# ST05 - Energy Saving and Carbon Reduction of Alumina Production under the Dual Carbon Strategy

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**Abstract**

With the rapid development of the economy in recent years, the Chinese national "double carbon" goal has been put forward. For the alumina production industry with high energy consumption, how to effectively reduce the energy consumption of alumina production and achieve energy saving and carbon reduction is not only the national and environmental development strategy needs, but also the green and high-quality development needs of enterprises. In this paper, the concepts of "systematization" and "integrality" are introduced. From the source of alumina production to the production process and emission, the ways of energy saving and carbon reduction are discussed.

**Keywords:** Dual Carbon Strategy, Alumina production, Energy saving, Carbon reduction, Emission reduction.

## 1. Introduction

In September 2020, China clearly proposed the goals of "carbon peaking" by 2030 and "carbon neutrality" by 2060. The launch of the "Dual Carbon Strategy" is conducive to promoting the efficient promotion of energy conservation and consumption reduction work, and guiding the rapid implementation of green innovative technologies. As a high energy consuming industry, alumina production's carbon emissions are also an important influencing factor in promoting the "Dual Carbon" standard in the future. Up to now, there is no clear way to reduce carbon in this industry. Today, when a Low-carbon economy is advocated, the industry only has to change its ideas, establish a systematic awareness of energy conservation, actively adopt effective energy-saving technologies and measures, and effectively achieve the goal of sustainable carbon reduction by introducing green energy.

## 2. Alumina Production and Energy Consumption Situation

In the past decade, China's alumina production has been increasing year by year. As of 2022, the annual alumina production was 81.5 million tonnes. From January to April 2023, the cumulative production was 26.7 million tonnes, an increase of 5.0 % year-on-year. The specific data is Shown in Figure 1 [1].

Bauxite resources in China are mainly diaspore, and the production process is high-temperature and high-pressure digestion. Its energy consumption is 407-814 kWh/t alumina higher than that of foreign Gibbsite production process. With the increasing emphasis on energy conservation, consumption reduction, and cost control of alumina, through measures such as process optimization and equipment upgrading and renovation, the energy consumption of alumina can be significantly reduced. According to the alumina energy consumption limit released in 2023, the overall limit has been reduced by 325.6 kWh/t alumina (40 kgce/t alumina) compared to before the revision. Due to the high production capacity of alumina, its total energy consumption is also considerable. Energy consumption quota of alumina is given in Table 1.

