Industrial Application Plan for Establishing a High-End Refractory Materials Industrial Base through Activated Roasting of Magnesite in an Intelligent Three-Ring Kiln

Project Plan Overview: The Dashiqiao area in Liaoning, renowned globally as the "Magnesium Capital of China," is one of the world's premier sources of high-quality crystalline magnesite. Currently, this valuable resource is trapped in a "low-end lock-in" dilemma. The region is home to over 1,000 traditional earth kilns (known in the industry as "reverberatory furnaces"), which are plagued by a series of problems including simple production processes, low output, high energy consumption, poor working environments, and low levels of automation. These issues are completely misaligned with current national strict requirements for energy conservation and environmental protection, as well as the urgent demand from downstream markets for high-performance materials. This extensive model not only represents a huge waste of national strategic resources but also creates a historic market window for this project plan.

This technical proposal, centered on the HNS series intelligent three-ring kiln developed by Shandong Hening Shun Kiln Industry Co., Ltd., proposes the investment and construction of a modern, intelligent, and green high-end magnesia-based refractory materials industrial base in the Dashiqiao area, with an annual processing capacity of 100,000 tons of magnesite.

Core Investment Highlights:

Disruptive Advantage in Kiln Technology: The intelligent three-ring kiln, with its technologies such as stepped calcination, closed-loop thermal energy circulation, intelligent robotic unloading, and digital twin control, can elevate the magnesite calcination process to a new level. The resulting high-activity light-burned magnesia powder (activity >95%) is of a quality far superior to that from traditional processes. The advanced kiln model is comparable to international industry counterparts like suspension furnaces and fluidized bed furnaces.

"Waste-Free" Value Chain for Ore: Through a triple cycle of "intelligent calcination/gas recovery/solid waste regeneration," the resource utilization rate of magnesite is increased to 99%. Not only is the quality of the main product significantly improved, but its by-products, such as food-grade CO_2 and solid waste derivatives (e.g., battery-grade magnesium carbonate, flame retardants), can also create enormous value, achieving a "doubling of output value per ton of ore."

Excellent Financial Model: Based on detailed calculations, a three-ring kiln project with an annual output of 100,000 tons of light-burned magnesia powder and by-products requires an investment of approximately 18.5 to 25.6 million RMB (calculated at 21.5 million). After reaching full production, the estimated total annual sales revenue can reach 45.58 million RMB, with an annual after-tax net profit of about 45.58 million RMB. Most critically, the **static investment payback period (including construction) is only 1.4 years**, demonstrating unparalleled profitability and risk resistance.

Huge Market Demand: With the transformation and upgrading of high-temperature industries such as steel, cement, and non-ferrous metals, the performance requirements for refractory materials are constantly increasing. There is strong market demand for high-quality magnesia (medium-grade, high-purity, and large-crystal fused magnesia) and high-end synthetic refractory materials represented by magnesia-alumina spinel, magnesia-calcia synthetic sand, and fused magnesia-chrome sand. This project's product matrix is precisely positioned in these high-growth, high-profit market segments.

High Alignment with National Strategic Policies: The project perfectly aligns with the "dual carbon" goals, green mine construction, and the development direction of "new quality productive forces." The comprehensive energy consumption per ton of product powder is nearly 40% lower than that of traditional rotary kilns (125 kgce/t vs. 205 kgce/t), and CO_2 emissions (including capture) are reduced by 67% (0.4 t/t vs. 1.2 t/t), offering significant social and environmental benefits.

By introducing and deploying the "intelligent three-ring kiln" on a large scale, this disruptive technology will enable the deep, high-value, and fully circular development of

Liaoning Dashiqiao's magnesite resources, completely reshaping the regional industrial ecosystem and creating a world-class high-end magnesia refractory materials industrial cluster.

This project is not only an inevitable choice in line with the national "dual carbon" strategy and industrial upgrading but also a high-quality asset with an extremely robust financial model and a very short investment payback period.

I. Market Opportunity and Industry Pain Point Analysis

1.1 Macro-level Background: The Era Calls for Industrial Transformation

Hard Constraints of the "Dual Carbon" Policy: The national "carbon peak and carbon neutrality" strategy has imposed unprecedented emission reduction requirements on the high-energy-consuming, high-polluting refractory industry. The energy consumption and emission models of traditional earth kilns have no room for survival. The only way forward for the industry is a green, low-carbon transformation.

