C. Transmission and Distribution Projects

This appendix describes the transmission and distribution projects that have been completed since our 2014 IRP, projects that are underway, and projects that we plan to start after 2020.

PROJECTS COMPLETED SINCE THE 2014 IRP

Barre North End Substation Rebuild

After retiring the Barre substation in 2014, three substations—Barre North End, Barre South End, and Websterville—remained as the primary supplies to Barre area distribution. Each substation was supplied from the 34.5-kV subtransmission system, which in turn, supplied distribution circuits at voltages of 2.4 kV, 4.16 kV, and 12.47 kV; each also had asset management concerns impacting the equipment's reliability.

A Vermont Public Service Board Order in Docket No. 8069 required us to examine rebuilding and relocating the Barre South End substation as well as converting all area substations to 12.47 kV to improve reliability in the Barre area. We are designing the Barre South End substation with a 15/28-MVA transformer and three circuits to provide complete feeder backup to nearby substations, which will significantly improve reliability for local residents and businesses. This necessitated rebuilding the Barre North End substation as well as rebuilding the Websterville substation.

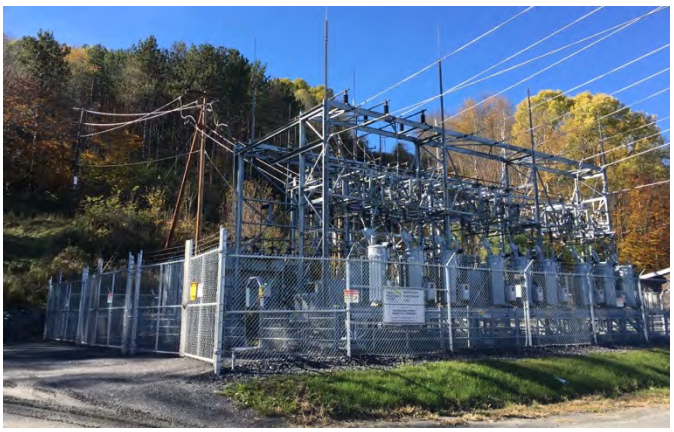

Figure C-1. Rebuilt Barre North End Substation

To rebuild the Barre North End substation, we created a new substation yard with a gravel parking area, fence, steel structures and foundations, oil containment system, ground grid, conduit system, cable trench system, yard stone, emergency fence lights and a security system. We installed a 34.5-kV circuit breaker, two 34.5-kV motor-operated load break switches, three 34.5-kV bus voltage transformers and fuses, one 15/28-MVA 34.5-kV-to-12.47-kV power transformer, one 15-kV load break switch, three 15-kV circuit breakers, three 15-kV bus voltage transformers, three 15-kV line voltage transformers, eighteen single-blade disconnects, nine 438A voltage regulators, three relay and communication equipment enclosures, one AC station service with associated AC panel, one 48V-DC battery bank, charger, and a DC panel.

The new Barre North End substation enables full feeder backup to the new Barre South End substation and partial feeder backup to the Berlin substation.

Project completion: May 2018.

East Middlebury to Smead Road Line Upgrade

A 46-kV subtransmission line runs from the East Middlebury substation for approximately one-half mile to the Smead Road substation, then for another three miles to the Silver Lake Hydro station (in Salisbury). The first half-mile section is conductored with 4/0 Aluminum Conductor Steel-Reinforced (ACSR, installed in 1954) and has aged pole plants; the three-mile section is conductored with 4/0 ACSR (installed in 1937), but with pole plants in good condition.

The VELCO Connecticut River Valley Study, which focuses on the need to upgrade the VELCO Coolidge to Ascutney 115-kV transmission line, shows that these two subtransmission lines are overloaded following certain contingencies on the VELCO transmission system. These post-contingency overloads expose the Connecticut River Valley to low voltages and possible voltage collapse.

To address these post-contingency thermal constraints and enhance reliability, we replaced the aged pole plants with new ones and installed a larger 477 ACSR conductor in the section from East Middlebury to Smead Road. We determined that the remaining

three miles were adequate for current conditions and do not require reconductoring. Project completion: October 2016.

Georgia Interconnection Subtransmission Replacement

Our subtransmission system in northwest Vermont includes networked 34.5-kV lines bounded by the towns of St. Albans, Milton, Fairfax, Johnson, and Lowell. Its current summer peak of 83 MW is forecasted to be 101 MW by 2024. Three interconnections supply the system:

- VELCO 115-kV-to-34.5-kV substations at Nason Street (in St. Albans) and in East Fairfax.
- A 34.5-kV line from the Johnson, Lowell, and Stowe areas.
- Local hydro generators at Milton, Peterson, Clark Falls, and Fairfax.

The VELCO supply, however, contained a number of deficiencies:

- Loss of the Nason Street source resulted in significant voltage and thermal violations at various points in our subtransmission system.
- Loss of the East Fairfax source also resulted in thermal overloads and widespread undervoltages.
- Loss of the 34.5-kV subtransmission line between the Nason Street substation and the Ben & Jerry's substation results in undervoltage at the Ben & Jerry's substation.

To address these deficiencies, we installed a new 115-kV-to-34.5-kV supply into the subtransmission system with an interconnection at Ballard Road in the Town of Georgia. To complete this project, we:

- Installed a new 56-MVA, 115-kV-to-34.5-kV transformer at the VELCO Georgia substation together with oil containment and associated switchgear and controls.
- Built a new Ballard Road switching station, comprised of three-circuit breakers and associated foundations, relaying, disconnect switches, control building, and SCADA that interconnected the VELCO source to the our subtransmission system.
- Erected a new two-mile-long, 34.5-kV subtransmission line (located within an existing VELCO transmission line right-of-way) from the VELCO Georgia substation to the Ballard Road switching station.
- Reconductored the five-mile-long Milton to St. Albans 34.5 kV subtransmission line.
- Installed a new 5.4-MVAR, 34.5-kV capacitor bank at the VELCO East Fairfax substation.

