



# Underground Transmission Lines

## INTRODUCTION

In today's urban, environmentally sensitive environment, how are you going to get power to the people who need it? In many cities, overhead transmission lines are considered unsightly and unwelcome. In national parks, they are almost impossible to build.

Burns & McDonnell combines top-flight engineering and construction services to take your high-voltage transmission line underground. By providing turnkey solutions, we can help you provide power to the people who need it while preserving the beauty and history of your parks, beaches and downtown business districts.

## RECENT PROJECTS

### **THERMAL ENERGY CORPORATION**

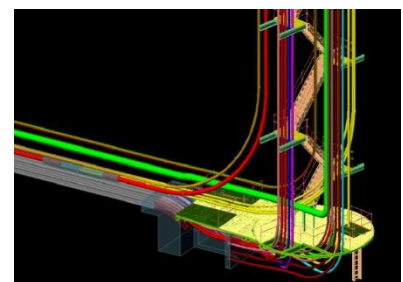
Associated with the upgrade of an existing thermal energy plant in Houston, TX, Burns & McDonnell provided design services for approximately 800 feet of new, dual-circuit 115-kV underground transmission line. Due to the congested nature of the site, Burns & McDonnell worked successfully with the construction contractor to design and construct approximately 400 feet of the line in a tunnel excavated approximately 15' below the main access drive for the site.



### **CONSOLIDATED EDISON COMPANY OF NEW YORK**

To provide a below-grade connection between Harlem and the Bronx, Con Edison is constructing a new utility tunnel approximately 130 feet deep and 700 feet long below the Harlem River

Burns & McDonnell was selected to provide engineering services for the routing of utilities down both shafts and through the tunnel. Utilities included a 345-kV HPFF transmission line, high-pressure gas line, 16 distribution conduits, and space for the future placement of a 345-kV XLPE line.



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Burns & McDonnell utilized 3D modeling software to route this large amount of proposed utilities through the tight confines of the tunnel and shafts, while avoiding all of the ancillary facilities associated with the tunnel and shafts (drainage, ventilation, stairs, etc.)

### **FIRST ENERGY**

Associated with a proposed expansion to the Cleveland Clinic, First Energy, through their subsidiary The Illuminating Company, is planning to construct approximately 13.5 circuit miles of 36-kV distribution feeders, via approximately 3.5 miles of duct bank, to meet the anticipated future demand.

Burns & McDonnell was selected to provide preliminary routing and estimating services for these new underground distribution lines and associated substations. For the project, First Energy required an accelerated completion schedule to facilitate discussions regarding the ultimate funding for the project. Burns & McDonnell was able to the estimate and routing study within the necessary timeframe to allow First Energy to continue to progress with the project.

### **NORTHEAST UTILITIES SERVICE COMPANY GLENBROOK CABLES PROJECT**

Burns & McDonnell was selected by Northeast Utilities Service Company (Connecticut Light and Power [CL&P]) as a Program Manager of Choice for the Glenbrook Cables Project. Program management provides for all an owner's project delivery needs as they relate 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 throughout the lifespan of a project(s). A program manager provides detailed managerial support with added technical value to the owner and is normally involved from the earliest stages of a project.



During the initial stages of the project CL&P retained Burns & McDonnell to assist in the preparation of an application to the Connecticut Siting Council (CSC) for a Certificate of Environmental Compatibility and Public Need (CECPN) to construct a new 115-kV double circuit transmission line and associated substation upgrades. The 9-mile project extends between the existing Glenbrook Substation in Stamford, CT to the existing Norwalk Substation in Norwalk, CT.

Burns & McDonnell acted as the primary consultant providing preliminary engineering and design services and identification of a preferred route as part of the CSC regulatory process. Burns & McDonnell assisted CL&P in the identification and evaluation of



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routes, development and participation in the public involvement process, the compilation of municipal recommendations, and the preparation of the CSC application documents.

Underground route alternatives were identified by Burns & McDonnell for consideration and evaluation. Routes along existing transmission, rail corridors and public streets and highways were considered and evaluated for underground construction based on sound environmental, social and engineering factors typical for similar voltage lines in the region. Burns & McDonnell also identified appropriate locations for river crossings and determined necessary methods for the crossings to minimize impacts. Burns & McDonnell used geographic information system (GIS) technology to identify and map constraints and analyze routes.

