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THE DECISION LAYER FOR COMPLEX ENTERPRISES

INSIGHT PAPER · CEMENT MANUFACTURING

From Process Variability to Decision Intelligence

Closing the Execution Gap in Cement Manufacturing

How leading cement producers are transforming operational data into faster decisions, stronger margins, and more resilient manufacturing operations.

Introduction

The cement industry has never suffered from a shortage of complexity. Every day, producers balance fuel availability, raw material variability, production targets, equipment reliability, environmental obligations, logistics constraints, and shifting market demand. Modern plants generate extraordinary volumes of information through process historians, laboratory systems, enterprise software, maintenance records, and plant control systems, yet many organizations continue to face familiar operational challenges: unstable kiln performance, rising energy costs, inconsistent quality, reactive maintenance, and mounting pressure to improve both profitability and sustainability. These pressures carry real weight: cement manufacturing accounts for approximately 7–8% of global CO_2 emissions, making operational efficiency not merely a margin question but a decarbonization imperative (Reuters, 2025; Global Cement and Concrete Association).

Over the past several decades, cement manufacturers have invested heavily in automation and digital technologies. Distributed control systems, manufacturing execution platforms, and advanced analytics have delivered meaningful improvements in efficiency and visibility. However, while the industry's technology stack has evolved, the fundamental process through which decisions are made has changed far less. Critical information remains dispersed across spreadsheets, emails, shift reports, and the experience of veteran operators. Production, maintenance, procurement, logistics, and finance teams often work within separate systems and pursue different objectives, making it difficult to develop a shared understanding of plant performance. Since 1990, the global industry has made genuine progress—improving energy efficiency by 17%, increasing alternative fuel use nearly 13-fold, and reducing CO_2 emissions per tonne of cementitious product by roughly 25% (GCCA, Getting the Numbers Right)—yet these gains have come largely through incremental process and fuel improvements rather than a fundamental change in how decisions get made.

As the industry confronts greater volatility in fuel markets, increasing adoption of alternative fuels, stricter environmental regulations, and the retirement of experienced personnel, the challenge is no longer simply one of collecting more data. The challenge is transforming operational information into faster, more transparent, and more financially informed decisions.

This paper explores why many cement organizations continue to struggle despite significant technology investments and examines how leading producers are beginning to close the gap between operational insight and execution.

> *"The future of cement manufacturing will not be defined by who has the most data. It will be defined by who can consistently turn information into faster, more transparent, and more profitable decisions."*

An Industry Rich in Data but Constrained by Fragmentation

Few industrial sectors have embraced operational instrumentation as extensively as cement manufacturing. Modern plants continuously monitor temperatures, pressures, fuel rates, chemistry, emissions, power consumption, equipment health, and production throughput. Yet despite this abundance of information, many organizations continue to rely on manual processes and disconnected systems to coordinate decisions across the enterprise.

Production teams optimize kiln stability and throughput. Maintenance departments focus on reliability and asset availability. Energy managers monitor fuel efficiency and emissions. Commercial teams respond to customer demand, while finance departments evaluate costs and margins. Each function generates valuable insight, but those insights are rarely connected in a way that allows leaders to understand the broader implications of operational decisions.

The consequences of this fragmentation are often hidden in plain sight. A fuel procurement decision may appear attractive based on the purchase price alone, but it can introduce instability into the kiln, increasing energy consumption and affecting clinker quality. Maintenance teams may prioritize equipment uptime while production teams push for higher output, creating conflicting objectives that remain unresolved until performance deteriorates. Commercial commitments may require changes in product mix that carry unforeseen operational consequences.

These disconnects are not the result of poor management or inadequate technology. Rather, they reflect the reality that many of the systems used throughout the cement industry were designed to solve specific problems at different points in time. Historians were designed to collect process data. ERP systems manage financial information and inventory. Laboratory systems monitor quality. Maintenance applications track equipment interventions. Very few of these platforms were built to help organizations understand how decisions in one area influence outcomes in another.

The result is an industry that produces enormous quantities of information while still struggling to create a complete picture of operational performance.

The Hidden Cost of Process Variability

Cement plants rarely lose profitability because of a single catastrophic event. Margin erosion is far more likely to emerge through hundreds of small deviations that accumulate over days, weeks, and months. A kiln operating outside its optimal thermal envelope, a gradual increase in specific heat consumption, instability in raw meal chemistry, or higher-than-expected grinding energy can each seem manageable in isolation. Collectively, however, these deviations can represent millions of dollars in annual cost exposure.

