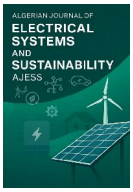
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Industrialization in Algeria: From Policy to Systems Execution

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Abstract

Algeria sits at an inflection point: abundant mineral resources, large gas reserves, strong solar potential and a favorable position at the southern rim of the Mediterranean present an opportunity to diversify its industrial base beyond hydrocarbons. Ambitious infrastructure projects — mining rail links, special economic zones (SEZs) and a national hydrogen roadmap — create the strategic canvas. Yet policy and resource endowments alone will not deliver competitive factories or resilient corridors. This article argues that Algeria needs to embed four execution capabilities — (1) professional project governance (PMOs), (2) rigorous facilities design & planning, (3) factory-physics operational discipline, and (4) systems engineering (MBSE and lifecycle integration) — to transform strategy into reliable industrial output at competitive cost and low carbon intensity. We analyze Algeria's industrial trajectory, translate the four levers into practical practices and metrics, illustrate with an Algeria-focused vignette, and close with a prioritized ten-point agenda for government, clusters and firms. Where relevant, we reference official policies and international standards to ground recommendations.

Keywords

Industrialization; Algeria; PMO; facilities design; factory physics; systems engineering; hydrogen; mining; SEZ; CBAM; Euro–Mediterranean value chains.

1. Introduction — strategy meets execution in Algeria

Algeria has long pursued state-led industrial development across energy, manufacturing, and infrastructure. Significant public investment, a large domestic market, and a strategic geographic position near Europe have shaped successive industrial strategies. Yet despite these favorable conditions, the gap between policy ambition and operational outcomes remains persistent. Recurrent delays, cost overruns, utility bottlenecks, supplier capability gaps, and fragmented governance continue to hinder the translation of national objectives into competitive industrial assets.

This execution gap has become more consequential as global industrial systems transition toward low-carbon production and tighter regulatory regimes such as the EU's Carbon Border Adjustment Mechanism (CBAM). Emerging opportunities in hydrogen, steel, renewables supply chains, and Special Economic Zones (SEZs) require not only investment and strategy, but **disciplined execution capabilities**—the ability to deliver complex, multi-actor, multi-technology systems reliably and at scale.

Against this backdrop, this paper examines Algeria's industrialization challenge through the lens of systems execution. It proposes a four-lever framework combining (i) PMO governance for portfolio control, (ii) facilities engineering to anticipate operational risks, (iii) factory-physics principles to stabilize flow and reduce embodied carbon, and (iv) model-based systems engineering (MBSE) for interface integration. The aim is not to offer a macroeconomic diagnosis, but to outline how execution capabilities can accelerate the emergence of competitive, CBAM-resilient, export-oriented industrial systems.

2. Concepts & frameworks — the four execution levers

We build on three execution levers familiar to industrial delivery — PMO governance, facilities design & planning, and factory physics—and add a fourth: systems engineering.

- PMO & governance. Owner-led PMOs align portfolio decisions with program sequencing and ensure discipline across front-end loading (FEL), stage-gates, risk control, and benefits realization—practices codified in PMI/ISO guidance. [1]
- Facilities design & planning. Site selection, utility sizing, layout (Systematic Layout Planning), and permitting are the physical enablers that determine whether flow, safety and sustainability constraints are met.
- Factory physics. Quantitative relationships—Little's Law (WIP, cycle time, throughput), Kingman's insights on variability—govern how lines respond to variability and dictate buffer strategies, takt, and bottleneck protection. These operational laws are essential to predictable ramp-up and low-carbon operation.[2]
- Systems engineering (SE/MBSE). SE provides a structured, model-based approach to integrate mechanical, electrical, automation, cyber/OT, safety and human factors across lifecycle phases. MBSE reduces ambiguity in interface definitions and accelerates verification and commissioning on complex corridors (e.g., renewables → electrolyzers → pipeline → steel plant). [3]

These four levers are complementary: PMOs govern and sequence; facilities design delivers fit-for-purpose physical platforms; factory physics makes operations predictable; and systems engineering binds multi-domain complexity into coherent, verifiable designs.

