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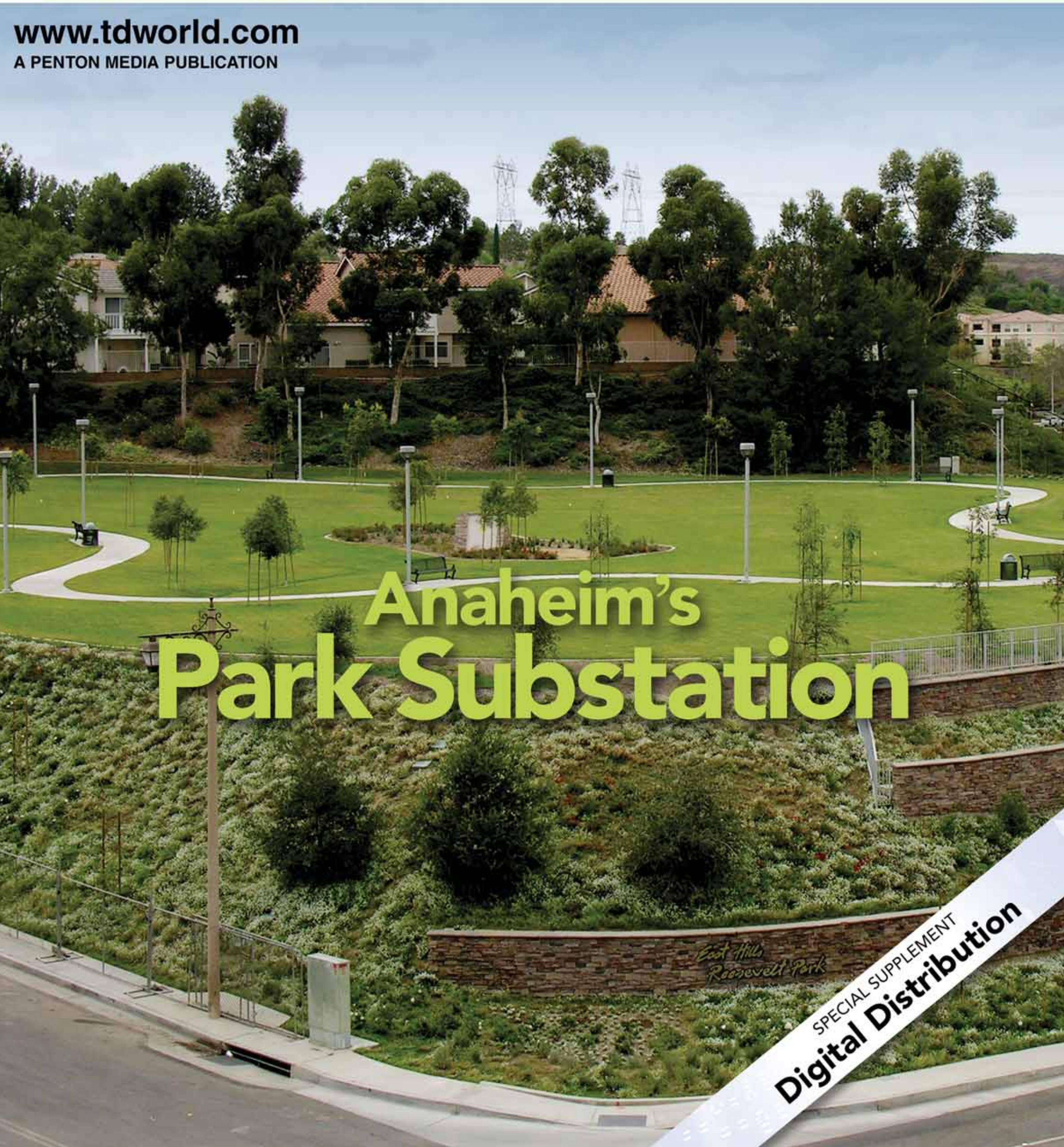

Anaheim's Park Substation

SPECIAL SUPPLEMENT
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Hidden Within

Cleverly disguised within a community park, Anaheim Public Utilities installs the first subterranean GIS substation in the United States.

