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How to Efficiently Engineer the Onshore Facilities: Standardized Modularization

Drivers, challenges and perspectives in the Oil and Gas industry

by Catalin Eftimie

The modularization concept for onshore facilities has become in the past few years a design choice (when applicable) for many EPCM contractors competing on a tight market driven by a fluctuating oil price. It responds to the producers expectations for a reduced project delivery schedule at a lower cost. This paper highlights the basics of modularization and explains its drivers, challenges and industry trends. It will also guide engineering professionals on potential future projects embracing this type of design philosophy.

Introduction

Modularization is an alternate way of doing engineering aimed to reduce the number of interfaces, the Total Installed Cost (TIC) and overall schedule length of a project, while optimizing the Return On Investment (ROI) and allowing standardization for future similar projects. This design philosophy was well known since the 1980s, then its related know-how and principles started slowly to transfer from offshore platforms toward onshore applications without the pressure of low oil price, as it is the case nowadays.

Given the right conditions, Workshop Fabrication of modules offers many advantages compared to on-site components production as in Stick-Built design

In contrast with the conventional projects (a.k.a. field-constructed or stick-built), modularization will split a unit into parts of a system (so-called "modules") to be prefabricated in a fabricator workshop (off-site) and assembled later on-site on a pre-laid foundation.

The defined modules are portable, having a compact design and the combined functionality of multiple skids. Modules are also self-supporting and consequently removable, if required. From this perspective, the design in case of modularization is not done around an equipment, but rather at a package level (modular) vs. the single point design in case of conventional engineering.

The decision toward this design strategy shall be taken very early after starting a project, typically during conceptual/pre-FEED phase, when the engineering consultant evaluates the most cost effective design strategy. A study of modularization feasibility vs. stick-built design, taking into account the Owner's input and considering all critical factors, will help conclude early on the project strategy.

Developing a modularization strategy

1. *Is modularization a viable solution for the project?[4]*

A few "checklist" items[4] may put the designer in the right direction:

- Is future plant capacity suitable for modularization?
- Are there any restrictions on where and who can fabricate modules?
- Is modularization impacted by shipping and transportation limits?
- How would equipment spacing limitations impact modularization?
- Are site permits available at the start of the project?
- Availability of on-site heavy-lift cranes (> 300 tons per module)
- Proven competence of shortlisted fabricators in modularization
- What is the gap of field vs. shop fabricator labor cost and productivity?

2. *Project Drivers for Modularization[1, 2]*

Several factors are definitely in favor of driving a project towards modularization, as follows:

- Remote locations: projects in poorly accessible places are more costly using the conventional construction strategy,
- Site security: maximizing project activities off-site reduces the cost/schedule impact in unstable areas (e.g. affected by war),
- Adverse weather/climate impact: long severe winters or too hot climate are in favor of maximizing yard fabrication (off-site),

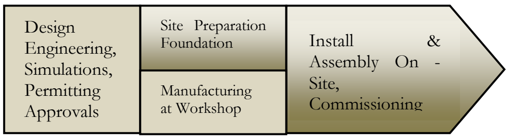
- Lack of skilled resources on- or near-site: typically off-site fabricator yards are using skilled electricians, welders, etc.,
- Improved productivity and schedule: workshop fabrication allows effective use of labor in an optimized environment, hence reducing cost overruns and delays often related to on-site activities,
- Minimized downtime impact in Brownfield projects: quicker site installation of pre-fabricated modules allow reduced schedule, less field disruption, safer handling and faster run,
- Standardization (design one & build many): allows re-using same design across many different projects in a scalable, interchangeable and safe way, reducing direct project time and costs (E&C) by 20% or more,
- Proven competence and experience of fabricators: modularization know-how is crucial in limiting rework and schedule reduction,
- Testing/acceptance and performance runs at fabricator yard: modular skids are assembled off-site and fully tested for equipment and piping, while cables are checked for continuity,
- Cost savings: maximized workshop fabrication translates in reducing field erection and construction man-hours involving costly manpower effort and costly logistics at site rates. Labor cost at yard is about 2/3rd than at field. Modules allow also important procurement savings along with reduced field management (including Owner´s supervision) and test-run/inspection costs.

