



Distribution Point-of-Delivery Interconnection Process Guideline

Standards of Service

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1.0 Introduction

1.1 Purpose

This guideline defines the principles and standards that Distribution Facility Owners (“DFO”) and/or Transmission Facility Owner (“TFO”) shall use to identify interconnection requirements on the Alberta Transmission System (“ATS”).

This guideline is intended solely for the purpose of supporting the AESO’s customer interconnection process to arrive at proposed interconnection concepts that are optimized on a technical and economic basis. It will not in any way address or determine the AESO’s facility cost allocation between system and customer, nor will it be used in any way as a guideline in applying the AESO approved tariffs and investment policy.

This guideline is intended to facilitate documentation of the project need and the evaluation done to support the need, in alignment with the interconnection process. The interconnection process has a requirement for AESO endorsement and AEUB approval of the project need.

1.2 Application of Guideline

This guideline is a reference for other Interconnection Process Guidelines. Because this guideline is used by various TFO’s and DFO’s with different planning and operating environments, it is recognized that differences may occur. To this end, these planning and operating environments are documented throughout this guideline.

The AESO expects that any deviations from this guideline will be documented, explained and supported by the TFO’s and/or DFO’s as part of the proposal(s) submitted to the AESO.

1.3 Modifications

In respect to this guideline the AESO will:

- a) seek the input and feedback of affected parties prior to making changes or additions to the guideline;
- b) make and manage all changes to this guideline;
- c) make this guideline publicly available via the AESO website;
- d) periodically and within five (5) years of the effective date shown on the cover page review this guideline.

2.0 Capacity Standards of Service

The expectation of electricity customers is that the transmission and distribution systems have the capacity to meet their power requirements when needed.

The two key components used in making a capacity assessment of the transmission and/or distribution system are:

1. Load Forecast - the AESO and Distribution Facility Owner (“DFO”) must forecast load in order to plan for the efficient and economical expansion of the transmission and/or distribution system in advance of the need materializing.
2. Capacity of Facilities – the TFO’s and DFO’s are responsible for identifying the voltage and thermal capacity of their facilities. The AESO, TFO’s and DFO’s will collaborate and coordinate in determining when the capacity of facilities is going to be exceeded during normal (“steady state”) and contingency conditions.

2.1 Load Forecasting Approach

The purpose of forecasting is to anticipate what the power system must be able to deliver in the future and how that differs from today’s requirements. This forecast is typically a geographical forecast that identifies how much, where and when capacity is required.

Transmission and distribution facilities are planned and designed to meet the expected peak demand on each distribution feeder and distribution delivery point (i.e. substation). The current approach used by TFO’s and DFO’s is:

- Feeder-by-Feeder: The peak demand for each feeder is examined separately to ensure the capacity rating of the facilities is adequate for future loading requirements.
- Substations: The peak demand supplied by the transformer(s) in the substation is reviewed to ensure there is sufficient capacity for future forecasted loading. The peak demand on the transformer reflects the coincident peak of all the distribution feeders supplied by the transformer. For substations with multiple transformers, the demand for the same date and time must be summed to obtain coincident peak of the substation.

The approach for forecasting load growth is typically one or both of the following:

- Load growth is determined by extrapolating the historical load into the future and by adding any specifically identified new and/or major loads.
- For proposed development in areas where no electrical facilities exist, the load forecast is developed using typical load density expectations as shown in Table 2.1-1.

Table 2.1-1 Ultimate Load Density

Classification of Load	Load Density (MVA/square mile)
Rural	Site specific ⁽¹⁾
Residential (Urban)	6 to 7
Light Commercial / Industrial	12 to 18
Heavy Commercial / Industrial	27 to 40

Notes:

(1) This is handled on a case-by-case basis, since there are many factors that affect rural load densities, such as terrain, access, agricultural, oilfield services, other land uses, and environmental requirements.

2.1.1 Geographical Load Forecasting Methodology

This section provides the methodology for creating a geographical load forecast that will ensure facilities of sufficient capacity are appropriately located and available when needed. The AESO requires clear and consistent load forecasts from all DFO's to evaluate TFO/DFO interconnection proposals. The size of the area covered by the "geographic load forecast" will vary depending on the type of facility being proposed.

Further, load forecasts are a prediction of a future possibility, given historical information and incorporating possible future development in the geographical area. All load forecasts are based on judgments of the future and are subject to variability, sensitivity and uncertainty. Therefore, the AESO will integrate the geographical forecast with its long-term forecasts to ensure that the geographical load forecast will support long term solutions. The long term (20 year) forecast is primarily used for bulk system planning and regional planning.

As a minimum, the geographical load forecast shall:

1. Include five (5) years of historical data and ten (10) years of forecasted load in MVA.
2. Provide load density maps that provide sufficient resolution (i.e. today, 5 year and 10 year) to make decisions and permit realistic siting of

facilities (e.g. substations). An example of a load density map is provided in Appendix 1 – Load Density Map Example.

3. Adjust recorded loads to account for load anomalies (i.e. load transfers between feeders) that could skew the projected load on feeder(s) and/or point of delivery substation(s).
4. Incorporate local information that is available, that could include plans of the Province, County, Municipality, Towns, Cities and/or local industrial or commercial developers that would give an indication of potential future development in the area.
5. Identify whether the geographical forecast is for winter or summer peak, which is typically the time period that the deficiency occurs.
6. Include the following:
 - Load MVA values provided to one decimal place.
 - Individual feeder peaks.
 - Transformer peaks that are the coincident peaks of all the feeders served by that transformer.
 - Station peaks are coincident peaks of all transformer peaks, summing each transformer peak with the same date and time stamp.
 - The area total load in both “Existing” and “Proposed” tables must be identical.
7. Provide two forecasts, one for the existing system and one that incorporates the proposed development clearly illustrating how load shifts between feeders and/or distribution delivery points (i.e. substations)
8. Include all stations that are relevant to the supply and/or backup of the load in the area under consideration. This is typically the point of delivery substations that are immediately adjacent to the location being studied.
9. Include specific notes to the tables that the TFO and/or DFO want to explain or identify. This could include:
 - Assumed power factor
 - Provide an explanation of significant (increases or decreases) in the load.

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- Lack of information (i.e. metering) that resulted in applying judgment to prepare the forecast.

2.1.2 Load Forecast Format & Content Required

Table Title [describe the area] – Existing System

Description	Recorded Loading [Summer or Winter peak] (MVA) ⁽¹⁾					Projected Loading [Summer or Winter peak] (MVA) ⁽¹⁾									
	Years					Years									
	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
Feeder 1															
Feeder N															
Transformer 1 Total ⁽²⁾															
Feeder 1															
Feeder N															
Transformer N Total ⁽²⁾															
Station [name & number] Total ⁽³⁾															
Repeat the above for all stations under consideration in the area															
Area Total Load															

Notes:

1. Load MVA values provided to one decimal place.
2. Transformer peaks are the coincident peaks of all the feeders served by that transformer.
3. Station peaks are coincident peaks of all transformer peaks, summing each transformer peak with the same date and time stamp.

