Bentley Solutions: Oil & Gas

A Bentley White Paper

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Bentley®

Sustaining Infrastructure

Executive Summary

Today's complex oil and gas facilities bring together key engineering and related disciplines needed to design, engineer, and operate the facility across its entire lifecycle. This white paper provides an overview of Bentley's oil and gas solution and how it addresses key aspects of the lifecycle from conceptual plant engineering, front-end engineering and design (FEED), detailed design, and construction through handover and operations. The solution includes a wide range of Bentley software applications that integrate data management, schematics design, multidisciplinary 3D plant modeling, design analysis and simulation, and visualization and reporting tools.

Bentley's oil and gas solution provides a comprehensive, data-centric environment to author and manage all data and engineering deliverables based on an integrated engineering information system. This offers significant benefits for both plant owners and engineering contractors by:

- Capturing evolving and maturing engineering data as it is created and modified;

- Reducing handover time by ensuring the data is correct (i.e., 'fit-for-purpose') at handover, based on a philosophy of continuous data handover;

- Maintaining the engineering data in a managed environment beyond the engineering, procurement, and construction (EPC) phase into plant operations;

- Interfacing the right data with other enterprise-based systems;

- Reusing the project data throughout the facility's life or for future projects to capitalize on existing investments.

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Introduction

Today's global business environment faces significant challenges following recent downturns in major industrial economies. Fluctuations in the price of oil and gas have changed the scope of, and amount of investment in, capital projects. Consequently, owner-operators now put more emphasis on increasing operational efficiencies using existing infrastructure while maintaining operation and production margins when market demand is low. Paradoxically, worldwide demand for energy is projected to increase as much as 45 percent by 2030.

According to estimates by the International Energy Agency (IEA), emerging economies will account for nearly 90 percent of the world's energy demand over the next two decades. Two factors are driving this demand for energy consumption: population growth and mass industrialization in emerging economies.

It is estimated that the global population will increase from 6.7 billion to more than 9 billion by 2050, with millions of people moving from the countryside to urban centers. While economic conditions have weakened global demand for primary energy in the short term, the long-term outlook for the oil and gas sector remains one of substantial, sustained growth.

> Bentley Systems' oil and gas solution offers a data-centric environment in which evolving plant and related data are properly managed throughout the plant lifecycle, eliminating data re-entry and data misuse, and improving overall engineering data quality and integrity.

The scope, nature, and complexity of today's current and planned capital oil and gas projects present additional challenges to plant owners and engineering contractors. Owner-operators' capital project timelines continue to shorten in an effort to speed time-to-market. At the same time, engineering contractors must reduce overall project costs and meet reduced project schedules with fewer skilled resources. To accomplish this, they must increase productivity while maintaining high engineering integrity and quality – all without compromising safety and environmental considerations.

These challenges can be addressed by employing an integrated data-managed engineering solution specifically designed to meet the demands of the global oil and gas sector. Bentley Systems' oil and gas solution offers a data-centric environment in which evolving plant and related data are properly managed throughout the plant lifecycle, eliminating data re-entry and data misuse, and improving overall engineering data quality and integrity. By offering a new approach to managing and reviewing these data, unnecessary documents can be eliminated during the engineering phase, timelines can be shortened, the level and quantity of data during handover can be enhanced, and access to the right information for operations can be improved.

Data-Centric Systems – Business Value and Benefits

The business value and benefits offered by an engineering content management environment in which data is effectively managed and controlled are now widely accepted by all project stakeholders. A common theme in a centrally managed, data-centric environment is "input data once, use many times." Data reuse is a cornerstone of Bentley's oil and gas solution and provides important advantages to plant owners and engineering contractors alike, including the ability to:

- Evaluate more plant configurations and options during conceptual design – even with limited resources;
- Produce more accurate designs earlier in the project lifecycle;
- Address plant economics alongside engineering.

In addition, data reuse can reduce engineering man-hours by 20 to 30 percent; lead to accurate, up-to-date project deliverables, reduce the cost of structural steelwork and piping due to better design optimization and plant configuration; and improve plant quality, safety, economics, and sustainability, as well as plant maintenance and spare parts inventory control.

