noises	Improve ingredient management	Reduce energy consumption, reduce single ball mill time 2h.	5(estimation)
F1-8	Molding workshop plaster material is old	Enhance staff working skill training	Reduce material loss	0.2
F1-9	Slight flying dust at compounding exit	Enhance operation management, hand out masks	Reduce dust pollution	0.2
F1-10	Glaze making workshop ball mill has huge noise	Increase vibration isolator, hand out earplugs	Reduce noise pollution	0.2
F1-	Base material breaks	Enhance operation	Reduce base	0

11	during base vehicle transporting	management	material loss, reduce material consumption	
F1-12	Outer layer of wind pipe is broken and wind leaking in branch plant #1	Wind pipe maintenance	Reduce energy consumption	1(estimation)
F1-13	Compressor motor is damaged in branch plant #2	Replace the motor	Ensure equipment well-functioning	5(estimation)
F1-14	Compounding has low accuracy	Check all raw material moisture before compounding, ensure the accuracy of ingredients	Save raw material	0
F1-15	Waste vacuum oil is not recycled	Timely recycle vacuum oil	Reduce pollution	0
F1-16	Enterprise does not use energy saving lights	Replace energy saving lights and reform circuit for the whole enterprise	Reduce energy consumption	15(estimation)
F1-17	Glaze making workshop has weak water emission	Expand and reform drainage channel	Reduce pollution	1(estimation)
F1-18	Low cleaner production awareness of staff	Carry out education and training on cleaner production	Enhance staff energy saving awareness	0
F1-19	No water, electricity and gas meter in the branch workshops	Install resource meters	Increase energy metering management, save energy consumption	80(estimation)
F1-20	High energy consumption during stoneware dry molding	Expand workshops, first use natural drying for base molding then enters the drying room	Reduce energy consumption	100(estimation)
F1-21	Enterprise does not separate rain and sewage pipe network	Currently rain water and sewage use the same pipe network. It should have separated reforming, recycling ceramics mud and glazing mud from sewage.	Reduce energy consumption	120(estimation)

3.3.3 Cleaner Production Evaluation

Working focus at this stage is actual measurement of input/output material flow, establish material balance, water balance and energy balance, analyze main reason for waste generation and formulate cleaner production plans. Based on audit focus analysis, the cleaner production audit focus is branch plant #1, its material balance, energy balance and water balance of the whole plant.

(1) Audit Focus: Branch Plant #1

1) Overview of Branch Plant #1

Operation performance and technology process is shown in Table 55 and Figure 13:

Table 55: Operation Conditions of Branch Plant #1

No.	Process	Unit Operation Content
1	Molding	Put the sintered ceramic mud into template jigger for template molding, plastic molding or slip molding
2	Sharpening	Wet mending the base material, or sharpening the slipped molding base material
3	Drying	Put base material in the drying room
4	Fine Base	Dried base material for fined dry mending
5	Washing water, glazing	Washing water the fine base, glaze internally or externally based on requirements.
6	Loaded and sintering	Load the kiln car with glazed products based on certain requirement and proportion, automatically or manually send into the furnace for sintering on fixed temperature curve.
7	Quality inspection	Inspect the products one by one based on national standards, enterprise standards and international standards
8	Packaging	Packaging qualified ceramics based on order requirements

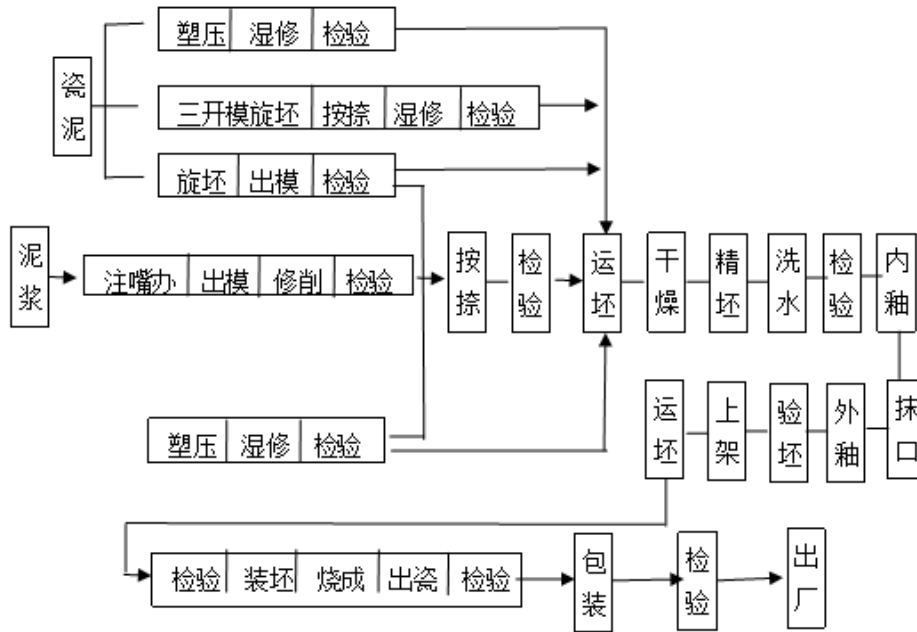


Figure 13: Technology Process of Branch Plant #1

2) Raw Material Balance Data

Raw material balance is shown in Figure 14:

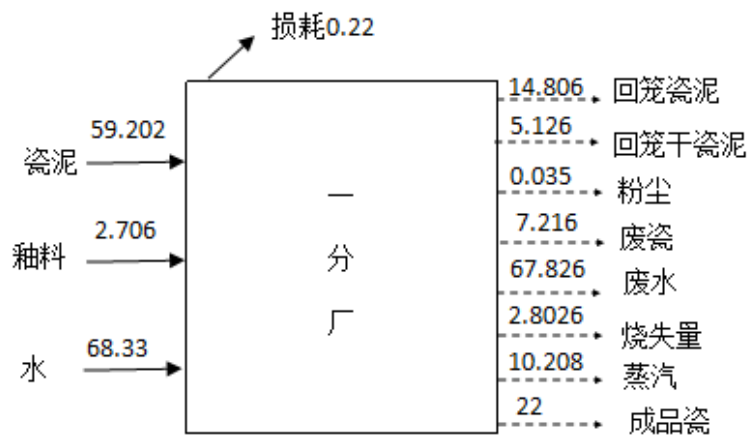


Figure 14: Raw material balance of Branch Plant #1 (Unit: t/d)

3) Two "high" and One "heavy" Analysis

The following conclusions can be drawn from the material balance analysis of branch plant #1:

① High Dust Emission

There is dust generation at every dry fine base spot and unorganized discharged. It is recommended to use aspirator to collect the dust, operator should wear a mask, recycle fragments and maintain site clean.

② High Waste Ceramics Generation

It is shown from the balance analysis that there produces 22t of qualified ceramics per day and 7.216t of waste ceramics. Therefore the qualification rate of branch plant #1

is 67.2%, far below the index requirement of 90%. There are several reasons for the low qualification rate: a. all the products are exported and the exporting countries have higher qualification standards than China. This is the main reason for this low qualification rate. Hence, there are part of waste ceramics being domestically sold as off sorts. Some waste ceramics are recycled after grinding and enters ball mill process; b. part of the waste ceramics have defects such as out-of-round holes/trimming and uneven glazing. Therefore should reinforce the training on staff working skills. For example when vacuum mud-making, only conduct mud-making after reaching vacuum index value. Control the mud added amount and maintain a moderate speed of mud adding.

③ Heavy Waste Water Emission

It is shown from the balance analysis that there produces 22t of qualified ceramics per day and 3.083t/t ceramics of waste water emission, far more than the standard value of 0.5t/t ceramics. Branch plant #1 has waste water treatment station but low recycling rate, this leads to huge fresh water consumption and external emission. The sediment sludge of the treatment station is regularly transported out of the plant by Liling city sanitation department and delivers to landfill. The sludge is mainly composed of recyclable material such as mud material, glaze material and plasters. If the sludge is calculated as 1% of production output, then annually generate 168.9t of sludge. After discussion with company technician, it is recommended to separately collect and discharge waste water to mud making workshop, glaze making workshop and molding workshop. Aiming to achieve the goal of waste utilization and material recycling.

(2) Whole Plant Energy Calculation

1) Energy Basic Data

According the enterprise's energy consumption data on January 2011, energy consumption performance is shown in Table 56:

Table 56: Energy Consumption in Jan.2011

Energy	Usage	Standard Coal(kgce/month)	Department	Usage (m ³ /month)	Standard Coal (kgce/month)
Natural (gasm ³ /month)	210406	255432.9	Main furnace	127293.6	154534.4
			Hot-blast stove	14040	17044.6
			Kiln	600	728.4

				grouting stand	6150	7466.1
				-	Subtotal: 179773.5(kgce/month)	
			Branch plant #2	Main furnace	39300	47710.2
				Hot-blast stove	7680	9323.5
				Kiln	9502.4	11535.9
				-	Subtotal: 68569.6(kgce/month)	
			Special ceramics plant		2160	2622.2
			Technology Center		1200	1456.8
			Development department		2480	3010.7
			Total: 255432.8(kgce/month)			
Energy	Usage	(kgce/month)	Department	(kW·h/month)	(kgce/month)	
Electricity (kW·h/month)	201562	70546.7	Branch plant #1	59935	2.977.25	
			Branch plant #2	28000	9800	
			Special ceramics plant	4520	1582	
			Mudmaking workshop	83602	2926.7	
			Glaze making workshop	9221	3227.35	
			Molding workshop	922	322.7	
			Technology Center	1600	560	
			Development Department	8400	2940	
			Household electricity	5362	1876.7	
			Total: 70546.7(kgce/month)			

Note: natural gas average lower heating value is 3893kJ/m³, electricity average lower heating value is 3600kJ/ kW·h, equals standard coal coefficient 0.35kgce/ kW·h.

2) Energy Consumption Analysis

The following conclusions can be drawn from the above data and on-site analysis:

① Natural gas usage of the whole plant equals standard coal 255432.8kgce/month, plant #1 uses natural gas equivalent to standard coal 179773.5kgce/month, account for 70.38%. Therefore plant #1 is the major energy consuming department of the enterprise. Sintering process has the largest energy consumption in plant #1, and roller kiln and drawer kiln equipment are aging. After discussing with technician, it is suggested to renovate and update plant # 1 to reduce energy consumption.

② The whole enterprise uses electricity equivalent to standard coal 70546.7kgce/month, mud making workshop uses electricity equivalent to standard coal 29260.7kgce/month, accounting for 41.48%. Therefore mud making is one of the major energy consuming departments. Mud making workshop has major energy consuming equipment such as ball mill, plunger pump, vacuum pump, etc. Ball mill time is 11-14h each time. After discussing with company technician, it is suggested to develop new energy saving ceramics material to shorten unit ball mill time, therefore to reduce energy consumption.

Therefore, if the enterprise enhance and improve on technology, equipment and management, reinforce equipment maintenance and replacement, adopt advanced technology, then it could reduce energy loss and achieve its cleaner production targets.

(3) Enterprise Water Balance

1) Water Balance Data and Procedure

This ceramics had incomplete water consumption data due to the lack of metering devices, in addition water using processes like cooling water and rinse water cannot be measured. Given that it is very difficult to measure the internal water usage due to the condition, this report only roughly analyses water input and output for water balance measurement. According to field data provided by the enterprise, water is mostly consumed in mud making workshop, glaze making workshop, plant #1 and 2, special ceramics plant and household water usage. Detailed data is shown in Figure 15:

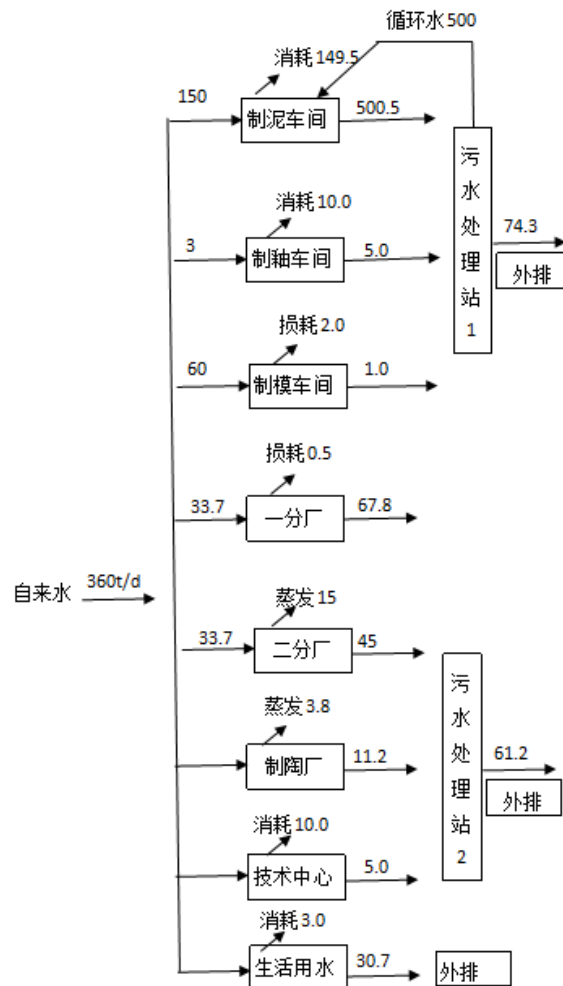


Figure 15: Enterprise Water Balance (Unit: t/d)

2) Water Loss Analysis

By measuring input and output water the corresponding water balance chart is obtained. With water balance and field investigation analysis, the following conclusions are drawn:

① Low water recycling rate

Due to the huge water demand in mud making workshop ball mill, glaze making workshop, plant #1 and 2 washing water process, in which ball mill and water washing could use recycled water. However the enterprise only uses part of the recycled water from waste water treatment station. Vacuum pump and other cooling water required equipment use a lot of fresh water for cooling, the cooling water does not contain other substances and is pure but they are discharged directly into water treatment station. Water recycling rate is low and results in deadweight loss of water resource.

② Staff quality needs to be further improved.

It is known from the initial site investigation and conversation with staff, due to the low staff quality and lack of water saving awareness, there are long-time running water in many steps like water washing or floor rinsing.

③ Incomplete metering

The enterprise does not have water meters, should complete water metering device establishment and management, it is beneficial to discover cleaner production potential in water consumption.

By enhancing management, optimizing process control and control water consumption, there is significant economic benefit and environmental benefit.

(4) Audit Phase Plan Overview

According to conclusions drawn from material balance, water balance and energy audit and combining with the discovered problems during performance investigation, the audit team proposes cleaner production audit problems in this stage and 9 cleaner production potential aspects. The potential is shown in Table 57:

Table 57: Overview of Cleaner Production Potential on Audit Stage

No.	Problem	Improvement Measurement	Improvement Result	Investment nt/ 10 ⁴ yuan
F2-1	Ball mill conveyor broken	Timely replace	Ensure equipment well-functioning	1
F2-2	Splashing Slurry	Control the distance between sludge exit and vibrating screen, prevent slurry splashing	Save raw material	0
F2-3	Holes in vibrating screen	Inspect vibrating screen, timely replace if have holes	Improve equipment working efficiency	0.5
F2-4	Air bubble in glazing process	Only start mud making after achieving vacuum index, control mud adding amount and maintain a moderate speed	Reduce blowhole, increase product qualification rate	0
F2-5	Leakage during rough blank grouting operation	Tighten the molds to prevent leakage; grouting speed should be slow, product grouting must be controlled separately; do not over grouting; do not use broken baskets for grouting; careful with grouting operation, control grouting and slurry adsorption time, control base thickness; property recycle grouting residue.	Save raw material	0
F2-6	Raising dust during fine	Use dust cleaner to collect dust at every dry/fine base, operator should wear mask. Properly collect base	Reduce dust pollution	5

	base	chips, keep site clean		
F2-7	Furnace equipment aging in branch plant #1	Sintering process has high energy consumption, and dust roller kiln, drawer kiln equipment are aging. Suggest to renovate and update plant #1 furnace.	Reduce energy consumption	100
F2-8	Unit ball mill time is long	Mud making workshop unit ball mill time is 11-14h. After discussing with enterprise technician, suggest to develop new energy saving ceramics material, shorten unit ball mill time.	Reduce energy consumption	100
F2-9	Unrecycled sludge in waste water treatment station	Waste water treatment station sludge is regularly transported out of the plant by Liling city sanitation department, to landfill at garbage disposal plant. These sludge are mainly composed of mud, glaze and plasters recyclable material. After discussing with technician, suggest to separately collect and discharge waste water for mud making workshop, glaze making workshop and molding workshop, and also improve waste water treatment technology in order to reach the goal of waste water utilization and material recycling. It can also recycle other ceramics plants mud wastes of Liling city.	Save raw and auxiliary material, reduce energy consumption	7800

3.3.4 Generation and Selection of Plans

(1) Generation and Summarizing, Selection and Categorizing of Plans

① Plans category

Audit group collects and summarizes 30 cleaner production plans and reasonable suggestions. After assessment, the plans are categorized according to investment.

Table 58: Classification of Types of Plan

Plan Types	Index Range/10 ⁴ yuan
No cost	0
Low cost	≤10
Medium cost	10<x≤100
High cost	>100

(2) Plans Selection

Audit group collects in total 30 cleaner production plans and categorize in investment order. There are 23 low/medium cost plans and 7 medium/high cost plans.

(3) Plans Summary

After previous plan selection, there are in total 30 implementable plans, in which 7 medium/high cost plans and 23 low/medium cost plans. Based on the cleaner production audit guideline of implementing while having effect, all the no/low cost plans are implemented. In total invested 230000yuan in no/low cost plans and gained economic benefit of 455000yuan/year. No/low cost plans and medium/high cost plans are summarized in Table 59:

Table 59: Summary of Plans

No.	Plan type	Index range/ 10^4 yuan	Plan Serial No.
1	No cost	0	F1-2、 F1-3、 F1-5、 F1-8、 F1-11、 F1-14、 F1- 15、 F1-18、 F2-2、 F2-4、 F2-5
2	Low cost	$\leq w$	F1- 1、 F1-4、 F1- 6、 F1- 7、 F1- 9、 F1-10、 F1-12、 F1-13、 F1-17、 F2-2、 F2-3、 F2-6
3	Medium cost	$10 < x < 100$	F1- 16、 F1- 19、 F1- 20、 F2-7、 F2-8
4	High cost	> 100	F1-21、 F2-9

3.3.5 Feasibility Analysis

In the plans generation and selection phase, there are initially 7 medium/high cost plans selected, part of the plans like F1-16 (energy saving lights replacement and circuit reform plans), F1-19 (install energy metering device plans) and F1-20 (stoneware molding technology reform plans), although they are medium/high cost plans but they are only reforms for metering, lights and plants, they do not impose negative impact on the environment and have no technology difficulties. This report will not elaborate on their technological, environmental and economic benefit evaluation. Now take two medium/high cost plans “energy saving ceramics material development plans”, “Cleaner Production Demonstration Project in Configuration Improvement of Standardized Mudglaze Mold “as examples for feasibility analysis.

(1) Evaluation on “Energy saving ceramics material development” plan

1) Technology Evaluation

The main technological measures of this plan are:

- ① The sintering temperature of industrial ceramics is 1350°C , can be reduced to $1250-1260^{\circ}\text{C}$ by adjusting base material formula. Measures are to self-produce mud material instead of external purchase and adjust the formula. So that on the condition of ensuring molding plasticity and product physicochemical properties, add flux, try to reduce 100°C of sintering temperature. It is estimated to save 30-40% of energy.

- ② The sintering temperature of **high whiteness fine ceramics** is 1250-1260°C, can be reduced to 1180-1200°C by adjusting base material formula. Measures are that on the condition of ensuring ceramics performance, add flux, use high whiteness and strong plasticity performance materials, try to reduce 50°C of sintering temperature. It is estimated to save 10-20% of energy.
- ③ The sintering temperature of medium/high-end wine bottles is 1250-1270°C, can be reduced to 1180-1200°C by adjusting base material formula. Measures are that on the condition of ensuring ceramics performance, add flux, reduce clay usage, try to reduce 70°C of sintering temperature. It is estimated to save 10-22% of energy.
- ④ By adjusting formula, using small particle material for the ball mill to reduce 1-2h of ball mill time.

In summary, energy saving ceramics material development: estimated to save natural gas 20% per year, in 2010 the enterprise gas usage is 2749668m³, could save natural gas 2749668*20%=549933.6 m³. If natural gas purchase cost is 2.5yuan/ m³, then could save fuel cost 1374800yuan; estimated to save electricity 10% per year, in 2010 the electricity usage is 2978760kW·h, then could save electricity cost 2978760*10%=297876 kW·h. If electricity purchase cost is 1.0yuan/ (kW·h) , could save cost 297900 yuan.

2) Environment Evaluation

After implementing this plan, could reduce natural gas consumption 549933.6 m³ per year. According to pollution emission coefficient of daily ceramics products in the manufacturing industry, estimated to reduce dust emission 13.79t per year, SO₂ emission 36.12t, NO₂ emission 55.04t; reduce electricity consumption 297876 kW·h per year, equals to standard coal 104.56t/a, estimated to reduce SO₂ emission 3.14t and ash residue 15.67t.

This plan could reduce waste gas and dust emission, cut dust pollution from the source, achieve the result of energy saving, consumption reduction and environmental protection.

3) Financial Evaluation

(2) “Cleaner Production Demonstration Project in Configuration Improvement of Standardized Mudglaze Mold” Plan Evaluation

1) Technology Evaluation

The main technological measures of this plan are:

① Standardized mudglaze ingredient preparation

Natural raw material are quite different in its condition and purity due to difference in origin and internal structure, resulting in diversity in mineral composition, chemical composition and Physical and chemical properties. The key of standardized mudglaze material preparation is to have raw materials with reasonable and stable chemical composition and the necessary physical performance, ensure to stay stable within the

maximum allowable fluctuation range. The main technology features are selecting proper and advanced refined processing integration technology. Through entrance storage prehomogenization, straight homogenization, pulp chest homogenization, blending and mandatory mixed method multiple joint controlling ingredient homogenization; precipitation method and whirl method multilayer joint mechanical desanding and deironing; ball mill and delaminating combined ultrafine grinding, screening; High gradient magnetic separation multiple joint fine grading and deironing refinement, use the new technology and equipment of flocculence and filter pressing combining thickening and dehydration method. Use proper computer monitor technology, mainly use computer auto-control ingredient blending technology, X ray fluorescence analysis, laser particle size analysis, etc. reinforced monitor and control measures, to achieve the final goal of mudglaze stabilization.

