Autonomous trade operations: the next leap in CETRM for energy and commodities trading enterprises

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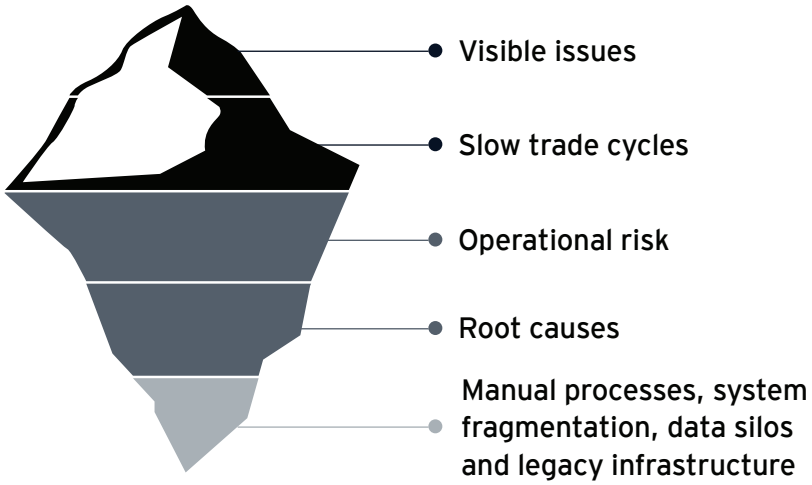
In today's rapidly evolving market, integrated companies face mounting pressure to optimize trading operations while seamlessly aligning them with origination to delivery logistics.

This white paper introduces autonomous trade operations (ATO) — an innovative paradigm that combines AI-driven decision engines, real-time asset scheduling and smart contract execution. It is conceived to revolutionize the Commodity Energy Trading and Risk Management (CETRM) landscape. Building on EY MENA's vision, this document provides a comprehensive conceptual reference architecture and a forward-looking implementation blueprint to guide future ATO adoption within integrated trading environments. While this framework outlines a powerful future state, the benefits described herein are projected outcomes based on industry analysis and conceptual design. These benefits represent anticipated advancements rather than presently realized achievements.

Industry context and the innovation gap

The commodity trading sector has traditionally lagged behind other financial services in adopting artificial intelligence (AI) and autonomous systems, despite the complexity and high-value nature of its decisions. Current Energy Trading and Risk Management (ETRM) or CETRM systems typically operate in environments characterized by reactive workflows, manual interventions and heavy reconciliation processes.



These limitations can manifest in several critical business challenges for integrated commodities and energy enterprises:

Potentially extended trade-to-cash cycles

Manual handoffs between trading, scheduling and settlement teams can create significant delays between deal execution and cash realization. Each delay could represent an opportunity cost and potentially increase working capital requirements across the organization.

Potential operational risk exposure

Human-dependent processes may introduce error potential at multiple touch points across the trade lifecycle. These errors could cascade through the system, affecting everything from position management to financial reporting and regulatory compliance.

Potential for missed arbitrage opportunities

Latency in data processing and decision-making could prevent traders from capitalizing on short-lived market inefficiencies. In volatile energy markets, even seconds of delay could transform profitable opportunities into missed chances.

Potential logistics-trading disconnects

Inconsistent integration between trading systems and physical logistics operations may create scheduling inefficiencies, suboptimal inventory management and unnecessary demurrage costs throughout the supply chain.

The innovation gap exists not from a lack of technological capabilities. Instead, it arises from the challenge of integrating advanced automation within the complex, interconnected workflows that define modern energy trading operations.

Based on industry analysis and conceptual design, bridging this gap requires a fundamentally new approach. This approach redefines how trading decisions, logistics management and settlement processes are conceptualized and executed.

Vision: autonomous trade operations (ATO)

The ATO framework represents a transformative operating model designed to enhance the governance of commodity trading and risk management within integrated energy and commodities companies. By prioritizing a human-in-the-loop governance structure, ATO promotes critical trade decisions, logistics scheduling, market exposure management and settlement processes are not only streamlined but also aligned with strategic oversight.

