E HOUSE
SMART POWER SOLUTION

CEMENT MANUFACTURING · MV DRIVE INFRASTRUCTURE

Cement Industry E-House Solution

Scenario-based MV drive E-House configuration for cement manufacturing processes. MPA-200 delivers integrated VFD solutions for fans, mills, kilns, and coolers.

- IP55 Dust Protection
- N+1 HVAC Cooling
- Novec 1230 Fire
- 6.6kV / 10kV MV
- Plug & Play
- SCADA Integration

15–20%
Total Plant Energy Reduction

1.5–2.5 yr
Typical Payback Period

40–60%
Faster Deployment

MARKET CONTEXT · ENERGY CHALLENGE

Cement Industry Energy Challenge

30%

Electricity Share of Production Cost

Electricity is the second-largest cost component in cement manufacturing after fuel. A 5000 TPD plant consumes 80-120 GWh/year, costing $8-12M annually.

70%

Grinding Operations' Electrical Load

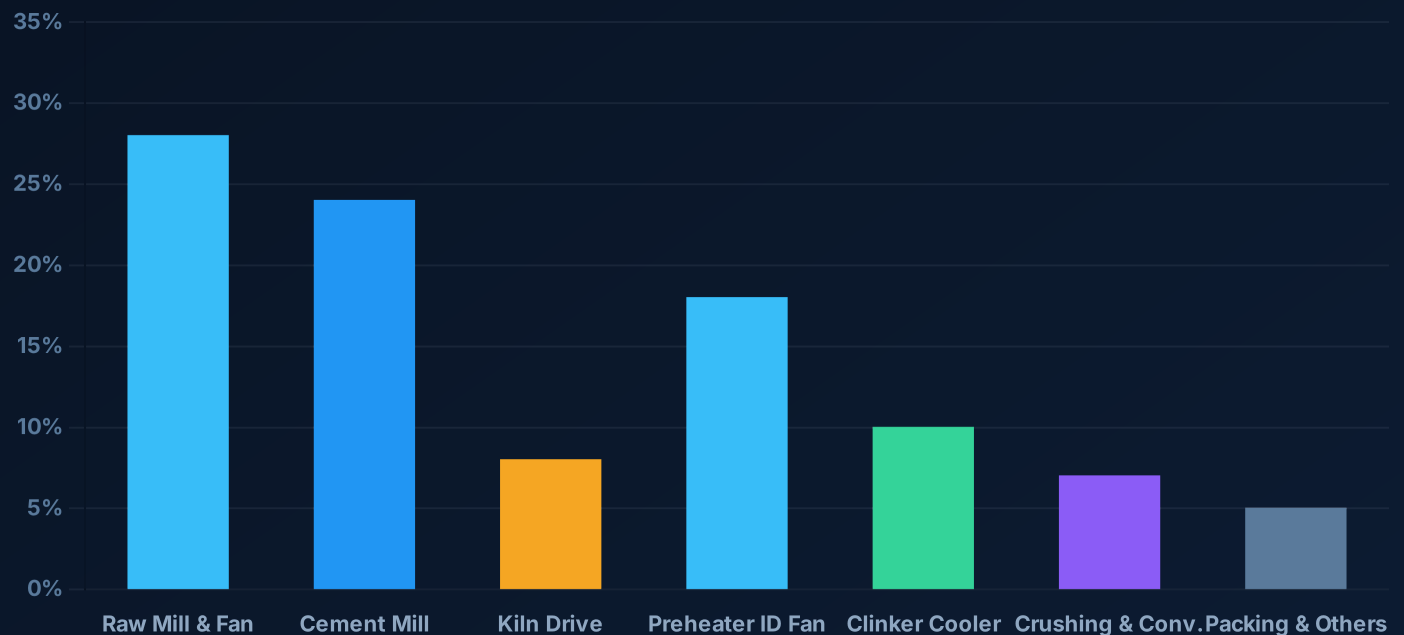
Raw mill and cement mill grinding operations dominate plant electricity consumption. These are prime targets for VFD energy optimization.

