WHITE PAPER

Streamlining Projects with a Modular Approach

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The economics of the upstream, downstream and chemical industries are under extreme pressure, due to the low cost of oil and natural gas and uncertainties regarding their future trajectory. Common to all of these industries is the requirement to continually invest in new processes and new plants, address new markets, innovate, and meet evolving demand for products. This has created a pressure point on the capital and lifecycle cost of assets and on the projects designed to create those assets. Project overruns in the oil, gas and petrochemical industries have cost impacts that extend over the lifetime of the delivered asset, pressuring companies to deliver on schedule to maximize the profitability of the completed asset. Owners have become convinced that standardized or modular designs are a big answer to this conundrum. By using standardized designs, whenever and wherever possible, a number of cost and risk issues are addressed. Upstream players such as Chevron, ExxonMobil and Marathon Oil have expressed this as a key business initiative. Consultants such as EY Consultants[1], Accenture[2], and Douglas-Westwood[3] all recommend this as a key strategy.

Implementing standardized designs and/or adopting a modular approach to process units reduces design, schedule and cost uncertainty and, as a result, saves significant amounts of time and money and may potentially help achieve a faster start-up. Owners are trading off the best possible design ("gold plated design") which have higher CAPEX for pre-designed processes known to fulfill the function and deliver a lower lifecycle cost. Standardized designs improve front-end engineering efficiency and execution, helping to get projects to the construction phase more quickly and with a lower engineering cost. Additionally, standardized designs improve construction management by increasing the proportion of fabrication work performed in the shop versus in the field, especially when combined with modularization and simplified construction management. With the aspenONE® integrated engineering workflow, based on model-based applications, process designs and cost estimates, a "best practices" reference design can be created, complete with engineering documentation and ready for reuse in a modular fashion to rapidly complete similar conceptual engineering projects. This includes quickly and reliably modifying the process based on varying locations, applications and scale, thereby reducing engineering, construction and cost risk.

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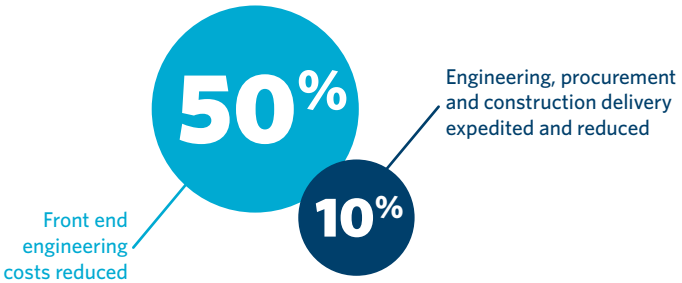
Reinventing Project Workflow

Breaking the habit of reinventing solutions associated with traditional engineering methods and organizational structures is difficult, organizationally. Engineers embrace creativity and continuous improvement, with their training and experience telling them to optimize the design for the production objectives, feedstocks and location, biasing them towards one-of-a-kind designs. However, some EPCs have seen the inexorable trend, and have begun to change their engineering processes by using standardized design as a potential strategic advantage. Some examples are Fluor's "Third Generation Modular Design" solutions, Chart Industries small packaged LNG plants, and Technip's standardized design corporate strategy. But, how do you achieve the required change in an organization so that it can be successful with this strategy?

The changes that are required are on the one hand organizational, requiring engineering disciplines to collaborate on definition of standardized designs, but they also must be coupled with an evolution of the underlying software tools: the right set of modular, model-based and modular design, workflow-supporting integration tools that can go a long way towards enabling and promoting change. When the right tools are available, the engineers can focus on the value-added engineering project at hand.

When an organization is dependent on traditional tools to create templates, such as Microsoft® Excel spreadsheets, they are then limited to scaling or factoring them to different project parameters, throughputs or locations, as well as enumerating their project schedules, costs and risks. That approach is sufficient when working in known locations and sizing, but it is hampered by many limitations when planning a project that is significantly larger or smaller than existing designs or is in a new location. It does not promote a rigorous approach to capturing best practices, or employ a sophisticated approach of adapting a standardized approach to a new situation. It also introduces high maintenance requirements for the customized Excel spreadsheets, which end up being dependent on a few individuals.