Fuel utilization remains one of the most significant drivers of operational performance. As producers incorporate alternative fuels and navigate increasingly volatile energy markets, maintaining a stable thermal profile becomes

more challenging. Variations in coal quality, petcoke availability, biomass composition, and waste-derived fuels directly affect kiln performance, clinker characteristics, emissions, and maintenance requirements. Research from McKinsey & Company finds that cement plant operating parameters such as throughput and energy consumption can fluctuate by as much as 50% under traditional control systems—a gap that represents one of the industry's largest untapped sources of value.

Despite the strategic importance of these variables, many organizations still evaluate energy performance through retrospective reporting cycles. Monthly KPI packages and historical dashboards provide valuable information, but they do little to help operators respond to conditions as they unfold. By the time inefficiencies are identified, opportunities to improve throughput, reduce costs, or prevent quality issues have often passed.

Compounding this challenge is the industry's continued reliance on manual interventions and operator intuition. Experienced operators possess an extraordinary understanding of plant behavior, yet the growing complexity of modern cement manufacturing makes it increasingly difficult for individuals to continuously monitor every relevant signal. As seasoned personnel retire, organizations risk losing decades of process knowledge that has never been fully captured within their systems.

> *"Many cement producers have modernized their equipment and digitized their operations, yet critical decisions are still shaped by spreadsheets, emails, and institutional memory."*

Why Digital Transformation Has Not Fully Delivered

Across the global cement sector, digital transformation initiatives have accelerated. Organizations have deployed predictive maintenance models, machine-learning algorithms, energy optimization programs, and sophisticated reporting environments. These investments have generated important insights, but many have struggled to deliver enterprise-wide improvements in decision-making and execution. This is not for lack of conviction: 82% of cement producers surveyed worldwide say digitalization is "very important" to their company's future, and 76% consider it essential to meeting emissions-reduction goals, while more than half already use cloud-based digital tools without having fully optimized their operations (World Cement). The gap lies not in intent, but in execution.

The problem is not analytical capability. In fact, the industry has become increasingly proficient at building specialized models that address individual challenges. One system predicts equipment failures. Another forecasts quality outcomes. A third monitors energy consumption or emissions. While each initiative contributes value, they often remain isolated from the broader operational context.

This fragmentation creates an unintended consequence: organizations accumulate more dashboards, alerts, and analytics without significantly improving how decisions are made. When multiple issues emerge simultaneously—a spike in fuel prices, instability in kiln performance, increased maintenance risk, or a logistics disruption—leadership teams are forced to reconcile competing priorities across different systems and departments.

Too often, decisions are made through meetings, spreadsheets, and personal experience rather than through a shared understanding of operational trade-offs. Teams may understand their own constraints, but they struggle to assess the broader consequences of their actions on production, quality, cost, and customer commitments.

This dynamic helps explain why many artificial intelligence initiatives stall after successful pilot programs. Technology alone cannot overcome fragmented operating models. Without mechanisms that connect operational signals, engineering expertise, financial considerations, and organizational accountability, even the most advanced analytical capabilities remain underutilized.

The Emergence of Decision Intelligence in Cement Manufacturing

As cement producers confront rising complexity, a new operating model is beginning to emerge—one that extends beyond automation and analytics to focus on the quality of decisions themselves.

Decision intelligence is not another dashboard, forecasting tool, or optimization algorithm. It represents a structured approach to connecting operational signals, engineering knowledge, business objectives, and organizational action. Rather than viewing production, maintenance, energy management, logistics, and finance as separate functions, decision intelligence recognizes that each choice made within a cement plant affects multiple dimensions of performance simultaneously.

Leading manufacturers are increasingly adopting repeatable processes that move from observation to action in a disciplined way. Operational signals are identified and analyzed in context. Scenarios are evaluated against technical and financial objectives. Stakeholders align around the implications of potential actions before execution begins. Once decisions are implemented, outcomes are measured against the assumptions that informed them, strengthening future decision-making.

This approach reflects a fundamental shift in thinking. The question is no longer simply whether organizations have access to data. Instead, the critical issue is whether they can transform information into decisions that improve operational performance and financial results.