Bentley Solution for Oil and Gas Lifecycle

Bentley's oil and gas solution addresses crucial business, engineering, and plant lifecycle needs for both upstream and downstream operations. Based on an intra-operable set of applications that form the backbone of Bentley's overall digital plant solution, the solution supports key aspects of the plant lifecycle. These include mapping the geographical area, initial site preparation and site development, engineering, procurement, and construction, and new facility operations.

Bentley's digital plant solution for oil and gas consists of an engineering information system that supports the development and management of the multi-disciplinary digital representation of the physical plant. Bentley's software applications accept, author, update, and manage data in the following lifecycle areas:

- Conceptual and front-end engineering design (FEED);

- Detailed design and engineering;

- Site preparation, mapping, and planning;

- Construction;

- Commissioning and handover;

- Plant operations.

Conceptual and Front-End Engineering Design (FEED)

Compressing project schedules without compromising engineering integrity, quality, environmental, and safety aspects is more important in the oil and gas sector than reducing overall project costs. Making good process engineering decisions up front to secure items with increasingly long lead times, such as compressors, vessels, pumps, and other major process equipment, is of critical importance.

To help owner-operators and engineering contractors meet these goals, Bentley's oil and gas solution offers front-end engineering and design (FEED) applications that interoperate with external third-party process simulation tools to support and manage process engineering data and equipment sizing workflows. The solution allows engineers to evaluate a broader number of facility layouts for rapid and more-accurate cost estimates.

Bentley® AXSYS®.Process V8*i* links to leading third-party process simulators such as HYSYS, Aspen Plus, UniSim, and Pro/II. It allows process engineers to prepare and evaluate design alternatives and to interchange process simulation and conceptual engineering design data in a common environment to ensure overall data consistency. AXSYS.Process also automatically creates process flow diagrams (PFDs) and preliminary piping and instrumentation diagrams (P&IDs). These are also combined with associated data sheets, line and equipment lists, and links to a variety of third-party equipment and heat exchanger sizing applications to support conceptual design and FEED activities.

Bentley® PlantWise® V8*i* is a highly productive design environment used during preliminary conceptual 3D plant layout and cost estimation. Using configurable design rules for equipment and nozzle placement and line and equipment lists imported from AXSYS.Process V8*i*, it combines powerful automatic, rule-based pipe routing and simplified structural modeling   allowing the layout designer to create alternative 3D

plant layout design cases. This facilitates accurate initial cost estimates directly from 3D digital plant layouts to determine an optimized and economical plant configuration that meets the plant owner's needs.

Detailed Design and Engineering

Bentley offers two industry-leading multi-disciplinary 3D plant design applications: **AutoPLANT®** and **PlantSpace® Design Series**. Both have been proven to reduce project timescales and eliminate errors before construction.

Bentley's **AutoPLANT** is recognized as the No. 1 AutoCAD-based plant design system available today. It is used worldwide on both large, distributed, enterprise-based projects and smaller plant rework projects. This 2D/3D application is for P&IDs, instrumentation, datasheets, piping, structural layout and modeling, equipment modeling, electrical raceway modeling and pipe support modeling. It also combines with powerful orthographic/piping isometric drawing production tools and material takeoff (MTO) reports.

PlantSpace® Design Series is Bentley's MicroStation®-based multi-disciplinary 2D/3D plant design system. It is used for P&IDs, instrumentation, datasheets, piping, structural layout and modeling, equipment modeling, electrical raceway modeling and pipe support modeling. PlantSpace is supported by comprehensive orthographic/piping isometric drawing production and MTOs.

Additional complementary software products from Bentley for detailed design engineering projects include:

- **ProjectWise®**– Bentley's collaboration system connects people and information, sustaining the value of information across the infrastructure lifecycle. It is useful for managing all project deliverables, including orthographic drawings, piping isometrics, 2D/3D models, and associated project documents across distributed project teams.

- **ProjectWise® Navigator V8*i*** – Bentley's visual collaboration application supports distributed teams with graphical navigation and 'walk-throughs' of 3D plant models and associated documents, and can be used to visualize project schedules and construction simulation. Integrated interference detection ensures design problems can be quickly identified and eliminated before fabrication and construction.

- **promis•e® V8*i*** – This application provides intelligent electrical wiring and control system design for schematics, panel layouts, bills of material, wire lists, and terminal plans.

- **Bentley® AutoPIPE® V8*i*** – This comprehensive pipe stress analysis application intra-operates with Bentley's related structural modeling and analysis tools.

