Substation Department

INTRODUCTION

Burns & McDonnell offers clients a long and impressive history of delivering responsive, high-quality substation design and construction services around the world. For more than 112 years, the mission of the employee-owners at Burns & McDonnell has been to "make our clients successful". These qualifications demonstrate that success.

Burns & McDonnell's substation projects include large and complex generating plant switchyards, transmission/distribution substations, line terminal or equipment additions, and upgrades to existing substations in locations all across the United States. Designs have included single bus, main and transfer arrangements, ring bus arrangements, breaker-and-a-half and double breaker arrangements. Our staff are specialists in substation design with most having extensive experience in substation and utility construction. Our engineers attend training courses in-house and at industry meetings to maintain their skills and to keep abreast of current technologies and advancements for systems up to 500-kV.

SPECIALISTS IN ALL DISCIPLINES

Burns & McDonnell can perform engineering for your company on a wide variety of substation and bulk power delivery related projects. Our system planning, project management, design, program management and construction management experience ranges from 4.16-kV through 500-kV on simple retrofit projects to large, complex projects. Project scopes vary widely and require Burns & McDonnell engineers to understand system design and the detailed substation design from the conceptual phase to final construction and energized testing. In addition, we have specialists in geotechnical engineering, site grading, steel structure design, foundations, oil containment systems, permits and regulations, transformers, reactors/capacitors, power circuit breakers, relays and controls, communications, SCADA, substation automation, switchgear, bus design, grounding analysis, control buildings, standby engine generators, and system studies.

Services are provided from the initial conceptual stages of a project, through the construction and energization of the substation. Our

engineers have the expertise to provide preliminary designs, equipment parameters, and estimates necessary to evaluate the viability of a project. Our experience with project administration provides for a smooth continuum of activities necessary for the execution of a project through the conceptual, design, bid and construction phases.

DESIGN TOOLS

Burns & McDonnell has developed an extensive library of advanced design and management tools to keep all of our substation projects moving in the right direction, from planning and design to implementation, on time and on budget. These tools include project-tested design procedures, standard details and specifications, and cutting-edge computer programs. Some of the programs that Burns & McDonnell engineers and technicians use include: AutoCAD, Primavera, Microstation, ASPEN OneLiner, ATP, CYMGRD, RELAY, SCADA, WINIGS, CDEGS, Softdesk, and TWRLOD.

RECENT PROJECTS

PUBLIC SERVICE ELECTRIC & GAS COMPANY

Construction of new 69/13-kV Franklin Substation consisting of a 69-kV bus, two 69-kV line positions, a 69-kV bus section breaker, two 27MVA 69/13-kV transformers, 13-kV sheltered aisle switchgear, and two 9MVAR 69-kV capacitor banks. Franklin Substation is configured for future expansion to include a second 69-kV bus, a third 69-kV line position, a second 13-kV sheltered aisle switchgear and two additional 9MVAR 69-kV capacitor banks. Burns & McDonnell's design, procurement and construction responsibilities included site grading, substation electrical, and protection and controls systems. Burns & McDonnell provided support for licensing and permitting by Owner. Construction was completed on a fast track schedule. The station was successfully energized five months after mobilization, with site grading and foundation work performed in winter conditions.

PUBLIC SERVICE ELECTRIC & GAS COMPANY

For PSE&G, Burns & McDonnell is engaged in a number of EPC projects as Prime EPC Contractor. To facilitate aggressive project schedules, PSE&G has selected Burns & McDonnell to provide an EPC approach to allow parallel scoping, preliminary design, detailed engineering, procurement, and construction activities cutting months from the typical project cycle. This has resulted in continual on-time energization schedules working under critical outage windows. Burns & McDonnell works closely with PSE&G to pre-qualify and select subcontractors and suppliers which include a combination of vendors familiar to either or both firms. Projects include the following:

At the Bayway Substation the existing 138kV W-1323 transmission line that ran from Federal Square to Linden Generation was now to be split and terminated at Bayway Substation. With the new line added to the Station the existing Ring Bus was upgraded to 3000 amps. This required the replacement/upgrades of twelve (12) 138-kV disconnect switches and four (4)138-kV breakers.

