

# ERP systems specialized for the transformer sector

Standard ERPs do not fit tailor made production

## ABSTRACT

The global transformer sector faces unprecedented pressure from rising energy demands and complex grid modernization. Standard ERP systems often fail to address the specific engineering requirements of this industry, leading to significant budget overruns and instead helping manufacturers, manufacturers fit the ERP specs and feel stuck. This article

explores the limitations of general-purpose software and introduces a new way of doing things, a domain specific solution designed for transformer manufacturing.

## KEYWORDS:

transformer ERP; manufacturing excellence; digital transformation; digital twins

# The transition from a fossil-fuel-dependent economy to electrification as a network has elevated the transformer as the silent backbone of the grid

As an engineer who completed 15 years in the electromechanical sector; I'd like to remind you of the definition of the word: electromechanical. The electromechanical sector encompasses the design and production of systems that integrate electrical and mechanical engineering principles to convert, distribute, and control energy and motion. Key equipment in this field ranges from transformers and switchgear to electric motors, generators, and industrial actuators, primarily produced through complex Engineer-to-Order (ETO) and discrete manufacturing processes. I find this as a key definition: ETO, which is often called tailor-made production.

## 1. The future of the electromechanical sector

The global energy landscape is currently at the peaks of the positive

side of the sine wave. As we navigate through 2026, the transition from a fossil-fuel-dependent economy to electrification as a network has elevated the transformer as the silent backbone of the grid; from a commodity to a high-value strategic asset.

According to the International Energy Agency (IEA), global electricity demand is projected to rise by 3.7% in 2026, marking one of the highest growth rates in a decade [1]. This translates to global consumption exceeding 29,000 TWh. Mirroring this, the global transformer market is valued at approximately \$82.23 billion in 2026 (per *The Business Research Company*) and is on a robust trajectory to surpass \$137 billion by 2032 [2]. This expansion is not merely quantitative; it represents a fundamental shift in grid architecture toward higher-voltage, more efficient, and smarter units.

The rapid scaling of AI and hyperscale data centers has become a primary driver of demand, with the North American Electric Reliability Corp (NERC) forecasting a 24% increase in peak demand by 2026 primarily due to these loads [3]. Concurrently, the proliferation of electric vehicle (EV) charging corridors and the aggressive integration of renewables, which are projected to more than double in capacity by 2030, are forcing a complete redesign of distribution networks. These transformers must now handle bi-directional power flows and extreme voltage swings, transforming the manufacturing floor into a high-tech lab where ETO is the standard rather than the exception.

Beyond material constraints, the industry faces a critical skilled labor shortage. As a generation of senior winding experts and design engineers retire, there is a widening knowledge gap. Without a system to institutionalize this expertise, factories risk losing decades of proprietary craftsmanship. Furthermore, the sector is operating under the shadow of geopolitical time bombs. Ongoing trade wars, tariff signaling, and real warfare risks, including the persistent regional conflicts, have made supply chain predictability nearly impossible. In this