15–20%

Achievable Reduction with VFD Program

A comprehensive MV VFD deployment across fans, mills, and coolers can reduce total plant electrical consumption by 15-20%, saving $1.2-2.4M/year for a 5000 TPD plant.

ELECTRICITY CONSUMPTION BY PROCESS AREA (%)



Global Cement Industry Context

4.1B tons/yr
Global Cement Production (2024)

18% only
Efficiency Gain Since 1990

$0.08–0.12/kWh
Industrial Electricity Rate

8–12 months
Fan VFD Payback Period

Source: IEA Cement Technology Roadmap, ABB Drives in Cement

PROCESS FLOW · E-HOUSE DEPLOYMENT MAP

Cement Production Process & E-House Deployment

E-HOUSE #1

Crushing & Raw Mill

Crusher, VRM drive, Mill circulation fan

2,000–5,000 kW

E-HOUSE #2

Preheater ID Fan

Main ID fan (largest motor in plant)

3,000–5,000 kW

E-HOUSE #3

Kiln Drive

Kiln main drive, auxiliary drive

500–1,500 kW

E-HOUSE #4

Clinker Cooler

6–12 cooler fans, exhaust fan

1,500–4,000 kW total

E-HOUSE #5

Cement Mill

Mill drive, separator fan, bag filter fan

3,000–6,000 kW

5 E-Houses
Typical 5000 TPD Plant

15–25 MW
Total VFD Capacity

15–20%
Energy Reduction

$1.2–2.4M/yr
Annual Savings

PROCESS STAGE 1 · QUARRY TO RAW MEAL

Raw Material Crushing & Raw Mill

2,000–5,000 kW
VRM Main Drive Rating

E-HOUSE

Limestone Crusher — 500–2,000 kW

Primary and secondary crushers reduce raw limestone from quarry size (up to 1.5m) to <75mm feed for raw mill. Limestone hardness varies ±30% requiring speed adjustment for optimal throughput and liner protection.

Motor Type	Squirrel cage IM	**Speed Range**	60–100% rated
VFD Benefit	Soft start, torque limit	**Savings**	10–15%

Vertical Roller Mill (VRM) — 2,000–5,000 kW

Grinds raw materials (limestone, clay, iron ore) into fine raw meal (<90µm). Table speed optimization based on material moisture and feed rate enables 10-20% energy reduction while maintaining fineness targets.

Motor Type	Synchronous / IM	**Speed Range**	70–100% rated
VFD Benefit	Table speed optimization	**Savings**	10–20%

Raw Mill Circulation Fan — 1,000–3,000 kW

Provides airflow for material transport, drying, and classification within the VRM circuit. Traditionally controlled by dampers wasting 30-40% energy. VFD eliminates damper losses via cubic-law speed control.

Motor Type	Squirrel cage IM	**Speed Range**	50–100% rated
VFD Benefit	Cubic law savings	**Savings**	25–40%

E-HOUSE #1 CONFIGURATION — RAW MATERIAL AREA

PARAMETER	CRUSHER VFD	VRM VFD	FAN VFD
Rated Power	1,500 kW	3,500 kW	2,000 kW
Input Voltage	6.6 kV	6.6 kV	6.6 kV
Output Frequency	0–50 Hz	0–50 Hz	0–50 Hz
Control Mode	V/f + Torque	DTC / V/f	V/f Sensorless
Overload	150% / 60s	110% / 60s	110% / 60s
Annual Savings	$18K	$85K	$120K
Payback	2.5 yr	2.0 yr	1.0 yr

Why VFD is Critical for Raw Mill Fans

Raw mill circulation fans operate at **variable load profiles** depending on raw material moisture (4-12%), feed rate, and ambient temperature. Traditional damper control wastes **30-40% of fan energy** as heat and turbulence. The cubic power-speed relationship means even a **20% speed reduction yields 49% power savings**.

$$P_2/P_1 = (N_2/N_1)^3 \rightarrow 80\% \text{ speed} = 51\% \text{ power} = 49\% \text{ savings}$$

A 2,000 kW fan running 7,500 hr/year at average 80% speed saves **~735 MWh/year = $73,500** at $0.10/kWh. Payback under **12 months**.