The Branchburg was a 230-kV ring bus expansion project. To prepare for a new 230-kV line, Burns & McDonnell designed, procured, and installed all adjacent and new facilities to support the addition of a line position into the existing 230-kV ring bus. One new breaker was added to the ring bus along with the bus, switches, CCVTs, and surge arresters to support the new line. To increase the reliability of the station, another breaker was added to the ring bus to split the existing capacitor bank from an existing line position, along with associated switches, and upgraded relaying for the capacitor bank. To support the new line, and reconfiguration of existing lines, Burns & McDonnell designed, procured, and installed relaying and disconnect switch upgrades at three other substations. Working with PSE&G, Burns & McDonnell coordinated with complicated outage schedules to meet the on-time line energization.

A 138-kV reactor bypass project to increase system transfer capability. Due to space constraints, single-phase candlestick power circuit breakers were installed immediately adjacent to 138-kV series reactors. Due to poor soils, clearance issues, and limited outage times; a helical pile system with spread footer foundations were utilized. Each new breaker was installed, wired, high-voltage connections made, and commissioned within a one-week period.

A substation controls upgrade/retrofit project. Due to a coming generating facility demolition project containing substation controls, an existing 26-kV substation protection and controls system servicing 18 feeder, transformer, and tie breakers required replacement. Burns & McDonnell provided a single-piece 16' x 50' control enclosure complete with relay panels, and AC/DC systems. Abandoned transformer pads were used which required close coordination with the enclosure manufacturer. New cable trench was installed throughout the substation serving as the backbone of the raceway system from the enclosure to existing breakers, instrument transformers, and station service equipment.

Three 500/230-kV autotransformer projects. With existing derated transformer banks and increasing transfer capacity demands, two banks of 500/230-kV autotransformers were scheduled for replacement and a third was added. Working with PSE&G and their transformer vendors, Burns & McDonnell designed, procured, and installed all adjacent and new facilities to support the replacement projects. Each replacement bank was allowed a five week outage. Within that timeframe and working nights, weekends and holidays; the following work was performed: existing transformers removed from the pads, existing rock removed, containment liners added, new conduit and grounding added, jacking pads modified, new units set and assembled, new rock installed, high voltage connections made, low voltage cables terminated, protection system upgraded, and all components tested and commissioned.

Other miscellaneous projects include breaker, switch, and circuit switcher replacements; line terminal additions and upgrades; and other retrofit and new construction

HORIZON WIND ENERGY

Burns & McDonnell performed engineering design on the collection system, substation and transmission of Blue Canyon V Wind Farm project located in Comanche County, Oklahoma.

The Blue Canyon V Wind Farm project required several specific responsibilities from Burns & McDonnell. The 34.5-kV Collection System. Burns & McDonnell was responsible for designing, specifying and supporting construction for one wind farm, consisting of approximately 100MW. There were four 34.5-kV underground collection feeders identified for the wind farm. The 138-kV Transmission Line. Burns & McDonnell was responsible for the designing, specifying and supporting one section (2.5 miles) of 138-

kV single circuit transmission lines. 34.5-kV/230-kV Collection Substation (approximately 100MW). Burns & McDonnell was responsible for designing, specifying and supporting construction for a 138-kV radial bus substation with major equipment consisting of one 138-kV breaker, one 34.5-kV/138-kV, 115 MVA step-up transformer, one 35-kV switchgear line-up, switched capacitor bank. 138kV Interconnection Substation. Burns & McDonnell was responsible for designing, specifying and supporting construction for a 138-kV three position ring bus substation with major equipment consisting of three 138-kV breakers.

DOMINION VIRGINA POWER

Dominion Virginia Power's Suffolk Substation was Burns & McDonnell's first opportunity to complete project work on Dominion's 500-kV transmission system. This project provided for the expansion of Dominion's Suffolk Substation to accommodate a new 500/230-kV, 840MVA transformer bank, two new 500-kV circuit breakers, one new 230-kV low side breaker and all associated auxiliary equipment.

This project was the largest in terms of design fee and man hours that Burns & McDonnell has performed for DVP spanning a four-year working relationship.
Burns & McDonnell was tasked with providing the engineering services at DVP's Suffolk Substation for the installation of a 500-230kV, 840 MVA autotransformer bank with two 500-kV breakers and one 230-kV breaker. This project cut DVP's existing 500-kV 531 Line from Surry Substation to Yadkin Substation that travels in the right-of-way adjacent to the Suffolk Substation. This was the first segment of a two phase plan to install a six position 500-kV ring bus with two transformer banks and four lines.

Burns & McDonnell provided all facets of physical design for this 500-kV yard addition. The services provided for the physical portion of this venture included rigid bus design, strain bus design, grounding design, conduit design, cable schedule design, grounding simulation using CDEGS, foundation design, surface voltage gradient calculations, steel structure design, lightning protection design, and the implementation of all associated equipment.