For executives and vice presidents of operations, this shift carries profound implications. Decisions regarding fuel strategy, maintenance interventions, production planning, emissions management, and capital investment increasingly require organizations to evaluate multiple variables simultaneously. Success depends on the ability to understand not only what is happening within the plant, but also why it is happening and which actions will create the greatest long-term value.

What This Looks Like in Practice

Consider a plant facing a sudden petcoke price spike at the same moment a kiln begins showing early signs of thermal instability. Under a fragmented model, procurement pursues the lowest-cost fuel option, production works to hold throughput, and maintenance flags a developing risk—each team acting rationally within its own mandate, with no shared view of how the three decisions interact. Weeks later, finance discovers that the

“savings” from the fuel switch were offset several times over by higher clinker rework and an unplanned kiln stop.

A connected decision framework changes the sequence, not the effort involved. The same signals—fuel chemistry, kiln temperature trends, production targets, and cost data—are evaluated together before the fuel decision is finalized, so the trade-off is visible up front rather than discovered in next month's variance report. The figure below illustrates how this connected layer sits between fragmented operational data and the outcomes that matter to the business.

This is not a theoretical exercise. When Heidelberg Materials integrated AI-driven process optimization at one of its European plants, the result was a 4% reduction in the fuel cost index and a 2% reduction in fuel-derived CO_2 emissions within the first month of continuous operation (World Cement; Carbon Re, 2024). More broadly, leading plants that have implemented Industry 4.0 technologies report gains of up to a 20% increase in production efficiency, a 15% reduction in energy consumption, and a 10% reduction in raw material waste (World Cement). The pattern is consistent: the technology delivers value once it is connected to a disciplined decision process, not before.