$223K/yr
Combined Annual Savings (Stage 1)

7,000 kW
Total VFD Capacity in E-House #1

1.2 years
Weighted Average Payback

±30%
Limestone Hardness Variation

CRITICAL APPLICATIONS · HIGHEST ENERGY IMPACT

Preheater ID Fan & Kiln Drive

MPA-200 E-House deployed adjacent to the rotary kiln and preheater ID fan motors. Cable connections run directly to the high-power fan and kiln drive motors, minimizing voltage drop and installation complexity.

Affinity Law — Cubic Power Relationship

$$P_2 = P_1 \times (N_2 / N_1)^3$$

Reducing fan speed by 20% cuts power by 49%. At average 76% speed, the ID fan consumes only 44% of rated power — saving 56% of energy continuously over 8,000+ operating hours per year.

Preheater ID Fan

LARGEST MOTOR IN PLANT

MOTOR POWER
2,000–5,000 kW

ENERGY SAVINGS
25–45%

ANNUAL SAVINGS
$150K–$400K

PAYBACK PERIOD
8–12 months

- Eliminates damper control
- Process gas flow optimization
- Reduced mechanical stress
- Soft start capability

Rotary Kiln Drive

PRECISION CRITICAL

MOTOR POWER
500–1,500 kW

SPEED RANGE
0.5–4.0 RPM

SPEED PRECISION
±0.1% accuracy

TORQUE CONTROL
150% overload 60s

- Clinker quality optimization
- Reduced ring formation
- Extended refractory life
- Smooth speed transitions

$250K–$500K
Combined Annual Savings
ID fan + kiln drive per production line

8,000+ hrs/yr
Continuous Operation
24/7 kiln operation maximizes ROI

2–3× longer
Motor Bearing Life
Soft start eliminates 6-8× inrush

99.5%+
Drive Availability
With bypass contactor for critical fans

PROCESS STAGE 4 & 5 · COOLING & FINISH GRINDING

Clinker Cooler & Cement Mill

Clinker Cooler

Grate cooler fan array + exhaust system

EQUIPMENT	POWER RATING	VFD FUNCTION
Grate Cooler Fans	6–12 × 200–500 kW	Zone temperature control
Cooler Exhaust Fan	500–1,500 kW	Waste heat recovery flow
Cooler Vent Fan	300–800 kW	Excess air management
Total Cooler Load	2,500–7,500 kW	Coordinated multi-fan

VFD BENEFITS — CLINKER COOLING

- ✓ **Zone-based temperature control** — individual fan speed adjustment based on clinker bed temperature sensors per zone
- ✓ **20–35% energy savings** — cubic law applies to each fan; average operating point at 70–85% speed
- ✓ **Reduced thermal shock** — smooth speed transitions prevent clinker dust carryover and improve cooler efficiency
- ✓ **Extended refractory life** — stable cooling reduces thermal cycling stress on kiln nose ring

Cement Mill (Finish Grinding)

Mill drive + classifier + dedusting system

EQUIPMENT	POWER RATING	VFD FUNCTION
Cement Mill Drive	3,000–6,000 kW	Grinding speed optimization
Separator Fan	500–1,500 kW	Particle size classification
Bag Filter Fan	500–1,000 kW	Dust collection airflow
Total Mill Load	4,000–8,500 kW	Integrated grinding loop

VFD BENEFITS — CEMENT GRINDING

- ✓ **Particle size optimization** — separator fan speed directly controls product fineness (Blaine 3200–4500 cm²/g)
- ✓ **15–25% fan energy savings** — separator and bag filter fans operate at variable demand based on mill loading
- ✓ **Multi-product flexibility** — quick changeover between OPC, PPC, and PSC grades via speed parameter sets
- ✓ **Reduced over-grinding** — precise classification reduces energy waste on already-fine particles

6–12 VFDs
Cooler Fan Array
Individual speed control per cooling zone for optimal clinker temperature profile.