The design was completed in August 2008 and construction was complete in June 2009.

AMERICAN ELECTRIC POWER

Burns & McDonnell provided engineering, procurement services for American Electric Power (AEP) using AEP INDUS system, construction support, and project management support services related to over 150 substation projects.

Burns & McDonnell provided engineering, procurement, construction, testing and commissioning services required for the modification of the Lane City Substation. AEP determined that in order to alleviate a commercially significant constraint, it was necessary to install .05-p.u. series reactors with by-pass capabilities between the TCC Lane City Substation and the Centerpoint Lane City Substation, and install a 28.8-Mvar capacitor bank on the Lane City 138-kV bus.

Burns & McDonnell was responsible for construction permits, civil/structural/electrical design, procurement of equipment (panels, substation materials, steel, construction and testing). Burns & McDonnell was also responsible for coordinating with soil report, survey, foundation, erection, and testing contractors.

The Lane City 138-kV Substation is located in Lane City, Texas, fifty miles south of Houston, TX. This site is served by a combination of all-weather and gravel roads.

The challenge of the project was to finish a smooth fast track project and at the same time to minimize the outage requirements, while minimizing the outage time. Creative designs were implemented to minimize the modification of existing structures and keep the interruption to the existing energized 138-kV bus to a minimum.

Burns & McDonnell worked very closely with AEP operations, capacitor bank vendor, circuit switcher vendor, steel vendor, disconnect switch vendor and insulator vendor to meet the required reactor energization date.

The project was finished and energized as scheduled in December 2005 and within the original budget.

FIRSTENERGY CORPORATION

Burns & McDonnell has provided Engineering, Procurement and Construction Services for First Energy for multiple substation projects.

Burns & McDonnell performed substation engineering, procurement, and construction services for the West Fremont 138-kV substation. This substation was a 15-breaker, 10-position breaker-and-a-half scheme for a new combined cycle power plant for Calpine Corporation in Fremont, Ohio.

Burns & McDonnell worked with FirstEnergy at the conception of the project to develop a new 138-kV layout, which would minimize the space available for the substation. The layout established became the new FE standard for 138-kV breaker-and-a-half stations.

Burns & McDonnell was responsible for all phases of design including foundations, raceway, grounding, control building, one lines, schematics and wiring diagrams. The project involved the complete design, procurement and construction of the substation. Burns & McDonnell was involved with reviewing vendor drawings and incorporating final vendor drawings into the construction packages. The line and bus protection included SEL-321, SEL-311B, SEL-311C, SEL-501, SEL-387, PVD, and KAB relays. Burns & McDonnell also developed detailed schematics and wiring diagrams for the entire project.

For the Wayne 345-kV ring bus project, Burns & McDonnell performed engineering design, procurement, construction, and construction management.

This substation contained a single 345-kV breaker and a 345/115-kV transformer. The project involved adding two new 345-kV breakers and creating a 3 position ring bus arrangement. There was also a separate project to replace the existing transformer. The existing 345-kV line that passed through the station was a major link in the transmission system so all of the new work had to be completed with minimal outages on the 345-kV system.

Burns & McDonnell was responsible for all phases of design including foundations, oil containment, raceway, grounding, one-lines, schematics and wiring diagrams. The project involved the complete design, procurement and construction of the substation. Burns & McDonnell worked closely with First Energy to coordinate

construction and outage sequences. Testing and commissioning functions were performed in conjunction with FirstEnergy crews.

CITY OF HOMESTEAD

Burns & McDonnell designed two new substations, a substation upgrade and four transmission lines for the City of Homestead in Homestead, Florida.

The 138/13.2-kV Redland Substation is a new distribution station located on the west side of Homestead. The station was designed for two transformer banks and eight distribution feeders in the ultimate configuration. Two transmission lines will terminate at the station, Redland-Lucy and Redland-FP&L. Burns & McDonnell was responsible for all phases of design, including foundations, raceway, grounding, control building, one-lines, schematics and wiring diagrams. Burns & McDonnell assisted the City with procurement specifications and managed the installation of the substation.

The 138/13.2-kV Renaissance Substation is a new ring bus/distribution station on the east side of Homestead. The station was designed for two transformer banks and eight distribution feeders in its ultimate state. Three transmission lines will terminate at the station, Renaissance-Lucy and two Renaissance-FP&L lines, to complete a loop of an existing FP&L transmission line. Burns & McDonnell was responsible for all phases of design and construction management similar to Redland Substation.