Table Title [describe the area] – Proposed Development

Description	Recorded Loading [Summer or Winter peak] (MVA) ⁽²⁾					Projected Loading [Summer or Winter peak] (MVA) ⁽²⁾									
	Years					Years									
	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10
Feeder 1															
Feeder n															
New Feeder 1															
Transformer 1 Total ⁽³⁾															
Feeder 1															
Feeder n															
Transformer N Total ⁽³⁾															
Station [name & number] Total ⁽⁴⁾															
Repeat the above for all stations under consideration in the area including any new station proposed															
Area Total Load ⁽¹⁾															

Notes:

1. Area Total load in both “Existing” and “Proposed” tables must be identical.
2. Load MVA values provided to one decimal place.
3. Transformer peaks are the coincident peak of all the loads served by that transformer.
4. Station peaks are coincident peaks of all transformer peaks, summing each transformer peak with the same date and time stamp.

2.2 Capacity Assessment Criteria

The facilities installed by either the TFO or DFO are designed to operate within certain voltage and thermal ratings during a normal and contingency conditions. Operating facilities beyond their ratings can have:

1. Economic implications such as higher maintenance costs, loss of life, and/or early replacement of equipment that has failed catastrophically.
2. Safety implications to TFO and DFO personnel and the public at large.

The intent of this section is to outline acceptable operating ranges on TFO and DFO facilities during normal and contingency conditions.

2.2.1 Voltage Assessment Criteria

Voltages shall be maintained within applicable limits during normal and contingency conditions, such that equipment and facility limits are not exceeded.

2.2.1.1 Voltage Fluctuation Guidelines

This section is for DFO's only and is applicable to the distribution power delivery system.

The voltage at an electricity customer's utilization point must be within the ranges specified by CSA Standard CAN3-C235-83, "Preferred Voltage Levels for AC Systems, 1 to 50,000 volts".

Generally, the DFO's plan their distribution power delivery system to meet the voltage requirements during normal forecast peak load conditions to levels above the minimum voltage levels. Planning in this manner provides operational flexibility and reduces risk of exceeding equipment or facility limits due to unexpected occurrences (e.g. faster load growth, forecast uncertainties).

Table 2.2-1 identifies specific planning methodologies for voltage limits by each DFO.

Table 2.2-1: Specific DFO Planning Methodology for Voltage

<u>DFO</u>	<u>Methodology</u>
ATCO Electric Distribution	<ul style="list-style-type: none"> • Urban <ul style="list-style-type: none"> ○ Voltage on 25 kV overhead feeder <ul style="list-style-type: none"> ▪ System Normal - 116.4V (0.97 p.u) ▪ Contingency (25 kV alternate feed or T-POD) - 113V (0.94 p.u.) ○ Feeders with both overhead and underground <ul style="list-style-type: none"> ▪ System Normal & Contingency (supply from alternate 25 kV feed or POD) - 116.4V (0.97 p.u.) • Rural <ul style="list-style-type: none"> ○ Two feeder voltage regulators on a feeder, and; ○ Three phase 25 kV voltage of 114V (0.95 p.u.), or; ○ 25 kV voltage of 120 V (1.0 p.u) where: <ul style="list-style-type: none"> ▪ On the primary of a distribution step down substation (i.e. towns or REA's) ▪ At the tap point of a long three phase tap or a number of long single phase taps, or; ○ Minimum primary voltage of 114 V (0.95 p.u.) on single phase systems
EPCOR Distribution Inc	<ul style="list-style-type: none"> • Voltage levels at the customer service entrance are consistent with CSA CAN3-C235-83 • Typically 118 V to 120 V on the primary
ENMAX Distribution	<ul style="list-style-type: none"> • Voltage levels at the customer service entrance consistent with CSA CAN3-C235-83 for single phase and three phase. • For Planning purposes, the desired feeder voltage range is 125 V⁽¹⁾ to 118.5 V⁽¹⁾ as modeled at primary of customer transformer to allow for adjacent feeder contingency backup to be within the CSA standard at the customer service entrance under normal and contingency operation. • Typically, due to the relatively short, heavily loaded urban feeders, no supplemental line voltage regulation is applied.
FortisAlberta	<ul style="list-style-type: none"> • The feeder voltage loading limit is reached when the feeder has the following during normal operations:

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<u>DFO</u>	<u>Methodology</u>
	<ul style="list-style-type: none"> ○ Two voltage regulators and; ○ Three phase voltage is at 115 V ⁽¹⁾ (minimum) as modeled on the primary of a distribution transformer on the three phase distribution line or; ○ Single phase voltage is at 113 V ⁽¹⁾ (minimum) as modeled on the primary of a distribution transformer on the single phase distribution line. <ul style="list-style-type: none"> ● The voltage levels correspond to the minimum acceptable voltage as per CSA Standard.
Lethbridge Distribution	<ul style="list-style-type: none"> ● Voltage levels at the customer service entrance are consistent with CSA CAN3-C235-83. ● Typically 118 V to 123 V on the primary. ● Due to the relatively short urban feeders, no supplemental line voltage regulation is applied.
Red Deer Distribution	<ul style="list-style-type: none"> ● Voltage levels at the customer service entrance consistent with CSA CAN3-C235-83 for single phase and three phase. ● Planned feeder voltage range at primary of customer transformer will allow for adjacent feeder contingency backup to be within the CSA standard at the customer service entrance under normal and contingency operation. ● Maximum voltage level is limited by changes in transmission voltage levels to high levels which can not be quickly enough reduced by transmission transformer OLTC. ● Due to the relatively short, heavily loaded urban feeders, no supplemental line voltage regulation is normally applied.

Notes:

- 1) Voltages are on a 120 V base, which is a standard practice for DFO's in Alberta.

2.2.1.2 Voltage Range at Distribution Delivery Points

This section is for TFO's only and is applicable to the transmission system at the point of delivery substation. The AESO's Reliability Criteria is followed with respect to voltage limits at point of delivery (POD) substations.

The distribution bus is the bus that is regulated by means of an upstream device (e.g. substation regulator or transformer equipped with an on load tap changer) within the point of delivery substation. The distribution bus voltage shall be maintained at 125 volts +/- 1.5 volts on a 120 volt base in order to meet the CSA Standard at the customer utilization point.