Project completion: May 2015.

Gorge Substation Voltage Conversion

The Gorge substation is a 34.5-kV switching facility and peaking hydro facility located on the Winooski River. This substation also serves approximately 600 distribution customers in Colchester, Winooski, and South Burlington. Rapid growth in the surrounding area overloaded a 12.47-kV circuit from our Essex substation, limiting our ability to serve existing and new loads or to provide feeder backup in the area.

Figure C-2. Gorge Substation

To mitigate these constraints, we removed the 7-MVA, 34.5-kV-to-4.16-kV transformer as the supply to the distribution circuits (but kept it as a generator step-up unit) and replaced it with a 10/14-MVA, 34.5-kV-to-12.47-kV transformer together with associated voltage regulators, station service transformers, and surge arresters. We also converted two 4.16-kV distribution circuits to 12.47-kV. We also created a footprint and take-off structure to accommodate a new 16Y3 feeder to serve load in Winooski. (See "Winooski 34.5-kV Feeder Addition" on page C-10 for details.)

The conversion relieved the overloaded Essex circuit, increased capacity to serve existing and new load, corrected low voltages, increased operational flexibility, and greatly enhanced feeder backup between the Gorge, Essex, and Ethan Allen substations. In addition, the conversion enables us to defer the construction of a new 115-kV-to-12.47-kV substation in the Susie Wilson Road area of Essex.

Project completion: July 2015.

Graniteville and Wetmore Morse Substations Rebuild

The Graniteville and Wetmore Morse substations supply load to the granite quarries and surrounding area in Barre Town. The 90-year-old, 3-MVA, 34.5-kV-to-2.4-kV transformer bank at Graniteville and the 1.5-MVA, 34.5-kV-to-2.4-kV transformer bank at Wetmore Morse were both aged and near the end of their useful lives.

To address these aged facilities and improve reliability, we rebuilt the Graniteville substation with new components that included a 7.5/10.5-MVA, 34.5-kV-to-12.47-kV transformer, an oil containment system, and associated bus work and foundations together with new distribution feeder circuit breakers, voltage regulators, security system, and a control cabinet. This larger transformer enables quarry-area motors to start

without voltage flicker, and allows for future backup of the Websterville substation. We also converted the 2.4-kV distribution line between the two substations to 12.47-kV to supply Wetmore Morse loads from the rebuilt Graniteville substation. Wetmore Morse substation was retired and the Wetmore load is now fed off the 61G1 (Websterville) circuit. The new Graniteville 12kV circuits was able to pick up majority of the existing 61G1 circuit heading to Williamstown.

Project completion: July 2017.

Highbridge to Lafayette (Line 92) Subtransmission Line Reconductoring

VELCO's analytical studies that supported its 2016 Long Range Plan identified the Highbridge to Lafayette 46 kV subtransmission path as potentially overloading to a very serious degree under credible first contingencies, which violates our transmission line criteria. These overloads were 139% of normal summer rating—high enough to pose both reliability and safety concerns.

As a result, we reconductored approximately 2.35 miles of the subtransmission line from 336 ACSR to 795 ACSR.

Project completion: March 2017.

Marble Street to Danby Subtransmission (Line 36) Line Reconstruction

In 2011, CVPS acquired the assets of Omya's Vermont Marble Power Division (VMPD), which we subsequently acquired from CVPS in 2012. One of those assets is a 46-kV subtransmission line from the Marble Street switching station in West Rutland to the Danby substation (which solely serves the Danby Imperial Quarry with approximately 500 kW of load).

That line contained structures installed between 1938 and 1951 together with #2 ACSR, and suffered from aging poles, crossarms, and insulators, all making the line vulnerable during storms. Terms of the acquisition required CVPS to reconstruct the line by 2016—an obligation that we inherited.

As such, we rebuilt the subtransmission line by installing new poles, crossarms, and insulators. While we reused the existing conductor, we redesigned the line to accept a larger capacity 477 ACSR conductor in the future.

Project completion: July 2016.

Marshfield Substation Rehabilitation

The aged Marshfield substation had numerous problems: clearances that do not meet modern code requirements, obsolete equipment, a transformer with limited ability to support load growth, a 4.16kV distribution voltage that could not back up the adjacent 12.47-kV feeder originating from the Plainfield substation, an inability to accept a mobile transformer, and a 34.5-kV distribution feeder that could not be adequately protected during certain system conditions and maintenance procedures.

To correct these deficiencies, we:

- Installed a new 6-MVA, 34.5-kV-to-4.16-kV generator step-up transformer, new steel structures, foundations, fence, and oil containment.
- Added a second 34.5-kV distribution circuit recloser that adequately protects the circuit under certain system conditions and maintenance procedures.
- Retired a 4.16-kV feeder, moving its load to an adjacent 12.47-kV feeder out of the Plainfield substation.

These upgrades not only improve reliability and enhance safety, but also enable growth on the distribution system.

Project completion: March 2015.

Sharon Substation Upgrade

Existing solar generation combined with a generation from new large solar project exceeded the top nameplate rating of the existing Sharon substation transformer, thus prompting the need to increase the transformer's capacity. In addition, aging infrastructure at the substation needed upgrading to improve safety and reliability.

We installed a new 7.5/10-MVA transformer, replaced the existing 35-year-old 15kV breaker with a new ABB RMAG circuit breaker; raised the existing distribution steel to increase clearances; added new yard stone, ground grid, new 7200V line voltage transformer and fuse, and alternate station service; and upgraded the existing protective relaying to include line voltage sensing and SCADA control of new voltage regulators.

Project completion: May 2018.