Burns & McDonnell completed detailed design for the addition of two, 138-kV circuit breakers at the existing ring bus, Lucy Substation. This addition included all physical requirements, including bus, fittings, conductor, foundations, grounding, raceway, etc., as well as protection requirements, including relay panels in the existing control house for the new breaker and line protection.

PACIFIC GAS & ELECTRIC

In conjunction with the Tri-Valley Expansion Project, Pacific Gas and Electric selected Burns & McDonnell to Engineer, Procure, and Construct the 230/23-kV Cayetano substation.

The project required the installation of a three position, 230-kV ring bus substation. The substation consisted of three 230-kV circuit breakers with two underground 230-kV transmission lines and a 50MVA 230/23-kV transformer. The substation layout and

protection scheme allowed for the future conversion to a six-position ring bus on the same property. Landscaping and a decorative wall minimized the visual impact to the residential community.

Burns & McDonnell was responsible for design of the substation including electrical and civil/structural design. Design responsibilities included field trips to substation site, preparation of equipment specifications, and preparation of construction specifications. It was also important to coordinate with other contractors and consultants responsible for other phases of this complex project. Electrical drawings, civil/structural drawings, protective relaying drawings, data systems interface, material requests, drawing lists and bills of material were provided by Burns & McDonnell.

Burns & McDonnell directly procured all engineered equipment including circuit breakers, disconnect switches, structural steel, and relay panels. Through its subcontractor, Burns & McDonnell procured the balance of the equipment and materials.

Burns & McDonnell was responsible for all substation construction including site work, installation, testing, and commissioning. Burns & McDonnell administrated the sites safety program and coordinated all subcontractors.

SANTA CLARA, CALIFORNIA

The Silicon Valley Power Northern Receiving Station 230-kV Transmission Project is located in the cities of Santa Clara and San Jose, California. The project consisted of a new 230-kV switching station, 1.75 miles of overhead and 2.5 miles of underground 230-kV transmission line and additions to an existing 230/115-kV substation. Eleven circuit breaker replacements are also included in the EPC project. The project will increase transmission capacity in San Jose and Santa Clara, California.

Burns & McDonnell teamed with a construction company as a joint venture partner for this project. The contractor performed all construction at the substations plus overhead and underground transmission line installation. The project was managed from the Kansas City office. Construction began in late 2003 and was completed in May 2005.

ORLANDO UTILITIES COMMISSION

Burns & McDonnell and a construction contractor designed and constructed three substations and two transmission lines for Orlando Utilities Commission in Orlando and neighboring St. Cloud, Florida. Kaley and Lake Nona Substations, located in Orlando, were constructed in 2004. St. Cloud South Substation and two transmission lines will be built in St. Cloud, Florida, in 2005.

The 115-kV Kaley Substation site was originally used as a termination site for the termination of a 115-kV underground High Pressure Liquid Filled (HPLF) transmission line. The station was converted to a 115-kV 8-position ring bus substation. The substation is a low profile design with a decorative wall and landscaping to shield the view of the substation by neighboring residents and commercial businesses. 12.47-kV and 27-kV distribution circuits were installed from the substation in underground ductbanks beneath Kaley Avenue.

A new 230-kV Lake Nona Substation was constructed near the Orlando International Airport on property owned by the Greater Orlando Aviation Authority. The new substation connects OUC's Airport Substation and OUC's Industrial Park and Airport Substations. The substation is low profile, designed to accommodate an ultimate 10-position ring bus configuration with three 230kV transmission lines, five 230/12.47-kV transformers, and two 230/24.94-kV transformers.

The 230-kV substation is a four position ring bus, and the 69-kV substation is an eight position ring bus. New 230-kV and 69-kV transmission lines totaling approximately 15 miles was constructed to tie the new substation to OUC's system. The 69-kV transmission line included approximately 1 mile of line built underground to satisfy local customer's concerns about aesthetics. Both the 230 and 69-kV transmission lines also included underbuilt 25-kV distribution to serve the growing load in Osceola County, Florida. The 230/69-kV St. Cloud South Substation was placed in service in 2005.

TENNESSEE VALLEY AUTHORITY

The Volunteer 500/161-kV Substation project consisted of several planning projects required by Tennessee Valley Authority (TVA). One project was to upgrade all of their existing relay protection to current standard microprocessor based relays. Another project included the addition of three single-phase 500/161-kV 400 MVA transformers. Also, the 500-kV portion of the substation was

reconfigured from a ring-bus to a double-breaker double-bus configuration.