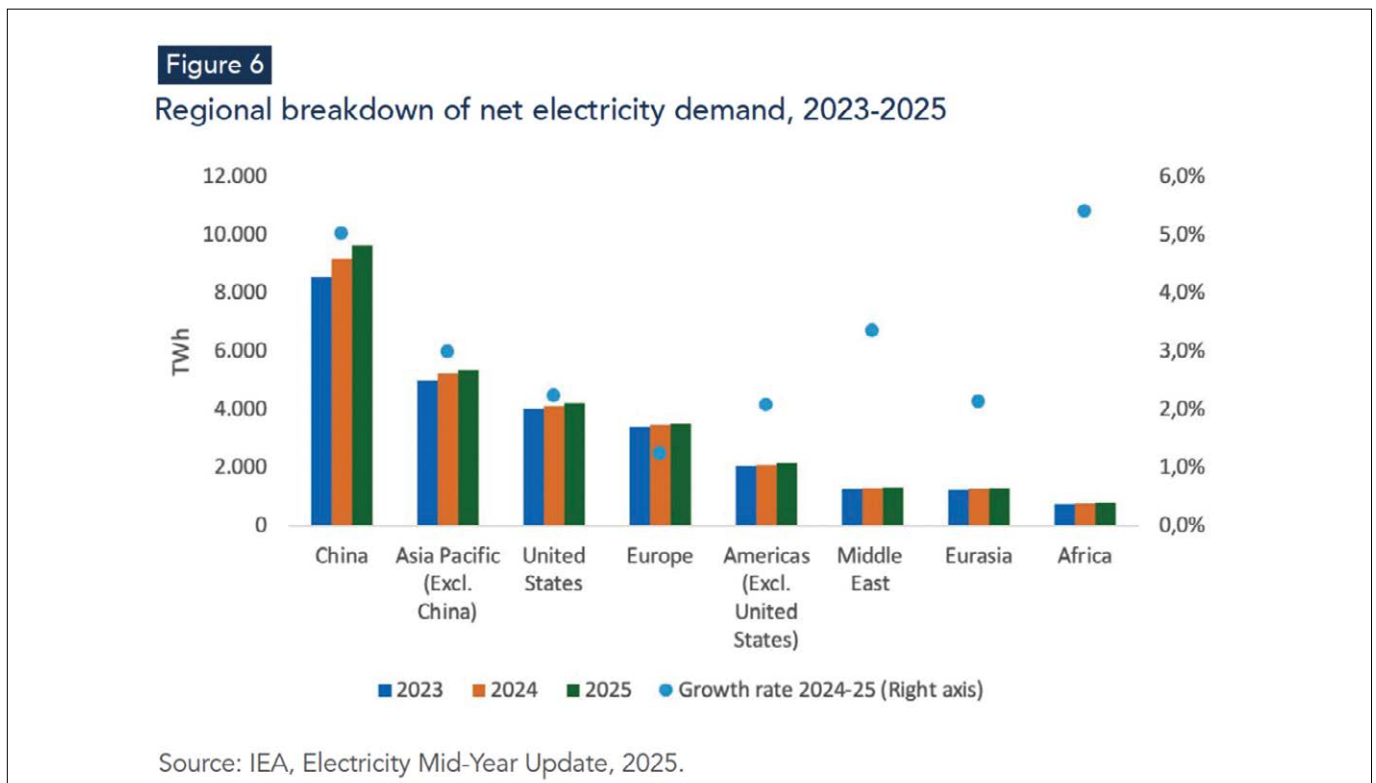


Figure 1. Energy demand in regions [1]

environment, manufacturers are not just building transformers; they are managing a high-stakes logistics and engineering puzzle where a single missing component can halt a multi-million-dollar project.

While many manufacturers of transformers and electromechanical components respond to this demand by scaling physical assets like new winding machines, they often fall into the Complexity Trap. This occurs when variety-induced complexity (the explosion of unique Bill of Material (BOM)'s and custom designs) leads to a loss of transparency and a significant drop in efficiency. Studies indicate that complexity costs can account for up to 25-40% of total manufacturing costs [4].

A specialized ERP system could serve as the antidote to this trap. It bridges the knowledge gap by digitizing the tribal knowledge of senior staff into repeatable digital workflows. By providing a single version of truth that accounts for geopo-

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litical supply fluctuations and specialized labor availability, a domain-specific ERP ensures that scaling production does not lead to operational paralysis, but to a sustainable, data-driven competitive advantage.

### 2. The failure of general-purpose ERPs in heavy electrical manufacturing

The industrial landscape of 2026 is littered with the remnants of failed ERP

implementations. For a transformer manufacturer, selecting a software partner is always risky. Data from 2025-2026 industry audits reveal that while average ERP failure rates across all sectors hover around 50%, discrete manufacturing, specifically the transformer sector, sees a staggering 73% failure rate in meeting primary project objectives [5]. This failure is driven by a fundamental paradox: the attempt to force a non-linear, engineering-led process into a linear, retail-centric software mold.