South Brattleboro Substation Upgrade

We upgraded the two transformers at the South Brattleboro substation to address aging infrastructure and provide feeder backup for the area. The previous 54-year-old, 3.75-MVA, 69-kV-to-12.47-kV transformer fed two circuits; the 27-year-old. 14-MVA, 69-kV-to-12.47-kV transformer also fed two circuits; both had limited capacity for feeder backup.

We upgraded both transformers by installing one new 28-MVA, 69-kV-to-12.47-kV transformer, oil containment, a 69-kV high-side circuit breaker and associated fence, ground grid, communications, and security. In addition, we installed three distribution circuits with associated circuit breakers and voltage regulators, and larger voltage regulators to allow for greater flexibility with circuit ties during planned outages and contingencies.

Project completion: February 2018.

South Poultney Substation Upgrade

Asset management combined with safety concerns prompted an upgrade to the South Poultney substation. The three single-phase transformers were almost 100 years old. As a result, we upgraded the substation to a 2,500-KVA 46-kV-to-12.47/4.16-kV power transformer with a new oil containment system, and installed a ground grid system, a perimeter fence, and a security system to prevent unauthorized entry.

Project completion: September 2018.

Wallingford Substation Transformer Upgrade

The Wallingford substation's 5/7 MVA transformer, relocated here when the substation was reconstructed in 2002, fed one circuit (#23) with three 328-amp voltage regulators. We upgraded the substation because the infrastructure was aging, and to increase its capacity, efficiency, and reliability.

We removed the existing transformer and installed a new 7.5/10.5-MVA transformer, three 46kV single-blade disconnects with a new pole, upgraded to 438-amp voltage regulators, and installed a new 15kV RMAG distribution circuit breaker, three 46-kV fuses, a new relay and control panel, a 15-kV line voltage transformer, and a security system.

Project completion: April 2016.

Waterbury Substation Relocation and Replacement

In 2011, Tropical Storm Irene caused significant flooding of our Waterbury substation, then located in a FEMA-designated 100-year floodplain at 48 Winooski Street. We realized we needed to relocate the substation, and to redesign and rebuild it for two reasons: One, significant load growth in the area from several large customers (including the State of Vermont and Vermont Coffee Roasters); and two, the need to provide feeder backup because the area's 4.16-kV feeders were approaching capacity and could not be backed up by the Waterbury Center substation because the feeder voltages are dissimilar. (The previous Waterbury substation included a 10.5-MVA, 34.5-kV-to-4.16-kV transformer, voltage regulators, and three 4.16-kV feeders; the Waterbury Center substation contains a 14-MVA, 34.5-kV-to-12.47-kV transformer, voltage regulators, and two 12.47-kV feeders.)

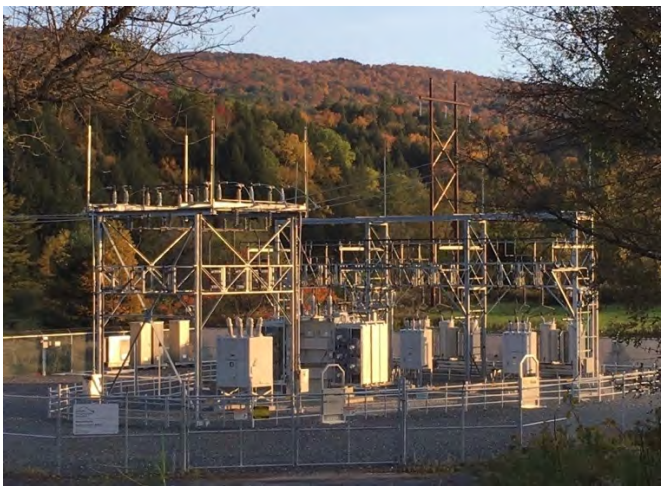

Figure C-3. Waterbury Substation: Relocated and Replaced

The new Waterbury substation comprises one 15/28-MVA, 34.5-kV-to-12.47-kV transformer, a high-side circuit breaker, motor-operated load break switches for transmission line sectionalizing, oil containment, three distribution circuits with associated circuit breakers, voltage regulation at each feeder, and SCADA. We also converted area feeders from 4.16 kV to 12.47 kV. The new substation is located along Vermont Route 100 (outside of the flood plain) adjacent to our Middlesex to Duxbury Switch 34.5-kV subtransmission line.

Replacing the substation and converting the area's feeders enables the two area substations to back up each other, lowers distribution line losses, accommodates new loads, and enhances the accommodation of distributed generation installations.

Project completion: December 2015.

White River Junction Substation Replacement

Our White River Junction substation and Wilder substation both feed the local area. Our recent upgrade to the White River Junction substation and its associated distribution system from 4.16 kV to 12.47 kV (for load growth and partially backing up circuits from the Wilder substation) proved inadequate. Larger load growth, limitations on the non-

standard 13.8-kV transmission supply from the National Grid Wilder substation hydro generation bus, and limited feeder backup all contributed to this inadequacy.

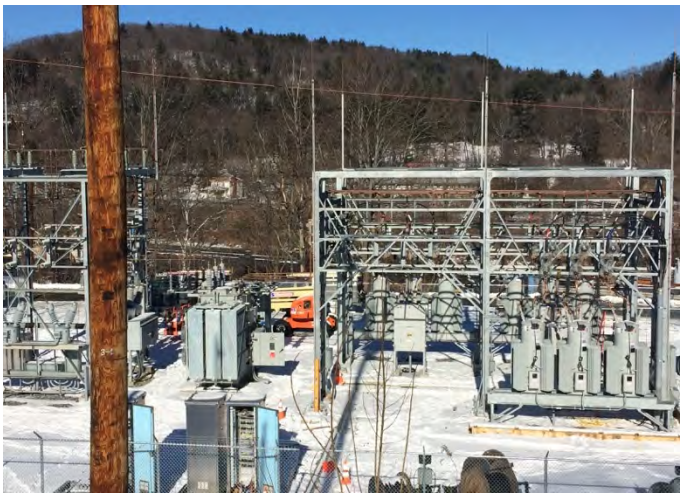

Figure C-4. White River Junction Substation During Construction

As a result, we have replaced the White River Junction substation. The new substation, located on the existing Lantern Lane site (albeit expanded), comprises a 15/28-MVA, 46-kV-to-12.47-kV transformer, oil containment, high-side circuit breaker, 5.4-MVAR capacitor bank, three distribution circuits (with space for a fourth circuit), voltage regulators, and SCADA control.

