Innovative Substation Projects, Crucial Elements of Power Delivery
**INTRODUCTION**

The growing need for reliable power supply has increased the demand for aging substation infrastructure redevelopment and driven new substation implementation into crowded cities and other demanding locations.

Utilities seeking to effectively respond to the myriad of substation challenges can benefit significantly from digitalization and applications that address the interdependencies of the many disciplines and workflows involved in designing and upgrading substations. Digital engineering models, intelligent 2D electrical and 3D physical substation models, can help utilities save time and money in the planning, design, and construction phases of the substation lifecycle. The models also support operations and maintenance (O&M) teams in forecasting problems and improving asset performance through the convergence of information, operational, and engineering technologies.

The innovative substation projects presented in this eBook were selected from Bentley’s *Be Inspired* Awards program. The program annually recognizes the world’s most outstanding infrastructure projects. The projects are submitted by Bentley’s software users and judged by a jury of independent experts who adhere to the highest standards in determining which of the projects exemplify innovation, superior vision, and an unwavering commitment to exceptional quality and productivity.

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PESTECH INTERNATIONAL BERHAD — Automation and Integration of Substation Design Work for 230-kilovolt Project

PESTECH International Berhad was retained to design and deliver a substation and transmission system from the town of Kratie to the city of Kampong Cham, Cambodia, as well as to undertake a 25-year contract to operate and maintain the power transmission system once completed. The organization planned, designed, engineered, manufactured, tested, delivered, installed, and commissioned the 230-kilovolt switchyard in the Kampong Cham substation, the new Kratie substation, and the interconnecting 230-kilovolt duplex ACSR bitter transmission line.

To effectively achieve this goal, PESTECH replaced their traditional manual design process with Bentley Substation, which provided an integrated platform for 2D electrical and 3D physical substation design. Bentley Substation provided the engineering team with a single platform for a unified 3D design environment. It also acted as an intelligent database, eliminating manual data reentry and manual coordination while facilitating cross-discipline collaboration, which minimized errors and rework, and enabled a truly intelligent design. This database also helped the team automate much of the design process, including drawing and report creation.

The project team also implemented Bentley applications to enhance productivity, facilitate collaboration, minimize errors, and enforce standards. ProjectWise® facilitated document sharing, design collaboration, faster reviews and approvals, and mobile design access.

With Bentley applications, PESTECH achieved accurate generated drawings and documentation, saved time on drawing production, saved money in procurement, and delivered better visualization of substations with 3D primary and 2D secondary engineering designs unified in a single application. PESTECH cut design work from weeks to days, saving an estimated 70 percent in project time, by utilizing Bentley applications. Schematic drawings that normally take 14 to 21 working days were completed in less than seven working days, and cable schedules that usually take three days to check and document were automatically generated in one hour or less.

Now completed and operational, the new substation and transmission system is extending the lifespan and reliability of customers’ transmission and distribution assets and supporting the region’s fast-developing transportation and building infrastructure.

To learn more about the Automation and Integration of Substation Design Work for 230-kilovolt Project and the Bentley solutions that were applied, click here.
San Francisco-based Pacific Gas & Electric Company (PG&E) owns and operates more than 1,000 transmission and distribution substations across two-thirds of California. Because of the recent push to modernize the electric grid, the substation engineering department of PG&E has struggled to handle the high number of projects. Spending 95 percent of its USD 1 billion substation budget on brownfield locations, the organization was manually converting existing 2D drawings to 3D models for use on retrofit projects.

To lessen costs, PG&E replaced their design process with reality modeling by deploying a combination of photographic techniques using unmanned aerial vehicles, man lifts, and on-ground equipment. The team generated highly accurate reality meshes using Bentley’s ContextCapture software that were integrated into Bentley Substation for intelligent 3D design of substation upgrades. The 3D engineering-ready reality mesh was created using imagery captured by drones and other sources. Then, the team used ProjectWise as a central repository for the data and shared the information among the design teams through the application.

PG&E also generated a reality mesh of the terrain, producing a quick and low-cost digital terrain model without a full land survey, using ContextCapture. The reality modeling application also processed images of substation assets, which were categorized, inventoried, and used to plan condition-based maintenance.