- **STAAD.Pro® V8*i*** – This application offers plant engineers finite element modeling and analysis of structures.

- **ProStructures** – ProStructures provides integrated 3D structural detailing and fabrication for steel and concrete based on **ProSteel** and **ProConcrete** applications.

Bentley's AutoPLANT is recognized as the No. 1 AutoCAD-based plant design system available today. It is used worldwide on both large, distributed, enterprise-based projects ands maller plant rework projects.

Bentley also offers **OpenPlant** – the first commercially available integrated plant design environment based on the ISO 15926 open information model. The OpenPlant environment includes an intelligent, process and instrumentation (P&ID) **OpenPlant PowerPID V8*i*** schematics application integrated with **OpenPlant Modeler V8*i***, the latest multi-disciplinary 3D plant modeling system.

Using **OpenPlant PDx Manager**, Intergraph PDS users, for the first time, have a viable, cost-effective data migration path to reuse existing PDS model and associated attribute data. The software accomplishes this by converting PDS models with full fidelity into an equivalent ISO 15926-based model, extending data investments.

When used in combination, Bentley's OpenPlant applications provide a highly productive, cost-effective and efficient plant design system to support today's complex, distributed oil and gas projects.

Site Preparation, Mapping, and Planning

The oil and gas sector faces increasing environmental pressures to reduce its plant footprint, manage water runoff, and minimize environmental impact. As a result, plant owners and engineering contractors need software applications that support rapid site/infrastructure development and analysis integrated with the overall plant layout. To serve these needs, Bentley offers:

- **Bentley® PowerCivil V8*i*** – A flexible 2D/3D design environment for land development and site modeling. It allows flexibility with visual modeling to reflect the way in which civil engineers work.

- **InRoads® Suite V8*i*** - An integrated civil solution for pipelines, roads, and site infrastructure development.

Owned land on which production facilities reside or extraction rights have been secured is a significant asset for the oil and gas industry. Bentley offers a number of industry-leading products, including mapping and geographic information systems (GIS), to better manage these assets. This software currently includes:

- **Bentley® Power Map V8*i*** – This application provides users with a geospatial view and gives spatial context to information. Drawings, maps, models, images, vendor-specific GIS data, and business documents can be related spatially in ProjectWise.

- **Bentley® Descartes** – This imaging application integrates with MicroStation to create image scenes for visualization and analysis with 3D terrain modeling/draping.

Construction

Effective management and planning of all construction resources deployed on site for today's complex oil and gas projects can have a major impact on the overall project schedule. Enabling construction planners to study and resolve potential problems before they become time-consuming delays on site means having access to accurate

project data. Bentley offers applications supporting complete construction planning and sequencing combined with simulation of specific construction activities such as heavy crane lifting. Bentley's construction applications include:

- **ConstructSim** – Used for work-face planning and 4D visualization of the complete plant design combined with issued plant design, construction, and piping isometric drawings;

- **ProjectWise® Navigator** – Suitable for 3D construction schedule simulation and visualization;

- **ProjectWise®** – Used for managing all issued construction deliverables;

- **Bentley® OnSite** – An electronic field book for construction site stakeout and inspection.

Commissioning and Handover

Bentley's oil and gas solution also provides tools to support and improve commissioning right through to plant handover. The schematic and physical digital plant models can be used to plan commissioning as well as monitor on-site progress and status prior to testing and final handover.

In addition, the oil and gas solution significantly improves project handover. Not only does it manage all project documents, by utilizing Bentley's engineering information system, all data and approved documentation created in the early stages of the project can be incrementally stored and managed before handover in a single, fully managed project data repository based on:

- **ProjectWise® Integration Server** – Which creates and maintains project documentations in a managed repository;

- **ProjectWise® Lifecycle Server** – Which manages all engineering data as part of a data warehouse.

Plant Operations

To support the operational phase of the plant lifecycle, Bentley's oil and gas solution provides tools for managing and maintaining engineering data needed for the operation and maintenance of a safe plant environment as part of an integrated engineering data warehouse. This data warehouse also acts as the primary interface to external spare parts management systems, maintenance systems, and other enterprise-based infrastructure systems.

Bentley's comprehensive as-built 3D modeling tools support brownfield plant modification and revamp projects to ensure timely plant turnarounds.