We replaced the existing, non-standard 13.8-kV transmission line (that traverses rugged and hard-to-reach terrain) with a new 2.5-mile, 46-kV transmission line, overbuilt on distribution. Located along Old River Road in Hartford, the new line taps the Hartford to Taftsville 46-kV line to supply the substation.

Project completion: January 2016.

Wilder Subtransmission Switching Station Upgrade

Our Wilder subtransmission switching station contains a 46-kV single-circuit breaker that ties the National Grid Wilder substation to our 46-kV subtransmission system in Hartford. The substation needed upgrading because much of the equipment was either near the end of its useful life, some replacement parts were unavailable, and current codes or design standards were not met.

We replaced and installed a new outdoor relaying cabinet including new SCADA and communication equipment; a 25KVA station service transformer including steel pedestal and concrete foundation; AC & DC distribution panels; a 48VDC battery bank with charger; new insulators for all bus work, disconnects, and air breaks; and lightning arresters for B-40 line termination, and upgraded the substation ground grid. All new equipment is within the existing switching station fence. This equipment modernization enables us to properly operate the substation, and improves its safety and reliability.

Project completion: December 2015.

Winooski 34.5-kV Feeder Addition

Two 34.5-kV feeders used to serve the Winooski load: the 46Y1 feeder (originating at the Winooski substation) and the adjacent 36Y5 feeder (originating at the Ethan Allen substation in Colchester) which provided only partial backup. As such, we added a third 34.5-kV feeder to provide full-time backup originating at the recently converted Gorge substation.

To add the new feeder, we rebuilt one-half mile of the existing 3309 transmission line between the Gorge substation and the downtown Winooski redevelopment area, upgrading the 3309 transmission conductor and installing the underbuilt 16Y3 feeder. We also upgraded the Gorge substation with a circuit breaker, reactor, and voltage regulators to accommodate the new feeder.

As a result of adding this new feeder, we improved reliability, created a full-time feeder backup, enhanced the thermal performance of the 3309 transmission conductor, replaced aged equipment, reduced line losses, enhanced area voltage performance following certain contingencies, and deferred the need for another substation in the area.

Project completion: December 2015.

Woodford Road Substation Upgrade and Pickett Hill Substation New Construction

Our Woodford Road substation used to include a 46-kV switching infrastructure and one 12.5-MVA, 46-kV-to-12.47-kV transformer supplying two 12.47-kV distribution feeders. Much of this equipment, however, was near the end of its useful life (so old in most cases that replacement parts were no longer available). We upgraded some of this equipment; and we retired some and replaced it with new equipment at our new Pickett Hill substation. We built the Picket Hill substation near a new VELCO Bennington substation to more easily connect to their transmission system.

For the Pickett Hill substation, we:

- Upgraded the 46-kV switchgear to accommodate the newly located VELCO Bennington substation, which is a 115-kV-to-46-kV source for the Bennington area.
- Built several sections of new 46-kV transmission lines to tie the Pickett Hill substation to the 46-kV subtransmission system.
- Built one section of 69-kV transmission line to tie the new VELCO Bennington substation to the 69-kV subtransmission system.

For the Woodford Road substation, we:

- Added new bus work, switches, breakers, relays, SCADA equipment, larger voltage regulators, batteries, station service transformer, oil containment, and a control house.
- Added a high-side circuit breaker and transformer differential to better protect the existing transformer.

This entire project of replacing infrastructure and equipment maintains system reliability to the Bennington area, improves system operation, corrects deficiencies of current NESC standards, and improves safety and reliability.

Project completion: January 2015.

PROJECTS PLANNED AND UNDERWAY

Airport Substation Conversion and Rebuild

The Airport substation is sited on Vermont Air National Guard property in South Burlington, adjacent the Burlington International Airport. The substation includes a 59-year-old, 1.5-MVA, 34.5-kV-to-4.16-kV transformer and two 4.16-kV distribution circuits, neither of which allow for feeder backup from adjacent substations. In addition, the wood structures are aged with clearances that do not meet modern code requirements.

As such, we plan to convert and rebuild the substation on a new larger site. We plan to install a new 15/28-MVA, 34.5-kV-to-12.47-kV transformer; oil containment; three 12.47-kV distribution circuits; three 34.5-kV breakers (two for transmission and one for transformer bank); and associated circuit breakers, voltage regulators, bus work, foundations, fence, ground grid, security system, control cabinet, and switchgear.

The new substation would still be centrally located in Chittenden County, and allow for the reconfiguration of existing circuit loads among the Gorge, Ethan Allen, Dorset Street, Essex, and Tafts Corners substations. The upgrade would thus enhance feeder backup in this area, extend the useful lives of the adjacent substations, address aging infrastructure, and improve safety and reliability.

We have petitioned the Vermont Public Utilities Commission for a certificate of public good (CPG), and expect to begin construction in 2019.

Projected start date: February 2020.

Barre South End Substation Replacement

As discussed previously in "Barre North End Substation Rebuild" (page C-1), our examination under Docket No. 8069 revealed that the Barre South End substation also needed to be rebuilt and relocated. As a result, we are currently in the process of newly constructing the Barre South End substation. The rebuild includes upgrading to a 15/28-MVA 34.5-kV-to-12.47-kV power transformer and three 12.47-kV feeders.