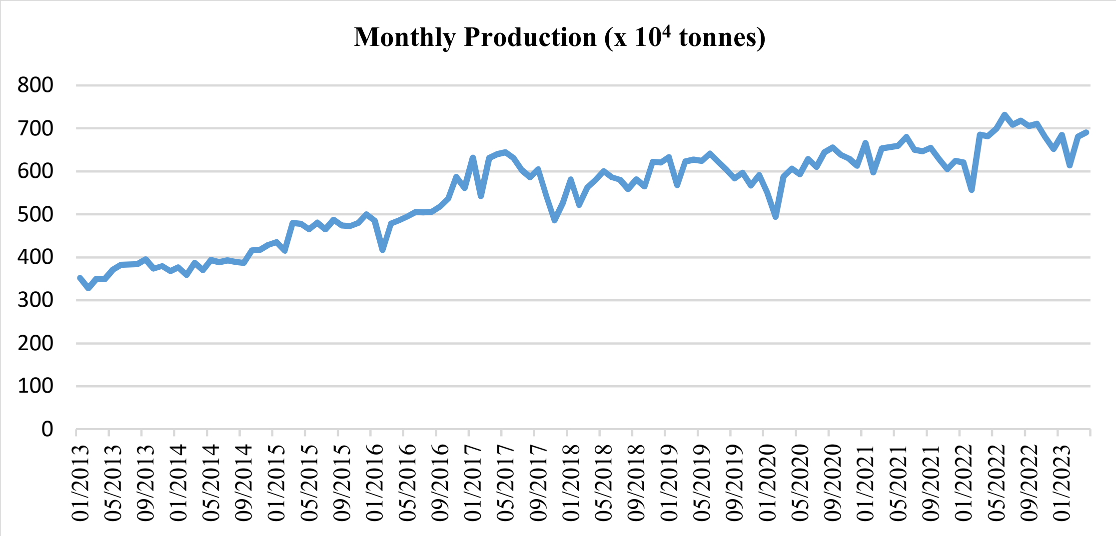


**Figure 1. Alumina production in China in the past decade.**

**Table 1. Energy consumption quota of alumina, released in 2017 and 2023 (per tonne of alumina).**

| | | Released in 2017 | | Released in 2023 | |
|---|---|---|---|---|---|
| | | kgce* | kWh | kgce* | kWh |
| Level 1 | Process energy consumption | ≤ 370 | ≤ 3022 | ≤ 330 | 2695 |
| | Comprehensive energy consumption | ≤ 400 | ≤ 3267 | ≤ 360 | 2940 |
| Level 2 | process energy consumption | ≤ 400 | ≤ 3267 | ≤ 360 | 2940 |
| | Comprehensive energy consumption | ≤ 430 | ≤ 3512 | ≤ 390 | 3185 |
| Level 3 | Process energy consumption | ≤ 470 | ≤ 3838 | ≤ 430 | 3512 |
| | Comprehensive energy consumption | ≤ 500 | ≤ 4084 | ≤ 460 | 3757 |

*kgce = kilogram coal equivalent. 1 kgce = 29.3 MJ = 8.167 kWh.

Based on the above situation, energy conservation and consumption reduction in the alumina industry have certain significance for the national "Dual Carbon Strategy.

## 3. System Energy-Saving and Carbon Reduction Thinking

The development process of the alumina industry in China is a process in which "energy consumption" is continuously optimized, such as the continuous enlargement of equipment, the continuous rationalization of process layout, and the continuous upgrading of energy-saving equipment. However, many optimizations are "dot" distribution, which is not fully considered according to the theory of "Carbon footprint". At the same time, the energy saving contribution of ancillary systems is also ignored. It should be emphasized here that the introduction of system energy conservation theory and global thinking is inevitably a revolutionary change. This requires comprehensive consideration of energy consumption and carbon emissions from the source mineral resource endowment, geographical location, resource matching, process investment, etc. In addition, utilizing exploitable resources such as land and mines in the system to implement green energy production and carbon sequestration is also an important measure for system energy conservation and carbon reduction. It should be said that the implementation of the "Carbon footprint" assessment in the alumina industry will promote the development of systematic and overall energy conservation and consumption reduction, which is also the concept that should be adhered to in the high-quality promotion of energy conservation and consumption reduction.

### 3.1 Linkage between Ore Source and Intermediate Processes

The stability of the ore indicators entering the system directly determines the stability of subsequent production indicators and the level of system efficiency. Therefore, the linkage between the ore source and the intermediate alumina production process is the focus of system thinking on energy conservation and consumption reduction. The linkage in this section mainly emphasizes the issue of ore "homogenization", which can be controlled from two aspects: mine pre homogenization and ingredient homogenization in the intermediate process. For example, a certain alumina plant in Henan has utilized its mine advantages since 2021 to reasonably match and load lower quality self-mining and higher quality purchased ore in the ore yard, homogenizing the ore with A/S between 3.5 and 7 to A/S 4.2 ± 0.4 finished ore, And enter the ore tank of the intermediate process; The intermediate process controls the A/S of the ground ore to 4.2 ± 0.1 through crushing and flat laying direct extraction processes, and the qualification rate of the indicators can reach over 85 %. This is compared to the A/S qualification rate of less than 50 % in 2020, which drives the leaching process α. The optimization of the index of k is 0.01, which contributes about 2 kg to the cycle efficiency and saves 10.6 kWh/t alumina (1.3 kgce/t alumina) of standard coal. Based on the alumina production capacity of 2 million tonnes, carbon emissions can be reduced by about 6 968 tonnes throughout the year.

### 3.2 Linkage between Intermediate Processes

The linkage of intermediate processes emphasizes the quality qualification rate and comprehensive utilization of waste heat of all output "products" between processes. For example, the batching process outputs qualified raw ore slurry for the dissolution process, the dissolution process outputs qualified dissolved ore slurry for the sedimentation process, and the sedimentation process outputs qualified semen and qualified red mud products for the decomposition process; In terms of waste heat utilization: In addition to preheating its slurry, the waste heat from the leaching process can also be used to heat the pre desilication system. The low-pressure exhaust steam generated can be used for heating the evaporation process, the unqualified water from the evaporation system can be used for settling and washing red mud, and the flue gas waste heat from the roasting system can be used for heating the flat plate washing water and heating the washing liquid alkali of the decomposition system. The linkage between intermediate processes is an important part of maximizing the utilization of energy and heat within the system, and it is also a way for the system to produce "0" for external discharge. Taking an alumina plant in Henan as an example, after implementing high- and low-pressure steam linkage and flue gas waste heat linkage, about 35 t of new steam can be saved per hour, 310 000 tonnes of steam can be saved annually, and carbon emissions can be reduced by about 89 000 tonnes.