Refer to the following sections in the AESO's Reliability Criteria for specifics regarding voltage capacity assessments of the ATS:

- Section 4.5 "Point of Delivery (POD) Criteria" in Part II -Transmission System Planning Criteria
- Section 5.1 "Voltage Standards" in Part II-Transmission System Planning Criteria
 - Table 5.1-1 in the AESO's Reliability Criteria identifies the acceptable voltage ranges for normal and contingency conditions.
 - Table 5.1-2 in the AESO's Reliability Criteria identifies the acceptable voltage changes during and after contingency conditions.
- Section 5.6.2 "Voltage Limits" in Part III-Transmission Operating Criteria
 - Table 1 "Transmission Standards – Normal and Contingency Conditions" in Part III-Transmission Operating Criteria of the AESO's Reliability Criteria identifies the acceptable thermal limits during and after contingency conditions.
- Section 5.6.4 "Point of Delivery Limits" in Part III-Transmission Operating Criteria

2.2.2 Thermal Assessment Criteria

Generally, thermal loading on power delivery facilities shall be maintained within applicable limits for both normal and contingency conditions. The normal and contingency conditions are defined as:

- Normal Conditions: For planning purposes, no power delivery facility shall be loaded beyond its continuous rating.

- Contingency Conditions: Power delivery facilities can exceed their rated capability for a brief time period, until the power delivery system is restored back to its normal condition. This may require automatic (i.e. remedial action schemes) and/or manual intervention such as;
 - Switching system devices to alter loading (e.g. line breakers, line and/or substation switches):
 - The following measures may be required during real time operations:
 - Shedding load to ensure that the thermal rating of power delivery elements are not exceeded; and/or
 - Rotating outages to ensure that the thermal ratings of power delivery elements are not exceeded.

2.2.2.1 Distribution Power Delivery Systems

All elements will have normal, contingency and emergency thermal ratings as specified by the DFO's. The normal and contingency thermal ratings for elements may be the same or different. During normal, contingency and emergency conditions, elements shall not exceed their respective thermal ratings.

Table 2.2-2 identifies planning methodologies for thermal limits employed by each DFO. Planning in this manner provides operational flexibility and reduces the risk of exceeding equipment or facility limits due to unexpected occurrences (e.g. faster load growth, forecast uncertainties).

Table 2.2-2: Specific DFO Planning Methodology for Thermal Capability

<u>DFO</u>	<u>Methodology</u>
ATCO Electric Distribution	<ul style="list-style-type: none"> • Refer to Appendix II for details regarding ATCO's definition for an urban area. • <u>Urban 25 kV Overhead Feeder</u> <ul style="list-style-type: none"> ○ Normal Conditions: maximum loading of an urban 25 kV overhead feeder is 10 MVA. ○ Maximum contingency (25 kV alternate feed or Distribution Point-of-Delivery) loading is: <ul style="list-style-type: none"> ▪ 266 Conductor: 20 MVA ▪ 477 Conductor: 25 MVA • <u>Urban 25 kV Underground Feeder</u>

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<u>DFO</u>	<u>Methodology</u>
	<ul style="list-style-type: none"> ○ Normal Conditions: maximum loading of an urban 25 kV underground feeder is 10 MVA. ○ Maximum contingency (25 kV alternate feed or Distribution Point-of-Delivery) loading is: <ul style="list-style-type: none"> ▪ 500 MCM Cable: 17 MVA • <u>Rural 25 kV Overhead Feeder</u> <ul style="list-style-type: none"> ○ The maximum loading is governed by: <ul style="list-style-type: none"> ▪ minimum line voltages under normal and contingency (25 kV alternate feed or T-POD) ▪ requirement to parallel feeders at the substation for 25 kV breaker maintenance, ▪ rating of line switches ▪ motor starting requirements ▪ occasionally U/G cable at the substation ▪ Typically, the maximum loading is much less than 25 MVA because of the preceding limitations. There may be exceptions on express feeders where loads approach 25 MVA.
EPCOR Distribution Inc.	<p>EPCOR’s thermal capabilities are based on the ratings of the substation exit cables (6 feeders in a ductline) with mutual heating. Ratings are derived using IEC 287 methods with temperature limits as recommended in CSA Standard 68.1 and AEIC CS5-87.</p> <p><u>Normal (Design Loading):</u></p> <ul style="list-style-type: none"> • Traditionally EPCOR has rated cables based on 2/3 of their emergency ratings assuming outages would be relatively short-term (2 to 3 days max). This assumes the ability to split circuits and transfer ½ of the load to two adjacent circuits i.e. this approach assumes highly reliable transmission supplies that preclude long-term outages. Based on this approach the normal peak feeder design limits for standard 750 MCM Cu cables would be (winter/summer): <ul style="list-style-type: none"> ○ 15 kV cables: 370 A/340 A (9.2/8.5 MVA @ 14.4 kV)

<u>DFO</u>	<u>Methodology</u>
	<ul style="list-style-type: none"> • In situations where: <ul style="list-style-type: none"> ○ transmission supplies cannot be counted upon to preclude long-term outages; or ○ in the case of 25 kV where there are very limited ties and/or too many customers (> 3,500) are at risk, cable loading is limited to ½ normal. On this basis the normal peak feeder design limits for standard 750 MCM Cu cables would be (winter/summer): <ul style="list-style-type: none"> ▪ 15 kV cables: 222 A/190 A (5.5/4.7 MVA @ 14.4 kV) ▪ 25 kV cables: 232 A/195 A (10.4/8.8 MVA @ 26 kV) <p><u>Emergency (Contingency) Loading:</u></p> <ul style="list-style-type: none"> • Short Term (2 to 3 days max. Winter/Summer): <ul style="list-style-type: none"> ○ 15 kV cables: 560 A/515 A (13.9/12.8 MVA @ 14.4 kV) ○ 25 kV cables: 535 A/470 A (24.1/21.1 MVA @ 26 kV) • Long Term (Continuous or >2 to 3 days max. Winter/Summer): <ul style="list-style-type: none"> ○ 15 kV cables: 445 A/380 A (11.1/9.5 MVA @ 14.4 kV) ○ 25 kV cables: 465 A/390 A (20.9/17.5 MVA @ 26 kV) • Note, EPCOR has a variety of older feeder cables, some smaller, that would have ratings determined on this same basis.
ENMAX Distribution	<ul style="list-style-type: none"> • Maximum feeder loading under normal operation for both 13 kV and 25 kV feeders is limited to 300A using either 477 MCM overhead conductor or 750 MCM underground cable. (7.2 MVA at 13 kV and 13.5 MVA at 25 kV). This achieves a full feeder restoration within a 600 A maximum loading. • Facilities are planned to function within normal operational rating however, on a temporary basis during contingency, may be allowed to operate at a higher level but still within the recommended manufacturers overload specification. In cases where there is a risk of overload during normal operation, corrective action is initiated.
FortisAlberta	<ul style="list-style-type: none"> • Refer to Appendix II for details regarding FortisAlberta’s definition for an urban area. • <u>Urban 25 kV Overhead Feeder</u> <ul style="list-style-type: none"> ○ Normal Conditions: maximum loading of an urban 25 kV overhead feeder using 477 MCM ACSR conductor as main-line conductor is 13 MVA. This provides capacity in the event that the entire load needs to be supplied from an adjacent feeder due to the loss of a feeder at the terminal or

