Best Practices in Front-End Design

A Bentley White Paper
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INTRODUCTION

Every year, owner-operators in the hydrocarbon and related process industries invest several billion dollars constructing new plants, revamping existing ones, improving safety and environmental compliance, and increasing system reliability. They invest even more in asset management and maintenance programs.

All of these projects must be cost-effectively delivered on ever-tighter schedules by firms and their project teams dealing with an increasing shortfall in the number of highly skilled engineers available to tackle these challenges. It’s clear that the shortage affects each project phase from concept, through front-end and detailed design, to construction, operations, and maintenance. This shortage in engineering talent also impacts every supply chain link, including plant equipment suppliers, which report increasing lead-times even for such once commonly available items as valves and pumps. The ability to secure, in a timely fashion, materials and labor to deliver projects or carry out maintenance is critical to business success, and requires effective information sharing among the multi-disciplinary firms typically involved in these efforts.

Unfortunately, today, this often isn’t the case. Because information generated by one discipline at a particular phase of a project’s lifecycle is not always shared or reused at another phase, businesses suffer from inefficient use of capital, poor returns on investment (ROI), and increased project risks due to inconsistencies in project deliverables that take time and cost money to resolve.

Engineers are increasingly pressured to make sound investment decisions earlier in a project, even as the pool of available engineering resources to tackle those decisions continues to shrink. However, process industries can improve project performance by

Fig. 1. Typical workflow in front-end design projects
adopting a multi-disciplinary, concurrent workflow that ensures all engineering decisions made during the conceptual design and front-end engineering phases of a project are based on sound asset lifecycle knowledge and best design practices. Ever more design decisions, such as material selections and plant layout that are typically made at the detailed design phase, are now made at the front-end engineering and design (FEED) phase (Fig. 1). In fact, detailed P&IDs and 3D plant models at the FEED stage are developed much earlier so that informed decisions based on cost implications can be made. This also ensures that major maintenance or constructability issues don’t arise during the engineering/procurement/construction (EPC) phase.

In the following, we will discuss some of the major challenges project teams face while working on front-end engineering and design projects. We will also describe the approach Bentley Systems has taken to address some workflow challenges during conceptual design and FEED. For example, Bentley offers AXSYS®.Process and PlantWise® for fast and effective solutions to screen alternative process designs and plant layouts, and to help project teams arrive at an optimum concept for the project.

Bentley also offers a comprehensive range of FEED applications that can be initiated from data in AXSYS.Process and PlantWise. These applications include piping and instrumentation diagrams (P&IDs), instrumentation and wiring schematics, electrical schematics, datasheets for initial vendor inquiry, tools for collaborative design reviews, methods for assessing failure resulting from corrosion, and initiating 3D plant design. Moreover, because Bentley uses the industry standard ISO 15926 data exchange model to deliver interoperability, users can select the best-in-class applications for their front-end design projects.

Key Challenges in Planning Capital Projects

**Screening Process Alternatives**

Screening process alternatives, generally performed by senior process engineers, involve the use of several stand-alone software tools including process simulation programs, heat exchanger design tools, equipment sizing methods, and various CAD tools to draft process flow diagrams (PFDs). Here, the challenge becomes the effective management of workflows and tracking of design changes during this fast-track activity. This calls for a central process database capable of dealing with both graphics and design data, and the ability to interface with information from external process simulators and sizing programs, thereby providing a managed concurrent engineering environment for screening process alternatives.

**Conveying the Design Intent**

By effectively conveying the design intent to plant owner-operators, delays in approval for the project can be avoided. Most people find it convenient to visualize the design intent in 3D. So the question becomes: How is it possible to develop a 3D representation of the proposed facility using only preliminary process scope? A further question is: How can we effectively deal with demands for lowering the total installed cost in a timely manner?
Early Scope of Bulk Materials
Every cost engineer should receive an early definition of bulk materials from the design team in order to project a reliable cost estimate for the capital investment. The challenge, once again, is to define the scope of bulk materials without a detailed 3D plant design model. However, a conceptual 3D plant design model actually can be generated in minutes using a fast auto-routing application for piping.

Integrated P&ID Development
When it comes to integrated P&ID development, the challenge involves not only developing P&IDs, but also maintaining data consistency with process information, line sizing data, and instrumentation and equipment definitions — all while providing a flexible workflow across different geographic locations. This requires a data-centric workflow for developing P&IDs with complete control of revision and design changes, facilitating reviews and incorporating comments.

Jump-Starting Detail Design
Jump-starting detail design has become the norm for FEED projects. Because owner-operators demand shorter project schedules (Fig. 2), most of them are not prepared to delay the start of the engineering/procurement/construction (EPC) phase. Clearly, owner-operators would rather jump-start the detail design phase by reusing FEED data.

Most conceptual design projects involve concurrent engineering workflows, with all design disciplines working simultaneously from a common database.