2.1 Methodological Approach

This study adopts a qualitative, practice-informed analytical approach combining conceptual frameworks, systems-engineering principles, and contextual insights from Algeria's emerging industrial programs. The methodology relies on four complementary sources:

- International normative references such as PMI's PMBOK, ISO standards, and INCOSE systems-engineering practices, which define the governance and integration mechanisms used in large-scale industrial programs.
- Engineering and operations science, including factory-physics principles and megaproject execution literature, providing a basis for analyzing flow stability, bottleneck behavior, and variability amplification.
- Contextual information on Algeria, derived from publicly available audit reports, infrastructure announcements, sectoral press releases, and recent publications in AJESS, which inform the diagnostic of execution gaps without claiming exhaustive empirical coverage.
- Model-based reasoning, used to structure interfaces, utility dependencies, and system-of-systems linkages between mining, logistics, SEZs, and energy systems.

This methodological stance is appropriate for a conceptual and strategic contribution, enabling the translation of national industrial policy into operational execution models.

3. Algeria's industrial trajectory — assets, projects and execution gaps

Algeria possesses strong and diverse industrialization assets: substantial natural gas reserves (for electrolyzer feedstock and transition hydrogen), very large solar and wind potential enabling low-cost renewable electricity, and important mineral resources such as the Gara Djebilet iron-ore basin. Public initiatives — including the 2023 national hydrogen roadmap and Algeria's participation in corridor studies with European partners — indicate a

growing ambition to anchor decarbonized industrial exports in an integrated Euro–Maghreb value chain. The proposed **SoutH₂ corridor**, linking North Africa with Italy, Austria and Germany, exemplifies both the scale and cross-border complexity of this ambition.

A number of priority sectors illustrate this trajectory:

- **Green hydrogen.** The national roadmap and exploratory MOUs with European TSOs and industrial partners aim to evaluate large-scale electrolysis, renewable siting, and export pathways. Although these studies remain early, they are politically significant for Algeria's positioning in future low-carbon supply chains.
- **Mining to metallurgy.** Development of the Gara Djebilet iron-ore basin, together with heavy-haul rail corridors, is intended to supply DRI/EAF steelmaking capacities. Recent progress on track construction and contracting underscores momentum, while also highlighting the engineering challenges of achieving reliable heavy-haul logistics in desert environments.
- **SEZs and industrial clusters.** Port-adjacent Special Economic Zones aiming to aggregate logistics, utilities, skills and supplier ecosystems are central to reducing lead times and enabling value-added industrial assembly. Their performance, however, depends on coordinated utility provision and streamlined customs and regulatory interfaces.

These developments reinforce the need for advanced technical skills and system-level engineering capabilities. As emphasised by Rekioua [4], emerging renewable-based industrial systems require new profiles in automation, energy management and digital engineering. Similarly, research in Algeria on Industry 4.0 systems — including model-based optimisation of automated logistics platforms [5] and advanced control strategies for renewable grid-connected systems [6] — illustrates the growing relevance of simulation-driven design, utility modelling and lifecycle integration for large industrial infrastructures.

Despite Algeria's structural advantages and ongoing strategic projects, **execution gaps remain persistent and material**. These include:

- insufficient grid reliability and slow reinforcement timelines;• lengthy and fragmented permitting procedures;
- limited supplier capability in quality, metrology and digital traceability (including product-passport readiness);
- shortages of integrated delivery skills in PMO governance, commissioning engineering and systems architecture.

Projects that do not **front-load utility sizing**, validate **multi-domain interfaces early**, or apply **flow-control and bottleneck-protection principles** face chronic underperformance, late commissioning, and higher embodied-carbon footprints — precisely the vulnerabilities exposed under emerging CBAM transparency requirements. Addressing these gaps requires structured PMO governance, rigorous facilities-engineering practices, factory-physics-based operational discipline, and the adoption of MBSE to integrate complex multi-stakeholder industrial systems.