This paradigm shift aims to fundamentally reshape how organizations navigate the complexities of the energy and commodities markets, fostering a more agile and responsive approach to trading and risk management. With a focus on governance, ATO empowers companies to harness automation while maintaining essential human oversight, ultimately driving greater efficiency and accountability in their operations.

Real-time digital twin

Envisioned as a comprehensive virtual representation of all trade and logistics operations, designed to provide:

- Live tracking of vessels, inventory levels, logistics and transportation
- Integrated visibility into market exposure, logistics bottlenecks and P&L risk
- Continuous monitoring of physical asset conditions and operational constraints
- Predictive analytics for demand forecasting and supply chain optimization

AI-driven trade assistants

Intelligent trading algorithms and recommendation engines that are designed to:

- Suggest, execute or rebalance trades based on market conditions.
- Leverage machine learning (ML) for dynamic credit optimization.
- Automate complex deal structuring based on counterparty preferences.
- Identify cross-commodity arbitrage opportunities across global markets.

Blockchain-enabled smart contracts

Secure, automated execution frameworks that could enable:

- Automatic triggers for nominations, confirmations and settlements
- Reduced reliance on traditional reconciliation workflows
- Immutable audit trails for regulatory compliance
- Secured multiparty transaction validation and execution

The ATO model represents a potential quantum leap beyond conventional ETRM or CETRM approaches. Rather than focusing solely on transaction recording and risk monitoring, ATO is designed to proactively drive operational efficiency through intelligent automation while maintaining appropriate controls. This proposed approach aims to align trading operations more closely with physical logistics, creating a seamless, integrated value chain that can respond dynamically to market conditions.

By potentially reducing manual touch points and accelerating decision cycles, ATO is anticipated to enable integrated energy enterprises to operate with greater agility and capture more value. It will also help maintain stronger risk governance than currently possible under traditional models.

Autonomous trade operations: empowering governance through a target operating model

The success of ATO hinges on a robust target operating model that emphasizes control governance as a foundational element. This model promotes automation in trading processes and is complemented by strong oversight and accountability, driving efficiency while safeguarding against risk.

Governance framework

Establish a comprehensive governance structure integrating risk management, compliance and operational oversight. Define clear roles and responsibilities to maintain accountability at all levels of trading operations.

Control mechanisms

Implement control mechanisms that monitor automated trading activities, maintaining alignment with organizational objectives and regulatory requirements. Utilize real-time analytics and reporting tools for transparency and informed decision-making.

Human oversight

Maintain a human-in-the-loop approach where experienced professionals oversee automated processes, allowing for strategic intervention when necessary. Foster collaboration between technology and human knowledge to enhance decision-making capabilities.

Continuous improvement

Establish feedback loops to continuously assess and refine the operating model based on performance metrics and evolving market conditions. Encourage innovation and adaptability within teams to respond effectively to changes in the trading landscape.

By focusing on a target operating model that prioritizes control governance, organizations can enable successful ATO, driving efficiency while safeguarding against risk.

Key enablers for ATO operating model

Beyond technological enablers, successful ATO implementation is anticipated to depend heavily on organizational readiness and change management. Trading operations have traditionally been highly dependent on individual trader knowledge and discretion. Transitioning to a more automated model will necessitate careful attention to cultural factors and skill development.

Cross-functional teams

Dedicated teams are being established to blend trading knowledge, logistics knowledge, data science skills and technology capabilities. These multidisciplinary groups are expected to help bridge the gap between business requirements and technical implementation while fostering innovation.

Capability development

Investments are being directed toward upskilling traders and operations staff to work effectively with AI-assisted systems. The focus should be on developing higher-order skills like scenario analysis, pattern recognition and strategic decision-making that complement automated processes.

Executive sponsorship

Visible support from senior leadership is essential to overcome organizational resistance and establish appropriate resource allocation. Establishing clear metrics for measuring success and reporting progress will be key to maintaining momentum.