Strong Pull from Downstream Industry Upgrades: Downstream industries such as steel, non-ferrous metals, building materials, power, military, aerospace, new energy, and new materials are transitioning towards high-quality development. This has led to increasingly stringent requirements for the purity, durability, and thermal shock resistance of refractory and insulation materials. Low-end, homogenized refractory raw materials can no longer meet market demand. High-end, customized high-purity raw materials and synthetic materials have become new profit growth points.

1.2 The "Siege" of Dashiqiao: A Huge Contrast Between Resource Advantages and Industrial Reality

The current state of the magnesite industry in the Dashiqiao area is a typical example of resource waste characterized by "high consumption and low returns."

1.2.2 Resource Advantages: The area boasts world-class crystalline magnesite with

natural mineral advantages such as high $MgCO_3$ content (90-96%), coarse crystals (50-200μm), and a moderate CaO/SiO_2 ratio, making it an ideal raw material for producing high-end magnesia materials.

1.2.3 Industrial Reality:

Outdated Equipment: Thousands of traditional earth kilns use simple and extensive production processes. They can only calcine large lumps of material, failing to ensure uniform heating and resulting in very low finished product efficiency.

Low Quality: Product quality is extremely unstable, with low active MgO content (60-75%) and high loss on ignition (3-8%). It cannot meet the demands of high-end applications and is forced into price wars in the low-end market.

Astonishing Energy Consumption: Thermal efficiency is low, and energy consumption per unit of product is high, running counter to green development.

Severe Pollution: Unorganized dust emissions create a harsh working environment and enormous environmental pressure.

Low Efficiency: The level of automation is extremely low, relying on a large amount of manual labor, which leads to low production efficiency and safety hazards.

This series of pain points has not only caused a serious waste of valuable mineral resources but has also eroded the profit margins of enterprises and damaged the brand image of the "Magnesium Capital of China." This provides an excellent entry point for us to intervene in the light-burned magnesia powder industry with advanced kiln technology and to carry out industrial integration.

II. Core Technical Solution: The Revolutionary Advantages of the Intelligent Three-Ring Kiln

The intelligent three-ring kiln technology is the "golden key" to solving all the aforementioned pain points. It is not a single piece of equipment but a complete, digitalized

process system.

2.1 Innovative Structure and Stepped Calcination

The main body of the kiln is vertically divided into three parts: a preheating zone, a firing zone, and a cooling zone. The material moves from top to bottom, while the hot gas circulates, achieving a precise division of functions in different temperature zones:

Inner Ring (Preheating Zone, 400-600°C): Utilizes the waste heat of high-temperature flue gas to remove free water and some crystal water, preparing for the subsequent decomposition.

Middle Ring (Decomposition Zone, 650-850°C): The core reaction zone where the decomposition of $MgCO_3$ is completed. The CO_2 concentration in this zone is extremely high (can reach >85 vol%), creating excellent conditions for the subsequent capture of pure CO_2 gas.

Outer Ring (Activation Zone, 900-1100°C): Through precise temperature control (±15°C), the growth of MgO crystals is regulated, and over-burning is suppressed, ensuring the production of high-activity, low-loss-on-ignition (<1.0%), and high-specific-surface-area (50-70 m^2/g) light-burned magnesia powder.

2.2 "Smoldering Homogenization" and Quality Leap

The "smoldering and homogenization" cooling process, lasting 24 to 36 hours in the lower part of the kiln, is its unique technical highlight. This process allows the residual $MgCO_3$ in the material to continue to decompose, ensuring that the final product's **loss on ignition is stably below 1%**. The product quality is stable and reliable, directly comparable to top international kiln types such as suspension furnaces, fluidized bed furnaces, sleeve kilns, and Maerz kilns.

2.3 Closed-Loop Thermal Energy Circulation and Ultimate Energy Saving

The system preheats the material in the middle ring with high-temperature flue gas

from the outer ring, then utilizes the waste gas from the inner ring for waste heat recovery (e.g., driving a waste heat boiler for power generation), ultimately reducing the flue gas discharge temperature to below 130°C. The kiln walls are made of multi-layer composite insulation materials. A series of technical measures, including waste heat circulation, rotary heat exchanger for hot air, and oxygen-enriched combustion, **increase the comprehensive thermal efficiency of the kiln to over 78%**, which is more than 30% higher than traditional kilns. The comprehensive energy consumption per ton of product is reduced to 125kg of standard coal (compared to 205kg for traditional reverberatory kilns), resulting in significant energy savings.