### 3.3 Linkage between Intermediate and Auxiliary Processes

Many alumina enterprises have their power plants and circulating water treatment systems, and the energy-saving linkage effect between these two auxiliary processes and the intermediate process of alumina production is very prominent. For example, the return water of the high-pressure digestion system can replace soft water and enter the thermoelectric boiler. According to the national energy consumption calculation standard, its conversion coefficient is 0.186 kWh/kg (0.0228 kgce/kg). If the return water of 1 tonne of alumina is 0.8 tonne of water, it can directly reduce the process energy consumption by 148.5 kWh (18.24 kg of standard coal). For an alumina plant with an annual output of 1 million tonnes, it can directly save 1484.5 MWh (182 400 tonnes of standard coal) and reduce carbon emissions by about 48 000 tonnes; at the same time, it can also save energy consumption and cost for producing desalinated water. Therefore, this link requires that the higher the water return rate in the alumina dissolution process, the better, to prevent material problems caused by unstable operation or equipment, and to achieve maximum energy linkage utilization.

### 3.4 Energy Consumption and Losses of External Raw Materials

Energy consumption of each process is given in Figure 2.

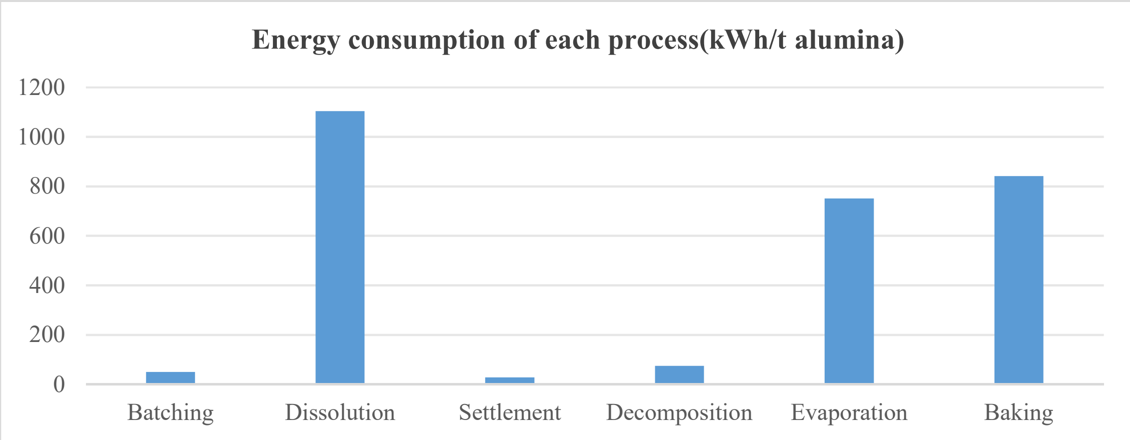


**Figure 2. Energy consumption of each process (kWh/t alumina).**

For pure Bayer process process alumina production enterprises, digestion process, evaporation process and roasting process are the main energy consuming processes. According to the current requirements of cleaner production, steam is used in digestion and evaporation processes, while natural gas is mostly used in the roasting process. The main source of steam is coal-fired boilers, especially some alumina enterprises that have their power plants. The stability of purchased coal, coal quality, and usage efficiency are the main reasons that affect boiler coal consumption.

Therefore, strengthening the stability of incoming coal and the reasonable combination of high and low heat coal are the best ways to improve boiler efficiency. How to reduce pipeline losses and improve the thermal efficiency of combustion in the roasting process of natural gas is also an important direction worth studying for energy conservation and consumption reduction.

## 4. Application of Energy-Saving Equipment and Technology

At present, there are many energy-saving technologies applied to alumina systems, both conventional energy-saving equipment and innovative low-carbon technologies, which provide conditions for the low-carbon development of alumina production.