Burns & McDonnell provided preliminary engineering support to CL&P for the design and cost estimates for proposed underground alternatives. Burns & McDonnell also assisted with the preliminary design and cost estimates for the substation upgrades.

Burns & McDonnell team members provided expert testimony at public hearings following the submittal of the application to the CSC. Together with NUSCO, Burns & McDonnell successfully obtained a unanimous decision in favor of the project application by the Connecticut Siting Council.

For the Program Management phase, Burns & McDonnell has opened a 26 person office in Connecticut to provide our client with immediate local access to the critical human resources needed to be successful on an effort of this magnitude. On site resources include public relations, safety, scheduling, budgeting, procurement, discipline engineering, inspection, construction management, environmental field monitoring, document control and project management. The Program Management office is responsible for developing the project execution plan and implementing its processes and procedures. Project execution includes the management of the project scope, schedule, budget, contracting strategies, risk, procurement, change orders, phasing, project reporting and control plans, QA/QC, permitting and environmental compliance, community relations, safety plan and real estate acquisition.

Glenbrook Cables Project was successfully energized in November of 2008 ahead of schedule.

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## **CONSOLIDATED EDISON COMPANY OF NEW YORK NEW ATHENS PROJECT**

Burns & McDonnell was contracted by New Athens Generating Company to provide engineering and construction management services for a new capacitor bank addition at Con Edison's existing Millwood Substation in Millwood, NY. The capacitor bank addition is to be connected to the existing substation with a 345-kV XLPE underground line. A portion of this underground line was installed using trenchless construction methods in order to pass under a 30-foot rock cliff that lies between the proposed capacitor bank yard and the existing substation.

The project was completed in 2008

## **CONSOLIDATED EDISON COMPANY OF NEW YORK JAMAICA SUBSTATION**

To increase the reliability of its Jamaica Substation in Queens, NY, Con Edison added a 138-kV solid dielectric cable system to connect breaker 14 position with breaker 15 position. During the outage Con Edison replaced breakers 13 & 14 and elevating disconnect switch 14-2. Burns & McDonnell was contracted to provide civil design services for the duct bank, breaker replacements and steel extensions for the disconnect switch.

The project was completed in 2008.

## **CONSOLIDATED EDISON COMPANY OF NEW YORK 13<sup>TH</sup> STREET – CHERRY STREET**

Due to their age, Con Edison needed to replace two existing 69-kV low pressure feeder with a cross-linked polyethylene system. The circuits run from Con Edison's Cherry St Substation to their East 13th St Substation in the Lower East Side of Manhattan.

Burns & McDonnell was contracted to provide a routing study and design services for the two-mile double circuit duct bank. Through a comprehensive search of utilities in the area and field reconnaissance, Burns & McDonnell was able to come up with an optimized route to minimize construction difficulties. The duct bank was routed in city streets through residential and commercial areas in an area heavily congested with existing and abandoned utilities. Burns & McDonnell put together a local team of surveyors and utility specialists to develop an accurate set of comprehensive plan and profiles. Burns & McDonnell also provided a test pit program to help anticipate and minimize construction conflicts.



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For this project, Con Edison required an extremely aggressive construction schedule. Burns & McDonnell was able to put together a stream lined schedule to meet their needs without compromising the design.

The project was completed in 2006.

### **CONSOLIDATED EDISON COMPANY OF NEW YORK MOTT HAVEN ROUTING STUDY**

To increase the capacity of its system, Con Edison planned on adding two new substations in Northern Manhattan and the Southwest Bronx, respectively.

Burns & McDonnell was contracted to provide a detailed routing study and cost estimate for routing five 138-kV circuits in three independent routes between the proposed East Harlem Substation and the proposed Mott Haven Substation. The study included: GIS mapping of the area, researching all utilities in the project area, contacting all potentially affected agencies, a feasibility analysis on trenchless crossings under the Harlem and East Rivers, looking at all potential environmental impacts, and providing cable ampacity calculations. The major obstacles involved included: Harlem and East Rivers, several major highways, several railroads and maintenance yards, adjacent subway lines, and severe utility congestion. In addition, Burns & McDonnell provided a detailed cost estimate looking at all potential construction issues and providing a cost/benefit analysis for each proposed route.