By **Jafar Taghavi** *and* **Keith Tieszen**, *Anaheim Public Utilities*

CAMOUFLAGED BY A NEIGHBORHOOD PARK IN A DENSELY POPULATED RESIDENTIAL AREA of Anaheim, California, U.S., is a subterranean gas-insulated switchgear (GIS) 69-kV/12-kV distribution substation. Only a single, partially exposed section of wall provides access and a clue as to the location of Park Substation. The park and adjoining slopes are landscaped and terraced to blend with the surrounding hillsides. The Anaheim community became involved in the project early on and offered strong support for it.

Anaheim Public Utilities, a department within the City of Anaheim, operates one of the oldest municipal electric systems in the state of California and is Orange County's only publicly owned electric utility. The utility has been an energy provider for more than 112 years, has more than 113,000 electric meters and recorded a 535-MW system peak in the summer of 2006. The utility receives power via a 230-kV/69-kV substation and distributes power to its customers through ten 69-kV/12-kV substations.

The park before substation construction began (above), and the completed Roosevelt Park as it is today (left).

SYSTEM STUDIES

The utility's Electric System Planning department concluded that locating a substation in a densely populated area was required to reliably and economically serve current and future load growth. As the city's diverse economy continues to grow and its demand for energy rises, land in the area is becoming increasingly expensive. Environmental and aesthetic issues need to be mitigated. Reliability and safety are becoming more important, and the ability of equipment to withstand seismic events is of critical importance.

Although a site for future expansion was selected more than three decades ago, it proved to be too small to accommodate today's conventional outdoor station requirements. A conventional substation would have been unacceptable in an area where land is valued in millions of dollars per acre and where existing electrical facilities were already located underground.

The System Planning department's studies concluded that GIS technology would allow the placement of a substation near a load center using only 30% of the land of a conventional substation. GIS also provided the flexibility to make the station quiet and virtually invisible to the public.

During the conceptual stages of the Park Substation project, System Planning contacted the main suppliers of GIS equipment to investigate their equipment capabilities and design-build experiences. Each manufacturer made presentations to Anaheim's key players. As a result, a comprehensive GIS functional specification was prepared to outline major items of work for the contractor. It listed applicable standards and codes, required rating of equipment, factory and field testing, quality assurance, inspection and maintenance, operating requirements, shipping requirements, field service and training, warranty of equipment, wiring requirements, protective relaying, controls, communication, high-voltage cable requirements and connections, and design and construction criteria.

Use of GIS also achieved the overall planning objectives of system reliability and improving community aesthetics, and was an acceptable approach for serving the customers and community. Although the innovative use of GIS is more common in Europe and Japan, its use in the United States is increasing, with aesthetically treated structures drawing more interest. Anaheim's installation, however, is the first underground substation with a park constructed on top of its roof.

System Planning faced formidable obstacles in getting this installation approved. An environmental study was required with its problematic outcome. Land, already scarce, located near a load center had to be acquired. Community concerns had to be mitigated. Design-build contracts were not allowed by the city and required a charter change. The utility had to prepare a comprehensive functional bid specification and provide project management without an increase in staff. However, the utility did have considerable experience managing diverse construction projects, and the Southern California area provided ample technical skills.

Construction sequence ending with a photo during dedication.

COMMUNITY INVOLVEMENT

System Planning evaluated three city-owned sites located near load centers. Each site was capable of serving expanding development, backing up existing distribution circuits and affording short transmission lines. The selected site provided more unencumbered front footage for T&D access, more area for substation construction and offered the best vehicle access.

