Chapter 6 - Transmission & Distribution

BED recognizes there is an ongoing shift in the fundamental aspects of power supply and delivery. The one-way energy flow from large scale generation via high voltage transmission lines to local distribution systems that has dominated grid structure for decades is becoming increasingly bi-directional and dynamic. With the growth of distributed generation and net metering, the traditional customer role as an energy user is expanding to include being an energy generator and potentially a supplier of other ancillary grid services. Just as the customer role is evolving, so too must utilities and their transmission and distribution systems.

In 2015, BED completed an internal reorganization that will support greater integration between engineering, generation, and operations. A single senior management position, Manager of Utility Services & Engineering, now oversees BED's generation, distribution, and grid services. By aligning responsibility for these functions under one position, a greater awareness of and emphasis on the need to coordinate customer load, net-metering, distributed generation, and transmission and distribution system management will be achieved. The sections below describe BED's ongoing efforts to provide reliable transmission and distribution services as well as future projects that will ensure BED is prepared for the challenges and opportunities of grid modernization.

Transmission and Distribution Description

BED is connected to Green Mountain Power (GMP) through the 34.5 KV bus tie breaker at the McNeil Plant Substation and to the rest of Vermont through VELCO at the East Avenue and Queen City Substations. The East Avenue 13.8 KV switchgear is supplied by VELCO's 115/13.8 KV T1 transformers rated 30/40/50 and T2 transformer rated 30/40/56 MVA. The Queen City 13.8 KV switchgear is supplied by a VELCO 115/13.8 KV, 33.6/44.8/56 MVA transformer. The McNeil 13.8 KV switchgear is supplied by a BED 34.5/13.8 KV, 20/26.7/33.3 MVA transformer. The VELCO transmission system connects all of the utilities in Vermont to each other and also has interconnections with New York, Quebec, Massachusetts and New Hampshire.

BED's sub-transmission system includes approximately 1.5 miles of 34.5 KV line from the East Avenue Substation to the McNeil Plant Substation. This line is jointly owned between BED (40 MVA) and GMP (20 MVA). The line is connected to the VELCO transmission grid at the East Avenue Substation by VELCO's 115/34.5 KV, 33.6/44.8/56 MVA transformer and to GMP's 34.5 KV system by the 34.5 KV tie bus breaker at the McNeil Plant Substation.

BED's distribution system throughout the city is comprised of fifteen 13.8 KV circuits with approximately 129 miles of 13.8 KV lines and 0.9 mile of 4.16 KV distribution taps. BED also owns the 0.9 miles 12.47 KV distribution circuit that serves the Airport. The distribution system is approximately 47% underground and 53% aerial.

BED has 25 MW of on-system generation in the Burlington Gas Turbine and 7.4 MW of Winooski One Hydro Plant that are connected to the 13.8 KV system. BED also operates, and is fifty percent owner of, the McNeil Generating Station. McNeil is on the GMP system, but is connected to the BED system through the GMP 34.5 KV bus at the McNeil Plant Substation.

BED's distribution system annual peak load for year 2015 was 63.54 MW. The substation transformer ratings and 2015 substation transformer coincident peak load demand are provided in the table below:

	Rating	Peak Load
East Avenue Bus #3 T1 Transformer	50 MW	13.7 MW
East Avenue Bus #4 T2 Transformer	56 MW	13.04 MW
Queen City Transformer	56 MW	22.7 MW
McNeil Transformer	33.3 MW	14.1 MW

Transmission & Distribution System Planning & Standards

BED's distribution system is operated as an open primary network. This is a system of interconnected primary circuits with normally open switches at the interconnection points. When problems arise on the circuit, back-up is provided to as many customers as possible by other circuits by changing the normally open and closed points on the system. Switching is performed by BED's Supervisory Control and Data Acquisition (SCADA) system or by manual switching when necessary.

The East Avenue, Queen City and McNeil Substation transformers load tap changers (LTCs) are set to hold voltage at the summer peak hour between 122.6 V and 124.8 V (set point of 123.7 V and bandwidth of 2.2 V) at the substation 13.8 KV bus. The voltage delivered to BED's customers meets ANSI C84.1-2011 Range A during normal operation and ANSI

Standard C84.1-2011 Range B during contingencies. The substation transformer LTC voltage settings allow for ISO New England Operating Procedure No. 13 (ISO OP-13) Standards for 5% Voltage Reduction, primary voltage drop, and 6 volts of secondary voltage drop (distribution transformer, secondary cable and service wire).

Most of BED's trunk lines are rated 600 amps. This is to allow for the switching of loads between circuits, even at the system peak. The loading on the 600 amps main trunk lines is typically kept below 9 MVA during normal operation. This is to allow for the isolation of a fault to a small section of a circuit and switching the remaining sections to adjacent circuits.

The power factor is measured and monitored by SCADA at the substation breakers for the substation transformer and each circuit, and at reclosers and switches along the circuits. BED maintains a 0.98 power factor or higher on its distribution circuits to comply with VELCO power factor requirements and to keep the circuit voltage from dropping below an acceptable level during normal conditions and contingencies. This is implemented by switched and fixed capacitor banks and close monitoring of the VAR load on each circuit.

BED standard wire sizes are as follow:

- Aerial Primary Circuits: #2 Aluminum, 1/0 Aluminum, 4/0 Aluminum, 336 AAC and 556 AAC;
- Aerial Secondary Circuits: #2 Aluminum, 1/0 Aluminum, 4/0 Aluminum and 336 AAC.
- Underground Primary Circuits: #2 Aluminum, 1/0 Aluminum, 350 Copper, and 1,000 Copper;
- Underground Secondary Circuits: #2 Aluminum, 1/0 Aluminum, 2/0 Aluminum, 4/0 Aluminum, 350 Aluminum, and 500 Aluminum.

BED standard transformer sizes are as follow:

- Pole mounted transformers: 15 kVA, 25 KVA, 37.5 KV, 50 KVA, 75 KVA, 100 KVA, and 167 KVA;
- Pad mounted single phase transformers: 15 KVA, 25 KVA, 37.5 KVA, 50 KVA, 75 KVA, 100 KVA, and 167 KVA
- Pad mounted three phase transformers: 75 KVA, 112.5 KVA, 150 KVA, 225 KVA, 300 KVA, 500 KVA, 750 KVA, 1,000 KVA, and 1,500 KVA;
- Submersible transformers: 15 KVA, 25 KVA, 37.5 KVA, 50 KVA, 75 KVA, 100 KVA, 167 KVA, 250 KVA and 333 KVA;

Distribution system planning studies are performed to improve system efficiencies, and identify the least cost options to meet future load requirements in a safe and reliable manner. Distribution system planning is performed consistent with the Distributed Utility Planning principles, and planning process under Docket 7081. In addition to energy efficiency and distributed generation, BED will also be looking at the potential use of battery storage to avoid future T&D upgrades. Distribution system studies are performed when the city peak load forecast, actual city peak or an individual circuit experiences significant load change. For instance, in 2015, BED performed a planning study to evaluate the ability of BED's distribution system to serve future UVM load additions. The anticipated Mall expansion project along with an updated BED peak load forecast may also trigger a new planning study.