3. Additional Benefits of Modularization[1, 2]

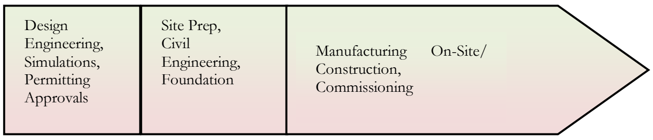
Workshop fabrication of modules offers many advantages vs. on-site components production as in Stick-Built design:

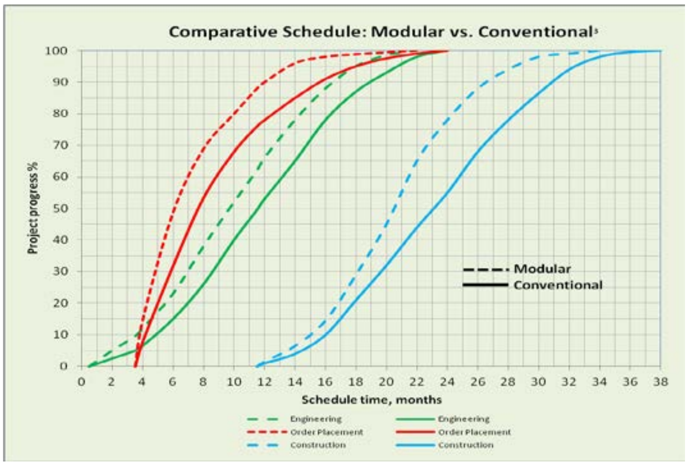
- Increased quality & HSE: workshop controlled environment (with required materials and tools already present) enables to meet highest standards, with routine operations (testing and inspection inclusive) performed by skilled manpower based on past experience and best know-how. It also allows increased safety and reduced risks.
- Reduced schedule (up to 25-50%): yard fabrication allows early procurement of critical equipment and maximized parallel works (workshop vs. field civil work/site preparation); yard work can start before obtaining a site permit. Short schedules are important when required to market products rapidly.

Modular Construction[5]:



Conventional Construction[5]:





- Efficiency: yard productivity is higher vs. on-site, due to an environment with less or no disruptions, as well as an organization allowing multiple shifts.
- Application of fabrication standards and unitization: modules incorporate many functions depending on complexity, and are ideally hooked-up by flanged connections at module edge at same plane and accessible elevation avoiding scaffolding which otherwise can reach up to 30% of module cost. Piping is fully painted and insulated; supports are inside module. Electrical/controls (with local panels) are incorporated in module (main field power/instrument cables are installed underground prior to module arrival, ready for inter-connection). If not unitized, modules are provided with 3-degree freedom spools. Pipe-racks are also unitized (continuous length fabrication, fully tested, cut apart in modules welded later at each connection).
- Mobility and re-usability: modular fabrication results in easier transportation (by truck, rail or sea) of less material/equipment, and allows modules relocation, if required
- Economical manufacturing: modular fabrication reduces labor hours and material loss, resulting in

compact packages with less piping due to optimized design
- Reduced on-site logistics: less lifting equipment and optimized field usage of heavy-lift cranes; minimized handling of materials on-site.
- Less on-site interfaces: compact design of modules reduces the number of inter-connections and simultaneous site operations.
- Less construction complexity: field operations are minimized
- Smaller footprints: modules can fit into a smaller plot area and typically gather all connections into one side

Modularization Challenges

The engineering module concept has both positive and negative aspects. Among the negative issues the most important is the cost of first design, which can exceed that of the conventional design up to 50-60% more[1] (or reaching up to 12% of the TIC[1]) depending on familiarity and modular past experience of the contractor.

Since the front-end effort is more intense than in conventional engineering and the number of long-lead items is greater with orders placed much earlier during the project, planning, schedule and activities sequencing are crucial in order to meet the hook-up and commissioning target dates. Modules interfaces shall be identified and frozen early to allow progress of parallel workshop and site activities, deviations shall be restricted to minimum, continuous schedule alignment is expected. Good coordination and claim management are critical, since procurement starts at earlier stage. Expediting needs also to be constantly evaluated to anticipate and avoid major delays.