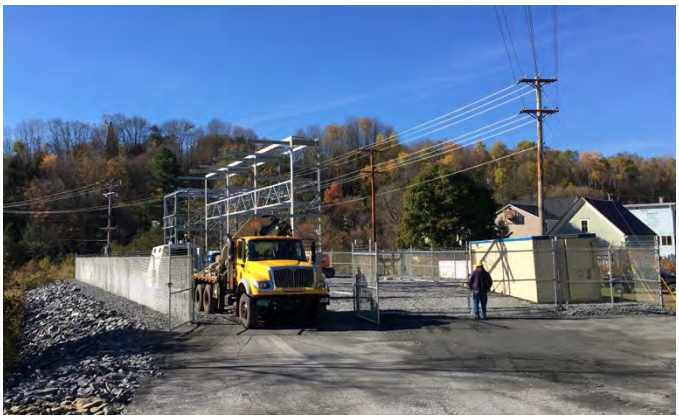

Figure C-5. Ongoing Construction of New Barre South End Substation

In addition, we are installing a new fence, yard lighting and security cameras, ground grid, below-grade trench and conduit systems, oil containment, 34.5 kV circuit breaker, two motor-operated load break switches, transmission voltage potential transformers, and relay protection and control. Distribution equipment includes three vacuum circuit breakers, arresters, line tie switches, potential transformers, and underground feeder getaways.

Once finished, this substation will be able to provide full feeder backup to the Barre North End substation and partial feeder backup to the Graniteville and Websterville substation.

Expected completion date: December 2018.

Cambridge Transmission Substation Expansion

We have upgraded and expanded our Cambridge substation to be configured with a new tap line associated with two new breakers. This project improves reliability to Vermont Electric Cooperative (VEC) customers as well as our customers in the area.

VEC first identified this project in their most recent Integrated Resource Plan as a way to manage assets and address safety issues. The Public Utilities Commission approved the project in its order in Case No. 17-2675-PET dated September 26, 2017.

When completed, the new tap line will automatically sectionalize our B8 line. If a fault occurs on one section of that line, this upgraded configuration will still allow energy to flow to VEC's substations while shutting off the faulted line. For line faults east of our Cambridge substation, VEC's Johnson substation would lose power; for line faults west of our Cambridge substation, VEC's Pleasant Valley substation and our Jeffersonville substation would lose power. In both cases, however, VEC's Cambridge and

Jeffersonville substations would retain power. Thus, thousands of customers who previously would have lost power, will now retain power.

Expected completion date: December 2018.

East Barnard to Bethel (Line 107) Subtransmission Line Rebuild

The VELCO Connecticut River Valley Study indicated that the existing 3/0 ACSR conductor on the six-mile East Barnard to Bethel line would overload after certain contingencies, resulting in cascading line overloads and losses of up to 40 MW of load. The study also indicated the existing Bethel to East Barnard 3/0 ACSR line section was overloaded by 115.7% of its thermal rating of 24.54 MVA.

This project reconductors the Bethel to East Barnard (Line 107) to 477 ACSR conductor. This line is 6.3 miles long, however, we plan to reconductor only a small portion of it (0.22 miles of 3/0 ACSR) because most of it is already thermally adequate (4/0 ACSR). Accordingly, we plan to replace this 0.22 miles of 3/0 ACSR located at the Bethel end of the line with 477 ACSR. This line is part of a 46-kV transmission loop in the Middlebury, Windsor, and Chelsea areas.

We have obtained a CPG to rebuild this line with new structures and a larger 477 ACSR conductor. This addresses the overloading and lower line losses, and remediates the structural issues. We began construction in September, 2018.

Projected completion date: February 2019.

Rutland Reliability Project

After extensively analyzing the load flow of our recently acquired VMPD system, we found that the Florence 115/46-kV source could not "ride through" a first contingency loss unless we reinforced the system by:

- Permanently closing the normally open 46-kV B7 tie at West Rutland.
- Reconductoring the Florence-to-West Rutland 46-kV line, which includes the Marble Street to Florence segment.
- Permanently closing the normally open second Rutland-to-West Rutland 46-kV line with reconductoring.

We submitted this Rutland Reliability Plan to the Public Utility Commission in 2015.

Without reconductoring, the existing Florence to West Rutland line could not carry peak demand. In addition, the Rutland area system substantially benefits from integrating VMPD by effectively adding another 115/46-kV transformer to support the area's

46-kV network (via Florence to West Rutland). This extra source improves area voltage and reduces loading on the area's other transformers, which could otherwise exceed their ratings post-contingency. Substation upgrades are required at Marble Street and Lalor Avenue to support this project. These upgrades will improve the connectivity and reliability of the former VMPD system that serves our customers in Florence, Danby, and Proctor. The project includes several components.

Upgrading the West Rutland Transmission Substation consists of adding two 46-kV Vacuum Circuit Breakers transmission breakers (B-4 and B-5) to replace the two existing 1969-vintage OCBs (B-7 and B-56). These vintage breakers have proven troublesome, experiencing many failures. We are also replacing the bus and line instrument transformers (as they have reached their limit for useful life) and adding a new security system.

Rebuilding the West Rutland to Marble Street (Line 39) Subtransmission Line. We will rebuild approximately 0.56 miles of 46-kV transmission line from Marble Street Substation to West Rutland Substation with 477 ACSR.

Rebuilding the Marble Street to Proctor (Line 37) Subtransmission Line. We will rebuild approximately 7.22 miles of 46-kV transmission line from the Florence Substation to the Marble Street Substation with 477 ACSR.