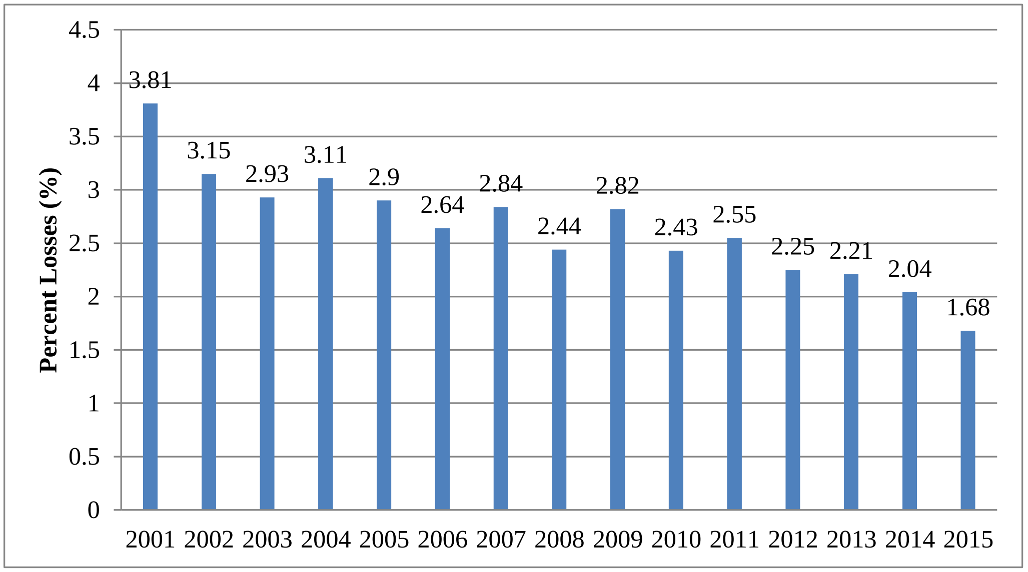
BED performs feasibility and system impact studies to identify the impact of proposed distributed generation on the distribution circuits. The impact studies evaluate the impact of distributed generation on the distribution system at the city peak load hour and also during light load condition and maximum generations under normal system configuration and contingencies. System impact studies have been performed for the Airport's 500 KW solar generation and the proposed 2.5 MW South Forty solar generation projects.

BED uses CYMDIST software for distribution system analysis, efficiency studies, impact studies and planning studies. The distribution system simulation model is presently updated manually. In FY17, BED is planning to integrate CYMDIST with the GIS system to automatically extract distribution circuits from the GIS system to the CYMDIST simulation model. This will increase the accuracy of the simulation model and improve staff efficiency by eliminating the manual update process.

Distribution System Efficiency Measures

The movement of power through the distribution system incurs electrical losses due to the resistance of the equipment to the flow of electricity. System losses increase the amount of electricity required to supply the customers' needs. BED has several programs in place and routinely performs analysis to improve system efficiency using methods that are both cost-effective and technically feasible. As a result of BED's system efficiency efforts, BED's total distribution system losses dropped from 3.81 percent in 2001 to approximately 1.68% percent in 2015. Figure 1 shows BED's historical distribution system losses.

Figure 1: System Losses



Distribution system efficiency measures are evaluated on each circuit and cost effective measures are implemented. The following efficiency measures are evaluated by BED:

- Optimal locations of capacitor banks;
- Distribution system configuration;
- Phase balancing;
- Single phase to three-phase conversion;
- Increasing distribution voltage level;
- Creating new 13.8 KV distribution circuits;
- Re-conductoring of lines with lower loss conductors;
- Equipment acquisition procedure;
- Transformer/load matching;

Optimal Locations of Capacitor Banks

Capacitor Banks are installed on BED's distribution circuits to reduce the VAR flows, reduce losses and improve voltage. BED maintains a 0.98 power factor or higher on its distribution circuits to comply with the VELCO power factor requirements, reduce losses, improve voltage and be able to serve load with acceptable voltage during contingencies.

Fixed or switched capacitor banks are installed on the distribution circuits. The switched capacitor banks are controlled through the SCADA system, and a few in the field are controlled via stand-alone voltage or VAR controllers. BED's Operator remotely opens and closes capacitor banks based on the voltage requirements or circuit breaker preset VAR alarm values to maintain a circuit power factor close to unity.

The optimal locations of existing and new capacitor banks on each circuit are determined using CYMDIST software to minimize losses or improve voltage.

In 2014, BED performed a capacitor bank study to determine the optimal locations for the existing capacitor banks on its distribution circuit. The results of this study showed that the relocation of the existing capacitor banks to new optimal locations is not cost effective in a 25-year societal-cost analysis (BED depreciates its distribution capacitor banks on a straight line basis over a 25-year service life).

Distribution Circuit Configuration

Distribution system configurations are evaluated when the City peak or an individual circuit experience significant load change. In year 2016, BED evaluated balancing the load between 1L1, 2L5, and 3L2 circuits to optimize losses and improve reliability. The analysis was performed when the 2L5 circuit experienced a load reduction as a result of transferring the UVM Medical Center load to 2L6 circuit. The results of this study show that transferring the So. Willard Street load from circuit 3L2 to circuit 2L5 reduces system peak losses by 15.2 KW and is cost effective in a 33-year societal-cost analysis (BED depreciates its distribution cables on a straight line basis over a 33-year service life). The new system configuration has been implemented.

Phase Balancing

Balancing the phase loading on the distribution circuits will decrease line losses, and improve line voltages and backup capability. On an annual basis, BED evaluates the loads among the phases at summer peak on each circuit and corrective actions are taken and implemented based on the results of this evaluation. BED evaluates the phase balancing at the substation switchgear breakers for each distribution circuit and going forward at the reclosers and switches located on the distribution circuits.

With BED's distribution system losses of approximately 1.68%, balancing the phases on the distribution circuits is typically done to improve the voltage for normal system operation and during contingencies.

Single Phase to Three-Phase Conversion

Single phase to three phase conversion are evaluated when the City peak or an individual circuit experience significant load change. Upgrading a line from single-phase to three-phase construction results in line loss reduction. However, the conversion of BED's circuits

from single phase to three phase construction has not been cost effective because the potential loss savings from this conversion is low (losses on BED's distribution system is approximately 1.68 %) vs. the high cost of rebuilding BED's aerial and underground circuits. Traffic Controllers may be required during the construction of aerial projects. The cost of placing BED's lines underground within a paved portion of a City street includes a City Administrative and Excavation fee of approximately $24 per square foot.
In 2014, BED evaluated upgrading the high loaded distribution circuits from single to three-phase construction. The results of this study showed that upgrading BED's lines from single-phase to three-phase constructions was not cost effective in a 33-year societal-cost analysis.

Increasing Distribution Voltage Level

In year 2014, BED completed the conversion of all the 4.16 KV distribution circuits to 13.8 KV and the elimination of all seven 13.8/4.16 KV 5 MVA substations. However, approximately 0.9 miles of 4.16 KV taps remained in the city and are fed from stepdown distribution transformers. The 4.16 KV taps are located at Appletree Point, Sunset Cliff and Pearl Street. BED will be working closely with its customers to complete the conversion of these taps to 13.8 KV in the next 5 years. This conversion plan is contingent on BED obtaining easements from private property owners.

Creating New 13.8 KV Distribution Circuits

The idea behind constructing additional 13.8 KV circuits is to reduce line losses by reducing the load on an existing feeder. In general, creating new circuits on BED's system solely to lower line losses is not cost effective because BED's distribution losses are low (approximately 1.68%), the main trunk lines have large size wires, and the cost associated with installing aerial and underground circuits is very high.

In 2015, the UVM Medical Center requested and paid for the construction of two circuits out of the East Avenue substation to support their load growth.

BED is currently working with GMP to take ownership of GMP's de-energized 34.5 kV line between Queen City Substation and Lake Side Avenue. By transferring this line to BED, GMP will save the labor cost of removing this circuit and BED will be able to use this circuit to create a new distribution circuit (3L5) out of BED's Queen City Substation switchgear. BED plans to extend this circuit from Lake Side Avenue to Pine Street and then connect it to the existing 3L3 circuit on Locust Terrace. The new 3L5 circuit reduces BED's distribution system peak losses by approximately 25 KW and is cost effective in a 33-year societal-cost analysis. In addition, the new 3L5 circuit provides BED with the following benefits:

Provides additional switching flexibility between circuits;
Reduces the number of customers impacted by outages on circuit 3L3 by transferring Locust Terrace, Lake Side Avenue and part of Winooski Avenue from 3L3 circuit to the new 3L5 circuit;

Re-Conductoring of Lines with Lower Loss Conductors

Upgrading the conductor size of a circuit will result in a lower line resistance and lowering the line resistance will reduce line losses. BED's trunk lines are oversized because BED's distribution system is designed to allow for the isolation of a fault to a small section of a circuit and switching the remaining sections of the circuit to alternate feeds.

