Enhancing EPC Efficiency from FEED to O&M Stages with Digital Twins

Vivek Prasad, Krishnaprasad Gajaraj, Nabhaneel Chattopadhyay

Abstract

The article explores how EPCs in India's expanding chemical and infrastructure sectors can overcome persistent efficiency challenges through digital integration. It dives deep into the issues caused by data fragmentation from siloed tools across FEED, construction and operations stages, leading to data loss, rework and cost overruns.

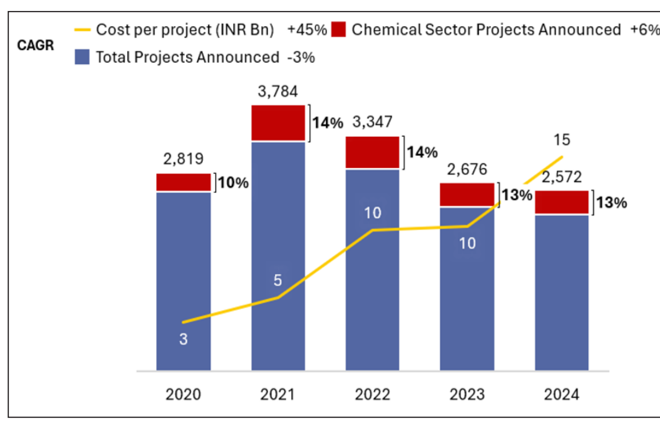
Using case studies, the article explains how digital twins have been and can be used to unify IoT, AI and design systems into a living model that evolves with the asset. It presents a phased roadmap for EPCs to adopt digital twins, emphasising value creation, process integration and enterprise intelligence, supported by strong governance, policy incentives and skill development. Ultimately, it argues that scaling IoT in EPC projects requires a conscious effort to coordinate between government, associations and industry supported by a clear governance framework.

Introduction

India's EPC sector is managing increasingly complex and high-value projects, but fragmented data across FEED, construction and O&M continues to drive delays and cost overruns. The article examines how digital twins can unify project information, improve decision-making and enhance lifecycle efficiency from design to operations.

Project Stakes Are Rising with Larger and More Complex EPC Scopes

Over the past five years, the average cost per project has become fivefold. This upward trend shows no signs of slowing and brings with it higher stakes, greater risks of cost overruns from delays and an increased risk of projects getting derailed[1].



Source: CMIE CAPEX

Number of New Project Announcements and Cost Per Project (INR Bn), 2020-24.

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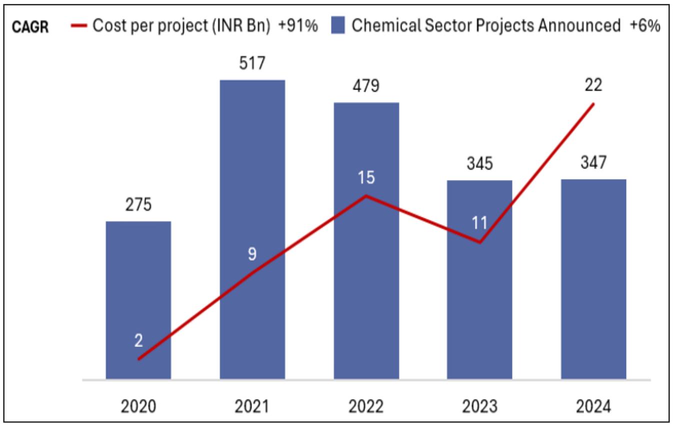
Within infrastructure, number of chemical projects has grown at a CAGR of 6% in the last five years, while average project costs rose almost 11 times over the same period, amplifying the need for careful planning and execution.



Source: CMIE CAPEX

Overall, Indian infrastructure sectors such as energy, oil and gas, chemicals, metals, power, renewables etc. are all expected to attract more than ₹143 trillion in total investments by 2030[3].