Although Algeria does not systematically publish consolidated performance statistics for large industrial and infrastructure programs, partial evidence from national audit reports, public procurement disclosures, and sectoral press coverage indicates recurring patterns that are consistent with those observed in comparable MENA industrial contexts. Typical issues include **schedule slippages of 20–40%**, primarily driven by late utility readiness and multi-vendor coordination gaps; **cost escalations linked to scope instability and redesign cycles**; and **commissioning delays** due to insufficient interface definition across civil, electrical, process and automation systems. These empirical signals underscore the need for structured PMO governance, early front-end loading, and model-based systems integration as foundational enablers for Algeria's hydrogen, mining and SEZ-related industrial programs.

4. PMO & governance — practical recommendations

A national or zone-level Owner's PMO should be the first institutional change. The PMO's mandate is to translate policy objectives into prioritized CAPEX decisions, to manage program-level interfaces (ports, grid, rail, skills), and to run stage-gate discipline through FEL-1/2/3, procurement and commissioning. Standards such as PMI's PMBOK and ISO 21502 provide frameworks for portfolio-to-project alignment and governance constructs that reduce scope ambiguity. [1]

Concrete organizational features:

- Portfolio → Program → Project hierarchy. Portfolio selects and sequences investments against measurable outcomes (jobs, CO_2 abatement, export readiness); program teams cluster related projects (rail + port + clusters) to manage shared risk; project teams focus on EPC/EPCM delivery with clear interface matrices. [1]
- Controls & KPIs. Integrated Master Schedule (IMS), Earned Value Management (EVM) for cost/schedule, commissioning readiness indices and benefits realization metrics (energy intensity, OEE, CO_2 per unit). Tie contractor incentives not just to mechanical completion but to "first-pass yield at rate." [1]
- Capability building. PMO academies, micro-credentials in gate reviews and commissioning, and placements with experienced European project teams will shorten the competency ramp while creating local career paths.

The PMO must also own interface governance across civil, electrical, process, automation, IT/OT and customs/compliance to prevent the "blame-game" that typically delays commissioning.

5. Facilities design & planning — engineering for flow and safety

Facilities design is where product and process choices become physical systems. For Algeria's green-hydrogen, metals and component lines, three principles matter: (a) size utilities to actual process loads (not rules of thumb); (b) design modularity for future expansion and electrified heat readiness; (c) embed safety and permitting analyses early in the 3-D model.

- Site & utilities engineering. Multi-criteria site selection should weight grid capacity and stability, water availability/recycling options, logistics (port/rail access), and local skills availability. Substation and transformer lead times are long; front-end decisions must lock long-lead items during FEL to avoid schedule overruns. [1]
- Layout & material flow. Use Systematic Layout Planning (SLP) to map flows and adjacencies; prefer U-cells or flow-aligned line cells where quality visibility and rapid problem detection matter. Design supermarkets and milk-runs (AGV/AMR routes) to reduce internal transport and hidden WIP. [10]
- Digital twin & permitting. A pragmatic digital twin (3-D model connected to process simulation and permitting rules) accelerates permitting reviews (fire/ATEX/environmental checks) and enables scenario testing for evacuation, battery-storage risks or hydrogen leak scenarios. Early digital sign-off reduces rework in construction and commissioning. [14]
- Resilience & EHS. Redundant feeders, segmented utilities and islandable microgrids for critical blocks increase uptime for DRI/EAF or electrolyzer parks. Zonal fire strategies, ATEX and ergonomic design protect both assets and operators, aligning with human-centric Industry-5.0 principles.

Facilities design thus converts strategic intent into reliable physical platforms; failing to invest adequate engineering time up front compounds risk exponentially during commissioning.

6. Factory physics — flow, variability and performance

Factory physics makes visible the trade-offs between throughput, work-in-process (WIP) and cycle time (Little's Law) and quantifies how variability inflates queues and cycle time (Kingman's formula). Applying these principles in Algerian clusters reduces hidden costs and embodied emissions.

