Modular and Standardized Design for Capital Projects offers Key Advantages

Modularization is a powerful capital-project tool, and astute designers and project managers are increasingly paying it close attention. Since no one likes to be left in the dark when it comes to project success, we've developed a quick modularization summary that reveals key benefits and limitations you need to know.

An ongoing trend has emerged toward modularization of piping and equipment onto transportable "drop-in" skids during the engineering phase of projects. As more owners and contractors realize the significant advantages and construction benefits of modular design, this trend will continue.

Modularization is an execution approach for design, procurement, contracting and construction that shifts construction/assembly of key functional modules offsite for easy incorporation into the field construction site. The entire skid package is designed, engineered, and fabricated in a shop facility rather than onsite. Modules/skids are typically built under contract in local fabrication shops—with requisite qualifications and capabilities—in the main construction site's vicinity, custom designed to fit within the site itself and the transport mode, and shipped in one shipment—on the back of a flatbed truck.

The decision to include modular components in an overall project design is often driven by factors including:

- Feasibility of on-site construction.
- Difficult labor conditions or high labor costs at the project site.
- Weather constraints at the site.
- Project schedule limitations.
- Availability of skilled technical construction personnel in the project location.
- The need for system testing and verification in a controlled environment.
- The need for multiple modules and design uniformity.
- Remote site location.

Modular design elements present a real opportunity to streamline this segment of the construction process and render it more efficient. But, for modular systems to succeed the owner and contractor have to be on board from the start of all design work, and owner operations personnel must be involved as early as possible. The decision to modularize project elements, and the level of modularization, needs full and early commitment from all stakeholders to ensure appropriate business planning, scope definition, engineering and procurement.

3D Module Modeling

Over the years, technology advances and tools available to engineers and designers have made it possible to execute projects more efficiently. The availability of 3D modeling software has significantly improved design accuracy—by allowing designers to *really* visualize the work and thoroughly understand spatial relationships in complex apparatuses. 3D modeling of modules can help owners and operators visualize how the module will fit in each facility to standardize the form factor (i.e. skid size, nozzle orientation) and other operating characteristics. Modular design was always beneficial, but 3D modeling revolutionized the process by allowing engineers to modify designs in real time. 3D design technology now permits engineers and designers to increasingly condense modules while improving performance and reliability.

This design flexibility can be a great benefit to modularization since different components may need to be supplied to meet codes or regulations applicable where the module will operate. These “fit-for-purpose” and readily adjusted designs drive costs down.

The Benefits of Modularization

The choice is between fabricating an engineered module in a shop and shipping it to a project site for drop-in installation, or fabricating it right on the project site. These two choices are very different—and each choice carries unique implications for cost, timing, and utility.

Self-contained portable modular systems are much easier to deliver on time and on budget due to control of the assembly/fabrication environment, and modular-design benefits like schedules and field-labor costs are measurable.

Significant benefits include:

- **Weather** — Weather-related delays common in field fabrication are avoided entirely.
- **Safety, Quality and Reliability** — Saving design and construction time reduces errors in construction, delays, and total onsite hours in riskier environments. Modular designs more readily focus on and ensure optimum access for operation, maintenance, repair, and safety. This attention in the design phase offers a significant advantage by reducing down time and added costs during construction.

  Because modular elements are fabricated in controlled environments—and are often tested and certified before shipment to the site—the module’s function and reliability is far more predictable. The chance of error in assembly or dysfunction or delay in assembly is dramatically reduced, and fabrication quality in a controlled environment is typically better than in the field. Quality control in fabrication-shop environments, and keeping trades in one shop, permits a higher quality assembly and lower inspection and testing costs.

  The development contractor or design team provide installation and startup services to the site operator/owner, and conduct complete and detailed training for use of the entire packaged system to operators to ensure maximum efficiency and system safety.

- **Scheduling Advantages** — An important advantage is overall project schedule reduction and control. While module design takes more advance planning, offsite fabrication and just-in-time site installation reduce site construction time and procurement and weather delays, for overall project schedule improvement. With modules, offsite fabrication shops can fabricate *simultaneously, while* contractors are conducting other onsite activities (saving 100% of the time). Onsite contractors don't need to wait while a system is assembled onsite or adjust schedules or work around the assembly.
- **Cost Savings** — Project owners realize savings, and can instead spend their money on more improvements at their facilities. Shop labor rates are definitely lower than field rates, but offsite fabrication does include some added costs like transportation. The overall cost of building a module is typically eight percent lower than onsite fabrication/construction (the savings can be higher). In some cases module fabrication can be done in other countries (offshore) at a much lower cost. Modular design generally reduces costs by:
    - reducing labor
    - improving safety
    - improving scheduling
    - reducing timelines to completion
    - improving quality
    - permitting replication and scalability
- **Footprint Advantages** — Compactly designed to fit in small spaces, self-contained modules can significantly reduce the footprint of equipment apparatus/skids.
- **Module Re-Use** — Some modules are reusable. After use is complete at one facility or project site modules can be re-packaged and shipped to another facility for re-use, dramatically increasing the module's long-term utility and ROI.

