HEEC Pilots 3D Digital Design Standards to Deliver Miluo Western 220-kilovolt Substation

Establishing Digital Twins with Bentley Applications Improved Substation Designers’ Productivity, Saving CNY 6.3 Million

A Lifecycle 3D Digitalization Initiative
The State Grid Corporation of China is developing and promoting 3D design standards to digitalize processes for lifecycle substation management throughout the country. The Miluo western 220-kilovolt substation is the organization’s CNY 120 million pilot initiative, and the first substation to use 3D digital modeling throughout construction, operations, and maintenance. Located in the Hubei province of China, the substation will significantly improve the grid structure in the Miluo area, covering 16-square kilometers and enhancing the reliability of power supplied to 160,000 residents.

POWERCHINA Hubei Electric Engineering Co., Ltd. (HEEC) won the bid as lead designer to implement 3D collaborative modeling in accordance with the State Grid’s design standards and to deliver digital twins to the owner.

The project presented numerous site challenges, including a complex surrounding landscape lined with large residential houses that restricted the layout of the substation facility. To accommodate the compressed footprint, the spatial location of each asset type – including underground works, building structures, electrical equipment, and cable trenches – required multiple contributing engineering disciplines in close collaboration. Working against an aggressive 10-month schedule to complete construction, HEEC had to effectively coordinate with each construction organization to safely deliver the project on time. Faced with these design and construction difficulties, the team required integrated BIM, reality modeling, and simulation and visualization technology to apply 3D digital standards and achieve full lifecycle digitalization.

Optimizes Collaborative Design
The compressed substation layout, while optimal from an environmental and residential perspective, required multiple engineering disciplines to collaborate to avoid collisions in the tight space. To ensure reliable, quality, detailed 3D design, and corridor planning. “ContextCapture generates high-precision reality models automatically and can visually reflect various information to help make decisions,” said Wei Wang, executive assistant, senior engineering at HEEC. Compared to traditional 2D drawings, using Bentley’s reality modeling application provided reliable environmental information to rationalize the substation layout amid the constrained site.

HEEC relied on the accuracy of the 3D reality model to visualize and analyze the existing conditions, optimizing the incoming and outgoing corridor lines while also minimizing impact on agricultural land and houses bordering the substation. Using the reality mesh enabled the team to avoid demolishing six houses and reduce the area occupied by the substation by 22%, saving 0.94 hectares when compared to the original design scheme. As a result, HEEC saved CNY 2.5 million through the optimal substation layout and reduced earthworks for bored and cast-in-place piles by 63 cubic meters to save an additional CNY 90,000.

Reality Modeling Uses Digital Context for Immersive Visualization
To accurately plan the project, HEEC used oblique photogrammetry, captured using an unmanned aerial vehicle, and ContextCapture to survey the substation site and generate a 3D reality mesh. Using geospatial reality modeling helped establish a digital context for the project, visually capturing landscape, vegetation, rivers, lakes, roads, and houses surrounding the project area to support substation site and corridor planning. “ContextCapture generates high-precision reality models automatically and can visually reflect various information to help make decisions,” said Wei Wang, executive assistant, senior engineering at HEEC.

Fast Facts
- Bentley’s reality modeling, BIM, construction simulation and visualization applications helped to overcome site constraints and optimize planning and construction.
- Adopting digital twins industrialized project delivery, supporting construction, operations and maintenance.

ROI
- Creating the project’s digital context to optimize substation layout reduced land occupation by 22%.
- Performing dynamic construction simulation enabled delivery of the substation project one month ahead of schedule.
- Leveraging Bentley software to create digital twins provided an integrated 3D solution for collaborative management, saving CNY 6.3 million.

