



# Transmission Department

## INTRODUCTION

Burns & McDonnell offers clients a long and impressive history of delivering responsive, high-quality transmission line 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.

## TRANSMISSION SERVICES FOR YOUR COMPANY

Burns & McDonnell performs engineering services for dozens of clients on a wide variety of overhead and underground transmission related projects. Our project management, design, and construction management experience ranges from 69-kV through 500-kV on simple structure relocation projects to large, complex international projects. Project scopes vary widely and require Burns & McDonnell engineers to understand overhead and underground transmission line design from the earliest siting and public involvement through the final phases of line construction and energized testing.

Our years of experience include every type of wood, steel and concrete structure design, solid dielectric and HPFF underground design, lightning analysis to improve system reliability, conductor selection studies, turnkey construction, and structure spotting methods that balance cost with customer sensitivity and the environment. Burns & McDonnell’s creative, team-oriented approach to design enables our engineers to meet project challenges and exceed your company expectations.

In addition, Burns & McDonnell engineers perform transmission upgrade and feasibility studies, power delivery asset evaluation studies and system operational policy studies. Burns & McDonnell has successfully applied our proven project approach for governments, investor owned utilities, municipals, and cooperatives from remote deserts and mountains to crowded urban streets.

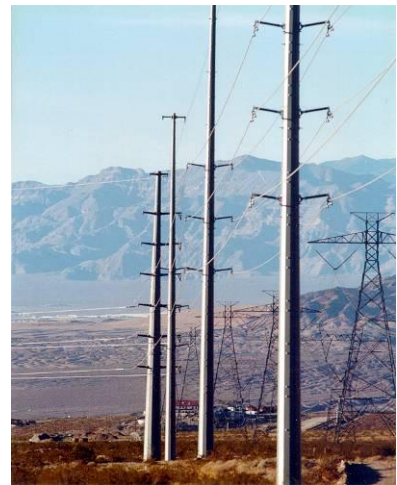


---

Each Burns & McDonnell designer has transmission line construction experience. Each senior engineer strives to develop special expertise in several areas of transmission design and many times is involved in IEEE or ASCE working groups or committees as a participant, presenter, or committee chairman. This valuable field, design, and industry experience enables the Burns & McDonnell project team to transform state-of-the-art design concepts into practical field solutions meeting the challenges of the project and saving your company time and money.

## STATE-OF-THE ART DESIGN TOOLS

Burns & McDonnell has broad experience with a wide variety of computer programs, design procedures and standard details that provides your company with high-quality, cost-effective engineering services. Burns & McDonnell engineers use and have written several specialized software applications for transmission line design and project management. Design programs calculate complex structural or electrical relationships to determine galloping ellipses, sag and tension (SAG10), structure spotting (PLSCADD), foundation and structural loads, anchor design, wood pole and lattice tower analysis, insulator swing, EMF, corona, audible noise, line losses and more. For EPRI members, Burns & McDonnell engineers can use TL Workstation. Project management software includes Suretrack, Primavera and MS Project.



## SPECIFICATIONS AND STANDARDS

Burns & McDonnell has a complete set of transmission specifications for procuring materials and for constructing transmission lines. The specifications have proven successful on many projects but remain flexible and are adaptable to the needs and special circumstances of your company. Specifications address general requirements, right-of-way, foundations, structures, grounding, insulators and hardware, conductors, OHGW/OPGW, and signage.



---

## RECENT 500-KV OVERHEAD PROJECTS

### **SOUTHERN CALIFORNIA EDISON Segments 1-3**

As one of the largest electric utilities companies in the nation, Southern California Edison (SCE) serves more than 13 million customers in their region of operation. SCE is dedicated to pursuing increased usage of renewable energy sources to reduce our nation's dependence on fossil fuels. Toward that end, SCE is pursuing transmission from wind farms under construction in the Kern and Los Angeles Counties to their customers.



In order to increase transmission of renewable energy to their customers, SCE requires the completion of a project known as the Tehachapi Renewable Transmission Project (TRTP). TRTP involves 11 segments with construction completion phased through 2013. Currently, Burns & McDonnell is assigned project oversight for the first three segments totaling approximately 87 miles of 220-kV and 500-kV transmission line. This will bring consumers power from wind farms in Kern and Los Angeles counties. This project is a demonstration of SCE's dedication to providing renewable sources of energy to its customers. Along with the 87 miles of transmission line, TRTP Segment 1, 2, and 3 requires the modification of three SCE existing substations as well as construction of two new ones.

Management of the project is being done from Burns & McDonnell's San Diego regional office with support from a project office located in Ontario, California. This provides management from people who are familiar with local California construction and environmental regulations, promising smooth implementation of the major project.

### **SOUTHERN CALIFORNIA EDISON Segments 4-11**

As one of the largest electric utilities companies in the nation, Southern California Edison (SCE) serves more than 13 million customers in their region of operation. SCE is dedicated to pursuing increased usage of renewable energy sources to reduce our nation's dependence on fossil fuels. Toward that end, SCE is pursuing transmission resources to connect their customers in southern California to planned wind farms in Kern County. The construction of Segments 4-11 of the Tehachapi Renewable Transmission Project (TRTP) will provide the transmission resources to deliver up to 4500 Megawatts of wind energy to SCE customers.



---

Burns & McDonnell is providing the engineering, permitting, and construction support for the construction of new and upgraded transmission infrastructure along approximately 173 miles of new and existing ROW's from the Tehachapi Wind Resource Area (TWRA) in southern Kern County, south through Los Angeles County and the Angeles National Forest and east to the existing Mira Loma Substation in Ontario, Calif. The scope of the project includes engineering oversight (transmission line, substation, telecomm, geotechnical), construction planning, construction bid phase services, material management, permitting and environmental support, project controls (scheduling, cost, document, reporting), contract administration, safety monitoring, GIS mapping, construction management and construction Quality Assurance/Quality Control.