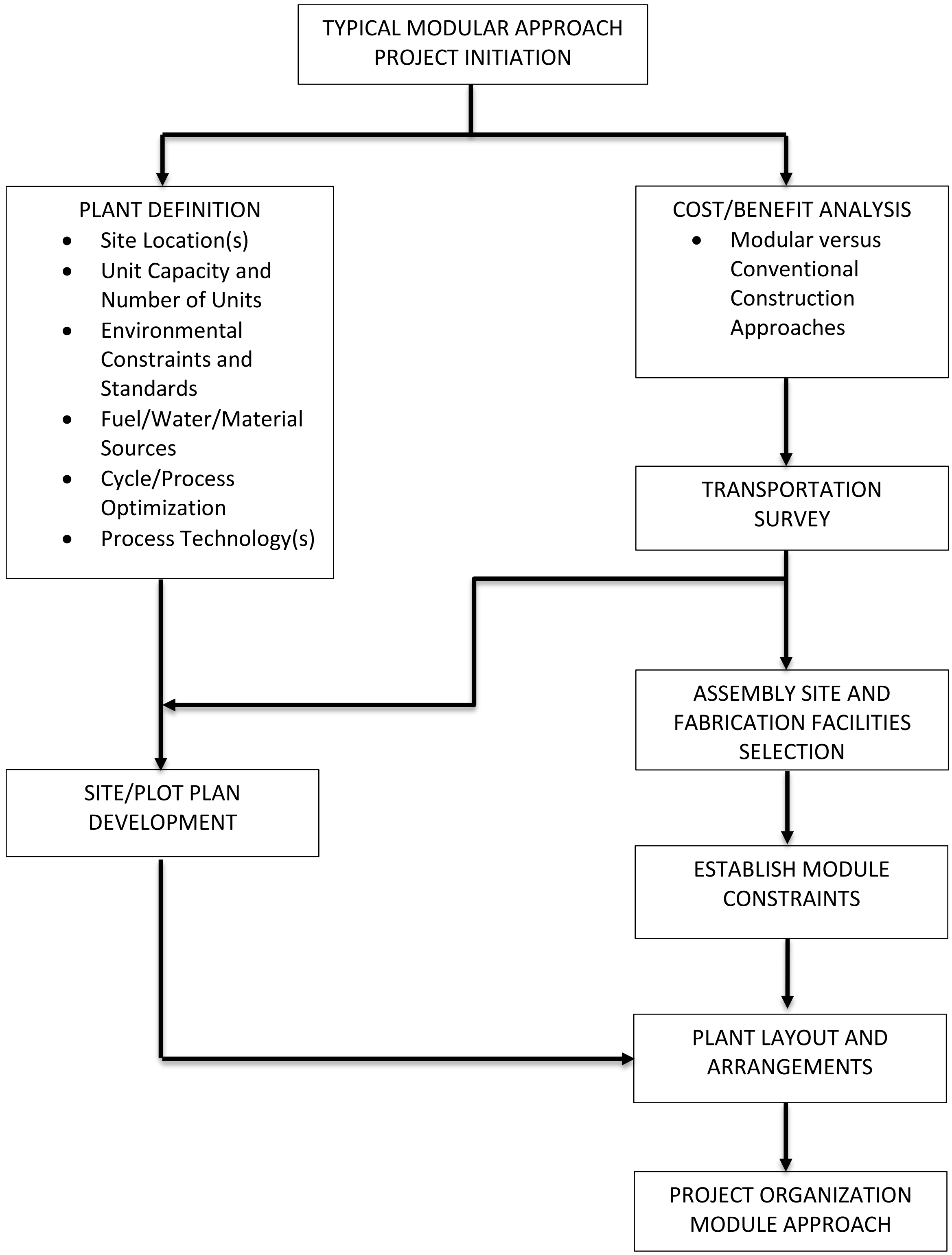
Limitations and Challenges

Modular design does have its limitations. Modules have to be shippable (i.e., road and logistics constraints) and must withstand travel rigors. They can't fit into some facilities due to congestion. A shipping study is usually necessary to ensure delivery and installation feasibility. Transporting modules can increase engineering and shipping costs. But, in most cases these challenges and costs are more than offset by advantages gained.

While there are no real disadvantages to these design and management practices, effective module design does require more planning and early engineering and procurement than onsite development.

The Decision to Modularize

Making effective decisions to modularize requires a series of steps and dialogs, including defining plant requirements, conducting a cost-benefit analysis, surveying transportation requirements and constraints, selecting module fabrication site/facility, and reviewing plant site layout arrangements needed to best accommodate the module, as suggested in the decision tree below:


TYPICAL MODULAR APPROACH PROJECT INITIATION
PLANT DEFINITION
• Site Location(s)
• Unit Capacity and Number of Units
• Environmental Constraints and Standards
• Fuel/Water/Material Sources
• Cycle/Process Optimization
• Process Technology(s)
COST/BENEFIT ANALYSIS
• Modular versus Conventional Construction Approaches
TRANSPORTATION SURVEY
ASSEMBLY SITE AND FABRICATION FACILITIES SELECTION
SITE/PLOT PLAN DEVELOPMENT
ESTABLISH MODULE CONSTRAINTS
PLANT LAYOUT AND ARRANGEMENTS
PROJECT ORGANIZATION MODULE APPROACH