Bentley’s Approach for Conceptual Design
Most conceptual design projects involve concurrent engineering workflows, with all design disciplines working simultaneously from a common database. Only a data-centric approach guarantees data consistency between schematics and design deliverables and allows:

- Process engineers to manage multiple process simulation case studies and rapidly establish the governing case,
- Equipment designers to reuse this data to design or rate critical heat transfer equipment,
• Mechanical engineers to develop their equipment specifications in the form of data sheets using Excel worksheets,
• Layout designers to try multiple alternatives in response to process changes,
• Cost engineers to extract the early bulk materials scope for their conceptual cost estimates — all from a common set of process data.

This is the approach Bentley takes to address concurrent engineering workflows in conceptual design, where rapid screening of alternative concepts is critical, and reviewing the impact of changes in the proposed concept must be visualized quickly to gain approval of the design intent.

Bentley AXSYS.Process for Conceptual Process Design

Bentley AXSYS.Process allows increased evaluation of conceptual design cases and leverages corporate knowledge to significantly reduce capital expenditure for new plants and plant upgrades. It is a data-centric, database-driven application that provides rule-based methods for automating the selection of equipment items and drawing creation directly from process simulation results (Fig. 4). By combining users’ best design practices in the form of templates, the resulting PFDs and P&IDs are automatically generated with minimum user intervention.

The product supports interfaces to most industry-standard process simulators, including HYSYS, Aspen Plus, Pro/II, and UniSim Design, along with such heat exchanger design programs as HTFS and HTRI. In addition, interfaces to Excel-based datasheets and reports are supported as standard tools. Moreover, preliminary P&IDs generated
from AXSYS.Process can be further detailed using Bentley’s P&ID tools, including AutoPLANT® P&ID, PlantSpace® P&ID, and OpenPlant PowerPID. In addition, all affected design disciplines can share the process data, while Lifecycle Server supports integration with an asset lifecycle data warehouse and ProjectWise® supports workflows and document management.

Benefits of Bentley AXSYS.Process

In order to realize the full benefits of AXSYS.Process, one must consider the “how-to’s,” such as how to generate process design deliverables, and “what-ifs,” including:

- What if a different process technology is used?
- What if the parts are not readily available from the manufacturer?
- What if a different material selection is made for prolonged asset lifecycle?

AXSYS.Process provides plant owner-operators with a unique opportunity to:

- **Compress time for process screening by up to 40 percent:** Users have experienced great results with workflows in which a key factor is the screening of process alternatives. Simply by using the multicase feature in AXSYS.Process, engineers can select the desired simulation case and rapidly derive a design or governing case for the process design. Subsequent deliverables, such as process flow diagrams and heat and mass balance tables, are fully automated in AXSYS.Process, thereby achieving this level of schedule compression.

- **Eliminate the need to re-enter data:** Engineers can spend up to 30 percent of their time looking for the most current data. With a data-centric approach to data and graphics in AXSYS.Process, users eliminate the need to re-enter data.
• Utilize existing MS Excel applications: Most companies keep in-house datasheets and sizing applications in MS Excel. Bentley minimizes retraining by providing a two-way interface mechanism that links data fields in these applications with the project data in AXSYS.Process.

• Track design changes: This step is critical during the early phases of process design. Tracking design change histories helps process engineers review previous scenarios and demonstrate the “before” and “after” case for critical process changes. Because AXSYS.Process is built on a central process database, it tracks the who-created, who-approved, and who-issued status on each design property as well as project deliverables.

• Jump-start P&IDs in FEED projects: This is critical to meeting tight project deadlines. AXSYS.Process provides methods to generate preliminary P&IDs directly from PFDs, and can provide transfers for both data and graphics to AutoPLANT P&ID, PlantSpace P&ID, and OpenPlant PowerPID.

**Bentley PlantWise for 3D Conceptual Plant Design**

PlantWise is a unique suite of knowledge-centric software solutions that enables fast creation of 3D plant conceptual design models for review and optimization. PlantWise provides users with flexible 3D modeling and automatic pipe routing to rapidly evaluate plant layouts in the early stages of conceptual plant design. PlantWise picks up PFD and early P&ID data from either AXSYS.Process, or legacy data using preconfigured MS Excel import spreadsheets specifically designed to capture basic line list and equipment information for use in PlantWise (Fig. 5).

![PlantWise](image)

**Fig. 5. Bentley PlantWise for 3D conceptual design**

**Benefits of Bentley PlantWise**

PlantWise is an effective tool for rapidly developing 3D conceptual layouts and presenting 3D visualizations to the project team. As a result, this helps engineers decide on
preferred layout concepts at an early stage. The benefits of using PlantWise during conceptual design include:

- **Reducing install costs by up to 4 percent**: Piping makes up a significant portion of plant costs, and unlike equipment costs, piping costs depend significantly on the layout. Using PlantWise to automatically route piping in 3D conceptual plant models has reduced install costs by up to 4 percent. This is because, compared with traditional approaches, PlantWise allows users to explore more alternative layouts than traditional methods and compare relative costs to arrive at the best layout.