20–35%
Cooler Energy Savings
Cubic law savings on multiple fans running at 70-85% average speed.

15–25%
Mill Fan Savings
Separator and bag filter fans respond to variable grinding demand.

2 E-Houses
Typical Configuration
Separate E-Houses for cooler fans and cement mill due to distance and load size.

ENVIRONMENTAL PROTECTION · EQUIPMENT RELIABILITY

Cement Plant Environmental Challenges

⚠ ENVIRONMENTAL HAZARDS

Extreme Cement Dust — CRITICAL

Fine calcium carbonate ($CaCO_3$) and calcium oxide (CaO) particles penetrate standard enclosures. Cement dust becomes conductive when moist, causing short circuits and blocking cooling airflow paths.

→ Failure mode: Thermal shutdown, insulation breakdown

High Ambient Temperature — CRITICAL

Near kiln and clinker cooler zones, ambient temperatures reach 55–65°C. Radiant heat from kiln shell adds thermal load. Standard VFD cabinets derate above 40°C, losing capacity.

→ Failure mode: Component derating, capacitor aging

Corrosive Gas Atmosphere — HIGH

SO_2, CO_2, and moisture combine to form sulfuric/carbonic acid. This attacks copper busbars, corrodes PCB traces, and degrades terminal connections over time.

→ Failure mode: Contact resistance increase, arcing

24/7 Operation & Vibration — HIGH

Continuous operation with minimal shutdown windows (1–2 stops/year). Crusher and mill vibration transmitted through ground. No opportunity for routine cleaning access.

→ Failure mode: Connector fatigue, mechanical loosening

MPA-200 PROTECTION SYSTEM

Sealed Enclosure & Positive Pressure

IP55
Ingress Protection Rating

25–50 Pa
Internal Positive Pressure

All Penetrations
Sealed with IP55 Glands

Double Gaskets
All Doors & Access Panels

Multi-Stage Filtration & HVAC

G4 → F7 → Carbon
3-Stage Air Filtration

3 × 180 kW (N+1)
Redundant HVAC Cooling

28,600 m³/h
Total Air Flow Capacity

Air-to-Air HX
Heat Exchanger (No External Air)

Corrosion & Chemical Protection

Conformal Coating
All PCBs & Control Boards

Epoxy-Coated
Busbars & Connections

SS316 Hardware
External Fasteners

C4/C5-M Paint
Exterior Corrosion Class

Vibration & Continuous Operation

Anti-Vibration Mounts
All VFD Cabinet Bases

Spring Isolators
Floor-to-Frame Decoupling

Torque-Marked
All Bolted Connections

Online Monitoring
Predictive Maintenance 24/7

IP55	-5 ~ 50°C	IEC 61439	≥ 25 Years	R120
Dust & Water Ingress	Operating Temperature	Switchgear Standard	Design Service Life	Fire Resistance Rating

PRODUCT CONFIGURATION · INTERNAL LAYOUT

MPA-200 Cement Configuration

25,800 × 7,800 × 4,000 mm
Overall Dimensions (L × W × H)

E-HOUSE

3D CUTAWAY VIEW — INTERNAL LAYOUT

MPA-200 internal layout configured for cement plant applications. Showing 4× MV VFD cabinets, MV switchgear, PLC control station with dual HMI, MCC section, and overhead cable tray/HVAC ducting. Anti-vibration mounts and raised floor for cable routing.