PG&E expects to reduce 3D modeling costs by 50 percent using reality modeling instead of manually converting 2D drawings. The automatically generated reality meshes are extremely precise and remove the need for field measurements, so personnel traveled to the substation facilities 50 percent less time than in the past. With the adoption of Bentley Substation, PG&E reduced project design time by 40 percent and saved an estimated USD 5.7 million across approximately 120 substation projects annually.

To learn more about the Reality Modeling in Bentley Substation project and the Bentley solutions that were applied, click here.
Hubei Electric Engineering Corporation – Miaoshan 220kV Secondary Transformer Substation

Hubei Electric Engineering Corporation designed an indoor secondary transformer substation to meet Year 2030 energy demands of over 400,000 kilovolts (kV). HEEC’s challenge was to work within the constraints of the dense urban location in Wuhan East Lake High Tech Zone, Hubei province, China. HEEC needed to create the layout and design of a three-story facility that houses three sets of 240-megavolt ampere transformers and provides 220kV, 110kV, and 10kV outgoing lines. Interdisciplinary collaboration on the substation design was essential to avoid clashes within the compact building complex, which comprised two floors above ground, one floor below ground, and an underground cable corridor for numerous cables of various voltages.

Bentley’s 3D digital design solutions for master planning and design were implemented across all disciplines, including physical substation design, electrical, civil, structural, HVAC, and construction. By using modeling and analysis technology to implement a collaborative 3D design approach, HEEC significantly improved design quality and accuracy.

The organization used ContextCapture for reality modeling of the surrounding buildings to justify the station location and limit environmental impact. Collaboration enabled by ProjectWise allowed the design team to work in a unified model space, reduce collisions between disciplines, and increase project efficiency.

The refined layout for dozens of high-voltage cables will help ensure stable substation operations. The completed substation optimized the area’s power grid and provided a reliable power supply for more than 400,000 residents. The 3D digital design saved 50 labor days and CNY 50,000 in design costs. Avoiding rework in at least 10 instances during construction saved CNY 2 million. Converting models into 3D PDFs aided communication during construction and saved an additional 15 labor days.

To learn more about the Miaoshan 220kV Secondary Transformer Substation project and the Bentley solutions that were applied, click here.
iSAT Networks Engineers were retained as the engineering, procurement, and construction contractor for a 132-kilovolt (kV) distribution substation in Dehradun, India. The substation had a total capacity of 80 million volt-amperes (MVA) using two transformers of 40 MVA each. The typical 2D design methodology for substations utilized in India necessitated frequent revisions before final plans were reached. As a result, undetected clashes often came up during on-site implementation.

During this project, iSAT used Bentley’s 3D modeling applications, which ensured that finalized plans were created in less time and with fewer revisions. The intelligent 3D substation layouts comprised the objects that possessed the properties of the equipment they represent. iSAT created 3D layouts with Bentley Substation, making clearance checking and clash detection easier, ensuring that any interferences were detected before the designs were approved. Project team members undertook concurrent engineering by using Bentley Substation, eliminating errors and accelerating project delivery. This capability reduced design revisions by 60 percent and design time by 40 percent, or 20 resource days in design and quantity estimation, which resulted in major cost savings for the organization. iSAT created precise and automated reports and all design revisions were reflected in these reports due to the automated processing.

Additionally, visualization capabilities quickened the speed at which designs were approved. Structural analysis and design engineering was conducted in Bentley’s STAAD.Pro®, as the substation was being erected in a seismic zone and proper support was essential. The application accurately evaluated and designed for static and dynamic loads, including seismic accelerations, wind, rainfall, and snow, in accordance with steel design codes and standards. Structural models were reused in the 3D layouts due to integrated structural modeling facilitating a collaborative workflow among Bentley applications.

To learn more about the 132kV Substation project and the Bentley solutions that were applied, click here.
Aurecon was hired to bolster the capacity of the substation that generates power to the municipality of Mthatha, South Africa and to enhance sustainable electricity to the region. The current substation’s configuration, including adjacent oil-filled equipment and firewalls to high-voltage equipment and overhead power lines, posed fire risk and electrical clearance issues. Aurecon needed to reconfigure the arrangement of the substation and meet electrical clearance standards.

