Transmission and Distribution System Development Plan

Appendix E

Distribution Planning Manual

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1 Distribution Planning Philosophy

This document identifies the philosophy utilized by System Planning in the development of the distribution system with voltage levels 35 kV and below.

1.1 Goals

- To plan the development of the most economical distribution systems that will provide service within specified standards to meet projected distribution loads of the future.
- Determine the changes required over the next five years to maintain standards of service while at the same time providing the most economical development of future distribution systems.
- Evaluate new facilities or anticipated rebuilds by comparing alternatives and recommending changes that will produce the most economical long-term development of the future distribution system.

1.2 Activities

- Project growth rates and forecast future load for areas within the service boundaries. Communicate with Regional Districts, Town Planners, etc., to gather information on anticipated development plans in their respective areas to incorporate into load forecasts.
- Develop alternative plans for systems that will supply projected future loads. Analyze each plan. Select the most economical as the long-range plan. Revise the long range plans and five year plans as a result of changing load patterns, regional and municipal plans or changing service standards.

1.3 Standards of Service

- Maximum feeder load during normal operating conditions is limited to the ampacity of the underground cable or overhead conductor exiting the substation. Refer to section 2.2 “Overhead Conductor and Underground Cable Ampacity”
- Maximum distribution equipment load during normal operating conditions is limited to the continuous rating of the equipment unless otherwise specified. Refer to section 2.3 “Capacity of Distribution Equipment”.
- Minimum Voltage as per CSA publication C235 “preferred Voltage Levels for AC Systems, 0 to 50,000 Volts”. Refer to Section 2.1
- Maximum Voltage as per CSA publication C235 “preferred Voltage Levels for AC Systems, 0 to 50,000 Volts”. Refer to Section 2.1
- Maximum three phase fault current is 8000 amps on primary distribution systems.
- Maximum single line to ground fault current is 5000 amps on primary distribution systems.
- Maximum load/L-G short circuit ratio is 25%.
- Maximum load/3-P short circuit ratio is 40%.

2 Planning Criteria

2.1 Voltage - Steady State Criteria

2.1.1 Introduction

This Planning criteria covers the application of minimum and maximum voltage levels on the distribution system. This criteria specifies the minimum and maximum voltage levels under steady state conditions used to plan the distribution system.

2.1.2 Planning Criteria

Planning designs the distribution feeders to ensure that customers have acceptable voltage at their utilization point. Planning will take corrective action when the predicted loading on the distribution feeder model indicates that the primary voltage (three phase and/or single phase) is outside of the minimum or maximum voltage parameters stated below:

Table 1- Planning Voltage Criteria

(on a 120 Volt base)	Minimum	Maximum
Three Phase Voltage	115 V	127 V
Single Phase Voltage	113 V	127 V

The minimum voltages shown above apply when the source voltage is set at 123.5 V and the maximum voltages shown above apply when the source voltage is set at 126.5 V. The 123.5 V and 126.5 V levels reflect the typical operating range of a source substation.

2.1.3 Background

Planning assesses the need for voltage support to ensure that customers have acceptable voltage at their utilization point in accordance with CSA Standard CAN3-C235-83: “Preferred Voltage Levels for AC systems 1 to 50 000 V”. This standard outlines the recommended steady state voltage variation limits for circuits up to 1000 V at the utilization point (i.e. plug in) as follows:

Table 2 – CSA Preferred Voltage Levels

	NORMAL	EXTREME
Three Phase	110 V – 125 V	108 V – 127 V
Single Phase	108 V – 125 V	104 V – 127 V

Planning will initiate voltage improvements when the voltage reaches or is projected to reach the minimum recommended voltage under normal operating conditions. Corrective action is also initiated for instances where the voltage is or is expected to be in excess of the maximum recommended levels under normal operating conditions.

Some extreme operating conditions are temporary in nature. So the decision to initiate system improvements will depend on factors such as location, customer type and the extent to which limits are exceeded (i.e. magnitude and duration reflecting safety concerns as well as the probability of equipment damage).