4 × 1,800 kW
MV VFD Capacity

6 Zones
Functional Areas

1,800 mm
Maintenance Aisle

MAIN EQUIPMENT LIST (PER E-HOUSE)

NO.	EQUIPMENT	SPECIFICATION	QTY
1	MV VFD Cabinet	1800kW / 6.6kV	4
2	MV Switchgear	6.6kV, 3-panel	1
3	Transformer (Integrated)	DFE 36-pulse	4
4	PLC Control System	Siemens S7-1500 / ABB	1
5	HMI / SCADA Station	Dual redundant screens	1
6	MCC Cabinet	400V auxiliaries	2
7	HVAC System	180kW each (N+1)	3
8	Fire Suppression	Novec 1230, 2 zones	1 Set
9	Aux. Distribution Panel	400V, lighting & socket	1
10	Instrument System	Endress+Hauser sensors	1 Set

Cement-Specific Configuration

Enhanced 3-stage air filtration (G4 + F7 + activated carbon) for calcium carbonate dust. Positive pressure 25-50 Pa prevents dust ingress. Conformal coating on all PCBs. IP55 enclosure rated for outdoor cement plant environments with ambient temperatures up to 50°C.

IP55
Enclosure Protection

14–16 Tons
Approx. Weight

28,600 m³/h
HVAC Air Flow

Novec 1230
Clean Agent Fire System

IEC 61439 / 62271
Design Standards

SMART OPERATIONS · IOT · AI-DRIVEN OPTIMIZATION

Digital Energy Management Platform

IIoT-Enabled · Cloud-Connected · AI-Optimized

PLATFORM ARCHITECTURE

LAYER 4 · USER INTERFACE

Dashboards & Alerts

Web portal, mobile app, automated reports, real-time alarms via SMS/email

Web UI | Mobile | API

LAYER 3 · CLOUD ANALYTICS

AI & Machine Learning

Long-term trend analysis, predictive models, energy optimization algorithms

Azure/AWS | ML Models | Big Data

LAYER 2 · EDGE COMPUTING

Local Intelligence

Real-time control decisions <10ms, data aggregation, local buffering

Edge PLC | MQTT | OPC-UA

LAYER 1 · FIELD DEVICES

Sensors & Instruments

Power meters, vibration sensors, temperature probes, current transformers

Modbus | Profinet | 4-20mA

500+

Data Points per E-House

Sampled at 1s intervals, 43M+ records/day for comprehensive operational intelligence

Real-Time Energy Monitoring

Live kWh/ton clinker tracking, power factor, harmonics (THD), load profiles. Per-motor and per-process energy allocation with automatic benchmarking.

kWh/t Specific energy consumption tracking

Predictive Maintenance

AI-driven bearing life prediction, vibration trend analysis, thermal anomaly detection. Maintenance scheduling optimized to avoid unplanned stops.

-30% Unplanned downtime reduction

Energy Optimization AI

Auto-tuning VFD parameters based on process conditions. Load balancing across parallel fans. Peak demand management and power factor correction.

5–8% Additional savings beyond VFD baseline

Remote O&M Platform

24/7 monitoring center with remote diagnostics, firmware updates, parameter tuning. Expert support without on-site visits. Response time <15 minutes.

<15 min Remote response time

Digital Twin Simulation

Virtual commissioning before deployment. What-if scenario testing for process changes. Operator training in simulated environment without production risk.

50% Faster commissioning time

Carbon & ESG Reporting

Automated CO_2 emission tracking per ton of clinker/cement. Energy KPI dashboards for sustainability compliance. Export-ready ESG reports.