② Standardized mold preparation

Plaster mold is the auxiliary tool widely applied to injection moulding and slip casting in the daily ceramics industry. It has the advantages of large porosity and Water absorption, but mechanical strength is weak and heat resistance and therefore a short service life. Hence, research on increasing plaster mold mechanical strength and surface quality has raised the attention of many enterprises. The disadvantages of plaster molds are largely depending on natural plaster purity and mold preparation methods, also slip casting technology control. Standardized mold preparation plans to introduce advanced mold production technology, use plaster vacuum molding equipment and high frequency vibration technology, eliminate air bubbles in gypsum plaster, increase mold density and strength, surface finish, prolong mold service life. Change the traditional fine base method, reduce fine base workload, beneficial for increasing ceramics surface flatness, in order to improve plaster mold quality still need to active experiment and promote adding Water soluble additives and synthetic resin during plaster mold making, to increase mechanical strength of molds and enhance abrasion resistance of working surface.

③ Add sewage treatment station, achieve zero emission

Standardized mudglaze configuration center estimates that total water usage is 1590m³/d, combining with the actual water usage of configuration center and water usage of old plants, this plan adopts water recycling and achieves zero emission. Estimated mud making water usage 800 m³/d, waste water mission 640 m³/d; glaze making water usage 670 m³/d, waste water mission 600 m³/d; molding water mission 120 m³/d, waste water mission 100 m³/d, in total waste water emission 940 m³/d. After waste water goes through the newly added sewage treatment station, 400 m³/d of water is reused for ball mill, the rest is used for floor washing, greening and flushing toilet.

④ Absorb social solid wastes

Absorb sludge generated from enterprise waste water treatment station, waste ceramics, sludge and other solid wastes generated from other ceramics plants of Liling city, and treat with grinding, screening and ball mill, reuse in standardized mudglaze preparation raw material.

After a joint discussion between cleaner production audit group and enterprise technical department, this plan is feasible in implementation, estimated to produce standard glaze 16500t/year, standard porcelain clay 165000t/year, and standard mold 8250t/year.

2) Environment Evaluation

By implementing this plan, estimated to reduce waste water emission 940 m³/d, yearly 329000m³, by reducing glazed waste base and waste ceramics 2400t/a, reduce waste water and treatment sludge 920t/a, reduce cadmium 32.9kg/a, lead 329kg/a. Significant environmental benefit.

3) Financial Evaluation

3.3.6 Plan Implementation

In this cleaner production audit, by detailed investigation on production technology process, pollution generation and emission phases and cleaner production site, formulates 30 cleaner production plans (23 no/low cost plans and 7 medium/high cost plans), implemented 23 no/low cost plans (implementation rate 100%), implemented 1 medium/high cost plan, implementing 1 medium/high cost plan, planning to implement 5 medium/high cost plans.

After pre-audit and all plans implemented, the ceramics enterprise has improved all its cleaner production indexes to some extent: reaching 12 qualitative secondary indexes, index value improves from 71 to 90; reaching 30 quantitative secondary indexes, index value increases from 88.71 to 95.58. This enterprise could reach the current cleaner production standard system requirement.

(1) Economic Benefit

In total invested 230000yuan in no/low cost plans, gained 455000yuan/year economic benefit; invested 83150000yuan in medium/high cost plans, could gain 24069400yuan economic benefit; return on investment is 29.4%, return on investment period 3.4 years. By implementing the plans, saves water 329000t/year, water saving benefit 317200yuan/year, saves natural gas 640249.68m³/a, gains benefit 1600600yuan/year.

(2) Environment Benefits

Reduce dust emission 14.748t/a, reduce SO₂ emission 40.796t/a, reduce NO₂ emission 58.757t/a, reduce ash residue 15.67t/a, reduce cadmium 32.9kg/a, lead 329kg/a, reduce solid waste like glazing waste base, waste ceramics 2400t/a, reduce waste water treatment sludge 920t/a.

With this cleaner production audit, the enterprise gains significant results on energy saving, consumption reduction, pollution reduction and effect enhancing.

3.3.7 Continuous Cleaner Production

Keeping cleaner production is the final phase of this round of cleaner production audit. The goal is to make the cleaner production work to be continuously implemented in the long run. Work focus at this stage is to keep improving cleaner production organizing institution, establish management system to promote cleaner production implementation, formulate continuous cleaner production plans.

4 Evaluation of Green Building Material

4.1 Management of Green Building Material Evaluation Certificate

To implement the requirements of *Guiding Opinions of the State Council on Resolving Serious Production Overcapacity Conflicts* ([2013]41 of the State Council), *Notice of the State Council on Issuing the Air Pollution Prevention and Action Plan* ([2013]37 of the State Council), and *Notice of the General Office of the State Council on Forwarding the Execution Plan of the National Development and Reform Commission on the Notice of the Ministry of Housing and Urban-Rural Development on Green Building Action Plans* ([2013]1 of the State Council), rapidly implement green building material, support building energy saving and green building/new urbanization construction needs, fulfill the basic state policy of resource conservation and environmental protection. Accelerate transforming urban and rural construction model and construction industry development methods, improve demand structure, nurture new industry, accelerate building material industry transform upgrading, promote the **positive interaction between** industrialization and urbanization. Ministry of Housing and Urban-Rural Development, the Ministry of Industry and Information Technology establish *Green Building Material Certificate Management Measures*. It has 5 chapters and in total 22 articles:

Chapter One: General Provisions

Article 1 To Accelerate the promotion of green building material, regulate green building material certificate management and further support green building development, this Law is formulated.

Article 2 For the purposes of this Law, “green building ” means the building material products that could reduce natural resource consumption and reduce ecological environmental impacts in its life cycle, and has the features of “energy saving, emission reduction, safe, convenient and recyclable”.

Article 3 For the purposes of this Law, “green building material evaluation certificate” (certificate) means according to green building material evaluation technology requirement, on the basis of procedure and requirements of this Law, to evaluate building material products that applied for evaluation, establish its level and give informative certificate.

Certificate includes certification and label and are traceable. The style and format of certificate are jointly formulated by the Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology

Certification has the following information:

- (1) Applicant enterprise name/address;
- (2) Product name, product series, Specification/model
- (3) Evaluation basis
- (4) Green Building Material Level
- (5) Issued date and expiration date
- (6) Issued facility

- (7) Green building material evaluation facility
- (8) Certification number
- (9) Other content to be marked

Article 4 Each category of building material products are formulated with green building evaluation technology requirement according to material content and usage feature.

Certificate level is ranked from 1 star to 3 star according to technology requirement and evaluation result.

Article 5 Evaluation certificate work follows the principle of enterprises voluntariness, stick to scientific, transparent, fair and just.

Article 6 Encourage enterprises to develop, produce, promote and apply green building material. Encourage new constructed, reconstructed, construction extension projects to preferentially use green building material that has evaluation certificate. Green building, green ecological urban area, government invested and financial invested construction projects should use green building material that has evaluation certificate.

Chapter Two: Organization Management

Article 7 The Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology are responsible for monitoring and management of national green building material evaluation certificate. Guide locals to carry out green building material evaluation certificate work. Responsible for formulating implementation by-laws and management measures for green building material evaluation institution. Formulate green building material evaluation technology requirement, establish a national integrated information distributing platform for green building certificate. Dynamically issue and manage all-star products evaluation result and certificate product catalogue.

Article 8 The Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology are responsible for the management of three-star green building material evaluation certificate. Provincial-level competent departments of housing and urban-rural development and departments of Industry and Information Technology are responsible for local one-star and two-star certificate management, publish product evaluation results and certificate product catalogue in the national integrated information distribution platform. Provincial-level competent departments could formulate local management measures or implementation by-laws based on this Law.

Article 9 Based on this Law and relative technology requirement, green building material evaluation institution is responsible for green building material evaluation certificate, including accept enterprises application, evaluate, public and affirm levels, issue certification and label.

Chapter Three: Application and Evaluation

Article 10 Green building material evaluation certificate application is handed from production enterprises to corresponding evaluation facilities.

Article 11 Enterprises can apply for corresponding star certificate based on product features and evaluation technology requirement

Article 12 Green building material certificate applicant enterprises should meet the following conditions:

- (1) With Independent Legal Qualification;
- (2) With production capacity and intellectual property matching application;
- (3) Meet the industry entry criteria;
- (4) With complete quality management, environment management and occupational health and safety management system;
- (5) Applicant building material products meet the technology requirement of green building material, and has practical application in green construction;
- (6) Other required condition

Article 13 Applicant enterprises should provide authentic and complete application material, provide evaluation declaration, provide relevant certification, inspection reports, usage reports and image records, etc.

Article 14 Based on this Law and technology requirement of each material category, green building evaluation institution evaluates independently, when necessary also conduct site inspection and product spot check.

Article 15 Evaluation results are published by green building material evaluation institution, formulate certificate level based on the published results, issue certification and label, meanwhile file to competent departments and published on information platform.

Certificate validity is 3 years. Could apply for extension re-evaluation 6 months before expiration.

Article 16 Certificated enterprises could use it on green building material product packaging and publicity.

Chapter 4: Supervision and Inspection

Article 17 Certificated enterprises should establish certificate usage management system, regulate on certification and label usage, ensure the products in compliance with certificate.

Article 18 Certificate cannot be transferred, forged or fake.

Article 19 Objection to evaluation process or results can be appealed to competent departments, competent departments should investigate and handle in time.

Article 20 Having one of the following major problems, evaluation institution revokes or competent departments order the institution to revoke the granted certificate, and publish to society via information distribution platform:

- (1) Severe events impacting environment or major quality accidents;
- (2) Certificate products are spot checked as unqualified by national or provincial/municipal quality inspection or industry and commerce circulation;

- (3) Certificate products not in line with sample products provided by enterprise;
- (4) Beyond certificate usage scope;
- (5) Obtain certificate with improper means of deceit;
- (6) Other situation should be revoked by law

The revoked certificate enterprises shall not re-apply within 2 years since revocation.

Chapter 5: Supplementary Provisions

Article 21 Evaluation technology requirements of each category of building material product, evaluation institution management, etc. supportive documents are issued by The Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology.

Article 22 This Law is implemented since publish date.

4.2 Action Plan of Promoting Green Building Material Production and Implementation

Ministry of Industry and Information Technology (MIIT) and The Ministry of Housing and Urban-Rural Development (MOHURD) issued *The Action Plan of Promoting Green Building Material Production and Implementation* on 31th August 2015, in order to promote green building material production and implementation, promote building material industry to stable development, adjust structure, reform process and benefit people's livelihood, to better service new urbanization and green building development.

Action goal: by the time 2018 the proportion of green building material should be significantly increased, development quality is evidently improved. The proportion of green building material increases to 20% of industry main business income, with good quality condition and meet green building requirements. Compared to 2015, building industry energy consumption per added-value decreases by 8%, oxynitride and dust emission decreases by 8%; green building material application stably increases. Green building material application in new constructions reaches 30%, 50% in green buildings, 70% in experimental demonstration projects, and 80% in current building reconstruction. To achieve the above goals implement the following actions:

4.2.1 Action of Green Building Material Industry

(1) Thoroughly implement cleaner production. Support the current enterprises to implement technology reform and improve green manufacturing level. Promote the application of common technologies such as building material kiln gas desulfurization, denitration and dedusting, coal purification gasification and building material intelligent manufacturing, resource comprehensive utilization, etc. Preferentially support cleaner production technology reform in building and sanitation ceramics industry. Plate glass industry limits on high sulfur petroleum coke fuel. Guide northern heating region cement enterprises to peak-shifting production during winter heating period, saves energy and reduces emission, reduces smog. Promote new fireproofing material. Fully implement non-chrome fireproofing material, reduce heavy metal

pollution from the source. Develop and promote new fireproofing material and cellular structure efficient heat insulation material that are integrated of structure and function, long lifetime and convenient construction

(2) Enhance comprehensive utilization and develop circular economy. Support the usage of city surrounding existing cement kiln to co-process household garbage, sludge and hazardous wastes. Support the usage of Tailings and industry solid wastes, produce new wall materials and mechanism gravel, etc. Emphasize on construction waste treatment and recycling, enhance building material regeneration technology and development, improve solid waste absorption and product quality.

(3) Promote integrating IT application with industrialization, develop intelligent manufacturing. Guide building material production enterprises to improve informatization and automation level, focusing on promoting intelligent manufacturing and enhance level in cement and building and sanitation ceramic industries. Strengthen e-commerce application, use QR-code and cloud computing to establish a traceable information system for green building material, enhance green building material logistics informationization and supply chain coordinating level. Develop and promote industry robots, implement “robot substitute people” trial in building ceramics, glass and glass fiber industries.

4.2.2 Action of Certification of Green Building Material Evaluation

(4) Carry out green building material evaluation. According to *Green Building Material Certificate Management Measures*, set up green building material evaluation certificate system. Timely introduce detailed implementing rules and evaluation technology requirements for each building material product category. Implement green building material star evaluation, publish green building material product catalogue. Guide building industry and consumers to select material, promote the establishment of national integrated, open and ordered green building material market.

(5) Establish green building material information system. Set up green building material database and information collecting/sharing system. Use “Internet +” information technology to establish green building material public service system, publish information on green building material evaluation certificate and experimental demonstration projects, popularize green building knowledge. Establish green building material selection scheme, open up constructional engineering green building material selection path, and realize the traceability of product quality. Research to establish green building material third party information distribution platform.

(6) Expand the application range of green building material. Centered on green building requirements and building material industry development direction, focus on implementing universal building material, energy saving, land saving, water saving, material saving and green evaluation on material and products of building indoor/outdoor environmental protection. In promoting green building development and implementing green building evaluation work, enhance the relevant requirements on green building material application. In the trial demonstration projects and promotion projects of Ministry of Industry and Information Technology and The

Ministry of Housing and Urban-Rural Development, further clear on the regulation of using green building material.

4.2.3 Action of Performance Promotion of Cement and Relevant Product

(7) Develop high quality and specialized cement. Establish and revise cement product standard, improve product quality standard system, encourage production and usage of high-grade cement, clinker cement. Prioritize in developing and regulating the usage of specialized cement for maritime work, nuclear power, and road projects. Support expanding industry chain, complete concrete additive standard, accelerate industrialization, standardization and greenization of mechanism gravel.

(8) Promote the application of high performance concrete. Encourage the usage of pre-mixing concrete above C35 strength level, promote high content admixture and recycled aggregate application technology, improve high performance concrete application technology level. Research and develop high performance concrete durability design and evaluation technology, extend project service life.

(9) Rapidly develop prefabricated concrete building and modular component. Actively promote mature prefabricated concrete structure system. Optimize and improve current prefabricated concrete structure system such as precast concrete frame, shear wall, and frame-shear wall structure. Improve the general structure for concrete prefabricated modular component, promote industrialized production of composite floor slabs, inside/outside wallboard, stairs and balcony and kitchen/bath decoration, etc. Guide the modular component industry to serialized development, scale production and matching supply.

4.2.4 Action of Popularization of Steel Structure and Wooden Structure Building

(10) Develop steel structure building and metal building material. In public buildings such as culture and sports, education and healthcare, transportation and commercial storage, etc. actively adopt steel structure, develop steel structure residence. Industrial buildings and Infrastructure massively use steel structure. Fully use steel structure in long-span industrial buildings. Promote light-steel structure rural housing. Encourage production and usage of light aluminium alloy module and colored Aluminum plate

(11) Develop wooden structure building. Promote the usage of wooden structure buildings in cities and towns, promote usage in government invested new public low-rise buildings such as school, kindergarten, nursing home and landscape architecture, etc. and city flat slope changes. Promote delta wood-steel, wood-concrete mixing structure buildings, mainly promote wooden structure buildings in regions characterized by wooden structure buildings and tourist resort. Promote wooden structure rural housing construction in self-built housing and new rural residential area in economically developed regions.

(12) Develop biomass building material. Promote wood processing and protect industry development, support using crops straw, bamboo fiber and wood chips to develop biomass building material. Prioritize in developing and using biomass fiber strengthened WPC, new Magnesium building material, etc. as envelope and

decoration products. Encourage to develop bamboo building material and bamboo structure buildings in areas with abundant bamboo resource.

4.2.5 Action of Popularization of Plate Glass and Energy-saving Doors and Windows

(13) Promote energy saving doors and windows. Implement building efficiency enhancement projects, build high star green building, and develop super low energy consumption, near zero energy consumption buildings. Newly built public buildings, green buildings and existing building energy saving reform should adopt low-emissivity coated glass, vacuum (Insulating) glass, bridge-cutoff aluminum alloy, etc. energy saving doors and windows, drive the production line update and reform of plate glass and aluminum profile.

(14) Strictly use safety glass. Enhance safety glass production and usage monitor and inspection, timely adjust *Regulations on Building Safety Glass Management*, truly regulate building safety glass production, circulate, design, usage and installation management, prevent shoddy, eliminate potential safety hazard in glass doors/windows and curtain wall.

(15) Develop new and deep processing glass products, encourage the integration of Solar Thermal, Photovoltaic and building fabrication, drive Photovoltaic-thermal glass industry development. Support the development of new products such as electronic information used screen glass placode, fireproofing glass, car and high-speed rail used windscreen glass, etc. Improve deep processing level and product added value.

4.2.6 Action of Innovation of Material of Building Wall and Insulation

(16) New wall material innovation. Prioritize in developing safe, energy saving, environmental production, lightweight and high strength walls and roofing material, guide the usage of renewable resources to build new wall materials. Promote premixed mortar, develop and promote wall materials for steel structure Prefabricated buildings.

(17) Develop high efficiency energy saving thermal insulation material. Encourage the development of outside wall thermal insulation materials that are heat preservation, thermal insulation, good fireproof performance, convenient construction and long service life. Develop and promote structure and heat preservation decoration integrated outside wall panel.

4.2.7 Action of Upgrade of Ceramic and Chemical Building Material Consumption

(18) Promote ceramics splits and water saving sanitary fittings. Promote the usage of large, thin-type ultrasonic ceramics tile, water saving and light toilet (urinal). Develop intelligent sanitary ware such as new Faucet and toilet lid, etc. Promote sanitary ceramics humanized and intellectualized production, to better satisfy personalized consumption. Develop city road construction materials such as water permeable brick, support sponge city construction.

(19) Improve tubular product and sectional material quality. Promote usage of new tubular product and sectional material that are corrosion resistant, leak-proof, thermal insulation and energy saving. Increase service life and durability. Support the production and promotion of High Polymer Material has Large diameter, corrosion resistance, long service life, little leakage and maintenance free, or composite tubular product and pipe fitting. Support underground pipeline construction.

(20) Promote environmental friendly coating material, water proof and sealed material. Support the development of low volatile organic compounds (VOC) water-borne building coatings, building adhesive, promote using High Polymer Material, sealing material and heat-mirror films that are corrosion resistance, aging resistance, long service life, convenient construction.

4.2.8 Action of Popularization of Green Building Material in Rural Area

(21) Support green rural housing construction. Combining with new rural construction and green rural housing construction needs, implement *Notice on Implementing Green Rural Housing Construction*, guide to adjust measures according to local conditions and apply green building material, formulate green rural housing material catalogue, primarily promote using energy saving doors/windows, light insulation block, prefabricated components/parts green building material, reinforce green rural housing disaster prevention and reduction ability.

(22) Support modern infrastructure agricultural development. Surround modern infrastructure agriculture, actively develop and promote safe, cost-effective and convenient to use glass and rock wool.

4.2.9 Action of Establishment of Pilot Programs

(23) Project application demonstration. Formulate green building material pilot demonstration declaration, evaluation and acceptance measures. Combining green building, affordable housing construction, green ecology cities, current building energy saving reform, green rural housing and building industry modernization, etc., clarify green building material application relevant requirements. Select typical cities and construction projects, deploy building applied green material pilot demonstration of steel structure, wooden structure, fabricated concrete structure, etc.

(24) Industrial park demonstration. In areas with good green building material development foundation, reply on advantage enterprises, integrate factor resources, improve research design, inspection and testify, modern logistics, e-commerce, etc. public service system, support the building of industry parks characterized by green building material.

(25) Co-processing demonstration. According to *Opinions on Promoting Production Process Co-processing Resource Treatment of Municipal and Industrial Wastes*, continuously deploy pilot demonstration of cement kiln co-processing municipal household garbage and wastes. Deploy demonstration on solid wastes regenerated building materials utilization, establish long-term monitor scheme for regeneration material projects, and accumulate technological information of regeneration material application safety.

4.2.10 Action of Enhancement of Organization and Implementation

(26) Reinforce organization leadership. Establish a green building material production and application coordination mechanism lead by The Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology, participated with relevant departments. Enhance the internal connection between green building material production application and green building development, green city construction. Coordinate green building material production, usage, standard and evaluation, reinforce policy connection, enhance department linkage, organize relevant actions implementation, monitor implementing major tasks, coordinate and complement promotion measures.

(27) Formulate matching policies. Use the current channels to guide social capital, enlarge investment in Generic key technology, and encourage the enterprises to deploy green building material production and application technology innovation. Formulate finance and tax, price related policies, encourage cement kiln to co-process, energy saving glass doors/windows, water saving sanitary fittings, ceramics thin tiles, new wall materials, etc. green building production and consumption. Support the areas with suitable conditions to set up green building material development special fund, give loan with discounted interest to enterprises using or producing green building material. Include green building material certificate information into information selection system of government procurement, bidding, financing and credit granting sections. Formulate building material going to countryside special fiscal subsidy and preferential added-value tax to steel structure component production enterprises.