Fragmented Data leads to Higher Incidents of Cost and Schedule Overruns

India's EPC ecosystem has made enormous progress in project delivery capacity but remains constrained by fragmented information, delayed visibility and poor linkage between design intent and operational reality.

Capital projects follow a structured lifecycle with the following stages:

- **FEED (Front-End Engineering Design)**

  Define process design and layout, and overall economics of project.

- **Procurement and Fabrication**

  Select vendors, manage contracts, track materials and logistics and ensures compliance.

- **Construction and Erection**

  Execute the civil, structural, mechanical, electrical and instrumentation works in the project site

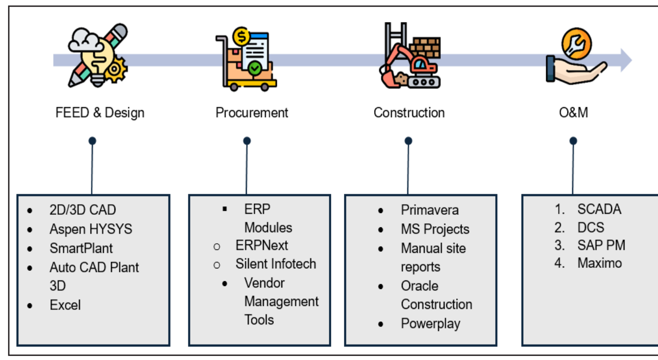
- **Pre-Commissioning and Commissioning.**

  Test installed systems and ensures readiness for safe operation.

- **Operations and Maintenance (O&M)**

  Ensure equipment, systems and facilities operate safely and efficiently.

Each stage generates critical data and the effectiveness of the entire lifecycle depends on how well that information flows forward. Despite deploying sophisticated tools in isolation, many EPCs and plant operators still make key decisions on incomplete or outdated data. Most EPCs and owner-operators still manage project and asset information through a patchwork of siloed systems which leads to delays and cost overruns in projects.



Tools Used in Each Stage of Value Chain

Each tool captures valuable information but doesn't talk effectively to the next stage. Only fragments of the original design data are transferred to the commissioning stage, often via PDFs, static spreadsheets or disconnected databases.

This lack of continuity means teams spend significant time recreating information instead of building on what already exists. Procurement rarely has live access to engineering specifications, construction lacks visibility into vendor updates and operations inherit incomplete digital records. The result is duplication, rework and decisions made with partial context which erodes both project efficiency and asset performance.

The impact of this fragmentation is felt throughout the project lifecycle:

- **During FEED:** Engineering decisions are made with limited feedback from actual operating conditions, resulting in design over-specification or underperformance once the plant is live.
- **During Execution:** Lack of real-time data creates blind spots, leading to scope creep, idle/insufficient materials and deviation from schedule often go undetected until too late.
- **During O&M:** When design data is not structured digitally, maintenance teams operate without accurate asset histories, causing more incidences of unplanned downtime and higher time to repair.

Impact of Fragmented Data On The Lifecycle

10-15%	35%	30%	20-25%	70%
Of total installed cost lost due to poor data continuity[3]	Of construction time is lost to rework, conflicts, and info searches[4]	Productivity loss due to poor data management[5]	Of projects in India achieve digital handover of design and construction data[6]	Of maintenance teams re-create asset databases from scratch post-commissioning[6]