<u>DFO</u>	<u>Methodology</u>
	<p>25 kV breaker maintenance. The terminal facilities have a capacity of 26 MVA (600A). The overhead line facilities have a thermal capacity of:</p> <ul style="list-style-type: none"> ▪ 477 MCM ACSR Conductor: 32 MVA <ul style="list-style-type: none"> • <u>Urban 25 kV Underground Feeder</u> <ul style="list-style-type: none"> ○ Normal Conditions: maximum loading of an urban 25 kV underground feeder is 10 MVA. This provides capacity in the event that the entire load needs to be supplied from an adjacent feeder due to the loss of the adjacent feeder. The terminal facilities have a capacity of 26 MVA .The underground line facilities which are the limiting components have a thermal capacity of: <ul style="list-style-type: none"> ▪ 500 MCM Cable: 17 MVA, 3 cables in one duct in air ▪ 500 MCM Cable: 21 MVA, 1 cable per duct in air • <u>Rural 25 kV Overhead Feeder</u> <ul style="list-style-type: none"> ○ Normal Conditions: maximum loading of a rural 25 kV overhead feeder is 13 MVA. Feeder is at its maximum loading when the measured load at the distribution delivery point (i.e. substation) is 50% of the feeder terminal capacity. This allows for the situation in which the combined load of two inter-connected feeders needs to be carried by one or the other for the loss of the terminal facility. The terminal facilities have a capacity of 26 MVA. The overhead line facilities have a thermal capacity of: <ul style="list-style-type: none"> ▪ 3/0 ACSR Conductor: 17 MVA ○ The maximum loading may also be governed by: <ul style="list-style-type: none"> ▪ minimum line voltages under normal conditions, ▪ rating of line switches
Lethbridge Distribution	<ul style="list-style-type: none"> • Feeder loading under normal operation for 13.8 kV feeders is limited to 5 MVA using either 336.4 MCM ACSR or 500 MCM CU 15 kV underground cables. Maximum Feeder loading during emergency basis is limited to 10 MVA. This allows for full feeder restoration between substations on a long term basis. It also allows for some unplanned load growth in established areas. • Normally, feeders function within normal operational rating however, on a temporary basis during contingency, may be allowed to operate at a higher level but still within the recommended manufacturers overload specification.

<u>DFO</u>	<u>Methodology</u>
Red Deer Distribution	<ul style="list-style-type: none">• Maximum feeder loading under normal operation is limited to 200A (8.7 MVA at 25 kV). Exceptions for single large loads are made. This 50% capacity loading enables the load to be supplied by an adjacent feeder.

2.2.2.2 Transmission Power Delivery Systems

This section is for TFO’s only and is applicable to the transmission system. All elements will have normal, contingency and emergency thermal ratings as specified by the TFOs. The normal and contingency thermal ratings for elements may be the same or different. Generally, during normal, contingency and emergency conditions, elements shall not exceed their respective thermal ratings.

The specific requirements regarding the thermal capacity of the transmission power delivery system is provided in the AESO’s Reliability Criteria. This Reliability Criteria is followed with respect to thermal capacity at point of delivery substations.

For planning purposes, no transmission facility shall be loaded beyond its continuous rating during normal conditions. Refer to the following sections in the AESO’s Reliability Criteria¹ for specifics regarding thermal capacity assessments of the ATS:

- Section 5.6.1 “Thermal Limits” in Part III -Transmission Operating Criteria

¹ AESO Reliability Criteria – available at www.aeso.ca

3.0 Reliability Standards of Service

The expectation among electricity customers is that the power supply system provides reliable service at reasonable rates by making economic and efficient use of the power system infrastructure. Within the context of reasonable rates, electric service means that electrical supply is available when required and that there is minimal impact to the electricity customer's ability to operate (loss of goods, services or benefits). As a result, the power supply components are evaluated on their ability to provide reliable electricity. Reliability is comprised of adequacy and security, and is impacted by the ability of the supply to be restored in a timely manner, after a system contingency.

Even though the intention is to avoid power outages, it is not possible or economical to avoid all component or combination of component failures that result in the interruption of electrical service.

Assessing the reliability of the service to electrical customers requires the following information:

- amount of load supplied;
- number of customers supplied;
- type of customers served;
- reliability data for one or a combination of the relevant feeders; and
- reliability data for the relevant distribution delivery points (i.e. substations) and transmission line(s).

Further, the reliability data of the transmission and distribution power delivery system shall be based upon a five (5) year system average historical performance. It is an accepted utility practice to utilize past performance as an indicator of future performance.

3.1 Backup Requirements Assessment Criteria

In principle, the DFO's plan and design their distribution systems with the capability to backup electricity customers. There are many factors that affect the DFO's and TFO's ability to restore service to electricity customers during a contingency. Some projects may be recommended based upon the assessment of the following factors that affect the TFO's and/or DFO's ability to restore service in a timely manner:

- Number of customers affected;

- Density of load;
- Social/economic/environmental impacts;
- Time to repair; and
- Time to restore service, which can be affected by accessibility

Unsupplied Load (see definition) must be restored in both urban and rural systems. A balance between the time required to restore service and the cost of facilitating the restoration of service must be achieved. Service may not be restored to all customers simultaneously following an outage. The intent is to reduce to an acceptable level the number of customers who remain out of service due to an outage while other restoration measures are deployed or the repair work is undertaken. The term acceptable level is at the discretion of the DFO and/or TFO to determine in any situation, since a number of factors affect this, including but not limited to:

- Number of customers.
- Type of load (hospitals, residential, commercial, industrial).
- Outage duration.
- Repair of damaged facilities in a safe manner.

Plans are developed that include one or a combination of the following that may be used to restore service to electricity customers during planned or unplanned outages on the transmission and/or distribution power delivery system. In implementing these plans, the TFO and DFO are responsible to decide what measures are appropriate and what order these measures should be applied in any situation.

- Automatic transfer of load to an alternate transmission or distribution supply.
- Manually or remotely switching the distribution supply system to provide an alternate supply route. It is recognized that switching time maybe longer in a rural area compared to an urban area.
- Manually or remotely switching to provide electrical supply from adjacent POD stations.
- Manually or remotely switching within the POD station to transfer the electricity customer to an alternate transformer.
- Other non-switching activities as described below may be used to restore load. An economic evaluation should identify the most cost effective solution.

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- Use of a mobile substation.
- Use of standby generation supplied by the DFO.
- Use of standby generation or UPS supplied by the customer.
- Repair the damaged facilities.
- In real time operations, the following provide additional ways to address conditions where the thermal capacity of facilities are exceeded:
 - Partial restoration or rotating outages.
 - Public announcements for curtailment of load

Table 3.1-1 outlines the backup criteria for planning and designing the distribution supply system for rural and/or urban areas. The target restoration times in the table applies to DFOs and/or TFOs.