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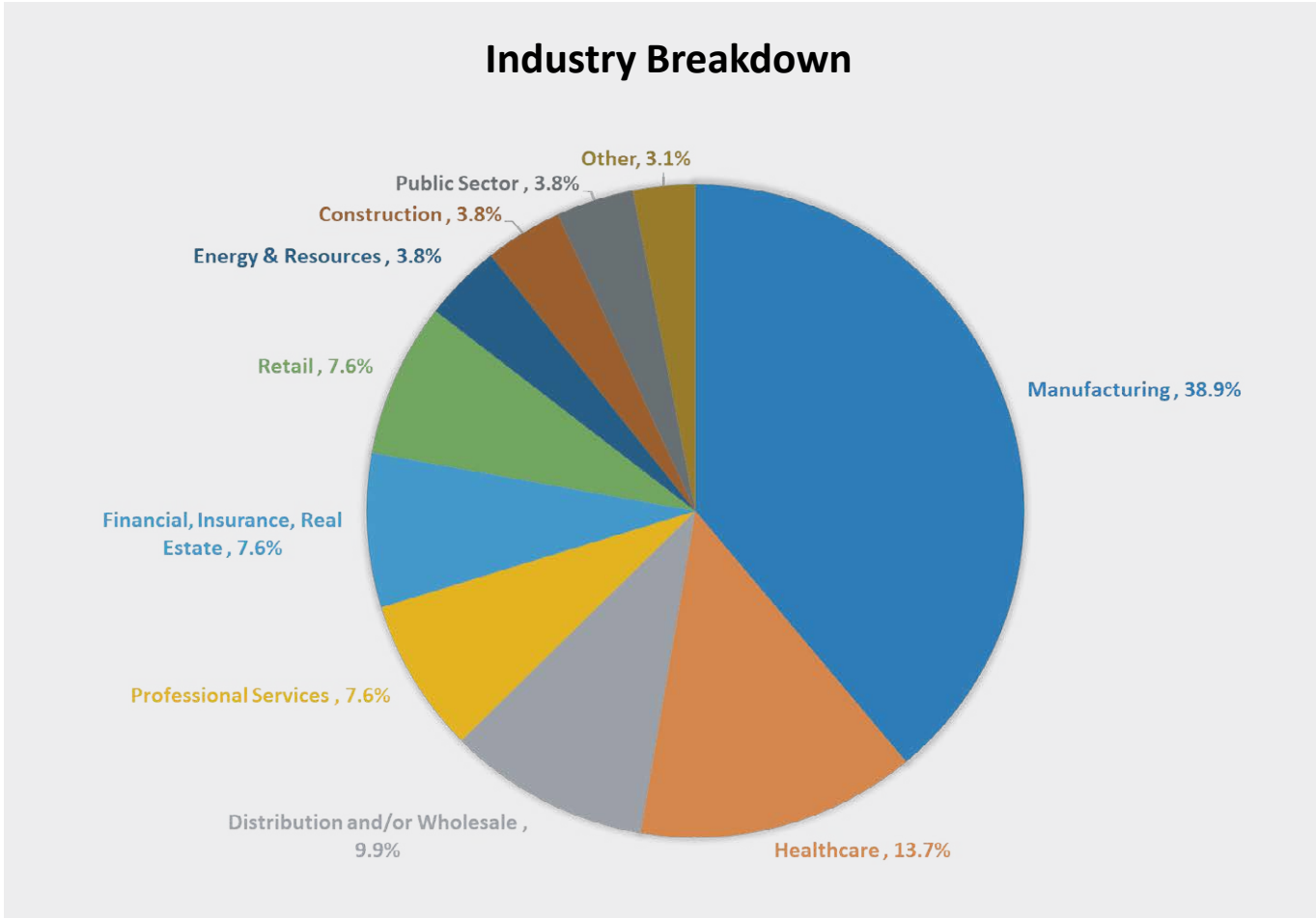


Figure 2. ERP usage industry breakdown [6]

## Over-customized systems become frozen in time in our very fast changing and updating world

Most Tier-1 ERP systems (such as SAP or Oracle) were architected for repetitive manufacturing or high-volume discrete assembly. These systems rely on static Bills of Materials (BOM) and fixed routing in manufacturing. However, transformer manufacturing is almost exclusively Engineer-to-Order (ETO).