In contrast, the modeling tools from AspenTech can capture both process units and entire designs as templates, showing that the reference design is easily usable as the starting point for the next project. And, by extension, the entire integrated ("activated") workflow supports capturing those multiple models (across disciplines), such as heat exchanger and energy models, as aspects of these standardized design templates. Having the right tools available supports the strategy in which the engineer can consider a plant as



being composed of modules - some requiring previously designed and used modules, while others are individually designed for the project. Samsung Heavy Industries[4], for example, has demonstrated that by using this approach for FLNG projects, EPCs can reduce front end engineering (FEED) costs by 50% or more and engineering, procurement and construction delivery can be significantly expedited and reduced by 10% or more.

Project design for upstream and midstream oil and gas is the first key area to embrace a modular approach and re-use standardized design modules. Many oil and gas companies, who have in the past designed and built customized projects to specific locations and hydrocarbon characteristics and the nature of the existing infrastructure, are exploring and driving forward standardization. Reusing

existing templates for repeatable process units heps de-risk the work, because many of these units are fundamentally the same from project to project. This includes dehydration, NGL separation and gas purification, but also includes more specific equipment modules such as large compressor systems, acid gas removal strippers and subsea modules. The precedent is the process licensor workflow and business model in which the capture of designs in software has proven to be highly successful by licensors, such as UOP, DuPont Clean Fuels, Technip Stone and Webster Process Technology, and Bechtel's LNG groups[5].

The concept of off-site fabrication and modularization in engineering and design can be scalable from small to large projects, such as floating production, storage and offloading vessels, that are scaled to the oil and gas flow characteristics and the size of a particular producing formation. Compressor modules can be standardized because the same equipment design and layout can be reused in various settings, accounting for throughput, contaminants, viscosity, weight and size limits, and other factors and verified using dynamic models. For larger facilities, such as liquefied natural gas (LNG) plants, the focus moves to replicating modules that make up the plant. The key risks that need to be traded off against stick-built and one-of-a kind design are the logistics involved in ship or land transport from the fabrication site and the lead times required to assemble modules in fabrication yards. This is not only a logistical and construction cost tradeoff, it also relates to factors such as safety risk in remote construction workforces, engineering quality achievable in fabrication yards, and the availability of peak onsite workforces.

Many companies have successfully adopted modular standardization to apply common design specifications and guidelines for process units across projects (i.e. a refinery or production platform). Dow Chemical Company, for instance, has discussed in public forums their use of standardized engineering reference designs for certain process equipment and units. The use of libraries containing design templates, which include datasheets, equipment and line lists, is a powerful way of avoiding unnecessary duplication of data entry and copying, helping to minimize engineering time and reduce costly overruns. A key to this strategy is aligning the engineering stages from conceptual design through basic engineering to detailed design. Collaboration across the project teams is essential to leverage important documentation.

Global Project Execution

Off-site modular assembly is becoming a strong alternative for construction in process plant development. This highly efficient process alleviates the challenges typically associated with tight project schedules, changing site conditions and the availability of skilled field labor, while minimizing variability in the quality of the finished product. The safe and correct assembly of equipment, such as columns and reboilers, is critical to performance and reliability. Units derived from fabrication workshops, such as steel casings, stacks and ducts, burners and piping, can be pre-assembled for shipping anywhere around the world and modular construction can be more easily executed with available on-site skills. Safety is often a driving concern, especially in remote or dangerous areas (such as the arctic).

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As modular design and construction projects become more prevalent, powerful and integrated engineering tools can help engineers complete datasheets faster and communicate with all stakeholders working on the project. Many E&Cs have standardized on the aspenONE Engineering software suite by AspenTech, which contains process modeling analysis and design tools that are integrated and accessible through process simulators. Engineers can optimize process designs for energy use, capital and operating costs and product yield through the use of activated energy, economics and equipment design during the modeling process.

E&Cs continually seek ways to improve workflow and streamline processes. Aspen HYSYS® and Aspen Plus® are the tools of choice for engineers using a modular approach to design. Process units targeted for reuse can be captured as templates, kept in an organized library and quickly accessed when a design is being modeled. The tool helps deliver faster project execution, meeting increasing demands and minimizing performance degradation, while complying to strict environmental and product quality standards.

In addition to process modeling, concurrent development of accurate CAPEX estimates is a key advantage of standardized design. To achieve that, it is imperative to deliver accurate cost estimation early in the concept design and basic design stages. Implementing standard practices and methods enterprise-wide ensures design quality, reduces maintenance costs and meets safety compliance. Costs can be equivalently captured in Aspen Capital Cost Estimator (ACCE) as templated costs. These can be easily accessed during process design via the Activated Economics workflow from the process modeling tools, which transfers the scope from process engineering teams to estimating teams. ACCE is a powerful tool for evaluating the efficacy of modules for projects. Its modeling approach enables costs to be evaluated based on the specific sizing and location parameters of a new instance of a standardized design. The software provides estimators with an early look at resource constraints, such as craft, labor and fabrication equipment and then enables them to easily evaluate and quickly shop versus field fabrication, including a whole host of tradeoff scenarios.