(28) Improve standard regulation. Further adjust and improve industry standard and entry criteria, publish enterprises and production lines comply with regulations. Reinforce environmental protection, energy consumption, and quality and safety constraint standards, establish a standard system with compulsory standards combining voluntary standards. Enhance the linkage between construction projects design regulation and green building material product standards. Eliminate composite cement 32.5 level standard, primarily promote special cement application.

(29) Set up innovation platform. Depend on large enterprise group, Research institutes and universities and colleges, etc., set up and improve production and research combined industry development innovation system. Establish technology center, engineering center or Key Laboratory features by green building material, improve industry development required public research, technology transform, inspection and certificate platform. Enhance building material production and building design, engineering construction, etc. upper and downstream enterprises interaction. Set up green building industry development alliance. Depend on tailings, building wastes, etc. resources to build new wall material and mechanism gravel production base.

(30) Deploy publicity education and inspection. Extend training intensity, deploy green building material production and application training. Carry out various green building material publicity activities, enhance public green production and consumption concept, enhance understanding and participation to green building material policies,

so that the production and application of green building material become a voluntary action for the whole industry and all society parties. Carry out green building material action inspection, for those who do not implement green building material production or relevant regulations, reinforce supervision by public opinion and public criticism.

4.3 Implementation Guidelines of Green Building Material Certificates and Technical Guidelines of evaluation of Green Building Material

To implement requirements of *Green Building Action Plans* and *Action Plan for Promoting Green Building Material Production and Application*, promote green building and building material industry transform and upgrade, promote new urbanization, properly implement *Green Building Material Certificate Management Measures*, on 14th October, MIIT and MOHURD jointly issued *Implementation Guidelines of Green Building Material Certificates and Technical Guidelines of evaluation of Green Building Material (trial issue)(first edition)*. The implementation guideline has 7 chapters, in total 35 articles; technical guideline introduces evaluation technical requirements of 7 product categories: masonry materials, insulation material, premixing concrete, building energy saving glass, ceramic tile, sanitary ceramics, premixing mortar.

4.3.1 Implementation Guidelines of Green Building Material Certificates

Chapter One: General Provisions

Article 1 To properly implement *Green Building Material Certificate Management Measures*, put into practice the *Green Building Action Plan*, promote green building and building material industry reform upgrade, promote new urbanization, according to relevant requirements of *Energy Conservation Law of the People's Republic of China* and *Regulation on Energy Conservation in Civil Buildings*, formulate this guideline.

Article 2 This guideline regulates on green building evaluation certificate work (“work”) organization management, committee of experts, evaluation institution application and publish, certificate application, evaluation and usage, supervision management.

Article 3 Green building material evaluation certificate is about green building needs and building material industry development direction, including general building material, land saving and outdoor environment, energy saving and resource utilization, water saving and water resource utilization, material saving and material utilization, environmental protection and indoor environment, operation maintenance, etc. material and product.

Article 4 Green building material evaluation technology requirements and process are national united, certificate is national general, publish in national green building material certificate management information platform (“information platform”).

Article 5 Green building material evaluation institution, experts and relevant staff are life responsible for evaluation results and certificate.

Chapter 2: Organization Management

Article 6 Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology (“two Ministries”) set up “green building material evaluation certificate management office” (“two Ministries management office”). The two Ministries management office has the following function and responsibility:

- (1) Organize the formulation of green building material evaluation technical requirements;
- (2) Certificate formulation, unify coding and usage management;
- (3) Establish and maintain national green building material certificate management information platform;
- (4) 3-star evaluation institution: application acceptance, evaluation organization and supervision management; 1 and 2-star evaluation institution: filing;
- (5) Guide local green building material evaluation certificate work;
- (6) Accept green building material evaluation certificate Inquiry, complain, Report, check and treatment;
- (7) Undertake expert committee activities;
- (8) Other events mandated by two Ministries.

Article 7 Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology of province, autonomous region and Direct-controlled municipality (“provincial Ministries”), are responsible for local green building material evaluation certificate work. Responsibilities are:

- (1) Organize provincial green building evaluation certificate management office (“provincial management office”);
- (2) Recommend 3 star evaluation institution, approve 1 and 2 star evaluation institution, publish after filing to two Ministries management office;
- (3) Coordinate and supervise of local or outside local green building material evaluation certificate application;
- (4) Publish local green building material evaluation certificate on information platform;

Chapter 3: Expert Committee

Article 8 National green building evaluation certificate expert committee (“expert committee”) is set up by two Ministries. Expert committee has the following responsibilities:

- (1) Provide technical consulting and support;
- (2) Inspect 3 star green building material evaluation institution;
- (3) Inspect green building material evaluation technical requirement;
- (4) Other relevant work

Article 9 Expert committee is composed of experts from building and building material, with 1 chairman, 2-3 vice chairman. Committee members have 3 years of tenure, could serve consecutive terms. Committee members should meet the following conditions:

- (1) Have senior technical title or engage in this professional field for a long time, have abundant theoretical knowledge and practical experience, have certain academic influence in area of expertise;
- (2) Familiar with building or building material industry development status and domestic/foreign trends, know well about relevant policy, legislation, regulation and standard;
- (3) Published relevant monograph, scientific paper, hosted relevant national or industrial standard formulation or national science projects;
- (4) Have sound scientific morality, serious and rigorous working ethic, act with justice and take responsibilities;
- (5) Healthy, generally below 70.

Article 10 Expert committee members are hired in the following process:

- (1) Recommended by work institution or individual, willingness, fill in Green Building Material Evaluation Certificate Expert Committee Expert Registration Form, and provide relevant evidentiary material, file to two Ministries for inspection after work institution agrees;
- (2) Passing inspection will be granted with *Green Building Evaluation Certificate Expert Certification*

Article 11 Provincial departments can formulate provincial expert committee taking this reference.

Chapter 4: Evaluation Institution Application and Publish

Article 12 Evaluation institution should meet the following conditions:

- (1) Evaluation work needs professional staff, 1 and 2 star institution should have at least 10 staffs, 3 star institution at least 30. In which medium and above professional title staff accounts for at least 60%, senior professional title staff accounts for at least 30%;
- (2) Independent legal personality, have authority, influence and relevant work experience in the industry;
- (3) Evaluation institution staff should in compliance with national law and regulation, familiar with policy and standard regulation, and green building material evaluation technical requirement;
- (4) Office condition suitable for carrying out the evaluation work;
- (5) National level certificated or above provincial level Ministry of Housing and Urban-Rural Development and Ministry of Industry and Information Technology certificated;
- (6) Other required conditions

Article 13 Evaluation institution application should file *Green Building Material Evaluation Institution Application Form*

The application form should enclose relevant material copies, such as Legal person qualification certificate, relevant inspection, certificate qualification certification and attachments, letter of entrustment from above provincial level departments

Article 14 Local application for 3 star institution, after pre-audit by provincial management office and filed to two Ministries management office.

Central enterprises and national industry association applying for 3 star evaluation institution, file directly to 2 Ministries management office, meanwhile copy to provincial management office.

Article 15 Evaluation institution inspection adopts material inspection combining site inspection, mainly inspect:

- (1) Applicant unit qualification and competency
- (2) Personnel allocation and professional proficiency
- (3) Relevant evaluation, inspection certificate and work performance
- (4) Work and results in green building material

Article 16 Public those passed the inspection, publicity period is no less than 10 working days. Without objection, two Ministries inspect and publish by management office on the information distribution platform.

Article 17 Evaluation institution validity period is 5 years, 60days before expiry date could apply for extension.

Chapter 5: Certificate Application, Evaluation and Usage

Article 18 Certificate application is filed by building material production enterprise to corresponding evaluation institution. Based on evaluation technical requirements, the production enterprise could apply for corresponding star evaluation and certificate to evaluation institution of equivalent level.

The same product of the enterprise could not file the same star level application to multiple evaluation institution.

Article 19 Certificate applicant enterprise should fill in the *Green Building Material Evaluation Certificate Declaration*, provide relevant technical data and evidentiary material according to evaluation technical requirements, and be responsible for the authenticity.

Article 20 After evaluation institution receives enterprise application, must finish formal examination within 5 working days. Those who passes the formal examination, evaluation institution issues notice of acceptance to the applicant enterprise and sign technical service contract, discussing both parties' rights, duties and service costs, etc. Service costs are charged on commonweal and non-profit principle, including site check and inspection, validity check and quality guarantee, etc.

Those who fails the formal examination, should be informed at once about providing additional documents.

Article 21 Evaluation technical requires to set up control item, grading item and bonus item. Control item is mandatory requirements on product performance, environmental impact and Safety and health. Total score is the sum of grading item and bonus item, grading item has a total 100 points, bonus item 5 points.

Article 22 Certificate level is classified according to this table:

Level	★	★★	★★★
Score	60-69	70-84	

Article 23 Evaluation should be finished within 30 working days (excluding sampling retest time)

Enterprises that pass the inspection will be published in information platform for 10 days. Without objection, evaluation institution applies for certification and certificate serial number from two Ministries management office, issue the certification and publish on information platform; With objection, corresponding management office organizes the re-inspection.

Enterprises that fail the evaluation, if having objection to the evaluation results should be filed within 10 days to the corresponding management office.

Article 24 Enterprises that obtain green building material evaluation certificate, should add a note, print or mold the green building material label on its products or minimum sales package.

Article 25 Certificated enterprises should establish certificate usage management scheme, regulates certification and label usage, ensure that products are in line with certification. Record and archive certification/label usage.

Article 26 Certification validity is 3 years, within validity the enterprises should file usage report to evaluation institution before end of December of each year. 6 months before expiry date could apply for extension to evaluation institution, the extension re-inspection process is the same as new application.

Article 27 If the certificated enterprises encounter major business activities change, should timely report to evaluation institution. Having one of the following major changes, should re-apply for evaluation:

- (1) Enterprise production equipment, technology have major changes and significantly influence product performance;
- (2) Production sites change;
- (3) Product standard updates and influence product inspection result.

Chapter 6: Monitoring Management

Article 28 Evaluation institution files annual working report to corresponding management office. Report includes: evaluation overview, statistics on issued certificate, evaluation performance analysis, institution and personnel performance, existing difficulties, problems and suggestions, and other explained situation.

Article 29 Two Ministries management office, provincial management office should spot check and inspect corresponding evaluation institution, and reports the results to competent departments.

Article 30 Having one of the following situation, cancel the evaluation institution for its qualification:

- (1) Provide false document and information during evaluation process and lead to untruthful evaluation result;

- (2) Issue false evaluation report;
- (3) Unable to ensure evaluation quality;
- (4) Other situation that should be disqualified.

Article 31 Disqualified evaluation institution is not allowed to re-apply.

Article 32 Certificated enterprises have one of the following major problems, evaluation institution should revoke or ordered by competent department to revoke the issued certificate, and publish to the society via information platform:

- (1) Have vicious events impacting environment and major quality problems;
- (2) Certificated products fail in spot-check;
- (3) Use certification beyond usage range;
- (4) Obtain certification by improper means of deceive;
- (5) Other situation should be revoked by law.

Article 33 Revoked enterprises cannot re-apply within 2 years.

Article 34 Two Ministries management office and provincial management office staff plays favoritism, abuse of power, misconduct or interfere evaluation which lead to improper evaluation result, will be given disciplinary punishment according to regulation; when constitutes a crime shall be transferred to the department of justice and subject to criminal liabilities.

Article 35 Any enterprise or individual could file for appeal or report to two Ministries, provincial departments, two Ministries management office or provincial management office, if having any objection to evaluation results.

Chapter 7: Supplementary Provisions

Article 36 Two Ministries management office will separately issue expert registration form and certification, evaluation institution application form, certificate declaration, certificate style and format.

Article 37 Provincial departments could formulate local implementation guidelines based on *Green Building Material Certificate Management Measures* and this Guideline.

Article 38 This Guideline is implemented since issued date.

4.3.2 Technical Guidelines of evaluation of Green Building Material

Chapter 1: General Provisions

(1) This Guideline is formulated to scientifically guide and regulate the management of green building material evaluation certificate, accelerate green building material promoted application and promote green building development.

(2) The first edition of the Guideline formulates evaluation technical requirement on 7 building material product categories: masonry material, insulation material, premixed concrete, building energy saving glass, ceramics tile, sanitary ceramics, and premixed mortar. It is used for green building material evaluation of the 7 categories of product.

Further on will gradually expand the evaluation technical requirement to other categories of building material product, constantly adjust and improve.

(3) While green building material evaluation is in line with this Guideline requirements and local features, it should also in line with national laws, regulations and standards.

Chapter 2: Definition

(1) Green building- In its full service life saves resource (energy, land, water and material) to the largest extent, protect environment, reduce pollution, provide healthy, suitable and efficient usage space for people, harmonious coexistence with natural.

(2)Green building material- In its full service life could reduce natural resource consumption and ecological environment impact, has the features of “energy saving, emission reducing, safe, convenient and recyclable”.

(3)Heat insulating material- Building material and product used to improve building envelope heat insulation properties, including organic heat insulation and inorganic heat insulation building material.

(4)Masonry material- Solid (hollow) or square hexahedron bulk building material and product made by sintering or non-sintering production process, including all masonry material except compound masonry.

(5)Premixed concrete- Composed of cement, aggregate, water and needed additive and mineral admixtures according to a certain proportion, produced in mixing station (building), delivered to usage site by transportation device as mixture building material, including regular product and specialty product.

(6)Building energy-saving glass- Regular plate glass after deep processing, used in transparent building envelope, including heat-absorbing glass, heat reflecting glass, low emissivity glass, hollow glass and vacuum glass, etc.

(7)Ceramic tile- Solid or hollow plate building ceramics product made of clay and other non-organic metal material, using forming and high-temperature sintering production process. Including building ceramic tile, ceramic plate and porcelain plate, etc.

(8)Sanitary pottery- Ceramic product used in sanitary ware, made of clay and other inorganic materials with mixing, forming and high-temperature sintering process.

(9)Premixed mortar- Composed of cement, sand, water, coal ash and other mineral mixtures, together with water-retentive and plastic material, additive as needed, according to a certain proportion, measured and mixed at central mixing station (plant), delivered to usage site by mixing carrier, put into special storage vessel, and used up within regulated time, including regular mortar, special mortar and plater mortar, etc.

Chapter 3: Terms

(1)Waste water- During premixed concrete production process, recyclable turbid liquid composed of cement, coal ash, mineral powder, additive and sand, etc. generated from washing production equipment and transportation equipment.

(2)Effluent- All the unrecyclable water generated from production and life activities of premixed concrete enterprises.

- (3) Scrapped concrete- Collected from premixed concrete production, transportation and inspection process, residue concrete mixture and hardened specimen which cannot be used to reduce design level after direct modulation.
- (4) Light to solar gain ratio- Ratio of glass visible light transmittance to total solar energy transmittance
- (5) General color rendering index- The average of color rendering indexes of the 1-8th standard color samples according to International Commission on Illumination (CIE)
- (6) Low quality raw material- Contain high proportion of ancient colored element of iron, Titanium and manganese. And all industrial tailings, waste residue and waste material, etc. used as ceramics production raw material
- (7) Ash material- In phases of premixing mortar, collected from dusting and cleaning.
- (8) Environmental product declaration (EPD- Environmental declaration providing quantitative environment data based on default parameter.
- (9) Energy consumption per unit product- Energy consumption from producing unit of product in the calculation period, converts standard coal.
- (10) Carbon emission per unit product- The greenhouse gases discharged of producing unit of product, converts to carbon dioxide.
- (11) Carbon footprint- Used to quantify greenhouse gas emission coefficient during process, process system or product system, to show their contribution to climate change.

Chapter 4: General Regulation

(1) Evaluation index system contains control item, grading item and bonus item. Participated products and enterprises must fully satisfy control item requirements. Grading item has total 100 points, bonus item 5 points. Total score is calculated as:

$$Q_{\text{总}} = Q_{\text{评}} + Q_{\text{加}}$$

$$Q_{\text{评}} = \sum_i w_i Q_i$$

In which:

$Q_{\text{总}}$ —total score;

$Q_{\text{评}}$ —grading item score;

$Q_{\text{加}}$ —bonus item score;

w_i ograding item all indexes weights;

Q_i rGrading item all indexes scores

(2) Control item mainly includes requirements on air pollutants, sewage, noise emission, workplace environment, safety production and management system. Grading item evaluates building material product lifecycle from 5 aspect: energy saving, emission reducing, safety, convenience and recyclability. Bonus item mainly considers building material production technology and advancement of equipment, environmental impact level, technical innovation and performance, etc.

(3) Grading item index energy saving is requirements on unit product energy consumption, raw material transportation energy consumption, management system; emission reducing is requirements on production plant pollutants emission, product certificate or EPD, carbon footprint, etc.; safety is indexes influencing safety

production standardization and product performance; convenience is requirements on construction performance, applicability and economical efficiency of applicant area; recyclability is indexes of waste recycling and utilization performance during production and usage process.

(4) Control item has yes/no as evaluation result; grading item has yes/no score obtained as result.

(5) Green building material level is decided by evaluation total score, from low to high three levels ★,★★ and ★★★. Level classification is shown in Table 60:

Table 60: Classification of Green Building Material

Level	★	★★	★★★
Score	60-69	70-84	85 and above

Chapter 5: Masonry Material

(1) Control item

Production enterprises should fulfill Table 61 requirements, and cannot use plough clay as main raw material.

Table 61: Basic Requirement of Production

Project Requirement	Article
Air pollutant emission	<i>Air Pollutant Comprehensive Emission Standards</i> GB 16297, level 3; or achieve local emission lowest standard
Sewage emission	<i>Sewage Comprehensive Emission Standards</i> GB 8978
Noise emission	<i>Boundary Noise Emission Standard for Industrial Enterprises</i> GB 12348
Workplace environment	<i>Occupational Contact Limit Value of Chemical Harmful Factors in Workplace</i> GBZ 2.1 <i>Occupational Contact Limit Value of Physical Harmful Factors in Workplace</i> GBZ 2.2
Safety production	<i>Enterprise Safety Production Standardized Regulation</i> AQ/T 9006, level 3
Management system	Complete quality, environment and occupational health&safety management system
Note: air pollutant, sewage and noise emission should in compliance with environmental impact evaluation acceptance and approval requirement	

Have detailed and feasible applicant technical document

Basic performance should meet current national and industrial standard requirements

Radioactivity should meet *Building Material Radionuclide Limit Value* GB 6566 requirements

(2) Grading Item

Grading item all index weights is shown in Table 62.

Table 62: Grading index weights

Index	Weight	Article	Weight
Energy saving	0.23	1) Energy consumption or carbon emission per unit product production	0.10
		2) Raw material transportation energy consumption	0.05
		3) Fresh water consumption per unit product	0.05
		4) Energy management system certificate	0.03
Emission reducing	0.10	5) Plant air pollutant and sewage emission	0.05
		6) Product certificate or evaluation, EPD, carbon footprint report	0.05
Safety	0.32	7) Safety production standardization level	0.02
		8) Coefficient of drying shrinkage and absorptivity	0.10
		9) Frost Resistance	0.10
		10) Compressive strength, block density	0.10
Convenience	0.20	11) Easily construction	0.05
		12) Size accuracy	0.05
		13) Applicability and economical efficiency	0.10
Recyclability	0.15	14) Recycle and reuse	0.05
		15) Wastes utilization	0.10

I Energy saving

1) Unit product energy consumption is rated according to Table 63

Table 63: Rating Rules of Energy Consumption per Product

Category	Rating rules	
	60 points	100 points
Aerated concrete	$18 \text{ kgce/m}^3 < E < 820 \text{ kgce/m}^3$	$E < 820 \text{ kgce/m}^3$
Sand lime brick	$17 \text{ kgce/m}^3 < E < 718.4 \text{ kgce/m}^3$	$E < 718.4 \text{ kgce/m}^3$
Sintering products	Comply with GB 30526 acceptance value requirement	Comply with GB 30526 advanced value requirement
Cement product	Consistently improve or file carbon emission report for three consecutive years, graded by experts	

2) Raw material transportation energy consumption score is the sum of the following two items, with total score no more than 100.

Raw material has accumulated transportation radius no more than 200km, weight ration no less than 60% but under 70%, gives 40 points; no less than 70% but under 80%, 60 points; no less than 80% but under 90%, 80 points; no less than 90%, 100 points;

Raw material using railway/ship transportation over 200km, weight proportion no less than 70% but under 80%, 20 points; no less than 80% but under 90%, 40 points; no less than 90%, 60 points.

3) Unit product fresh water consumption rating rule:

- <400kg /m³, >350kg /m³, 20 points;
- <350kg /m³, >300kg /m³, 40 points;
- <300kg /m³, >200kg /m³, 60 points;
- <200kg /m³, >100kg /m³, 80 points;
- <100kg /m³, 100 points

4) Pass GB/T 23331 energy management system certificate, 100 points.

II Emission Reduction

5) Plant air pollutant and sewage mission score is the sum of the following two items:
 Comply with *Air Pollutant Comprehensive Emission Standards* GB 16297 Table 2 regulated level two or local emission standard highest requirement, 50 points;
 Comply with *Sewage Comprehensive Emission Standard* GB 8978 regulated level one, 50 points.

6) Pass product certificate or evaluation, submit EPD and carbon footprint report.
 Total score is the sum of the following items:

- Pass product certificate or evaluation, total 40 points, rated by experts
- Submit EPD report, total 30 points, rated by experts
- Submit product carbon footprint report, total 30 points, rated by experts.

III Safety

7) Safety production standardization level complies with *Enterprise Safety Production Standardized Regulation* AQ/T 9006 regulated level 2, 80 points; complies with level 1, 100 points.