Table 3.1-1: TFO/DFO Back up and Restoration

Type of load	Possible means for backup (more than one may be used in any situation)	Target Restoration Time Standard (100% of load restored for recognized contingencies)					
		ATCO Electric Distribution	EPCOR Distribution Inc.	ENMAX Distribution	Fortis Alberta	Lethbridge Distribution	Red Deer Distribution
Urban Critical - Critical commercial or industrial operation, large downtown core, or public safety related load (hospitals)	<ul style="list-style-type: none"> ▪ Onsite customer provided UPS with auto transfer from DFO ▪ DFO auto transfer ▪ TFO auto transfer ▪ Customer emergency generation 	Automatic Transfer	Automatic Transfer	Automatic Transfer	Automatic Transfer	< 2 hrs ⁽⁶⁾	Customer emergency generation. Less than or equal to 1 hr
Urban commercial load	<ul style="list-style-type: none"> ▪ Auto transfer ▪ Remote switching ▪ Manual switching 	less than or equal to 4 hours Note (1)	less than or equal to 1 hour	Immediate (with Distribution Automation) to <1 hour (if remote or manual switching)	less than or equal to 1 hour	<2 hrs ⁽⁶⁾	Less than or equal to 2 hr
Urban residential load	<ul style="list-style-type: none"> ▪ Auto transfer ▪ Remote switching ▪ Manual switching 	less than or equal to 4 hours	less than or equal to 1 hour	Immediate (with Distribution Automation) to <1 hour (if remote or	less than or equal to 1 hours	< 2 hrs ⁽⁶⁾	Less than or equal to 3 hr

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Type of load	Possible means for backup (more than one may be used in any situation)	Target Restoration Time Standard (100% of load restored for recognized contingencies)					
		ATCO Electric Distribution	EPCOR Distribution Inc.	ENMAX Distribution	Fortis Alberta	Lethbridge Distribution	Red Deer Distribution
				manual switching)			
Rural Critical commercial, industrial or agricultural load	<ul style="list-style-type: none"> ▪ Onsite customer provided UPS with auto transfer from DFO ▪ DFO supplied auto transfer ▪ Manual switching ▪ Customer or DFO standby generation 	Automatic Transfer ≤ 4 hours (if manually switching)	Note 4	Note 4	Automatic Transfer ≤ 4 hours (if manually switching)	Note 4	Note 4
Rural Load (Residential, Farm and Commercial)	<ul style="list-style-type: none"> ▪ Remote switching ▪ Manual switching 	less than or equal to 4 hours	Note 4	Note 4	less than or equal to 4 hours	Note 4	Note 4
Oilfield and Industrial	<ul style="list-style-type: none"> ▪ Remote Switching ▪ Manual Switching ▪ Mobile Substation ▪ Customer Emergency Generators 	Summer = less than or equal to 24 hours Winter = less than or equal to 4 hours for lights, heat trace and glycol pumps All Load = less than or equal to 24 hours	Note 4	Note 4	Summer = less than or equal to 24 hours Winter = less than or equal to 4 hours for lights, heat trace and glycol pumps	N/A	N/A for oilfield Industrial customer emergency generators Industrial less than or equal to 1 hr

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Type of load	Possible means for backup (more than one may be used in any situation)	Target Restoration Time Standard (100% of load restored for recognized contingencies)					
		ATCO Electric Distribution	EPCOR Distribution Inc.	ENMAX Distribution	Fortis Alberta	Lethbridge Distribution	Red Deer Distribution
		Note 5					
Remote rural load	<ul style="list-style-type: none"> ▪ Remote switching ▪ Manual switching ▪ Customer Standby generation ▪ Mobile substation (Note 3) ▪ Partial restoration or rotating outages 	less than or equal to 4 hours Note (2)	Note 4	Note 4	Note (2)	Note 4	Note 4

Notes:

- 1) Priority is given to restoring feeders that supply hospitals, institutions and commercial loads.
- 2) Outages beyond 4 hours are a concern due to freezing up the premise for residential, farm, commercial loads and oilfield and industrial. Restoration time of radial, across country transmission lines and single transformer PODs can be well beyond 4 hours due to the nature of the failure, time of day, accessibility and weather conditions. After 24 hours there is to be no unsupplied load.
- 3) The mobile substation can be considered as an acceptable method of restoring load in remote rural areas. In assessing if the mobile is an acceptable solution, recognition should be given to the probability of the event, the duration of the event, the consequences, size of load impacted by the event, number of customers, type of load, environmental consequences, location and economic evaluation of the cost of possible solutions to search for the most cost effective solution.
- 4) Is considered an urban utility and as such does not normally serve rural type load.
- 5) It may be impractical to manually switch off oilfield only on a feeder that supplies both residential, commercial, and farm as well as oilfield and achieve a restoration time of 4 hours, so in those instances oilfield also may be restored in 4 hours.
- 6) Time may vary during non-working hours (Lethbridge Distribution)

3.2 Distribution Feeder Reliability Indices

When recommending a system reinforcement project for reliability reasons, the AESO expects the DFOs to provide the following. In Alberta, two of the key feeder reliability indices commonly used by DFO's are SAIDI and SAIFI. SAIDI and SAIFI indices are defined in the definition section.

- A classification of interruptions as either momentary or sustained. Momentary and sustained are defined in the definitions section of this guideline.
- Provide a comparison of the feeder SAIDI and SAIFI (i.e. SAIFI-SI and SAIFI-MI) against the average SAIDI and SAIFI for momentary and sustained interruptions for that DFO's distribution system. The SAIDI and SAIFI indices for momentary and sustained are to be calculated using the standards established by Canadian Electric Association ("CEA").
- A description of the methodology used for tracking and calculating performance of the distribution power delivery system, where the DFO does not use the CEA method for reliability tracking and evaluation (i.e.. SAIDI, SAIFI).
- Additional information that supports the recommendation, that could include:
 - How often the feeder is out.
 - Substantiated customer complaints
- A description of improvements that were implemented to address the feeder performance through maintenance, modifications and/or other means. This should include the timing of such improvements, since sufficient time may or may not have elapsed to determine the impact on reliability of the improvements.

Table 3.2-1 summarizes specific methodologies used by DFO's to identify and recommend system reinforcement projects to address reliability concerns.

Table 3.2-1: DFO Methodologies for Feeder Reliability Concerns

<u>DFO</u>	<u>Methodology</u>
ATCO Electric Distribution	<ul style="list-style-type: none"> • Does not collect momentary outages for feeders at 25 kV and below. • Tabulates SAIFI, CAIDI and SAIDI for each 25 kV feeder, for each of our service areas and for the total 25 kV system for each year. SAIFI and CAIDI are compared to CEA average indices. • Does not differentiate urban and rural feeders and tabulate an annual number for each category. • Differentiates Planned and Unplanned outages. • Selects the 5% worst performing feeders and does a review to determine the cause of the sustained outages and restoration time.
EPCOR Distribution Inc	<ul style="list-style-type: none"> • Tracks the performance of all circuits on an on-going basis. Circuits that register 3 outage events in 30 consecutive days trigger an alert. • On a monthly basis the performance of all circuits and YTD system performance are reviewed, tabulated and compared to historical trends. This review includes customer complaints, system and equipment performance trends and maintenance practices. • Although EPCOR does not necessarily rank the circuit based on reliability indices (SAIDI/SAIFI etc.); these are considered in reviewing the numbers of outages (sustained & momentary) and the numbers of customer hours. Not all poorly performing circuits need long-range actions; some causes may be beyond EPCOR’s control • All System or Circuit Problems considered “actionable” are assigned for a more thorough investigation; problem solving and ultimately correction actions are taken. If actions were not effective it is expected that the same circuits will again trigger alerts & further investigation/actions will result.
ENMAX Distribution	<ul style="list-style-type: none"> • Recommends system reinforcement projects based on analyses of worst performing feeders, which are identified through comparison of their relative SAIDI & SAIFI indices and number of operations on a 5 year rolling average. • This is consistent with the AEUB wire owner Service Quality and Reliability Performance Plan (SQRP). • Considers poor feeder performance as only one of the components which may drive the need for a specific system upgrade or addition.