In year 2014, BED evaluated upgrading the conductor size on its distribution circuits to larger size conductors. The results of this study showed that reconductoring the existing three phase 336 AL aerial 13.8 KV circuit along Manhattan Drive between pole P1845 (between Intervale Road and Walnut Street) and pole P1979 (Park Street) with larger size wires 556 AL reduces system peak losses by 6.8 KW and is cost effective in a 33-year societal-cost analysis. The study also showed that reconductoring the existing three phase 4/0 AL aerial 13.8 KV circuit along North Avenue between pole P3083 (Leddy Park Road) and pole P3131 (Starr Farm Road) with larger size wires 556 AL reduces system peak losses by 13 KW and is cost effective in a 33-year societal-cost analysis.

Equipment Selection & Utilization

BED utilizes least-cost principles to select transformers and cables. The specific processes used for transformer and cable acquisitions are outlined below. Other major equipment such as aerial wires, breakers, reclosers, switches, and capacitors are purchased per BED standards, specifications and purchasing process.

a) Transformer Acquisition Procedure

BED requests quotations for steel metal core and amorphous metal core distribution transformers. BED uses a distribution transformer acquisition program to make purchase decisions based on societal-cost analysis per the Memorandum of Understanding between the Public Service Department Board and BED dated December 27, 2004. The analysis considers the initial cost of the transformer, and the economic value of the increase in capacity costs, energy costs, VELCO transmission costs, distribution costs and environmental externalities over 25 years (BED depreciates its distribution transformers on a straight line basis over a 25-year service life). The least societal cost transformers are purchased.

b) Cable Acquisition Procedure

BED uses a cable acquisition program to make purchase decisions based on 33-year societal-cost analysis. The analysis considers the initial cost of the cable and the economic value of the increase in capacity costs, energy costs, VELCO transmission costs and environmental externalities over 33 years (BED depreciates its cables on a straight line basis over a 33-year service life).

Transformer/Load Matching

New or replacement transformers installed on BED's system are purchased using BED’s transformer acquisition procedure and sized to match customer load. For new transformers, BED sizes the transformers based on coincident peak load estimates from the customer, engineer or electrician, similar facilities’ loads in the City, and our engineering judgement. When BED replaces an existing transformer, a load study is first done to determine the correct size for the replacement transformer. The residential transformers are not sized to allow every customer connected to the transformer to add electric vehicle, heat pump, or other strategic electrification loads. Depending on the total magnitude of the additional load, the transformer may need to be replaced. By correctly matching the size of the transformer to the load being served and existing distributed generation while also allowing for a margin of growth, transformer losses are reduced which improves the overall system efficiency.

The Advance Metering Infrastructure (AMI) provides BED with the energy, demand and reactive power or power factor for each customer. This information is stored in the meter data management system (MDMS). BED has created a manual process to use this information when replacing existing transformers and evaluating the load on existing commercial/institutional transformers. This manual process was used to evaluate the peak loading on three phase transformers during summer peak 2015.

The next step is to establish a link between customer meter accounts and the transformer supplying these accounts, integrate the Geographic Information System (GIS) and/or customer information system with the MDMS and then develop appropriate reporting tools. This will improve staff efficiency by eliminating the manual process and allow BED’s engineering staff to access the MDMS to create load reports on existing transformers and size future transformers. BED is currently developing a 5 year plan for all strategic information technology projects. This aggressive plan will touch nearly ever system currently in use at BED, including the MDMS and GIS. Specific timing of projects has not yet been finalized, but based on current assumptions it is likely this specific element would not occur until 2019.

Reliability

BED is committed to supplying the highest system reliability and power quality to its customers that is economically feasible. Like other utilities, BED tracks power interruptions or outages. An interruption of power is considered an "outage" if it exceeds five minutes. There are two types of outages, planned outages and unplanned outages. Planned outages are outages that are initiated and scheduled in advance by BED for purposes of construction, preventative maintenance or repair. Unplanned outages are outages due to unexpected and unscheduled events. BED's distribution system reliability is measured by the System Average Interruption Frequency Index (SAIFI), and Customer Average Interruption Duration Index (CAIDI) pursuant to PSB rule 4.900. These indices are also impacted by BED's planned outages and include major storms.
Every year, BED analyzes the outage information on its distribution circuits, identifies the worst performing distribution circuits, and updates its action plan to improve the performance on these circuits.

BED's System Average Interruption Frequency Index (SAIFI) for 2015 was 0.4 interruptions per customer, significantly better than our SAIFI Service Quality and Reliability target performance of 2.1 interruptions per customer. BED's Customer Average Interruption Duration Index (CAIDI) for 2015 was 1.7 hours, unfortunately above our CAIDI target performance of 1.2 hours.

Calendar year 2015 was the first year BED used all outage data from the advanced metering infrastructure (AMI) system to calculate the reliability indices. BED expected the reported duration of outages to increase due to the accuracy of the AMI outage data compared to our past practice of estimating the number of customers impacted by outages and duration of outages, however this may not indicate an actual worsening of performance.

To reduce outage duration and restoration times, BED has taken the following actions:

- Line Worker/Troubleshooter Call-In Procedure:

BED's procedure was to call in the Troubleshooter to investigate an after hour outage call. If required, a line worker was called in for restoration. Under BED's new procedures, Dispatch no longer calls in the Troubleshooter on an outage. Dispatch will call in the on-call line worker for all outage calls who is then able to restore a large portion of the outage calls.

In the past, if an outage occurred after normal business hours and additional line workers were needed, the line worker on the scene was required to call our Dispatch Center. The

Dispatch Center was directed to call the Distribution Superintendent who would authorize/call for a second line worker. BED’s new procedure allows the on call line worker to call for a second line worker directly if the outage requires more than (1) person, eliminating the time it takes to call for authorization from the supervisor. The on call worker often can determine by the initial outage call if they will need assistance and calling the second line worker in at the same time the outage call is received reduces outage times.

- Weekly Meeting with Line Crews:

BED instituted weekly meetings with the line crews to discuss scope of work for projects and how to reduce outage durations while keeping safety in the forefront. In addition, every effort is made to reduce the number of customers affected by outages for system repairs and improvements keeping safety in mind. BED is also monitoring YTD CAIDI and SAIFI on a monthly basis and sharing this information with the line crews.

- AMI Meter Outage Notification to Dispatch:

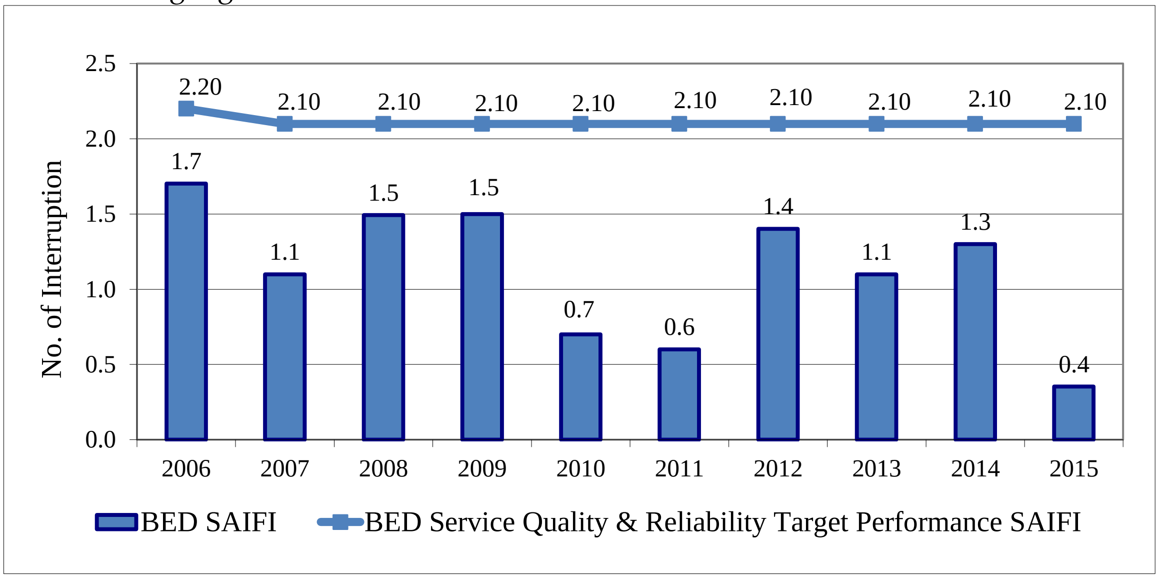
In some instances outages may occur but property owners may not notify Dispatch until they discover the outage upon their return home, which could be hours after the start of the outage. This wasn't an issue prior to AMI meters as the start time of the outage was the time the customer called, now the start of the outage is based on the AMI meters. BED has recently addressed this issue and the AMI meter will now send an email directly to Dispatch when outages occur, with the customer name and location.

- Line Crew Access to Stockroom after Hours:

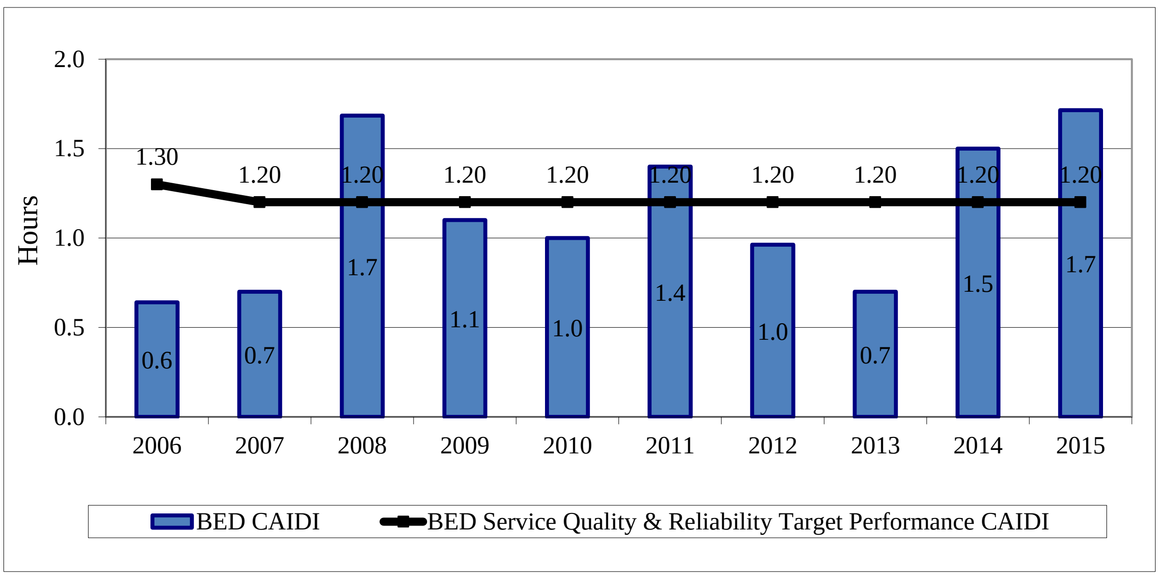
In the event of an outage after normal business hours, BED’s past practice has been to call the stockroom keeper to open the stock room and provide material needed for the repairs. While BED’s practice is to carry stock on the trucks that is normally required to handle common small outages, the line crew may arrive at the shop prior to Stockroom personnel and are required to wait until the stockroom staff arrives to open the doors for material they may need. If our crews are waiting, this increases the time to restore services which impacts the customers even more. BED’s new procedure allows for the line crew to access the material once the stockroom personnel have been called. The line crew can immediately secure needed material to restore the outage. Not having to wait for the stockroom personnel will reduce the outage time.

Going forward, BED plans to explore the possibility of reducing the Service Quality and Reliability target performance SAIFI and increasing the Service Quality and Reliability target performance CAIDI as a result of the increased accuracy of reporting.

The following Figure 2 shows BED's historical SAIFI.



The following Figure 3 shows BED's historical CAIDI.



RELIABILITY IMPROVEMENT PROGRAMS

BED's distribution system is designed to allow for the isolation of a fault to a small section of a circuit and switching the remaining sections of the circuit to alternate feeds prior to making repairs. In addition, BED has several programs in place to ensure that system reliability and power quality remain as high as possible. The following are a few of these programs:

- Distribution System Operating Procedures
- Distribution System Protection
- Wildlife Protectors
- Pole Inspection and Maintenance Plan
- Tree Wire
- Fault Indicators
- Reclosers/SCADA Controlled Switches
- Replacement of Underground System
- 100 and 500 Year Flood Plains
- Underground Damage Prevention Plan

<u>Distribution System Operating Procedures</u>
BED has created contingency plans for the loss of each 13.8 KV distribution circuit and 13.8 KV substation switchgear. These contingency plans are updated annually and used by BED's dispatch center during planned and unplanned outages to expedite restoring service to impacted customers.

<u>Distribution System Protection</u>
Adequate distribution system protection is required to avoid and/or minimize hazards to the public, and BED's line workers, to prevent damage to electric utility infrastructure, to reduce the number of customers impacted by outages, and allow for prompt power restoration. Any time a protective device is installed on a circuit, BED performs a protection study to ensure coordination between the new and existing devices on the circuit.

BED has the following protective equipment installed on the Distribution and Sub-transmission System:

- Circuit Breakers are installed at each end of the 34.5 KV sub-transmission line.
- Distribution Circuit Breakers are installed in each of BED's three substations. These are the primary distribution circuit protection and quickly de-energize an entire circuit to protect the substation transformer from damage.
- Reclosers are similar to circuit breakers but are used as secondary protection mainly on aerial distribution circuits and to tie circuits together.
- Underground distribution switches with protective breakers are similar to circuit breakers but are used as secondary protection on underground distribution circuits and also to tie circuits together.
- Distribution line fuses isolate permanent faults to minimize the size of outages to the smallest possible number of customers interrupted.

- Transformer fuses protect distribution transformers and secondary serving individual or groups of customers.
- Current limiting fuses installed on distribution taps and aerial transformers. These fuses limit the energy released during a short circuit and protect the associated equipment from failing.
- Over-voltage arresters are used for protection of all aerial transformers, capacitors, normally open switches, normal open points, and at each end of primary underground circuits.

BED's specific Sub Transmission Protection strategies include:

- The primary forms of protection for the 34.5 KV line are relays with a high speed line differential scheme on both ends of the line. Relays communicate with each other via fiber, and quickly determine if a fault is within their zone of protection and open the breakers.
- Overcurrent and step-distance relay functions are utilized for backup protection, in case the fiber link between the relays is lost.

BED's specific Distribution Protection strategies include:

- The loading on each circuit is typically kept below 65% of the circuit steady state summer current carrying capability during normal operation and below 80% of relay pickup setting at all operating conditions. This strategy establishes adequate cold-load pickup capability, and allows for the switching of loads between circuits.
- Overcurrent protection includes coordination of circuit breakers, reclosers and fuses. Overcurrent protection is designed to maximize load current, allow for cold load pickup and feeder back up configurations, and maintain sensitivity required to keep the system protected from bolted faults.
- BED utilizes the so called "fuse saving" protection method on all of its overhead circuits. This method allows for breakers or reclosers to operate faster than a fuse attempting to clear the fault without causing a long duration permanent outage. The same breaker or recloser recloses after approximately 8 seconds, attempting to restore the power to the circuit. In the case of a transient fault (squirrel, bird, branch), the fault is cleared at this point and power is restored to all customers. In the case of a permanent fault, the fault is still present and is cleared by the nearest upstream fuse. This method is not used on predominantly underground circuits.
- Most of BED overhead circuits utilize multiple recloser schemes, which improve the capability of minimizing outages and back feeding circuits. Similarly, all BED underground circuits utilize multiple underground switches for the same purpose.
- All BED distribution breakers utilize synchronism check function, eliminating the

potential of connecting non compatible sources and causing a significant outage.