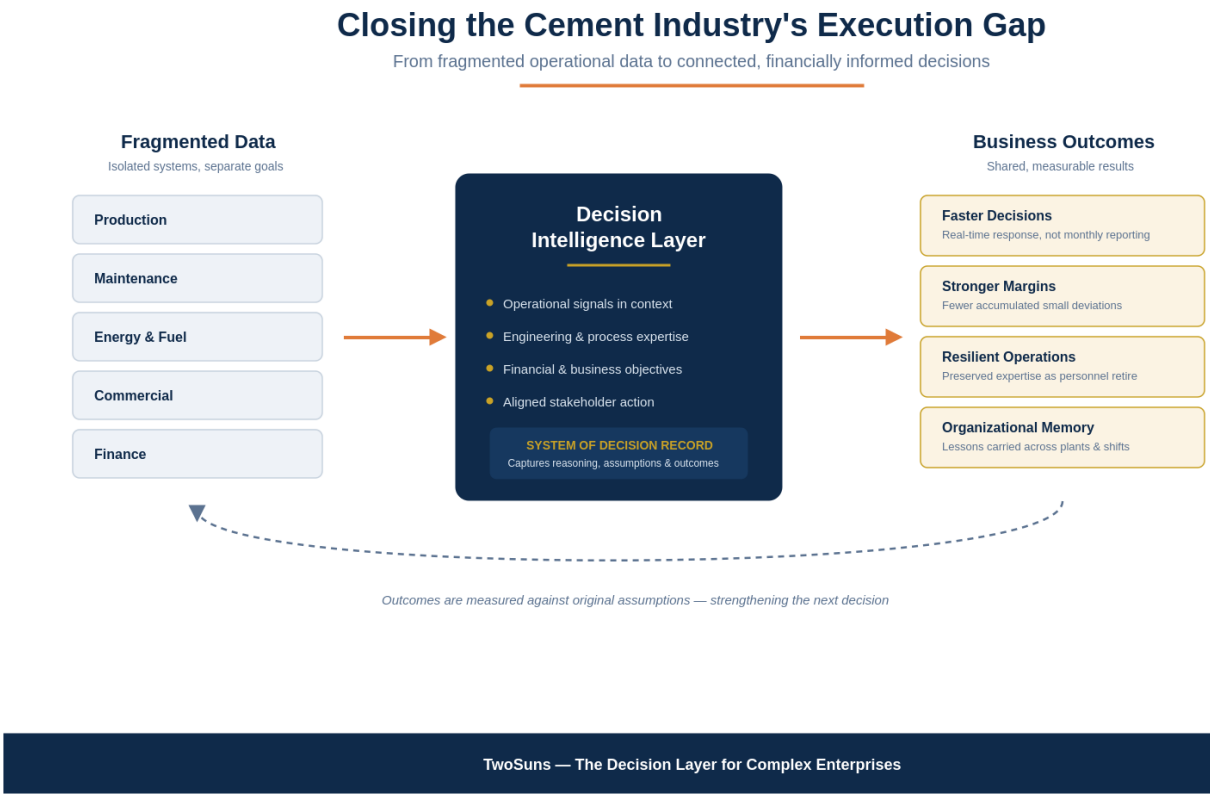

Figure 1: The Decision Intelligence Layer connects fragmented operational data to shared, measurable business outcomes.

Building Organizational Memory Through a System of Decision Record

One of the most persistent challenges facing cement manufacturers is not the collection of operational data but the organization's ability to understand, explain, and learn from the decisions made every day across the business. When a plant changes its fuel mix, adjusts production targets, postpones maintenance, or responds to a quality excursion, the technical outcome is usually visible. What is far less clear is the reasoning that led to those choices, the assumptions that shaped them, and whether the expected results were ultimately achieved.

In many organizations, the context behind critical decisions is scattered across shift handovers, maintenance logs, spreadsheets, emails, and conversations between operators, engineers, and management teams. Months later, when leadership attempts to understand why a kiln experienced instability, why costs increased, or why a particular investment failed to deliver the expected return, reconstructing the chain of events becomes difficult. The data exists, but the decision-making process itself has effectively disappeared.

This challenge is becoming more significant as cement producers navigate increasing complexity. The adoption of alternative fuels, stricter environmental regulations, volatile energy markets, and the retirement of experienced personnel are placing greater pressure on organizations to demonstrate not only what decisions were made, but why they were made and whether they created value. Investors, regulators, and corporate leaders increasingly expect transparency and accountability in high-consequence operating environments.

Forward-looking manufacturers are beginning to recognize that operational excellence depends on more than process optimization. It requires the ability to preserve institutional knowledge and create continuity between signals, analysis, decisions, actions, and outcomes. A System of Decision Record establishes that continuity by capturing the operational conditions that existed at a given moment, the alternatives that were considered, the stakeholders involved, and the results that followed.

Over time, this creates something that many industrial organizations lack today: organizational memory that extends beyond individual plants, individual shifts, and individual employees. Lessons learned from a fuel disruption in one facility can inform decisions elsewhere in the network. The reasoning behind a successful maintenance intervention can be retained rather than rediscovered. Strategic investments can be evaluated not only against financial outcomes but against the assumptions that originally justified them.

The most effective cement organizations of the future will not simply operate more efficiently. They will become better at learning from experience, preserving expertise, and improving the quality of their decisions over time. In an industry where margins are narrow and operational complexity continues to increase, that capability may prove to be one of the most important competitive advantages available.

> *“The most valuable asset inside a cement plant is no longer data alone. It is the organization’s ability to capture expertise, explain decisions, and learn from outcomes.”*

Closing the Execution Gap

The cement industry stands at an inflection point. The technologies required to collect operational information already exist in most plants. Automation systems, enterprise platforms, advanced analytics, and artificial intelligence will continue to evolve, but technology alone will not determine which producers emerge as leaders over the coming decade.

The defining advantage will belong to organizations that can connect operations, maintenance, energy management, procurement, logistics, quality, and finance into a common decision framework. Those organizations will be better equipped to respond to market volatility, optimize production networks, manage sustainability objectives, and preserve the expertise that drives long-term performance.

The objective is not to generate more dashboards or automate every decision. The objective is to build organizations capable of transforming operational information into insight, insight into action, and action into measurable business outcomes.

In a sector defined by energy intensity, capital investment, and operational complexity, the ability to consistently make better decisions may ultimately become the industry's most valuable source of competitive advantage.

ABOUT TWOSUNS

TwoSuns helps industrial organizations transform fragmented operational data, engineering expertise, and enterprise workflows into structured, explainable, and actionable intelligence. Designed for complex operating environments, the platform enables teams to evaluate operational conditions, improve visibility, strengthen collaboration, and preserve institutional knowledge across production, maintenance, energy, and business functions.

By connecting operational performance with financial outcomes, TwoSuns helps cement producers improve efficiency, strengthen margins, and build more resilient manufacturing organizations.

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