The organization utilized 3D modeling applications to virtually modify the arrangement of the substation. Aurecon employed a collaborative design methodology with Bentley applications, producing precise 3D models with Bentley Substation. These realistic visualizations included distances from the substation structures to the overhead lines as well as the ability to adjust the layout to compensate for inaccurate electrical clearances. In addition, the team designed the oil spillage and drainage areas to mitigate fire risk.

Aurecon moved equipment to different positions, experimented with different supports, and analyzed numerous design scenarios within a short time with Bentley Substation. This capability minimized risk and optimized returns on investment.

A comprehensive model was created by importing the 3D CAD-designed platform and drainage system into Bentley’s integrated modeling platform. Bentley mobile applications were used on site to confirm constructability and accuracy of design measurements and track construction progress and ensure all on-site team members received the most up-to-date information.

Aurecon reduced substation design time by 50 percent, compared to traditional 2D design, by implementing Bentley’s 3D modeling solution. The organization was also able to produce more accurate component lists, which allowed the team to reach the tender phase within three months of the project’s start date. Bentley applications enhanced Aurecon’s collaboration and information mobility, enabling them to reduce overall project costs and use the Bentley 3D model throughout the construction phase of this project.

To learn more about the Sidwadwa 66/11kV Substation project and the Bentley solutions that were applied, click here.
The main transmission network service provider in southern Australia, Electranet strived to develop preliminary project designs and 3D models within the organization. Electranet uses these deliverables to garner development approvals and come up with cost estimates. The organization previously outsourced this work, and it was often incorrect. As a result, Electranet wanted to develop an internal, common CAD and georeference system to ensure that all designs created with differing systems could seamlessly integrate.

Electranet incorporated Bentley Substation into its software repertoire, permitting internal staff to generate 3D models and preliminary designs without external help. The modeling platform Electranet implemented used traditional CAD file formats and georeferencing to ensure designs created by different sources could be integrated with no issues. To assess the new workflow, Electranet executed on three pilot projects and staff generated 3D models and designs faster, cheaper, and more precisely than when the deliverables were created externally. Creating the models internally saved each pilot project over USD 20,000 in direct costs and saved more than one month of time per project.

The interoperability of Bentley Substation facilitated design sharing between Bentley software and Electranet’s third-party survey and transmission line design software. This capability enhanced information sharing and will ultimately move Electranet toward creating a building information modeling (BIM) workflow within their organization to streamline operations.

To learn more about the Bentley Substation Implementation and Integration into Electranet SOP project and the Bentley solutions that were applied, click here.
Jiangxi Electric Power Design Institute (JXEPDI), a subsidiary of Power Construction Corporation of China (POWERCHINA), was retained to design and deliver the 220-kilovolt (kV) Duxiling Substation in Pingxiang, China for China State Grid Corporation. This new substation improved the electricity network and power supply reliability to the area. The organization delivered an intelligent digital substation model for construction and operations by using Bentley's substation solution. The platform improved design quality and efficiency by implementing a unified, collaborative design environment.

The Bentley solution utilized by JXEPDI included an integration of design, simulation, and collaboration applications that allowed all disciplines to accelerate design, advance constructability, and lessen operating costs. Bentley Substation was used for intelligent electrical and physical substation design, enabling the creation of an intelligent substation model. Designers at JXEPDI developed a 3D physical layout with wiring and sag modeling to check clearance and spacing. Then, based on the 3D model, 2D schematics and construction drawings were created, as well as bills of material and 3D renderings.

By incorporating Bentley’s substation solution, collaborative and concurrent design took place and ProjectWise allowed the multi-discipline team to work concurrently, sharing information and designs in real time. Other Bentley applications were used for building design, civil works, and structural design and analysis.

Substation design efficiency was boosted by 30 percent as a result of incorporating Bentley’s substation solution. Additionally, errors and inconsistencies were eradicated across all disciplines, increasing project quality.

To learn more about the 220kV Duxiling Substation project and the Bentley solutions that were applied, click here.