TENNESSEE VALLEY AUTHORITY

The Watts Bar Hydro 161-kV Substation project was required by Tennessee Valley Authority (TVA) due to a fire in the existing control room inside the Hydro plant. A new control building and all new relay panels complete with microprocessor relays was installed to replace the existing controls that were damaged in the fire. Due to the immediate nature of the project, this project was split into five phases in order to get the substation back to complete restoration order in a minimum timeframe. Burns & McDonnell provided engineering services for Phases 4 and 5.

SOUTH TEXAS ELECTRIC COOPERATIVE

Burns & McDonnell provided professional engineering and design services related to the Pawnee-San Miguel 345-kV Transmission Project, for South Texas Electric Cooperative. The San Miguel-Pawnee 345-kV Transmission Project consisted of approximately 35 miles of 345-kV double-circuit transmission lines, with one circuit initially installed; the new Pawnee 345/138-kV substation; expansion of the existing 345-kV yard at the San Miguel Power Plant Substation; and modification of an existing 138-kV transmission line in order to loop it through the Pawnee 345/138-kV substation.

Initial construction of the Pawnee 345/138-kV substation consisted of a 4-position, 6-breaker, breaker-and-a-half 345-kV yard; one 345/138-kV, 150 MVA autotransformer; and a 3-position, 3-breaker, ring bus 138-kV yard. The Pawnee 345/138-kV substation is located northwest of El Oso, Texas. This site is served by combination of all-weather, gravel and unimproved dirt roads.

Expansion of the existing San Miguel Power Plant Substation consisted of the addition of a 2-position bay to the existing breaker-and-a-half 345-kV yard with 2-breakers and 1-position initially installed. This site is located southeast of Christine, Texas and is served by all-weather roads.

Burns & McDonnell's responsibilities included design and engineering services related to the selection of routes and sites, acquisition of properties and rights-of-way, environmental and geotechnical investigations, design and engineering studies, procurement and construction specifications, and other subcontract services directly related to the complete design of the project. Burns

& McDonnell also performed construction observation in order to verify to STEC that the construction contractor performed in accordance with the plans and specifications. Construction was completed in June 2002.

GEORGIA POWER

Burns & McDonnell substation engineers have worked hard to become familiar with Georgia Power's system. Burns & McDonnell currently has several engineers from our Kansas City and Atlanta offices assigned to multiple control system projects around the state of GA. The scope of work includes the modification of existing 230/115-kV substations and the design of new Greenfield substations. Projects also include the modification of several 115-kV distribution substations with low side voltage ranging from 13.8-kV to 25-kV. Modifications such as the removal of obsolete equipment, the addition of power circuit breakers and circuit switchers, transformer additions and capacitor bank additions require that Burns & McDonnell engineers exercise sound engineering judgment and work closely with Georgia Power engineers and technical staff. Georgia Power requires that consultants use on-site proprietary systems to enter bills of material and project man-hours. Burns & McDonnell engineers work closely with Georgia Power field engineers to design relay panel installations and have attended on-site substation safety training sessions with Georgia Power staff. Physical and control designs are prepared to match the Georgia Power design philosophies and standards. Drawing files for these projects are transferred electronically from Atlanta to Kansas City for the review, comment and approval process as well as final product delivery to Georgia Power.

AQUILA ENERGY

Aquila Energy planned and financed the construction of a simple cycle 388MW nominal output gas fired Crossroads Energy Center peaking power plant located in Clarksdale, Mississippi. The new plant is an independent power producer (IPP) plant owned and operated by Clarksdale Public Utilities (CPU) and is physically adjacent to the CPU Wilkins Power Plant. The plant is electrically connected to the City of Clarksdale and to Entergy's transmission system via one 115-kV transmission line and one 230-kV transmission line. The transmission upgrades associated with the project included construction of a new 230/115-kV plant substation, construction of the Entergy Moon Lake 230-kV switching station, construction of a 23-mile 230-kV transmission line, and the upgrade of a ¾-mile 115-kV transmission line.

Burns & McDonnell was responsible for design of the 230/115-kV plant substation and the 230-kV switching station projects as well as design of the new 230-kV transmission line and the upgrade of the 115-kV transmission line. Design responsibilities included determination of equipment ratings, line conductor selection, conceptual design and planning, protective relay selection, field trips to the project sites, preparation of the scope of work, and coordination with equipment vendors and construction contractors. It was also necessary to coordinate with Aquila, CPU and Entergy design activities. Electrical drawings, civil/structural drawings, plan and profile drawings, structure loading diagrams, protective relaying drawings, equipment purchase specifications, construction specifications, protective relay settings and energization procedures were provided by Burns & McDonnell.