- Set takt to demand. Align staffing and buffer sizes to takt time derived from market demand; protect the bottleneck machine with scheduled maintenance windows and quality gates. [3]
- Use pull where appropriate. CONWIP or other pull methods with WIP caps stabilize complex mixes; supermarkets near bottlenecks and kanban levels limit excessive WIP that hides problems and lengthens CT. [3]
- Metrics that matter. OEE, first-pass yield, WIP turns, queue-time share, and throughput-weighted CO_2 per unit should be tracked and tied to contractor/operational incentives. Stable flow reduces scrap, idling and rework—all of which raise both unit cost and carbon intensity.

Operational discipline based on factory physics is the final mile that turns a commissioned line into reliable output meeting both cost and CBAM transparency expectations. [15]

7. Systems engineering — integrating the corridor

Complex industrial corridors—e.g., renewables → hydrogen electrolysis → pipeline → industrial off-takers (steel, ammonia)—are systems-of-systems. Systems engineering (SE) and MBSE deliver two critical functions: (1) unambiguous interface definitions and traceable requirements from policy to component, and (2) virtual verification that reduces physical rework during commissioning. INCOSE's SE handbook and MBSE guidance explain how modelling replaces document-only handovers and shortens verification loops. [3]

Practical SE activities for Algerian projects:

- Requirements traceability. From national targets (e.g., % of low-carbon steel exported) to plant control logic and MRV requirements for product passports.
- Interface matrices & verification plans. Define responsibilities for civil/electrical/process/automation vendors; specify FAT and staged SAT criteria that include CO_2 metering and data exchange protocols for product passports.
- MBSE simulation. Use MBSE models to simulate hydraulic/power/sequence interactions across sub-systems (electrolyzer ramp with variable renewables, pipeline pressure control, steel plant feed schedules). This reveals emergent behaviors that single-discipline designs miss.[11]

SE is not a bureaucratic add-on: it is the glue that keeps complex multi-party projects on schedule and ensures that commissioning tests the right behaviors. For Algeria, building MBSE capability within PMOs and major contractors will reduce the most expensive source of delay — interface mismatches during commissioning.

8. Indicative Quantitative Impacts of PMO, MBSE, and Factory-Physics Adoption

International performance benchmarks demonstrate that adopting structured PMO governance significantly enhances project delivery reliability. Empirical studies on large industrial programs show that robust front-end loading, stage-gated decision processes, and integrated risk controls can reduce average schedule slippage by **20–30%** and lower CAPEX overruns by **15–25%**. These improvements stem from earlier scope stabilization, clearer interface allocation, and proactive long-lead item management.

Model-Based Systems Engineering (MBSE) further strengthens delivery performance by enabling explicit, verifiable interface definitions across mechanical, electrical, automation, and civil disciplines. Comparative project analyses indicate that MBSE-enabled interface management can reduce commissioning rework cycles by **40–60%**, accelerating the transition from mechanical completion to stable operational throughput.

Complementing these governance and systems-integration gains, factory-physics-based operational design reduces variability across production flows. Applying WIP caps, bottleneck protection, takt alignment, and queue-time management typically decreases cycle-time variability by **30–45%** and reduces scrap by **5–12%**. These operational stabilizations directly influence **CO_2-per-unit intensity**, since variability, scrap, and rework are among the primary contributors to avoidable embodied emissions in industrial value chains.

Together, these indicative quantitative impacts illustrate how integrated PMO governance, MBSE adoption, and factory-physics operational discipline can materially improve the reliability, cost efficiency, and sustainability of Algeria's emerging industrial corridors

9. Algeria vignette — An Integrated SEZ and Rail-Enabled Low-Carbon Steel Corridor

To illustrate how execution capabilities translate into tangible industrial outcomes, this vignette examines an integrated system linking mining resources, heavy-haul rail logistics, industrial utilities, and SEZ-based metallurgical activities. Focusing on the emerging Gara Djebilet–rail–coastal SEZ value chain, it highlights how disciplined execution conditions the feasibility, competitiveness, and sustainability of such industrial systems.