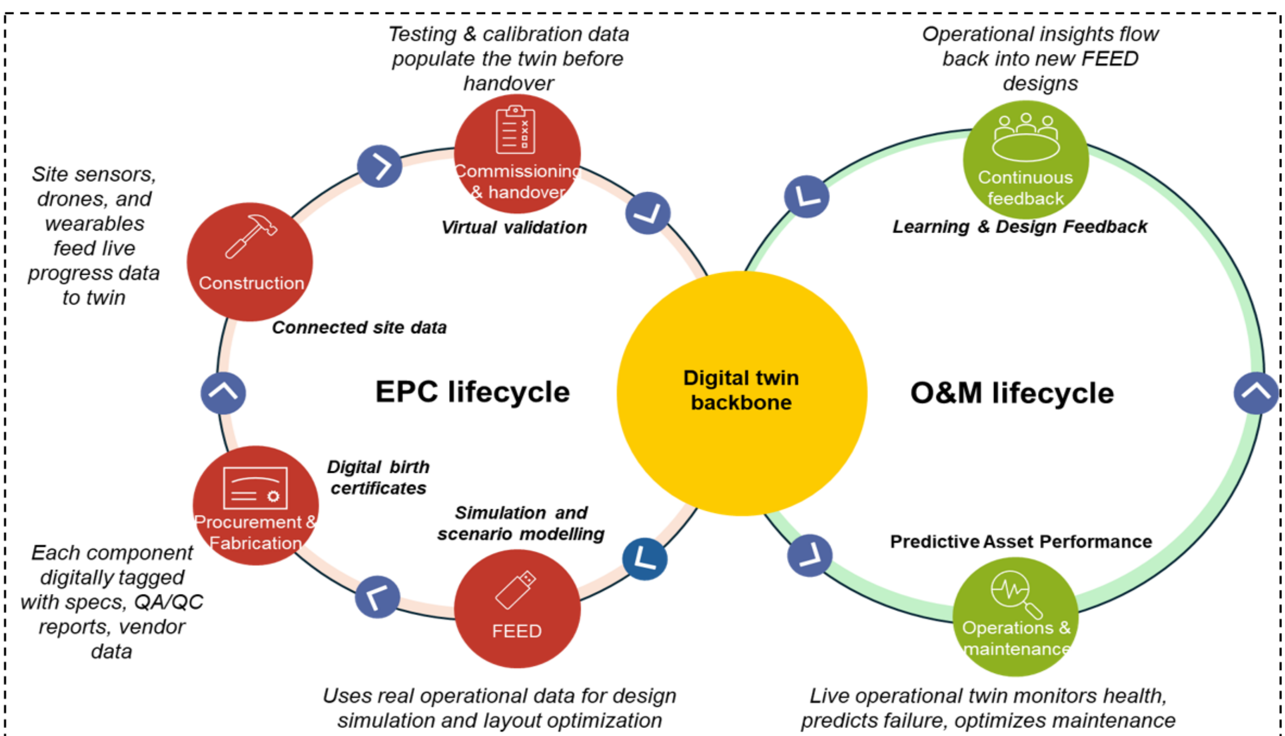
Digital Twins Connect Disconnected Systems into One Data Backbone

EPCs and asset owners in India's process industries sit on vast amounts of data, design parameters, procurement records, construction logs, sensor data, yet most of it dies in silos.

A digital twin changes that by creating a virtual mirror of the physical asset and its evolution over time. It integrates IoT, AI, engineering design and asset performance systems into a single model that mirrors the assets from conception stage to decommissioning.

It starts as a scenario modelling tool in FEED stage to help improve design accuracy and reduce capex and continues to become a connected execution platform during construction, helping reducing delays and rework. When the asset moves into operations, the twin transforms to a predictive performance model, aiding reduction in downtime and O&M costs.

This continuous feedback loop between EPC and O&M lifecycle, ensures that lessons from every project are integrated to the next. This means that, EPCs not only can deliver faster and safer projects but also create long-term value with digital twin being the intelligence backbone of this more efficient industrial ecosystem.