The project was completed in 2006.

### **CONSOLIDATED EDISON COMPANY OF NEW YORK CEDAR STREET – WASHINGTON STREET**

To increase the capacity of its Westchester County system, Con Edison added a new 138-kV feeder from its Cedar St Substation in New Rochelle, NY to its Washington St Substation in Mt. Vernon, NY.

Burns & McDonnell was contracted to provide design services for the three-mile single circuit duct bank. The duct bank was routed in city streets through residential and commercial areas in an area heavily congested with existing and abandoned utilities. Burns & McDonnell put together a local team of utility specialists to develop an accurate set of comprehensive plan and profiles. Burns & McDonnell also provided a test pit program to help anticipate and minimize construction conflicts.

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Coordination was required with the local municipalities and the New York Department of Transportation.

The project was completed in 2007.

**CONSOLIDATED EDISON COMPANY OF NEW YORK  
GREENWOOD - BERNSONHURST**

Due to load growth in west Brooklyn, Consolidated Edison required a four-mile underground feeder to increase the capacity of an existing substation. The feeder was a 138-kV, solid dielectric, in duct bank, routed through city streets.

Burns & McDonnell and its subcontractor's provided professional services which included surveying, utilities locating, route selection, duct bank design, cable sizing and specification, and preparation of contract documents.

The project was completed in 2003.

**PUERTO RICO ELECTRIC POWER  
AUTHORITY (PREPA)  
115-KV UNDERGROUND TRANSMISSION**

To increase system reliability, PREPA is putting its 25.4 mile 115-kV overhead transmission loop around San Juan underground. Project design included 28,700 feet of 2750 kcmil solid dielectric cable, concrete encased ductbank, six trenches crossings totaling 2800 feet. The project was divided into five phases, Burns & McDonnell assisted in the engineering of Phase I and Phase IV.

Phase I of this project spans 5.4 miles from Monacillos Substation to Hato Rey Substation and Phase IV spans 5.9 miles from Bayamon Substation to Monacillos Substation. The system includes a new 115-kV circuit, a future 115-kV tie in, and a future 38-kV circuit.

Burns & McDonnell worked in conjunction with the turnkey team to provide a seamless and cost effective design through weekly conference calls and periodic design conferences. Engineering services included providing: final routing of ductbank, a complete set of plan and profiles, pulling tension calculations, cross bonding calculations, ductbank design, ampacity calculations, and construction support.

The project was completed in 2006.

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## **AQUILA 161-KV UNDERGROUND TRANSMISSION LINE**

Burns & McDonnell was the design build firm for Aquila's 161-kV underground transmission line. This 161,000-volt underground cable is the first XLPE solid dielectric cable installed in Aquila's transmission system.

Installation of approximately one mile of underground transmission line was needed to replace a previously existing overhead line at Staley Farms new golf course and subdivision that was being built on previously undeveloped property.

Burns & McDonnell furnished equipment and materials, managed the trenching and concrete encased conduit system and installed the cable.

The project was completed in 2002.



## **SILICON VALLEY POWER NORTHERN RECEIVING STATION 230-KV TRANSMISSION**

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, CA.

Burns & McDonnell teamed with a joint venture partner for this project. The construction contractor performed all construction at the substations plus overhead and underground transmission line installation. The project was managed from the Kansas City office with environmental and permitting support from the San Francisco office.

Construction began in late 2003 and was completed in May 2005.



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## **NORTHEAST UTILITIES SERVICE COMPANY MIDDLETOWN TO NORWALK**

Burns & McDonnell was selected by the Northeast Utilities Service Company (NUSCO) as Program Manager of the Middletown/Norwalk Bulk Transmission Project consisting of a \$1.1 billion portion of a \$1.4 billion program. The project scope includes nearly 70 miles of new 345kV transmission line of which 24 miles will be cross-linked poly ethylene (XLPE) 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 as they relate 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 throughout the lifespan of a project(s). A program manager provides detailed managerial support with added technical value to the owner and is normally involved from the earliest stages of a project. The BMcD Program Management teams 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 because the project's planning, permitting, design and construction phases are effectively integrated into a single process.

