Vermont Electric Cooperative

System Planning Criteria

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1 Introduction

This VEC planning criteria document develops metrics via which capital projects are identified and given to engineering for design. These criteria are based on the recommendations contained in RUS bulletin 1724D-101B or practices generally accepted in the industry. The types of problems documented and the numerical quantities addressed will be somewhat different for each distribution system. This contains both a traditional analysis and evaluation of T&D plant based on age and condition as well as new analysis of the capability of the T&D system to handle increasing levels of distributed generation.

Revision	Revised By	Date	Description
1	CB	8/22/2016	Document Created
2	CB	1/17/2016	Reformat
3	CB	3/21/2017	Reformat and PRECorp Additions
4	CB	3/28/2017	Engineering Review
4	CB	3/19/2018	Engineering Review
5	BH	7/12/2024	Engineering Review, General comments changed

2 General

1. System improvements including transmission line, substations and major feeder lines will be constructed to coordinate with expected long range system requirements.

2. Priority will be given to identified system improvements that are shown to improve reliability indices.

3. Overhead line construction will be the cost-effective construction method unless underground construction is required by governmental, environmental, or local restrictions.

4. Priority will be given to those projects that benefit the largest number of consumers or provide a solution to a system constraint.

5. System improvements which will reduce wholesale demand and energy costs enough to pay the annual carrying costs on the required investment will be considered economically justified and will be given a high priority.

6. A high priority will be given to improvements that reduce potential safety hazards to the general public and operating personnel, or are found to be in violation (at the time of construction) of the National Electrical Safety Code or other applicable code clearances.

7. Consideration will be given to projects that will remove transmission wheeling needs or distribution voltage point of deliveries.

8. Line improvement is recommended to create or increase load transfer capability which will reduce outage time and increase operating flexibility. Alternative means of serving areas not only shorten the time to restore service when the normal method of service fails but also enables major line maintenance and rebuild work to be done de-energized and thereby reducing the number and duration of planned outages.

9. When feasible, primary lines which are being rebuilt across terrain difficult to patrol or private property with limited access, will be rerouted adjacent to accessible roads. Designer will consider aesthetic impacts

10. It is VEC's goal to maintain close to unity power factor across its system with emphasis at substations and points of delivery to aid in reduced losses, power supply requirements, system performance, etc. VEC will evaluate projects based on this goal and other criteria when adjusting priority.

3 Distribution

Construction proposed herein is required for the Cooperative's system to meet the following minimum standards of adequacy for voltages, thermal loading, safety, and reliability. These criteria are based on the recommendations contained in RUS bulletin 1724D-101B or practices generally accepted in the industry.

3.a Voltage

a) VEC conducts distribution planning to assure it can deliver power safely and reliably with a focus on voltage performance that meets ANSI standard C84.1. Basic Criteria include:

   a. System voltage equal or above 114 volts (0.95 p.u.) and equal or below 126 volts (1.05 p.u.),
   b. Target consumer voltage at the meter is 120V +/- 5% (114V – 126V), and
   c. Conductors below normal ampacity rating (< 1 p.u.), and
   d. Equipment below normal ampacity rating (< 1 p.u.).

   The CBEMA curve allows for +6% and -13% voltage before damage occurs, but we design to the above criteria.

b) Three phase distribution line Voltage shall be less than 2% unbalanced per equipment manufacture recommendations.

c) Locations with system voltage equal to or below 115 volts (0.958 p.u.) and equal or above 125 volts (1.04 p.u.) shall be reviewed for improvement via reconductoring, tie lines, multi phasing, or voltage conversions.

3.b Current

The following equipment shall not be thermally loaded by more than the following percentages of the device's nameplate rating.

	Normal	Contingency
Power Transformers*	105%	See ANSI appendix C52 92-1962
Substation and Line Voltage Regulators	100%	Must sustain ANSI standard C84.1
Hydraulic Oil Circuit Reclosers	80%	100%
Electronic Recloser Control Trip Settings	50%	75%
Line Fuses	75%	100%
Primary Overhead Conductors	75%	90%
Primary Conductors – Substation Tie Lines	50%	90%
Line 12/25kV Autotransformers	100%	See ANSI appendix C52 92-1962

* Substation power transformer ratings are based on the maximum capacity of the transformer in its existing state.

a) Engineering model predicting loading shall not exceed 40 Amps on 7.2/12.47 kV single-phase taps per RUS Bulletin 1724D-101B and 1724D-101A.

b) The substation low side bus phase currents shall be less than 20% unbalanced per RUS Bulletin 1724D-101B.

3.c Equipment

3.c.1 Overhead Design

a) All new construction and modifications will accommodate 7.2/12.47 kV primary distribution voltage.

b) All new construction will utilize a full sized neutral

c) All new construction will maintain a minimum BIL rating of 95kV.

d) New construction will have ground rods installed at minimum NESC requirements.

e) VEC distribution lines are designed in accordance with NESC 250B: Combined ice and wind district loading: Heavy Loading; 4 lb./ft2 wind, 0.5 inches radial ice, 0 deg. F

f) NESC Grade B construction is required where line crosses, or could potentially fall into a Limited Access Highway, Navigable Waterways or Railroad ROW.