Integrating EPC and O&M through the Digital Twin backbone

Successful Case Studies Of Digital Twin Implementation			
Company / Case	**FEED / Design**	**Technology / Platform Used**	**Reported Impact**
L&T Energy Hydrocarbon (India)	Unified all engineering deliverables and 3D models into a single execution platform for downstream access by fabrication and construction teams	Dassault Systemes 3D EXPERIENCE (Virtual Twin)	~20% less time spent searching for information, improved coordination
Wipro PARI + Siemens (India)	Simulated the production line and validated PLC logic upfront, reducing trial-and-error during installation	Siemens Tecnomatix / Process Simulate	Commissioning time reduced by 70%; Rework reduced by 40-50%
BPCL Kochi Refinery (India)	Live digital twin implemented to monitor emissions, optimise unit performance and support operations decision-making	Aspen HYSYS + InfoPlus.21	Improved emissions visibility and real-time energy optimisation
Shell + Kongsberg Digital (Global)	Kongsberg Digital – Global Operational digital twin deployed for major offshore assets to provide real-time asset integrity monitoring, production optimisation and remote collaboration	Kongsberg Kognitwin Energy	Reduced site travel and improved asset availability; faster decision-making on production scenarios

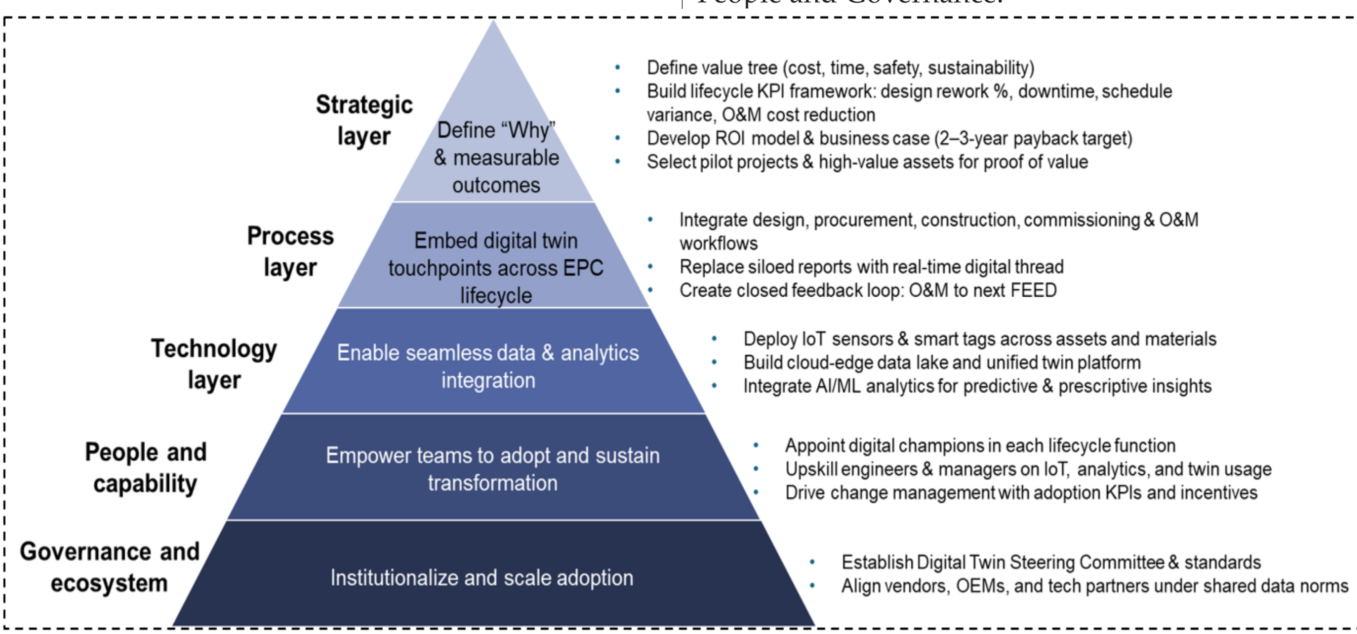
These examples show that digital twin applications are already up and running in India and it is no longer only a theoretical model. EPCs are already using them to shorten commissioning cycles, improve asset uptime and strengthen decision making in operations.

The solutions have been deployed on production lines, offshore platforms and complex process units, proving the technology's maturity across different industrial environments.

The opportunity now is to achieve maximum potential of these digital twins by taking these proven capabilities and scaling them across the full project lifecycle, from FEED till O&M.

How EPCs Can Build and Scale Digital Twin Capabilities?