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<u>DFO</u>	<u>Methodology</u>
FortisAlberta	<ul style="list-style-type: none"> • Does collect momentary outages for feeders at 25 kV and below. • Presently tabulates SAIFI, CAIDI and SAIDI for each 25 kV feeder and for the total 25 kV system for each year. SAIFI and CAIDI are plotted by year against the CEA annual numbers for the period 2000 to present to see how FortisAlberta numbers are trending as well as checking to see how FortisAlberta numbers are trending relative to CEA averages. • Does differentiate urban and rural feeders and tabulates an annual number for each category. • Does differentiate Planned and Unplanned outages. • Selects the 5% worst performing feeders and does a review to determine the cause of the momentary and sustained outages and restoration time. FortisAlberta then develops work orders to spend capital to reduce the cause of the momentary and sustained outages, to reduce the number of customers impacted, and to reduce the length of time to find the fault.
Lethbridge Distribution	<ul style="list-style-type: none"> • Tracks all unplanned outages on an ongoing basis. • Does not rank circuits based on reliability indices (SAIDI/SAIFI) but considers these in system reporting. • Circuit outages with an undetermined cause are patrolled for an obvious visible cause and for public safety. 2 outages within 6 months per circuit are inspected in more detail. • Currently evaluating Distribution Automation. Circuits will be evaluated to set criteria.
Red Deer Distribution	<ul style="list-style-type: none"> • Does not collect momentary outages for feeders. • Tabulates SAIFI, CAIDI and SAIDI for the total service area but not for individual feeders. SAIFI and CAIDI are compared to CEA average indices. • Conducts a review to determine the cause of sustained outages and restoration time. • Poor feeder performance is only one of the components considered when evaluating the need for a specific system upgrade or addition.

3.3 Distribution Delivery Point Substation Reliability

The delivery point substation is the interconnection point between the transmission and distribution power delivery systems. The reliability of the delivery point substation will impact the reliability of all distribution feeders emanating from the substation.

In Alberta, three of the key reliability indices commonly used for point of delivery substations are SAIDI, SAIFI-MI (momentary) and SAIFI-SI (sustained). Each one is broken down by voltage class and computed separately for both single-circuit and multi-circuit supplied point of delivery substations. When recommending a system reinforcement project for reliability reasons, the AESO expects the TFO's and/or DFO's to provide the following for point of delivery substations.

- A classification of interruptions as either momentary or sustained. Momentary and sustained are defined in the definitions section of this guideline.
- TFO's to provide to the AESO, the SAIDI, SAIFI-MI and SAIFI-SI numbers based on the most recent five years of data for the point of delivery substations. The SAIDI, SAIFI-MI and SAIFI-SI shall be calculated using the standards established by the CEA. These reliability indices will include both transmission and point of delivery substations interruptions.
- A description of the methodology used for tracking and calculating performance of the point of delivery substations, where the TFO does not use the CEA method for reliability tracking and evaluation (i.e. SAIDI, SAIFI).
- Provide a comparison of the point of delivery substation SAIDI and SAIFI against the average SAIDI and SAIFI for that TFO and the overall Alberta system average for point of delivery substations. The overall Alberta system average for delivery point substations will be calculated by the AESO based upon the annual information provided by each TFO. The SAIDI and SAIFI indices are to be calculated using the standards established by CEA.
- Additional information that supports the recommendation, that could include:
 - How often the point of delivery substation is out of service.
 - Substantiated customer complaints

- A description of improvements that were done to address the point of delivery substation performance through maintenance, modifications and/or other means. This should include the timing of such improvements, since sufficient time may or may not have elapsed to determine the impact on reliability of the improvements.

Table 3.3-1 summarizes specific methodologies used by TFO’s to identify and recommend system reinforcement projects to address reliability concerns at point of delivery substations.

Table 3.3-1 TFO Methodologies for POD Substation Reliability

<u>TFO</u>	<u>Methodology</u>
AltaLink	<ul style="list-style-type: none"> • AltaLink compiles sustained and momentary outage data for delivery points SAIFI, SAIDI, SARI(Restoration), and POD SAIF and SAIDI are also calculated per year and trended over the past five years. Information is available for the Maintenance Planning group to use to develop maintenance programs and capital programs. • When a POD suffers from a sustained or momentary fault a root cause failure analysis is performed to identify concerns with equipment/environment. When a particular a class of equipment is identified as susceptible to a particular failure mode, then an evaluation of possible solutions is undertaken and a business case is prepared. Corrective action can range for equipment modification to requests for a station redesign.
ATCO Electric Transmission	<ul style="list-style-type: none"> • Compiles sustained and momentary outage data for delivery points. Points of delivery with >2 sustained faults per year and >4 sustained faults over the past five years are selected and put in the under performing table in the annual ATCO Electric Delivery Point Reliability Report. SAIFI, SAIDI, SARI(Restoration), SALI(Load), SAUEI(Unsupplied Energy Index), DPUI(Delivery Point Unreliability), and customer SAIF and SAIDI are also calculated per year and trended over the past five years. Information is available for the Maintenance Group and Planning to use to develop maintenance programs and capital programs. • Loss of a POD is a significant outage and unacceptable outage due to the magnitude and the impact of the outage. AE analyzes all sustained substation outages via an internal review committee that meets monthly to check that all systems performed as expected and whether corrective