EY reference architecture: a vision for ATO

The EY reference architecture for ATO proposes a conceptual blueprint for organizations seeking to implement ATO capabilities within their existing technology ecosystem. This architecture is envisioned to leverage cloud-native services and secure application programming interface (API) integrations and containerized microservices to create a flexible, scalable foundation for future autonomous trading operations.

1 **Operating model and governance**	The operating model and governance would be clearly defined to enable effective oversight, accountability and decision-making. A robust governance framework would establish clear decision rights, escalation mechanisms and accountability across the organization. Performance management frameworks would then be designed with meritocracy-based structures, supported by KPI tracking and measurement systems to provide consistent and transparent monitoring of outcomes. Comprehensive change management would be embedded to support adoption, capability building and long-term sustainability. Human-in-the-loop interfaces would be incorporated to promote operational visibility, override capabilities and establish appropriate governance controls. This layer would feature role-based access control, structured approval workflows and comprehensive audit logging to meet regulatory and compliance requirements.
2 **Data integration layer**	This layer would connect to existing ETRM systems, market data feed, Internet of Things (IoT) sensors (tankers, terminals) and enterprise resource planning (ERP) systems through secure, high-throughput APIs and event streams. It is designed to implement data harmonization and quality controls to maintain consistent information across systems.
3 **Intelligence layer**	AIOps platform could be configured with EY-specific logic models for trade optimization, risk assessment and logistics scheduling. This layer is anticipated to incorporate both rule-based expert systems and advanced ML models trained on historical trading and operations data.
4 **Execution layer**	A secure smart contract infrastructure would be hosted on enterprise-grade blockchain (e.g., Hyperledger Fabric) with configurable business logic for automated trade execution, nomination processing and settlement workflows. This layer is also envisioned to include edge analytics for real-time pipeline and tank management optimization.

This conceptual architecture embraces a hybrid approach that would allow organizations to preserve investments in existing ETRM systems while incrementally adding autonomous capabilities. The envisioned reference implementation is designed to rely heavily on containerization and microservices to maintain portability across cloud environments and on-premise infrastructure.

Security considerations would be embedded throughout the conceptual architecture, with particular emphasis on securing the interfaces between traditional systems and autonomous components. The design is intended to incorporate multiple redundancies and fail-safes to aim for continuity of operations even in degraded connectivity scenarios.

Use case: crude trading and scheduling optimization

Problem statement

Crude oil trading organizations face significant inefficiencies due to systems that cannot seamlessly transition between movement-based and time-based pricing methodologies. Today, pricing triggers — such as Notice of Readiness (NOR) events — often require extensive manual updates by traders and schedulers to confirm that the correct pricing framework is applied. This dependency on manual intervention creates operational risk, slows down decision-making and reduces confidence in price integrity.

Business impact

- **Pricing inaccuracies** leading to financial exposure and increased P&L volatility
- **High operational burden** due to repeated adjustments across trading, scheduling and accounting functions
- **Delays and opportunity cost** throughout the trade lifecycle caused by inefficient, nonautomated processes
- **Weakened risk management** stemming from inconsistent and delayed pricing updates

Proposed ATO solution

A targeted ATO pilot with EY at the client's crude trading unit would introduce **intelligent pricing variables** capable of recognizing scheduling event patterns (e.g., NOR arrival) and automatically applying the correct pricing approach. This solution eliminates the need for manual rework and reduces dependency on system customization.