Auto Automated carbon accounting

99.5%	IEC 62443	< 10 ms	OPC-UA	24/7
System Availability (SLA)	Cybersecurity Standard	Edge Response Time	Open Protocol Standard	Remote Monitoring Center

ENGINEERING DATA · FULL PARAMETER SHEET

Technical Specifications

ELECTRICAL PARAMETERS

Input Voltage	6.6kV / 50Hz / 3Ph
Output Voltage	0 – 6.6kV (variable)
Motor Power (each)	1,800 kW
Configuration	4 × 1800kW VFD
Total Capacity	7,200 kW
Converter Type	Medium Voltage VFD
Topology	Multi-level / CHB
Output THD	< 3% (no filter)
Overload	110%/60s, 150%/10s
Control Mode	DTC / V/f / Vector
Speed Accuracy	±0.1% (closed loop)
Communication	Profinet / Modbus TCP
Efficiency	≥ 97.5%

PHYSICAL & STRUCTURAL

Dimensions (L×W×H)	25,800 × 7,800 × 4,000 mm
Internal Height	3,200 mm (clear)
Weight (approx.)	14 – 16 Tons
Structure	Steel frame + sandwich panel
Wall Insulation	Rockwool 100mm (A1)
Roof Insulation	Rockwool 100mm + membrane
Fire Rating	R120 (2 hours)
Service Door	2000(W) × 2400(H) mm
Cable Entry	Bottom entry (trench)
Foundation	Reinforced concrete pad
Min. Soil Bearing	≥ 200 kPa
Floor Loading	≥ 10 kN/m²
Maintenance Aisle	1,800 mm center

ENVIRONMENTAL & AUXILIARY

Enclosure	IP54 / IP55
Ambient Temp.	-5 ~ +50°C
Relative Humidity	5 – 95% (non-cond.)
HVAC System	3 × 180kW (N+1)
Air Flow	28,600 m³/h
Air Filtration	G4 + F7 + Carbon
Internal Pressure	+25 ~ +50 Pa
Fire Suppression	Novec 1230 (2 zones)
Fire Detection	VESDA (very early)
Lighting	≥ 500 lux (work areas)
Exterior Paint	C4 / C5-M corrosion class
Seismic Rating	Zone 2B (optional)
Design Life	≥ 25 years

IEC 61439
LV Switchgear & Controlgear

IEC 62271
HV Switchgear Standard

IEC 61800-5
Adjustable Speed Drives

NFPA 2001
Clean Agent Fire Suppression

IEEE 519
Harmonic Control

ATEX Zone 22
Dust Explosion (Optional)

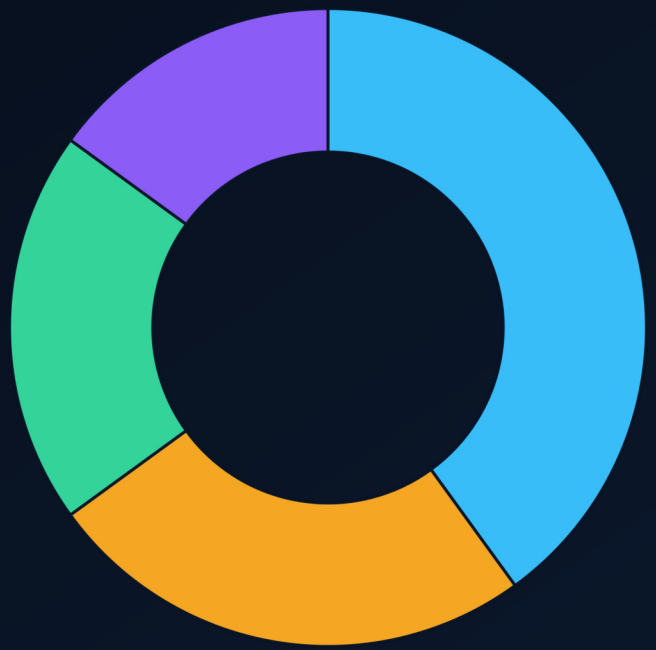
FINANCIAL ANALYSIS · 5000 TPD REFERENCE PLANT

Energy Savings & ROI Analysis

1.5–2.5 yr
Simple Payback Period

Case Study: 5,000 TPD Integrated Cement Plant · 5 E-Houses · Total VFD Capacity 15 MW · Electricity Rate $0.10/kWh