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<u>TFO</u>	<u>Methodology</u>
	<p>action needs to be taken. Corrective action may be immediate or via a planned program to correct similar deficiencies at other PODs. The corrective action may lead to a request for a POD configuration change or transmission breaker addition.</p> <ul style="list-style-type: none"> • ATCO Electric is measuring sag and swells for each POD 25 kV bus. Non zero voltage sag and swell deviations is a measure of the quality of the voltage supplied over a period of time. It is usually associated with power quality analysis however it is included here. Zero voltage sags which are a POD outage are also included with the records. Sag and swell Information has been collected over the past three years. The data collection is triggered by a 10% threshold for over or under voltage. The information collects sustained outages to the POD 25 kV bus as the voltage drops to zero volts as well as collecting sags during transmission and distribution faults on area lines. The frequency and depth of the sags is indicative of the area transmission system and distribution system, and available short circuit level.
<p>EPCOR Transmission Inc</p>	<ul style="list-style-type: none"> • Review the historical performance of the POD and comparison with similar PODs within EPCOR system. Considerations will include number of customer complaints, magnitude of customer load supplied and the sensitivity of load in addition to SAIDI and SAIFI statistics. • As a component of reliability analysis, EPCOR investigates the cause of failure of individual equipment and identifies “type faults”. Corrective measures including repair or replacement decisions are undertaken based on the severity of situations. • EPCOR Distribution PODs are designed to ensure no loss of customer load for periods greater than the normal restoration times
<p>ENMAX Transmission</p>	<ul style="list-style-type: none"> • The process ENMAX follows is: <ul style="list-style-type: none"> ○ Failures of equipment in service are investigated to determine the cause of failure. ○ Where a class of equipment is identified as susceptible to a particular failure mode, then an evaluation of possible solutions is undertaken. ○ This may result in a business case being advanced for

<u>TFO</u>	<u>Methodology</u>
	<p>the replacement of the equipment after other factors such as age, environmental factors, and serviceability are taken into account. An example is the replacement of hook stick operated switches in our substation where the analysis showed that replacement was cheaper than continuing a shortened maintenance cycle.</p> <ul style="list-style-type: none"> • All ENMAX Distribution Point of Delivery substations shall be planned and designed to ensure no loss of load due to transmission capacity limitations under normal operating conditions for a period greater than the switching transfer time required to restore service. • Restoration capability is assessed based on a combination of firm POD capacity remaining, adjacent POD capacity import through distribution feeder interconnections, and the prevailing SAIDI reliability target. The nature and timing of system expansion required to maintain the desired level of service restoration is determined on a site specific basis.
Lethbridge Transmission	<ul style="list-style-type: none"> • Information to Follow
Red Deer Transmission	<ul style="list-style-type: none"> • Failures of equipment are investigated to determine cause. • Identify if a particular class of equipment is susceptible. • Evaluate possible solutions to determine if replacement, design change or maintenance is best solution. • POD substations are designed to minimize the potential loss of entire load due to capacity limitations for a time greater than the required switching transfer time to restore service. • Restoration capability considers the POD capacity remaining and the capacity available from other PODs through distribution feeder interconnection.

3.4 Transmission Line and Cable Reliability

Transmission lines transport electricity from generators to and between the point of delivery substations. The reliability of the transmission lines and

cables can impact the reliability of the point of delivery substations and distribution feeders emanating from the substation.

In Alberta, transmission line and cable reliability is calculated based upon CEA standards. When recommending a system reinforcement project for reliability reasons, the AESO expects the TFO's to provide the following for transmission lines and cables; in regards to this section, cable refers to a conductor that is buried and operating at a transmission voltage (i.e. 69 kV or above).

- A classification of outages as either momentary or sustained. Momentary and sustained are defined in the definitions section of this guideline.
- TFO's to provide to the AESO, the transmission line and cable indices based on the last five years of data for transmission lines.
- A description of the methodology for tracking and calculating performance of the transmission lines and cables, where the TFO doesn't use the CEA method for reliability tracking and evaluation of transmission lines.
- Provide a comparison of the transmission line and cable indices against the average indices for that TFO and the overall Alberta system average for transmission lines. The overall Alberta system average for transmission lines will be calculated by the AESO based upon the annual information provided by each TFO.
- A description of improvements that were done to address the transmission line or cable performance through maintenance, modifications and/or other means. This should include the timing of such improvements, since sufficient time may or may not have elapsed to determine the impact on reliability of the improvements.

Table 3.4-1 summarizes specific methodologies used by TFO's to identify and recommend system reinforcement projects to address reliability concerns for transmission lines and cables.

Table 3.4-1 TFO Methodologies for Transmission Lines and Cables

<u>TFO</u>	<u>Methodology</u>
AltaLink	<ul style="list-style-type: none"> • The performance of each transmission line is tracked for sustained and momentary outages, and duration on an annual basis as well as a five year rolling average. Indices for annual and a five year rolling average are also tabulated by voltage class. The performance of all transmission lines is

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<u>TFO</u>	<u>Methodology</u>
	<p>compared to AltaLink’s average for the particular voltage class (69kV, 138 kV, 240 kV). Information is available for the Maintenance Planning group to use to develop maintenance programs and capital programs</p> <ul style="list-style-type: none"> • When a line suffers from a sustained or momentary fault a root cause failure analysis is completed to identify concerns with equipment/lines. When a particular a class of equipment/line is identified as susceptible to a particular failure mode, then an evaluation of possible solutions is undertaken and a business case is prepared. Corrective action can range for equipment modification to requests for a line rebuild.
<p>ATCO Electric Transmission</p>	<ul style="list-style-type: none"> • The performance of each transmission line is tracked for sustained and momentary outages, and duration on an annual basis as well as a five year rolling average. Indices for annual and a five year rolling average are also tabulated by voltage class. The performance of deficient transmission lines is compared to ATCO Electric average for the particular voltage class as well as to the 144 kV class which is the most common regional and POD supply voltage. • ATCO Electric has been collecting data for sags and swells for each POD for three years. For a POD supplied by more than one transmission supply and with the assumption that N-1 transmission voltages are acceptable, the impact of a poor performing transmission line is the voltage sag during a line fault. Sags and swell is often incorporated as power quality. • ATCO Electric will include the cost of the option of bringing poor performing lines up to an acceptable level of performance.

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<u>TFO</u>	<u>Methodology</u>
EPCOR Transmission Inc	<ul style="list-style-type: none"> • EPCOR Transmission Inc. utilizes CEA Methodologies to record transmission reliability statistics. Transmission element outage data and POD outage data is compiled and summarized on a yearly basis. Multiple year data summaries are used to calculate historical performance indices. The analysis does not include distribution related outages. • EPCOR performs root cause analysis for failures and identifies solutions • Results of system inspection and testing are used to evaluate the risk and consequences of failure and corrective actions are recommended.
ENMAX Transmission	<ul style="list-style-type: none"> • The process ENMAX follows is: <ul style="list-style-type: none"> ○ Failures of equipment in service are investigated to determine the cause of failure. ○ Where a class of equipment is identified as susceptible to a particular failure mode, then an evaluation of possible solutions is undertaken. This may result in a business case being advanced for the replacement of the equipment after other factors such as age, service environment, and serviceability are taken into account. One example is the replacement of fiberglass arms on our transmission structures which degrade due to the ultraviolet radiation. The arms lose their insulating capability and fail in service. This failure process is accelerated by the high contamination levels produced by the mixture of sand and salt used on urban streets, especially when coupled with weather conditions. • All ENMAX Distribution Point of Delivery substations shall be planned and designed to ensure no loss of load due to transmission capacity limitations under normal operating conditions for a period greater than the switching transfer time required to restore service • Restoration capability is assessed based on a combination of firm POD capacity remaining, adjacent POD capacity import through distribution feeder interconnections, and the prevailing SAIDI

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<u>TFO</u>	<u>Methodology</u>
	reliability target. The nature and timing of system expansion required to maintain the desired level of service restoration is determined on a site specific basis.
Lethbridge Transmission	<ul style="list-style-type: none">• Information to Follow

4.0 Power Quality

Power quality is simply defined as the severity of voltage and frequency deviations supplied to the electric customer. If there are sufficient deviations in voltage and frequency of the power supplied to electricity customers, it can affect the safe and reliable operation of the electricity customer's facility.