3.c.2 Underground Design

a) All new construction will maintain a minimum BIL rating of 95kV.

3.c.3 Rebuild/ Replacement

a) Poles and/or crossarms shall be replaced if found to be physically deteriorated by visual inspection and/or test. Conductor replacement and structure upgrades may also be considered in certain areas with a high density of deteriorated poles. VEC plans to continue its pole testing and replacement program.
    a. Distribution poles will be tested on a 10-year cycle. Poles that are planned to be replaced in the next 10 years will not be treated.

b) Primary distribution lines shall be rebuilt and/or relocated if they are found to be unsafe or in violation (when constructed) of the National Electric Safety Code or other applicable code clearances.

c) Overhead conductors shall be replaced if found to contain an average of over 2 splices per phase per span in a 1 mile section per RUS 1724D-101B Section 2.1.2.1. The conductors of primary lines with broken strands and/or broken ties at supports will be replaced.

d) Primary conductors will be replaced if the conductors appear to have been damaged from excessive tension stress due to ice and/or high winds. Some indications of tension stress damage are bird caging of aluminum strands, splices not related to initial installations and excessive sag. Since the cost of reconductoring is a significant portion of the total cost of line replacement, complete line replacement will be done if the poles are in marginal condition or the line is routed where it cannot be easily patrolled during inclement weather conditions.

e) Primary lines will be rebuilt if the majority of the supporting structures are in poor condition.

f) 2.4/4.16 kV distribution systems will be converted to 7.2/12.47 kV.

3.c.4 Regulators

a) No more than two stages of line regulation will be utilized per RUS 1724D-101B Section 2.1.2.1.

b) Maximum load on substation voltage regulators will be limited to 100% of the nameplate rating during both summer and winter peaking conditions.

c) Maximum load on line voltage regulators will be limited to 100% of the nameplate rating during both summer and winter peaking conditions.

3.c.5 Reclosers

a) VEC generally installs oil circuit reclosers. In some scenarios an electronic recloser will be installed at the discretion of systems engineering.

b) Recloser settings will be sufficiently high to provide for cold load pick-up for the maximum amp loading.

c) Reclosers shall not be loaded to more than 70% of their minimum phase trip setting.

3.c.6 Capacitors

a) Capacitors will be installed at the discretion of systems engineering in order to save on cost as opposed to the installation of a regulator.

3.c.7 Distribution Transformers

a) No distribution transformer shall be normally loaded above 100%.

b) Generally, a new service is sized to 60% of the existing load and is replaced when the load reaches 80% of the transformer service rating.

c) Any tapped distribution transformers should be set to neutral

3.d Motor Start

a) Primary distribution voltage flicker due to motor starts and/or large loads will be limited to 3% of the present primary voltage.

b) If the 3% cannot be achieved, special conditions may be imposed on the service (e.g. Limited number of motor starts, startup during certain hours), or a system improvement may be required.

3.e System Protection Philosophy

VEC develops its own distribution relay settings. The settings are set to accommodate cold load pick up, feeder back up and normal peak loads. All distribution relays are tested every five years, including under-frequency systems which are under the jurisdiction of NPCC.

VEC designs substation high side protection to protect its substation transformers, and coordinate with VELCO/GMP transmission line protection schemes. VEC designs its low side protection to coordinate with the high side protection to allow for adequate down-stream sectionalizing.

VEC generally does not use fuse-saving trip operations on substation circuit reclosers, allowing the down-stream fuses to clear without causing momentary interruptions to the circuit reclosers located within the substations.

VEC is continually adding fuses to these taps in an effort to sectionalize outages to minimize the quantity of members affected.

3.f Territorial Rationalization

VEC seeks the most efficient way to serve its member/owners and often explores opportunities to make connections to other distribution systems in a way to minimize its plant and reduce O&M costs, including transferring consumers and plant among neighboring utilities.

4 Transmission

4.a Voltage

a) With a single facility (line or supply point) out of service, the primary voltages at all load serving substations should be 90% or above for the expected peak loading conditions.

b) Normal operating voltage to be within ±5% of nominal (0.95-1.05 per unit)

4.b Motor Start

a) Voltage drop due to motor starts and/or large loads will be limited to 1.5% of the present voltage or 1.5% at the point of delivery.

b) If 1.5% voltage flicker cannot be achieved, special conditions may be imposed on the service (e.g. limited number of motor start, startup during certain hours).

4.c Power Factor

c) The transmission design criteria are based on a minimum 95% power factor. Power factor is measured and monitored via Nexus meters at many of VEC's substations and synchronous or large inverter-based generator interconnections.

d) The power factors for each substation load were set at 95% for the load flow studies. In some cases, capacitance was added on the transmission bus or the distribution voltage bus to improve the transmission system power factor. It is preferable to correct power factor closer to the source, in this case the distribution bus.