2.4 Intelligent Robots and Efficiency Revolution

The manual unloading method of traditional reverberatory kilns is completely replaced by the **24-hour continuous operation of intelligent robots** in the three-ring kiln. The robots sense the calcination state of the material through far-infrared sensors and precisely control the force and position of the extraction. Operating in a fully sealed environment, this not only eliminates dust and heat loss but also, on the basis of ensuring product quality, **increases the kiln's output by three to five times or more, while saving 80% of labor**.

2.5 Full-Process Digitalization and Green Production

The system integrates infrared thermal imaging, CO_2 concentration sensors, and material residence time algorithms to build a digital twin kiln control platform.

The AI quality prediction system can predict product activity (accuracy ≥95%) and loss on ignition in advance based on raw material composition and calcination parameters. All data is transmitted to the central control room in real-time, achieving the "four modernizations" management goals:

Precision in material calcination, digitalization of product quality, safety of personnel and equipment, and cleanliness of the site environment.

III. Industrialization Development Path and High-Value Product Matrix

Our strategic vision is to "achieve it all in one step, but implement in phases," with the intelligent three-ring kiln at the core, to build a circular economy industrial cluster of "one core and three chains."

3.1 "One Core": Intelligent Calcination Center

The implementing enterprise can build one or more intelligent three-ring kiln calcination centers with an annual processing capacity of 100,000 tons, serving as the heart of the entire magnesia raw material industrial cluster.

3.2 "Three Chains": High-Value Product Matrix

3.2.1 Chain One: High-End Magnesia Materials Main Chain (Core Profit Source)

Premium Light-Burned Magnesia Powder (Activity ≥96%): A direct product, priced much higher than ordinary magnesia powder.

Fused/High-Purity Magnesia (MgO ≥98%, 97.5%): Produced using premium powder as raw material through electrofusion or re-burning processes. Used for high-end magnesia raw materials, high-grade magnesia refractory bricks, and electrical-grade insulating materials. The premium ore from Dashiqiao can be directly used to produce these products.

Magnesia-Alumina Spinel Synthetic Material, Fused Magnesia-Chrome Sand, Medium-Grade Magnesia, High-Purity Magnesia, Magnesia-Calcia Synthetic Sand: Synthesized by combining high-activity light-burned magnesia powder with α-Al_2O_3 micropowder, chromite concentrate, and calcium oxide under controlled conditions (electrofusion, sintering). Used in high-tech fields such as steel ladle castables, cement kiln refractory bricks, stainless steel smelting, non-ferrous smelting of gold, silver, copper, and aluminum, transparent ceramics, advanced ceramics, and military applications. The market price is much higher than that of single raw materials.

Main Chain Product Example	Technical Path	Target Market	Raw Material Market Price (Reference)
Premium Light-Burned Magnesia Powder	Direct calcination in intelligent three-ring kiln	High-end refractory materials, chemicals	1,200 - 1,600 RMB/ton
Fused Spinel Granules, Fused Magnesia-Chrome Sand, High-Purity Magnesia, Magnesia-Calcia Sand	Arc furnace melting, re-burning in vertical kilns, high-temperature rotary kilns, intelligent three-ring kilns	Steel ladles, continuous casting components, RH furnaces, AOD furnaces, copper smelting reverberatory furnaces, high-grade magnesia refractory bricks	3,800 - 8,500 RMB/ton
Medical-Grade MgO Micropowder	Deep acid leaching + plasma purification	Medical, pharmaceutical, fine chemicals	18,000 RMB/ton
Electrical-Grade Nano-MgO Powder	Vapor deposition method (CO_2 as protective gas)	Electronics, special coatings, advanced ceramics	25,000 RMB/ton

3.2.2 Chain Two: Solid Waste Resource Utilization Chain (Cost Center to Profit Center)

Calcination Dust -> Magnesium Hydroxide Flame Retardant: Adopts wet collection + filter press technology. The product is used in building materials.