8) Drying shrinkage index of nonsintered masonry material and water absorption index of sintered masonry material are rated as Table 64:

Table 64: Rating Table of Drying Shrinkage Index of Non-Sintered Type Masonry Materials and Water Absorption Rate of Sintering Class Masonry Materials

Drying shrinkage index of nonsintered masonry material	Water absorption index of sintered masonry material	Points
<0.70mm/m and >0.60mm/m	<25% and >20%	60 points
<0.60mm/m and >0.40mm/m	<20% and >15%	80points
<0.40mm/m	<15%	100points

9) Freezing resistance index (based on product standard for freezing and thawing test) grading rules:

Table 65: Rating Table of Frost Resistance Index Requirement

Project	Requirement	Points	
		Sintered	Non sintered
Compressive strength loss	<15% and >10%	30 points	—
	<10% and >5%	40 points	—

ratio	<5%	50 points	—
Qualification loss rate	<4.5% and >3%	30 points	60 points
	<3% and >2%	40 points	80 points
	<2%	50 points	100 points
Note: sintered products freezing resistance is determined by appearance as regulated in the standard, give 100 points for meeting requirement.			

10) Compressive strength and nonbearing product bulk density is rated according to Table 66.

Table 66: Rating Table of Compressive Strength and Bulk Density

Project	Requirement	Points	
		Bearing	Nonbearing
Ratio of actual measured strength and design strength	>1.0 and <1.05	40 points	20 points
	>1.05 and <1.10	60 points	30 points
	>1.10 and <1.15	80 points	40 points
	>1.15	100 points	50 points
Ratio of design density and actual measured density	>1.0 and <1.05	—	20 points
	>1.05 and <1.10	—	30 points
	>1.10 and <1.15	—	40 points
	>1.15	—	50 points

IV Convenience

11) Construction evaluation is the sum of the following two items:

Standardized design, meet building module requirement, total points 50, rated by experts;

Customize and prefabricate based on building required size, reduce site cutting, total points 50, rated by experts.

12) Size deviation lower than corresponding product standard required allowable deviation more than 25%, 100 points.

13) Applicability and economical efficiency is the sum of the following two:

Matching the applied region economic development level, environment, industry association, total 50 points, rated by experts;

Matching the applied region laws and regulation, standard regulation, total 50 points, rated by experts.

V Recyclability

14) Recycling and reuse rating rules are:

Recyclable, but need complex demolition, recycle and processing, 30 points;

Recyclable, only need simple demolition, recycle and processing, 60 points;

Recyclable after disassembly, simple and convenient, do not need second processing, 100 points.

15) Wastes utilization rating rules are:

>30% and <40%, 40 points;

- >40% and <50%, 60 points;
- >50% and <60%, 80 points;
- >60% and <80%, 90 points;
- >80%, 100 points

Chapter 6: Insulation Material

(1) Control item

Production enterprises should meet requirements in Table 67

Table 67: Basic Requirement of Production

Project	Requirement
Air pollutant emission	<i>Air Pollutant Comprehensive Emission Standards</i> GB 16297, level 3 or meet local emission lowest standard requirement
Sewage emission	<i>Sewage Comprehensive Emission Standard</i> GB 8978
Noise emission	<i>Boundary Noise Emission Standard for Industrial Enterprises</i> GB 12348
Workplace environment	<i>Occupational Contact Limit Value of Chemical Harmful Factors in Workplace</i> GBZ 2.1 <i>Occupational Contact Limit Value of Physical Harmful Factors in Workplace</i> GBZ 2.2
Safety production	<i>Enterprise Safety Production Standardized Regulation</i> AQ/T 9006, level 3
Management system	Complete quality, environment, occupational health and safety management system
Note: air pollutant, sewage and noise emission should meet environmental impact evaluation acceptance and approval requirements	

Production enterprises should have detailed and feasible application technical document.

Basic performance should meet current national and industrial standard requirements.

Combustion performance should not be lower than national standard *Building Material Consigned Goods Combustion Performance Level* GB8624 required level B₂

Durable, safe and easily repaired using function

(2) Grading item

Scoring item index weights is shown in Table 68

Table 68: Value of Indexes

Index	Weights	Article	Weight
Energy saving	0.34	1) Unit product production energy consumption or carbon emission	0.10
		2) Raw material transportation energy consumption	0.05

		3) Heat conductivity coefficient	0.16
		4) Energy management system certificate	0.03
Emission reduction	0.15	5) Plant air pollutant and sewage emission	0.05
		6) Do not use Chlorofluorocarbons foaming agent and hexabromocyclododecane fire retardant	0.05
		7) Product certificate or evaluation, EPD, carbon footprint report	0.05
Safety	0.23	8) Safety production standardized level	0.02
		9) Combustion performance	0.15
		10) Structure linkage safety	0.06
Convenience	0.20	11) Application property	0.05
		12) Construction process environmental impact	0.05
		13) Applicability and economical efficiency	0.10
Recyclability	0.08	14) Recycle and reuse	0.03
		15) Nonorganic insulation material solid wastes utilization	0.05
Note: weight of organic insulation material 15) is added to 14)			

I Energy saving

1) Unit product production energy consumption rating rules are:

Rock wool and mineral cotton unit product energy consumption meets *Rockwool and Mineral Cotton and Their Products Unit Product Energy Consumption Limit Value* GB 30183 acceptance value, give 80 points; meets advanced value, give 100 points.

Other insulation material production enterprises consistently improve unit product consumption level or provide unit product carbon emission report for three consecutive years, total 100 points, rated by experts.

2) Raw material transportation consumption score is the sum of the following two, total score is no more than 100 points:

Raw material with accumulated transportation radius less than 500km, weight ratio no less than 60% but under 70%, give 40 points; no less than 70% but under 80%, 60 points; no less than 80% but under 90%, 80 points; no less than 90%, 100 points;

Raw material over 500km uses railway and shipping transportation weight ratio no less than 79% but under 80%, give 20 points; no less than 80% but under 90%, 40 points; no less than 90%, 60 points.

2) Thermal conductivity coefficient is rated based on Table 69:

Table 69: Rating Table of Thermal Conductivity

Thermal conductivity λ , W/(m·K)	Points
$0.060 < \lambda \leq 0.065$	10 points
$0.055 < \lambda \leq 0.060$	20 points
$0.050 < \lambda \leq 0.055$	30 points
$0.045 < \lambda \leq 0.050$	40 points
$0.040 < \lambda \leq 0.045$	50 points

$0.035 < \lambda \leq 0.040$	60 points
$0.030 < \lambda \leq 0.035$	70 points
$0.025 < \lambda \leq 0.030$	80 points
$0.020 < \lambda \leq 0.025$	90 points
$\lambda \leq 0.020$	100 points

4) Pass GB/T 23331 energy management system certificate, give 100 points.

II Emission reduction

5) Plant air pollutant and sewage emission score is the sum of the following two:

Meet *Air Pollutant Comprehensive Emission Standards* GB 16297 Table 2 regulated level two or local emission standard highest requirement, give 50 points.

Meet *Sewage Comprehensive Emission Standard* GB 8978 regulated level 1, give 50 points.

6) Do not use Chlorofluorocarbons foaming agent, give 50 points; do not use hexabromocyclododecane fire retardant, give 50 points.

7) Pass product certificate or evaluation, submit EPD and carbon footprint report. Score is the sum of the following items:

Pass product certificate or evaluation, total 40 points, rated by experts

Submit EPD report, total 30 points, rated by experts

Submit product carbon footprint report, total 30 points, rated by experts.

III Safety

8) Safety production standardized level meets *Enterprise Safety Production Standardized Regulation* AQ/T 9006 regulated level 2, give 80 points; meet level 1, give 100 points.

9) Combustion performance is rated based on the highest fireproofing level achieved:

Meet level B₁ requirement, give 60 points;

Meet level A requirement, give 100 points

10) Ensure self-strength and structure linkage safety, give 100 points.

IV Convenience

11) Construction score is the sum of the following items:

Insulation material size stability no more than 1% but more than 0.5%, give 20 points; no more than 0.5%, 30 points;

Insulation material modularization design or product size matching equipment, reduce site cutting, total 40 points, rated by experts;

Prefabricated assembly construction or insulation decoration integration construction, total 30 points, rated by experts.

12) Environmental impact rating during construction process is the sum of the following two:

No dust or light dust pollution during construction, total 50 points, rated by experts;

No organic solvent pollution during construction process, total 50 points, rated by experts.

13) Applicability and economical efficiency rating is the sum of the following two:

Matching the applied region economic development level, environment, industry association, total 50 points, rated by experts;

Matching the applied region laws and regulation, standard regulation, total 50 points, rated by experts.

V Recyclability

14) Recycling and reuse rating rules are:

Recyclable, but need complex demolition, recycle and processing, 30 points;

Recyclable, only need simple demolition, recycle and processing, 60 points;

Recyclable after disassembly, simple and convenient, do not need second processing, 100 points.

15) Ratio of solid waste weight in product raw material reach 5%, give 30 points; reach 10%, 50 points; reach 15%, 70 points; reach 25%, 100 points.

Chapter 7 Premixed concrete

(1) Control item

Production enterprises should meet requirements in Table 70.

Table 70: Basic Requirement of Production

Project	Requirement
Air pollutant emission	<i>Air Pollutant Comprehensive Emission Standards</i> GB 16297, level 3 or meet local emission lowest standard requirement
Sewage emission	<i>Sewage Comprehensive Emission Standard</i> GB 8978
Noise emission	<i>Boundary Noise Emission Standard for Industrial Enterprises</i> GB 12348
Workplace environment	<i>Occupational Contact Limit Value of Chemical Harmful Factors in Workplace</i> GBZ 2.1 <i>Occupational Contact Limit Value of Physical Harmful Factors in Workplace</i> GBZ 2.2
Safety production	<i>Enterprise Safety Production Standardized Regulation</i> AQ/T 9006, level 3
Management system	Complete quality, environment, occupational health and safety management system
Note: Air pollutant, sewage and noise emission should meet environmental impact evaluation acceptance and approval requirements	

1) Enterprise production and management should meet *Premixed Concrete Green Production and Management Technical Regulation* JGJ/T 328 requirements or local premixed green production management regulation.

2) Production enterprises should have detailed and feasible application technical documents.

3) Basic performance should meet current national standard *Premixed Concrete* GB/T 14902 requirements.

2) Grading item

Grading item index weight is shown in Table 71.

Table 71: Value of Indexes

Index	Weight	Article	Weight
Energy saving	0.26	1) Raw material transportation	0.05
		2) Unit product energy consumption or carbon emission	0.06
		3) Strength level	0.10
		4) Energy and measurement management system certificate	0.05
Emission reduction	0.13	5) Plant air pollutant and sewage emission	0.05
		6) Product certificate or evaluation, EPD, carbon footprint report	0.08
Safety	0.27	7) Standard deviation	0.10
		8) Impervious level, chloride resistance impervious level, carbonization resistance level, frost resistant level	0.15
		9) Safety production standardization level	0.02
Convenience	0.10	10) Construction performance, self compact concrete	0.05
		11) Applicability and economical efficiency	0.05
Recyclability	0.08	12) Waste concrete generation rate	0.06
		13) Waste concrete recycling rate	0.06
		14) Solid wastes comprehensive utilization rate	0.06
		15) Industrial waste water recycling rate	0.06

I Energy saving

1) Raw material transportation consumption rating is the sum of the following two items, but total score is no more than 100 points:

Raw material with accumulated transportation radius less than 200km, weight ratio no less than 60% but under 70%, give 40 points; no less than 70% but under 80%, 60 points; no less than 80% but under 90%, 80 points; no less than 90%, 100 points.

Raw material over 200km uses railway and shipping transportation weight ratio no less than 70% but under 80%, give 20 points; no less than 80% but under 90%, 40 points; no less than 90%, 60 points.

2) Unit product consumption level or carbon emission consistently improves for 3 consecutive years, total 100 points, rated by experts.

3) Strength level is in line with design strength level, give 100 points.

4) Management system rating is the sum of the following two:

Pass GB/T 23331 energy management system certificate, give 60 points;

Pass GB/T 19022 measurement management system certificate, give 40 points.

II Emission reduction

- 5) Plant air pollutant and sewage emission score is the sum of the following two:
Meet *Air Pollutant Comprehensive Emission Standards* GB 16297 Table 2 regulated level two or local emission standard highest requirement, give 50 points.
Meet *Sewage Comprehensive Emission Standard* GB 8978 regulated level 1, give 50 points.
- 6) Pass product certificate or evaluation, submit EPD and carbon footprint report. Score is the sum of the following items:
- Pass product certificate or evaluation, total 40 points, rated by experts
 - Submit EPD report, total 30 points, rated by experts
 - Submit product carbon footprint report, total 30 points, rated by experts.

III Safety

- 7) For the same mix proportion, 10 consecutive batch of product compressive strength (MPa) standard deviation rating rules are:
Larger than level strength standard deviation upper limit σ for 1.0 time and less than or equal to 1.2 times, give 60 points.
Larger than level strength standard deviation upper limit σ for 0.8 time and less than or equal to 1.0 time, give 80 points.
Less than or equal to level strength standard deviation upper limit σ_{max} for 0.8 time give 100 points.
- 8) Durability rating rules are:
Impermeability level is higher than *Concrete Durability Inspection Evaluation Standard* JGJ/T 193 regulated level P8, give 30 points; level P10, 40 points; level P12, 50 points;
Chloride penetration resistance level meets *Concrete Durability Inspection Evaluation Standard* JGJ/T 193 regulated level II, give 10 points; meets level III, give 20 points; meets level IV and above, give 30 points;
Carbonization resistance level meets *Concrete Durability Inspection Evaluation Standard* JGJ/T 193 regulated level III, give 5 points; meets level IV and above, give 10 points;
Frost resistance level higher than F300, give 5 points; higher than F400, give 10 points.
- 9) Safety production standardization level meets *Enterprise Safety Production Standardized Regulation* AQ/T 9006 regulated level 2, give 80 points; meets level 1, give 100 points.

IV Convenience

- 10) Premixed concrete reaches self-compact concrete performance, give 100 points.
- 11) Premixed concrete applicability and economical efficiency rates are the sum of the following two:
Matching the applied region economic development level, environment, industry association, total 50 points, rated by experts;

Matching the applied region laws and regulation, standard regulation, total 50 points, rated by experts.

V Recyclability

12) Waste concrete generation rate rating rules:

>1.0% and <1.5%, give 60 points

>0.5% and <1.0%, give 80 points

<0.5%, give 100 points.

13) Waste concrete recycling rate rating rules:

>50% and <70%, give 60 points;

>70% and <90%, give 80 points;

>90%, give 100 points.

14) Solid wastes comprehensive utilization rate rating rules:

>30% and <50%, give 60 points;

>50% and <70%, give 80 points;

>70%, give 100 points.

15) Waste water recycling rate reaches 100%, give 100 points.

Chapter 8: Building Energy Saving Glass

(1) Control item

Production enterprises should meet the requirements of Table 72.

Table 72: Basic Requirement of Production

Project		Requirement
Air pollutant emission	plate glass	<i>Plate Glass Industry Air Pollutant Emission Standard</i> GB 26453
	others	<i>Air Pollutant Comprehensive Emission Standards</i> GB 16297, level 3 or meet local mission standard lowest requirement
Sewage emission		<i>Sewage comprehensive emission standard</i> GB 8978
Noise emission		<i>Boundary Noise Emission Standard for Industrial Enterprises</i> GB 12348
Workplace environment		<i>Occupational Contact Limit Value of Chemical Harmful Factors in Workplace</i> GBZ 2.1 <i>Occupational Contact Limit Value of Physical Harmful Factors in Workplace</i> GBZ 2.2
Safety production		<i>Enterprise Safety Production Standardized Regulation</i> AQ/T 9006, level 3
Management system		Complete quality, environment, occupational health and safety management system
Note: air pollutant, sewage and noise emission should meet environmental impact evaluation acceptance and approval requirements		

Production enterprises should have detailed and reasonable application technical documents.

Basic performance should meet current national and industrial standard requirement.

(2) Grading item

Grading item index weight is shown in Table 73

Table 73: Value of Indexes

Index	Weight	Article	Weight
Energy saving	0.53	1) Unit product energy consumption	0.10
		2) Raw material transportation energy consumption	0.10
		3) Thermal performance	0.30
		4) Energy management system certificate	0.03
Emission reduction	0.15	5) Cleaner production level	0.05
		6) Product certificate or evaluation, EPD, carbon footprint report	0.10
Safety	0.22	7) Safety production standardized level	0.02
		8) Construction safety performance	0.10
		9) Visible light reflection rate	0.10
Convenience	0.10	10) General color rendering index	0.05
		11) Applicability and economical efficiency	0.05

I Energy saving

1) Energy saving glass unit product consumption is the sum of the following two, total 100 points:

Plate glass unit product consumption meets *Plate Glass Unit Product Energy Consumption Limit Value* GB 21340 regulated limit value, give 40 points; meets advanced value, give 60 points.

Energy saving glass production enterprises unit product consumption level or carbon emission consistently improves for 3 consecutive years, totally 40 points, rated by experts.

2) Raw material transportation consumption rating is the sum of the following two, but total score is no more than 100 points.

Raw material with accumulated transportation radius less than 500km, weight ratio no less than 60% but under 70%, give 40 points; no less than 70% but under 80%, 60 points; no less than 80% but under 90%, 80 points; no less than 90%, 100 points.

Raw material over 500km uses railway and shipping transportation weight ratio no less than 70% but under 80%, give 20 points; no less than 80% but under 90%, 40 points; no less than 90%, 60 points.

3) Thermal performance is rated as Table 74:

Table 74: Thermal Performance Rating Rules

Climatic region	Project	Rating Rule		
		60 points	80 points	100 points
Bitter cold	U, W/(m ² ·K)	1.2 < U ≤ 1.7	1.0 < U ≤ 1.2	1.0U ≤

	Visible light transmittance T_v , %	$40 \leq T_v \leq 60$		$T_v \geq 60$
Cold	U , W/(m ² ·K)	$1.5 < U \leq 1.8$	$1.2 < U \leq 1.5$	$U \leq 1.2$
	Light-to-solar gain (LSG)	$1.2 < LSG \leq 1.3$		$LSG > 1.3$
Hot summer and cold winter	U , W/(m ² ·K)	$1.7 < U \leq 2.0$		$U \leq 1.7$
	Light-to-solar gain (LSG)	$1.3 < LSG \leq 1.4$	$LSG > 1.4$	
Hot summer and warm winter	U , W/(m ² ·K)	$1.8 < U \leq 2.0$		$1.5 < U \leq 1.8$
	Light-to-solar gain (LSG)	$1.4 < LSG \leq 1.6$	$1.6 < LSG \leq 1.9$	$LSG > 1.9$

4) Pass GB/T 23331 energy management system certificate, give 100 points.

II Emission reduction

5) Production enterprises cleaner production meets current industry standard *Cleaner Production Standard Plate Glass Industry HJ/T 361* regulation, rating rules are:

Reaching level 2, 60 points;

Reaching level 1, 100 points.

6) Pass product certificate or evaluation, submit EPD and carbon footprint report.

Score is the sum of the following items:

Pass product certificate or evaluation, total 40 points, rated by experts

Submit EPD report, total 30 points, rated by experts

Submit product carbon footprint report, total 30 points, rated by experts.

III Safety

7) Safety production standardized level meets *Enterprise Safety Production Standardized Regulation AQ/T 9006* regulated level 2, give 80 points; meet level 1, give 100 points.

8) Safety performance meets *Building Glass Application Technical Regulation JGJ 113*, steel glass at the same time meets *Building Doors/Windows Curtain Wall Usage Steel Glass JG/T 455* requirement, give 100 points.

9) Visible light reflection rate rating rules:

<0.30 and >0.16 , 60 points;

<0.16 , 100 points

IV Convenience

10) General color rendering index rating rules:

>0.80 and <0.90 , 60 points

>0.90 , 100 points

11) Applicability and economical efficiency rates are the sum of the following two:

Matching the applied region economic development level, environment, industry association, total 50 points, rated by experts;

Matching the applied region laws and regulation, standard regulation, total 50 points, rated by experts.

Chapter 9: Ceramic Tile

(1) Control item

Production enterprises should meet the requirements in Table 75:

Table 75: Basic Requirement of Production

Project	Requirement
Pollutant Emission	<i>Ceramics Industry Enterprise Pollutant Emission Standards</i> GB 25464
Noise emission	<i>Boundary Noise Emission Standard for Industrial Enterprises</i> GB 12348
Workplace environment	<i>Occupational Contact Limit Value of Chemical Harmful Factors in Workplace</i> GBZ 2.1 <i>Occupational Contact Limit Value of Physical Harmful Factors in Workplace</i> GBZ 2.2
Safety production	<i>Enterprise Safety Production Standardized Regulation</i> AQ/T 9006, level 3
Management system	Complete quality, environment, occupational health and safety management system
Note: air pollutant, sewage and noise emission should meet environmental impact evaluation acceptance and approval requirements	

Production enterprises should have detailed and reasonable application technical documents.

Basic performance should meet current national and industrial standard requirement.

Radioactivity should meet *Building Material Radionuclide Limit Value* GB 6566-2010 building material category A requirements.

(2) Grading item

Grading item index weight is shown in Table 76

Table 76: Value of Indexes

Index	Weight	Article	Weight
Energy saving	0.33	1) Unit product energy consumption or carbon emission	0.15
		2) Raw material transportation consumption	0.05
		3) Ceramic tile thickness	0.10
		4) Energy management system certificate	0.03
Emission reduction	0.15	5) Radioactivity pollution	0.10
		6) Product certificate or evaluation, EPD, carbon footprint report	0.05

Safety	0.12	7) Safety production standardized level	0.02
		8) Usage safety performance	0.10
Convenience	0.23	9) Unit packaging weight	0.05
		10) Building module requirement	0.03
		11) No need of post processing after sintering	0.05
		12) Pollution resistance	0.05
Recyclability	0.17	13) Applicability and economical efficiency	0.05
		14) Production wastes recycling	0.09
		15) Low quality raw material usage	0.08

I Energy saving

1) Unit product energy consumption meets current national standard *Building Sanitary Ceramics Unit Product Energy Consumption Limit Value* GB 21252 regulation. Rating rules are:

Meet entry level regulation, 60 points;

Meet advanced level regulation, 100 points.

2) Raw material transportation energy consumption score is the sum of the following two, but total score is no more than 100 points.

Raw material with accumulated transportation radius less than 500km, weight ratio no less than 60% but under 70%, give 40 points; no less than 70% but under 80%, 60 points; no less than 80% but under 90%, 80 points; no less than 90%, 100 points.