2.1.4 Process

Recognizing that the specified CSA voltage limits apply at the utilization point, some allowance must be made for the voltage regulation through the service transformer as well as the secondary and internal wiring voltage drop to the plug ins. Generally, a 3-5 Volt drop from the main line to the customer utilization point under peak loading conditions and a 1 – 2 volt drop under light load is assumed. In order to comply with CSA limits, Planning models the distribution feeder and will take corrective action when the primary voltage of a peak load feeder model indicates an existing or projected steady state voltage of 115 V (120 V base) or less on the three phase lines and/or 113 V (120 V base) or less on single phase lines. Similarly, Planning will take corrective action when the primary voltage of a light load feeder model (three phase or single phase) indicates an existing or projected steady state voltage of 127 V (120 V base) or more.

2.2 Overhead Conductor and Underground Cable Ampacity

2.2.1 Introduction

This document covers the Planning Criteria for the application of ampacity levels for overhead conductors and underground cable used in the distribution system. This document specifies the maximum ampacity levels used to plan the distribution system.

During actual operations, higher ampacity ratings may be used taking into account actual temperatures, wind speed, pre-loading and duration of loading. Operation at higher ampacity levels may reduce the life of the equipment in order to supply load and such risks will be assessed at time of operation.

2.2.2 Planning Criteria

Planning designs the distribution feeders to ensure that the conductors, cables and connectors, on the distribution system, have the capability to supply customer load for forecast load conditions without any conductor, cable and connector loss of life.

This document outlines the normal ampacity ratings for overhead conductors, underground cable, and the maximum feeder loading used by Planning in the distribution system.

2.2.3 Overhead Conductor

Planning models the distribution feeders to ensure that the overhead conductors are not loaded above their ratings. Planning will take corrective action, when the model of the distribution feeder indicates that any equipment will be operated above its rating under the forecast peak load conditions.

Table 3 – Overhead Conductor Ampacity Limits

Conductor Type	Trigger Ampacity	MVA by Voltage			
		25 kV_{LL} 3Ø	**14.4 kV_{LG} 1Ø**	**13 kV_{LL} 3Ø**	**7.2 kV_{LG} 1Ø**
8C	110	4.8	1.6	2.4	0.8
6C	147	6.4	2.1	3.2	1.1
4C	195	8.4	2.8	4.2	1.4
3C	228	9.8	3.3	4.9	1.6
2ACSR	210	9.1	3.0	4.5	1.5
2C	276	11.9	4.0	6.0	2.0
2/oACSR	318	13.7	4.6	6.9	2.3
3/oACSR	385	16.6	5.5	8.3	2.8
90C	329	14.2	4.7	7.1	2.4
266ACSR	510	22.0	7.3	11.0	3.7
336ACSR	652	28.2	9.4	14.1	4.7
397ACSR	660	28.5	9.5	14.3	4.8
477ACSR	745	32.2	10.7	16.1	5.4
927AAC	1118	48.3	16.1	24.1	8.0

2.2.4 Underground Cable

Planning models the distribution feeders to ensure that the underground cables are not loaded above their ratings. Planning will take corrective action, when the model of the distribution feeder indicates that any equipment will be operated above their rating under the forecast peak load conditions.

Table 4 – Underground Cable Ampacity Limits

		Trigger Ampacities (Three phase)			
		In Duct		Cable at Riser	
Cable	Grounding	Normal	Emergency	Normal	Emergency
#2 Cu	Both Ends	164	200	125	179
#1 Cu	Both Ends	183	222	140	201
350Al	Both Ends	322	389	286	420
750Al	Both Ends	435	543	418	619
750Al	One End	555	667	550	781
1000Al	Both Ends	484	609	472	704
1000Al	One End	663	799	668	950
1000Cu	Both Ends	634	801	611	918
1000Cu	One End	828	1002	835	1193

Note: Emergency rating is limited to 1500 hours in the life of the cable.

2.3 Capacity of Distribution Equipment

2.3.1 Introduction

This document covers Planning Criteria for the application of ampacity levels for equipment used on the distribution system. This document specifies the maximum ampacity levels used to plan the distribution system.

Under actual operations, higher ampacity ratings may be used taking into account actual temperatures, wind speed, pre-loading and duration of loading. Operation at higher ampacity levels may reduce the life of the equipment in order to supply load and such risks will be assessed at time of operation.