In a transformer factory, no two 100 MVA units are identical; variations in cooling systems, tap changer specifications, and specific loss requirements mean the BOM is alive until the final design freezes. Generic ERPs struggle with this fluidity, often requiring engineers to manually re-enter CAD data into the ERP; a process that introduces human error and creates massive data silos. When designs change mid-production, these systems lack the agility to update

procurement and shop-floor instructions instantly, leading to costly re-works and material waste.

When a generic ERP fails to meet the specific needs of a transformer plant, the standard response is heavy customization. While customization appears to be a solution, it frequently leads to technical debt. Over-customized systems become frozen in time in our very fast changing and updating world. The core code has been heavily modified in these systems; the manufacturer cannot easily upgrade to newer versions of the software without breaking the custom logic. This leads to Upgrade Paralysis, where companies remain on 10-year-old software because the cost (time, effort and money) of re-customizing for an update is prohibitive.

The financial fallout of this path is severe. Research indicates that for every dollar spent on software licenses in heavy manufacturing, an additional \$3 to \$5 is typically spent on consultants [6]. In the transformer sector, average budget overruns have reached 215% of the initial quote, largely due to consultants needing to learn electromechanical business on the client's dime [7].

The path to go-live is often much longer than anticipated. Generic implementations in this sector are frequently delayed by 30% or more due to data migration [8]. Moving decades of complex transformer design history and material specifications into a system that does not understand silicon steel grades or harmonic loss calculations requires thousands of man-hours of manual mapping. The paradox is that by the time a heavily customized system is finally ready, often 12 to 18 months behind schedule, market conditions or the factory's technical requirements have evolved [6]. The result is a system that is functionally obsolete upon arrival, having already drained the company's capital and management focus.

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Perhaps the most critical failure point is user adoption. If an ERP is designed by IT

