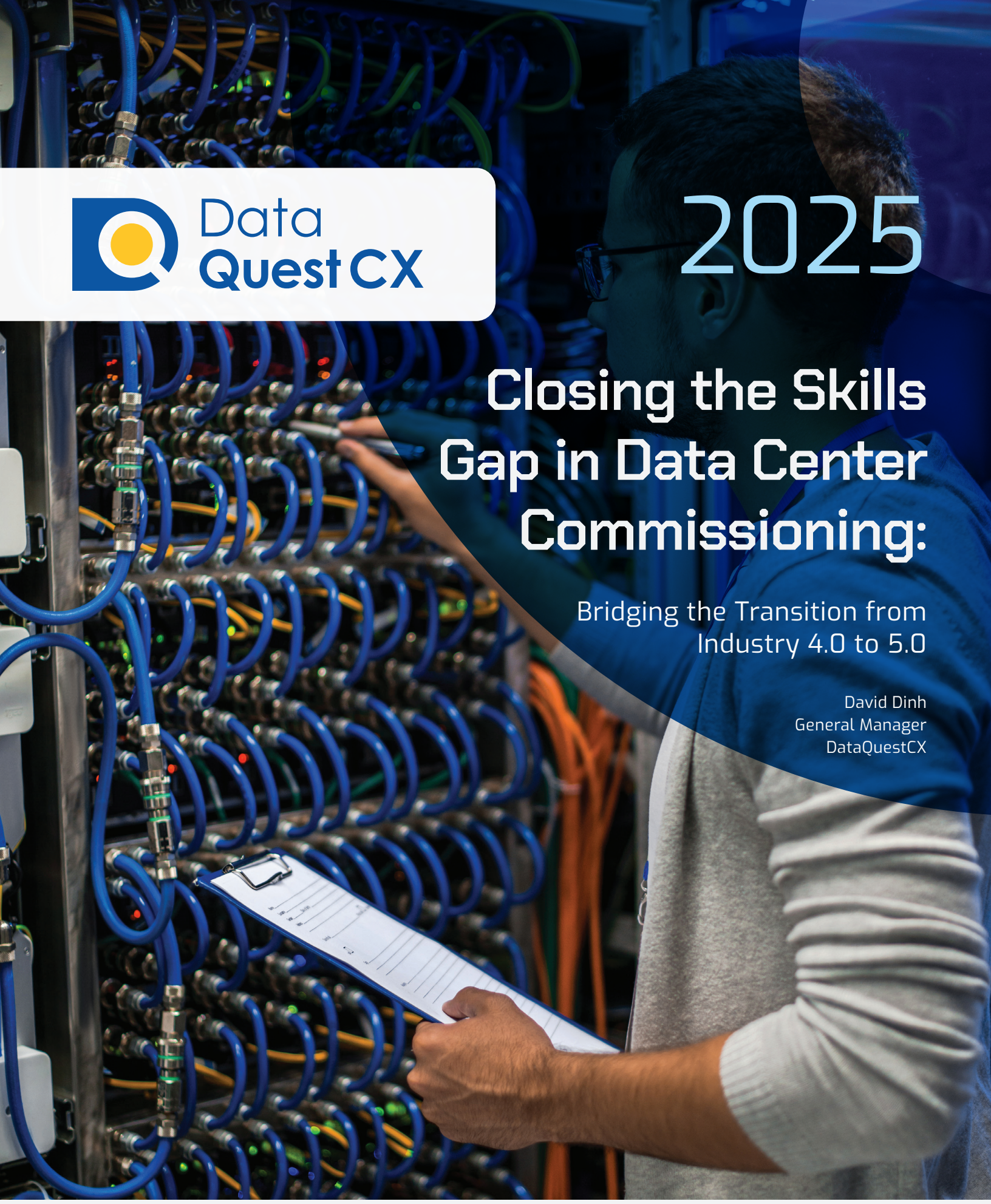

Data QuestCX

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Closing the Skills Gap in Data Center Commissioning:

Bridging the Transition from Industry 4.0 to 5.0

David Dinh
General Manager
DataQuestCX

Your roadmap to bridging the gap.