Burns & McDonnell furnished Owner's Engineer construction inspection services for the Moon Lake Switching Station and transmission line projects. A full time Engineer was on site to observe construction activity for the duration of these projects. The Crossroads Energy Center plant and substation project was a design-build project which Burns & McDonnell had responsibility for all Engineering, Procurement and Construction activities. Burns & McDonnell provided construction project management from the home office in Kansas City and on site project management to manage construction sub-contractors, manage testing sub-contractors and to coordinate with equipment and materials suppliers.

ALABAMA POWER

To improve reliability and operability of their 115-kV system, Alabama Power required an upgrade of their Fulton Springs Substation, located north of Birmingham, Alabama. Prior to the upgrade, the Fulton Springs arrangement consisted of manually-operated disconnect switches mounted on a lattice structure. The 115-kV portion of the station allowed pass-through of transmission lines that could be connected in a limited number of arrangements.

Due to limited flexibility of the existing system and ongoing transmission upgrade projects, the substation was required to maintain service throughout the construction period. Therefore, the new arrangement was constructed under energized transmission lines with no outages.

Burns & McDonnell teamed with a construction company as a joint venture partner for this project. Turnkey services were provided to

complete the project on time with an aggressive schedule. Burns & McDonnell procured all engineered equipment and the construction company provided commodity materials.

The new 115-kV equipment was in a breaker-and-a-half configuration with a 3000A main bus and four 2000A bays. The power circuit breakers had an interrupting rating of 63-kA and the bus and grounding systems were designed for 50-kA available fault current.

Spread footings were used and locations of piers for dead-end structures were located to allow excavation under energized lines. During the geotechnical investigation portion of design phase, solid sandstone was encountered within seven feet of the surface requiring five six-foot diameter 11-ft. deep rock sockets. Burns & McDonnell and the construction contractor subcontracted the rock drilling to an industry specialist.

Each of the seven existing transmission lines were modified for connection to the new switchyard. This work included the addition of new concrete poles and modification of existing concrete, wood, and steel structures. Burns & McDonnell worked closely with Alabama Power staff to coordinate outages for the transmission conversion from the existing structures to the new arrangement.

ALABAMA POWER

Alabama Power's West Vernon Switching Station was a joint venture EPC project between Burns & McDonnell and a construction contractor. The project consisted of a new 500-kV, 4-bay, breaker-and-half switchyard to handle the capacity from new generating facilities on a site that had al 60 foot vertical drop. This grade was not conducive to developing a switching station in an area already populated with existing transmission line structures. Before crewmembers leveled the grade, they removed a tower that supported an energized transmission line, allowing for new structures. To ensure that electrical service to customers remained uninterrupted, Burns & McDonnell designed a dead-end structure for this line. After the line was terminated on the structure, the tower was removed and the grade was leveled.

PACIFIC GAS & ELECTRIC (PG&E)

Burns & McDonnell recently designed a major addition to PG&E's 500-kV Tesla Substation. This project included the addition of 1200MVA of 500/230-kV transformer capacity, modifications to the existing 500-kV and 230-kV buses, extensive relaying changes, breaker additions, and electrical and physical design. The new system was energized in June 2001.

SEMPRA ENERGY-MESQUITE 500-kV SUBSTATION

Burns & McDonnell provided preliminary design and owner's engineering for a new 500-kV/230-kV substation for Sempra Energy's Mesquite Power Plant near Phoenix, AZ. The project tied the new power plant into the Hassayampa Switchyard. This project included a 230-kV collector bus, four 500MVA 500/230-kV transformers, 500-kV line terminal, protective relaying, and communications.

TENASKA – LAKEFIELD JUNCTION 345-kV SUBSTATION

Burns & McDonnell performed an EPC project for this 345-kV ring bus connection a new 600MW power plant to the Northern States Power 345-kV system in southern Minnesota. The project included complete engineering, procurement and construction services. The substation was energized December 2000.

SEI (MIRANT) – 345-kV ZEELAND SUBSTATION

Burns & McDonnell performed this EPC project for a new 345-kV, eight-breaker switchyard for a new 900MW power plant in southwest Michigan. The project included complete engineering, procurement, and construction services. This project was energized in 2001.