Raw material over 500km uses railway and shipping transportation weight ratio no less than 70% but under 80%, give 20 points; no less than 80% but under 90%, 40 points; no less than 90%, 60 points.

3) On the condition of meeting usage requirement, ceramic tile thickness is rated as Table 77:

Table 77: Scoring Rules of Ceramic Tile Thickness (Unit: mm)

Project		Scoring rule		
		60 points	80 points	100 points
Dry hanging hollow ceramic plate	Nominal thickness H	$24 < H < 4in$	$18 < H < 8in$	H8in
Square brick	Thickness D	$15 < d \leq 17$	$13 < d \leq 15$	$d \leq 13$
Other products	Thickness D	$8 < d \leq 10$	$5.5 < d \leq 8$	$d \leq 5.5$

4) Pass GB/T 23331 energy management system certificate, give 100 points.

II Emission reduction

5) Internal exposure index ≤ 0.9 , external exposure index ≤ 1.2 , 100 points.

6) Pass product certificate or evaluation, submit EPD and carbon footprint report. Score is the sum of the following items:

Pass product certificate or evaluation, total 40 points, rated by experts

Submit EPD report, total 30 points, rated by experts

Submit product carbon footprint report, total 30 points, rated by experts.

III Safety

7) Safety production standardized level meets *Enterprise Safety Production Standardized Regulation* AQ/T 9006 regulated level 2, give 80 points; meet level 1, give 100 points.

8) Usage safety performance rating rules are:

Floor tile coefficient of friction (COF) ≥ 0.60 , or wet floor used floor tile friction performance (BPN) ≥ 45 , 100 points;

Floor tile should have backside pattern, backside pattern side should comply with national standard requirement, totally 100 points.

IV Convenience

9) Unit packaging weight is rated as Table 78

Table 78: Single Package Weight Rating Rules

Project	Rating rules		
	60 points	80 points	100 points
Single package capacity W, kg	$40 < w_{git}$	$30 < w_{git}$	$w_0 < w$

10) Comply with building module requirement, give 100 points

11) No need for post processing after sintering, give 100 points.

12) Pollution resistance rating rules are:

Reaching level 4 requirement, 60 points;

Reaching level 5 requirement, 100 points.

13) Applicability and economical efficiency rates are the sum of the following two:

Matching the applied region economic development level, environment, industry association, total 50 points, rated by experts;

Matching the applied region laws and regulation, standard regulation, total 50 points, rated by experts.

V Recyclability

14) Production wastes recycling rating is the sum of the following:

Waste ceramics utilization r_a , 30 points;

Waste base (including glaze base) utilization $\geq 99\%$, 30 points;

Waste glaze slip recycling rate $\geq 90\%$, 40 points.

15) Low quality raw material usage rating rules are:

Proportion in ingredient $>30\%$ and $<40\%$, 60 points;

$>40\%$ and $<50\%$, 80 points;

$>50\%$, 100 points.

Chapter 10: Sanitary Ceramics

(1) Control item

Production enterprises should meet Table 79 requirements

Table 79: Basic Requirement of Production

Project	Requirement
Pollutant Emission	<i>Ceramics Industry Enterprise Pollutant Emission Standards</i> GB 25464
Noise emission	<i>Boundary Noise Emission Standard for Industrial Enterprises</i> GB 12348
Workplace environment	<i>Occupational Contact Limit Value of Chemical Harmful Factors in Workplace</i> GBZ 2.1 <i>Occupational Contact Limit Value of Physical Harmful Factors in Workplace</i> GBZ 2.2
Safety production	<i>Enterprise Safety Production Standardized Regulation</i> AQ/T 9006, level 3
Management system	Complete quality, environment, occupational health and safety management system
Note: air pollutant, sewage and noise emission should meet environmental impact evaluation acceptance and approval requirements	

Production enterprises should have detailed and reasonable application technical documents.

Basic performance should meet current national and industrial standard requirement. Radioactivity should meet *Building Material Radionuclide Limit Value* GB 6566-2010 building material category A requirements.

Water usage efficiency reaches national sanitary ware water usage standard regulation level 3.

(2) Grading item

Grading item index weight is shown in Table 80

Table 80: Value of Indexes

Index	Weight	Article	Weight		
			Toilet	Urinal Squatting pan	Other
Energy saving	0.58	1) Unit product energy consumption or carbon emission	0.10	0.10	0.20
		2)Raw material transportation consumption	0.10	0.10	0.15
		3)Sanitary ceramics unit weight	0.05	0.05	0.20
		4)Water usage efficiency	0.25	0.30	—

		5)Cleaning function	0.05	—	—
		6)Energy management system certificate	0.10	0.15	0.15
Emission reduction	0.15	7)Flushing noise	0.05	—	—
		8)Radioactivity pollution	0.10	0.15	0.15
		9)Product certificate or evaluation, EPD, carbon footprint report	0.05	0.05	0.05
Safety	0.12	10) Safety production standardized level	0.02	0.02	0.02
Convenience	0.10	11)Installation, replacement and maintenance	0.05	0.05	0.05
		12)Applicability and economical efficiency	0.05	0.05	0.05
Recyclability	0.10	13)Production wastes recycling	0.05	0.05	0.05
		14)Low quality raw material usage	0.05	0.05	0.05

I Energy saving

1) Unit product energy consumption meets current national standard *Building Sanitary Ceramics Unit Product Energy Consumption Limit Value* GB 21252 regulation. Rating rules are:

Meet entry level regulation, 60 points;

Meet advanced level regulation, 100 points.

2) Raw material transportation energy consumption score is the sum of the following two, but total score is no more than 100 points.

Raw material with accumulated transportation radius less than 500km, weight ratio no less than 60% but under 70%, give 40 points; no less than 70% but under 80%, 60 points; no less than 80% but under 90%, 80 points; no less than 90%, 100 points.

Raw material over 500km uses railway and shipping transportation weight ratio no less than 70% but under 80%, give 20 points; no less than 80% but under 90%, 40 points; no less than 90%, 60 points.

5) Single piece weight meets Table 81 requirement, give 100 points

Table 81: Weight Requirements for Single Piece

Product Category	Single piece weight,kg
Toilet (including water tank)	≤il
Squatting pan	≤ua
Urinal	≤in
Others	≤he

4) Water usage efficiency precedes national sanitary ware water usage standard regulation level 3, rating rules are:

Reaching level 2 requirement, give 80 points;
 Reaching level 1 requirement, give 100 points.

5) Toilet cleaning function rating rules are:

After every flushing accumulated residue incline total length is less than 25mm, and each residue incline is less than 13mm, give 60 points;

After every flushing accumulated residue incline total length is less than 15mm, and each residue incline is less than 6mm, give 100 points;

6) Pass GB/T 23331 energy management system certificate, give 100 points.

II Emission reduction

7) Toilet flushing noise is rated as Table 82

Table 82: Scoring Rules of Toilet Flushing Noise Requirements

Project	Rating rule		
	60 points	80 points	100 points
Flushing noise, dB	$60 < L_{10} \leq 0d$	$55 < L_{10} \leq 0d$	$L_{10} \leq 0d$
	$50 < L_{50} \leq 0d$	$45 < L_{50} \leq 0d$	$L_{50} \leq 0d$

8) Internal exposure index ≤ 0.9 , external exposure index ≤ 1.2 , 100 points.

9) Pass product certificate or evaluation, submit EPD and carbon footprint report.

Score is the sum of the following items:

Pass product certificate or evaluation, total 40 points, rated by experts

Submit EPD report, total 30 points, rated by experts

Submit product carbon footprint report, total 30 points, rated by experts.

III Safety

10) Safety production standardized level meets *Enterprise Safety Production Standardized Regulation* AQ/T 9006 regulated level 2, give 80 points; meet level 1, give 100 points.

IV Convenience

11) Easy to install, replace and maintain, totally 100 points, rated by experts.

12) Applicability and economical efficiency rates are the sum of the following two:

Matching the applied region economic development level, environment, industry association, total 50 points, rated by experts;

Matching the applied region laws and regulation, standard regulation, total 50 points, rated by experts.

V Recyclability

13) Production wastes recycling rating is the sum of the following:

Waste ceramics utilization $\geq 90\%$, 30 points;

Waste base (including glaze base) utilization $\geq 99\%$, 30 points;

Waste glaze slip recycling rate $\geq 90\%$, 40 points.

14) Low quality raw material usage rating rules are:

Proportion in ingredient >30% and <40%, 60 points;
 >40% and <50%, 80 points;
 >50%, 100 points.

Chapter 11: Premixed mortar

(1) Control item

Premixed mortar production enterprises should meet Table 83 requirement

Table 83: Basic Requirement of Production

Items	Requirement
Air Pollutant Emissions	<i>Air Pollutant Comprehensive Emission Standards</i> GB 16297, Level 3; Or meet the minimum requirements of the local emission standards
Sewage Emission	<i>Sewage comprehensive emission standard</i> GB 8978
Noise Emissions	<i>Boundary Noise Emission Standard for Industrial Enterprises</i> GB 12348
Workplace Environment	<i>Occupational Contact Limit Value of Chemical Harmful Factors in Workplace</i> GBZ 2.1 <i>Occupational Contact Limit Value of Physical Harmful Factors in Workplace</i> GBZ 2.2
Safe Production	<i>Enterprise Safety Production Standardized Regulation</i> AQ/T 9006, Level 3
Management System	Complete quality, environment and occupational health and safety management system
Noted: Air pollutants, sewage, noise emissions should be in line with the requirements of environmental impact assessment approval	

The whole process management of equipment, facilities matching and so on should meet the relevant requirement of local ready-mixed mortar green (cleaner) production management.

Production enterprises should have a detailed and feasible application of technical documents

The performance of ordinary mortar, dry-mixed ceramic tile adhesive mortar should meet the requirements of current national standard *Premixed Mortar* GB/T 25181; the performance of adhesive and surface mortar that is used in EPS exterior insulation system should meet the requirement of current national standard "molded polystyrene board thin plaster wall insulation material" GB/T 29906; other premixed mortar performance should be consistent with the relevant requirement of current national standards.

(2) Grading item

The weight of each index in the table is shown in Table 84.

Table 84: Value of Indexes

Item	Weight	Article	Weight
Energy saving	0.15	1) Raw material transportation energy consumption	0.05
		2) Unit product energy consumption or carbon emission	0.07
		3) Energy management system certificate	0.03
Emission reduction	0.25	4) Emissions of air pollutants (excluding particles)	0.05
		5) Particles emission	0.10
		6) Ordinary mortar bulk rate and the special mortar bag rate	0.05
		7) Product certificate or evaluation, EPD, carbon footprint report	0.05
Safety	0.40	8) Strength	0.12
		9) Strength dispersion coefficient	0.12
		10) Durability	0.12
		11) Standardization level of Safety Production	0.02
		12) Measurement management system	0.02
Convenience	0.10	13) Construction performance	0.05
		14) Applicability and economical efficiency	0.05
Recyclability	0.10	15) Comprehensive utilization rate of solid wastes	0.05
		16) Use of ashes	0.05

I Energy saving

1) Energy consumption of raw material transportation. The rating is the sum of the following two scores, but the total score is not more than 100 points:

Raw material with accumulated transportation radius less than 500km, weight ratio no less than 60% but under 70%, give 40 points; no less than 70% but under 80%, 60 points; no less than 80% but under 90%, 80 points; no less than 90%, 100 points.

Raw material over 500km uses railway and shipping transportation weight ratio no less than 70% but under 80%, give 20 points; no less than 80% but under 90%, 40 points; no less than 90%, 60 points.

2) Energy consumption per unit of product consistently improve for 3 consecutive years, the rating is the sum of the following:

Having energy classification measurement, 20 points;

Energy measurement instruments with online collection, upload functions, 20 points;

Establishment of energy efficiency management information system, 30 points;

Continuous improvement based on energy efficiency management information system analysis results, 30 points

3) Pass GB/T 23331 energy management system certificate, give 100 points

II Emission reduction

4) Plant sulfur dioxide emissions meets Level 2 according to Table 2 in *Air Pollutant Comprehensive Emission Standards* GB16297, 60 points; In line with the relevant local standards in comprehensive emission of air pollutants, 100 points

5) The emission of atmospheric particulate matter in the factory shall be rated as the sum of the following items:

In the case of organized emission, the particles exhausted from the gas emission cylinders complies with *Cement Industry Air Pollutants Emission Standard* GB 4915, 40 points; In line with the relevant local standards in comprehensive emission of air particles, 60 points;

In the case of unorganized emission, the particles exhausted from the gas emission cylinders complies with <Standards on Emission Standards for Air Pollutants in Cement Industry> GB 4915, 20 points; In line with the relevant local standards in comprehensive emission of air particles, 40 points

6) Ordinary mortar bulk rate, special mortar bag rate. The rating rules are as follows
Ordinary mortar annual bulk rate achieves 70%, 60 points; achieves 80%, 80 points, achieves 90%, 100 points.

The average consumption per ton of special mortar on the bags is ≥ 40 , 0 points, ≥ 25 but < 40 , 60 points; ≥ 20 but < 25 , 80 points; < 20 , 100 points;

7) Submit environmental product statement (EPD), carbon footprint report through product certification or evaluation, the rating is the sum of the scores of each items as follows:

Pass product certification or evaluation, total 40 points, according to the experts' rating;

Submit environmental product statement (EPD), total 30 points, according to the experts' rating;

Submit carbon footprint report, total 30 points, according to the experts' rating;

III Safety

8) The rating rules for strength rating as follows:

If the ratio between measured value and design value of compressive strength of ordinary mortar is > 2.0 , 50 points; ≥ 1.0 but < 1.15 , or ≥ 1.5 but < 2.0 , 75 points; ≥ 1.15 but < 1.5 , 100 points;

If the ration between measured value and design value of the original tensile bond strength of adhesive and surface mortar that is used in EPS exterior insulation system is ≥ 1.0 but < 1.2 , 50 points; ≥ 1.8 , 75 points; ≥ 1.2 but < 1.8 , 100 points;

If the ration between measured value and design value of the original tensile bond strength of dry mixed ceramic tiles adhesive mortar is ≥ 1.0 but < 1.5 , 50 points; ≥ 2.5 , 75 points; ≥ 1.5 but < 2.5 , 100 points;

9) The rating rules for the dispersion coefficient of 10 continuous batches of product strength are as follows:

$\leq 30\%$ but $> 20\%$, 40 points;

$\leq 20\%$ but $> 10\%$, 40 points;

$\leq 10\%$, 100 points

10) The rating rules for durability are as follows:

If the ration between design and measured value of compressive strength loss after ordinary mortar freeze-thaw cycles is: ≥ 1.0 but < 1.5 , 50 points; > 1.5 but ≤ 2.0 , 75 points; > 2.0 , 100 points;

If the ration between measured value and design value of water resistance, freeze-thaw resistance and tensile bond strength of adhesive and surface mortar that is used in EPS exterior insulation system and dry mixed ceramic tiles adhesive mortar is ≥ 1.0 but < 1.2 , 50 points; ≥ 1.8 , 75 points; ≥ 1.2 but < 1.8 , 100 points.

11) If the safety production standardization level meets Level 2 according to *Enterprise Safety Production Standardized Regulation* AQ/T 9006, 80 points; if meeting Level 1, 100 points;

12) If passing the certification of GB/T 19022 Measurement management system, 100 points.

IV Convenience

13) The rating rules for construction convenience are as follows:

If the ration between measured value and design value of ordinary mortar water retention rate is ≥ 1.0 but < 1.05 , 50 points; ≥ 1.10 , 75 points; ≥ 1.05 but < 1.10 , 100 points;

When the operational time of adhesive and surface mortar that is used in EPS exterior insulation system is ≥ 1.5 , if the ration between measured value and design value of the original tensile bond strength is ≥ 1.0 but < 1.2 , 50 points; ≥ 1.8 , 75 points; ≥ 1.2 but < 1.8 , 100 points;

After dry mixed ceramic tiles adhesive mortar is dries for 20mins, if the ration between measured value and design value of the original tensile bond strength is ≥ 1.0 but < 1.2 , 50 points; ≥ 1.8 , 75 points; ≥ 1.2 but < 1.8 , 100 points.

14) The rating for applicability and economy are the sum of the following two ratings: Matching the application regional economic development level, environment, industry supporting and so on, total 50 points, according to the experts' rating; Matching the application regional law and regulations, standard specification and so on, total 50 points, according to the experts' rating;

V Recyclability

15) The rating rules for the comprehensive utilization rate of solid wastes are as follows:

$\geq 30\%$ but $< 40\%$, 40 points;

$\geq 40\%$ but $< 50\%$, 55 points

$\geq 50\%$ but $< 60\%$, 70 points

$\geq 60\%$ but $< 70\%$, 85 points

$\geq 70\%$, 100 points

16) Consuming the ashes from production process, equipping with automatic ash return equipment, metering ingredient system, strong operable, and reasonable recycling, total 100 points, according the experts' rating.

Chapter 12: Others

1) In the condition of fulfilling the definition of green building materials and fundamental requirements, other building products can be evaluated via the evaluation method and technical index in the guidelines.

2) The scores can be given by fulfilling the requirements of grading items in the guidelines, no score if not fulfilling.

Chapter 13: Bonus Items

1) Advanced production process or equipment are used in the production process of building materials and the influence in environment is obviously lower than average level of the industry. Total 2 points, according to the experts' rating.

2) The building materials are significant innovation and the performance is obviously better than the average level of the industry. Total 3 points, according to the experts' rating.

5. Labels and Environmental Product Declaration of Sustainable Building Materials /Components in Europe

In Europe, there are various information tools that intend to inform customers (users, downstream manufactures, retailers, etc.) about the environmental impacts from manufacturing and using the products. They are operated by governments, private companies, and other non-governmental organizations. Some of them are tested independently. Others are declared by manufacturers, importers, and distributors themselves. These independently verified information tools can be categorized into two types: eco-labeling and environmental product declaration.

This chapter will mainly focus the first type. It starts with an overview various eco-labels of sustainable building materials/components and then presents how various green buildings schemes and these materials/components labels are linked. Important tools that facilitate the selection of sustainable building materials/components will also be highlighted. Finally, the chapter will briefly introduce the second type, i.e. environmental product declaration and its principles.

5.1 Ecolabels of sustainable building material and components

Those are developed in Europe (such as the Blue Angel and EU Ecolabel) or internationally. (such as Cradle-to-Cradle (C2C) and Forest Stewardship Council (FSC)). Their rating system also varies according to the scheme and they are valid for one to five years. Scope of product certification, include limited products (such as wood products in FSC) to a wide range of products (such as insulation, floorings, plasters and wall panels etc.). The criteria of these certification include various sustainability features, such as environmental, climate, health, resource efficiency, ethics, etc. The certification bodies can be government agency (such as in the Blue Angel in which RAL organizes award) or accredited third party (such as in EU Ecolabel and FSC).

5.1.1 European and German labels of sustainable building materials

Three European and German sustainable building labels, i.e. The Blue Angel, EU Ecolabel, and The Passive House Components Label, and their features are presented in the table below.

The Blue Angel	
Label Description	Organization structure
The Blue Angel, a type I Eco-label, is designed to promote goods and services that have – based on the entire life cycle – reduced environmental and health impacts compared to the market average.	Established in 1978
	Awarding body: Umweltbundesamt (German Federal Environment Agency), RAL – German Institute for Quality Assurance and Certification)
	Type: In line with the international standard for

<p>Combined with other environmental policy instruments, eco-label initiatives can play their part to restructure the economy towards sustainable development.</p>	eco-labelling, ISO 14024
	Ratings:
	Validity:
	<p>Webpage: http://www.blauer-engel.de/index.php</p>
Scope and Range	
<p>Products for home and living (such as recycled cardboard, paper and plastics, and textile floorcoverings etc.), construction (such as composite Wood Panels, Wood products, Low-Emission Internal Plasters and Thermal Insulation Material etc.), electric devices, office, energy and heating, and garden.</p>	
Criteria determination	
<p>Criteria under product groups and services:</p> <ul style="list-style-type: none"> -protects environment and health -protects climate -protects water -protects resources 	
Certification bodies	
<ul style="list-style-type: none"> - German Federal Environment Agency (Umweltbundesamt) which develops the technical criteria - expert hearings involving representatives from industry and other expert groups - Environmental Label Jury composed of representatives from HDE (Central Association of German Retail Trade), BUND (Friends of the Earth Germany), BDI (Federation of German Industries), NABU (Nature and Biodiversity Conservation Union), DGB (Confederation of German Trade Unions), vzbv (Federation of German Consumer Organizations), SWR (South West German Broadcasting Corporation) as well as Stiftung Warentest (Foundation for comparative product testing), churches, state ministries of the environment, local authorities and science, decides on the award of a Blue Angel - RAL which organizes the award with the label users - German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the supporting organization of the Blue Angel 	
Certification procedure	
<p><u>A. for existing basic award criteria</u></p> <ol style="list-style-type: none"> 1. The supplier submits their application - In order to use the environmental label, verification of compliance with the requirements is sent to the awarding body RAL. 2. RAL checks the application for the use of the environmental label for compliance with the stipulated requirements. 3. German Federal Environment Agency submits statement 4. RAL concludes the contract on the use of the environmental label with the supplier/manufacturer 5. Advertising by the supplier using the environmental label based on the contract on the use of the environmental label concluded with RAL <p><u>B. for the development of new Basic Award Criteria</u></p> <ol style="list-style-type: none"> 1. Anybody can submit a new proposal including comprehensive information on the product to the German Federal Environment Agency 	

2. Specialist evaluation by the Federal Environment Agency
3. The Environmental Label Jury decides on the investigative order
4. Federal Environment Agency Expert preparation and proposals for the Basic Award Criteria
5. RAL - Organization of the expert hearing
6. Expert hearing Participants - RAL (Chair), UBA, Sector supplying the product/service (BDI), Consumer associations (BVZV/StiWa), and Environmental associations, Trade unions, Other experts (if required)
- Recommendations for the Environmental Label Jury
7. Environmental Label Jury ratify the Basic Award Criteria
8. Announcement of the decisions by the BMUB

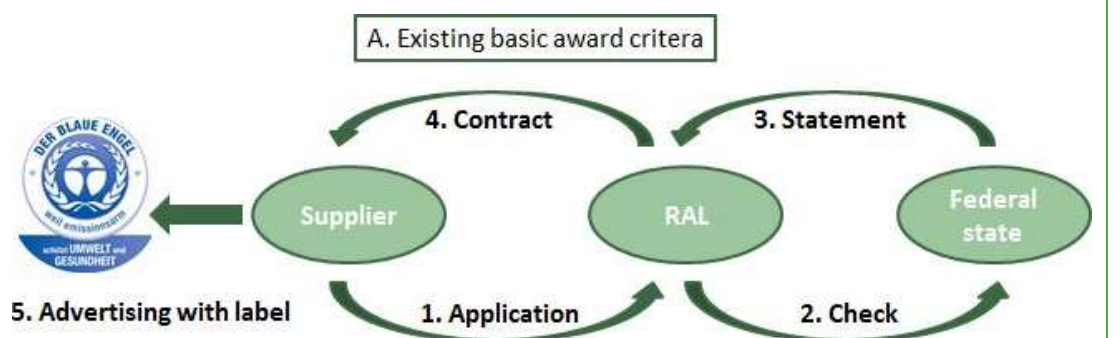


Figure 16: Certification procedure for existing basic award criteria.