- All new designs for underground systems use protective and/or switching devices at taps from the main line circuit.

BED and VELCO are evaluating the installation of phase reactors at the East Avenue and Queen City transformers to reduce the line to ground and 3 phase fault currents to an acceptable level on BED's distribution system. BED will then be performing a comprehensive coordination study of its entire distribution system, which will include breakers, reclosers, line fuses and transformer fuses. The projected date of completing this study is 12/30/2017.

Wildlife Protectors

BED construction standards include the installation of wildlife protectors on all new exposed transformer, capacitor, and circuit breaker bushings and arresters. In addition, BED has started the installation of static guard protectors on reclosers, switches and disconnects. However, wildlife protectors do not exist on equipment bushings and arresters that were installed prior to the establishment of BED construction standards.

Most of the unplanned outages on BED's distribution system in year 2015 were caused by animal contact (33 outages), and BED is taking active steps to address these outages. BED has identified McNeil Line 1 (1L1), McNeil Line 4 (1L4), and Queen City Line 3 (3L3) as the circuits with a high number of "animal" outages. To improve the reliability of these circuits, BED has identified all exposed equipment on these circuits that are not equipped with animal wildlife protectors, completed the installation of wildlife protectors on 3L3 circuit equipment, and plans to install the wildlife protectors on 1L1 and 1L4 circuit equipment by December 2017.

Pole Inspection and Maintenance Plan

The purpose of BED's Pole Inspection and Maintenance Plan is to identify poles that are damaged, show sign of decay and to take corrective action before the poles fail. BED's pole inspection program visually inspects all distribution and street light wood poles every 7 years and tests the poles that are over 10 years old. Poles are visually evaluated and inspected for cracks, split, and rot and then tested using a resistograph wood pole testing device. All poles that fail the inspection and testing will be labeled as condemned poles and will be replaced.

In 2015, BED completed a comprehensive inspection and testing of all its distribution circuits and street light wood poles. Poles that failed the inspection and testing were tagged indicating condemned. BED has started replacing the condemned poles based on the severity of the inspecting and testing results.

Tree Wire

BED uses covered (tree) aerial wire where appropriate to limit the number of faults caused by tree contact.

Fault Indicators

BED installs fault indicators on the aerial and underground distribution circuits to assist the field crews in locating the fault location. The fault indicators are installed at major junctions to allow the crews to identify the direction of the fault.

Reclosers/SCADA Controlled Switches

Reclosers improve the reliability of upstream customers by protecting them from all downstream faults and allow for quick restoration of downstream customers for a fault upstream of the recloser. BED has installed aerial Reclosers and SCADA controlled switches on its main distribution circuits, normal open tie points and on long lateral taps.

To further improve reliability and expedite service restoration, BED plans to replace the following equipment with reclosers and smart switches:

- Replace switch 342S with a recloser;
- Replace disconnect 346D with a smart switch;
- Replace fused cutout at pole #58 with a recloser; and
- Replace manual switches 144S, 227S, 316S, 343S, 407S, 426S, 815S, 844S, and 917S with smart switches.

Replacement of Underground System

Approximately 47 percent of BED's distribution system is underground. Although underground circuits experience fewer outages than aerial circuits, underground circuits are more difficult to repair and result in outages of longer durations. In addition, some of BED's underground circuits are direct buried. The loss of a direct buried underground circuit will result in long customer outages. BED's capital construction plan calls for the replacement of underground circuits throughout the city in an effort to reduce long duration unplanned outages, improve operating efficiencies, and coordinate with the City of Burlington's Street Pavement Plan. Underground circuits are replaced based on first-hand knowledge of specific problems, age of cable, existing installation (direct buried, availability of spare conduits), type of load, engineering judgment, coordination with DPW pavement plan or city/state road rebuild projects, and budget constraints.

Over the next five years, BED plans to rebuild the old underground system along Franklin Square, Laurel Court, Church Street, and Cherry Street from Battery Street to St. Paul Street, Juniper Terrace, Deforest Road, and Farrell Apartment.

<u>100 and 500 Year Flood Plains</u>

BED's McNeil, East Avenue and Queen City Substations are not within FEMA designated flood hazard areas. This conclusion is based on BED's review of Burlington FEMA FIRM (Flood Insurance Rate Map) 50007C0252D for the McNeil and East Avenue Substations, and FEMA FIRM 50007C0254D for the Queen City Substation.

<u>Underground Damage Prevention Plan</u>

BED's has an underground damage prevention plan that complies with the Public Service Board's Rule 3.800 and 30 V.S.A. Chapter 86. A copy of this plan has been provided to the Department of Public Service outside the IRP process. BED's underground cable locators locate BED's underground facilities. The plan document focuses on the requirements to locate BED's underground facilities upon receiving notification from Dig Safe Systems, Inc., closely monitor BED's own excavation efforts, and manage our damaged infrastructure repairs with an emphasis on employee/public safety and service restoration.

Volt/VAR Optimization

The voltage and VAR flow on BED's distribution system are controlled by the substations transformers LTCs controllers, and fixed and switched capacitor banks on the distribution circuits.

The East Avenue and Queen City Substation transformer LTCs controllers are owned and maintained by VELCO while the McNeil Substation transformer LTC controller is owned and maintained by BED. The East Avenue, Queen City and McNeil Substation transformer LTCs are set to hold voltage between 122.6 V and 124.8 V at the substation 13.8 KV bus. The voltage at the substation transformer LTC is set as low as possible for the summer peak hour while still providing all the customers on each circuit with ANSI C84.1-2011 Range A voltage during normal operation and ANSI Standard C84.1-2011 Range B during contingencies and meeting ISO OP-13 Standards for 5% Voltage Reduction. The East Avenue, Queen City and McNeil Substation transformer LTCs controllers do not allow for multiple voltage settings and 5% Voltage Reduction.

The substation transformer LTCs regulates the 13.8 KV bus voltage for all circuits connected to the substation 13.8 KV bus. As a result, all the distribution circuits fed from the substation transformer have the same voltage set point. BED does not use the Line Drop Compensation

(LDC) for voltage regulation because the transformer LTC regulates the 13.8 KV bus voltage, two large generators (Winooski 1 Hydro and Lake Street Gas Turbine) are connected directly to BED's distribution circuits, and the distribution system is operated in a network configuration when the gas turbine is running.

As discussed in the Optimal Locations of Capacitor Banks section, BED remotely controls the capacitor banks. The SCADA system monitors each circuit's VAR flow and will send an alarm to the system operator when the VAR flow is outside of the set points. One or more capacitors are then either turned on or off to return the VAR flow to within the limits. Two of the three large pad-mounted capacitor banks on the distribution system are controlled by SCADA and also by stand-alone voltage controllers. Recently, BED has started installing stand-alone capacitor bank control units on all aerial SCADA controlled capacitor banks and is connecting them to the fiber system. These controllers would operate independently on each circuit to control the VAR and voltage.

BED plans to replace the existing substation transformer LTCs controllers with new ones that will allow for multiple voltage set points and a 5% Voltage Reduction. The new LTCs controllers would allow BED to operate the distribution system at a at a lower voltage setting during certain months of the year taking into consideration ISO OP-13 Standards for 5% Voltage Reduction. Monitoring of the AMI system voltage information will allow for the LTC parameters to be optimally set and provide feedback to BED to assure the voltage stays within required parameters.