The substation is approximately 20 ft (6 m) above street level on the north side and located in hilly terrain, with adjacent terraced residential construction and gradual slopes throughout the area. The park buffers several single-family residences overlooking from and immediately adjacent to the west. A street separates the site from single-family residences overlooking from the south. The northerly and west sides are elevated above streets. This type of design allows the substation entrance to blend with the adjacent landscaped greenbelts. The roof of the structure is approximately 4 ft (1.2 m) beneath the park.

System Planning organized and participated in extensive community outreach: It held neighborhood meetings, contacted numerous affected businesses, opened communication lines with residents and businesses, discussed the project with local media and encouraged newspaper articles. Comments and participation in the design process of the neighborhood park were requested and incorporated. A monthly newsletter with the progress schedule was placed at the site to keep local residents informed.

CONTRACT MANAGEMENT

State statutes and the city's charter and municipal ordinances provide specific legal guidelines concerning the soliciting, evaluating and awarding of public works contracts. The design, build and construct contracting for this project required a city ordinance change. After considerable internal review, the city council approved an ordinance that allowed for design-build contracts for the public utilities department.

The major change to the typical public works process is that the award required the contractor to provide and manage the equipment procurement, fabrication and delivery, to provide all design and construction, and to be completely responsible for the end product. Additionally, city staff are allowed to negotiate for a best and final offer.

As a result, the project was ultimately advertised for bid and awarded to a project design and construction team joint venture headed by Siemens Power Transmission & Distribution Inc. (Raleigh, North Carolina, U.S.), a supplier of GIS equipment. The project was managed by Anaheim Public Utilities System Planning staff, in partnership with Sargent & Lundy, LLC (Chicago, Illinois, U.S.), an internationally renowned engineering firm with extensive experience involving GIS substations, which provided the construction management.

As a design-build project, the contractor was responsible for engineering, procurement of the material and construction of the facility. The design-build team consisted of three companies: Siemens Power T&D; Turner Construction Co. (New York, New York, U.S.), a general contracting firm; and BETA Engineering California LP, a highly experienced specialty electrical engineering firm.

DESIGN AND CONSTRUCTION

The contractor used mass-grading excavation equipment to prepare the site for the cast-in-place concrete structure. All excavation activities occurred during normal working hours to minimize the noise impact to the neighborhood, and lasted approximately 20 days. The 110-ft by 130-ft (34-m by 40-m) excavation required the removal of 225,000 ft^3 (172,000 m^3) of dirt. Sufficient land was available for the excavation to be sloped to eliminate the need for shoring. All foundations were machine excavated. Water trucks were used for dust control during all mass-excavation operations, and daily street cleaning was performed.

However, the start of excavation for the underground building experienced an initial hurdle. Southern California received record rainfall in excess of 35 inches (890 mm) in the fall of 2005. This resulted in the installation of an extensive shoring support system with drilled 40-ft (12-m) concrete-encased I-beams to secure an adjacent slope. There were several homes overlooking the slope, and there was no subsequent soil subsidence.

The foundation rests on concrete pile caps placed over more than 138, 2-ft (610-mm)-diameter drilled caissons with a perimeter concrete-grade beam. The slab on grade is approximately 12 inches (305 mm) thick. The perimeter walls

are 20-inch (508-mm)-thick cast-in-place concrete, and the roof deck is an l8-inch (457-mm)-thick concrete slab with 540 post-tensioned cables.

The building structure (including entrance and exit doors, walls, roof support, fire rating, moisture proofing, safety requirements and noise abatement) was designed and constructed to meet all required codes. The design is compact yet allows for easy access to all equipment. It incorporates a pitched roof with a waterproof membrane treatment applied to the roof, exterior walls and retaining walls. A perforated drainpipe system was placed at the bottom of the exterior walls.

The ventilation system serving the transformer vault and vehicle access area is a direct evaporative cooling unit located in the mechanical room. The unit duty is sized for 30,000 cubic feet per minute (CFM). The air volume is based on the equipment design heat-load values.