4.d Ampacity and Thermal Limits

a) Pre-contingency transmission line thermal limits are 80% for radial lines and 50% for looped facilities.

b) VEC strives for N-1 planning criteria for all looped transmission lines and radial transmission lines. On radial transmission lines VEC looks for feeder backup opportunities.

c) If the above criteria are satisfied, existing distribution substation transformers and transmission lines would be utilized to their thermal rating without overloading under contingency conditions before major improvements are considered. The thermal limits of transmission lines were established for 95% power factor with the conductor at various conductor design temperatures in accordance with RUS Bulletin 1724E-200 Table D-1.

d) All MVA Conductor limits should be accordance with RUS Bulletin 1724E-200 Table D-2

4.e Equipment

4.e.1 34.5 kV and 46 kV Overhead Design

a) The design of all transmission lines shall meet the requirements of the National Electrical Safety Code and RUS Bulletin 1728F-810. The edition of the NESC in effect at the time of the design shall govern.

b) Design Loading Conditions - the provisions of the NESC Heavy Loading District, Class B Construction shall apply to all structure types. All wires intact.

c) Monopole structure will be used unless terrain, reliability, or other factors necessitate H-frame structure.
    a. Structure framing based on RUS 115kV structures and should be used unless extraordinary or other justifiable criteria are present.

d) Three separate Air Break switches (or switching substation) will be used for all taps.

e) Switches shall be load break and rated for the appropriate load break rating. Transmission lines shall be designed for a maximum operating temperature of 212° F.

4.e.2 Rebuild/Replacement

a) Lines prone to galloping or Aeolian vibration that cannot be corrected through other means will be considered for rebuild.

b) Poles and/or crossarms to be replaced if found to be physically deteriorated by visual inspection and/or tests (ordinary replacements). Transmission Poles will be treated and tested every 10 years

c) Conductors will be replaced if the conductors appear to have been damaged from excessive tension stress due to ice and/or high winds. Some indications of tension stress damage are bird caging of aluminum strands, splices not related to initial installations and excessive sag. Since the cost of reconductoring is a significant portion of the total cost of line replacement, complete line replacement will be done if the poles are in marginal condition or the line is routed where it cannot be easily patrolled during inclement weather conditions.

d) Conductors with broken strands and/or broken ties at supports will be replaced.

e) Lines will be rebuilt if the majority of the supporting structures are in poor condition. When feasible, lines which are being rebuilt, and cross terrain difficult to patrol or private property with limited access, will be rerouted adjacent to accessible roads.

4.e.3 Breakers

a) Settings will be sufficiently high to provide cold load pick-up for the maximum Amp loading.

b) Minimum operating temperature to be at least -40°C

c) Maximum operating temperature to be at least 40°C

d) New construction or modifications should be vacuum Breakers unless justified by an System Engineering analysis

5 Substation

5.a Voltage

With all facilities in service, the primary voltages at all load serving substations should be between 95%-105%

5.b Equipment

a) All new substations will be designed to accommodate VEC's SCADA system.
b) All substations shall have an SPCC plan

5.b.1 Transformers

a) Transformers emergency loading of up to 120% of rating are to be permitted. All other overloads must be remedied with the installation of a mobile or a temporary operating guide that is implemented to relieve the overload.

b) No substation transformer can be loaded above the percentage value identified in figure 1 of ANSI appendix C52 92-1962. Figure 1 is the permissible kVA loading for varying ambient temperature for self-cooled transformers for normal life expectancy.

c) All distribution load must be able to be served either by a mobile substation or another source for the loss of a substation transformer. As a rural cooperative, the capability to serve load remotely during peak is generally fairly limited. Most ties are not strong enough to serve the whole substation load on peak, which is why the substation was built. Remote load serving capability must be evaluated when determining the need for additional capacity.

d) Substation transformers will be reviewed for replacement once the load exceeds 80% of base rating MVA at 30 degrees Celsius per ANSI C57.92-1962 and NEMA Pub. Num. TR 98-1964

e) Substation Transformers are tested every 5 years the tests include: Power Factor Test (DOBLE), Insulation Resistance Test (Megger test), Transformer Turns Ratio Test (TTR) and visual Inspection. A Dissolved Gas Analysis (DGA) test is performed annually along with moisture content and other oil tests. If any of the tests fail the transformer will be replaced or repaired.

5.b.2 Substation Structure

a) Substation lightning protection is accomplished using the fixed angle mast system with a shield angle in accordance with IEEE standard 998. The edition of IEEE Standard 998 in effect at the time of the design shall govern.

a) New substation designs will have accommodations for mobile substations and\or parallel transformer operation for contingency purposes.

b) Ground grids are designed specifically for each substation based upon system fault current, station design, and local soil conditions, in accordance with IEEE Standard 80.

c) The design of all substations shall meet the requirements of the National Electrical Safety Code. The edition of the NESC in effect at the time of the design shall govern.

5.b.3 Substation Regulators

a) The voltage regulator rating is sized to match the power transformer's base rating. The bus is designed to withstand the fault current rating.

b) Bus voltage regulators are used in all VEC distribution substations.

5.b.4 Substation Reclosers

a) VEC has standardized on a triple-single feeder reclosers to provide operational flexibility for three phase or single phase tripping. The tripping criteria are based on local loads, feeder back up or the presence of generation. All distribution reclosers are purchased with potential and current transformers

6 CBEMA Curve