Management of the project is being done from Burns & McDonnell's San Diego regional office with support from a project office located in Ontario, California. This provides management from people who are familiar with local California construction and environmental regulations, promising smooth implementation of the major project.

### **TRI-STATE GENERATION & TRANSMISSION ASSOCIATION**

The Eastern Plains Transmission Project, a proposed joint construction project between Tri-State and the Western Area Power Administration, included approximately 1,000 miles of new 230 and 500-kV transmission lines and ten (10) new and upgraded substations. This major transmission project was to expand into western Kansas and eastern and southern Colorado.



Tri-State Generation and Transmission Association is a wholesale electric power supplier owned by the 44 electric cooperatives that it serves. Tri-State generates and transmits electricity to its member systems throughout a 250,000 square-mile service territory across Colorado, Nebraska, New Mexico and Wyoming. It serves more than 1 million consumers.

Tri-State determined the project was needed to provide additional transmission system capacity to deliver more economical, reliable, diverse and flexible power to the public.

Burns & McDonnell was contracted by Westminster, Colo.-based Tri-State Generation and Transmission Association to act as Owner's Engineer.

This project would be Tri-State's first 500-kV system. As Owner's Engineer, Burns & McDonnell was to prepare bid documents and would manage design and construction activities for several large EPC contracts for several greenfield substations and a DC converter station. Burns & McDonnell lead in the development of design criteria and numerous vendor interviews in order to establish a procurement strategy for the 500-kV system.

This project is currently on hold while Tri-State develops alternative sources of generation.

### **M&A ELECTRIC POWER COOPERATIVE**

On April 2, 2006, spring storms ripped through southern Missouri and northern Arkansas. A tornado demolished nine 500-kV lattice steel structures on the M&A New Madrid – Blytheville transmission line. A long-time client, M&A called on Burns & McDonnell to help with rebuilding the line Burns & McDonnell originally designed in 1979.

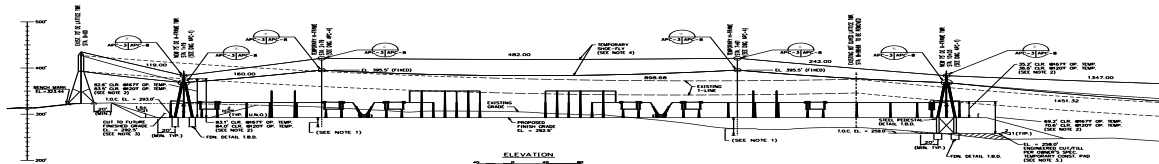
Burns & McDonnell is preparing the lattice tower specifications, material quantities, and construction specifications and drawings. To aid in this project, Burns & McDonnell was able to retrieve microfilm of the original design and shop drawings, including the steel fabrication drawings. In addition, four staff members who worked on the original design still work for Burns & McDonnell.

During construction, Burns & McDonnell will be on-site for construction observation.



### **ALABAMA POWER**

Burns & McDonnell provided engineering, procurement and construction services for Alabama Power's 500-kV transmission line re-route and substation take-off structures. Burns & McDonnell utilized PLS-CADD to model transmission line configurations for existing, temporary and ultimate grading plans to allow for the construction of Alabama Power's West Vernon Substation under an energized 500-kV transmission line.



---

## RECENT 345-KV OVERHEAD PROJECTS

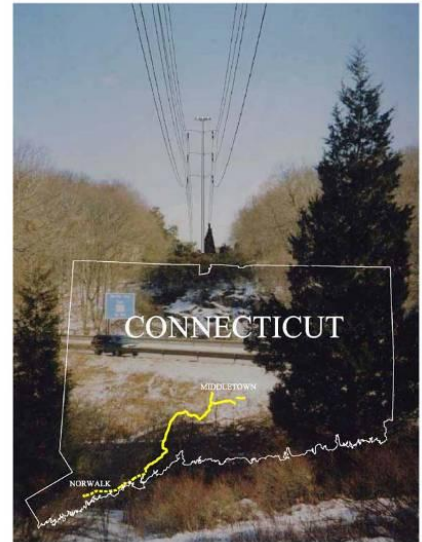
### NORTHEAST UTILITIES SYSTEM

Burns & McDonnell is providing Program Management of the Middletown/Norwalk Bulk Transmission Project, a \$1 Billion project. The current energization date for the project is targeted for December 2008 and the Program Management should be completed during the 4<sup>th</sup> quarter of 2009.

The project includes nearly 70 miles of new 345-kV transmission line of which 24 miles will be solid dielectric underground cable. Middletown/Norwalk is the largest transmission capital project in the country and the first application of program management in the power delivery industry.

Program management provides for all an owner's project delivery needs related to a large and complex effort involving the construction of multiple facilities over a several year period. The program manager is an agent of the owner and serves as a single point of management for the entire process of completing the project(s). The program manager provides detailed managerial support and added technical value to the owner and is normally involved in the earliest stages of a project. They offer current planning methodologies, public involvement and testimony capabilities, design expertise, knowledge of construction methods and pricing, an understanding of competitive market conditions, and effective scheduling and cost control systems. Program management is successful when the project's planning, permitting, design and construction phases are effectively integrated into a single process.

For the past three years, Burns & McDonnell has worked on the preliminary phases of the Middletown/Norwalk project and, together with NUSCO staff, successfully obtained a unanimous decision in favor of the project application by the Connecticut Siting Council. Burns & McDonnell has opened a Connecticut office that will provide immediate local access to some of the critical human resources needed to be successful on an effort of this magnitude. In addition, Burns & McDonnell's Kansas City office will provide technical expertise and executive support.



---

## VERMONT ELECTRIC POWER COMPANY

Burns & McDonnell provided design and procurement services for several 345-kV, 115-kV, and 46-kV substations and transmission lines as part of VELCO's Northern and Northwest Reliability Projects, scheduled to be completed in 2007.