With expanded control of the LTCs and monitoring and control of the distribution capacitors, BED can improve the optimization of the system voltage and VAR flow on each circuit.

Grid Modernization/Distributed Generation/Strategic Electrification

BED's year 2016 base case 90/10 peak load forecast assumed a very low penetration of vehicles chargers and heat pumps load. In the best 90/10 peak load forecast scenario with high penetration of vehicles chargers and heat pumps load, the installation of electric vehicles chargers and heat pumps doesn't add a significant load on BED's distribution system. While in general this small load addition may not impact BED's distribution system main trunk lines, it may create line overloads if the load additions are concentrated on a small radial tap. In addition, depending on the number of electric vehicles and heat pumps being connected to an existing transformer, the total load added may result in an overload on the distribution transformer, secondary wire and/or service wire and require the replacement of the overloaded equipment. BED's AMI system can play a major role in identifying transformers and secondary/service wires that may be impacted by the penetration of the electric vehicles and heat pumps load. Thus the need for our engineering staff to access the MDMS to create load reports on existing transformers becomes important.

The low penetration and small size distributed renewable generation on BED's distribution system has not yet presented operational issues associated with reverse power flow and solar generation intermittency. Depending on the type of connection, size of the proposed units, and total generation on BED's circuit, one or more studies (feasibility, impact, stability, facility) may be required to identify and remedy potential problems. BED has also developed Distributed Generation Interconnection Guidelines that will be posted on BED's website and provided to the applicants. In addition, BED has developed a solar map to show the distributed generation on each circuit and provide a preliminary screening tool to assess BED's circuit capabilities to accept new distributed renewable generation projects.

To support future potential high penetration of electric charging stations, battery storage, and distributed renewable generation, BED will need to further modernize its distribution system. The following are BED's initial initiatives to modernize the distribution system:

- SCADA Upgrade;
- SCADA Redundancy;
- Geographic Information System;
- Asset Management System;
- Solar Map;
- Outage Management System;
- AMI Integration;
- Distribution Automation; and
- Micro Grid

<u>SCADA Upgrade</u>

BED's old Supervisory Control and Data Acquisition (SCADA) system communicates with the equipment RTUs in the field by radio. Communications with many of the field devices were often lost because of the inherent problems of radio frequency operation (i.e. interference from other RF signals, buildings, trees and other obstructions). To improve the reliability of the SCADA system, BED has upgraded its SCADA software system and installed an Ethernet network using a fiber optic cable to transmit data between SCADA and field devices to replace the SCADA radio system.

BED is transferring all SCADA controlled field devices (switches, reclosers, and breakers) to the new SCADA fiber system. This project is expected to be complete by December 2016.

In addition, BED will be expanding the fiber system to all SCADA controlled capacitor banks and transfer them to the new SCADA fiber system. This would allow BED to eliminate the old SCADA radio system.

SCADA Redundancy

BED will be installing a redundant SCADA system in the Lake Street gas turbine building that will provide BED with an alternate dispatch center to operate and restore the distribution system. This is part of BED's plan to develop a Disaster Recovery Site and expected to be completed by June 2018.

Geographic Information System (GIS)

BED maintains a comprehensive, state-of-the-art Geographic Information System (GIS) that includes the primary distribution circuits, secondary system, service wires, transformers, and distributed generations. In addition, customer service points are linked to distribution transformers, significantly simplifying the transformers loading evaluations.

The GIS database will also be used to track BED's assets. The quantities and conditions of all poles and equipment attached on the poles will be stored and maintained in the GIS data base.

Asset Management System

In 2015, BED completed a comprehensive pole survey program to collect data on poles and associated equipment including condition of poles and equipment, pole attachments, street lights, and leased lights. BED is currently transferring the pole survey data into the GIS system. This information will be stored and maintained in BED's GIS system. The survey data will be used in forecasting BED's future maintenance projects.

Solar Map

BED has created an online map showing the distributed generation on each circuit, both active and in the process of becoming active, the distributed generation size and type, and identifying the circuits capability of accepting additional distributed generation. This online map can be used as a preliminary screening tool to assess the ability of BED's circuits to accept new distributed renewable generation projects.

http://www.burlingtonelectric.com/distributed-generation-map

Outage Management System

As part of the implementation of an Outage Management System, BED was to include a data feed to the web site www.vtoutages.com; however, due to the issues with the deployment of new SCADA system field devices, the Outage Management System was not deployed. As an interim measure, BED implemented a feed based on the outage notification capabilities of its Itron AMI meters. That feed went live, automatically updating the vtoutages.com site, in November of 2016.

It should be noted that this system has a limitation compared to a more full featured Outage Management or Distribution Management System in that it will not be able to count meters where outages are not reported by the AMI system. This situation would result from either a mesh network meter being out of communication during the outage ("islanded" without a communication path and thus unable to report), or due to the customer having opted out of AMI metering. As a result, the reported information would likely represent a lower number of customers without power, with the relationship being dependent on the size of the outage. For example, if a single meter reports an outage, it is likely that is very close to the extent of the outage. However, if the full system were out, the reported count would be low by the number of non-AMI and "islanded" meters.

BED has recently completed its SCADA upgrade and will now be able to undertake a comprehensive examination of Outage Management and Distribution Management Systems. This project will be one of several initiatives undertaken as part of a 5 year information technology plan. Specific timing of projects has not yet been finalized, but based on current assumptions it is likely this specific element would not occur until 2019.

AMI Integration

BED has completed the deployment of its advanced metering infrastructure (AMI) meters across its entire service territory replacing nearly 19,484 of the 20,356 electric meters with advanced AMI meters. The remaining meters on BED's system are 445 Automated Meter Reading (AMR) meters and 427 non AMI/AMR meters. The next step is to establish a link between meter accounts and the transformer supplying these accounts, integrate the GIS system and/or customer information system (CIS) with the MDMS and then develop appropriate reporting tools. This will allow the engineering staff to access the MDMS to create load reports on existing transformers and size future transformers.

In addition to transformer sizing, BED will be investigating the development of a system that will use the AMI meter capability to provide BED's dispatch center with real time outage notification. The goal of this system is to improve outage response time and shorten outage duration. BED will also be investigating the integration of the AMI meter information with potential addition of Distribution Management System.

Distribution Automation

BED's SCADA system allows BED to collect operational and planning data, and remotely control and operate key field devices such as breakers, reclosers, switches, capacitor banks, and transformer load tap changers (LTCs). The SCADA system increases customer satisfaction through reduced service interruptions, less customer down time, and improved quality of supply.

BED has replaced all of its substation electromechanical relays with microprocessor-based relays. The protective devices associated with substation breakers, reclosers, and underground switches allow temporary faults to be removed from the system before automatically restoring normal service. In conjunction with fuses, the protective devices give BED the capability to limit permanent faults to the smallest possible number of customers. These devices have greatly increased BED's ability to isolate faults, clear temporary faults, reduce the number of customers impacted by outages and restore service more quickly to customers when outages do occur.

BED has installed reclosers on its aerial distribution circuits to isolate the faulted part of a circuit, and improve reliability. These reclosers are also controlled by the SCADA Operators.

BED has installed pad-mounted switches with means to automatically transfer critical customer load from a faulted circuit to a different circuit within seconds. In addition, BED has installed pad-mounted switches with protective relays on its underground distribution circuits to isolate the faulted part of a circuit, and improve reliability. These switches are also controlled by the SCADA Operators.

BED plans to install new and replace/upgrade existing aerial switches and disconnects with Reclosers and SCADA controlled “smart” switches as discussed in section 4.1.7. These devices will be able to provide real time information such as amps, KV, KW and KVAR.

BED is installing stand-alone capacitor bank voltage and VAR control units on all aerial SCADA controlled capacitor banks. These controllers would operate independently on each circuit to control the VAR and voltage. The controllers are also controlled by the SCADA Operators. This project is expected to be complete by June 2017.