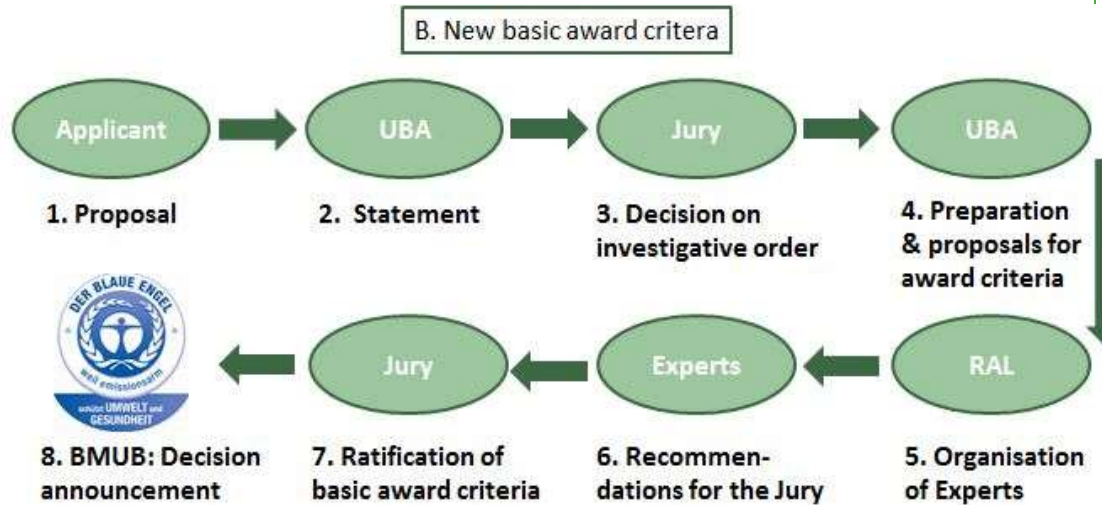



Figure 17: Certification procedure for new basic award criteria.

EU Ecolabel	
Label Description	Organization structure
	Established in 1992
	Awarding body: European Eco-labelling board (EUEB)
	Type: Type I according to ISO 14020
	Ratings:
	Validity: 4 years
	Webpage: http://www.eu-ecolabel.de
Fig. 3: Ecolabel.	
Scope and Range	
<ul style="list-style-type: none"> - Products and services, consumer-oriented - Building products included: Paints, varnishes, heat pumps, wooded floor coverings, soft floor coverings and textile floor coverings 	
Criteria determination	
<ul style="list-style-type: none"> -Criteria determination on the basis of lifecycle analysis and the focus on the stages (manufacturing and packaging, distribution, use and finally the 'end of life') depends on where the product has the highest environmental impact, and this differs from product to product. -Consider the most significant environmental impacts, mainly the impacts on climate change, the impact on nature and biodiversity, energy and resource consumption, waste generation, emissions to all environmental media, pollution through physical effects and use and release of hazardous substances -Substitute hazardous substances by safer substances or the use of alternative materials or designs, wherever it is technically feasible -Reduce environmental impacts due to the durability and reusability of products - Include health and safety aspects at various life stages of the products that helps to balance between environmental benefits and burden -Consider social and ethical aspects 	
Certification bodies	
<ul style="list-style-type: none"> -Runs via a third party, National Competent Body (PFS Product Policy for Belgium) -Product testing by accredited laboratory 	
Certification procedure	
<p><u>Getting Started</u></p> <p>Which products and services are eligible?</p> <p>Every product or service supplied for distribution, consumption or use in the European Economic Area market (European Union plus Iceland, Lichtenstein and Norway) and included in one of the established non-food and non-medical product groups is eligible for EU Ecolabel. Discover the full list of established product groups and the related product criteria.</p> <p>Who can apply?</p> <p>Producers, manufacturers, importers, service providers, wholesalers and retailers. Retailers can apply for products placed on the market under their own brand name</p> <p><u>Getting Advice</u></p> <p>Start the application in the right product group and contact the Competent Body The</p>	

Competent Body is responsible for evaluating the application and awarding the EU Ecolabel, and also give the applicant technical support and answer the questions about meeting the criteria.

Starting the application

To get your EU Ecolabel license, it is mandatory to apply using the online application tool, ECAT_Admin.

Collecting the Evidence

In order to prove compliance to the criteria for the product group, it is required to provide a dossier made up of the declarations, documents, data sheets and test results. The User Manual for each product group explains the requirements. The EU Ecolabel checklist is a useful tool to manage the dossier. The checklist can be downloaded.

Submitting the Application

Once the online application is submitted, the required paper files are also required to be submitted to the Competent Body.

Within two months of the initial application submission, the Competent Body will assess the product against the criteria set for it. If documentation is missing, the applicant will be informed and they will need to provide additional information.

Ecolabel awarded

Application approval:

If the criteria are met and the dossier is complete, the Competent Body will award the EU Ecolabel to the product by creating a contract with the applicant.

Once that's complete, the applicant can use the EU Ecolabel logo on all the products that have met the criteria and on the associated promotional material.

Compliance monitoring:

Once the applicant becomes a license holder, it is their responsibility to stay compliant with EU Ecolabel criteria. The Competent Body will explain how often it will need test samples of your product.

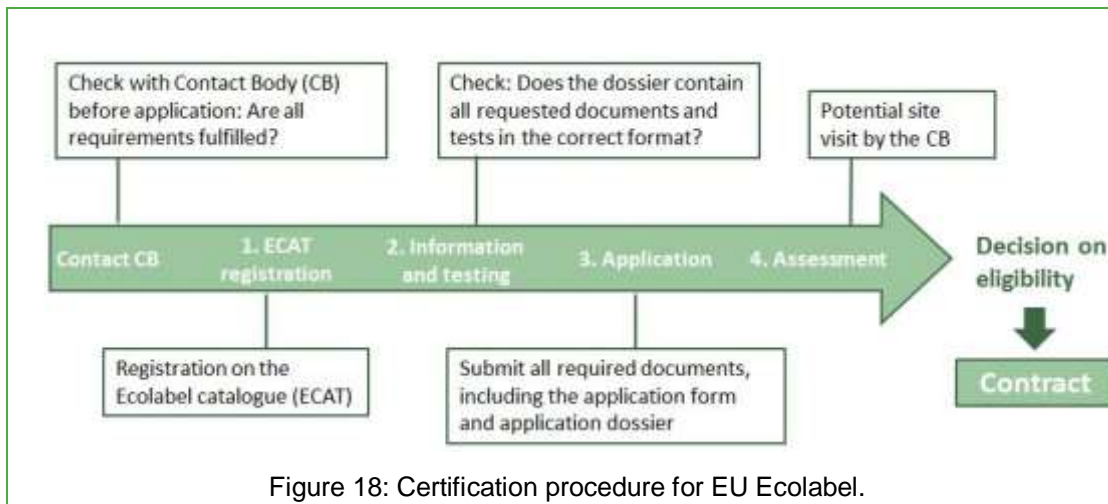
From time to time, the Competent Body may carry out factory inspections and product tests. This ensures that the environmental excellence is maintained for consumers.


The applicant (or the supplier) will need to keep a journal on the test results and all the relevant documentation. This documentation should be available at all times.

If the Competent Body receives evidence that during the validity period, the product no longer complies with the criteria, it will prohibit the use of the EU Ecolabel on that product.

Marketing their product with the EU Ecolabel

Once the EU Ecolabel is awarded to the products, it is the applicant's responsibility as the license holder to register the products and services on the ECAT Product Catalogue and Tourist Accommodation Catalogue via ECAT_Admin.



The Passive House Components Label	
Label Description	Organization structure
<p>The use of Passive House components simplifies the planner's task significantly and contributes significantly to ensuring the proper functioning of the resulting passive house.</p> 	<p>The Passive House Institute (PHI) is an independent research institute which developed the Passive House Standard.</p> <p>Validity: Each certificate has a validity of year after which it can be re-certified by the Passive House Institute. With each new validation the previous certification loses validity.</p> <p>Webpage: http://database.passivehouse.com/de/components/</p>
<p>Figure 19: Passive House Label.</p>	
Scope and Range	
<p>These are defined depending on the category of the component. These being divided into three categories:</p> <ul style="list-style-type: none"> - Opaque Building Envelope: Wall and building systems, Façade anchors, Ground slab, Roof parapet, Flue and exhaust systems, Balcony thermal break technology, Attic steps and ladders, Airtightness systems. - Building Technologies: Heat Pumps, Ventilation system, Waste water heat recovery system. - Transparent Building Envelope: Windows, Roof windows, Skylight, Mullion and transom, Glass roof, Opening elements in glass roof, Roller shutters, Entrance doors, Sliding doors, Glazing, Spacers (windows). <p>The components are also declared according to a specific climate zone:</p> <ul style="list-style-type: none"> - Arctic Climate - Hot Climate 	

- Temperate Climate
Criteria determination
<p>PHI certifies high energy-efficient materials and components according to their international criteria for Passive House. The criteria are divided into two groups, comfort criteria (including residential health and comfort) and thermal criteria (relevant to the thermal balance of a building).</p> <p>All criteria can be specified by ascertainable physical or physiological criteria and verified by measurements with established practices and tested according to standard criteria with respect to their characteristics.</p> <p>If possible, there is a climate-independent formulation of the criteria. However, this is usually less clear for the user - therefore applicable criteria to define climates are also specified.</p>
Certification bodies
PHI as an independent body test and certifies products as to their suitability for use in passive houses.
Certification procedure
<p>Products that bear the certificate "Certified Passive House component" are tested according to standard criteria, with respect to their characteristics comparable and of excellent energy quality.</p> <p>In certifying a material or component a manufacturer will commission the Passive House Institute and provide them with the necessary components and documentation for calculation and test for on-site application. PHI uses the provided data to prepare calculations and simulations of each component. The results are documented and presented in the final certificate if the component reaches approval. If approval is not reached the same documentation is sent back to the manufacturer from PHI with comments on possible improvements. All criteria, testing methods etc. are defined by PHI. Calculations and testing can however be based on technical standards for the relevant component.</p> <p>On approval and payment of the certification fee, the component is documented and presented in the database, the calculation software PHPP (for Passive Houses) as well as in the newsletters of the International Passive House Association and IG PassivHaus. Each component also then receives its own ID for verification.</p> <p>Additional measures</p> <ul style="list-style-type: none"> - Tracking and monitoring are responsibility of the manufacturer but are subjects to control by the Passive House Institute. Controls are conducted by PHI and are repeated as seen necessary at the last year after the first certification. - The Passive House Institute also awards a yearly Component Award, with a changing focus every year. The Passive House Component Award focuses on cost-effective and qualitative components that meet the Passive House Criteria. - As part of the certification process, PHI advises manufactures to optimize their products. This feedback allows for an improved, sustainable product with reliable thermal characteristics. In addition, guaranteed information for minimum requirements for

building calculation is provided.

- In some cases such as for building technologies, Passive House recognized third party testing centers/laboratories which are working according to Passive House Criteria

Cradle to Cradle

Label Description	Organization structure
The Cradle to Cradle Certification framework focuses on using safe materials that can be disassembled and recycled as technical nutrients or composted as biological nutrients. Unlike single-attribute eco-labels, the Cradle to Cradle Certification takes a comprehensive approach to evaluating the design of a product and the practices employed in manufacturing the product	Established in 2005
	Awarding body: MBDC (McDonough Braungart Design Chemistry)
	Type: Not classified i.e. it can't be regarded as an environmental declaration type I, II or III according to the ISO 14020 standard.
	Ratings: Basic, Bronze, Silver, Gold and Platinum
	Validity: 1-2 years
	Webpage: http://www.c2ccertified.org/

Scope and Range

The products include building materials, interior design, paper and packaging, textile and fabric and other products

Criteria determination

- Criteria in 5 categories:
- Material Health
 - Material Reutilization
 - Renewable Energy and Carbon Management
 - Water Stewardship
 - Social Fairness



Figure 20: Cradle to cradle certified product scorecard. (Cradle to Cradle)

Certification bodies
- Runs via MBDC and possibly EPEA
Certification procedure
<p>1. Determine if the product is appropriate for certification: Is it within the scope of certification? Does it comply with the Banned Chemicals Lists? Is there a commitment to continuous improvement and product optimization? Does your product meet eligibility requirements in the Cradle to Cradle Certified Product Standard?</p> <p>2. Select an Accredited Assessment Body for the testing, analysis, and evaluation of your product: Select from the list of Accredited Assessment Bodies, and develop a certification plan including cost, timeline, and necessary resources</p> <p>3. Work with the assessor to compile and evaluate data and documentation: Work with assessor and supply chain to collect data. Assessor evaluates data based on Standard criteria and develops optimization strategies. Submit an Assessment Summary Report, assembled by the assessor, to the Institute for final review.</p> <p>4. Receive certification for the product: The Institute reviews Assessment Summary Report to ensure completeness and accuracy. Applicant signs a Trade-mark License Agreement, and pays the certification fee to the Institute. The Institute makes the final certification decision, conferring a certificate and the use of the Cradle to Cradle Certified mark, considering the requirements of the Trademark Use Guidelines. Work with the Institute to post the products on the product registry.</p> <p>5. Work with Institute and the marketing teams: Make the customers aware of the innovation and certification story</p> <p>6. Report the progress: Every two years, work with the assessor and supply chain to gather new data for re-certification. The Assessor evaluates the data and progress on optimization strategies. Submit the Re-certification Assessment Summary Report to the Institute for review.</p> <p>Additional measures:</p> <p>Cradle to Cradle has a website providing simple and clear information of labelling and its application process. This website also includes an online certified product registry, which facilitates project developers to choose these products;</p> <p>These Assessors are accredited by the Institute based on the experience, qualifications, and training of organization's staff;</p> <p>With the launch of the new LEED v4, Cradle to Cradle Certified products are written into LEED. Choosing certified products can earn project teams up to two points for Materials & Resources Credit, Building Disclosure and Optimization—Material Ingredients. In addition, BREEAM-Netherlands—the 'Environmental Assessment Method' -is now rewarding the use of Cradle to Cradle Certified Products;</p> <p>Cradle to Cradle also provide training courses to leading companies in the building sector by exploring design methodologies, material health programs, product and systems innovations, and a new definition of waste.</p>

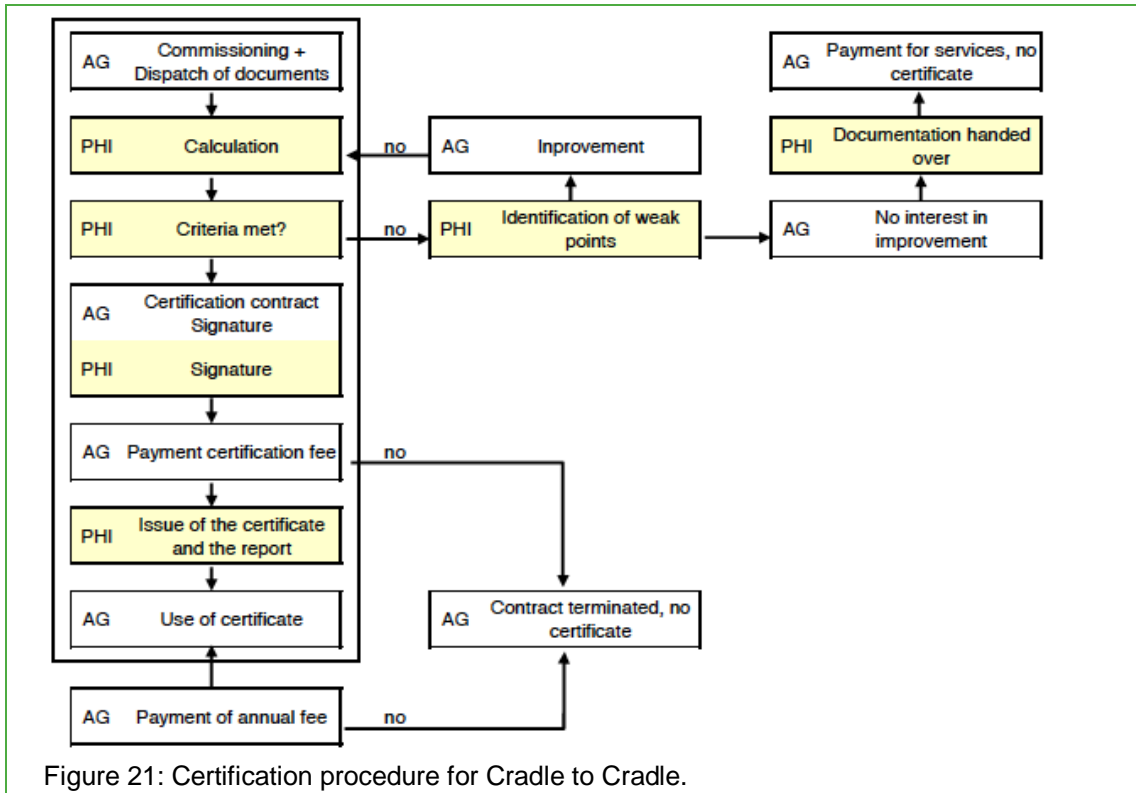


Figure 21: Certification procedure for Cradle to Cradle.

5.1.2 International labels of sustainable building materials

Two sustainable building labels (Cradle-to-Cradle and Forest Stewardship Council) and their features are presented in the table below.

Forest Stewardship Council (FSC)	
Label Description	Organization structure
<p>The Forest Stewardship Council mission promotes environmentally sound, socially beneficial and economically prosperous management of the world's forests. FSC-certified products ensure environmental protection, community engagement and access to markets. There are 3 types of the FSC certificate: Forest Management Certification, Chain of Custody Certification and Controlled Wood Certification.</p>	Established in 1993
	Awarding body: FSC accredited certification bodies. Accreditation Services International (ASI) is responsible for checking the certification bodies.
	Type: Type I according to ISO 14020
	Ratings:
	Validity: 5 years, conduct annual surveillance audits to verify the continued compliance with FSC certification requirements
	Webpage: https://ic.fsc.org/
Scope and Range	
<p>The FSC promotes environmentally appropriate, socially beneficial, and economically viable management of the world's forests:</p> <ul style="list-style-type: none"> • Environmentally appropriate forest management ensures that the harvest of timber and non-timber products maintains the forest's biodiversity, productivity, and ecological processes. 	

- Socially beneficial forest management helps both local people and global society to enjoy long term benefits and also provide strong incentives to local people to sustain the forest resources and adhere to long-term management plans.
- Economically viable forest management means that forest operations are structured and managed so as to be sufficiently profitable, without generating financial profit at the expense of the forest resource, the ecosystem, or affected communities. The tension between the need to generate adequate financial returns and the principles of responsible forest operations can be reduced through efforts to market the full range of forest products and services for their best value.
- The FSC Principles and Criteria is applied to the entire geographic space inside the boundary of the forest management unit which is being submitted for evaluation of the quality of forest management; FSC-POL-10-004 (Scope of application of the FSC Principles and Criteria for Forest Stewardship, June 2005) backed by FSC-DIS-01-001

Criteria determination

10 principles/new proposed titles:

1. Compliance with laws and FSC Principles/ Compliance with legal requirements
2. Tenure and use rights and responsibilities/ Workers' rights and employment conditions
- 3 Indigenous peoples' rights/ Indigenous and traditional peoples' rights
4. Community relations and worker's rights/ Community relations and development
- 5 Benefits from the forest
6. Environmental impact/ Ecosystem functions
7. Management plan/ Management planning
8. Monitoring and assessment
9. Maintenance of high conservation value forests
10. Plantations/ Management activities

Certification bodies

Organizations listed in <http://www.accreditation-services.com/archives/standards/fsc>

Certification procedure

1. Contact one or several FSC accredited certification bodies (CB): To give the applicant a first estimate regarding cost and time demands, the certification body will need some basic information about your operation. The, the certification body will provide the applicant with information about the requirements for FSC certification.
2. Auditing: A certification audit takes place to assess the applicant's qualifications for certification.
3. Certification: After working with a CB towards achieving full FSC requirements compliance, the applicant's operation will receive its FSC Certificate.

5.1.3 Sustainability building schemes and their requirements of sustainable building products and components

In highly efficient or even plus energy buildings – the buildings of the future, the lifetime operational energy consumption is much lower compared with conventional new buildings, while the share of embodied energy is higher due to additional sophisticated construction materials, energy production and recovery systems (Dutil, Rouse & Quesada, 2011), along with the use of renewable technologies. Therefore,

it is necessary to select building materials carefully, with low embodied energy to minimize the adverse effect on the environment. Beyond the energy dimension, sustainable buildings require construction products that are sustainable in terms of health and material efficiency.