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Executive Summary & Introduction

The commissioning phase of data centers is critical to ensuring operational readiness, reliability, and energy efficiency.

However, a growing skills gap in commissioning professionals threatens the timely and cost-effective delivery of these facilities.

As the industry transitions from Industry 4.0 to Industry 5.0, this challenge intensifies: traditional skillsets are no longer sufficient, and new competencies in automation, digitalization, and human–machine collaboration are essential.

This paper analyzes the scope of the skills gap in commissioning, explores how Industry 4.0 and 5.0 paradigms intersect with this issue, and provides actionable strategies for industry, academia, and policymakers.

Introduction

Global demand for data centers is increasing rapidly due to the growth of cloud computing, AI workloads, and the expansion of digital infrastructure. Dubai, North Virginia, Dublin, and Singapore are experiencing explosive growth with hyperscale facilities expanding at record pace, with $1.8 trillion in planned investment through 2030. Yet one of the greatest risks to these projects is not technology, but people.

The commissioning workforce faces shortages in mechanical, electrical, and controls commissioning professionals with experience in mission-critical systems.

To further complicate the issue, 19% of data center professionals in the UK and 16% in the US are over 55 and approaching retirement. As new technologies and operational paradigms emerge, this shortage revolves around both a quantitative issue (not enough people) and a qualitative issue (not enough of the right skills).

“The real challenge isn’t just a lack of people—it’s a lack of commissioning professionals with the cross-disciplinary expertise to manage today’s complex, high-density facilities. Unless we close this skills gap, risk and downtime will only grow.”

— J.J. Malloy - Managing Director, DataQuestCX

The Commissioning Skill Gap

Seeing the Problem, Shaping the Future

The Problem

Commissioning in data centers requires multidisciplinary expertise: power distribution, UPS systems, cooling infrastructure, building automation, and integrated testing. The data center industry faces three main gaps:

- **Technical Knowledge Gap:** Fewer workers are trained in critical power, HVAC, and automation systems.
- **Digital Skills Gap:** Lack of familiarity with digital twins, BIM integration, and connected worker platforms. The rapid emergence of AI has left many companies with the task of proper integration before being able to leverage.
- **Leadership Gap:** Experienced commissioning managers are retiring, leaving a thin pipeline of replacements who can connect the technical with commercial demands.

Reports from the Uptime Institute (2023) estimate a global shortfall of nearly 300,000 qualified data center staff by 2025, with commissioning specialists among the most difficult roles to fill.

Industry 4.0 and Commissioning

Industry 4.0 has fundamentally reshaped commissioning in data centers through the introduction of digitalization, IoT, AI, and advanced automation. Commissioning processes that were once sequential and heavily manual are now integrated and data-driven. Building Information Modelling (BIM) and IoT-enabled systems enable engineers to test electrical, mechanical, and control systems in parallel, providing cross-system visibility and earlier issue identification (Xie, Li, & Zhang, 2023; MDPI, 2023), as observed during the L3-L5 commissioning phases. Real-time data streams from IoT sensors and advanced metering enable predictive adjustments during commissioning rather than relying on static post-testing reports (Sangchan et al., 2023). This approach reduces rework and generates a digital record for operational teams.

The adoption of digital twins has enabled teams to simulate loads, airflow, and system performance before physical testing. Xie et al. (2023) demonstrate how digital twins are applied to real-time monitoring and autonomous robotics, which allows human personnel operators to rapidly respond to alarms. Complementing this, automation and virtual commissioning streamline many test sequences, reducing errors and increasing efficiency (Slansky, 2020).