Rebuilding the Evergreen Tap to West Rutland (L43) Subtransmission Line. We will rebuild approximately 0.94 miles of 46-kV transmission line from Evergreen Tap to West Rutland Substation (Line 43) with 477 MCM ACSR conductor. The larger conductor on Line 43 allows this radial feed to become part of the looped transmission system in the Rutland Area.

Projected completion date: November 2019.

Taftsville to Windsor (Line 105) Subtransmission Line Rebuild

The VELCO Connecticut River Valley Study indicated that the existing 477 ACSR conductor on the 10.5-mile Taftsville to Windsor line would overload by 124% of its thermal rating of 49 MVA following certain contingencies. This line is part of a 46-kV transmission loop extending across Windsor County.

In the 248 process under Docket 8605, the need to upgrade this line was identified in the VELCO Connecticut River Valley Project filing. The VELCO pre-filed testimony stated "Related to these improvements, GMP will replace conductors for three 46 kV line sections: the East Middlebury to Smead Road line (Project 143180 completed in 2016), the Bethel to East Barnard line (Project 148615 FY2019), and the Windsor to Taftsville line (Project 148614 FY2020)."

ISO-New England and VELCO studies determined that upgrading an existing 115 kV line, supplemented with other component transmission and subtransmission upgrades, would be the most cost-effective solution to mitigate the identified concerns. As such, we plan to reconductor the Taftsville to Windsor (Line 105) to 795 ACSR conductor. This line is part of a 46-kV transmission loop in the Middlebury, Windsor, and Chelsea areas.

Projected completion date: December 2020.

Websterville Substation Rebuild

We plan to rebuild the Websterville substation on its existing site as part of our complete revamp of the substations that feed the Barre area. (See "Barre North End Substation Rebuild", page C-1, and "Barre South End Substation Replacement", page C-12, for information on our rebuilding all three substations.)

The rebuilt substation would be equipped with new transmission circuit breakers, two capacitor banks, a new 15/28-MVA transformer, and three 12.47-kV feeders. The new substation will permit full feeder backup to the Graniteville substation and partial feeder backup to the Barre South End substation.

In conjunction with a Websterville substation rebuild, a 34.5-kV recloser will be added to tie the Websterville to Barre 3306 line to the Websterville to McIndoes Falls 3311 line to maintain a 34.5-kV network while the Websterville substation is being upgraded. This bypass will be permanent and allow for additional operational flexibility to reconfigure the 34.5-KV network in the future as needed to optimize system conditions.

In October 2018, we filed for a certificate of public good with the Public Utilities Commission. We intend to begin construction in spring 2019.

Projected completion date: February 2020.

Welden to North St. Albans (Line 135) Subtransmission Line Reconductoring

VELCO, conducting a study for us in the St. Albans area, identified an existing overload of the Welden St to East St Albans 3/0 ACSR line segment of Line 135. The overload exceeded 10% of the line segment's thermal rating when the Nason Street end of the B10 line was opened for planned or emergency outages. This overload could result in a hazard from a conductor sag resulting in inadequate clearance, or in a complete burndown of the conductor, resulting in loss of customer load. VELCO also identified this overload in their 2018 Long-Range Transmission Plan.

To remedy these hazards, we are reconductoring the 0.41-mile long, 34.5-kV subtransmission overhead line (Line 135) with the larger wire 477 ACSR. This segment, which runs from our Welden Street substation to the North St. Albans substation, is part of the 34.5-kV subtransmission loop that provides redundant transmission supply to the substations feeding the distribution system in the affected area. The reconductoring will increase reliability to our customers by preventing the line from failing from the aforementioned contingencies.

Expected completion date: March 2019.

PROPOSED PROJECTS STARTING AFTER 2020

Danby Substation New Construction

Building a new substation in Danby will create multiple benefits for the area. Our plan for the new Danby substation includes a 7.5/10.5-MVA, 46-kV-to-12.47-kV transformer, oil containment, a 46-kV high-side circuit breaker, two 12.47-kV distribution circuits with associated circuit breakers and voltage regulators together with a fence, ground grid, communications, and security.

We plan to initially supply the Danby substation from the 46-kV Marble Street to Danby Quarry subtransmission line, relieving capacity issues by providing a portion of the load presently supplied by the Wallingford substation. The 12.47-kV distribution installed at the Danby substation will supply the Danby Imperial Quarry, thus improving voltage regulation at the quarry.

Next, we plan to build a new 46-kV tie line from the Dorset substation, forming a three-way network that adds capacity to both the Danby and Wallingford substations (and thus the surrounding area) while providing backup for the latter. The three-way network also enhances area reliability by reconfiguring two relatively long and weak radial 46-kV subtransmission lines, the Marble Street to Danby Quarry line and the Blissville to Dorset line.

After this 46-kV tie line is built, we will be able to reconductor the Marble Street to Danby line to 477 ACSR without interrupting service to Danby substation customers, including the quarry. In addition, should it become necessary, we could build a new 46 kV tie line from the Bromley substation to either the Danby substation or the Dorset substation to further increase network reliability in the area.

Projected start date: 2022.

East Ryegate Substation Upgrade

We need to upgrade the East Ryegate substation to improve reliability. We plan to eliminate two radial transmission lines to form a 46-kV network between Hartford and Ryegate. The upgrade comprises two transformers (one 46/34.5 kV and one 34.5/12.47 kV), oil containment, circuit breakers, relay protection upgrade and associated fence, ground grid, communications, and security.

Projected start date: 2020.

East St. Albans Substation Upgrade

As part of its St. Albans study for us, VELCO looked at a proposed load increase for the area. VELCO identified low voltage in the St. Albans area with the loss of the St. Albans 115/34.5-kV source at existing loads.

To increase reliability, we plan to install two SCADA-controlled, 3.6-MVAR capacitor banks at our East St. Albans substation. These two capacitor banks will provide voltage support during emergency contingency situations as well as during planned maintenance on the St Albans area 34.5-kV network.