Low-Grade Tailings -> Battery-Grade High-Purity $MgCO_3$ Micropowder: Adopts ammonium salt leaching → precipitation technology. The product is used in new energy battery materials. The market price is about 12,000 RMB/ton.

Acid Leaching Residue -> Porous Ceramic Filter Material: Sintered with diatomite composite. Used in the field of sewage treatment.

3.2.3 Chain Three: Carbon Capture and Utilization Chain (Creating Value from Environmental Protection)

High-Purity CO_2 -> Food/Industrial Grade Products: Adopts pressure swing adsorption (PSA) devices to purify the decomposition gas from the middle ring to a purity of ≥99.5%. It can be sold as a food additive, welding protective gas, etc. Processing 100,000 tons of magnesite annually can recover 42,000 tons of CO_2.

IV. Project Implementation Plan

To ensure controllable investment risk and rapid cash flow return, we recommend a three-step progressive development strategy.

Phase 1 (0.8-1.5 years): Core Base Construction and Rapid Commissioning

Goal: Build an intelligent three-ring kiln production line with an annual processing capacity of 100,000 tons of magnesite and a supporting CO_2 capture system.

Main Products: Graded premium/first-grade/second-grade light-burned magnesia powder, food-grade CO_2.

Purpose: Quickly enter the market, establish a brand reputation with high-quality basic products and by-products, and generate stable cash flow to provide financial support for subsequent development.

Phase 2 (1.5-2 years): Industrial Chain Extension and Value Enhancement

Goal: Build a solid waste treatment center and a synthetic material production

line.

Main Products: In addition to the products from Phase 1, add magnesium hydroxide flame retardant, battery-grade $MgCO_3$ powder, magnesia-alumina spinel synthetic material, fused magnesia-chrome sand, medium-grade magnesia, high-purity magnesia, and magnesia-calcia synthetic sand.

Purpose: Achieve "waste-free" utilization, maximize resource efficiency, and further increase the output value per ton of ore and comprehensive profit margin.

Phase 3 (3-5 years): Advancing to the Technological Frontier

Goal: Plan for the R&D and production of cutting-edge materials.

Main Products: Explore products with higher technical barriers and larger profit margins, such as nano-grade magnesium oxide, transparent ceramics, and medical-grade magnesia materials.

Purpose: Establish a long-term technological moat for the enterprise and become a technology leader in the industry.

Core Equipment Configuration (for a scale of 100,000 tons/year)

System Module	Core Equipment	Technical Parameters/Description
Raw Material Pre-treatment	Intelligent Graded Crusher	Includes near-infrared sorting, accuracy ≥95%
Main Calcination Unit	Intelligent Three-Ring Kiln Body	Φ8.5×45m, temperature resistance 1300°C
Thermal Energy Recovery	Four-Stage Waste Heat Boiler System	Can support 3.2MW power generation

Intelligent Control	Digital Twin Central Control Platform	Includes AI temperature algorithm + accretion prediction model
Environmental Protection System	CO_2 Pressure Swing Adsorption Unit	Food-grade CO_2 purity 99.5%
Finished Product Handling	Multi-stage Cyclone Powder Collector + Micropowder Classifier	Particle size control from 40 to 2500 mesh

V. Investment Estimation and Financial Benefit Analysis

This section is based on the most detailed 100,000 tons/year project model provided in the documents, and its data is highly referential.

5.1 Total Investment Estimation

Item	**Investment (10,000 RMB)**	**Description**
Total Investment	2,150 - 2,860	Includes all costs for equipment, civil engineering, installation, etc.
Equipment Investment	1,850 - 2,560	Intelligent three-ring kiln, environmental protection, intelligent control systems, etc.
Civil Engineering & Installation	Approx. 300	Factory buildings, warehouses, supporting facilities, can be adapted to local conditions

5.2 Operating Cost Analysis (per ton of light-burned magnesia powder)

Item	**Unit Consumption**	**Cost (RMB/ton of product)**
Magnesite (MgO ≥45%)	1.8 tons	260 * 1.8 = 468
Natural Gas	85 m³	3.0 * 85 = 255
Electricity	65 kWh	0.8 * 65 = 52
Catalyst (Nano-TiO_2)	0.8 kg	80 * 0.8 = 64
Labor & Maintenance	-	80
Total	**-**	**919**

Total Annual Cost = 919 RMB/ton × 100,000 tons/year = **91.9 million RMB**.