ANNUAL SAVINGS BREAKDOWN BY APPLICATION AREA



- **Preheater ID Fan — 40%**
  $360K–$480K/yr · Cubic law savings
- **Mill Fans (Raw + Cement) — 25%**
  $200K–$300K/yr · Variable demand
- **Clinker Cooler Fans — 20%**
  $160K–$240K/yr · Zone control
- **Kiln Drive & Others — 15%**
  $120K–$180K/yr · Process optimization

INVESTMENT & RETURNS SUMMARY

ITEM	CONSERVATIVE	OPTIMISTIC
Total CAPEX (5 E-Houses)	$3,500,000	$3,200,000
Annual Energy Savings	**$800,000**	**$1,200,000**
Annual Maintenance Savings	$120,000	$180,000
Avoided Downtime Value	$80,000	$150,000
Total Annual Benefit	**$1,000,000**	**$1,530,000**
Simple Payback	**3.5 years**	**2.1 years**
Discounted Payback (8%)	4.2 years	2.5 years

Key Financial Metrics (10-Year Horizon)

$4.2M
Net Present Value (NPV)
At 8% discount rate, conservative

28–42%
Internal Rate of Return (IRR)
Far exceeds 8% WACC threshold

3.5:1
Benefit-Cost Ratio
Every $1 invested returns $3.50

15–20%
Energy Cost Reduction
Total plant electricity bill

15 MW
Total VFD Capacity
Across 5 E-Houses, all process areas

$1.0–1.5M/yr
Total Annual Benefit
Energy + maintenance + downtime

8,000–12,000
MWh Saved Per Year
Equivalent to 4,000–6,000 t CO_2

≥ 20 Years
E-House Service Life
Long-term asset with residual value

Source: Industry benchmarks · ABB/Siemens VFD case studies · IEA Cement Roadmap

IMPLEMENTATION ROADMAP · RISK-MANAGED ROLLOUT

Phased Deployment Strategy

PHASE 1 · QUICK WIN

Preheater ID Fan

Months 1–6 · Highest ROI First

- Single E-House deployment near preheater
- ID fan VFD: 3,000–5,000 kW (largest motor)
- Damper elimination → cubic law savings
- Proves concept, builds internal confidence

$300K/yr Annual Savings
8–12 mo Payback Period
1 E-House Scope
25–45% Energy Reduction

PHASE 2 · SCALE UP

Raw Mill & Cement Mill Fans

Months 6–18 · Expand to Grinding

- 2 E-Houses: raw mill area + cement mill area
- Mill circulation fans, separator fans, bag filters
- Total 4,000–8,000 kW VFD capacity added
- Leverages Phase 1 operational experience

$400K/yr Additional Savings
1.5–2.0 yr Payback Period
2 E-Houses Scope
20–35% Fan Energy Reduction