Burns & McDonnell opened an 80 person Connecticut office near the M/N project site to provide the client with immediate local access to the critical human resources needed to be successful on an effort of this magnitude. On site resources include community relations, safety, scheduling, budgeting, procurement, discipline engineering, inspection, construction management, environmental field monitoring, document control and management. In addition, the Burns & McDonnell Kansas City office provides technical expertise and executive support to the CT-based project staff and CT-based client.

One unique facet of the project was the implementation of IEC 61850 communication protocol at two of the project substations. The protocol was used to integrate relays and pass system critical data directly rather than costly wiring. One site utilized the protocol only during a construction sequence that elevated system criticality and required special tripping. The second substation required a permanent implementation of the protocol to protect critical system



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components during certain system configurations.

The Middletown-Norwalk Project was completed **one year ahead** of schedule and significantly under budget.

### **BALTIMORE GAS & ELECTRIC MT. WASHINGTON TO COLDSRING UNDERGROUND TRANSMISSION LINE**

Burns & McDonnell provided design and preparation of an EPC specification for 230-kV Mt. Washington to Coldspring underground transmission line. Burns & McDonnell worked with its subconsultant to determine cable requirements for a 230-kV XLPE cable installation approximately two miles in length. Two circuits, required to carry 1450 amperes, were installed in a common ductbank with the majority of the right of way along the Maryland Transportation Authority light rail system. The project also incorporated the replacement of a 230-kV HPFF cable system.

The project was completed in 2001.

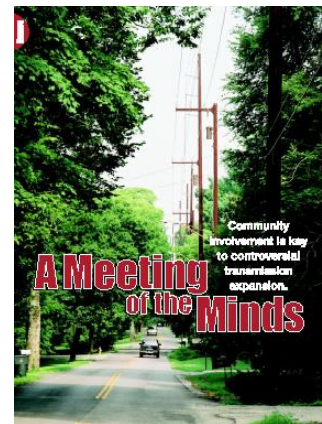
### **NASHVILLE ELECTRIC SERVICE CENTRAL POWER LOOP**

As part of Phase I of the Central Power Loop, Burns & McDonnell designed a 69-kV underground transmission line through an established residential area of Nashville. This portion of the project included significant involvement of the Citizen's Advisory Committee and the public.

Burns & McDonnell services include duct bank routing; reinforced concrete duct bank design; conductor pulling tension calculations; manhole design; riser structure loading diagrams and foundation design; and conductor bonding and grounding design. The project also included a horizontal boring beneath an existing box culvert. The horizontal boring design included a grout-filled steel casing to protect the duct bank.

Additional Burns & McDonnell services included plans and specifications for material and construction, and coordination with the Metropolitan Government of Nashville to limit street closures and utility interruptions.

Phase I was completed in 2000, Phase II was completed March 2002 and Phase III was completed November 2002.



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### **NEVADA POWER COMPANY 138-KV LOOP-IN TO STRIP SUBSTATION UNDERGROUND TRANSMISSION PROJECT**

Burns & McDonnell provided design for two circuits of 700 feet of 138-kV, 2000kcmil XLPE cable. The project included 300 feet of 36-inch diameter steel casing 20 feet below Sands Avenue. The overhead transmission line was constructed underground for the Nevada Monorail Project and went from riser structures to a 138-kV gas insulated substation. The design consisted of calculating the ampacity, sheath voltage rise, grounding requirements and cable pulling. The drawings consisted of Plan & Profile drawings with associated details and cable vault details for connection into the gas insulated substation.



### **NEVADA POWER COMPANY PALACE STATION UNDERGROUND TRANSMISSION**

For the 138-kV Palace Station Underground Transmission Project, Burns & McDonnell provided design of 1300 feet of 138-kV, 2000kcmil XLPE cable. The project was constructed to eliminate the overhead transmission lines in front of Palace Station along Sahara Avenue. The project included tying into an existing 30-inch diameter hdpe casing 10 feet deep under the I-15 interchange. The design consisted of calculating the ampacity, sheath voltage rise, grounding requirements and cable pulling. The drawings consisted of Plan & Profile drawings with associated details.