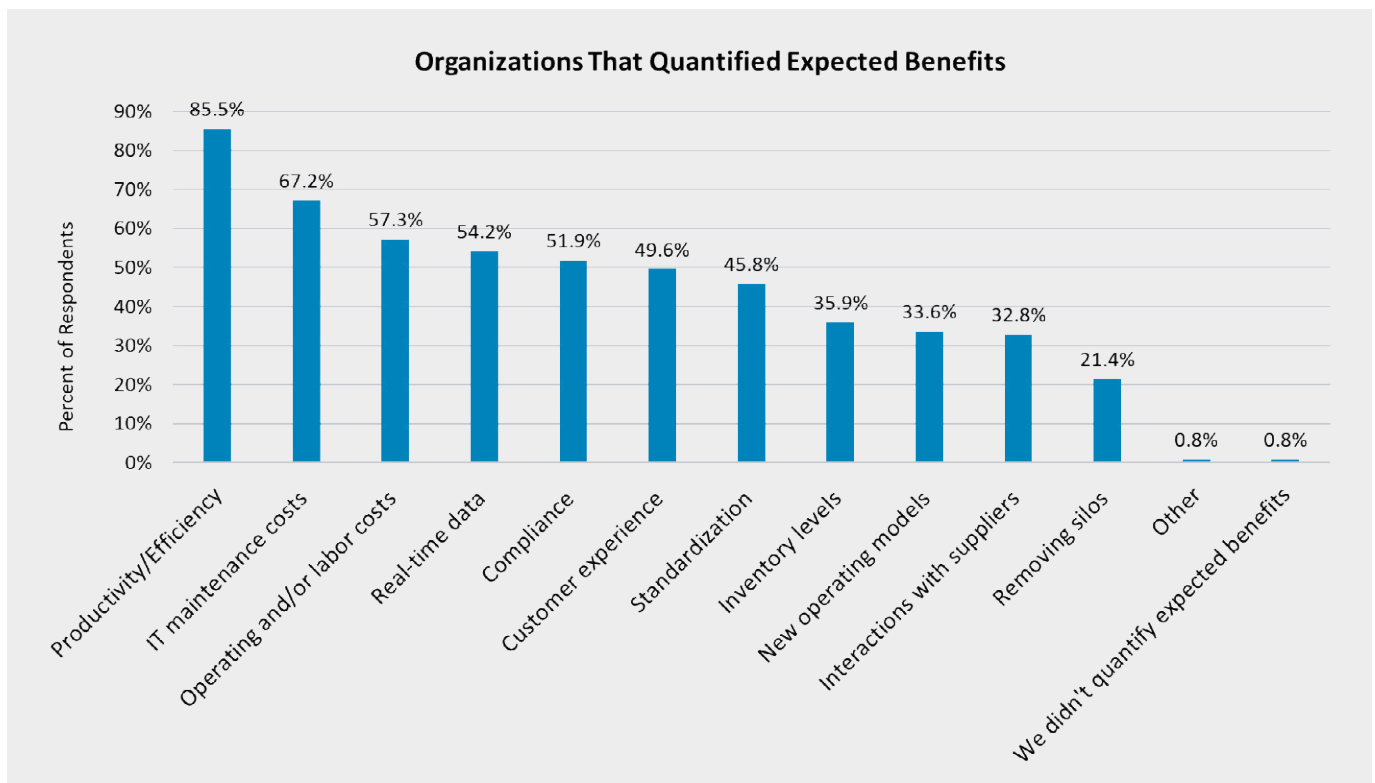


Figure 3. ERP expectations [6].

generalists, the winding technician or the test lab engineer will find the interface unintuitive. They will naturally revert to Shadow IT: the spreadsheets and paper logs that the ERP was supposed to eliminate. This creates a data vacuum where the single version of truth is lost. Without traceability, if a failure occurs during a Routine Test, the manufacturer lacks the digital DNA to trace the issue back to a specific batch of insulation paper or a particular operator's shift, leaving the company vulnerable in a high-demand, high-liability market.

### **3. A paradigm shift in transformer ERP design**

The friction between generic ERP capabilities and the high-precision requirements of transformer manufacturing necessitates a domain-specific architectural approach. To mitigate "technical debt" and accommodate the non-linear workflows of the electromechanical sector, a specialized ERP architecture must integrate eleven core functional dimensions.

#### **3.1 Sales and CRM: Technical RFQ management**

Unlike discrete manufacturing for retail, transformer procurement begins with complex technical specifications. A specialized system must allow for the direct input of electrical parameters (voltage levels, MVA ratings, loss capitalization values) during the bidding phase to ensure that commercial quotes are synchronized with actual design feasibility and current production capacity. This module should cover standard CRM abilities, such as success factors to move engineer focus on right direction, AI based technical schedule reading could reduce mistakes and shorten time for schedule to design. Additionally, sales team should update prices that have passed offer validity, without help with design. Optimization points could be changed but to reduce time for price update, a quick calculation could help to inform customers faster. An alert system should help sales engineers to update their requests; reminders offer validity dates and other milestones during a tendering/sales process. This tool must be integrated with e-mail clients since many connections are done with e-mails and calendar integrations.

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Mobile reach to app and database is also crucial for mobile sales teams. Such tools must come with built-in segmentation for customers, such as EPCs, distributors and other groups, that create base for data. Maybe the best ability of such tool must be automated technical data schedule for transformer parameters. When all data is in the ERP, creating a data page should be automated and revisions could be followed and updated easily.

#### **3.2 Engineering (CAD/PDM): The CAD-to-BOM synchronizer**

The transition from Engineering to Production represents a significant bottleneck. A technical ERP must feature native integration with CAD/PDM environments. By automatically extracting design data to generate a Dynamic Bill of Materials (BOM), the system ensures that mid-cycle design revisions are propagated to procurement and the shop floor in real-time, eliminating manual entry errors. This part of ERP is the DNA of the transformer, since all critical data will be stored there. When design is finished, data will automatically flow to purchasing department, with standard forms of equipment manufacturers, order sheets will be created in seconds.