PHASE 3 · FULL COVERAGE

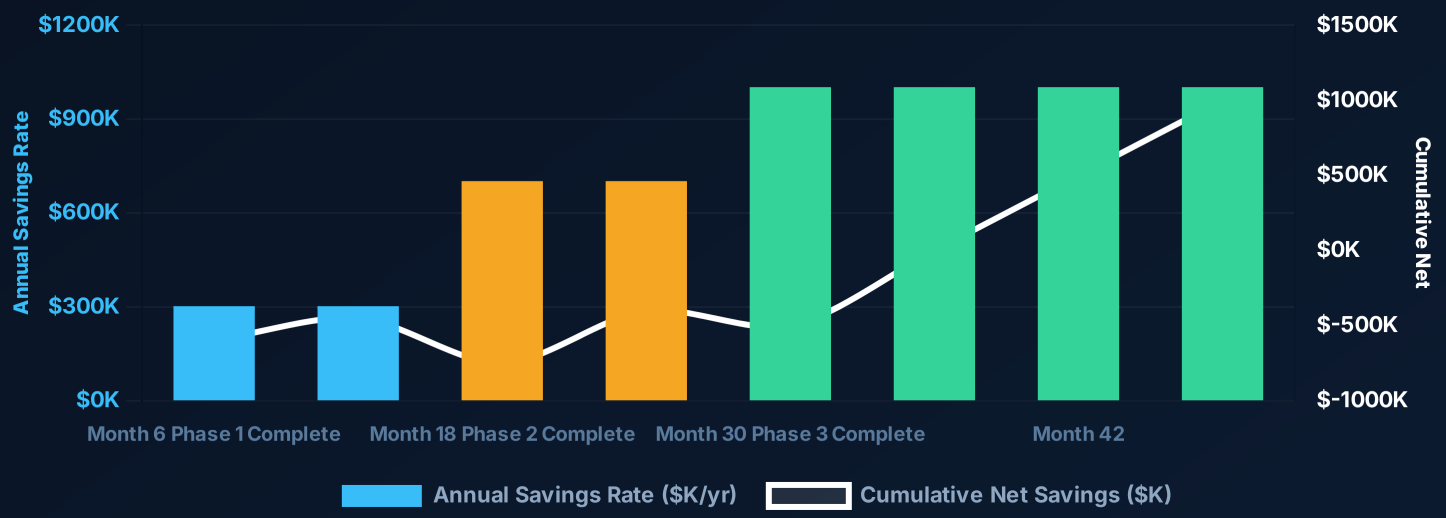
Kiln Drive & Clinker Cooler

Months 18–30 · Complete Plant VFD

- 1–2 E-Houses: kiln area + cooler fan array
- Kiln drive precision control (0.5–4 RPM)
- 6–12 cooler fans with zone-based control
- Completes full plant VFD deployment

$300K/yr Additional Savings
2.0–2.5 yr Payback Period
1–2 E-Houses Scope
20–35% Cooler Fan Savings

CUMULATIVE ANNUAL SAVINGS & INVESTMENT RECOVERY (5000 TPD PLANT)



FULL DEPLOYMENT SUMMARY

$1.0M / year
Total Annual Savings (All Phases)
Combined energy + maintenance + downtime savings across all 5 E-Houses at full deployment.

15–20 MW
Total VFD Capacity Installed
Covering ID fans, mill fans, kiln drive, cooler fans, and auxiliary systems.

30 months
Full Deployment Timeline
Risk-managed phased approach with each phase self-funding the next through proven savings.

PARTNERSHIP · NEXT STEPS · CONTACT

Ready to Optimize Your Cement Plant

KEY BENEFITS SUMMARY

All-in-One Packaged Solution
Factory prefabricated, FAT completed — plug & play on site

40–60% Faster Deployment
Reduce on-site construction from 12-18 months to 4-8 months

15–20% Energy Reduction
Across fans, mills, coolers — $800K–$1.2M annual savings

1.5–2.5 Year Payback
ID fan VFD alone pays back in 8-12 months

Cement-Grade IP55 Protection
Positive pressure, 3-stage filtration, conformal coating

COMMERCIAL MESSAGE

For cement producers and EPCs, MPA-200 reduces on-site construction time by **40–60%** while delivering **15–20% energy savings** across the entire production line — from raw mill to cement mill.

ENGAGEMENT PROCESS

1 — Site Assessment & Load Analysis
On-site survey of motor loads, electrical infrastructure, ambient conditions, and available footprint. Energy audit to quantify savings potential.

2 — Configuration Design & Proposal
Custom E-House configuration based on plant-specific requirements. Detailed ROI calculation and phased deployment roadmap.

3 — Factory Acceptance Test (FAT)
Complete system integration and testing at factory. Customer witness FAT before shipment ensures quality and reduces site commissioning time.

4 — Delivery & Commissioning
Transport, installation, cable connection, and system commissioning. Training for plant O&M team. Remote monitoring setup.

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15–25 MW	$800K–$1.2M	≥ 25 Years	5 E-Houses
Total VFD Capacity per Plant	Annual Energy Savings	Design Service Life	Typical 5000 TPD Deployment