Burns & McDonnell was retained by Vermont Electric Power Company, Inc. (VELCO) to assist in the preparation of an application to the Public Service Board (PSB) for a Certificate of Public Good to construct a new 48/115-kV double circuit transmission line. The 6.5-mile project extends between the existing Irasburg Substation in Irasburg, VT to the existing 48-kV tap in Newport, VT. Burns & McDonnell also provided the final design, procurement and construction management for the approved project.

The project included the preparation of right-of-way clearing plans, erosion prevention and sediment control plans, structure framing plans, assembly drawings, preparation of technical specification and bidding documents, cost opinions, bidding phase services for materials and contractors, and the procurement of materials.

The line consists of single wood poles framed with braced post polymer insulators with 1272 kcmil ACSR (Bittern) conductors for the 115-kV line and 556.5 kcmil ACSR (Dove) for the 48-kV line. One optical ground wire (OPGW) with 72 single mode fibers was installed in the overhead ground wire location of the double circuit line.

The centerline of the proposed double-circuit was off-set 5 feet to the east of the centerline of an existing 48-kV line. The existing line remained in service during a portion of the new line construction. The installation of a three-phase 12 kV distribution circuit underneath the transmission circuits was constructed for 3.88 miles of the project. The distribution consisted of three 336.4 kcmil ACSR (Linnett) conductors framed with porcelain post insulators mounted on wood cross arms plus one 336.4 kcmil ACSR (Linnett) neutral conductor. Also included in the project was the installation of approximately ½ mile of single-phase 12-kV distribution with neutral using 336.4 kcmil ACSR (Linnett) conductor.

The project also included modifications to the existing 115-kV and 48-kV mainlines at Mosher's Tap to accommodate the new tap lines and the installation of three line isolating switches for both the 115-kV and 48-kV tap line arrangements. Removals included 6.48 miles



---

of 48-kV single wood pole line comprised of 556.5 kcmil ACSR framed on porcelain post insulators mounted on wood arms; and 3.88 miles of three phase 12-kV distribution under build also mounted on wood cross arms.

### **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 Transmission project consisted of the design of approximately 35 miles of 345-kV double-circuit transmission line, with one circuit initially installed. The line was designed using tapered tubular steel poles with direct embedded foundations to carry a double horizontal bundle of 1590 kcmil “LAPWING” conductor in a v-string configuration with two No. 8 alumoweld overhead ground wires.

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, ground and aerial surveys, 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 is performing in accordance with the plans and specifications. Construction was completed in June 2002.

### **LOWER COLORADO RIVER AUTHORITY (LCRA)**

Rebuilding 25 miles of existing, double-circuit 138-kV transmission line for operation as a double-circuit 345/138-kV transmission line from LCRA’s Kendall Substation to the Bexar County line to interconnect with a 345-kV transmission line being constructed by San Antonio’s City Public Service Board (CPSB). The finished circuit will be approximately 45 miles in length and extend from LCRA’s Kendall Substation to CPSB’s Cagnon Road Substation. CPS permitted, designed, and constructed the line from the Kendall/Bexar County line to the CPS Cagnon Road substation.

The line will be operated as a double-circuit, 345/138-kV electric transmission line capable of being upgraded to a double-circuit, 345-kV transmission line supporting 6x2-1590 kcmil 54/19 ACSR “Falcon” conductors with one (1) 3/8" 7-strand extra high-strength steel shield wire and one (1) optical ground wire. The 345-kV circuit



---

will be rated for operation at 2690 amperes, yielding a nominal 1600 megavolt-amperes (MVA). The 138-kV transmission line will be rated for operation at 920 amperes, yielding a nominal 220 mega-Volt-amperes (MVA) capacity.

Burns & McDonnell performed the following services for the described project:

- \* Develop loading criteria and structure framing drawings to include hardware assemblies for each segment of line as previously described. Self-supported steel poles will be used throughout this project
- \* Model existing line in PLS-CADD to best determine existing easements, distribution underbuild limitations, and establishment of existing centerline
- \* Design newly proposed line in PLS-CADD
- \* Complete Construction Package Including:  
Plan and Profile Drawings, Sag & Tension Charts, Phasing Diagrams, Structure Framing Drawings, Hardware/Assembly Drawings
- \* Model of steel/concrete poles using PLS-Pole (latest version) upon receipt of details from pole supplier
- \* Preparation of bid documents for steel/concrete poles, conductor/shield wire, insulators, and hardware
- \* Preparation of required permits
- \* Develop Construction Bid Specification
- \* Construction Support
- \* R.F.I. & T.V.I. Study



### **AMERICAN TRANSMISSION COMPANY**

Burns & McDonnell provided engineering services for ATC's 345-kV Switchyard Transmission Line Deadends, and Thermal Upgrade Project.

Burns & McDonnell performed PLS-Cadd clearance analysis of approximately 58 miles of the L111 345kV circuit from the new ICO34 Sheboygan Peaking Plant switchyard to Granville substation, based upon a Lidar survey and post processing by others.

Two new 345-kV full-tension structures were required to break the Point Beach – Granville 345-kV line and connect to the incoming dead end structures constructed within the switchyard. One of the existing double-circuit lattice towers was used to support the adjacent 138-kV circuit as it bypassed the switchyard drop structures. Burns & McDonnell utilized structure drawings from a recent ATC project



---

with similar full-tension steel pole deadend structures. Structure loading and clearances were reviewed. A subsurface investigation specification based on the ATC standard documents was prepared. Burns & McDonnell used the investigation to perform drilled-shaft foundation design for the new tubular structures.