The ore resource defines upstream mass flows that must be synchronized with rail capacities, unloading cycles, stockyard buffering, and the continuous process requirements of DRI units. Achieving stable throughput in this type of corridor depends on early **dimensioning of utilities** (power, water, hydrogen, cooling), **interface verification** across civil, mechanical, electrical, automation and permitting disciplines, and the explicit protection of bottlenecks in both rail and process operations.

In a conventional delivery model, mismatches between ore logistics, utility readiness, and plant commissioning often generate cascading delays and rework. By contrast, a PMO–MBSE–factory-physics approach provides a structured pathway:

- **PMO governance** sequences enabling works, long-lead items, and inter-agency coordination.
- **Facilities engineering** validates utility envelopes, ATEX and safety rules, and 3D spatial integration.
- **Factory physics principles** ensure stable flow by controlling WIP, defining takt-aligned operating windows, and protecting bottlenecks in rail unloading and shaft furnace throughput.
- **MBSE integration** provides traceable requirements, digital interface matrices, and system-of-systems verification between logistics, utilities, and metallurgical units.

This illustrative corridor shows that the real differentiator is not only mineral endowment or geography, but the capacity to implement **disciplined execution tools** that reduce risk, accelerate commissioning, and enable a credible low-carbon export industry aligned with CBAM constraints. [8]

10. Risk Mitigation Through Structured Execution and System Integration

Risk mitigation in complex industrial programs requires more than conventional checklists or contractual safeguards. It depends on the capacity to **anticipate, quantify and neutralize sources of uncertainty** across governance, engineering interfaces, utilities, and operational flows. In Algeria's context—where industrial zones, hydrogen corridors, and large-scale metallurgical projects must interact simultaneously—risk emerges primarily from **interface mismatches**, **late utility readiness**, **variability amplification**, and **weak commissioning discipline**.
A structured, multi-layered mitigation approach is therefore essential:

10.1. Governance-Level Mitigation (PMO Discipline)

A robust PMO ecosystem establishes predictable rhythms of decision-making and early escalation. Key practices include:

- stage-gated validation of scope, utilities, and long-lead items;
- centralized risk registers shared across contractors and authorities;
- synchronized permitting sequences to avoid late regulatory blockers;
- integrated master schedules capturing interdependencies across rail, utilities, and construction packages.

This reduces systemic risks associated with fragmented delivery and scope drift.

10.2. Engineering-Level Mitigation (MBSE and Interface Management)

Technical risks arise when disciplines operate in silos. MBSE directly addresses this by:

- creating traceable requirement sets for energy, logistics, safety, and process equipment;
- formalizing interface obligations in digital matrices rather than informal documents;
- enabling early verification of flows, utilities, and capacities through system models and digital twins;
- reducing commissioning surprises by validating control logic, interlocks, and handover conditions in advance.

This lowers the probability of redesign loops and late-stage conflicts.

10.3. Facilities and Utility Mitigation (Front-Loaded Engineering)

Many high-impact risks originate from invisible infrastructure. To mitigate them, Algeria's industrial plans must prioritize:

- early grid reinforcement and redundant supply pathways;
- sizing and siting of water, hydrogen, cooling, and fire safety systems based on extreme-case envelopes;

- detailed constructability and access studies to de-risk installation phases;
- ATEX, fire, evacuation, and environmental compliance integrated from the earliest design stages.

This minimizes downstream disruptions and environmental or safety-related delays.

10.4. Operational Risk Mitigation (Factory Physics and Flow Control)

Variability is a major amplifier of operational risk. Factory physics offers proven levers:

- WIP limits to prevent congestion and instability;
- bottleneck protection to safeguard throughput;
- takt alignment to coordinate logistics and production rhythms;
- queue-time control to stabilize quality and reduce scrap.

These practices mitigate the risks of chronic underperformance and high CO_2-per-unit — a critical factor under CBAM.

10.5. Commissioning and Start-Up Readiness

The most frequent project overruns occur during commissioning. Mitigation requires:

- predefined readiness indices (mechanical, energization, loop checking, dry run, wet run);
- structured defect logs and systematic clearance gates;
- multi-disciplinary commissioning squads;
- simulated start-up sequences using MBSE or digital twins to expose failure modes early.