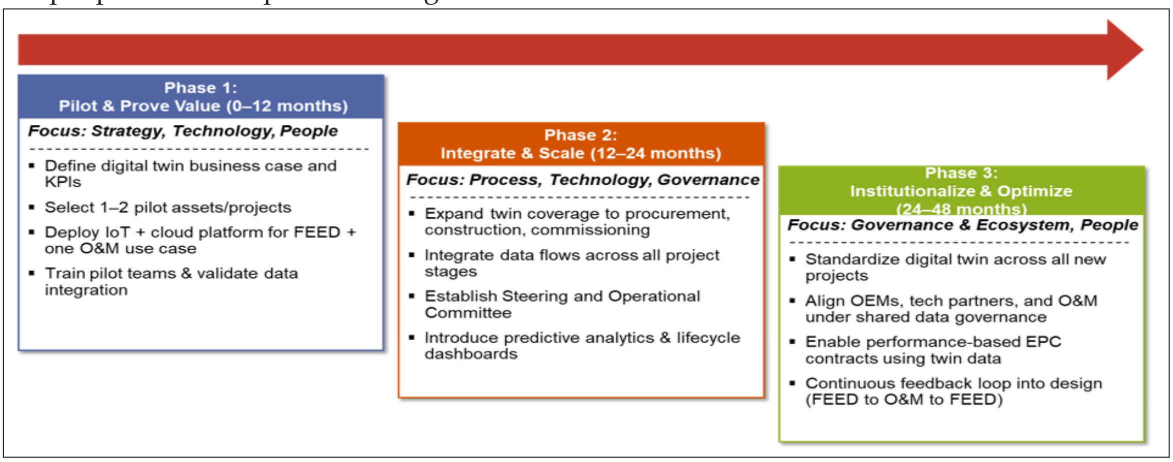
The path to achieving full potential of digital twins in EPC projects is not just via technology but through five critical layers - Strategy, Process, Technology, People and Governance.



Implementation Levers

- Clear strategy defines where value will be created.
- Redesigned processes ensure digital continuity across FEED, construction and O&M.
- Technology backbone connects IoT, cloud and analytics.
- Skilled people drive adoption on the ground.
- Strong governance with ecosystem partnerships sustains momentum.

When these elements align, EPCs move from pilot experiments to enterprise-scale transformation. The journey to enterprise-scale digital twin adoption is evolutionary and EPCs can seldom achieve full lifecycle integration in one leap.

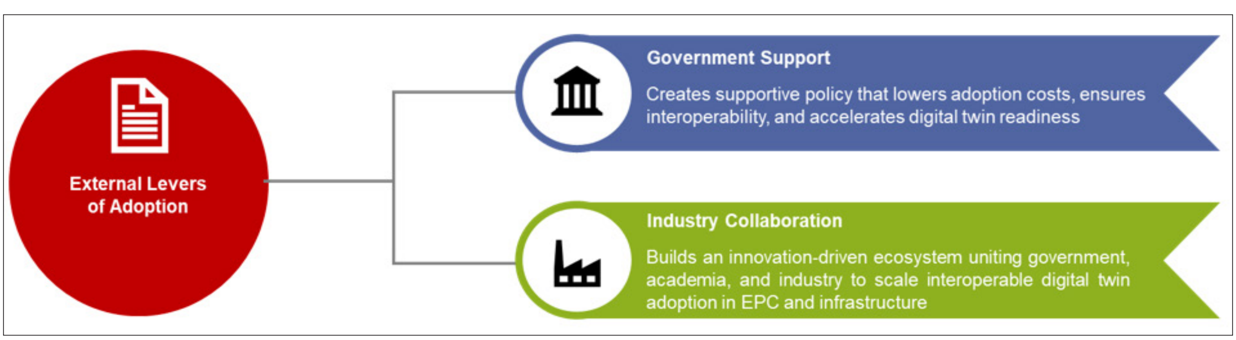


Implementation Roadmap

The **first phase** is about implementing pilots to create proof of concept. It involves identifying pilot projects, aligning the business case and building confidence in the technology.