The purpose of the line upgrades was to meet the transmission service request for the Sheboygan Peaking Plant IC034. The section of line L111 from the location of the switchyard south of State Highway 23 south to Granville substation required an uprating to 167 degrees Fahrenheit in order to meet the transmission service request for IC034. The existing conductor is 2156 kcmil ACSR with 84/19 stranding and has two (2) 7/16" EHS steel 7-strand overhead shield wires.

### **AMERICAN TRANSMISSION COMPANY**

Burns & McDonnell provided engineering services for ATC's Central Wisconsin to Weston and Morgan to Werner West 345kV Line Siting and Preliminary Engineering project.

Burns & McDonnell provided preliminary design for the new Central Wisconsin to Weston 345-kV Transmission Line and the Morgan to Werner West 345-kV Transmission Line, for submittal as part the Certificate of Public Convenience and Necessity (CPCN) from the Public Service Commission of Wisconsin (PSCW).

Preliminary design included determination of typical tangent structure requirements for the various transmission line routes evaluated, and also included analysis of electrical clearances and EMF computations for families of tangent structures to be considered. Cost estimates were prepared by performing detailed structure spotting along all routes evaluated using USGS terrain modeling data and aerial photography. The routes evaluated consisted of combinations of 345-kV single-circuit configurations along new right-of-way and 345-kV double-circuit configurations along existing right-of-way. Detailed drawings were produced to show ingress and egress at the existing substations and alternative locations, including three potential Central Wisconsin substation sites.

Burns & McDonnell prepared documents to establish applicable design criteria prior to commencing with line and structure design, including electrical clearance requirements, conductor size and wire stringing limits, OHGW/OPGW sizes and stringing limits, shielding design criteria and applicable structure loading cases.



---

## MIDAMERICAN ENERGY COMPANY

Burns & McDonnell provided engineering services for MEC's Council Bluffs Energy Center – Grimes 345-kV Transmission Project.

Burns & McDonnell is MEC's Owner's Engineer for this EPC project. The project involves design and construction of 124 miles of double-circuit 345-kV line on tubular steel structures.

Burns & McDonnell performed several studies and design tasks in support of MEC's design of the CBEC – Grimes 345-kV Transmission Project. These tasks include:

- Calculations, plots, and discussion of electric and magnetic field strength, predicted radio and TV interference levels, and audible noise for the transmission line
- Review of the electrical characteristics of the Council Bluffs Energy Center to Grimes 345-kV line and recommend the number and general location of the wire transpositions
- Provide a recommendation of the lightning protection design and resistance value, grounding details, and testing procedures
- Provide a recommendation concerning the conductor bundling orientation, including calculation of magnetic attraction of the sub-conductors and construction methods which should also be considered
- Review and expand on MEC specifications for steel poles, conductor, OPGW, OHGW, insulator, transmission line hardware, and transmission line construction
- Design the foundations and provide construction drawings and specifications for the foundation installation
- Provide contract administration and shop drawing review for the materials specifications



## CENTERPOINT ENERGY

Burns & McDonnell completed one of the nation's largest transmission system survey and modeling projects. Centerpoint Energy retained Burns & McDonnell to model over 3200 miles of their 69 through 345-kV transmission system. The lines, representing approximately one-third of their total system, were selected for upgrading to accommodate new power generation projects. Centerpoint hired an aerial laser imaging firm for survey data collection and processing. Aerial surveying is significantly cheaper and faster than traditional ground-based surveys. The survey is being accomplished with both helicopters and fixed-wing aircraft with limited supplementary ground surveying. Helicopters, flying parallel



---

to the transmission line, collect data from a laser that scans perpendicular to the flight line. The laser signal returns and is encoded with GPS coordinate data. The fixed wing aircraft provide aerial photography, including video, of the transmission corridor. The laser data is then filtered and classified as conductor, structure, ground and obstacle data. The filtered data, along with supplemental ground survey data, is then used by Burns & McDonnell engineers to create a three-dimensional model of the line in PLS-CADD, a transmission line modeling and engineering software package. The complete model is then analyzed at the new increased load. The line is then checked for interference or other problems at the increased load.

### **TXU ELECTRIC DELIVERY (FORMERLY ONCOR ELECTRIC DELIVERY)**

Burns & McDonnell transmission line engineers have done extensive work for TXU Electric Delivery including such projects as green field 345-kV lines, rebuilding 138-kV lines, reconductoring 138-kV lines, and various 138-kV relocations. The 25-mile Anna Switch to Farmersville 345-kV line, an ERCOT driven project supporting the growing Dallas/Fort Worth metro-plex, was designed by Burns & McDonnell as a quadruple circuit line to be installed in phases beginning with a single circuit. By structurally analyzing and proposing modifications to a 6.5 mile section of lattice towers in this project, Burns & McDonnell was able to work with TXU Electric Delivery engineers and grid management to develop creative ideas to string or rebuild this 6.5 mile stretch of line during the summer of 2001 in order to expedite the project and minimize the number of outages. The remaining 18.5 miles of the project was granted a Certificate of Convenience and Necessity (CCN), constructed using hybrid steel/concrete poles, and energized in June 2002.



Burns & McDonnell has been heavily involved in helping TXU Electric Delivery rebuild and improve upon its 138-kV transmission grid. This work has typically consisted of projects that require detailed engineering, scheduling, estimating, material procurement, construction support, and environmental studies. A few of the projects Burns & McDonnell has recently completed or is currently working on are the Round Rock – Round Rock South 138-kV and Round Rock – Round Rock Westinghouse 138-kV reconductor jobs, both of which are located in an environmentally sensitive aquifer zone. These two projects required the Burns & McDonnell and TXU Electric Delivery environmental departments to team up with our transmission line engineers to ensure due diligence. Other

---

projects include the Primrose – Wedgwood 138-kV and Handley – Everman 138-kV double circuit transmission lines that were designed to be rebuilt with new structures and new conductor on existing right-of-way. The Paris – Commerce 69-kV/138-kV project is a good example of how we are helping TXU Electric Delivery improve its grid reliability by designing a new double circuit transmission line for both voltages. Additionally, the Whitney – Walnut Springs 138-kV and Seldon – Walnut Springs 138-kV single-circuit transmission lines were designed and constructed in existing right-of-way that contained sensitive bird habitat. This existing habitat was judicially monitored throughout construction by on-site Burns & McDonnell environmental inspectors who followed state regulations required to minimize disturbance. The Allen Switching Station – McKinney Substation 138-kV double-circuit transmission line, in the heart of the booming north-south corridor North of Dallas, is being constructed to supply current and future energy demands as this busy metro-plex continues to expand.