In order to fulfil these criteria, specific materials should be used which are listed in various database such as greenbuildingproducts.eu for DGNB and LEED and greenbooklive.com for BREEAM. This section discusses on how material efficiency is achieved in green building certificates used in Europe. Different sustainable building material certificate schemes are also discussed with their certification process. A number of building material database are accessible online in Europe and some of them are listed and discussed in this chapter.

Green building certification systems evaluate the green performance of a building and confirm its green building status (Nelson et al. 2010) by rating and certifying it by an independent third party. Some of the certifications used in Europe are BREEAM (Building Research Establishment's Environmental Assessment Method) from the UK, DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen e.V./German Sustainable Building Council) from Germany, LEED (Leadership in Energy and Environmental Design) from the USA and HQE from France. The rating systems and weightings for criteria differ between these schemes and they are either limited to their country of origin or used internationally (e.g. LEED in the USA and Europe). To date, these systems are voluntary and have been developed through non-governmental or governmental organizations. Figure 22 shows the evolution of these green building certification systems in different countries.

A short overview of some of the green building certificates are given in the tabular form below with the information gathered from the individual websites. Regarding material efficiency in the selected green building certificates, all consider life cycle impact reduction, along with the emphasis on reusing and recycling the materials in order to reduce waste generation and to dispose. Material efficiency is further enhanced by the use of green products from the green material schemes. The FSC products are suggested by all green building certificates, and some green material schemes are country specific. The product list is also suggested by the various database which shows the product details as well as their suppliers.

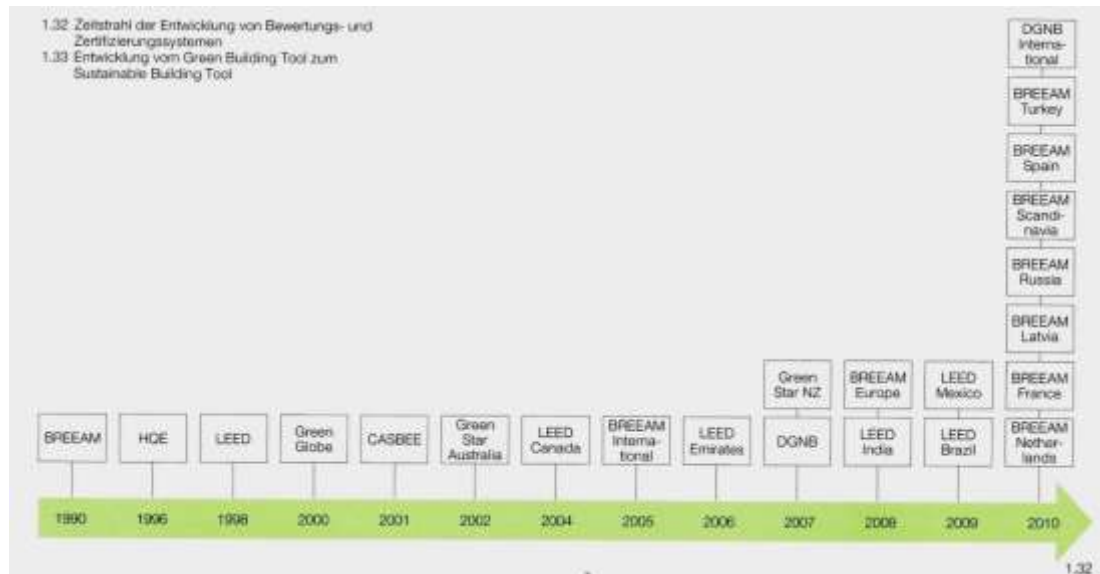


Figure 22: Evolution of Green building certification (Source: Ebert et al. 2011).

DGNB (CORE 14 scheme)	
Label Description	Organization structure
DGNB is a meritocratic rating system that covers all relevant topics of sustainable construction. It was developed to respond for a society that faces a wide range of challenges such as climate change, resource scarcity, as well as the financial crisis. It includes ecological, economical and socio-cultural issues in the planning, construction, and operation of buildings for sustainable buildings (DGNB 2012).	Established in 2007
	Country of Origin: Germany
	Responsible: DGNB together with BMVBS (German Federal Ministry of Transport, Building, and Urban Affairs)
	Criteria: Environmental Quality, Economic Quality, Sociocultural and Functional Quality, Technical Quality, Process Quality and Site Quality
	Ratings: Bronze (35%) / Silver (50%) / Gold (65%) / Platinum (80%)
	Regulation: Voluntary
	Webpage: http://www.dgnb.de/en/
Material efficiency	
DGNB focuses on avoidance of construction waste by the design that are ease of deconstruction, recycling and dismantling; use environment friendly materials that have Green Product Certification; and design alteration with resource saving.	
Material sub-criteria	Environmental quality ENV 1.1 Life Cycle Impact Assessment ENV 1.2 Local environmental impact ENV 1.3 Responsible Procurement
Certification requirement	A Project Certification Query (PCQ) process must be completed (in general)
Certifier	DGNB Auditor (650 DGNB auditors till date) or DGNB Consultant (400 DGNB consultants till date)

Material schemes suggested (voluntary)	The Blue Angel, timber from FSC or PEFC certified sources, stones with Xertifix, Fair Stone certificates, Gut (Gemeinschaft umweltfreundlicher Teppichböden e.V.) -signet label for textile floor coverings
Material database suggested (voluntary)	LCA data in ESUCO database must match the methodological standards, quality and completeness set by ESUCO database and this must be documented comprehensively for verification, GISCODE/product code: Safety data sheet, technical information, www.wingis-online.de, greenbuildingproducts.eu

BREEAM 2014	
Label Description	Organization structure
BREEAM is the world's leading sustainability assessment method for master planning projects, infrastructure and buildings. It inspires developers and creators to excel, innovate and make effective use of resources. The focus on sustainable value and efficiency makes BREEAM certified developments attractive property investments and generates sustainable environments that enhance the well-being of the people who live and work in them. BREEAM has 80% market share and is applied in over 70 countries worldwide.	Established in 1990
	Country of Origin: UK
	Responsible: BRE Global (under BRE Trust)
	Criteria: Energy, Health and Wellbeing, Innovation, Land Use, Materials, Management, Pollution, Transport, Waste and Water
	Ratings: Pass ($\geq 30\%$), Good ($\geq 45\%$), Very Good ($\geq 55\%$), Excellent ($\geq 70\%$) and Outstanding ($\geq 85\%$)
	Regulation: Voluntary
Webpage: http://www.breeam.com	
Material efficiency	
BREEAM considers life cycle impacts of building material used, the reuse of existing building facades, building structure, recycled aggregates, the minimization of construction waste and the use of low embodied and environmentally friendly materials determined by their Green Guide Rating.	
Material sub-criteria	Materials Mat 01 Life cycle impacts Mat 03 Responsible Sourcing of Materials Mat 04 Insulation Mat 06 Material efficiency
Certification requirement	During the assessment process, each category is sub-divided into a range of issues, which promotes the use of new benchmarks, aims and targets. When a target is reached, credits are awarded. Once the development has been fully assessed, depending upon the total number of credits awarded, a final performance rating is achieved.
Certifier	Licensed BREEAM assessors
Material schemes suggested	Cradle to Cradle, FSC and PEFC certificates, BRE Environmental Profile methodology, (As a licensed BREEAM/EcoHomes/Code for

(voluntary)	Sustainable Home Assessor, you may now use the Green Guide Calculator online tool to model a new bespoke element using available Green Guide Components.) Green Guide rating?
Material database suggested (voluntary)	A list of products approved to BES6001 and additional information in www.greenbooklive.com/

LEED 2013	
Label Description	Organization structure
USGBC's LEED green building rating system has been a significant driver for market transformation since its debut in 2000. Even if some progress is already achieved, urgency to improve our built environment still exists. LEED v4, the next version of LEED, was released in 2013 and redefines leadership in green building. It includes many new concepts and more rigorous requirements to continue the transformation of our construction industry. Until 2016, nearly 3,800 projects in Europe were participating in LEED.	Established in 1998
	Country of Origin: USA
	Responsible: US Green Building Council
	Criteria: Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources, Indoor Environmental Quality, Innovation and Regional Priority
	Ratings: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80 and above)
	Regulation: Voluntary, consensus-based, and market driven, performance based
	Webpage: http://www.usgbc.org
Material efficiency	
LEED emphasizes on building material reuse and promotes recycling; manage the construction waste and use regional environmentally friendly materials with Green Product Certifications. It focuses on materials to get a better understanding of their compound and health and environmental impacts.	
Material sub-criteria	Materials and Resources MR Storage and Collection of Recyclables, MR Construction and Demolition Waste Management Planning MR Building Life Cycle Impact Reduction MR Building Product Disclosure and Optimization – Environmental Product Declaration, Sourcing of Raw materials, Material Ingredients MR Construction and Demolition Waste Management
Certification requirement	Third-party verified corporate sustainability reports (CSR)
Certifier	LEED Accredited Professional
Material schemes suggested (voluntary)	Wood products must be certified by the Forest Stewardship Council or USGBC- approved equivalent, Cradle to Cradle, ANSI/BIFMA e3 Furniture Sustainability Standard?
Material database suggested	Data sets must be compliant with ISO 14044, Environmental Product Declarations which conform to ISO 14025, 14040, 14044,

(voluntary)	and EN 15804 or ISO 21930 and have at least a cradle to gate scope
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5.1.4 Sustainable building materials and components database

Material databases with detailed information support architects and planners to find sustainable building materials and at the same time help manufacturers to present their sustainable building materials.

Below some of these material databases will be presented in table, including Greenbuildingproducts.eu, WECOBIS, Ecoinvent, Ökobau-dat and Green Spec. The products from the database are preferable materials to be used to get green building certification. They are generally available online for free, some with user registration requirement (as in Greenbuildingproducts.eu). Some green building certifications follow country specific database (such as Ökobaudat for DGNB and Green Spec for BREEAM), while Greenbuildingproducts.eu include products that can be used to get the building certified from DGNB and LEED.

Greenbuildingproducts.eu
Description
This is the 1st database for products assessed in terms of LEED and DGNB criteria. Separate database for manufacturer (construction material producer, product manufacturer and framework manufacturer) and database users (Builders, planners and planning offices, construction companies, Accredited DGNB Auditors and LEED Accredited professionals) is provided. It also offers the specific product related assessment declaration with all necessary evaluation results concerning the certification criteria and furnishing of proofs and documentation.
Database for which criteria in Green building certificates
LEED Indoor Environmental Quality: IEQ Credit 4.1 Low Emitting Materials – Adhesives and Sealants, IEQ Credit 4.2 Low Emitting Materials – Paints and Coatings LEED Materials and Resources: MR Credit 4: Recycled Content, MR Credit 5: Regional Materials, MR Credit 6: Rapidly Renewable Materials, MR Credit 7: Certified Wood DGNB Criterion 6 Risks for the local environment:
Online database contains
ID name, Product name, material provider companies, Indoor Environmental Quality (IEQ) (Adhesives, paints and coatings, flooring systems and composite fibre woods) and Materials and Resources (MR) (Recycled content, regional materials, rapidly renewable materials and FSC certified wood). The search result includes: - declaration sheet for specific product, - technical data sheet, - contact information of the manufacturer.
Published by: HOINKA GmbH
Webpage: www.greenbuildingproducts.eu
Access requirement: User registration, free access

WECOBIS

Description

The WECOBIS building material information system provides the holistic ecological selection of building materials by providing product-independent, environmental and health-related data. This information is provided for the life cycle phases of raw materials, production, processing, use and end of life disposal.

Database for which criteria in Green building certificates

BNB criteria (Risks to the Local Environment – New Construction (BN_1.1.6), Risks to the Local Environment – Refurbishment (BK_1.1.6), Indoor Air Quality (3.1.3) and Dismantling, Separation and Utilization (4.1.4)

Online database contains

Building Products (Construction panels, Flooring, Insulation, Seals, Glue, Wood-based materials, Solid building materials, mortar and screed, surface treatments, and Glazing. Raw materials (Binders, Aggregates, Plastics and Metals)

Published by: The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

Webpage: <http://www.wecobis.de>

Access requirement: Free of charge

Ecoinvent

Description

Ecoinvent lists product databases provided by the Swiss Center for Life Cycle inventories. It holds the world's leading database with consistent and transparent, up-to-date Life Cycle Inventory (LCI) data (current version Ecoinvent version 3). The data is available in the 'ecoSpold2' data format and compatible with most of the Life Cycle Assessment (LCA) and eco-design software tools such as LEGEP Software tool (LEGEP Software GmbH, Germany), GaBi (PE International/ LBP-GaBi, University of Stuttgart, Germany) and Umberto (ifu Hamburg/ ifeu Heidelberg, Germany).

Database for which criteria in Green building certificates

Online database contains

Published by:

Webpage: <http://www.ecoinvent.org/database/database.html>

Access requirement: Online register for free as a guest (limited access), buy a licence for full access

Ökobaudat

Description

Ökobaudat is a German building material database for assessment of global ecological effects. As a standardized database for ecological evaluations of buildings it is made available by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety to all persons involved in building construction. Building materials,

construction and transport processes are described regarding their ecological effects. ÖKOBAUDAT contains both generic datasets and specific environmental declaration datasets from diverse companies or associations. Data published in ÖKOBAUDAT is publicly available at no charge and can be used for life cycle assessment of building components and buildings. The owner of the datasets remains responsible for them (contents, values).

The first database was published in 2009 and since then has been updated and expanded regularly. Until 2016, datasets on more than 700 different building products are provided. Since September 2013, ÖKOBAUDAT has been the first life-cycle analysis database that completely complies with standard DIN EN 15804.

Database for which criteria in Green building certificates

DGNB, Bewertungssystem Nachhaltiges Bauen für Bundesgebäude (BNB)

Online database contains

1. Mineral building products 2. Insulation materials, 3. Wood, 4. Metals, 5. Coverings, 6. Plastics, 7. Components for windows and curtain walls, 8. Building service engineering, and 9. Others

The first seven categories include information on production, maintenance and disposal of materials phases. Building service engineering contains further information on the use phase. The “Other” category contains information on for example transport of materials and waste disposal of materials.

Published by: the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Webpage: <http://www.oekobaudat.de/en>

Access requirement: Publicly available at no charge

Green Spec

Description

Originally set up in 2003 as a two-year project, in conjunction with the BRE (Building Research Establishment) Green Spec was funded by the UK Government with the purpose to develop information on low environmental impact building materials for architects and specifiers. Since 2006 Green Spec has been run commercially by a small group of industry professionals dedicated to disseminating information about products and building techniques which optimize the practice of Green construction. Green Spec is split into two parts – one part provides design guidance and the other is a directory of PASS (Product Assessment Screening System) endorsed Green building products.

Green Spec, a UK based and in conjunction with BRE, is dedicated to disseminating information about sustainable building products and construction techniques. It identifies and endorses sustainable building products, systems and services using the PASS (Product Assessment Screening System) and includes a directory of endorsed products along with supporting environmental and specification data.

Database for which criteria in Green building certificates

BREEAM (Material)?

Online database contains

Green products such as L1 Ground treatment and retention, L2 Complete construction entities and components, L3 Structural space and division products, L4 Access, barrier and circulation products, L5 Coverage, cladding, lining, L6 Construction fabric products, L7 Services, and L8 Fixtures and fittings

Published by: Green Spec

Webpage: <http://www.greenspec.co.uk>

Access requirement: Free online available?

Materialdatensammlung für die energetische Altbausanierung, MASEA ("Material Data Collection for Energy Refurbishment")

Description

This materials database contains all the necessary thermal and hygro-thermal characteristics for a wide range of typical as well as historical building materials. The database was created by the Fraunhofer IBP in cooperation with the Institute for building climate control of the Technical University in Dresden and the Centre for Environmentally Conscious Construction in Kassel, supported by the Federal Ministry of Economics and Technology within the framework of the research program EnSan. As there is little information on the building physics properties in existing building the project was started so as to offer relevant information that might be difficult to obtain. This as prediction and calculation is only as good as the knowledge of the existing materials. The information helps to make energy efficient calculations as well as hydro-thermal calculations more accurate, helping to assess energy consumption as well as potential damage risks. The materials chosen are seen as representative of the "historical" building industry in Germany.

Database for which criteria in Green building certificates

Online database contains

The database covers relevant building material information for building physics, a picture showing the building material as well as other relevant information with notes and information on special features. The material information includes:

- material density
- specific heat capacity
- thermal conductivity
- diffusion resistance (dry) 23 ° C - 3/50% of
- diffusion-equivalent air layer thickness (sd value)
- sorption
- free water saturation
- water absorption coefficient
- open porosity

The materials database will be continuously expanded and updated with current materials and new building materials. Therefore, both manufacturers of building materials as well as research institutions have a secure online access. The database contains 474 materials.

Published by: Das Fraunhofer-Institut für Bauphysik

Webpage: <http://www.masea-ensan.de/>

5.2 Environmental Product Declaration (EPD)

An Environmental Product Declaration (EPD) communicates the quantified environmental impacts of a product in a standard format. It is based on Life Cycle Assessment (LCA) and common rules known as Product Category Rules (PCR). The latter ensures that EPDs of products of the same functional use category created by different organizations apply the same data scope and metrics. Unlike the various ecolabels presented above, the EPD report does not provide judgement of products, leaving that task to consumers. It looks similar as the nutrient table of food.

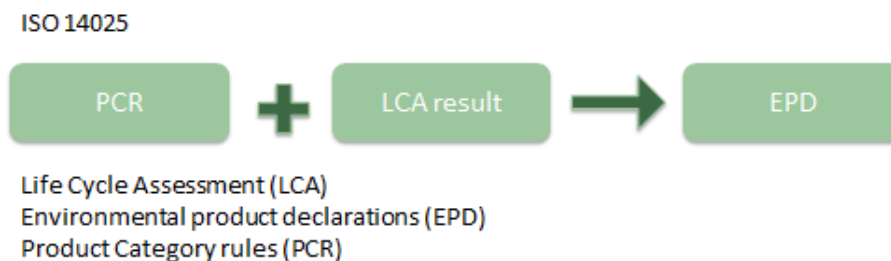


Figure 23: Compound of the Environmental product declarations (EPD).

In 2012, the European Commission published “Sustainability of Construction Work– Environmental Product Declarations – Basic Rules for the Product Category of Building Products” (often shortened to EN 15804). It is a European environmental product declaration of construction norm that ensures that all EPDs for building products, building services, and building processes are derived, verified, and represented in a uniform manner according to through PCR. The aim is to have common format and methodology underlying the environmental indicators of construction products. This standard defines the set of environmental indicators to be used, underlying calculation rules and reporting requirements for an EPD for building products and building related services. It also includes calculating rules of the life cycle inventory and the life cycle impact assessment underlying the EPD. This standard is applicable to construction products, processes and services. The product category rules specify requirements for all construction products for the intended audience (business or consumer) in accordance with ISO 21930 and ISO 14025.

Currently six mandatory impact categories shall be included in an EPD based on EN 15804 :

- Depletion of abiotic resources (elements) in kg Sb equiv. or depletion of abiotic resources (fossil).in MJ
- Global Warming Potential (GWP), in kg CO₂ equiv.
- Eutrophication Potential (EP), in kg PO₄ equiv.
- Acidification Potential (AP), in kg SO₂ equiv.
- Ozone Depletion Potential (ODP), in kg CFC-11 equiv.

- Photochemical Ozone Formation Potential (POFP), in kg ethylene equiv.

Environmental information that is presented in an EPD consists of information modules, based on which the LCA is conducted. Fig. 3 depicts the LCA structure, where product life cycle is divided in module A to C and recycling is module D.

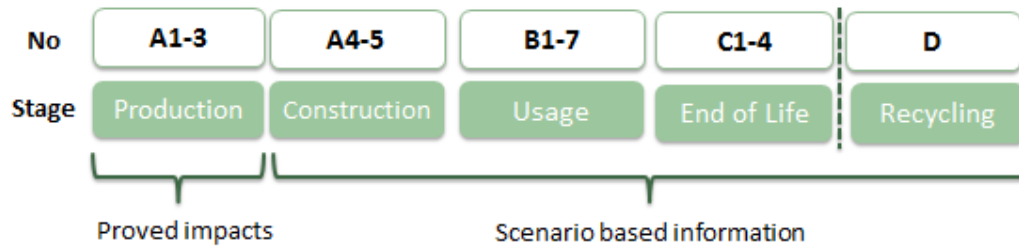


Figure 24: Module-based dissociation of the LCA.

While the production module (A1–3), i.e. cradle-to-gate, is based on existing or historical data, impacts from the downstream stages are assessed based on assumptions (i.e. scenario based information). Thus, the production module (A1–3) is the only mandatory part of the EPD.

Currently, EPD is voluntary. The third party reviews all information given. The procedure to develop an EPD and the requirements on the organisation responsible for each EPD system, the “program operator”, are defined in ISO 14025 (2006).

6. Future-oriented sustainable building materials/components in Europe

This chapter will present different future-oriented sustainable building materials and components in Europe, their energy saving and sustainable potential, and their application examples. The materials and components include insulation materials, windows, Phase Change Materials (PCMs), and Advanced Building Integrated PV (BIPV) systems.

6.1 Insulation

6.1.1 Aerogels

Aerogels are a form of translucent insulation material. Aerogels are materials that are mostly air – usually around 99 % by volume – and can be fabricated from silica, metals and even rubber. They are formed by dehydrating gels and are extremely light because of the resultant porous structure. For example, a cubic metre of silica glass would weigh about 2000 kg. A silica aerogel block of the same dimensions would weigh 20 kg. Despite this, aerogels are relatively strong. Silica aerogels consist of tiny dense silica particles of about 1 nanometre size. Aerogels are excellent insulators, having about one hundredth of the thermal conductivity of glass.