5.3 Revenue Forecast

Product	**Annual Production/Sales**	**Unit Price (RMB/ton)**	**Annual Sales Revenue (10,000 RMB)**
Light-Burned Magnesia Powder (Weighted Avg.)	100,000 tons	1,240	12,400
Food-Grade CO_2	28,000 tons	750	2,210
Recovered Dust Flame Retardant	5,000 tons	3,000	1,500

Total Annual Sales Revenue	**-**	**-**	**16,000**

5.4 Profitability and Investment Return Analysis

Financial Indicator	**Value (10,000 RMB)**	**Calculation Logic**
Annual Sales Revenue	16,000	See table above
Annual Total Cost	9,190	91.9 million RMB
Annual Gross Profit	6,810	Revenue - Cost
After-Tax Net Profit (est. at 25% income tax)	4,558	Gross Profit 6,810 - Depreciation 2,150*8% - 16,000*13% Taxes
Total Return on Investment (ROI)	238%	Gross Profit 6,810 / Total Investment 2,860
Static Investment Payback Period (After-Tax)	1.4 years (0.6 + 0.8 years construction)	Total Investment 2,860 / (Net Profit 4,558 + Depreciation 2,150*8%)

Financial Conclusion: This is an extremely rare industrial investment project with characteristics of "high growth, high profit, and fast recovery." A 1.4-year investment payback period means the project has extremely strong cash generation capabilities and very low time risk. For any investor seeking stable and high returns, it has irresistible appeal.

VI. Risk Assessment and Response Strategies

Despite the bright prospects, we must still prudently assess potential risks.

Risk Category	Specific Risk Point	Response Strategy
Technical Risk	Fluctuation in ore composition affects product quality.	Build an intelligent raw material sorting system, grade materials before entering the kiln; use an AI dynamic formula model to adjust calcination parameters.
	Accretion may occur in the outer ring of the kiln.	Deploy an AI accretion prediction model and equip it with a sonic cleaning system for preventive maintenance.
Market Risk	Price fluctuations of main products or by-products (e.g., CO_2).	Sign long-term supply agreements with leading downstream enterprises to lock in base volume and price; for products like CO_2, a dry ice production line can be added to increase product added value and hedge against price fluctuations.
	Market acceptance of high-end products (e.g., nano-materials).	Conduct joint R&D with target customers (e.g., lithium battery separator companies) in the early stage, sign cooperation agreements, and bind the demand of leading customers.
Operational Risk	Shortage of key technical personnel.	Establish long-term cooperation with the technology provider to commission the training of the operation team; cooperate with local

		vocational colleges to establish targeted training programs.
Policy Risk	Changes in environmental protection and tax policies.	This project is highly aligned with national policy directions and is an encouraged project, so the policy risk is low. Actively communicate with the government to strive for tax incentives for high-tech enterprises, comprehensive resource utilization, etc.

VII. Social and Environmental Benefits

The value of this project extends far beyond the financial statements.

Environmental Benefits: It fundamentally solves the pollution problem of the Dashiqiao magnesite industry. Through energy saving, consumption reduction, and carbon capture, the project itself is a huge "emission reduction project." It will reduce annual CO_2 emissions by about 80,000 tons and achieve 100% resource utilization of solid waste, making a landmark contribution to the construction of a "waste-free city" in the region.

Social Benefits:

Industrial Upgrading: It will promote the transformation of Dashiqiao from a raw material production area to a new material manufacturing base, enhancing the entire region's position in the global industrial chain.

Job Creation: It will create hundreds of high-tech, high-income jobs, replacing the original high-intensity, low-skill positions.

Demonstration Effect: The success of the project will provide a replicable and scalable "Dashiqiao Model" for the industrial transformation of other resource-based

cities in China.

VIII. Conclusion and Investment Suggestions

This project, by introducing the core technology of the intelligent three-ring kiln, systematically solves all the core pain points of the Liaoning Dashiqiao magnesite industry. It perfectly combines resource advantages, technological advantages, and market demand to build a new industrial ecosystem that is high-value-added, fully circular, and environmentally friendly. Its financial model is extremely strong, and the projected 1.4-year investment payback period fully demonstrates its excellent profitability and investment security.