Burns & McDonnell is currently in various stages of designing and supporting approximately twenty 138-kV transmission line projects for TXU Electric Delivery.

To date, Burns & McDonnell has engineered over 230 miles of 138-kV transmission line for TXU Electric Delivery that has been constructed and placed in-service.

### **CENTERPOINT ENERGY**

Burns & McDonnell engineered, procured and constructed the 2500 ft. 345-kV plant tie circuit to connect the new channel Energy Center Generation Plant with the Deepwater Substation, located in Pasadena, Texas.

This tie circuit crossed a very congested industrial area and set the stage for a complex and highly schedule-sensitive project. Burns & McDonnell chose to use self-supporting steel poles throughout the transmission line due to the relatively small footprint area allowed inside the refinery. The poles ranged from 186 feet to 214 feet in height with the largest pole requiring an FAA approved aircraft warning light. Due to the loading of this pole, an unconventionally large drilled shaft was required for the foundation that resulted in dimensions of 16 feet in diameter and 62 feet below grade. The design of the foundation was accomplished with a special built continuous reinforcement cage that was placed in the shaft by three cranes. The reinforcement cages built for the three other foundations



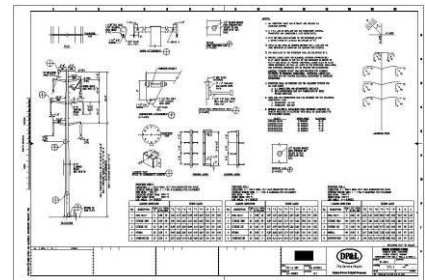
---

included custom built stiffener rings placed throughout the cage and mechanically connected to the longitudinal steel. This dramatically increased the ease in which these large cages could be lifted and placed within the drilled shafts. The combination of unique tubular steel poles and customized drilled shaft foundations provided a great solution to daunting restrictions. These giant structures allowed the line to span over petroleum tanks, refinery equipment, multiple elevated pipe racks, and an existing 138-kV transmission line among other obstacles.

Coordinating with three different entities: Centerpoint, Calpine and Citgo-Lyondell-Citgo refinery, Burns & McDonnell was charged with constant communication between all parties to meet one goal. Burns & McDonnell met sensitive schedules, produced designs and construction methods without impacting the day-to-day operations of the new Energy Center and refinery.

### **DAYTON POWER & LIGHT**

Burns & McDonnell designed approximately 40 miles of new double circuit 345-kV steel pole transmission line carrying bundled ACAR conductors for this investor-owned utility client in the upper Midwest. The new transmission line occupied existing transmission line right-of-way corridors that range from 150 to 300 feet in width that contained a 30-year-old single and double circuit 345-kV lattice towers. The project scope included preparation for siting hearings and permits, geotechnical field testing and analysis, inspection of condition of existing towers and conductors, micro-environmental analysis of the corridor to identify the probabilities of extraordinary loading cases, line design using PLSCADD, structural design of single, double and triple circuit tubular steel structures, drilled pier foundation design, development of stock and non-stock material and construction specifications, compilation of a complete materials list for the project, lightning analysis using historical lightning data for the corridor, and analysis of EMF, RFI and TVI.



### **KANSAS CITY POWER & LIGHT**

This project consisted of relocating approximately 3000 feet of a KCP&L 345-kV transmission line in Lenexa, Kansas that traversed the signature hole of the Falcon Ridge Golf Course. The existing line was relocated around the perimeter of the golf course to facilitate up-scale residential development in the area. The existing line consisted of two pole wood H-Frame structures and a three pole guyed wood angle structure. Preliminary engineering was performed to develop several options for the preferred centerline and structure



configuration. These options were used for meetings with the developer to determine his preferences. Discussions were held with adjacent property owners to address their concerns about the reroute. The design balanced the aesthetic preferences of the golf course with the practical considerations for the transmission line design. Tubular steel poles were used to minimize the impact of the golf course. The final design utilized KCP& L's design criteria and their standard hardware. The foundations were constructed and structures erected without an outage on the 345-kV line. A short outage was required to string the conductor and cut in the deadends.



---

## RECENT 230-KV TRANSMISSION LINE PROJECTS

### SILICON VALLEY POWER

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 consists 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. Upgrades to two other substations are also included in the EPC project. The project increased capacity in San Jose and Santa Clara, California.

Burns & McDonnell has teamed with a construction contractor as a joint venture partner for this project. The construction contractor will perform all construction to the substations plus overhead and underground transmission line installation. The project will be managed from Burns & McDonnell's Kansas City office with environmental and permitting support from the San Francisco office. Technical support will also be provided by Essex Environmental and Lowney and Associates. Construction began late 2003 and was completed by April 2005.



### SAN DIEGO GAS & ELECTRIC

SDG&E upgraded approximately 35 miles of a 69/138-kV transmission line from Miguel Substation to Mission Substation in San Diego County. This is the first stage of the SDG&E's 230kV-MM#2 master project. The existing 69/138-kV circuits will be relocated onto a new steel pole line while the existing lattice towers will be modified to support a new 230-kV circuit. Both lines will be located in the existing SDG&E right-of-way ranging from 150-ft. to 250-ft. in width. Existing 230-kV and various 69-kV lines are also located within this right-of-way. Along the varied sections of the alignment, new 69/138-kV poles will be constructed on the west side, between tower lines, and to the south edge of the corridor. The line consists of three primary segments: Miguel Substation to Los Coches Substation, Los Coches Substation to Fanita Junction and Fanita Junction to Mission Substation.