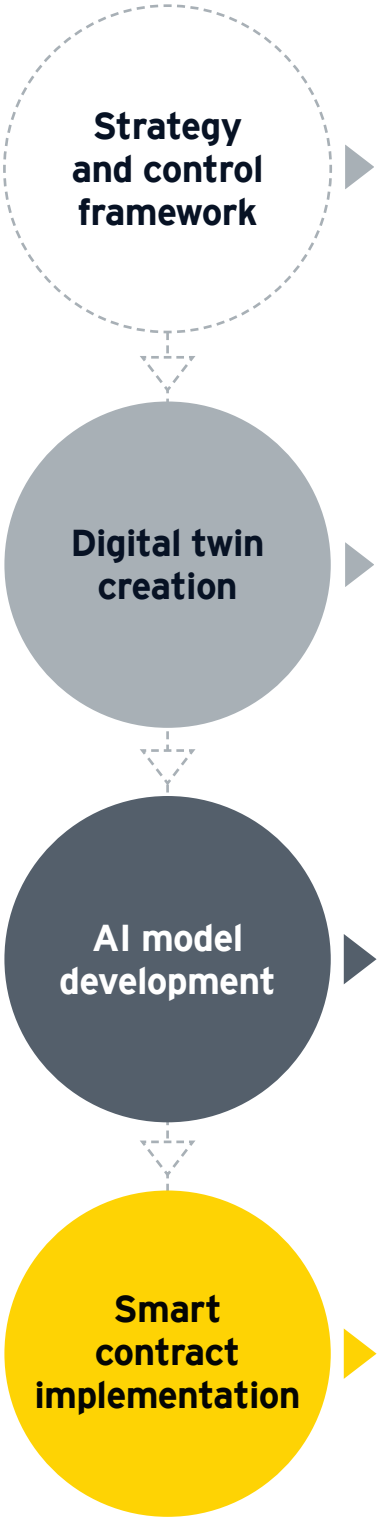
The enhanced capability would deliver:

- **More accurate and timely price calculations,** improving hedging effectiveness and risk reporting quality
- **Substantial reduction in lifecycle maintenance effort,** freeing traders, schedulers and accountants to focus on higher-value activities
- **Improved control environment,** reducing operational risk and increasing auditability

This pilot would demonstrate how automation and event-aware pricing logic can modernize crude trading workflows and unlock measurable operational efficiencies.

Use case: crude trading and scheduling optimization (contd.)

Conceptual implementation approach



Successful implementation of the solution requires a robust operating model, SOPs and comprehensive management frameworks:

- SOPs for trading decisions
- Management framework's including performance management
- Decision rights and approval threshold for autonomous vs. human controlled trades
- Escalation protocols when system encounters exceptions
- Governance structures and oversight mechanisms

Development of a comprehensive virtual representation of the crude supply chain, including refineries, terminals, vessels and inventory positions. This would involve connecting real-time feeds from vessel tracking systems, terminal operations and refinery production forecasts.

Training machine learning models on historical trading and scheduling data to identify patterns and optimization opportunities. This could include implementing reinforcement learning algorithms to continuously improve recommendations based on outcomes.

Deployment of blockchain infrastructure connecting the EY client with key terminal partners and shipping companies. This would involve developing smart contracts with configurable business logic for automated nominations and confirmations with appropriate approval workflows.

Key enablers for ATO implementation

Successfully implementing ATO is envisioned to require a coordinated approach across multiple technological and organizational dimensions. Based on EY MENA's proposed approach, the following enablers are projected to be critical for successful ATO adoption.

Category	Enabler	Description	Implementation considerations
Data infrastructure	On prem and cloud-native data lake	A unified repository for market and operational data with standardized taxonomies and access patterns	This will require careful data governance and stewardship to promote quality.
AI and ML	Reinforcement learning models	Advanced algorithms for trade recommendations, anomaly detection and continuous optimization	The strategy suggests starting with supervised learning on historical data before progressing to reinforcement learning; human oversight should be maintained.
System integration	API-first architecture	Seamless connection across ETRM, ERP, logistics and market data systems via standardized interfaces	It is proposed to leverage API gateways with strong security controls; implementing circuit breakers for resilience will be important.
Security and trust	Smart contracts via Hyperledger	Automated execution frameworks with immutable audit trails and multiparty validation	The approach indicates beginning with permissioned networks among trusted counterparties; thorough testing of contract logic will be essential.
Governance	Human-in-the-loop oversight	A framework for monitoring autonomous operations with defined guardrails and escalation procedures	This will involve balancing automation with appropriate human intervention points; creating a clear accountability model is recommended.

Strategic implementation roadmap

Implementing ATO is envisioned through a phased approach that starts with establishing the right strategy and operating model, then building visibility through dashboards, before implementing advanced automation technology.