### 4.1 Conventional Energy-Saving Equipment

In terms of system heat utilization, alumina commonly uses plate heat exchange and waste heat utilization heat exchange equipment, mainly used in the heat exchange of semen and mother liquor in the decomposition system, flue gas, and waste heat utilization in the dissolution system. The efficient operation of heat exchange equipment can effectively improve energy conservation and consumption reduction effects; In terms of system power consumption, the main power consuming devices used in alumina include motors, transformers, and low distribution systems. Energy efficiency can be improved by equipping the system with frequency converters, reasonably matching the load of transformers, and optimizing the distribution system. Of course, large-scale equipment is also a major aspect of energy conservation. For example, the leaching system for alumina production has increased from 100 000 to 200 000 tonnes/group before 2000 to over 1 million tonnes/group currently; The settlement tank has evolved from the initial singlelayer settlement tank to the current efficient settlement tank with a diameter of Ø 22 meters, and so on.

### 4.2 Innovative Energy-Saving and Low-Carbon Technologies

Innovative low-carbon energy-saving technology application for the auxiliary system:

(1) Development and application technology of high-temperature resin in thermoelectric mixed bed, which breaks the bottleneck of boiler return water requiring heat exchange and cooling to enter the mixed bed system. A high-temperature mixed bed resin that can be used for high-temperature return water at 75-85 ℃ has been developed, which can directly recover condensate water from the alumina plant's dissolution and evaporation system and enter the boiler system. A 2.1 million tonne boiler has been developed, giving annual energy savings of 40.69 GWh (5 000 tonnes of standard coal), equivalent to total carbon emissions of 13 400 tonnes;

(2) The application of RDF biomass, according to the national division of carbon emission boundaries, the combustion and consumption of biomass and urban waste are not included in the total carbon emissions. Especially for circulating fluidized bed boilers, the high adaptability of fuel can fully consider using 10-20 % biomass to replace coal, which can save considerable energy annually.

Application of low-carbon energy-saving technology in the alumina process:

1) Low temperature roasting technology. Currently, this technology is technically modified for the alumina roasting furnace, which can achieve a combustion temperature of 900-950 ℃ to complete the alumina roasting process and produce qualified alumina products. This technology is about 100 ℃ lower than the normal roasting temperature, saving more than 5 % of the total natural gas. For an alumina factory with an annual alumina output of 1 million tonnes, an annual savings of 4 million $Nm^3$ of natural gas is equivalent to a total carbon emission of 13 014 tonnes.

2) Application of green electricity technology: Currently, the country encourages the use of green electricity in carbon emissions. In the near future, the proportion of green electricity applications in high-energy consuming industries should be clarified. Therefore, utilizing solar energy, wind energy, and other green electricity will also become a way for alumina plants to achieve carbon reduction.

## 5. Green Carbon Sequestration

Carbon sequestration refers to the process of absorbing carbon dioxide from the atmosphere through measures such as afforestation and vegetation restoration, thereby reducing the concentration of greenhouse gases in the atmosphere. Based on traditional carbon sinks, ecological carbon sinks have increased the role of multiple ecosystems such as grasslands, wetlands, and oceans in carbon absorption. The process of terrestrial Viridiplantae fixing carbon dioxide through photosynthesis is called "green carbon". Forests, rivers and lakes, wetlands, grasslands, farmland, etc. belong to the "green carbon" category. One mu of forest can absorb 24.5 tonnes of carbon dioxide every year, so the carbon sink generated is 24.5 tonnes [2]. Alumina production enterprises are generally equipped with red mud dam areas or their mines. After the red mud reservoir area is closed, it can be covered with soil or undergo in-situ ecological restoration of red mud, and green plant coverage can be carried out. Similarly, the reclamation and greening of self-owned mines is also a way to implement green carbon sequestration in alumina enterprises.

## 6. Conclusion

In response to the high-energy consumption production industry of alumina, transforming production and management concepts, utilizing technological progress and systematic energy-saving thinking to comprehensively plan and optimize layout, reduce losses from large-scale raw fuel procurement, maximize production process equipment, and efficiently utilize heat, achieving low-carbon and green development is the only way for enterprises to enhance their competitiveness. In this process, "energy conservation", "consumption reduction", "green", and "sustainable" must be deeply rooted in the hearts of every alumina production operator, allowing "I want low-carbon" to replace "I want low-carbon", to truly make the necessary contributions to the national "Dual Carbon Strategy”.

## 7. References

1. The data is sourced from the National Bureau of Statistics (China).
2. According to the calculation formula for deep forest carbon sink.