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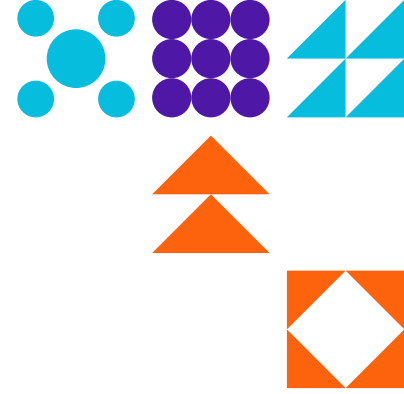
Strategies for Effective Project Delivery and Modularization Excellence



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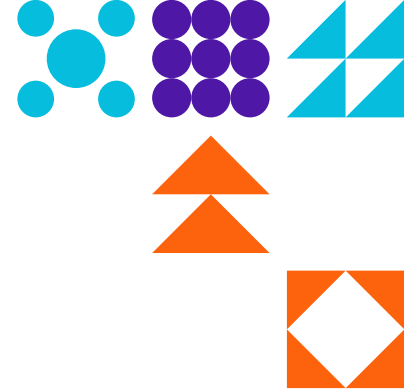
INTRODUCTION



Modularization in oil and gas refers to the offsite fabrication and assembly of process units and utility systems into standardized modules that are later transported and installed at the project site. These include Pre-Assembled Units (PAUs), Pre-Assembled Racks (PARs), and Pre-Assembled Structures (PAS). This approach shifts construction from site to controlled environments, improving safety, quality, and project predictability.

The most critical advantage modularization brings is schedule assurance. By executing civil works onsite while modules are built in parallel offsite, projects compress timelines significantly. This is particularly crucial for remote or brownfield facilities where site congestion, access, and HSE risks can delay stick-built construction. Global chemical and process giants like SABIC, ExxonMobil, Shell, and Dow have embedded modular strategies into their delivery models. Notable examples include:

- SABIC's Corpus Christi facility on the U.S. Gulf Coast, where large-scale modularization enabled cost control and fast commissioning.
- Motiva Enterprises in Texas (a Saudi JV), using modular units to expand refinery capabilities with minimized site impact.
- Modular refineries in Asia and petrochemical complexes in Europe that rely on PAS, PARs, and PAUs for schedule and safety optimization.



UNDERSTANDING THE CHALLENGES

While modularization offers significant benefits, its adoption; especially in the context of Saudi Arabia comes with several challenges. However, these should be seen as opportunities to strengthen the ecosystem.

- **Transportation and Logistics Constraints**

Transporting large, heavy modules across kingdom poses practical challenges, particularly in regions with limited road width, bridge capacity, or urban congestion. Modules that exceed standard transport envelopes may require special permits, escorts, or even modification of infrastructure. Onshore (shoreline) projects with port access have an advantage, but inland (far from shoreline) projects demand early and detailed logistics planning with authorities.

- **Design Freeze and Early Engineering**

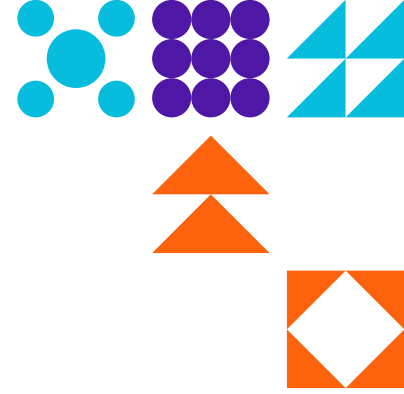
Modularization requires early locking of design packages. This can conflict with traditional project workflows, where design flexibility is preserved longer through many phases. Teams must be prepared to front-load decisions and ensure that process, electrical, and civil design disciplines are tightly coordinated in early project stages to assure early issued for Construction for any scope related to Modularization.

- **Integration Complexity**

Modules are only as successful as their ability to integrate smoothly on-site. Misaligned piping tie-ins, mismatched cable lengths, or instrumentation conflicts can cause major delays. To overcome this, laser scanning, and rigorous 3D modeling must be enforced across vendors and contractors.

- **Supply Chain Gaps**

Although Saudi Arabia's industrial base is growing, some modular components like specific instrumentation, control panels, or specialized valves are still sourced internationally. This creates risks in delivery timelines, especially when global supply chains are under pressure. Strengthening local content and qualifying new suppliers will help close this gap.



- **Fabrication Yard Standardization and Capacity**

Not all local yards are currently equipped with standardized modularization workflows or experienced supervisory teams. Variability in quality and productivity may exist. Establishing best practices, workforce training, and unified inspection protocols across yards is essential to ensuring repeatability and scalability.