2.3.2 Planning Criteria

Planning designs the distribution feeders to ensure that the equipment on the distribution system has the capability to supply customer load for forecast load conditions. This Planning criteria outlines the ampacity ratings for equipment used in the distribution system.

2.3.3 Distribution Service Transformers, Voltage Regulators and Switches

Planning models the distribution feeders to ensure that the distribution line voltage regulators and switching devices are not loaded above their ratings.

Planning does not model individual service transformer loading, but recommends that when load is found to exceed the rating on these transformers that corrective action is taken.

Planning will take corrective action, when the model of the distribution feeder indicates that any equipment will be operated above the rating of the equipment under the forecast peak load conditions.

Table 5 – Distribution Equipment Capacity

Voltage Regulators	100% of Nameplate Rating
Switches and Cutouts	100% of Continuous Rating
Distribution Service Transformers	100% of Nameplate Rating

2.3.4 Distribution Source Transformers

Planning monitors the load on distribution source transformers to ensure that they are not loaded above their ratings.

Distribution source transformers are those that supply distribution feeders at 25 kV or below, predominantly 25 kV and 13 kV, including transmission transformer tertiaries where used.

Transformer capacity upgrades will be planned in the year that the forecasted transformer load:

(1) exceeds nameplate rating at the forecast summer peak, or
(2) exceeds nameplate rating plus 25% at the forecast winter peak.

3 Backup Planning Guidelines

3.1 Introduction

This guideline addresses the criteria for backup associated with the distribution system. Backup in addition to service continuity (i.e., absence of interruptions) composes reliability. Backup refers to the ability to restore service after an interruption without necessarily first repairing the cause of the interruption.

3.2 Backup Requirements

3.2.1 Distribution Contingencies

Planning will assess the distribution system to determine the backup capability for a single Distribution contingency event. In the event of a single Distribution contingency, a percentage of the peak load must be able to be supplied from the remaining distribution feeders in the study area. The percentage of peak load to be supplied is determined from the load duration curve shown below if available or 80% of peak load.

After the interruption, without first repairing the cause of the interruption, the remaining distribution feeders should have the capability to supply the load on the upper flat portion of the load duration curve. In the graph below, this would be 7 MW. Hence, it is recognized, that during peak load conditions the remaining distribution system may not have the capability to supply the entire load in the event of a distribution contingency.

In municipalities that require subdivisions be supplied underground, the company will ensure that all new underground circuits are looped and that the load can be fully supplied by either end of the loop for a single cable section failure.

When determining the capability of the remaining distribution system in the event of a distribution contingency, the minimum voltage level will be allowed to drop by 2 V to 113 V for three phase and 111 V for single phase.

Planning will take corrective action, when for the predicted loading, the distribution system is not capable of meeting this backup criteria.

3.2.2 Transmission Contingencies

Planning will study the distribution system to develop the backup requirement for the loss of one substation transformer in either a single or multi transformer substation.

- For loss of the transformer in a single transformer substation, a percentage of the peak load normally supplied by that transformer must be able to be supplied from the remaining distribution feeders and substations in the study area. The percentage of peak load to be supplied is determined from the load duration curve shown below if available or 80% of peak load. After the interruption, without first repairing the cause of the interruption, the remaining distribution feeders should have the capability to supply the load on the upper flat portion of the load duration curve. In the graph below, this would be 7 MW. Hence, it is recognized, that during peak load conditions the distribution system may not have the capability to supply the entire load in the event of the loss of the single transformer and full recovery may be dependent on installation of a mobile transformer.

- For loss of a single transformer in a multi transformer substation, 100 percent of the peak load must be able to be supplied from the remaining station transformer or a combination of the remaining station transformer and other supplies in the study area.

When determining the capability of the distribution system, in the event of the loss of the single transformer, the minimum voltage level will be allowed to drop by 2 V to 113 V for three phase and 111 V for single phase.

Planning will take corrective action, when for the predicted loading, the distribution system is not capable of meeting this backup criteria.

Graph 1 – Typical Load Duration Curve