Burns & McDonnell's responsibilities include coordinating surveying tasks and reviewing the deliverables of airborne LiDAR data. Providing preliminary engineering services for the upgrade of the existing 69/138-kV lattice tower line and the design of the new 69/138-kV pole line. Due to the limited distance between the 230-kV



---

circuits (both the existing and the proposed upgrade) and the new 69/138-kV line, an extensive review of clearances under blowout conditions were completed. Burns & McDonnell also provided project support by preparing construction bid packages.

### **PACIFIC GAS & ELECTRIC**

Burns & McDonnell was responsible for reconductoring of approximately 30 circuit miles of 230-kV transmission lines in the Bay Area. Burns & McDonnell performed design and quality control tasks for PLS-CADD modeling, plan & profile drawings, material lists, structure modifications, and development of structure data sheets. Work required coordination with PG&E staff and site visits.

### **JACKSONVILLE ELECTRIC AUTHORITY**

Burns & McDonnell provided transmission line design on Phase I of III of the Northside-Normandy 240-kV Transmission Line Structure Replacement Project, and provided procurement of materials. Burns & McDonnell was responsible for determining the scope, schedule and budget for two alternative designs; for final scope including the loading and assembly drawings for the family of tubular steel structures required to replace 195 double steel pole, double circuit 240-kV structures in three phases over a three year period; for obtaining LiDAR survey of the 28 miles of existing transmission line, for modeling the modified structures in the line; and for managing the inquiry for fabricating steel and for the purchase of the steel as fabricated.

### **IMPERIAL IRRIGATION DISTRICT**

Burns & McDonnell was responsible for structural modifications to an existing 230-kV steel pole transmission line. Responsibilities included developing the concept, structure loading trees, drawings, and specifications for conversion of 41 steel pole structures to h-frames.

Burns & McDonnell has completed several projects for the Imperial Irrigation District since 1988 to include the Coachella to Highline 230-kV transmission line (85 miles of lattice and tubular steel structures), the Midway 92-kV transmission line (eleven miles of wood poles), the “L” Line Extension (eleven miles of steel poles), and the Colmac 92-kV transmission line (7 miles of wood and steel poles).



---

### **SAN DIEGO GAS & ELECTRIC**

Burns & McDonnell was responsible for reconductoring, with ACSS conductor, approximately 10 miles of a 230-kV transmission line in San Diego. Responsibilities included developing new PLS-CADD models and plan & profile drawings, quality control, thermal ratings studies for the new conductor, and coordination with SDG&E staff.



### **SOUTH CAROLINA ELECTRIC & GAS COMPANY**

Burns & McDonnell was responsible for the design of approximately 7 miles of 115-kV and 3 miles of 230-kV transmission line for the South Carolina Electric & Gas Company. The project is located along the Congaree River in Columbia, South Carolina, and generally follows existing SCE&G right-of-way.



The 115-kV line connects existing Edenwood Substation with a new 115/230-kV switchyard built on the grounds of a nearby manufacturing plant, Carolina Eastman Company. The switchyard is part of the new Columbia Energy Center (a combustion turbine plant) constructed at Carolina Eastman to support plant operations and provide surplus electricity for sale.

The 230-kV transmission line starts at an existing SCE&G line approximately three miles east of the new switchyard. It runs westward to the plant crossing the Congaree River. It enters the switchyard, then exits with a second line parallel and 40 feet from the first, then runs back to the existing 230-kV line.

### **PUGET SOUND ENERGY**

Burns & McDonnell designed the 1992 upgrade of the 29-mile Cle Elum to Hyak wood pole line from 115-kV operation to 230-kV operation. In 1997, Burns & McDonnell performed a grounding study for the recently upgraded Sedro Woolley Sammamish 230/115-kV right-of-way. Project included field measurement and analysis of electric field and induced currents on and near the transmission right-of-way.





*Diagram 2 – 230-kV  
Overhead  
Transmission Line  
Project Locations*

## RECENT 161-KV TO 69-KV TRANSMISSION LINE PROJECTS

### CITY OF HOMESTEAD

Burns & McDonnell completed the design of two new substations, a substation upgrade and four transmission lines for the City of Homestead in Homestead, Florida. Redland, Renaissance, Lucy and the four transmission lines energized in the Spring of 2006.

Burns & McDonnell designed approximately 7.5 miles of single circuit, 138-kV transmission line for connecting each of the substations stated above, as well as for interconnections with FP&L. The project involved the complete design of the transmission lines, assisting the City with procurement specifications and construction management of the transmission lines.



---

## **SOUTH TEXAS ELECTRIC COOPERATIVE**

Burns & McDonnell provided professional engineering and design services to STEC for the San Miguel – Pawnee 138-kV Transmission Line Reroute.

This line is to be on tubular steel poles and constructed on the right-of-way adjacent to the existing 345-kV transmission line. The project generally consists of the design of approximately 10 miles of 138-kV single-circuit transmission line.

Burns & McDonnell’s responsibilities included coordination of all subcontract services related to the plan-profile design, structure and conductor support designs, and other subcontract services directly related to the complete design of the project. Detailed design for the transmission line include developing a family of structures required for the transmission line, preparing configuration and loading diagrams for each structure type, for use in purchasing structures, creating PLSPOLE models of the structure designs provided by the steel supplier, preparing design criteria data, conductor data, structure criteria, and wire clearance requirements for creating the plan/profile drawings in PLSCADD, foundation design, and material and construction specifications.