Bentley's products used to support plant operations include:

- **ProjectWise® Lifecycle Server** – ProjectWise Lifecycle Server connects to engineering resource planning (ERP) systems such as SAP and related maintenance

> Bentley offers applications supporting complete construction planning and sequencing combined with simulation of specific construction activities such as heavy crane lifting.

management systems such as Maximo to ensure plant operators can quickly access current engineering documents and data. Engineering management-of-change is also supported to manage data as it changes during the operational life of the oil and gas facility.

- **ProjectWise®** – ProjectWise manages all engineering documents and data linked to Bentley's Lifecycle Server engineering data warehouse.

- **Bentley® CloudWorx** – Provides as-built modeling in MicroStation from 3D point clouds created by laser scanning.

'Data for Life' – Data Exchange During the Plant Lifecycle

Bentley's oil and gas solution addresses data management of the complete project lifecycle. It accurately saves validated project information during the engineering phase of the plant lifecycle for handover into operations and maintenance, while significantly reducing overall handover costs.

The Bentley oil and gas solution provides a comprehensive data repository – or *data warehouse* – specifically designed to capture engineering data during detailed design. It then manages it to support downstream plant operations.

According to a study conducted by Coopers & Lybrand, engineers are increasingly frustrated when looking for relevant information. Over 25 percent of their time is spent searching for information, adjusting it to their purposes, and re-entering it. The study found that by using a managed data environment based on industry standards, engineers can expect significant savings in time and cost throughout the project lifecycle, including:

- 10 to 30 percent reduction in time spent preparing for reviews to support project decision making;

- 15 to 28 percent reduction in engineering costs;

- 1- to 2-month reduction in overall project execution time;

- 30 percent increase in productivity from improvement in work relations between contractors and suppliers;

- Significant improvement in the quality of documentation;

- Better reuse of components in the project, resulting in lower maintenance costs;

- Reduction of 40,000 to 80,000 man-hours during commissioning for a typical project, resulting in a dramatic reduction in handover costs;

- 10 to 20 percent reduction in maintenance and operations from improved efficiency in operations, due to more readily available and accurate information.

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Bentley Oil and Gas Solution Architecture
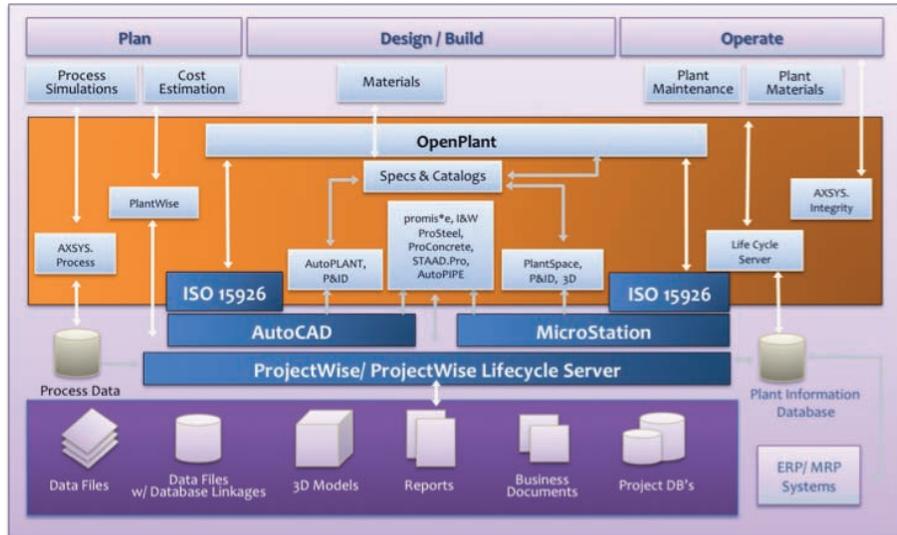
Bentley's oil and gas solution provides a scalable data management platform that allows users to fully realize the benefits identified in the Coopers & Lybrand study. Project deliverables based on a wide range of industry-standard data and file formats are effectively managed across the entire infrastructure lifecycle.

Bentley's Oil and Gas Solution – ISO 15926 Adoption

Bentley's latest OpenPlant applications address the growing demands of today's highly distributed oil and gas projects. By adopting the ISO 15926 open information model, Bentley's oil and gas solution enables plant owners and engineering contractors to capitalize on their investments in plant data without the constraints imposed by current propriety third-party applications and associated closed data formats.