KNOXVILLE UTILITIES BOARD

The Construction of a new convention center and redevelopment of the Worlds Fair Park in Downtown Knoxville required the removal of an existing downtown network substation. Consequently, a new substation was needed to supply electricity to the downtown area. The location of the new substation presented unique challenges from both a technical and aesthetics standpoint. In addition, the construction of the new substation was on the critical path of the construction of the new convention center.

Due to the critical nature of the schedule, the Knoxville Utility Board and Knoxville Public Utility Board selected Burns & McDonnell to design and construct the substation in eight months.

BRAZOS ELECTRIC POWER COOPERATIVE

The Bosque Switch project was constructed to provide an interconnection point for a new generating facility. The project consisted of new 345-kV and 138-kV switchyards constructed in the vicinity of an existing 345/138-kV substation. An adjacent 345-kV transmission line was modified to loop through the new 345-kV transmission line was modified to loop through the new 345-kV switchyard. A new 138-kV transmission line was constructed to connect the new switchyard to the existing substation.

Unique design aspects included the following:
Provided for a "fast-track" construction schedule from preliminary design to energization in eight months.

Tapped a 345-kV transmission structure by converting it to a double deadend using isolating suspension insulators to electrically divide the existing line into two circuits.

Provided EPC services for the portions of the switchyards owned by the generation interconnecting company, including deadend structures, circuit breakers, and switches.

Coordinated phasing, grounding, raceway, backup station service, and relaying interfaces with the generating facility.

Burns & McDonnell was responsible for the design of a 138-kV transmission line. In its short half-mile, the line crosses another 138-kV line, a 69-kV line and a distribution line. Burns & McDonnell assisted the owner with right-of-way procurement, developed the plan and profile drawings, and provided guying and other miscellaneous details.

CINERGY (formerly PSI Energy and CG&E)

Burns & McDonnell designed over 38 substations for Cincinnati Gas & Electric and over 40 substation projects for PSI Energy. Design work included Civil/Structural, Electrical/Physical, and Relay Control drawings.

Burns & McDonnell provided engineering design for the new Hortonville 345/69-kV substation to be located under the existing IP & L 34504 line that extends from the Whitestown 345-kV substation to the Noblesville generating plant in Indiana. This line was split to form two lines, and each line ended in-line with a new 345-kV substation bus.

The 345-kV bus arrangement consists of a single main bus with breakers for each line segment for protection. Between the two 345-kV breakers, the main bus is tapped by the 345/69-kV 200 MVA power transformer. The low side of the substation is arranged in a ring bus configuration consisting of four 69-kV line terminals and one transformer position.

Burns & McDonnell has performed a significant amount of distribution substation design for Cinergy. One of seven recent distribution substations included the Greenwood-Averitt Rd substation. A 69/12-kV substation project with a 20 MVA transformer providing service to three distribution circuits through outdoor 15-kV breakers. The feeders were protected with relays mounted in the circuit breaker control cabinets. Cinergy's standard auto-sectionalizing scheme was used to establish the primary and secondary sources from the two 69-kV lines coming into the substation. Load-break switches were used to sectionalize the lines.

COLORADO RIVER COMMISSION OF NEVADA

Burns & McDonnell provided design and construction management services for the Colorado River Commission's Power Delivery Project. This Project was constructed to provide electrical power to pump water from Lake Mead to the Southern Nevada area. Since the water supply to the Las Vegas area is dependent on its Project, the facilities were designed with redundant systems to provide a high degree of reliability. The Project included two 230/69-kV substations, four 69/4.16-kV substations, underground 69-kV transmission lines, overhead 69-kV and 230-kV transmission lines, a fiber optic and microwave communication system and a PLC-based SCADA system.

The first 230/69-kV substation included a four-position 230-kV ring bus, two 180/240/300MVA transformers, and an eight-position 69-kV breaker -and-a-half bus. The second 230/69-kV substation included a four-position 230-kV ring bus, two 120/160/200MVA transformers, and a six-position 69-kV ring bus. Each of the four 69/4.16-kV substations included redundant single terminal buses. Two 69-kV breakers and two 12/16/20MVA transformers were located in each substation.

NEVADA POWER COMPANY

The Pecos substation expansion consisted of adding a new 400-MVA 230/138-kV autotransformer, twelve 230-kV power circuit breaker, one 138-kV capacitor bank, and supporting equipment. This expansion added a fourth transformer, a third capacitor bank and five new 230-kV bays to an existing 230/138-kV transmission substation.