Remote commissioning capabilities, enabled by cloud platforms, allow experts to oversee tests and validate performance globally, mitigating local labor shortages (Munvaria, 2023). Furthermore, AI and predictive analytics help identify anomalies or inefficiencies during commissioning, transforming it from a pass/fail process to one of continuous optimization (TechRadar, 2023). These changes, as summarized in Table 1, illustrate how Industry 4.0 has transformed commissioning from a reactive, manual process into a proactive, integrated, data-rich discipline (Vitor et al., 2022; Ikeda et al., 2023).

From Industry 4.0 to Industry 5.0

Industry 5.0 is still in its infancy, and the following discussion reflects current predictions and expert opinions on how commissioning may evolve. These projections are subject to global market trends and emerging technologies.

Industry 5.0 emphasizes human–machine collaboration, resilience, and sustainability, and these principles are expected to reshape commissioning practices in data centers. Industry 5.0 will likely introduce augmented reality (AR) and virtual reality (VR) guidance tools to assist less experienced technicians, providing immersive, step-by-step instructions during commissioning activities. Collaborative robotics is expected to reduce manual labor in repetitive testing processes, enhancing safety and efficiency. Human-centric design principles will prioritize ergonomics, adaptability, and safety in both system and workplace design. Additionally, sustainability metrics are anticipated to become integrated into commissioning checklists, supporting alignment with ESG and net-zero objectives.

While these innovations offer significant potential to close the skills gap, it is essential to recognize that commissioning professionals will need to evolve into hybrid experts with a combined expertise in engineering, digital tools, sustainability, and leadership. As Industry 5.0 technologies and approaches continue to develop, these predictions remain contingent on how global market trends, technology adoption, and workforce readiness unfold (Padovano et al., 2024; Brkovic et al., 2023).

Table 1: The Commissioning Transformation

Traditional Commissioning (Pre-Industry 4.0)	Industry 4.0 Commissioning	Industry 5.0 Commissioning
Manual checklists & paper reports	Real-time data dashboards	AR/VR-guided interactive checklists with a human-centric interface
System-by-system verification	Integrated, cross-system testing	Collaborative human–robot testing with ergonomic and sustainable design
Sequential workflows	Parallel, automated workflows	Flexible, adaptive workflows guided by AI-human collaboration
Human-driven troubleshooting	AI-assisted predictive insights	Human-in-the-loop AI decision support with continuous learning
Local experts only	Remote/global collaboration possible	Global collaboration augmented with immersive virtual presence
Minimal knowledge retention	Digital record + reusable models	Enhanced knowledge retention through digital twins and personalized training modules

The Cost of Delays

The commissioning skill storage is generally divided into three categories: Revenue loss due to delays in going live, overruns arising from additional equipment/labor costs and quality failures that require rework, resulting in service level agreement penalties. The following summarizes the costs of these categories by facility size to provide readers with the potential exposure when delays are a result of skill storage:

Facility Size	Monthly Delay Cost (Lost Revenue + Financing)	Typical Overrun Costs (Labor + Rentals)	Quality/Failure Risk (First 2 yrs)	Total Potential Exposure
5 MW (edge/enterprise)	~$1–1.5M	$100–200k	$0.5–1M	$2–3M/month delay risk
10 MW (mid-scale colo)	~$2–2.5M	$200–400k	$1–2M	$3.5–5M/month delay risk
30 MW (regional cloud)	~$6–7M	$400–700k	$2–5M	$9–12M/month delay risk
50 MW+ (hyperscale)	$10M+	$1M+	$5–10M+	$15–20M+/month delay risk