The **second phase** focuses on integration by connecting design, procurement and site data into a one digital backbone. It also involves establishing a governance structure to manage it.

The **third phase** embeds this transformation across the organisation. Digital twins become part of every new project, data standards will be formalised and OEMs along with O&M partners are brought together into a unified system.



External Levers for Adoption

Each phase learns from the previous one. It starts with value creation, expands into process integration and eventually leads to enterprise intelligence. EPCs that follow these stages can see cost and time savings and will be creating assets that learn, adapt and continuously improve over their lifecycle.

While technology and processes are important, there is also a need for the external enablers in government support and industry collaboration to increase digital twin adoption among EPCs:

1. **Government Support:** Focuses on policy, financial and skill-building initiatives that lower adoption barriers and promote digital twin investment.
2. **Industry Collaboration:** Encourages partnerships, standardisation and knowledge sharing across EPCs, OEMs and academia to drive collective adoption.

Government Support

i) Policy and Financial Incentives

- Capital subsidies or accelerated depreciation for IoT, sensors and digital twin investments.
- Tax credits for digitalisation of EPC projects, like PLI schemes for smart manufacturing.

- Ex: India's SAMARTH Udyog Bharat 4.0 and sectoral PLI programs provide funding for Industry 4.0 technologies[7].

ii) Standards & Interoperability

- Mandate digital-friendly formats for project re porting, as-built data and O&M records.
- Ex: NITI Aayog's Genesys Program applies open BIS/ISO-based standards for digital-twin models[8].

iii) Skill Development

- Fund training programs for engineers and operators in digital twin, IoT etc.
- Ex: IISc's Industry 4.0 CoE has trained 9,800 + professionals on digital-twin and VR applications[9].

Industry Collaboration

i) Technology Partnerships

a. Collaborate with IoT platform providers (Azure IoT, AWS IoT), simulation/scenario modelling vendors (AVEVA, Siemens) and digital service providers (Wipro PARI, L&T Technology Services).

Ex:

i. Wipro PARI used Tecnomatix from Siemens for virtual commissioning, leading to on-site time reduction by 70%[10].

ii. Ola Electric leveraged NVIDIA Omniverse to cut design-to-production time by 20%[11].

ii) Supplier & OEM Integration

- Encourage vendors to provide IoT-enabled equipment and digital documentation.
- Use smart contracts or shared digital BOMs for traceability and reduced rework.

iii) Industry Consortia & Knowledge Sharing

- Share masked plant performance data for benchmarking.
- Collaborate on common standards for digital twin data and analytics.
- Ex: The Digital Twin Consortium India and Industrial Digital Twin Association (IDTA) are localising standards and organising pilots[12].

iv) Academia & Innovation Labs

- Partner with IITs, CSIR labs and startups for predictive models and new digital-twin tools.
- Ex: IIT Madras's research centre in collaboration with Hyundai India is developing digital-twin models for industrial application[13].

Time to Transform EPC Delivery with Digital Twins is Now

With average value and complexity of EPC projects constantly rising, the costs of delays and overruns have never been higher and it's a vital time for EPCs to move beyond their traditional systems which operates in silos at each stage to an integrated digital backbone enabled by digital twins. Early deployments across different industries have already demonstrated tangible benefits in the form of cost and time savings.

The opportunity now lies in scaling these proven capabilities across the entire lifecycle and to many more projects, supported by a clear and strong implementation plan and a governance structure and aided by enablers in the form of government, industry support, etc.

Conclusion

Digital twins offer EPCs a unified, continuously evolving view of projects, enabling faster execution, smarter operations and reduced lifecycle costs. With proven industry success, the priority now is scaling adoption through strategic roadmaps, integrated processes, skilled talent and supportive government and industry collaboration. By doing so, EPCs can deliver more resilient, efficient and future-ready infrastructure.

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