- **Cultural and Institutional Familiarity**

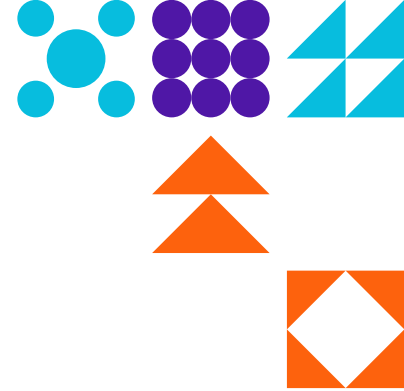
Some project teams, EPCs, or proponent may still prefer traditional stick-built methods due to comfort with long-established practices. Shifting to modularization requires a cultural shift in mindset toward front-end planning, offsite control, and digital execution. Executive buy-in and structured onboarding help drive this transformation.

- **Regulatory and Permitting Process**

Modules that involve pressure vessels, lifting operations, or import of foreign-built components must navigate regulatory approvals (e.g., SASO, customs, civil defense). Early engagement with government entities and clear documentation help prevent delays in module delivery and site installation.

- **Interfacing with Brownfield Constraints**

In existing facilities, space limitations, tie-in restrictions, and simultaneous operations (SIMOPS) increase the complexity of modularization. Planning crane access, ensuring utility connections, and coordinating shutdowns with operations teams can be intensive especially in congested zones with old infrastructure.



IDENTIFYING THE MODULAR SYSTEM CLASSIFICATIONS

Typical modular systems include:

- PAU (Pre-Assembled Unit): Large, standalone modules containing full process systems compressors, vessels, pumps, and control systems.
- PAR (Pre-Assembled Rack): Multi-service pipe racks with electrical and instrumentation cable trays, built offsite and installed as full racks.
- PAS (Pre-Assembled Structure): Structural modules such as substations, shelters, or elevated platforms fabricated and tested in controlled yards.

These units are integrated through standardized tie-in points and often undergo FAT and pre-commissioning before delivery

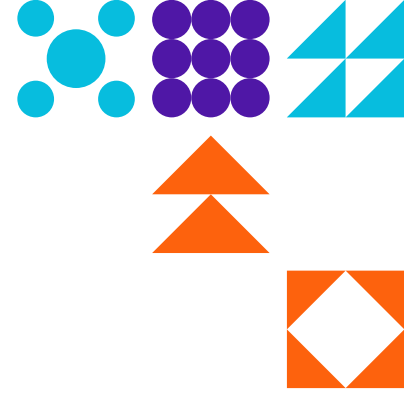
ASSESSING MODULARIZATION FEASIBILITY: STEP-BY-STEP

GENERAL FRAMEWORK

The Kingdom's ambitious industrial growth has placed process modularization at the forefront of project execution strategies. To ensure efficiency, cost-effectiveness, and timely delivery, project teams must adopt a structured approach to modularization. Best practices emphasize a systematic process to integrate modularization into complex projects effectively.

1. Conducting a Feasibility Study

A thorough feasibility study assesses the viability of modularization within the Kingdom's industrial landscape. This step involves analyzing project scope, supply chain limitations, workforce availability, and regional logistical constraints key factors influencing modular execution.



2. Defining Modular Scope

Successful modularization begins with a well-defined scope. Project teams must determine which process components can be prefabricated off-site while ensuring seamless integration with existing infrastructure. This early assessment optimizes design efficiency and reduces site-related risks.

3. Establishing Transport Envelope Early

The Kingdom's vast geography requires careful logistics planning. Transport constraints including road accessibility, module dimensions, and weight limitations must be identified early. This proactive approach prevents costly delays and ensures smooth module delivery.

4. Integrating 3D Design for the module index

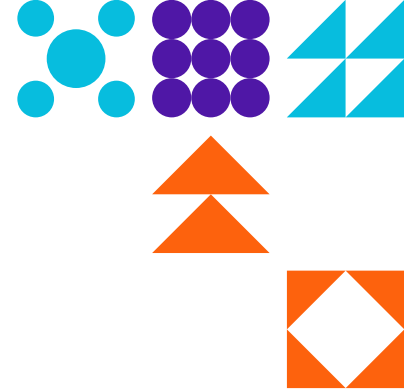
Advanced 3D modeling and interface management streamline modular coordination. Digital tools allow teams to simulate installations, minimizing spatial conflicts. This strategy enhances stakeholder collaboration, reducing rework and improving design accuracy.

5. Engaging with Local Fabricators and Logistics Early

A strong partnership with Saudi fabricators and logistics providers is critical in the Kingdom's modular projects. Early engagement helps synchronize module fabrication and transport logistics, ensuring efficient production and on-time delivery.

6. Aligning Site Civil Works with Module Fabrication

Modularization demands seamless coordination between on-site civil works and off-site module production. Proper sequencing avoids bottlenecks, ensuring foundational readiness for incoming modules. Early alignment enhances project execution speed and minimizes downtime.