Values above are based on $200/kW/month average pricing

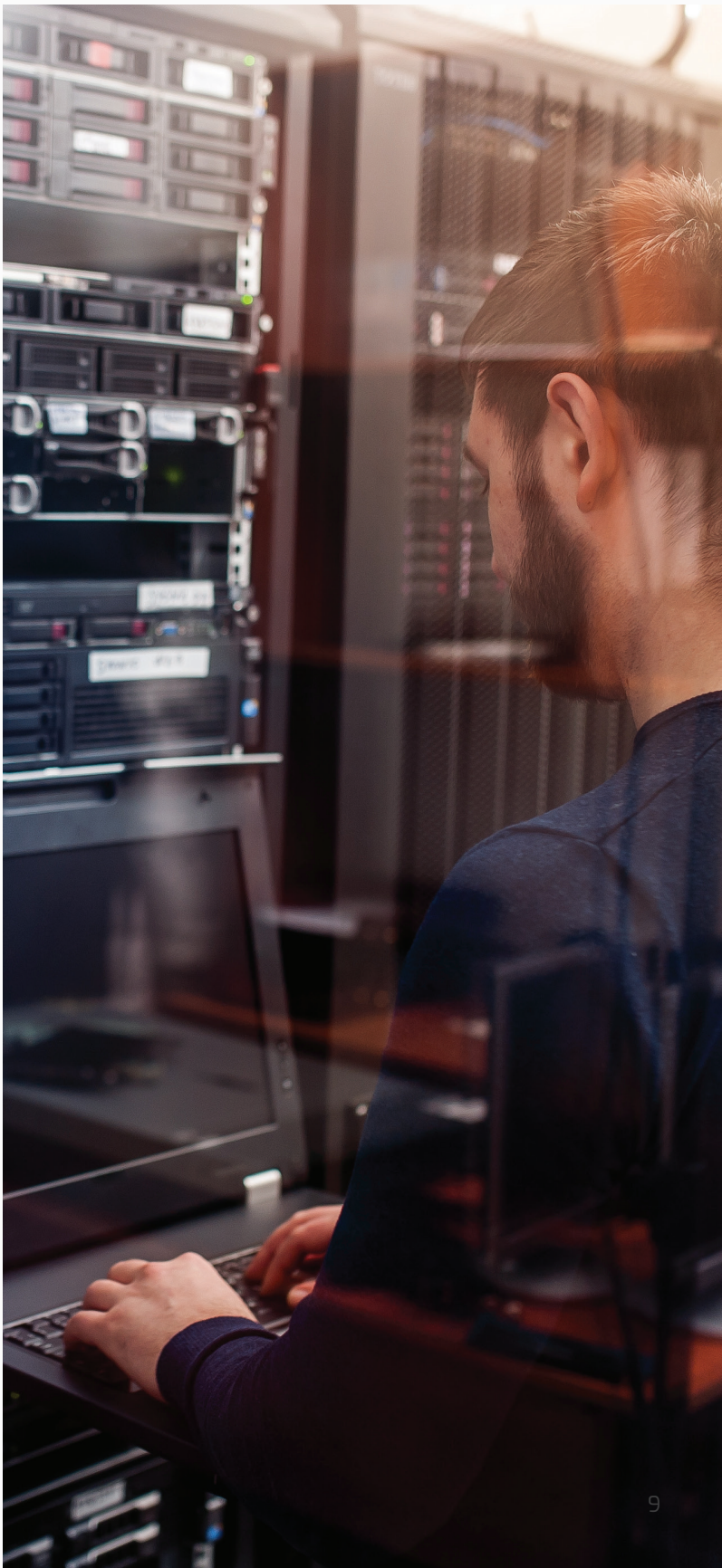
The Uptime Institute (2022) estimated the average cost of an outage to be around $500,000, with critical/hyperscale outages ranging from $1 1 to $5 million. Furthermore, poor commissioning increases the risk of warranty claims against OEMs, which adds additional hidden costs of 1-3% of CAPEX within the first two years of coming online.

Strategies to Close the Skills Gap

Addressing the commissioning skills gap requires a multifaceted approach that combines workforce development, technology adoption, and policy interventions. Workforce development strategies should focus on establishing specialized commissioning training programs in partnership with universities and trade schools, ensuring that the next generation of professionals acquires both foundational and advanced skills. This includes encouraging personnel to obtain **recognized commissioning certifications** such as the Certified Data Centre Commissioning Professional (CDCCP), Certified Commissioning Authority (CxA), and LEED commissioning credentials, which validate expertise in best practices, sustainability standards, and integrated testing procedures.