#### **3.3 Procurement & SCM: The LME-aware engine**

Transformer materials like copper and silicon steel are highly volatile. This module includes LME (London Metal Exchange) Price Indexing, allowing procurement teams to adjust purchase orders based on real-time market rates. It also manages specialized sub-suppliers for components like Bushings and Tap Changers with long-lead-time tracking. Many transformer manufacturers have partly in-house manufacturing for core, tank and some other activities. When capacity is available at these plants and data is strong, it must be easy to calcu-

late costs and perform a make or buy analysis. Developing suppliers is also a key process to perform this systematically; continuous improvement must be followed with scorecards, together with quality management. Stock management and framework agreements with sub-suppliers should also be managed there. Reservations for long-delivery parts and KANBAN-based stock management for standard products could also be managed in this module.

#### **3.4 Inventory management: Batch and lot traceability**

Dielectric integrity requires stringent material control. The architecture must support inventory management at the lot level, linking specific batches of insulation oil or crepe paper to their respective laboratory Certificates of Analysis (CoA), ensuring 100% material "DNA" transparency. 3D map of storage areas will lead to easy finding of stored materials in shop floor and together with other modules, following critical stocks with KANBAN must be a part of this tool. Instead of supplying material from the storage one by one, creating kits (sets) that cover specific operation will reduce the time needed to look up the material, which will help to reduce manufacturing time.

#### **3.5 Production planning: Multi-level ETO scheduling**

Managing a 100 MVA transformer requires coordinating disparate manufacturing paths. The scheduling logic must synchronize winding, core stacking, and tank fabrication to converge at the final assembly stage, accounting for the unique constraints of each sub-process. It is not easy to schedule such physical equipment, with changing sizes and thousands of different sub-products. Smart MRP systems should cover all workshops, from mechanical plants to core manufacturing, final assembly and test laboratories.

## To ensure compliance with international standards, the system should pull raw data directly from power analyzers

### 3.6 Shop floor (MES): Granular manufacturing execution

The heart of the factory is the winding shop. This module provides Real-Time Tracking of winding turns, tension levels, and operator performance. It also integrates oven and Vapor-Phase (VPD) systems to log temperature and vacuum profiles against specific serial numbers, ensuring the digital fingerprint of every unit is captured. Paperless manufacturing is possible for transformer manufacturers. With QR codes, following up the product from warehouse entrance to the shipping of the complete unit creates reliable and transparent manufacturing.

### 3.7 Quality control: The digital test lab

To ensure compliance with international standards, the system should pull raw data directly from power analyzers. This automates the generation of Factory Acceptance Test (FAT) reports, comparing measured losses against theoretical design calculations without manual data manipulation. Not just FAT data, but internal test during manufacturing (such as resistance measurement of windings etc.) should be logged in the ERP. This could help with early warnings and statistical process control. Nonconformities should be created easily and following up this report with corrective actions is a key skill for a customized ERP.

This module could also serve as a sustainability pillar, which could follow the carbon footprint in manufacturing and calculate carbon emissions for the product and production. This will create a base for a Digital Product Passport (DPP), will help manufacturers that export to the EU.

### 3.8 Project management: Tracking long-cycle projects

Every transformer is a project. This module provides a high-level view of

milestones, from design freeze to final shipping. It monitors critical path delays, allowing management to see how a delay in a component like a radiator will impact the delivery date months in advance. Milestones of a project will be followed there, approvals for design and customer comments should be integrated into the system. Especially, tender and production cost comparison is key for factory success. Customer satisfaction is another important piece of feedback that every manufacturer should follow closely.

### 3.9 Plant maintenance: Specialized asset care

A transformer plant relies on specialized machinery: core cutting lines, foil winding machines, and vacuum pumps. This module schedules predictive maintenance based on actual machine cycles, reducing unplanned downtime that can halt an entire production line. Digitally logging all machinery, hand tools and equipment will help operation to continue smoothly. Predictive maintenance and calibration management must be key skills for such a tool. Critical stock management for machinery will help safe manufacturing in these busy times for the transformer sector.