7. Applying Digital Tools and QA/QC Standards

Leveraging digital twin technology and QA/QC protocols guarantees consistency across modular units. The Kingdom's projects benefit from stringent quality assurance measures, ensuring compliance with safety standards and performance benchmarks.

Process modularization in the Kingdom is transforming project delivery by reducing costs, enhancing efficiency, and mitigating risks. PMI methodologies emphasize early planning, stakeholder engagement, and digital integration to ensure successful modular execution. By following these structured steps, organizations can achieve operational excellence in modular projects.

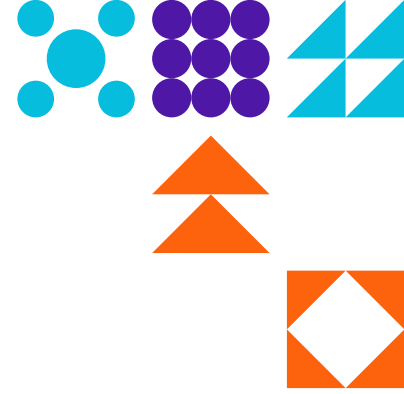
MODULARIZATION WITHIN FACILITIES

(Brownfield and Live Facilities)

Modularization inside existing facilities (brownfield or live operating environments) focuses on upgrading or adding systems with minimal disruption. Common examples include pump skids, chemical injection units, instrumentation shelters, utility bridges, water treatment modules, and substations.

Why it matters

- **Safety:** Reduces hot work and working in congested, hazardous areas.
- **Schedule Assurance:** Allows offsite fabrication while the plant remains online.
- **Access:** Enables installation in tight, restricted spaces.
- **Standardization:** Reuse of modular designs across similar units or sites.



Execution considerations

- Tie-ins: Minimized and standardized for speed and safety.
- Crane access: Requires 3D scans and rigging feasibility in tight plant spaces.
- Internal transport: Modules must fit through gates and around equipment.
- Compact footprint: Often designed vertically to fit limited space.
- SIMOPS: Must plan carefully around live operations and utilities.

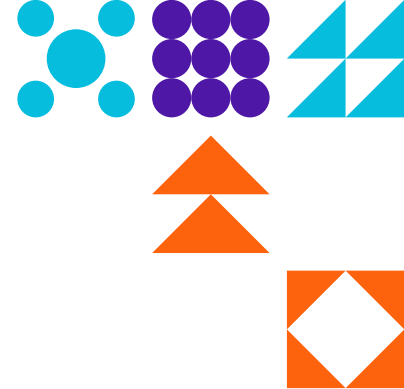
Challenges include

- Lifting under overhead structures
- Vibration sensitivity to rotating equipment; may trigger VMS alarms.
- Complex permitting (permit issuance) in operating zones or life facilities

Best practices

- Lifting under overhead structures
- Vibration sensitivity to rotating equipment; may trigger VMS alarms.
- Complex permitting (permit issuance) in operating zones or life facilities

• Interface integration with old systems
Intra-plant modularization enhances safety, efficiency, and execution certainty especially in shutdown-constrained environments.



MODULARIZATION IN NEW PROCESS FACILITIES (Greenfield Projects)

In greenfield (grassroots) projects, where a new facility is built from scratch modularization serves as a cornerstone for accelerating delivery and managing mega-scale complexity.

Greenfield modularization is typically used in large oil and gas complexes, or utilities infrastructure. It involves modularizing major systems such

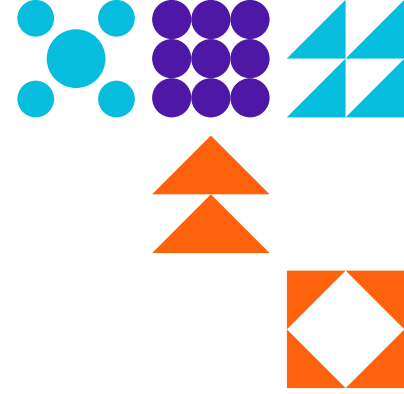
- Process trains (PAUs)
- Pipe racks and electrical systems (PARs)
- Substations, shelters, and MCC buildings (PAS)
- Utility skids and early production facilities

Advantages in new facilities modularization

- Faster execution by parallelizing module fabrication and site development.
- Cleaner site conditions: reduced field congestion, lower manpower, better logistics.
- Schedule Assurance: reduced weather impact and workforce limitations.

Strategic Considerations

Greenfield modularization is crucial for remote or high-safety-risks environments, such as remote locations or offshore platforms. By locking design early and managing execution in parallel workstreams, proponent achieve cost and schedule certainty essential for large capex, fast-track facilities. In greenfield (grassroots) projects, where a new facility is built from scratch modularization serves as a cornerstone for accelerating delivery and managing mega-scale complexity.