Projected start date: 2020.

Fair Haven and Hydeville Distribution Substation Conversions

Whenever feasible, we convert existing 2.4-kV, 4.16-kV, and 8.3-kV distribution circuits to our standard distribution system voltage of 12.47/7.2-kV grounded wye. Converting these substations is one of those projects.

We plan to convert the Fair Haven and Hydeville substations from 46/4.16 kV to 46/12.47 kV with all new components including, at minimum. a top nameplate 10.5-MVA, 46-kV-to-12.47-kV transformer, oil containment system, and associated bus work and foundations. Also included would be distribution feeder circuit breakers, voltage regulators, security system, and a control cabinet. The larger transformer will allow for feeder backup capability between these substations, for the Castleton substation, and for potential future ties to the Carvers Falls and Poultney area substations. Converting these substations to 12.47 kV will also reduce losses.

Projected start date: 2020–2021.

Haystack Substation New Construction

There is very limited capacity for the GMP Dover and Wilmington substations, and there is very limited feeder backup capability. In addition, the Hermitage Club at Haystack Mountain in Wilmington has future plans for an expansion requiring 10 MW of additional load. As such, we plan to build a new Haystack substation in Wilmington to accommodate future load growth, improve area reliability, and reduce system losses; as well as to improve the limited feeder backup capability between the Dover and Wilmington substations. This upgrade is necessary even if the Hermitage Club does not proceed with their expansion.

Our plan for the substation comprises a 28-MVA, 69-kV-to-12.47-kV transformer with oil containment, a high-side circuit breaker, three distribution circuits with circuit breakers and voltage regulation for each feeder, motor-operated load break switches, and SCADA. The transmission supply will be from the 69-kV Searsburg-to-Dover subtransmission line.

We initially intended to site the substation close to the load to reduce system losses, but the adjacent land owner would not grant us access, thus the project is on hold until we can find a suitable parcel of land.

Projected start date: Currently in 2020 budget.

Highbridge Substation Upgrade

The Highbridge substation needs to be upgraded to improve reliability. We plan to replace an existing breaker and voltage transformer, and add two new breakers, associated relaying, ground grid, fence, and control house.

Projected start date: 2021 (depending on land acquisition).

Hinesburg Substation Rebuild

An eight-mile, 12.47-kV distribution line originating at the Charlotte substation serves Hinesburg. New development in the area is likely to increase its 4.6 MW winter peak. This increasing load and distribution line length contribute to potential thermal and voltage limitations as well as challenges in protecting the line from contingencies. To temporarily mitigate this situation, we connected a portion of the load to the Vermont Electric Cooperative (VEC) Rhode Island Corners substation. Nonetheless, this short-term solution still exposes the area to a number of long-term reliability and capacity needs: the potential for continued load growth, voltage constraints, high distributed solar penetration, and motor start limitations.

Initially, we planned to build a new substation. Instead, we conducted a Reliability Plan (filed under Docket No. 7873 in October 2016) to analyze the situation and identify a robust, cost-effective, long-term solution. The Plan concluded that we could initially address these issues with a non-transmission alternative (NTA). As such, we now plan to install a battery energy storage system (BESS) solution with deferred construction of a new Hinesburg substation jointly owned with VEC together with distance relay protections, distributed energy installations with reactive inverters, and energy efficiency measures.

The new Hinesburg substation would include a new 15/28-MVA, 34.5-kV-to-12.47-kV transformer with oil containment, high-side circuit breaker, associated fence, ground grid, communications and security, and two distribution circuits with circuit breakers and voltage regulators. A new one-mile, 34.5-kV subtransmission line extension of the existing Richmond to VEC Hinesburg substation 34.5-kV transmission line would supply the substation. This substation would increase the available capacity to serve existing and new load, allow for appropriate circuit protection, reduce losses, and provide feeder backup to the Charlotte substation, as well as provide backup for VEC area circuits and back up circuits originating at the North Ferrisburgh substation.

After acquiring property for siting, the current plan is to install the NTA solution in 2023.

Irasville Substation Upgrade

The Irasville substation is tapped off from a 37-mile-long line between Middlesex and Montpelier with inadequate remote line protection. To improve reliability, we plan to upgrade the substation. The upgrade comprises oil containment, 34.5-kV circuit breakers, relay protection upgrade, yard expansion associated fence, ground grid, and communications

Projected start date: 2021.

Johnson to Lowell (Line 133) Subtransmission Line Upgrade

We plan to upgrade the Johnson to Lowell (Line 133) subtransmission line to address aging infrastructure, and improve reliability.

Projected start date: 2020.

Lowell Substation Upgrade

The Lowell substation is aged and near the end of its useful life. As such, we plan to upgrade the substation to address aging infrastructure and to improve safety and reliability.

The current transformer, a 15/20-MVA, 46-kV-to-34.5-kV bank, is 43 years old. The existing 34.5-kV B-20 breaker is 1973 vintage of a style that has proven to fail without warning. The protection and control technologies are obsolete, utilizing electromechanical relaying.

Projected start date: 2021.

Maple Avenue Substation

This project will add two SCADA-controlled 2.7-MVAR capacitor banks at the Maple Avenue substation to provide voltage support during emergency contingency situations as well as during planned maintenance of the 46-kV network extending from Lafayette Street substation to National Grid Bellows Falls substation. This project will also address asset management issues with the Joy substation located approximately 2.0 miles away from the Maple Avenue substation. We will install a 46-kV breaker at Maple Avenue and retire the Joy substation.

Projected start date: 2019.