Although their high cost of production has initially limited their application to high end industrial and space applications, they are lately finding commercial applications as building insulation as well (typically in form of blanket insulation). Double glazing that replaced the air gap with an aerogel would improve the insulation value by a factor of three as against the very best current multiple glazing. It would be possible to achieve a 99% vacuum between the panes, since a solid supports them. They are best suited for applications such as skylights etc. where a clear line of sight to the exterior is not required, but only daylight is required. However, even with a thin aerogel sandwich the window would have a slightly frosted appearance. The thermal properties of aerogels also make them ideal for harvesting solar heat: Flat plate solar panels could collect heat and then radiate it back into space.

6.1.2 Vacuum insulation panels

Vacuum Insulation Panels (VIPs) are formed by creating vacuum in the hollow core between two tightly sealed rectangular panels. The walls of the panels are made of rigid, yet highly porous materials such as treated silica, perlite or glass fibre. The entire panel is then enclosed with a barrier film typically made of aluminium metalization. They are mostly used in insulating walls and roofs. Although they offer superior insulation properties compared to all other building insulation materials, their cost and handling still act as barriers to their wide spread application . They are not as flexible as other insulation materials which can be cut on site into different sizes. They are however, best suited to use in prefabricated wall panels etc.

Table 85 compares typical values of different materials used in building insulation. .

Table 85: Comparison of insulation values of building materials

Material	R-Value (mK/W)
Vacuum insulated panels	0.003-0.005
Aerogel	0.014
Extruded Polysterene (XPS)	0.025-0.04
Expanded Polysterene (EPS)	0.3-0.5
Polyurethane	0.02
Fibre glass	0.4-0.6

6.2 Advanced windows and glazing systems

Windows are the least insulating elements of the building shell. At the same time, they represent an important part of the building envelope. There is an optimum design for windows, which attempts to provide a balance between these energy flows. Advanced double or triple layered glazing systems with low-e coatings offer cooling or heating energy savings in the range of 3 % to 10% compared to typical single glazing systems.

6.2.1 Double or triple glazing systems with low-e coating

The thermal performance of windows has improved enormously through the use of multiple glazing layers, low-conductivity gases (argon in particular) between glazing layers, low-emissivity coatings on one or more glazing surfaces and the use of framing materials with much lower conductivity. Operable windows are available with heat flows that have only 25-35% of the heat loss of standard non-coated double-glazed (15-20% of single-glazed) windows (Smith, 2005). In recent years the performance of glazing design has been improved from single glazing with U-value as high as 5.6 W/m²K (undesirable), to triple or even quadruple glazing with special treatment, achieving U-values as low as 0.4 W/m²K (desirable). However, the overall window U-value depends on the window frame and thermal bridging and thus reduces the glazing U-value by a marginal factor in highly insulated frames and by considerable factor in poorly insulated metal or wooden frames. Windows frames most often have the lowest U-Value of a window and can have a large impact on the insulating properties of the window. Window rating systems such as National Fenestration Rating Council (NFRC) rates windows for their performance based on prescribed standards and testing procedures.

Table 86: Typical U-Values of glazing.

Operable windows	U-Value (W/m ² K)
Single glazing	5.6
Double glazing	3.0
Triple glazing	2.1
Double glazing with gas infill and coatings	1.1 – 1.6
Triple glazing with gas infill and coatings	0.4 – 0.8

Note: The U-values refer to the glazing only; the overall window U-value will be different depending on the performance of the frame. The frame as the weakest link in window design will lead to an overall lower achievable U-value than the figures shown above; Source: Institute Wohnen und Umwelt & Hessische Energiesparaktion, 2016.

6.2.2 Smart and dynamic windows

Smart or intelligent windows are generally categorized as windows that can dynamically change their characteristics based on the surrounding optical and thermal characteristics. They are divided into two major categories: passive systems which are self-regulating and active systems which can be modulated based on user's needs.

Passive systems

Passive systems react to the natural light or heat stimuli in the immediate surroundings. They are easy to install and to maintain compared to the active systems; However, they lack the user controllability. The following table describes two key passive technologies.

Table 87: Key passive systems for windows technology.

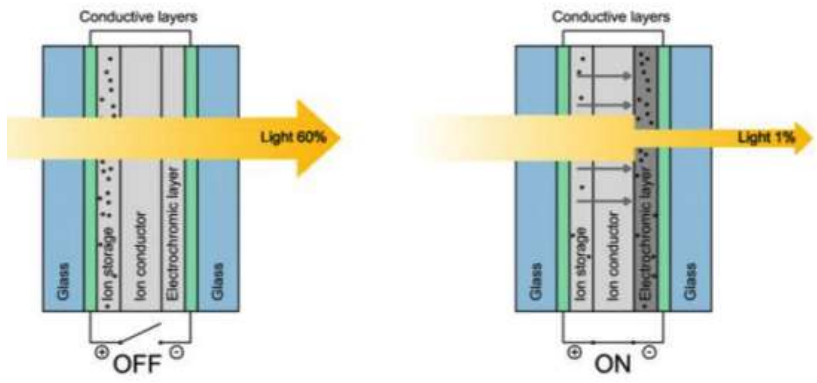
Passive system	Description
Photochromic glazing	<p>This is a property of the window glass. Photochromic glass modulates the transparency based on the incident light intensity. This is due to the presence of organic or inorganic compounds such as metal halides that react to the ultraviolet light or due to the presence of plastics that absorb sun's energy based on the output colour spectrum variation. When subjected to direct solar radiation, the colour intensity of the glass increases in the order of few minutes and gradually reverses in about twice that time. Their application is more prominent in optical and car industry, because high costs, uniform distribution of photochromatic substances and the loss of reversibility over time are major obstacles to their application in buildings.</p>
Thermochromic glazing	<p>Thermochromic glazing is similar to photochromic glazing in terms of modulating the transparency. However, the change is due to the external surface temperature of the glass instead of the external radiation. It is caused either by a chemical radiation or by the inclusion of a phase transition material consisting of a wide range of organic and inorganic compounds, and films of metal oxides such as vanadium oxide. The transition is made between 10 °C (maximum transparency) and 65 °C (minimum transparency). Polyvinyl butyral (PVB) is one of the most promising thermochromic film technologies available in the market. Their application is more prevalent compared to photochromatic glazing. However, key drawbacks of this technology include lack of</p>

user controls, disability to eliminate glare in specific situations of low temperature and high solar radiation.

Active systems

They are similar to passive systems in terms of modulating the optical properties. However, active systems differ as they can be directly controlled by the users or controlled automatically by the integration of a building automating or management system. They can be adjusted using minuscule energy, based on a variety of factors such as internal and external temperature, external radiation, natural lighting levels and user needs etc. The following table describes three key active technologies.

Table 88: Key active systems for windows technology.

<p>Electrochromic devices (EC)</p>	<p>Electrochromic devices work on the principle of electrolysis activated by external electrical stimuli. The transparent electrode (electrochromic film) and counter electrode (ion storage) are applied to the inside of glass panels and are separated by an ion conductor (or electrolyte). When an electrical charge is applied the electron migrates from the ion storage through the conductor and gets deposited on the electrochromic film rendering it in dense colours. When the charge is removed the whole systems becomes transparent again. The advantage of this system is the possibility to be controlled by the user. The light transmission varies between 1% and 60%. The energy required for the transition is minimal at about $1-2-5 \text{ W}_p/\text{m}^2$ and requires about $0.4\text{W}/\text{m}^2$ to maintain the desired tinted state.</p>  <p>Figure 25: Electrochromic glazing operation (Casini, 2014, p.277)</p>
<p>Suspended particle devices (SPD)</p>	<p>In SPD technology, a thin laminate of suspended particles is placed between two transparent conductor films. In their natural state, the particles are randomly oriented blocking the light. When a charge is applied, the particles orient themselves thereby allowing the light to pass. SPD is capable of blocking 99.4% of visible radiation, while providing a visual light transmittance in the range of 0.5-65% and SHGC of 0.57-0.06. The system required about $5\text{W}/\text{m}^2$ for switching between states and about $0.55\text{W}/\text{m}^2$ to maintain the desired state.</p>

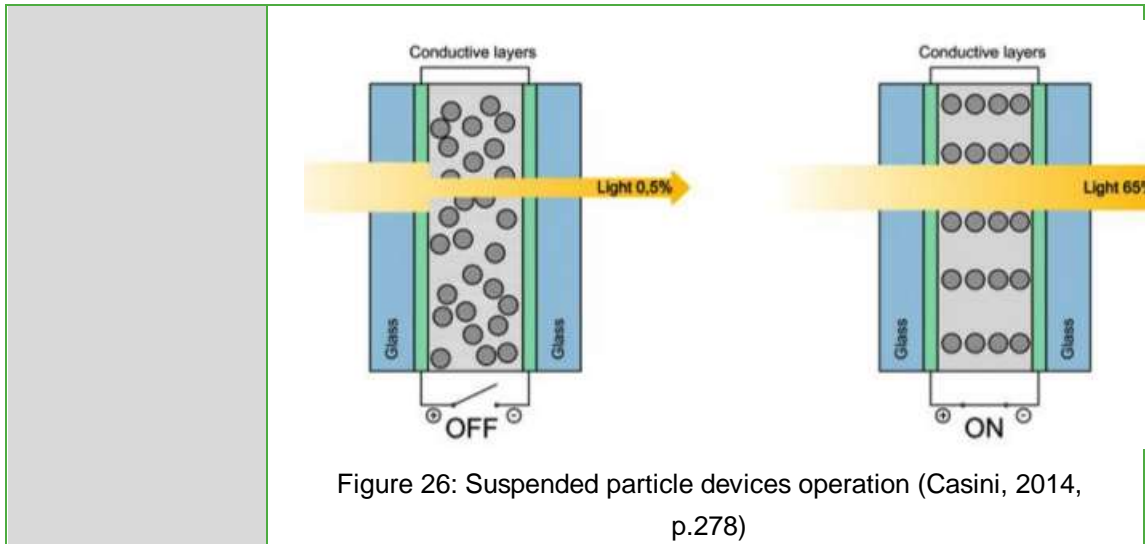


Figure 26: Suspended particle devices operation (Casini, 2014, p.278)

Polymer Dispersed Liquid Crystal Device (PDLC)

PLDC operates similar to that of the SPDs. However, instead of a layer of suspended particles, a layer of polymer matrix (PLDC) films is suspended between the two electrical conductors. The liquid crystals in the polymer matrix are randomly oriented in their natural state and align themselves on applying charge. The light transmission is between 50-70 and they require continuously about 5-10 W/m² of energy to maintain the desired state.

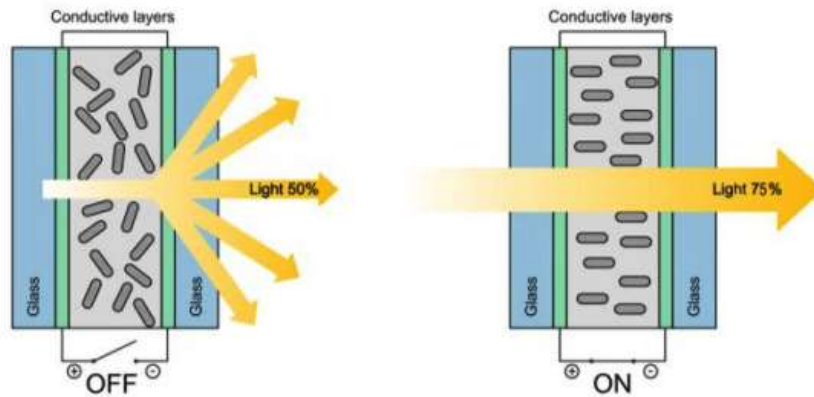


Figure 27: Polymer dispersed liquid crystals devices operation (Casini, 2014, p.278)

A choice between different smart technologies is made based on various design and functional aspects such as the range of visible light allowance, ultraviolet high performance, energy consumption in natural and transitions states, tint and colour requirements, availability and maintenance etc. Commercial glass manufactures such as Guardian, View etc., manufacture a variety of passive and dynamic smart glass systems.



Figure 28: Example of a smart glass technology.
 Right:less transparent , left: more transparent (Albright, p.17)

6.3 Phase Change Materials

The application of Phase Change Materials (PCMs) in building construction has been an innovative technology. PCMs work on the principle of storage and release of latent heat. PCMs typically store heat during day (or during intense heat periods) and release it during the night (or less intense heat periods), changing from solid phase to liquid phase and vice versa. The heat required for this process is known as latent heat. This latent heat absorption helps in absorbing significant amount of heat without raising the ambient temperature. The following figure shows an example of the application of a BioPCM. Enthalpy is shown on the y-axis and temperature on x-axis. As it can be seen, the rise in enthalpy is used up in the phase change without an increase in the temperature.

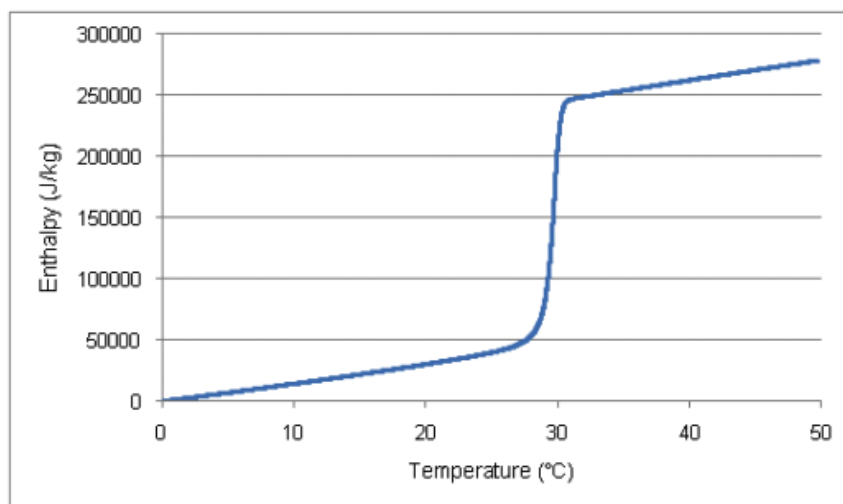


Figure 29: Enthalpy Profile of the BioPCM.(Muruganantham, 2010, p.15)

PCMs are made up of different organic, inorganic materials and also derived from agricultural sources products. For building applications, organic PCMs such as heptadecane (phase change temperature 21 °C), dodecanol (phase change

temperature 24 °C), octadecane (phase change temperature 29 °C) and dodecanol (phase change temperature 24 °C) are used. PCMs could reduce the building's peak cooling loads by approximately 11% and annual cooling load by approximately 9%. Inorganic PCMs are usually salt hydrates of inorganic salts containing one or more water molecules. Some examples are $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ etc. They are nontoxic, non-combustible and less corrosive compared to organic PCMs. They have melting points in the range of 5 °C to 130 °C and are suitable for a range of building related applications. PCMs are capable of saving cooling energy in the range of 9-25% depending on the enthalpy of the PCMs, the PCM loading and PCM location. Biobased PCMs are typically hydrogenated hydrocarbons from various plant and animal based products such as oils from palm, coconuts and soybeans and animal fat such as beef tallow etc. They are chemically stable, they offer higher fire-resistance compared to organic PCMs and can last for decades.

The PCMs are packaged in pouches, plates, balls etc. depending on their area of application. They can either be flat or tubular in shape. PCMs are integrated into buildings as extended layers on walls and roofs, or can be added in the interiors on to the ceilings and floors. PCMs can also be integrated with materials (mixed within the material): insulation materials such as fibreglass insulation, finishing materials such as plasters and also with interior partition and ceiling systems such as gypsum board etc. The advantage of PCM technology is that they can be added to existing buildings as sheets, blocks, and layers with minimum invasion in the structure. The choice of the PCM material and application depends on factors such as usage, space design, temperature profile of the space and PCM material, and fire rating etc. The following figures show different applications of PCMs in buildings.



Figure 30: Passive working delta cool ceiling panels containing inorganic PCM (Kośny, 2015, p.41).



Figure 31: Installation of the active-chilled ceiling system containing PCM-enhanced plaster and plastic micro-tubing - Fraunhofer ISE, Germany. (Kośny, 2015, p.43)



Figure 32: Fig. 18: Construction details of a roof assembly containing, reflective insulation, and subventing air channels, followed with two PCM insulation systems produced by Outlast, USA. (Kośny, 2015, p.46)



Figure 33: Experimental attic module containing microencapsulated PCM blended with cellulose insulation, ORNL, USA, testing facility. (Kośny, 2015, p.48)



Figure 34: Installation of the test wall containing PCM-enhanced fibreglass insulation. (Kośny, 2015, p.37)

Left side presents wall cavity instrumentation with array of thermocouples installed across the wall cavity. Right side Cavity finish task, after blowing in fiberglass



Figure 35: Installed BioPCM Mat in the Ceiling. (Muruganantham, 2010, p.16)

6.4 Advanced Building Integrated PV (BIPV) systems

Modern PV systems offer customization to be integrated into building façade as an external finish. Building elements such as shading devices like fixed shades and louvers could be replaced with PV panels to serve dual purpose of shading and energy generation. Sunspaces and sky roofs can be replaced with modern transparent/translucent PV panels instead of plain glass.

Two main aspects of Solar Photovoltaics in current and future building integration would be the panel technology and mounting technology. The efficiency of the panel

technology lies in the transparency levels that can be achieved while producing the maximum energy possible. Mounting technology should enable smooth integration into the building and at the same time allow for smooth operation and maintenance. Mounting the PV glazing systems can be done using the regular architectural glass mounting technologies such as linear mounting (mullion and transom facades, and structural glazing systems) or point fixing systems such as spandrel glazing systems. However, the installation required proprietary technology based on the PV glass panel to interconnect the panels with each other and with the balance of systems such as inverters, storage and distribution systems.

6.4.1 Panel technology improvements for transparent panels

Commercial organizations such as Polysolar, OnyxSolar etc. offer proprietary technology based on transparent solar photovoltaic glass technologies (typically a transparency of up to 40% can be achieved). They can be customized for their transparency, thickness, color and size. Transparency is typically achieved by encapsulating the photovoltaic cell in an encapsulation material and then sandwiching it between two layers of glass. The cells are spaced depending on the transparency that needs to be achieved. Although technically these are not clear glass photovoltaic systems, the future generation polymer solar cells could be designed to capture light in visible and non-visible spectrum to create actual transparent PV glass. Color tint could also be added to these modules by using color glass or by applying coatings, although it comes at some expense of the efficiency.



Figure 36: Example of BIPV, PV panels as canopies. (Polysolar Limited, 2015, p.19)

An EU-funded project called B-first (fibre reinforced solar technology) focuses on “development and demonstration of a set of standardized multifunctional photovoltaic products for building integration based on a recently developed technology for solar cells encapsulation within glass fibre-reinforced composite materials”.

Some of the key objectives of the programme are:

- Design and development of BIPV products based on composite materials, yet at par with the efficiency levels of traditional modules.
- Increasing light transmission properties
- Demonstration of these innovative BIPV products
- Development of product catalogues and datasheets

Products that have been developed during the course of the project are integration of BIPV in:

- Ventilated façade
- Roof shingle
- Curtain wall
- Skylight
- Shading elements

A demonstration building has also been erected under B-first programme using advanced photovoltaic triple glazing system curtain wall based on fibre reinforced composite materials developed within the project. A total of 10 PV modules will be installed covering an area of approximately 18m², with a total power of 1.28kWp and generating an estimated annual energy of 1,229 kWh/year.



Figure 37: Demonstration building from B-first programme. (BFIRST-FP7)

Advanced BIPV is another EU funded project aimed to increase the architectural application of photovoltaic panel in buildings with a concept, more glass, more transparency and more complex geometries. One of the work package involves developing a BIPV vision glass of high quality and stable photovoltaic performance

showing light transmission (LT) as high as 50%. This project is also linked with the Small and Medium-sized Enterprises instrument for promoting the manufacturing of the developed technologies.

Typical applications of such transparent PV glass in atria glazing systems, corridor glazing, staircase glazing systems, double glazed facades, roofing, canopy roofs, green houses etc. where high level of visual light transmittance (VLT) (>50%) is not required. They can also be used in window systems where high VLT is not required.



Figure 38: Example of transparent PV glass application. (Sapa Solar)

Living Tomorrow Brussels, Belgium. PV panels in atrium. 33 see through panels each with a rated power of $136W_p$ have been used in the project along with 14 opaque panels with a rated power of $100 W_p$ each.

6.4.2 Panel technology improvements for opaque panels

Instead of mounting photovoltaic panels on building envelope, it offers both economic benefits and convenience in construction when the building components are integrated with photovoltaic cells. PV panels can be typically integrated into building cladding systems, roofing systems etc.

Construct-PV is a European Commission funded project with an objective to develop and demonstrate customizable, efficient and low cost BIPV for opaque surface of buildings with partnership in research and industry.

Two pilot projects are being undertaken in this initiative. One project is integrating PV into façade cladding systems as planned in Züblin campus in Stuttgart.



Figure 39: Integrated PV into façade cladding systems in Stuttgart – model. (Construct PV).

Another example of the Construct-PV are BIPV roof shingle modules for school buildings of Mining and Metallurgical Engineering, which are located in Zografou campus of the National Technical University of Athens (NTUA).

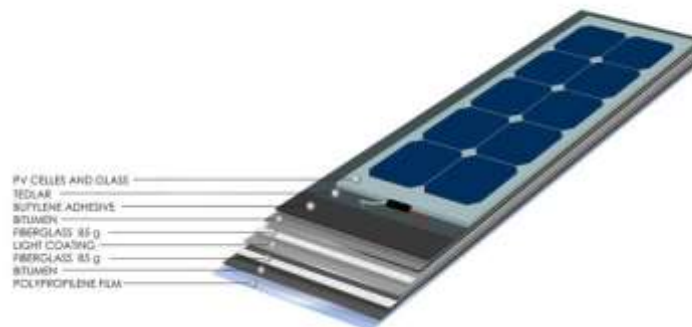


Figure 40: BIPV roof shingle modules in Athens.(Fraunhofer ISE)

Key objectives of the project is to replace typical shingles with PV shingle modules ensuring leak-tightness and other physical characteristics that can be achieved by using a typical shingle. The PV shingle modules used glass-glass modules containing high-efficient crystalline heterojunction solar cells and are electrically connected using many thin wires in “smart wire” technology making them invisible from a distance.

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