BED plans to replace the substation transformer LTCs controllers with new ones that will allow for multiple voltage set points.

Additional steps toward Distribution Automation, includes investigating the deployment of Distribution Management System and integration with AMI system.

Micro Grid System

BED is currently investigating the installation of micro grid systems at the Burlington International Airport to improve the reliability of power to the Airport and at BED's Pine Street facility which is designated as the City's emergency operation center. The micro grid systems would take advantage of the existing solar arrays, existing back-up generators and potential energy storage system such as batteries.

Emergency Preparedness and Response

BED participates in the statewide emergency preparation conference calls. Based on the available information from these calls, BED assesses the appropriate response to an anticipated event and responds appropriately. If additional crews are needed, there are sources available to BED. First, BED is a member of the Northeast Public Power Association's Mutual Aid program (NEPPA) and as a result has access to numerous Municipal utility crews in the northeast. Second, BED would reach out to Green Mountain Power (GMP) to provide aid. In the event that BED needs are not met through either the NEPPA Mutual Aid program or GMP, BED would reach out to utilize contract crews.

Currently VTOutages is updated automatically when outages occur and during system restorations as described in the Outage Management System section above.

BED currently contacts customers for planned outages using several forms of communication. Customers are contacted directly by using phone calls, emails, letters or the use of door hangers. Customers are contacted well in advance and reminders are sent before the date of the planned outage. In the event of unplanned outages, customers can contact BED during normal business hours for information and the dispatch office after hours. Voice messages are used to let customers know that an outage is occurring and that crews are responding.

Utilities Coordination

BED coordinates pole installations and construction of underground distribution projects with COMCAST, FAIRPOINT, and Burlington Telecom. This coordination between utilities cuts costs through sharing of trenching costs, repaving, permit fees, etc. and also expedites the transfer from old installations to new ones.

In addition, BED coordinates its underground construction projects with City of Burlington Department of Public Work street paving plan to eliminate the City excavation fees when trenching in the road.

Track Transfer of Utilities

BED uses the NJUNS database to track transfer of utilities and dual pole removal.

Relocating Lines to Roadside

In the process of re-building BED's old aerial lines located behind private properties, BED evaluates the feasibility and cost of relocating these lines into the City right-of-way along the roadway and sidewalk areas. Typically, these relocations take many years to complete due to the scope of work, need for securing easements, and cost for potentially placing the lines underground (the cost of placing BED's lines underground within a paved portion of a City street includes a City Administrative and Excavation fee of approximately $24 per square foot).

Vegetation Management Program

The purpose of BED's Vegetation Management Program is to maximize employee and public safety, and minimize power outages associated with tree contacts with BED distribution circuits.

BED has adopted a tree trimming program based on outage history, right-of-way requirements and constraints, as well as the associated rates of growth for the particular tree species indigenous to the City of Burlington.

BED has approximately 130 miles of aerial and underground distribution circuits and has divided the City into three maintenance sectors. Every three years a sector is given priority and our trimming efforts are concentrated in that area. In addition, BED augments its trimming cycle program by identifying specific areas of need through inspection patrols, outage reports, feedback from customers and BED employees, as well as other agencies such as the Burlington Parks and Recreation Department.

During our trimming cycles, BED's inspector and tree trimming contractors will document any danger trees outside the right of way. BED would then work with the City of Burlington's resident Arborist and private property owners on the removal of these trees.

The City of Burlington's resident Arborist contributed the following information about the various species of trees and their associated growth rates. According to the City Arborist these same growth rates apply to pruned branches of healthy trees. The growth rates, however, do slow whenever the health of a tree is compromised.

Species	Growth Rate	Growth Rate After Pruning (assuming healthy tree)
Ash Species	Fast	Fast
Birch Species	Medium	Medium
Box Elder	Fast	Fast
Cedar, White	Medium	Medium
Cherry, Black	Medium	Medium
Cherry, Ornamental	Fast	Fast
Crabapple Species	Medium	Medium
Elm, Species	Fast	Fast
Hackberry	Medium/Fast	Medium/Fast
Honeylocust	Fast	Fast
Hawthorn Species	Medium	Medium
Ginkgo	Slow	Slow
Linden, Species	Medium/Fast	Medium/Fast
Locust, Black	Medium/Fast	Medium/Fast
Maackia, Amur	Slow	Slow
Maple, Amur	Medium	Medium
Maple, Hedge	Slow	Slow
Maple, Norway	Fast	Fast
Maple, Red	Fast	Fast
Maple, Sugar	Medium	Medium
Maple, Tatarian	Slow/Medium	Slow/Medium
Oak, Red	Medium	Medium
Oak, White	Slow	Slow
Pine, White	Fast	Fast
Pear, Ornamental	Fast	Fast
Spruce, Species	Slow	Slow
Willow, Species	Fast	Fast

BED utilizes standard pruning, flat cutting and brush mowing techniques in its vegetative management program. BED has selected these types of vegetative management controls in an effort to minimize our environmental impact as well as comply with a City ordinance prohibiting the use of chemical herbicides.

BED mainly employs the services of the Burlington Parks Department, qualified independent tree trimming contractors, and its own line workers to carry out its vegetation management program.

The "tree" outages in year 2015 were approximately 2.2% of BED's total outages compared to the 5 year average of 3.7% and 10 year average of 4.2%. BED experienced approximately 26% less "tree" outages in 2015 compared to the 5 year average (4 in 2015 vs. the 5 year average of 5.4), and 43% less "tree" outages in 2015 compared to the 10 year average (4 in 2015 vs. the 10 year average of 7). BED's vegetation management plan has been successful in reducing the number of outages caused by "tree" contact. BED feels that we have achieved the appropriate ratio of spending to outcome and will continue to budget one hundred thousand dollars per year for vegetation management.

BED maintains a vegetation management tracking database that identifies the employee overseeing the project, the circuit number, the date and location as well as what entity performed the work.

The following table provides the total miles of BED's distribution system, miles needing trimming, and trimming cycle:

	Total Miles		Miles Needing Trimming		Trimming Cycle	
Transmission						
Distribution	130		71.6		3-years	
	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019
Amount Budgeted	$60,000	$100,000	$100,000	$100,000	$100,000	$100,000
Amount Spent	$76,756	$105,161	Expected amount $100,000			
Miles Trimmed	About 23.8	About 23.8	About 23.8	24.5	23.7	23.4

Studies & Planning

Long Range Planning Study

In year 2015, BED performed a long range planning study to evaluate the impact of UVM's proposed 5,900 KW peak load addition on the distribution system (UVM Revised Future Electric Load Summary document dated September 24, 2015). This new load was incorporated into BED's year 2012 90/10 peak load forecast w/DSM. The modified peak load forecast resulted in BED's peak load of approximately 74.5 MW in year 2019, and 81MW in year 2032.

Two cases corresponding to a distribution system load level of 74.5 MW in year 2019, and 81

MW in year 2032 were analyzed for the loss of each source - East Avenue, Queen City, and McNeil Substations.

The projected load on East Avenue Line 4 (2L4) circuit of 12.3 MW for the 74.5 MW case exceeds the allowable loading of 9.5 MVA during normal operation and creates line overloads during contingency analysis. The results of the analysis for the 74.5 MW case showed the need to re-configure BED's distribution system at Substation #3 to address 2L4 line overloads during contingency analysis; add a 600 KVAR capacitor bank at 3L1 circuit to address low voltage at 3L1 circuit for loss of 2L3 circuit; and add a 2,400 KVAR capacitor bank at 2L4 circuit to address low voltage along 2L4 circuit for loss of East Avenue Bus#4.

The results of the analysis for the 81 MW case showed the need to extend 3L2 circuit from Main Street near the water reservoir to the new UVM Chiller project to address 2L5 circuit overload for back-feeding loss of East Avenue Switchgear Bus#4 load from Queen City and McNeil Substations circuits.