Fresh air is provided by acoustic louvers in the exterior wall of the mechanical room, which also serves as a fresh-air plenum. Equipment areas have in-line centrifugal exhaust fans with a fan duty sized for 30,000 CFM. Exhaust air for vehicular traffic is through five inlets located within 18 inches (457 mm) of the finished floor.

Conventional air conditioning typically found in computer room-type cooling provides conditioned air (HVAC) for the control room and the ac-dc rooms. HVAC sizing is based on an interior heat load of 25 W/sq ft of area plus overhead lighting. Design temperature for these rooms is 75°F (24°C). The floor-mounted HVAC units are located in their respective rooms at floor level. Each HVAC unit consists of ductwork, compressor section, electric reheat coil, humidifier, 30% filtration and refrigerant piping between the unit and condensers.

The intake and exhaust louvers are not visible from the community park or street. The louvers are located within the terraced wall of the substation, hidden by the terracing and landscape planting.

Fire protection for the building was achieved through use of an extinguishing agent called HFC-125, a DuPont product that is safe, clean and electrically nonconductive. The goal of this action was to protect people, minimize loss or damage to equipment, and maintain business continuity.

GIS TECHNOLOGY

Gas-insulated switchgear (GIS) is a proven technology used throughout the world that offers many advantages over a conventional substation. A primary advantage is its compactness, which allows a GIS to be placed closer to a load center, and it is a more aesthetically attractive alternative for a neighborhood. It requires less field construction work, resulting in quicker installation time, reduced maintenance, higher reliability and safety, and excellent ability to withstand seismic events.

All switchgear is enclosed in an inert, nontoxic insulating gas medium, which allows the phase spacing of the electric components to be very close and protects the components from outside contamination. GIS compartments on the equipment are continuously monitored to ensure that any leaks are detected and eliminated. It has low noise emission, and reduced fire and explosion potential. Cost benefits accrue over the life of the equipment because of greatly reduced inspection and maintenance requirements.

A portion of the 12-kV GIS switchgear being assembled.

When all these advantages are taken into consideration, a gas-insulated substation is a cost-effective alternative to a conventional substation in an urban community.

Service and maintenance vehicles access the facility through a 20-ft wide by 18-ft high (6-m by 5-m) roll-up door. A main vehicle-access aisle within the building provides access to the 69-kV GIS equipment, two 50-MVA 69-kV/12-kV power transformers, five 69-kV lines, twelve 12-kV distribution circuits and two 12-kV capacitor banks. Sufficient maintenance and service aisles throughout the building provide easy maintenance access, removal and replacement of all equipment.

Connections from the GIS to the high-voltage and low-voltage sides of the transformers were made via 69-kV and 12-kV underground cable installed in PVC conduit duct banks located beneath the building floor slab. Open-air flexible cable was used to connect the cable terminators to the high-voltage and low-voltage bushings of the transformers.

SUBSTATION DEDICATION

On Oct. 17, 2006, Anaheim dedicated the project as Park Substation. It is the first underground 69-kV/12-kV GIS electric distribution substation in the United States. Adding to the uniqueness of the substation is the fact that it sits below the new Roosevelt Park, a two-acre community park that serves the surrounding east Anaheim neighborhood. TDW

Jafar Taghavi is responsible for system planning and major capital project management for Anaheim Public Utilities. He has more than 25 years of experience in the areas of utility and consulting engineering. Taghavi managed Park Substation as well as a 230-kV GIS substation and associated transmission line, now under construction. He is also responsible for an upcoming 69-kV/12-kV indoor GIS substation to be located in a historical-looking building in downtown Anaheim and another upcoming project consisting of a 200-MW generation plant with GIS switchgear. Prior to Anaheim, he was a project engineer for American Electric Power in Columbus, Ohio, U.S. Taghavi received BSEE and MSEE degrees from Ohio State University and is a registered professional engineer in California and Ohio. **JTaghavi@Anaheim.net**

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