> Through its work with FIATECH and its partners, Bentley is able tosupportandimplement the ISO standard data framework for information exchange across the infrastructure lifecycle.

Through its work with FIATECH and its partners, Bentley is able to support and implement the ISO standard data framework for information exchange across the infrastructure lifecycle. Bentley's digital plant framework is based on the ISO 15926 standard, which ensures open and easy access to third-party software and supports intelligent data exchange between owner-operators and contractors. As a result, the overall cost of ownership to implement, use, and maintain ISO 15926-based engineering design and data management systems is considerably reduced.

A further benefit of adopting an open information approach based on industry standards is that it increases competition among software vendors, resulting in better technology. It forces vendors to resist locked-in proprietary formats in favor of formats that increase end-user productivity and efficiency across the plant lifecycle. An open data exchange also liberates data access and data exchange by providing more competition for services because users are not dependent on specific software expertise.

By improving operation efficiencies for plant owners and design capabilities for engineering contractors, OpenPlant increases competitive advantage in today's global market.

Distributed Design and Engineering

One important aspect of the Bentley oil and gas solution is support for distributed design and engineering. Through project worksharing, engineering contractors can take full advantage of distributed offices working together, simultaneously, on a single project. This allows flexibility in the way engineering activities can be shared across the extended enterprise to maximize the use of available skilled resources and capitalize on expertise in different locations.

Bentley's proven project workshare environment allows workflows to be centrally managed, but enables documents and data to be distributed and shared globally. This environment is scalable with options based on database replication, model file transfer, or a combination to suit specific project or location needs.

Real-World Examples of Projects Deploying Bentley's Oil and Gas Solution

Bechtel Corporation used Bentley's ProjectWise document repository to collaborate on the Jamnagar Export Refinery Project (JERP) in India. JERP has a plot plan bigger than that of London and has a target completion time of less than 36 months.

Bechtel tackled this mega-project using engineering resources dispersed around the globe, including a design and engineering team of 2,500 professionals in 10 design locations, 19 offices, and eight countries. Overall, the project employed more than 90,000 people during construction and called for the fabrication and installation of 109,170 metric tons of steel, approximately 5 million meters of varied-size pipe, over 4,000 pieces of major equipment, and more than 110,000 isometrics.

Nearly 1,000 users in nine locations employed Bentley's ProjectWise to ensure that more than 50,000 drawings were available to the correct discipline at the correct location. Using ProjectWise, drawings could be worked on collaboratively, enabling designers in one location to view the results of design teams in other offices almost immediately. Bechtel was able to rapidly distribute the project work to the different locations in a much more granular way – by unit, by discipline, and even by drawing – as the needs of the project dictated.

A key advantage realized by the project team was the ability to search for and find all files that had been changed during the previous week, and to cross-reference the location of the files found with the location of the person who last changed them. This enabled the JERP team to regularly reassess and redistribute their project content, optimizing productivity and reducing network traffic.

Using ProjectWise to track and manage data, Bechtel has been able to facilitate the reuse of more than 25 percent of the design and engineering information generated during construction of the original facilities. This has proved to be critically important in meeting the project's aggressive schedule.

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BP Tangguh used Bentley's ProjectWise Lifecycle Server to capture, manage, and maintain plant information based on a common information handover specification for BP's $5 billion (US) Tangguh LNG facility. The main business driver was to reduce and streamline multiple file and data formats to facilitate the automatic population of validated project data into plant operations systems and the Maximo maintenance management system. The information handover specification defined by BP in collaboration with Bentley was used by multiple EPC's in Japan and Indonesia, more than 12 major subcontractors, and over 300 vendors for nearly 100,000 items of equipment.

During the EPC phase, ProjectWise Lifecycle Server facilitated collaboration across the project team by providing change management control between as-designed and as-built data combined with defined workflows and sign-off responsibilities. The transition from the EPC phase into operations also highlighted a major shift from document handover to data handover.

As a result, BP was able to quickly access validated project data from all project participants within ProjectWise Lifecycle Server, along with project work instructions. The system also automatically tagged document links in an easy-to-use environment for use by the operations team. Validated project information is now available via a web portal interface for use by operations and maintenance teams.