### **NEVADA POWER COMPANY FLAMINGO UNDERGROUND TRANSMISSION**

Burns & McDonnell provided an Engineer Procurement & Construction Specification for the request of bid for the Flamingo Underground Project. The project consisted of approximately 3200 feet of two circuits of 138-kV, one circuit of 69-kV and four 12-kV circuits. The project will eliminate the high voltage overhead lines from I-15 to Audrey Street along Flamingo Boulevard in front of Caesars Palace, Bellagio, Flamingo and Ballys. The project consisted of an ampacity study, cable pulling, survey, plan & profile drawings and incorporation of Nevada Power Company's transmission and distribution standards.

These projects were completed in 1996.

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## **OHIO EDISON COMPANY CRISSINGER-TANGY 138-KV TRANSMISSION LINE UNDERGROUND RELOCATION**

Burns & McDonnell Engineering Company, Inc. provided the project management, engineering, material procurement, construction and testing of the Crissinger-Tangy 138-kV Transmission Line Underground Relocation for the Delaware, Ohio, Airport. Burns & McDonnell had overall responsibility for the project from initial design to procurement, construction and testing. Burns & McDonnell teamed with Nokia as the cable supplier for this project. Burns & McDonnell developed all detailed design, as well as procured: the 138-kV XLPE cable, terminators, clamps; surge arresters, fiber optic cable splice boxes, fiber optic cable, and tubular steel structures. The construction contractor supplied all on-site construction management, construction supervision, construction labor, testing labor equipment, construction equipment, and construction materials. Burns & McDonnell worked with Ohio Edison to optimize the cable size and duct bank configuration with construction methods.

## **COLORADO RIVER COMMISSION OF NEVADA POWER DELIVERY PROJECT**

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. The Project included two 230/69-kV substations, four 69/4.16-kV substations, approximately 8 circuit miles of underground 69-kV transmission lines, 4 miles of double and quad-circuit 69-kV transmission line, 4 miles of double-circuit 230-kV transmission line, a fiber optic and microwave communication system, and a PLC-based SCADA system.



The underground transmission lines were installed in concrete encased ductbanks with fiber optic communication circuits that included a 4000-foot underwater crossing of Lake Mead. The 69-kV XLPE power cable sizes ranged from 500 kcmil to 1250 kcmil. The cables were provided by Silec and installed in the fall of 1997 by an independent electrical contractor.

Burns & McDonnell worked with the Colorado River Commission from the inception of the project through the planning, permitting, design and construction management activities.

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The construction contractor constructed underground power and communications ductbanks and provided installation of 69-kV power and fiber optics.

This project was completed in 1999.

**CAPE HATTERAS ELECTRIC MEMBERSHIP CORPORATION**  
**115-KV CAPE HATTERAS TRANSMISSION LINE**

Burns & McDonnell worked with Cape Hatteras Electric Membership Corporation to install one of the longest bridge supported high voltage cables in North America. Daily power outages in the resort area of Cape Hatteras Island required an upgrade of the 34-kV system to 115-kV prior to the busy summer tourist season. Burns & McDonnell engineers worked with the North Carolina DOT, Brugg Cable and area permitting agencies to design and install approximately 3 miles of single circuit 500 kcmil XLPE 115-kV cable in fiberglass ducts.



Other challenges faced by Burns & McDonnell included preserving wildlife refuges and national parklands, and the threat of hurricanes. Since activation in 1995, Cape Hatteras has not experienced a power outage. Burns & McDonnell won a Kansas Consulting Engineers Council Award for the Cape Hatteras Island Oregon Inlet Bridge Cable Project.

This project was completed in 1994.

**CAPE HATTERAS ELECTRIC MEMBERSHIP CORPORATION**

Provided consulting engineering services for developing capital cost estimates for the relocation of approximately 17 miles of 115-kV transmission line associated with North Carolina Department of Transportation's Bonner Bridge replacement project. The bridge replacement project involves construction a 17 mile bridge in Pamlico Sound west of Hatteras Island. Capital cost estimates were developed for three relocation alternatives including:

1. Traditional overhead line design supported on independent foundation adjacent to bridge structure.
2. Solid dielectric cable supported by hanger system on underside of bridge structure.
3. Buried submarine cable.