The re-configuration of BED's distribution system, addition of a 2,400 KVAR capacitor bank and extension of 3L2 circuit are needed to support the UVM projects. The cost estimate for these upgrades ($315,715) was provided to UVM as part of BED ability to serve this new load. The table below provides a cost breakdown for these upgrades:

Project	**2015 Cost**
Reconfigure BED's System	$46,318
Install 2,400 KVAR capacitor bank at the Chiller Switch	$176,545
Extend 3L2 from Sub #3 to the Chiller switch	$92,852
Total	$315,715

The 600 KVAR capacitor bank is needed on BED's system regardless of the UVM projects to address low voltages on 3L1 circuit for the loss of 2L3 circuit in year 2019. The cost estimate for this capacitor bank is approximately $41,000.

<u>Updated Load Projections</u>

BED's year 2016 90/10 peak load forecast w/DSM shows BED's distribution system peak load at approximately 70.85 MW in year 2019, and 69.26 MW in year 2032. This updated load forecast is lower than the load forecast used in the long range planning study. However, the upgrades identified in the long range planning study are still needed to address UVM new 5,900 KW load projects that will be added to 2L4 circuit.

On April 29, 2016, UVM provided BED with a new peak load addition projection of approximately 4,808 KW. The new load projection represents a reduction of 1,092 KW from the previous load projection of 5,900 KW. The re-configuration of BED's distribution system is still needed with the UVM updated load projection. BED's 2016 peak load forecast and the new UVM load projection may impact the size of the capacitor bank. A new analysis would be needed to determine the size of this capacitor. The UVM 1,092 KW peak load reduction would eliminate the need to extend 3L2 circuit from Main Street to the UVM Chiller vault.

List of Capital Distribution System Projects

a) The following is a list of BED's capital distribution system projects that were constructed between FY13 and FY16:

- Curtis Avenue, Starr Farm, Sunset Upgrade 13.8KV
- Lake Street Extension
- Rebuild 13.8 KV Queen City to Velco
- Rebuild Circuit (3L4) Austin Dr to Lakeside Avenue
- Convert GMP's Line to BED's Circuit
- Rebuild North Avenue Circuit (Leddy-Starr Farm)
- Replace Poles at Green Street
- Upgrade 4.16 KV to 13.8 KV Cottage Grove
- Upgrade 4.16 KV to 13.8 KV West Road
- Upgrade Saratoga Avenue (4.16 KV to 13.8 KV)
- Waterfront North Access St. Lighting
- Waterfront Access Improvement
- Rebuild the underground feed to Champlain School
- Cherry Street (Rebuild utility hole)
- Rebuild the Underground System at Deforest Heights
- Rebuild the Underground System at Leonard Street
- Rebuild the Underground System at Redrock Condominium
- Rebuild the Underground System at Sandra Circle
- Rebuild the Underground Service to BED's Building
- Upgrade Utility Holes Downtown
- Utility Holes Upgrade
- Relocate BED Lines @ UVM Cage
- UVM MC-Relocate BED Circuit EA
- UVM MC-Relocate BED Circuit UH 344-365
- CCTA - St. Paul Street New 3-Phase Service

- Dispatcher Console
- Electric Vehicle Charging Station
- Install Capacitor Bank Control Units
- Microprocessor Relay
- Municipal EV Charging Stations
- Outage Management System (GIS)
- Phase Identifying Tool Replacement
- Pole Survey
- Reconstruction of Lake Street Facility
- Removal of Substation #1 & #6
- Replace Queen City Sub Switchgear
- SCADA Security Computer Hardware
- SCADA Security Hardware
- Fiber Optical Time Domain Reflectometer
- Solar Project at the Airport
- UVM Charging Stations
- UVM Projects
- Other (pole attachments, replace cables at St Paul Street, replace poles on Green Street, & various small projects)
- American Recovery & Reinvestment Act (ARRA)
- Distribution Plant - Blankets
  Aerial
  Distribution System Transformers
  Fiber Optic Emergency Repair
  Field Device Component (RTU)
  GPS Survey Unit
  Lighting
  Meters
  Secondary Services
  Substation Maintenance
  Substation Maintenance/RTU Upgrades
  Tools & Equipment
  Underground
  Wind Turbine

b) The following is a list of BED's capital distribution system projects planned for the next 3 years:

- UVM Chiller Project
- Convert GMP Line to a BED Circuit
- Replace Lafayette Switch
- South Forty Project

- Install Animal Guards & Replace Porcelain Cutouts
- Replace the aerial & underground system at Harrington Terrace
- Rebuild the aerial circuit at Manhatten Drive from pole P1845 (Walnut Street) to P1979 (Park Street)
- Replace Condemned Poles
- Install Capacitor Banks Control Units
- Install a 600 KVAR aerial capacitor Bank
- Rebuild underground at Jackson Court
- Replace switch 342S with a recloser (S. Union Street)
- Replace the underground system at Franklin Square
- Provide a line extension to UVM New Dorm Project
- Install an interface between the distribution simulation software (CYME) and the GIS
- Install a SCADA controlled switch module at switch 343S (Maple Street & S. Willard Street)
- Replace the underground cables (#2 copper) along Church Street
- Replace condemned poles
- Install Animal Guards & Replace Porcelain Cutouts
- Rebuild BED's aerial circuit at Lake Street bikepath from Pole P2812 (Leddy Park Road) to 124S at Pole P2824 (Stanniford Road)
- Replace the underground system at Laurel Court (Off Shore Road)
- Replace the underground cable (#2 aluminum) along Cherry Street between Church Street and S. Winooski Avenue
- Replace the underground system at UVM Living & Learning
- Replace fused cutout at pole #58, Austin Drive, with a recloser
- Install a SCADA controlled switch module at switch 316S P233 (Pine Street)
- Replace disconnect #346D (normal open point between 3L1 & 3L2) with a SCADA controlled switch
- Replace the underground system on Cherry Street from Macy's Parking Lot to St. Paul Street
- Rebuild the aerial circuit at Appletree Point (Pole P3412 to Pole P3434) from 4.16 KV to 13.8 KV
- Replace the underground feed to Burlington High School
- Replace the underground system at Juniper Terrace (Off Summit Street)
- Replace the underground system at Deforest Road
- Rebuild the aerial circuit at Latham Court (Off Colchester Avenue)
- Rebuild the aerial circuit at Starr Farm Road and Sunset Cliff (Pole P3706-Pole P3723) from 4.16 KV to 13.8 KV
- Replace old reclosers with new ones
- Distribution Plant – Blankets
- Distribution Transformers
- Street Lighting

Maintenance & Implementation of System Efficiency

Through the strategies and procedures described above, BED proactively maintains the efficiency of its distribution system. BED's commitment to linking software and equipment together will further enhance the automation of efficiency efforts and will improve our ability to operate the system as efficiently as possible in the future.

Implementation of Distribution Efficiency Improvements

The following summarizes BED's cost effective efficiency projects and implementation timeline:

- Balance the load between 1L1, 2L5, and 3L2 circuits. This project has been implemented.
- Reconductor the existing three phase 4/0 AL aerial 13.8 KV circuit along North Avenue between pole P3083 (Leddy Park Road) and pole P3131 (Starr Farm Road). This project has been completed.
- Conversion of the remaining 4 KV taps on Appletree Point, Sunset Cliff, and Pearl Street to 13.8 KV. This project is expected to be complete in the next 5 years contingent on BED obtaining easements from private property owners.
- Create 3L5 circuit using GMP disconnected line. This project is scheduled to be complete by June 2017.
- Reconductor the existing three phase 336 AL aerial 13.8 KV circuit along Manhatten Drive between pole P1845 (Intervale Road and Walnut Street) and pole P1979 (Park Street) with larger size wires 556 AL. This project is scheduled to be complete by June 2017.
- Investigate the possibility of implementing multiple voltage set points at the substation transformer LTCs controllers.