Above: BP Indonesia – Tangguh LNG Plant

Cianbro Constructors – Following the closure of a local paper mill in January 2004, that had operated in Brewer, Maine, for more than 100 years, Cianbro Constructors revitalized the brownfield site by turning it into a state-of-the-art $110 million manufacturing facility. The facility was used to fabricate and construct 54 modules for the Motiva Refinery Expansion Project in Port Arthur, Texas.

The assembled modules averaged 40-feet wide by 40-feet high by 120-feet long and weighed up to 700 tons. Once completed, they were loaded onto barges for shipment to Port Arthur.

The fabrication team had never seen a refinery before the manufacturing site opened. Moreover, they had never dealt with the commonly delivered piping fabrication isometric drawings before starting this project.

To overcome these challenges, Cianbro deployed Bentley's ConstructSim application. It used the software's rich 3D visualization and work-face planning capabilities to show the craft teams what they were building, module by module, down to specific details for pipework and steel. ConstructSim also helped the construction team plan, sequence, execute, and monitor all the construction activities from within the data-rich 3D plant model.

ConstructSim enabled Cianbro to visually communicate the scope of this project to the production and craft teams within the planned construction schedule. The success of the project and new manufacturing facility also brought new life to the town of Brewer.
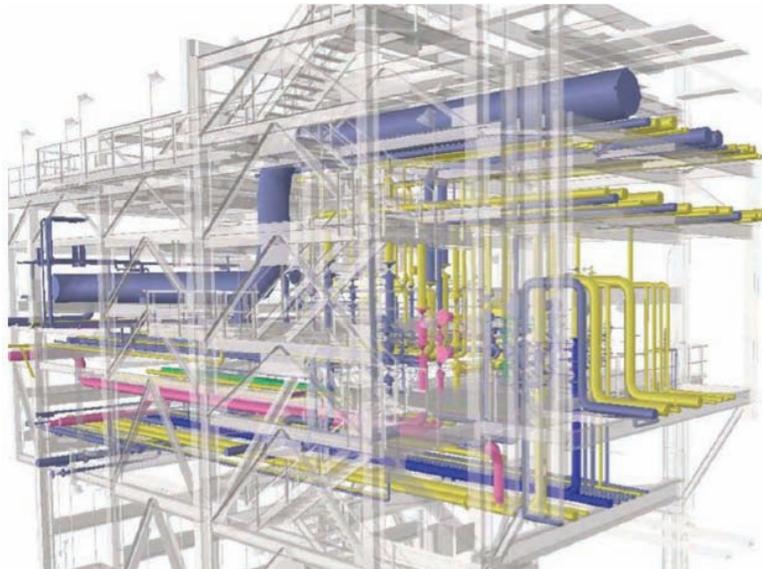
Above: Process module for Motiva Refinery Expansion

Giprotyumenneftegaz developed project deliverables and cost estimates for the West-Salym oil field development in Russia. This was a complex project integrating many disciplines, including the process site, industrial area, camp, and utilities. A large volume of information was generated by the many companies working on the project, including survey maps, 2D drawings and 3D models, explanatory notes, cost estimates, and bills of materials. Bentley's oil and gas solution was employed for all design phases, allowing Giprotyumenneftegaz to maintain coordination across disparate teams and to automate the generation of accurate project deliverables. A 3D digital model of the site landscape allowed Giprotyumenneftegaz to make exact site leveling as well as to calculate estimated earthworks.

Giprotyumenneftegaz achieved schedule savings of more than six months across the life of the project using Bentley's applications. PlantSpace Design Series was used to create 3D models of the facilities under design.
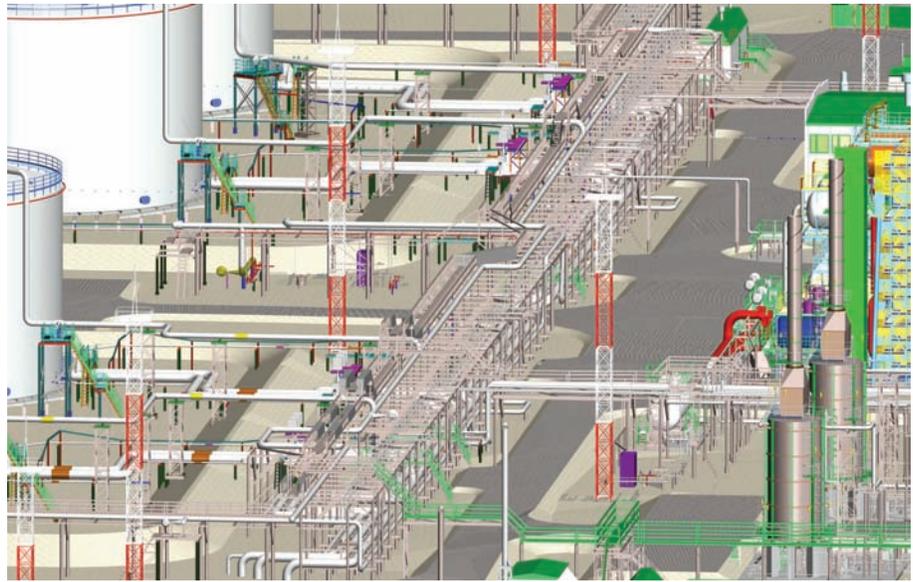
Above: 3D PlantSpace models of the West-Salym facility