This reduces rework cycles and accelerates safe ramp-up to nameplate performance.

Synthesis

Mitigation effectiveness ultimately depends on **integration**: aligning governance, utilities, engineering models, and operational flows. A fragmented approach merely transfers risks from one discipline to another. A structured PMO–MBSE–factory-physics framework, by contrast, absorbs uncertainty early, prevents cascading failures, and increases the reliability of Algeria's industrial corridors and SEZs under emerging global constraints such as CBAM.

11. Ten-Point Agenda for Strengthening Algeria's Industrial Execution Capabilities:

Translating national industrial ambitions into tangible, competitive assets requires a coordinated shift in execution capabilities. Based on the four-lever framework, a ten-point agenda is proposed to guide policymakers, project owners, and engineering organizations.

1. **Institutionalize PMO governance across major industrial programs.**
   Standardize stage-gating, risk management, and interface coordination for all state-backed projects.
2. **Strengthen Front-End Loading (FEL) quality.**
   Mandate multidisciplinary concept studies, utility envelope validation, and constructability reviews before procurement.
3. **Establish model-based interface management.**
   Adopt MBSE tools to create digital requirements, interface matrices, and traceable verification workflows.
4. **Secure early utility readiness for SEZs and corridors.**
   Prioritize grid, water, hydrogen, and logistics infrastructure to prevent late-stage bottlenecks.
5. **Develop a national digital engineering capability.**
   Scale training in MBSE, 3D modeling, simulation, and digital twins for industrial and energy systems.
6. **Deploy factory-physics-based operational design.**
   Generalize WIP control, bottleneck protection, takt-based planning, and variability reduction in industrial plants.
7. **Professionalize commissioning and start-up disciplines.**
   Create specialized commissioning teams with standardized procedures, quality gates, and readiness indices.
8. **Enhance supplier capability in metrology and traceability.**
   Prepare local firms for digital product passports, CBAM compliance, and export-grade quality systems.
9. **Create integrated SEZ governance models.**

Bundle permitting, utilities, logistics, and workforce development within a single accountable authority.

10. **Establish performance benchmarking and transparency.**
    Publish yearly indicators on CAPEX deviations, schedule adherence, OEE, and grid reliability for industrial zones.

This agenda consolidates the execution capabilities required to anchor a competitive, low-carbon industrial base and to position Algeria credibly within Euro-Maghreb supply chains.

12. Comparative Analysis of Industrial Execution Models: Traditional vs. PMO–MBSE–Integrated Approaches

Effective industrialization requires not only strategic intent but also the systematic orchestration of governance, engineering integration, and operational flow control. To highlight the structural differences between conventional delivery models and an integrated execution framework based on PMO governance, MBSE lifecycle integration, and factory-physics discipline, Table 1 provides a comparative synthesis.

This table summarizes the typical patterns observed in legacy industrial project execution and contrasts them with the expected performance characteristics of projects designed and delivered under structured PMO governance, model-based engineering practices, and quantitative flow-based operational design. The goal is to provide a concise, evidence-informed view of how execution capabilities reshape outcomes across cost, schedule, quality, and sustainability dimensions.

Table 1. Comparative Execution Model: Traditional vs. PMO–MBSE–Integrated Industrial Delivery

Execution Dimension	Traditional Industrial Execution Model	PMO–MBSE–Factory Physics Integrated Model
Strategic Alignment	Policy objectives loosely translated into projects	Explicit strategy-to-execution translation through system requirements
Governance & Decision-Making	Fragmented oversight; weak owner coordination; ad hoc decisions	Centralized Owner's PMO with stage-gated governance and portfolio control
Front-End Loading (FEL)	Limited early engineering; scope frozen prematurely	Robust FEL with multidisciplinary validation and constructability reviews
Utilities & Enabling Infrastructure	Utilities sized late; frequent grid, water, or hydrogen constraints	Front-loaded utility envelopes validated through MBSE and scenario analysis
Interface Definition	Discipline silos; interfaces managed informally	Model-based interface matrices with early verification cycles
Systems Integration	Minimal cross-domain coordination	Full system-of-systems integration (logistics, utilities, process, automation)
Facilities Design	Layout driven by construction sequence rather than operations	Facilities engineered for flow, safety, access, and long-term operability
Digital Engineering	Limited use of digital models; document-based workflows	MBSE, 3D models, and pragmatic digital twins supporting lifecycle decisions
Operational Design	High WIP; unstable cycle times; bottlenecks exposed late	Factory-physics-based flow control, WIP limits, and bottleneck protection
Variability Management	Variability absorbed reactively	Variability reduced proactively through takt alignment and buffering strategies
Commissioning & Start-Up	Sequential, reactive commissioning; extended ramp-up	Structured readiness indices, parallelized testing, and simulated start-up
Supplier Capability & Quality	Limited traceability; variable quality	Digital traceability, metrology discipline, and export-grade QA/QC systems