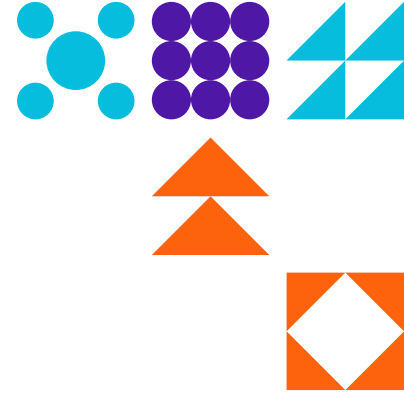
TRANSPORTATION AND THE TRANSPORT ENVELOPE

Transportation is a defining constraint in modular design. Projects must define their transport envelope early this includes:



- Width, height, and weight limits for road or port access
- Turning radius and bridge load capacities
- Lifting points and structural integrity during moves

Kingdoms road infrastructure is strong in industrial zones, strict permitting, clearance limits, and bridge load capacities can restrict module size. Permits, escorts, and customs can take weeks if not planned early.



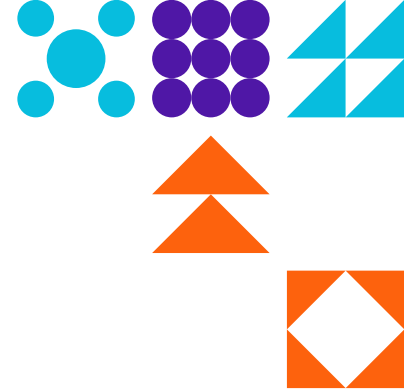
To overcome this:

- Some projects use near-site modular yards to build and move modules within short distances.
- Heavy haul contractors with SPMTs and hydraulic trailers are engaged during early design.
- The design team sets envelope limits (e.g., 5.5 m wide, 6.0 m tall, 200 tonnes max weight) to guide the entire 3D modeling process.
- Slice and dice the models in a way that is within your transport envelope and assemble it near by the site.
- Try to be in touch with other projects that is located within the same area of your project and utilize their logistics and heavy hauling studies; this will save time of doing new study.

Failure to define the transport envelope upfront leads to rework, late-stage redesign, or splitting of modules, which defeats the purpose of modularization.

SUCCESS STORIES OF MODULARIZED PROJECTS IN SAUDI ARABIA

Modularization is no longer a conceptual strategy in Saudi Arabia; it has been successfully implemented in several high-impact projects under several portfolio. These cases demonstrate the feasibility, value, and scalability of modular execution in the Kingdom's unique logistical and regulatory environment; as below cases that are not limited to the following:



1. Hawiyah Unayzah Gas Reservoir Storage Project (HUGRS)

The HUGRS project marked Saudi Arabia's entry into subsurface gas storage. Modular components, including gas compression systems and utility skids, enabled parallel fabrication and civil construction, helping meet tight delivery windows while minimizing site congestion and HSE exposure.

Source: [Aramco Life – HUGRS Project](#)

2. South Ghawar Gas Compression Project

Aramco's Haradh and Hawiyah Compression Projects incorporated modular substations and utility systems to accelerate installation timelines. The modular approach supported early testing and integration, while also enhancing construction safety in remote desert zones.

Source: [Aramco Life – Gas Compression Projects](#)

3. Jazan Refinery and Terminal

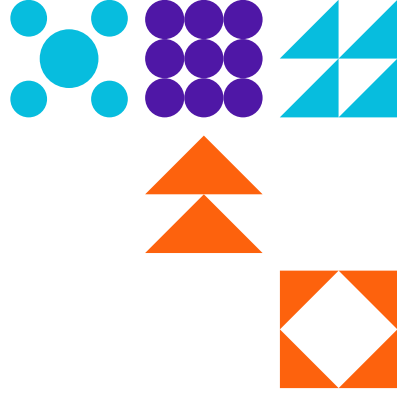
This 400,000 bpd mega-refinery used modularized piperacks and offsite substations to reduce congestion on-site and improve schedule reliability. The approach enabled better logistics planning and safer construction operations at a complex coastal location.

Source: [Aramco.com – Jazan Complex](#)

4. Fadhili Gas Plant

Fadhili is one of the Kingdom's most advanced gas processing facilities. It reached full design capacity of 2.5 BSCFD while utilizing pre-assembled skids and modular sulfur recovery units. The modular strategy reduced on-site work, helped maintain schedule, and supported early commissioning.

Source: [Aramco.com – Fadhili Gas Plant](#)



CONCLUSION

Modularization is more than a design choice; it's a strategic delivery model. When deployed properly, it enables:

Faster and more predictable project delivery

- Lower HSE and integration risk
- Early revenue generation
- High-quality fabrication and controlled installation
- Stronger alignment with Saudi Arabia's localization goals