Based on EY MENA's proposed approach, we outline a structured roadmap designed to deliver incremental value while building toward comprehensive automation capabilities.

Phase 1

Strategy and operating model (Envisioned for three months)

The initial phase focuses on establishing the foundational strategy and operating model for ATO:

- Defining target operating model for autonomous operations
- Establishing governance framework, decision rights and escalation protocols
- Developing Standard Operating Procedures (SOPs) for autonomous decision-making
- Creating performance management frameworks (meritocracy, KPIs, gamification)
- Conducting an organizational readiness assessment and change management planning
- Establishing baseline metrics for measuring improvements

Phase 2

Visibility and dashboards (Envisioned for six months)

This phase concentrates on building essential visibility and monitoring capabilities:

- Deploying real-time visibility dashboards integrating trading and logistics data
- Implementing scheduling alerts and anomaly detection systems
- Creating performance monitoring dashboards with KPIs
- Establishing data integration and API connections with key counterparties and logistics providers
- Building reporting frameworks for governance and oversight

Phase 3

Automation and technology (Envisioned for more than 12 months)

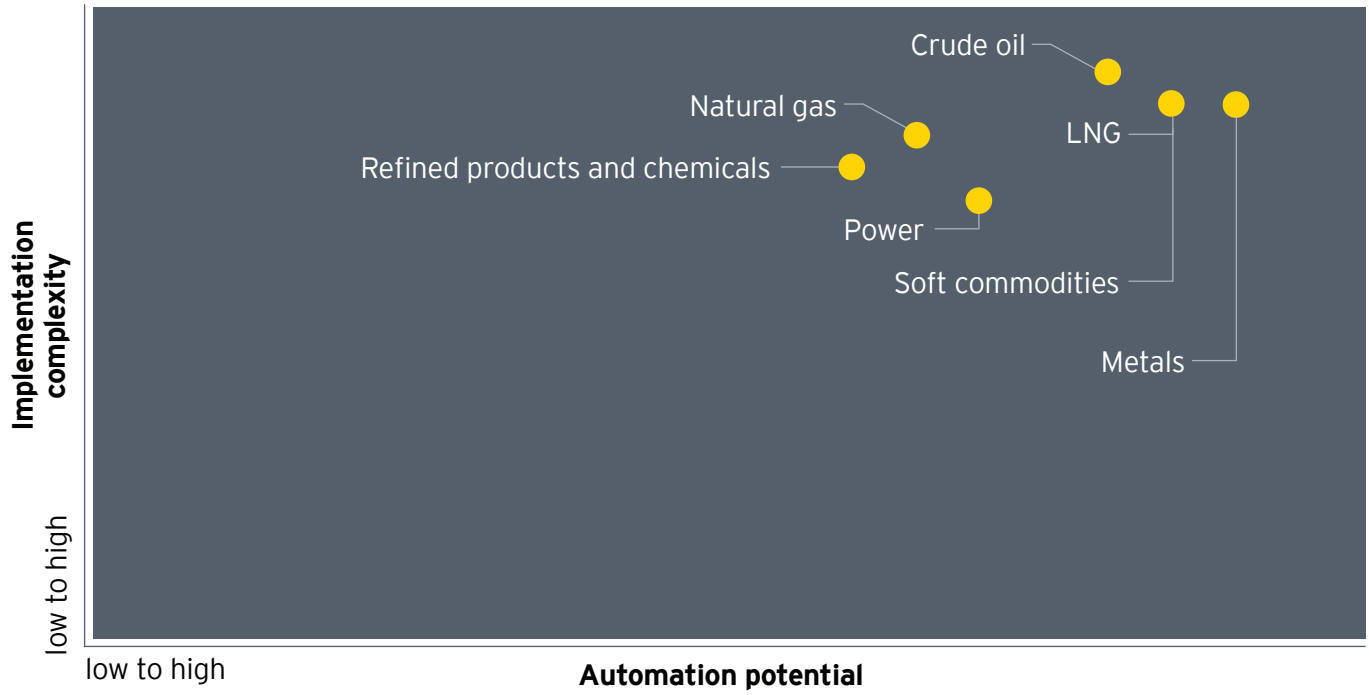
The final phase scales autonomous capabilities across the trading operation, leveraging advanced technology:

- Deploying an AI trade assistant with recommendation capabilities for specific trade types
- Implementing risk-aware deal structuring algorithms for standard transactions
- Launching a pilot blockchain network for selected trade confirmation processes and expanding smart contracts to cover nominations, scheduling and settlements
- Deploying reinforcement learning models that continuously improve based on outcomes
- Scaling autonomous capabilities with human-in-the-loop oversight
- Integrating physical asset optimization with evolving trading strategies

Implementation considerations by commodity class

The pace and focus of ATO implementation should be tailored to the unique characteristics of different commodity classes, reflecting industry analysis and conceptual design:

Outside in view of ROI potential by commodity class



Organizations are encouraged to prioritize implementation based on the intersection of projected automation potential, complexity and anticipated value impact for their specific portfolio mix. Early successes in high-potential areas are expected to build momentum and generate further investment for more challenging implementation domains.

Risks and mitigation strategies

Implementing ATO is envisioned to introduce several categories of risk that will need to be proactively addressed. Based on EY MENA's proposed approach, we anticipate key risk areas and propose corresponding mitigation strategies to maintain successful ATO adoption.

Organizational resistance

Risk:

Traders and operations staff may resist automation due to concerns about job security, reduced autonomy or skepticism about AI decision quality.

Mitigation strategy:

- Implement human-in-the-loop approach that positions automation as augmentation rather than replacement.
- Maintain transparency in AI decision logic with a clear explanation of recommendations.
- Create career development paths that emphasize higher-value strategic activities.
- Involve experienced traders in algorithm development and training.

Technical integration challenges

Risk:

Legacy ETRM systems may present integration obstacles that could limit automation potential or create data inconsistencies.

Mitigation strategy:

- Implement API-layered abstraction to isolate legacy systems.
- Adopt hybrid architecture that allows gradual migration.
- Establish strong data governance to promote consistency.
- Create reconciliation processes to validate automated outcomes.

Regulatory compliance

Risk:

Autonomous trading operations may create new compliance challenges or regulatory scrutiny around market manipulation and audit transparency.

Mitigation strategy:

- Implement automated audit logging in smart contracts.
- Build in compliance checkpoints with documented approvals.
- Engage regulators early with transparency about automation approach.
- Maintain comprehensive documentation of algorithm logic.

AI hallucination and responsible AI

Risk:

AI models may generate plausible but incorrect recommendations (hallucinations), make decisions based on spurious correlations or operate in ways that lack transparency and accountability.

Mitigation strategy:

- Establish validation layers that cross-check AI recommendations against market fundamentals, historical patterns and expert trader knowledge.
- Deploy confidence scoring systems that flag low-confidence recommendations for mandatory human review.
- Establish "AI limitations awareness" training for all users to understand when to trust vs. question AI recommendations.
- Build in circuit breakers that halt automated trading when AI behavior deviates from expected patterns.
- Document known AI limitations and edge cases where human judgment must override automation.

Responsible AI and governance

Risk:

Without proper governance frameworks, AI systems may operate without adequate transparency, accountability or ethical oversight, leading to unfair outcomes or decisions that cannot be explained or justified.

Mitigation strategy:

- Implement responsible AI frameworks with explainability requirements for all automated decisions.
- Create ethical AI guidelines addressing fairness, transparency, accountability and bias prevention.
- Implement model governance with regular audits of AI decision quality, bias detection and performance degradation.
- Maintain human oversight for high-value, unusual or complex transactions.
- Establish clear accountability structures for AI-driven decisions.
- Promote diverse stakeholder input in AI system design and deployment.