Burns & McDonnell provided design services including civil, structural, and electrical design. This included preparation of bill of materials and incorporating manufacturers drawings into the plans.

The Harry Allen substation expansion extended two 230-kV buses with the addition of five transmission bays. The additional equipment included fifteen power circuit breakers, five 48MVAR capacitor banks, supporting equipment and a second control building to house the 230-kV relay/communication equipment.

ARCHER DANIELS MIDLAND COMPANY

Archer Daniels' new process facility required an electrical supply with outages limited to 10 minutes under any contingency condition. Burns & McDonnell provided complete detailed design of a 34.5-kV process substation and conceptual design of a new 138-kV/34.5-kV utility substation.

The new facility included 4000 hp motors. Burns & McDonnell provided electrical system studies including short circuit, load flow, harmonic analysis and relay coordination studies.

A. E. STALEY MANUFACTURING COMPANY

By rebuilding an existing 50-year-old 50,000 kVA, 34.5-kV substation, Burns & McDonnell improved the reliability of the plant's primary power distribution system. Burns & McDonnell provided complete design services from the initial studies to final start-up of the new substation. Space limitations required the new substation to be built around the original substation while it remained energized. All the distribution circuits were transferred to the new equipment in a single 60-hour plant shutdown.

KOCH REFINING COMPANY

Burns & McDonnell design responsibilities for this project included expansion of one 69-kV substation and relocation of a third substation in conjunction with a major refinery expansion.

Burns & McDonnell's design included the complete replacement of a conventional air insulated 69-kV substation with a new gas insulated substation (GIS) due to space limitations. The new GIS consisted of six breaker ring bus with connections to 69-kV oil filled cable and multiple transformers. Several lineups of 1000 MVA, 15-kV metalclad switchgear lineups were added to replace an existing outdoor 12.47-kV substation. The new switchgear and GIS equipment are housed in a blast-proof two-story building. Total substation capacity is 125,000 kVA.

A second 138-kV/69-kV substation was expanded to include two additional 50 MVA transformers, expansion of the existing 138-kV bus to a ring bus arrangement and two lineups of 750 MVA, 15-kV switchgear. The 15-kV circuits were housed in an elevated equipment building.

A third substation located in the center of the refinery was relocated to reclaim the space for a future process expansion. New switchgear and transformers will be installed at a different location on the perimeter of the refinery. Existing 15-kV circuits are being extended to the new substation location through cable tray installed on existing piperacks.

The new substations include state-of-the-art protection, control and monitoring. Substation automation consists of microprocessor based relays and meters that communicated with a central network to report data and transmit alarms to key locations.

Over 100 15-kV circuits were redesigned and installed in cable tray installed on existing piperacks and under ground ductbanks. Total 15-kV circuit length was over 30,000 ft. The underground duct banks included hand-holes and man-holes located underneath the existing roadway systems within the facility.

TENNESSEE VALLEY AUTHORITY

The Alpha 230/115-kV Substation is located near Dalton in Murray County, Georgia. This project involved design and construction with Burns & McDonnell being the lead partner in a joint venture formed with a construction contractor. The substation design was based on TVA standards. Drawings were prepared according to TVA detailing standards and drawing set requirements. The Alpha 230/115-kV substation consists of an 8-bay 115-kV main and transfer bus, two 115-kV, 36 MVAR capacitor banks, one 230/115-26-kV, 200 MVA

autotransformer and a three-position 230-kV ring bus. Also included as part of this substation were a prefabricated substation control building complete with all relaying, control, supervisory and communication equipment, a warehouse/maintenance building, an oil containment system and portable water/sanitary systems. With the exception of the power circuit breakers and the power transformer, which were furnished by TVA, all equipment, structures and materials were furnished and installed by the joint venture.

POTOMAC ELECTRIC POWER COMPANY

Phase I of the project consisted of replacing eighty-two 13-kV single phase oil breakers in concrete cells with new Siemens three phase SF6 circuit breakers. Phase II of the project consisted of upgrading and replacing the relaying and controls for the eighty-two 13-kV circuit breakers, thirteen 33/13-kV transformers and three 66/13-kV transformers. A new raceway system was designed for the control circuits between the transformers and the control room. New relay panels, using microprocessor relays were added to the existing control room. Phase III of the project involved replacing thirteen 33/13.2-kV transformers, foundations, portions of the existing transformer bus and adding a new annunciator for eighty-two 13-kV circuits.