### 3.10 After-sales service: Lifecycle and warranty tracking

The relationship with the customer doesn't end at the gate. This module tracks the transformer's field performance, managing warranty claims, maintenance contracts, and spare part history. A "feedback loop" is established by maintaining the "as-built" record through the after-sales phase. Field failures are cross-referenced with production and design data to identify engineering trends and optimize future iterations. Operations in site, mobile reach to the ERP, warranty governance, spare part ordering and field staff management are critical parts for this module.

### 3.11 Tra-Pulse (Executive decision support panel)

The most critical and visionary component of the new ERP architecture could be an executive decision support panel designed to overcome the limitations of standard costing and reporting that often lack the pulse of both the factory floor and the global market. Serving as a high-level Business Intelligence (BI) nerve center, this module could synthesize complex operational metrics such as real-time Overall Equipment Effectiveness (OEE) and technical test success rates with high-precision financial data, including detailed analyses of raw material cost and efficiency variances driven by the LME Effect and granular project profitability. Lifetime expectancy is also a parameter of this module. By utilizing engineering-focused visualization techniques tailored specifically for electromechanical decision-making, the system transforms abstract data into actionable insights. Furthermore, historical reporting by incorporating a sophisticated simulation layer that leverages current production loads and material stocks to generate future projections effectively empowering executive leadership to move away from subjective forecasting and ground their strategic decisions in verified, multi-dimensional technical and financial data.

## 4. ROI and the future of manufacturing excellence

As we navigate the complexities of the 2026 electromechanical market, the transition from managing production to engineering information has become the primary driver of competitive advantage. For the transformer manufacturer, the implementation of a domain-specific system is no longer a back-office upgrade; it is a strategic investment in operational resilience and long-term profitability.

The financial justification for moving away from generic ERPs is rooted in measurable efficiency gains. Based on current 2026 industry benchmarks for specialized manufacturing ERP deployments, organizations typically realize:

- **25% reduction in indirect labor costs:** By automating the transfer of CAD data to production and the gen-

eration of test reports, engineers and QC staff can redirect their expertise toward high-value design optimization rather than manual data entry.

- **35-40% improvement in material variance accuracy:** The procurement logic and precise batch tracking eliminate the ghost inventory and material waste that typically account for 3% to 5% of annual revenue leakage in standard factories.
- **Accelerated order-to-cash cycles:** By eliminating the information bottlenecks between the design office and the final Factory Acceptance Test (FAT), manufacturers can reduce lead times by an average of 15%, a critical factor in a market defined by urgent grid modernization needs.

One of the most profound advantages of a native industry configuration is the elimination of Technical Debt. Unlike generic systems that require millions of lines of custom code, rendering them impossible to upgrade, such specific ERP could evolve with the industry. When international standards or company procedures are updated, the software logic is updated at the core, ensuring that your factory remains compliant without the need for expensive consulting interventions.

As discussed in Chapter 1, the industry faces a critical expertise gap. ERPs could act as a Digital Knowledge Repository. By embedding the tribal knowledge of senior winding technicians and design engineers into repeatable digital workflows, the system ensures that quality and precision are maintained regardless of labor market volatility. Every unit produced adds to a digital library of designs and test results, allowing for AI-driven predictive analysis on future projects.

## 5. Conclusion

The transformer industry is at a crossroads. The surge in global electricity demand, fueled by AI data centers and renewable integration, offers a historic growth opportunity. However, this growth cannot be captured using the fragmented, spreadsheet-heavy, or over-customized legacy systems of the past. The complexity trap is the single greatest threat to a manufacturer's margins. By adopting a specialized ERP architecture, manufacturers move beyond

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simple integration; they create a digital twin of their entire enterprise. In a world where every 1% of efficiency can translate to millions in bottom-line growth, the question is no longer whether a specialized ERP is necessary, but how quickly can it be deployed to secure a seat at the table of the future global grid.

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