Beyond these primary risk categories, organizations considering ATO implementation should also account for the following secondary risks and corresponding mitigation approaches:

Cybersecurity vulnerabilities

Autonomous systems are projected to introduce new attack surfaces that could be exploited by malicious actors. Organizations will need to implement comprehensive security frameworks including:

- Zero-trust architecture with continuous verification
- Advanced threat monitoring specifically tuned for trading anomalies
- Segregated environments for algorithm testing and deployment
- Regular penetration testing and vulnerability assessments

Algorithm bias and drift

Machine learning models may develop biases over time or drift from their intended function as market conditions change. Mitigation will require:

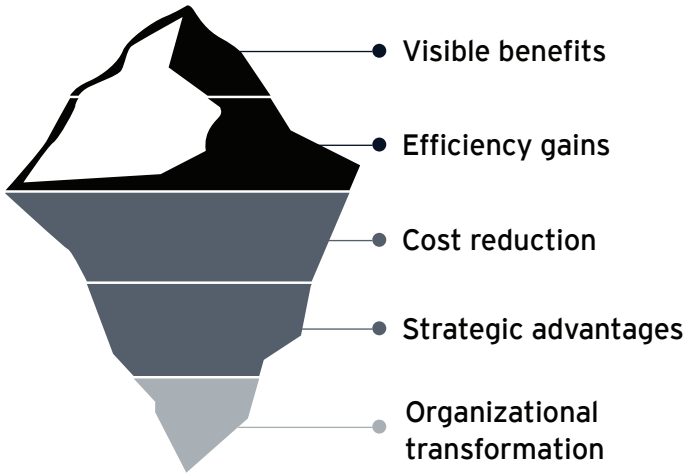
- Continuous monitoring of algorithm performance against baseline expectations
- Diverse training data that represents various market conditions
- Regular retraining and validation procedures
- Clear thresholds for human intervention when algorithms operate outside expected parameters

Effective risk management for ATO implementations is anticipated to require a cross-functional governance approach that brings together proficiency from trading, risk management, compliance, IT security and data science. Regular risk assessment reviews should be planned and conducted throughout the conceptualization and potential implementation process to identify emerging concerns and adjust mitigation strategies accordingly.

Conclusion: the way forward

ATO represents not merely a technological evolution but a fundamental reimagining of how integrated energy and commodities enterprises manage their trading activities across the value chain. As market volatility increases and margin pressures intensify, the ability to execute with greater speed, precision and intelligence is envisioned as a critical differentiator.

EY MENA's vision is that ATOs are not just a technological possibility but a strategic necessity for energy companies to thrive in increasingly volatile and complex markets. By combining EY MENA's deep operational domain knowledge with digital and CETRM knowledge, this proposed approach is designed to set a new industry benchmark for integrated trading operations.



The future of energy and commodities trading belongs to organizations that can seamlessly blend human knowledge with autonomous systems — creating an operating model that is simultaneously more agile, more disciplined and more intelligent than traditional approaches.

Next steps for industry leaders

1 Conduct an ATO readiness assessment

Evaluate your organization's current capabilities across trading, logistics and settlement processes. Identify high-value automation opportunities and potential integration challenges. Map the organizational and cultural considerations that will impact adoption.

2 Develop a strategic roadmap

Create a phased implementation plan tailored to your organization's specific commodity mix, systems landscape and strategic priorities. Balance quick wins with long-term transformation goals. Establish clear metrics for measuring success.

3 Pilot in a controlled environment

Start with a limited-scope implementation focused on a specific commodity type or geographical region. Use this pilot to validate assumptions, refine the approach and build organizational confidence in autonomous operations.

The journey toward ATOs requires commitment, investment and persistence. However, the organizations that successfully navigate this transformation are anticipated to gain substantial advantages in operational efficiency, trading effectiveness and strategic agility. In an industry where margins are increasingly compressed and volatility is the new normal, these advantages are projected to translate directly into competitive differentiation and financial performance.

By leveraging the EY reference architecture and conceptual design outlined in this white paper, integrated energy enterprises can accelerate their ATO journey while reducing risks and increasing anticipated returns. The future of energy trading is emerging — and it is increasingly autonomous, intelligent and integrated.

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