Schedule Performance	Frequent slippage and cascading delays	Improved schedule reliability and reduced time-to-rate
CAPEX & Rework	CAPEX overruns driven by late changes and redesign loops	Reduced rework, lower CAPEX volatility, and earlier cost stabilization
Environmental Performance	High embodied carbon due to inefficiencies and rework	Lower CO_2 intensity per unit through stable flow and reduced scrap
Regulatory & CBAM Readiness	Reactive compliance; limited transparency	Proactive CBAM alignment, data traceability, and product passports
Learning & Replicability	Project-specific learning; limited institutional memory	Reusable execution templates and institutionalized best practices

This comparison underscores that execution failures are structural rather than incidental: they emerge from fragmented governance, misaligned utilities, and insufficient interface definition. Accordingly, improving industrial competitiveness requires institutionalized execution capabilities rather than isolated technical corrections.

The comparative analysis illustrates that traditional execution models tend to suffer from scope instability, weak multidisciplinary coordination, and limited flow predictability—factors that systematically degrade delivery performance and increase embodied carbon. In contrast, the integrated PMO–MBSE–factory-physics approach strengthens governance discipline, enhances interface clarity, and embeds quantitative flow control across the lifecycle. These improvements translate into measurable gains: reduced CAPEX overruns, shorter commissioning cycles, improved operational efficiency, and a more robust alignment with emerging sustainability and traceability requirements such as CBAM.

This synthesis reinforces the central argument of the paper: **industrial policy alone is insufficient without execution capabilities that align governance, systems engineering, and operational science**.

13. Limitations and Future Research

This article offers a conceptual and practice-informed framework for strengthening industrial execution capabilities in Algeria. As such, it is subject to several limitations. First, the analysis relies on publicly available information and indicative quantitative signals rather than a systematic empirical dataset. This is consistent with the paper's strategic scope but limits the ability to generalize certain observations. Second, while the framework integrates PMO governance, facilities engineering, factory-physics principles and MBSE, it has not yet been validated through longitudinal case studies or project-level measurements in Algeria. Third, execution performance in complex industrial systems is affected by institutional, contractual and behavioral factors that extend beyond the technical mechanisms discussed here.

Future research could address these limitations by developing structured datasets on project execution metrics in SEZs and industrial corridors, quantifying the effects of interface definition and utility readiness on commissioning performance, and applying MBSE-based evaluation tools to specific industrial programs. Comparative studies across North African or Euro-Maghreb industrial ecosystems would also help assess the external validity of the proposed framework.

14. Conclusion

Algeria's path to diversified, low-carbon industrialization is feasible but demands more than strategic intent. The country's resource endowment and geography provide an advantageous starting point, yet export-ready, CBAM-resilient industries will materialize only through disciplined execution. This requires robust Owner's PMOs to govern complex portfolios, facilities engineering that anticipates operational risks, factory-physics principles that

stabilize flow and reduce embodied carbon, and MBSE frameworks that integrate multi-domain systems. Embedding these capabilities in a set of flagship corridor projects would deliver early demonstrators, accelerate time-to-rate, and institutionalize modern industrial practices. In doing so, Algeria would establish a credible, low-carbon industrial base and strengthen its position within emerging Euro-Maghreb value chains.