- **Reducing lifecycle costs**: PlantWise saves lifecycle costs by reviewing the 3D design early to address maintenance and operability concerns. Operators and contractors can walk through the 3D plant model, uncover operations and maintenance issues, and take actions before starting the detailed design.

- **Shortening the project schedule**: Rapid decisions and accurate material take-offs permit early procurement of critical-path materials, which helps compress project schedules. Early validation of the layout that includes piping significantly reduces changes once the detailed design begins. The benefit is that users report this reduces the piping design effort by as much as 20 percent.

- **Communicating design intent**: The rapid modeling and auto-routing features in PlantWise let users communicate plant concepts far beyond the capabilities of 2D plot drawings. Further, the realistic visualization in ProjectWise Navigator facilitates review for constructability, operation, maintenance, and safety aspects during the early stages of project development.

- **Starting from early process data**: PlantWise starts from the PFD and preliminary process P&ID data (from AXSYS.Process or from legacy data), so 3D layout proceeds in parallel with the P&ID development.

**Bentley’s Approach for Integrating FEED Activities**

By integrating conceptual design and FEED activities, projects can achieve a significantly higher productivity and schedule compression. The FEED phase is considered by many to offer an optimum opportunity for implementing best design practices. By implementing Bentley’s Integrated FEED solution, users can select best-in-class software for each discipline while providing scalability, data consistency, and minimizing the retraining of new engineers through the implementation of best practices. Various articles have reported that applying best design practices can reduce project costs by an average of 20 percent, irrespective of the project’s size. To-date, Bentley has developed and implemented significant ISO 15926 capabilities within the functionality parameters of our comprehensive product portfolio. The adoption of ISO 15926 replaces the traditional command and control software construction with flexible and adaptable connectors (OpenPlant plug-ins) to provide interoperability among different applications (Fig. 6).
Integrated FEED projects generally start with P&IDs. This is the single most intensive activity which involves input from all major disciplines. Bentley offers a number of possible paths that serve an individual project’s need starting with preliminary P&IDs in AXSYS.Process:

- Extend the preliminary P&IDs into detailed P&IDs using AXSYS.Process. This path is suitable for projects where a pre-requisite for another P&ID tool is not required.

- For those who already use a detailed P&ID tool such as AutoPLANT P&ID and PlantSpace P&ID, users have the option to jump-start detailed P&IDs with full intelligence from initial P&IDs in AXSYS.Process.

- Lastly, those who commit to ISO 15926 and desire to use applications that store data in native ISO 15926 format can use OpenPlant PowerPID.

For any of these options, Bentley offers a comprehensive suite of 2D applications that builds on conceptual design data. These products for FEED include Bentley Instrumentation & Wiring for instrumentation and control schematics, Bentley® Datasheets for data into models via excel like interface, Bentley promis.e® for electrical schematics, and AXSYS®.Integrity for validating construction materials by carrying out a corrosion risk assessment for the plant.

While P&IDs are developed on FEED projects, a parallel function is also started on the 3D plant design. Here, too, Bentley offers a comprehensive suite of 3D applications starting with 3D layout in PlantWise and extending to 3D plant design systems such as AutoPLANT and PlantSpace. Integrated stress analysis can also be carried out directly from 3D plant design models using AutoPIPE® for pipe stress analysis and STAAD.Pro® for structural analysis.

Lastly, it is equally important to provide an effective collaborative design review tool that opens both graphics and data from any of the Bentley products described above.
Bentley meets this critical requirement for collaborative design review with ProjectWise Navigator. For those who need to capture early design data and apply it throughout the design-build-operate phase of the plant asset, Bentley offers ProjectWise Lifecycle Server, which captures design data and tracks it throughout the life of the plant asset. Similarly, Bentley ProjectWise Integration Servers offer support for collaborative project workflows, including distributing projects across different geographical locations and managing revisions for project deliverables.

Conclusion

Bentley offers an Integrated FEED solution with the flexibility to use best-in-class software for your projects, while still ensuring interoperability among various software products based on ISO 15926, which is now quickly becoming the standard for plant data exchange.

Implementing Bentley’s Integrated FEED Solution offers many benefits including:

- Ability to present design intent with interactive 3D plant visualizations,
- Up to 40 percent schedule compression in conceptual process design,
- As much as a four percent lower total installed cost,
- Ability to jump-start P&IDs directly from preliminary P&IDs,
- Interoperability that ensures best-in-class software is used.

Further information

For further information on our comprehensive range of applications and tools for conceptual design and front-end engineering design, please visit www.bentley.com.

About the author

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