Project Summary
Organization: POWERCHINA Hubei Electric Engineering Co., Ltd.
Solution: Communication and Utilities
Location: Miluo City, Hunan, China

Project Objectives:
- To deliver a substation digital twin in accordance with the State Grid’s design standards.
- To optimize construction management throughout the substation’s lifecycle with a BIM design model.
- To improve operations and maintenance with digital twins that facilitate virtual reality scenes.

Project Playbook:
Bentley Raceway and Cable Management, OpenUtilities Substation, ContextCapture, LumenRT, MicroStation, Navigator, OpenBridge, OpenBuildings Designer, OpenPlant, ProjectWise, Promis.e, ProSteel, ProStructures, STAAD, SYNCHRO

CASE STUDY
HEEC established an open, connected data environment, and reengineered the design process using Bentley’s integrated digital applications. ProjectWise provided the coordinated platform to integrate electrical, structural, and underground modeling works. Using OpenUtilities Substation, OpenBuildings Designer, STAAD, Bentley Raceway and Cable Management, and Promis.e streamlined workflows to optimize collaborative design and avoid 30 collisions, saving CNY 800,000.

The electrical and civil engineering groups shared data and information through 3D models in Bentley’s discipline-specific digital applications that were then imported into the comprehensive substation model available within the connected data environment. Integrating STAAD for structural design and analysis helped refine the architectural model to achieve less than 1% deviation in accuracy between the designed and actual steel material, optimizing the steel frame with just 8 tons of steel to save CNY 120,000 in material costs.

The interoperability of Bentley’s applications (with one another and with third-party software) facilitated coordinated digital design to save 65 design days. Establishing collaborative 3D design workflows within the connected data environment, the team created an optimal engineering model, which identified and resolved clashes in advance, resulting in zero changes during underground construction. “Through comprehensive collision inspection of the underground facilities, design errors are found in advance and about 30 construction reworks are reduced,” said Wang.

### 3D Model Streamlines Construction Management

The engineering design model, combined with the reality model, forms the substation digital twin where construction drawings and material quantities can automatically be extracted. Committed to full lifecycle digitalization for delivery of the substation, HEEC explored various methods to use the 3D design model to digitally guide construction. The team relied on mobile applications, including Bentley’s mobile versions of ProjectWise and Navigator, to enable on-site construction staff to access and check the substation model and associated drawings. Using iModels and 3D PDF models facilitated integration of various forms of data and dynamic simulation, allowing construction crews to visualize equipment installation and better understand the construction process. Working in a connected data environment with these mobile digital solutions provided on-site workers with convenient access to the 3D design model, improving workflow and communication while effectively guiding construction to save 15 working days.

Integrating SYNCHRO for 4D construction sequencing provided visual coordination and simulation of construction progress to track and manage the construction schedule. Using Bentley’s dynamic construction simulation application, HEEC performed a comparative analysis between the planned construction schedule and actual on-site process to effectively manage changes in real time. “With SYNCHRO, we can systematically and comprehensively manage and control the progress of the project, analyzing the progress deviation at all times to control the possible risks,” explained Wang. Introducing mobile technology and SYNCHRO, HEEC used the 3D design model to streamline construction management, achieving full construction digitalization to complete the Miluo substation 30 days ahead of schedule.

### Digital Twins Modernize Substation

By creating a digital twin of the substation using Bentley’s reality modeling, BIM, construction simulation, and virtual reality applications reduced total investment of the project by CNY 6.3 million. To realize full lifecycle digitalization of the substation, HEEC used LumenRT to establish and deliver digital twin models to the owner for more efficient operations and substation maintenance. Moreover, Bentley’s visual animation technology adds the immersive virtual reality element to the 3D design model for optimal communication and understanding of the substation facility operations.

As China’s first substation project put into operation using 3D design standards and digital twins during construction, HEEC industrialized substation delivery for future State Grid initiatives. Bentley’s integrated technology applications optimized this pilot implementation of collaborative lifecycle 3D modeling to deliver digital twin models, improving design productivity and providing strong technical support for construction, operations, and maintenance.