Apprenticeship ratios can be mandated in contracts to provide hands-on learning opportunities, while reskilling programs can support existing workers transitioning from adjacent industries, such as oil and gas, into data center commissioning roles.

Technology adoption plays a critical role in mitigating the skills gap. The use of digital twins and simulation platforms enables workers to train virtually before engaging in live projects, providing a safe and efficient learning environment. Connected worker platforms, augmented by AR-based step-by-step commissioning guidance, enhance learning and reduce errors on-site. Additionally, investing in modular and prefabricated systems can reduce the dependency on scarce skilled labor, allowing teams to focus on more complex, value-added tasks.



Strategies to Close the Skills Gap (Continued)

For example, modular chiller plants can be deployed to facilitate process familiarization and simplify operations.

Contractual and policy levers further support these initiatives. Including workforce development clauses in commissioning contracts ensures that training and knowledge transfer are embedded in project planning. Partnerships with governments can provide pathways for skilled immigration, expanding the available talent pool. Tax incentives and other financial rewards can encourage organizations to invest in workforce training programs aligned with Industry 5.0 principles. Together, these strategies provide a comprehensive roadmap to close the commissioning skills gap while supporting the sustainable growth of data center infrastructure.

These strategies are wholly dependent on the stakeholder's interest and ability and as such Table 2 summarizes recommended skills gap mitigation strategies as such.

Table 2: Stakeholder Recommended Strategies to Address the Commissioning Skills Gap

Stakeholder	Recommended Actions	Time Horizon
Owners	Require commissioning contractors to demonstrate training pipelines and digital capabilities.	Immediate
	Ensure personnel have relevant CxA or CDCCP certifications and experience.	Immediate
	Lean into modularization and simply repeatable design that is conducive to both stability and streamlining familiarization.	Medium-Term
	Standardize owner project requirements (ORPs) across various campuses to streamline commissioning scripts	Medium-Term
Construction (EPC)	Mitigate commissioning bottlenecks by awarding multiple subcontracts to commissioning authorities (CxAs)	Immediate
	Promote workforce certifications and reskilling programs.	Medium-Term
	Invest in AR/VR training, modular construction, and hybrid skill development.	Medium-Term
Commissioning Authority	Invest into training and retention of commissioning talent.	Medium-Term
Academia	Develop Industry 5.0–aligned curricula for commissioning professionals, including hands-on programs and certification preparation.	Long
Governments	Support workforce mobility, apprenticeships, and targeted reskilling initiatives. Offer incentives for organizations investing in commissioning workforce development and training aligned with Industry 5.0 principles.	Long

DataQuestCX Solutions

Our approach addresses both immediate staffing needs and long-term talent pipeline development:

Immediate Impact Services

- **Embedded Training Programs:** Our commissioning leads work directly with your teams during L2-L6 phases, transferring knowledge through hands-on validation of critical systems

- **Custom Script Development:** We create detailed commissioning procedures tailored to your specific equipment configurations, enabling your teams to execute future testing with precision

- **Operational Readiness Support:** L5 and L6 handovers include comprehensive operator training ensuring seamless transition to operations

Immediate Impact Services

- **Advisory Integration:** During concept and design phases, we embed commissioning considerations that simplify future testing requirements

- **Documentation Standards:** Our detailed reporting creates institutional knowledge that persists beyond individual employee tenure

- **Cross-Training Protocols:** Multi-disciplinary exposure across electrical, mechanical, and control systems reduces single-point-of-failure risks in your staffing.

Conclusion

The transition from Industry 4.0 to 5.0 amplifies both the challenges and opportunities in data center commissioning. The skills gap is real, but it is not insurmountable. By combining human development, technology adoption, and smart contracting, the industry can ensure that future data centers are not only built, but built smarter, faster, and more sustainably.

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