## **MIDAMERICAN ENERGY COMPANY**

Burns & McDonnell designed a new 161-kV transmission line for MEC as an interconnection with Omaha Public Power District. The project involved design and construction inspection of 6 miles of 161-kV line on tubular steel structures.

Detailed design for the transmission line included developing a family of structures required for the transmission line, preparing configuration and loading diagrams for each structure type, for use in purchasing structures, creating PLS-POLE models of the structure designs provided by the steel supplier, preparing design criteria data, conductor data, structure criteria, and wire clearance requirements for creating the plan/profile drawings in PLS-CADD, foundation design, and material and construction specifications.



---

## **KANSAS CITY BOARD OF PUBLIC UTILITIES**

Burns & McDonnell designed a 161-kV transmission line using Bunting ACSS conductor and OPGW for the shield wire on self supporting single steel poles from the existing BPU Maywood South Substation to a new substation (Piper) that the BPU is building. There are two underbuilt distribution circuits on the 161-kV structures.

## **LOWER COLORADO RIVER AUTHORITY**

Zorn to McCarty Lane - A 9 mile 138-kV line requiring reconductoring one circuit to 1033.5 Merrimack ACSS/TW. Burns & McDonnell provided structural analysis of the existing lattice towers, where necessary. modified the structures to provide additional capacity and clearance improvements.

McNeil to Round Rock – A 8 mile 138-kV line rebuild requiring new monopole construction for bundled, 795 kcmil Drake. Burns & McDonnell designed the line with both steel and concrete poles.

Macedonia to Hockley – Burns & McDonnell designed a new 13.5 mile 138-kV line. The line consists of 3 miles of double circuit line along an existing San Bernard Electric Cooperative right-of-way, 6 miles of single circuit paralleling a CenterPoint Energy 345-kV line, and four and a half miles of low impact single circuit construction meandering through farmland and tying in to a CenterPoint Energy 138-kV line. All construction utilizes both steel and concrete monopoles.

Kendall to Miller Creek - A 40.4 mile existing 138-kV transmission line that connects the Kendall substation to the Miller Creek substation. The line was single circuit with Linnet 336 kcmil ACSR conductor. The line was being operated at 82 MVA. Burns & McDonnell evaluated and redesigned the line to a re-rated 128 MVA.

Buchanan-Graphite Mine-Lampasas - A 27.5 mile 138-kV transmission line from Buchanan to Graphite Mine to Lampasas. The existing line was single circuit with 336 ACSR conductor and wood H-frame structures. Burns & McDonnell designed an upgrading to the conductor on the transmission line to 795 ACSR Drake. The conductor upgrade increases the power transfer capacity from 128-MVA to 220-MVA.



---

Hill Country Cut In-A 2.8-4.2 mile 138-kV double-circuit-capable transmission line between the existing Cico-Helotes 138-kV line and a new distribution substation (Hill Country Substation) that will improve the reliability of electric service to customers served by Bandera Electric Cooperative and the City of Boerne. Without this project, load growth and contingencies in this area will continue to threaten the integrity of the electric system and its ability to provide stable and acceptable service to the growing loads in the Kendall County area. Burns & McDonnell evaluated concrete and steel monopoles and steel lattice towers. The amount of right-of-way required varies for each type of structure and depends on structure width, phase spacing, span length, and wind-induced conductor movement.

Comfort to Raymond Barker-Upgrade and re-conductoring from 69-kV to 138-kV. The upgrade will utilize 795 ACSR “Drake” conductor and OPGW fiber optic shield wire. This line is located in Kendall and Kerr County. With the exception of the tangent structures between Cypress Creek and Raymond Barker substations, all structures will be replaced. The circuit will be rerouted into the Comfort Substation. This 10 mile circuit will be operated as a single circuit, 138-kV electric transmission line utilizing 3x1-795 ACSR “Drake” conductors with one OPGW fiber optic shield wire, and will be rated for operations at 920 amperes, yielding a nominal 220 mega-Volt- amperes (MVA) capacity. Burns & McDonnell provided the following services: Finalizing Plan & Profile Sheets in accordance with LCRA standards, Hardware & Assembly Drawings, Sag & Tension Charts, Finalizing PLS-CADD model of transmission line, Developing Construction Bid Specification and Construction Support.

Transmission facilities for the T119 Comal to Freiheit and the T264 Freiheit to Seguin transmission lines required rebuild to support the Clear Springs 138/345 auto-transformer upgrade project. Burns & McDonnell designed the 138-kV transmission line from Freiheit to Seguin for the Clear Springs project. All structures were replaced except for the double-circuit located outside the Geronimo substation. This structure was previously modeled in PLS-Tower and will be evaluated for capacity by the Lower Colorado River Authority. The project proceeded with the existing transmission line alignment and with a new 180-ft. right-of-way acquired for the tap into Clear Springs Substation (0.4 miles).



---

## **BRAZOS ELECTRIC POWER COOPERATIVE**

Burns & McDonnell designed several new substations, switchyards and substation upgrades ranging in voltage from 345-kV to 25-kV. Burns & McDonnell prepared full design documents, assisted with contract administration for equipment procurement and construction. In addition, Burns & McDonnell designed 27 miles of 138-kV and 69-kV transmission lines using concrete, steel and wood structures. The designs included assisting with route selection, coordinating aerial and ground surveys, structure spotting, structure modeling and line design using PLS-CADD, transmission line modeling and engineering software. Burns & McDonnell provided detailed assembly drawings and assisted with contract administration, design, procurement and construction. Several of the lines were completed on a fast track basis to facilitate schedule and meet outage dates.



## **CITY OF ROCHELLE, ILLINOIS**

Burns & McDonnell designed 14 miles of 138/12-kV single-circuit transmission line through, and around, this small rural community. The project was designed using wood single pole weathering tangents, direct embedded weathering steel single poles for small angles and weathering steel single poles with reinforced concrete caisson foundations were used for larger angles and deadends. The portion through town utilized a very compact design in order to limit the structure height and visual impact.