References

1. Project Management Institute (PMI). A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 2021, 7th ed.
2. Hopp, W. J., & Spearman, M. L. (2008) Factory Physics, 3rd ed.; McGrawHill
3. Laura E. Hart, Introduction To Model-Based System Engineering (MBSE) and SysML, Delaware Valley INCOSE Chapter Meeting, Introduction To Model-Based System Engineering (MBSE) and SysML
4. Rekioua, D. "Overview On Future Technical Skills And Sustainable/Renewable Energy." Algerian Journal of Electrical Systems and Sustainability (AJESS), Vol. 1, No. 1, pp. 1–10 (2025). https://univ-bejaia.dz/revue/AJESS/article/view/650
5. Sari, Z. "Energy-Efficient Design and Control of AS/RS for Industry 4.0." Algerian Journal of Electrical Systems and Sustainability (AJESS), Vol. 1, No. 1, pp. 11–26 (2025). https://univ-bejaia.dz/revue/AJESS/article/view/651
6. Krim, S. A., May, A., & Krim, F. "Fuzzy Modulated Model Predictive Control of a PV Grid-Tied Quasi-Z-Source System." Algerian Journal of Electrical Systems and Sustainability (AJESS), Vol. 1, No. 1, pp. 47–55 (2025). https://univ-bejaia.dz/revue/AJESS/article/view/654
7. SNAM. "SONATRACH, SONELGAZ, VNG, SNAM, SEACORRIDOR and VERBUND GREEN HYDROGEN sign a Memorandum of Understanding relating to Green Hydrogen." SNAM press release, 14 Oct 2024. snam.it+1
8. Railway Gazette. "Heavy haul railway tracklaying makes progress through the desert." RailwayGazette.com. Railway Gazette
9. ISO. *ISO 50001 — Energy management.* International Organization for Standardization. iso.org
10. Muther, R., (2015) Systematic Layout Planning (SLP), 4th ed. Management & Industrial Research Publications richardmuther.com
11. INCOSE. *Systems Engineering Handbook / MBSE resources.* INCOSE publications and MBSE initiative overviews. Model-Based Systems Engineering (MBSE) - SEBoK
12. Rail Journal. "Algeria's iron ore railway progresses." RailJournal.com (project coverage). International Railway Journal
13. ISO 21502:2020. Project, Programme and Portfolio Management — Guidance on Project Management; ISO 21500 family. 2020. iso.org
14. SoutH₂ Corridor. "SoutH2 Corridor – Our connection for a clean future." South2corridor.net. south2corridor.net
15. European Commission — Taxation & Customs Union. "Carbon Border Adjustment Mechanism (CBAM)." Official guidance and legislation pages. Taxation and Customs Union

Biography



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Zaki Sari is currently a freelance senior consultant and expert for industry, services and higher education. Before, he was a Manufacturing Engineering Professor at Aboubekr Belkaid University of Tlemcen (UABT), Algeria; the founder and past Director of the Manufacturing Engineering Laboratory of Tlemcen (MELT), and the founder and past head of the National Curriculum of Manufacturing Engineering. He obtained his Engineer degree in electrical engineering from the National Institute of Electrical Engineering, Boumerdes, Algeria in 1987; his Magister degree in power engineering from the National Polytechnic School of Algiers, Algeria in 1990; and his Doctorate degree in manufacturing engineering from Tlemcen University in 2003. He obtained also a postgraduate certificate in system engineering from University of Missouri Rolla, USA, in 2003.

His main domain of interest concerns the Design, Modeling, Optimization, Simulation and Control of Automated Storage and Retrieval System, he made several investigations on non-conventional AS/RS systems like flow rack systems but employed for different uses than the ones designed for. Other domains that he is interested in, include Project Management & PMO, Facilities Design & Planning, Factory Physics, Flexible Manufacturing Systems, Planning & Scheduling, Supply Chain Management…

He advised several magister and doctorate thesis. Some of his students are in professor position. He is associate editor of two international journals and regular reviewer of many ones. He was the chair of six international conferences and IPC member of more than thirty ones