KBR used Bentley's plant structural analysis, design, and documentation tools for an existing refinery facility to support the increased production of a fluid-catalyst cracking unit. A structural evaluation of the 47-year-old reactor in Toledo, Ohio, was required to determine the feasibility of the proposed expansion.

Bentley's STAAD.Pro structural analysis application was used to generate wind load on this complex structure. Modeling was also performed using the graphical user interface. Record-low execution time for this project elicited praise from the client.

KBR saved 300 man-hours and $30,000 as a result of enhanced 3D graphical views and application of wind load using Bentley's STAAD.Pro® structural analysis application.

M7 Offshore of Norway innovatively used Bentley technologies to upgrade an existing Bilabri floating oil, production, storage, and offloading vessel (FPSO). Whakaaropai is a Suezmax-sized vessel operating on the Maui B oil field off New Zealand for Shell Todd Oil Services Ltd. Constructed in 1976 and converted in 1995-1996, the vessel was re-named Bilabri and upgraded to include a new test separator module and a riser balcony.

Tying a new module into an existing process module of this size is normally a complex engineering task. Using Bentley software, a 3D digital model was created with accuracy down to a millimeter by scanning the site and obtaining a point-cloud model. Bentley CloudWorx was used to convert the interface sections into CAD elements to be imported into the CAD model. M7 Offshore also used Bentley's PlantSpace Design Series to produce, non-intelligent P&IDs, 3D models, piping isometrics, and orthographic drawings.

Quip S.A. used Bentley's plant visualization and simulation applications for its offshore floating production unit (FPU), the P53 platform. Located 120 kilometers off the Brazilian coast and moored at a depth of 1,080 meters, the P53 FPU produces and processes 180,000 barrels of gas and 6 million cubic meters of gas a day for transfer to other platforms.

> KBR saved 300 man-hours and $30,000 as a result of enhanced 3D graphical views and application of wind load using Bentley's STAAD.Pro® structural analysis application.

Quip S.A. developed the P53 FPU and presented all review sessions using Bentley Navigator. This environment gave the engineers and technical team access to 3D visualization so potential problems could be identified, reviewed, and resolved in advance. This was the first 3D visualization initiative in Brazilian offshore projects, and now other Brazilian EPCs are adopting this concept.

Conclusion

Bentley Systems' oil and gas solution applications continue to be used and have been successfully deployed by major participants in the oil and gas industry worldwide. Bentley recognizes the growing demand for solution-based engineering and data management software that properly integrates and manages project data and associated deliverables throughout the infrastructure lifecycle.

Plant owner-operators who have deployed the applications that comprise Bentley's oil and gas solution have now virtually eliminated unnecessary or redundant project documentation, reduced expenditures in managing and streamlining multiple data sources and, in many cases, are now seeing and capitalizing on an immediate return on their software investment.

Engineering contractors who have deployed the interoperable applications that make up Bentley's oil and gas solution have completed major capital projects within agreed project schedules. In many cases they have seen significant improvements in end-user productivity, design quality, and overall project execution as a result of their integration between Bentley's design authoring and analysis tools coupled to Bentley's document and engineering content management systems.

The Bentley oil and gas solution offers both plant owner-operators and engineering contractors a comprehensive, scalable environment to create and manage project data and associated deliverables more cost-effectively. In addition, it helps them achieve on-time project delivery with lower costs in application deployment, data creation, management and handover.

For more information contact a local Bentley office or visit **www.bentley.com**.