## **NASHVILLE ELECTRIC SERVICE**

Burns & McDonnell provided professional engineering services for Nashville Electric Service, including the Central Power Loop around downtown Nashville, Tennessee. The Central Power Loop was routed, designed and constructed in three phases, beginning in 1997 with completion of the third phase in fall 2002. The total length is approximately 10 miles of single and double circuit 161 and 69-kV transmission line with several miles of multi-circuit distribution underbuild. The lines are routed through dense urban areas along major city streets and interstate highways, including several major highway crossings.

Each phase of the Central Power Loop included route analysis and selection that included participation by a Citizens Advisory Committee (CAC) appointed by local politicians, homeowners associations or civic groups. Each phase also included multiple open houses to include additional public input in the route selection process.



---

After final route selection, Burns & McDonnell provided all aspects of transmission line design including conductor sag and tension design; structure loading; insulation analysis; vibration analysis; structure spotting using PLS-CADD; and foundation design. The lines are designed using tapered tubular galvanized steel, weathering steel structures and drilled shaft foundations.

Other services included preparation of material and construction specifications; preparation of all construction drawings; review of structure designs and shop drawings; coordination and administration of aerial surveys; ground surveys and geotechnical investigations. Burns & McDonnell also provided full-time, on-site construction management for all phases of construction from initial structure staking through energization. Construction management including coordinating outages of other lines to facilitate foundation construction, structure erection and conductor installation.



### **CHAD AFRICA TRANSMISSION LINE**

ExxonMobil is developing a major oilfield in the African country of Chad near Kome. Ultimately the field will consist of over two hundred wells with gathering lines, pumping stations and a pipeline from the field in Chad to the tanker loading facilities on the coast of Cameroon. Chad is an under-developed country with minimal infrastructure. Engineering for the development project is being completed by a consortium led by Kellogg Brown & Root, Inc. Burns & McDonnell was retained by KBR to design the electric transmission and distribution network. The line design poses several unique engineering, construction and design challenges. The electric system consists of a backbone of 66-kV and 33-kV radial transmission and 33-kV distribution to the wells and other facilities from the field's power plant. Oil will be pumped from the wells with medium voltage submersible pumps of up to 1500hp. The pumps are designed for continuous operation and will tolerate only a few restarts before requiring a rebuild that can cost up to \$250,000. Additionally, if oil flow is stopped, there is no guarantee that it will resume once the pump is reinstalled and started. A highly reliable electric system is required to allow sustained and economical operation of the field.



Chad has a very high level of lightning activity, approximately 180 thunderstorm days a year, and extremely high soil resistivity of up to 9,000 ohm-meters. The extremely high soil resistivity caused an unacceptably high incidence of back-flashovers. Increasing the insulation level from 66-kV to 345-kV reduced the number of back-

---

flashovers to 6/100 mile-year but still did not reduce them to an acceptable level. Additionally, designing the lines for such high insulation levels greatly increased the structure height and foundation requirements with the associated increase in material and construction costs.

Burns & McDonnell engineers determined the best method to economically obtain the desired level of reliability was to utilize a separate shielding structure adjacent to the structure supporting the conductors. The shielding structure would shield the line from direct lightning strikes the same as a traditional shield wire design. The increase in potential of the shielding structure will not cause a back-flashover to the phase conductors on the adjacent structure. The two-pole system results in comparable overall steel and concrete quantities as the 345-kV design while achieving an acceptable level of direct and back-flashovers.

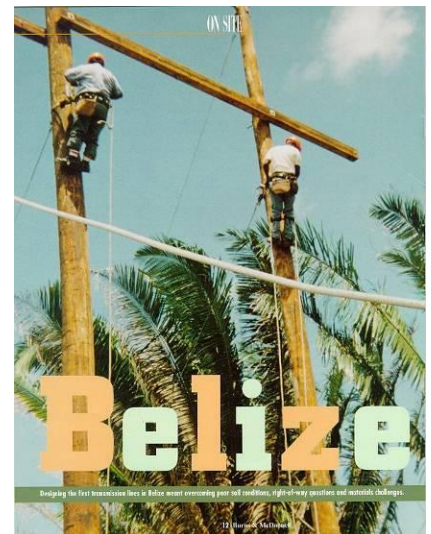
### **SOUTH CAROLINA ELECTRIC AND GAS COMPANY**

The project includes approximately 6.7 miles of new single-circuit 115-kV transmission line and approximately 5.6 miles of new single circuit 230-kV transmission line. The 115-kV line connects the existing Edenwood Substation with the new Columbia Energy Center being built on the property of Carolina Eastman Corporation. The 230-kV line taps into an existing 230-kV line and runs east 2.8 miles to the Columbia Energy Center and then loops back the 2.8 miles to the existing line.



### **BELIZE ELECTRIC COMPANY, LIMITED (A SUBSIDIARY OF DOMINION RESOURCES)**

Burns & McDonnell engineers designed 92 miles of wood poles and wood pole H-frames for the Mollejon to Belize City 115-kV transmission line in the Central American country of Belize. This challenging project was constructed through mountainous jungles and was completed on time and within budget in 1995.



## NEVADA POWER COMPANY

Burns & McDonnell designed the quad circuit 69/12-kV Loop into Lindquist Substation project. This project required a tap into an existing 69-kV H-frame transmission line and 12-kV distribution circuit. Burns & McDonnell used PLSCADD and strict Nevada Power design standards to produce a construction turnover package in time to meet summer peak load demands. This steel pole transmission line was built on reinforced concrete caisson foundations and included several distribution risers to serve load.



*Diagram 3 – 161-kV to 69-kV Overhead Transmission Line Project Locations*