Maple Avenue to Charlestown (Line 102) Subtransmission Line Reconductoring

VELCO 2018 Long-Range Transmission Plan identified the Maple Avenue to Charlestown 46-kV path as potentially overloading under first contingencies at existing loads (that is, the loss of Lafayette Street to Maple Avenue), which violates our transmission line criteria. As such, we plan to reconductor the Maple Avenue to Charlestown subtransmission line to conform to our line criteria and, as a result, improve reliability.

Projected start date: 2021.

McNeil to Gorge (Line 3309) Subtransmission Line Reconductoring

After certain contingencies on the VELCO 155-kV system, a bulk system deficiency results in thermal overloads and low voltages on sections of the 34.5 subtransmission line (Line 3309) between the McNeil generating station and the Gorge substation. VELCO's 2015 Long-Range Transmission Plan originally identified this condition several years ago. To remedy this condition, we plan to reconductor this line.

Projected start date: 2021.

Mill Street Substation Upgrade

The 14-MVA, 46-kV-to-12.47-kV transformer, enclosed switchgear, and 12.47-kV distribution feeders at the Mill Street substation (in Bennington) is aging. Much of the substation, constructed in 1974, is close to the end of its useful life, and many replacement parts are unavailable. In addition, the control wiring, cabling, distribution panels, and groundings are deficient in meeting current safety codes.

To address these issues, we plan to install a new 15/28-MVA, 46-kV-to-12.47-kV unit, oil containment, and a high-side circuit breaker (to better protect the transformer); replace the enclosed switchgear with open-air bus work; and install new switches, breakers, relays, SCADA equipment, circuit regulators, batteries, station service, and a control building. We also plan to upgrade the 350-MCM-Cu underground getaways with 1,000 MCM Cu to enhance feeder backup capability and support distributed generation, and to install larger voltage regulators to increase the flexibility of circuit ties to the adjacent Lyons Street, South Bennington, Woodford Road, and Silk Road substations during planned outages and contingencies.

All told, the upgrade addresses aging infrastructure, improves system operation, corrects deficiencies, and improves safety and reliability.

Deferred project start date: 2024.

Newbury Distribution Substation Upgrade

The Newbury distribution substation needs to be upgraded to improve safety and reliability. We plan to install a new foundation for the transformer, a new 12.47-kV circuit breaker, and a security system, as well as replace the old porcelain insulators.

Projected start date: 2022.

North Brattleboro Substation Upgrade

The North Brattleboro substation contains a 14-MVA, 46-kV-to-12.47-kV transformer, 328-amp voltage regulators connected to the 12.47-kV bus by 750 MCM copper underground cable getaways; and two 12.47-kV distribution circuits each with 350 MCM copper underground cable getaways.

The 750 MCM copper underground cables, summer rated at 619 amps, do not fully utilize the capacity of the 14-MVA transformer; the 350 MCM copper underground cable getaways, summer rated at 384 amps, constrain the North Brattleboro substation's ability to backup area substation feeders.

To relieve these constraints, we plan to replace the current cables with 1,000 MCM copper cables, and upgrade the existing 328-amp voltage regulators to 437-amp regulators, which will allow for greater flexibility with circuit ties during planned outages and contingencies. Overall, the upgrades will improve reliability and increase the substation's transfer capacity.

Deferred project start date: 2023.

Pleasant Street Distribution Substation Upgrade

Aging equipment on the Pleasant Street distribution substation is being replaced with similar replacement parts to improve safety and reliability.

We plan to replace the three 12.5-kV vacuum circuit breakers. with new 12.5-kV ABB RMAG circuit breakers, raise the existing steel to accommodate the new 12.5-kV circuit breakers, and install steel adapters to mount the new 12.5-kV breakers on existing foundations. In addition, we plan to install new conduit and control cables, add cameras to the security system, install a new RTU, add line voltage transmitters to each distribution circuit, and replace the existing electromechanical protection with new microprocessor-based protective relays housed in a new outdoor relay cabinet.

Projected start date: 2021.

Putney Distribution Substation Conversion

Whenever feasible, we convert existing 2.4-kV, 4.16-kV, and 8.3-kV distribution circuits to our standard distribution system voltage of 12.47/7.2-kV grounded wye. Converting the Putney distribution substation is one of those projects. We plan to convert the Putney 69/8.32-kV substation to 69/12.47-kV.

Projected start date: 2020.

Richmond Substation

The primary reason for completing this project is to improve reliability. The upgrades to the substation would be comprised of adding two breakers, replacing an existing recloser with a breaker associated relaying and control house. This will improve reliability to customers served out of Richmond and Bolton.

Projected start date: 2021.

Sand Road to Richmond (Line 3334) Subtransmission Line Rebuild

Our analysis revealed system limitations when the Sand Road end of this line is open. Thus, we plan to rebuild the existing 34.5-kV line that was constructed in the 1930s to improve reliability.

Projected start date: 2022.

Websterville to VELCO Barre (Line 3306) Subtransmission Line Reconductoring

VELCO's 2015 Long-Range Transmission Plan identified the Websterville to VELCO Barre 34.5 kV subtransmission line as potentially overloading under first contingencies at existing loads (that is, at the VELCO Barre 115/34.5 kV source), which violates our transmission line criteria. Thus, we plan to reconductor the Websterville to VELCO Barre (Line 3306) subtransmission line to improve reliability.

Projected start date: 2021.

Wilder Distribution Substation Upgrade

Capacity limitations in the area served by the White River Junction and Wilder substations could overload the White River Junction substation and leave little remaining capacity for Wilder to address contingencies. Upgrading the Wilder substation would address these capacity issues and provide robust feeder backup between the substations.

As such, we plan to replace the existing 14-MVA, 46-kV-to-12.47-kV transformer with a new 15/28-MVA, 46-kV-to-12.47-kV transformer and install a high-side circuit breaker, oil containment, distribution circuit breakers, and feeder voltage regulation.

Deferred project start date: 2021.