Successful modularization requires a more mature design and a rigorous project execution organization

Several other aspects shall be carefully evaluated before going forward with a modular strategy:

- Space utilization: module design shall allow access to the components needing to be shut-off, which may require advanced 3D ergonomics analysis,
- Optimization of the level of modularization: modules sizes/weight are limited by local transportation regulation (typical size: 12'x12'x60' up to 24'x24'x120' by truck/rail, or larger by sea; weights up to 400-600 tons by truck/rail or up to 12,000 tons by sea),
- Accessibility and maintainability: equipment and instrumentation within a module have less access/maintenance space as in the case of conventional design,
- Accelerated procurement and complexity: number of long-lead items (LLI) is increased and order placed earlier vs. conventional design; it requires a transportation strategy (e.g. access routes, loading/off-loading facilities) for intense expediting,
- Managing a modularization project within a conventional one requires to consider equipment spacing requirements and confined area accessibility for maintenance in an existing limited plot area,
- Interface management and execution strategy: requires experience in both off-site modular fabrication and field construction/assembly, which implies also multiple work sites supervision and possibly more complexity,
- Shipping costs: larger modules are transported by sea, but may need to consider damage, delays or loss risks and fees related to insurance, marine surveyors and customs, plus costs for heavy lifting and special transport. Transportation and lifting in land-locked locations (with less or no roadways) may also become very challenging,
- Local laws and regulations: awareness of local national laws is critical for a modularization project planning, since it may impact shipping schedule and coordination between multiple sites,
- Construction and Quality standards: their implementation and/or deviations may become critical; potential conflicts between fabricator vs. owner standards can be solved via industry practice and adopting standards deviations, if justified,
- Materials/Logistics: material and equipment timely delivery and handling, heavy lifting/hauling, shipping constraints-truck/rail/barge, routing and clearances are all critical,
- Project Management: modularization is not as change-friendly as stick-built projects, so designer shall be prepared for no changes after IFD issue of P&IDs (except for safety and/or code reasons),
- Fabrication shop capabilities: ability of a fabricator to build, assemble and plan/coordinate transports shall be completed by its access to roads, rail system or deep-water (for larger modules).

Current trends in Oil and Gas industry: the need of investment into modularization for Engineering Companies and Contractors

It is currently recognized that the efficiency driven by modularization in the energy industry is somehow behind compared to other heavy industries (e.g. car industry, civil infrastructure, shipbuilding, etc.) which have applied with great success along the years this design strategy. However, many oil and gas industry Licensors and workshop fabricators have adapted faster to this new reality compared to the engineering companies where efforts are still on-going to improve their competitiveness.

The key elements in modularization are interfaces standardization and change management. It shall be noted however a few significant contributing aspects:

- Standardized modularization: mini-refineries with capacities up to 50 kBPD and gas plants up to 200 MMscfd capacity, as well as FPSOs have been built and operated based on the modularized approach. Important cost saving have been reported based on replication or templating in multiple similar parallel trains. This implies that engineering companies shall continue to adapt to the market with a new set of engineering standards and to become familiar with vendors standards for packages and materials,
- Minimizing peak manpower pressure at field: maximizing the work in the fabrication shops will continue to reduce dependability on less available field skilled workers. This includes performing off-site most of the pre-commissioning and commissioning work,
- Reorganization of engineering companies: facing the new provocations of the oil industry, many engineering companies are now expressing more interest to review for Owners the integration and optimization opportunities of the existing and future new plants. In this area, modularization may also become a "preferred choice", and many companies invented a "module architect" position which is a more skilled engineering position requiring not only a techno-commercial overall project view, but also the know-how of supply chain elements across multiple projects,
- Technologies offered as packages: many licensors started and shall continue to offer licensed technologies based on modularized packages concept.

Conclusion

Despite the reservation and sometimes the resistance toward this new accelerated way of doing engineering, modularization will continue to develop as a widespread revolution since it proved already its benefits. It allows to move complex and costly tasks from field into fabricators yard in addition to reducing risks and labor effort, while improving quality, schedule and savings via a higher off-site productivity. It requires however a strong know-how of both fabricators and contractor based on past experience and lessons learnt in similar projects.

The trend of modularization will continue in the coming years under the pressure of fluctuating oil price and reduced skilled workers availability, along with tighter environmental regulations.

However, successful modularization requires a more mature design and project execution organization. Engineering companies need to invest in this new reality. They need to improve their expertise, be open to alliances with specialized fabricators and especially adapt their project management approach to the challenges of standardized modularization.

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About the author

Mr. Catalin Eftimie is a freelance Senior Consultant with a diversified process/project engineering portfolio focused on downstream oil & gas technologies. He is a former graduate of IFP School (France) and his overall professional expertize was developed on EPC, Client (Producer) and Licensor sides, covering Greenfield and Brownfield projects.

For any further questions, please contact Catalin Eftimie (Catalin.Eftimie@shaw.ca*)*.