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It is also important to capture design knowledge to improve the ability of less experienced engineers in delivering high-quality designs. Aspen Basic Engineering (ABE) is an industry-leading process engineering solution that enables global organizations to seamlessly and accurately bring together and template all aspects of front end engineering design and basic engineering. Now it is possible to achieve a huge competitive advantage by delivering process data packages for licensed technologies and other repeatable designs in half the time that's currently required. Through capturing process technologies and best practice designs in reusable templates, engineers can apply them repeatedly in future projects for dramatic time savings. In addition, time-consuming datasheet and equipment list development is automated.

Customer Success: Sadara and DSM

A prominent example of the effective application of modularization is Sadara Chemical Company's Petrochemical Complex Greenfield project[6]. During pre-feed, the company used Aspen Capital Cost Estimator to identify an infeasibly large temporary workforce requirement at the project location in Saudi Arabia, which was based on the resource loading predicted by the model-based estimating methodology. At that point, modular construction of many process units was compared with onsite stick-built construction, and it was determined that the work force requirement could be reduced to feasible levels at a reasonable cost tradeoff. That project is now nearing startup in 2016 and is tracking close to the original FEED estimate.

Another interesting example of modularization is the global science-based company, DSM[7]. The company has entered a mode of rapid introduction of new health and science products. To support that business strategy, the engineers at DSM developed concept designs and costs for reusable process building-block modules, amenable to the style of batch manufacturing that supports this new generation of products. Using these reusable building blocks, process engineers can support the business by rapid development of conceptual designs with associated lifecycle cost estimates, enabling better commercialized decision-making.

Standardized Design and Modularization Supports Today's Business Strategies

With business leaders seeking lower capital project investments, while still driving towards business growth, standardized designs and modularization are two engineering strategies that respond to those business pressures. Standardized designs reduce project risk and therefore project cost in multiple ways, as we have described in this paper. Modularization increases project management efficiency and presents opportunities for tradeoffs between on-site fabrication and shop modular fabrication. When modular construction is considered, lead times can be improved, helping the shop fabricator efficiently fabricate and then ship. Therefore, early and accurate conceptual design becomes even more important when trying to achieve fast-tracked designs.

A key for both strategies is more focus on front end design and the supporting engineering workflows. When better engineering tools are put in place, organizations can evolve towards a more integrated and collaborative workflow in which standardized designs can be used to achieve lower costs and in many cases, more successful projects. Using these standardized designs, it can reduce the time spent on repetitive design tasks and increase the time available for value-added engineering work, such as being able to optimize the design for lifecycles CAPEX and OPEX, reduce energy consumption and increase sustainability. aspenONE Engineering is an ideal platform to achieve this, with a focus on Aspen HYSYS, Aspen Plus, ACCE and ABE.

Standardized modular design gives EPCs the opportunity to gain a competitive position and take advantage of the unique characteristics of integrated engineering modeling and analysis software tools. This supports the concept of repeatable designs, which saves time when re-entering data and enables the optimization of a design across the feasibility study, conceptual engineering and FEED workflows. The software tools also help knowledge sharing across the organization and allow efficient access for project delivery teams to streamline and deliver accurate engineering solutions that meet deadlines. In essence, modularization expedites project execution by compressing project schedules and integrating global design teams for faster on-time delivery. Companies that are embracing this approach are seeing significant success in the marketplace.

BENEFITS AND ROI OF MODULARIZATION AND STANDARDIZED DESIGNS	
Templated Designs for Repeat Processes	• Up to 50% reduction in FEED timetable • 10-30% reduction in engineering man hours
Modular Construction	• Reduce onsite construction workforce 10-70% • Increase workforce productivity • Improved quality

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AspenTech is a leading supplier of software that optimizes process manufacturing—for energy, chemicals, engineering and construction, and other industries that manufacture and produce products from a chemical process. With integrated aspenONE® solutions, process manufacturers can implement best practices for optimizing their engineering, manufacturing, and supply chain operations. As a result, AspenTech customers are better able to increase capacity, improve margins, reduce costs, and become more energy efficient. To see how the world's leading process manufacturers rely on AspenTech to achieve their operational excellence goals, visit **www.aspentech.com**.

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