There are many factors such as the following that can affect the power quality to the electricity customer:

- Sensitivity of the electricity customers' equipment that varies from one manufacturer to another.
- How the electricity power customers' facility was designed and constructed.
- The type of distribution feeder the electricity customer is connected to.

The following categories relate to specific power quality areas that each DFO must manage in supplying its customers. The following is only a brief summary and specific questions should be directed to the DFO. Further, if these standards aren't met, investigation would be initiated by DFO which may ultimately lead to a transmission solution.

4.1 Voltage

Voltage is a relatively broad term area of concern with respect to the area of power quality and may include the following considerations:

- Transients: voltage spikes can be caused by lightning strikes, capacitor switching and switching on the transmission or distribution power delivery system.
- Swells: voltage swells can be caused by switching or circuit to circuit faults on the transmission or distribution systems.
- Sags: voltage sags can be caused by power system faults, customer motor starting, or switching on the transmission or distribution system.
- Flicker
- Voltage Variation
- Interruptions

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- Voltage Imbalance
- Waveform Distortion
- Frequency

Table 4.1-1 is summary of the standards that each DFO applies to their distribution system with respect to the quality of voltage provided to electric power consumers.

Table 4.1-1: DFO Standards for Voltage Quality

<u>DFO</u>	<u>Standards</u>
ATCO Electric Distribution	<p><u>Voltage Flicker:</u></p> <p>CAN/CSA –C61000-3-7:04 Electromagnetic Compatibility(EMC) – Part 3: Limits-Section 7: Assessment of emission limits for fluctuating loads in MV and HV power systems – Basic EMC publication</p> <p>ATCO Electric Distribution System Standard for the Installation of New Load</p> <p><u>Voltage sag(dip) threshold:</u> <90% nominal at Point of Common Coupling</p> <p><u>Voltage swell threshold:</u> >110% nominal at Point of Common Coupling</p> <p><u>Voltage Unbalance limit:</u> 2% (95% CPF) at Point of Common Coupling</p>
EPCOR Distribution Inc	<ul style="list-style-type: none"> • As per CSA CAN3-C235-83 • Voltage imbalance limited to 3 %
ENMAX Distribution	<ul style="list-style-type: none"> • As per CSA voltage standard CAN3-C235-83 • Voltage imbalance limited to 4%
FortisAlberta	<ul style="list-style-type: none"> • As per CSA CAN3-C235-83 • Voltage imbalance limited to 3 %
Lethbridge Distribution	<ul style="list-style-type: none"> • As per CSA CAN3-C235-83 • Voltage imbalance limited to 3 %

<u>DFO</u>	<u>Standards</u>
Red Deer Distribution	<ul style="list-style-type: none"> • As per CSA voltage standard CAN3-C235-83 • Voltage imbalance limited to 4%

4.2 Harmonics

Harmonics is defined as the steady state distortion of the fundamental frequency (60 Hz). Current distortion occurs when sinusoidal voltage is applied to a non-linear load (i.e. electronic light ballast, PLC, adjustable-speed drive, arc furnace, any ac/dc converter). On the other hand, voltage distortion is indirectly the result of harmonic currents flowing through a distribution system.

Table 4.2-1 is summary of the standards that each DFO applies to their distribution system with respect to the harmonics on the distribution power delivery system.

Table 4.2-1: DFO Standards for Harmonics

<u>DFO</u>	<u>Standards</u>
ATCO Electric Distribution	<p>CAN/CSA – C61000-3-6:04 Electromagnetic compatibility (EMC)- Part 3: Limits –Section 6:Assessment of emission limits for distorting loads in MV and HV power systems – Basic EMC publication</p> <p>CAN/CSA – CEI/IEC 61000-2-4:04 Electromagnetic Compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low frequency conducted disturbances</p> <p>ATCO Electric – Distribution System Standard for the Installation of New Loads</p> <p>IEEE Std. 519-1992 – IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems CAN/CSA – C61000-3-6:04 Electromagnetic compatibility (EMC)- Part 3: Limits –Section 6:Assessment of emission limits for distorting loads in MV and HV power systems – Basic EMC publication</p>
EPCOR Distribution Inc	<ul style="list-style-type: none"> • IEEE Standard 519 and Guide 519A
ENMAX Distribution	<ul style="list-style-type: none"> • IEEE Standard 519

<u>DFO</u>	<u>Standards</u>
FortisAlberta	<ul style="list-style-type: none"> • IEEE Standard 519
Lethbridge Distribution	<ul style="list-style-type: none"> • IEEE 519 Standard
Red Deer Distribution	<ul style="list-style-type: none"> • IEEE Standard 519-1992

4.3 Fluctuations/Flicker

Typically within Alberta voltage flicker is related to the voltage fluctuations/flicker as a result of starting motors connected to the distribution power delivery system. The fluctuations/flicker depends upon:

- The type of motor starting used by the electric power customer
- Size of motor
- Type of feeder that the electric power customer is interconnected to.
- Available short circuit current

Table 4.3-1 is summary of the standards that each DFO applies to their distribution system with respect to the allowable voltage fluctuations/flicker.

Table 4.3-1: DFO Standards for Fluctuations/Flicker

<u>DFO</u>	<u>Standards</u>
ATCO Electric Distribution	<ul style="list-style-type: none"> • During the planning phase of a new motor addition, AE applies a table with the most common application being starts \leq two times per week. • Max Flicker for \leq two times per week <ul style="list-style-type: none"> -25 KV regulated bus = 5% -Urban = 5% -Rural = 8 - 10% -Oilfield = 10 – 12 % -Industrial = 10 -12 % • ATCO Electric will allow the upper limit for flicker during motor starts to approach 10 and 12 % for rural, and oilfield and industrial customers, respectively where there are few customers and long

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<u>DFO</u>	<u>Standards</u>
	<p>25 kV lines.</p> <ul style="list-style-type: none"> • AE has a further table with more stringent flicker requirements for more frequent starts. • When an area concern is raised, AE will install recording instruments and apply the following: <ul style="list-style-type: none"> ○ Cannot lead to voltage sags or swells outside Swell and Sag thresholds (see Table 4.1-1 above) ○ Cannot violate normal voltage limits: -8.3/+4.2% of nominal per CSA CAN3 C235-83 at the PCC (Point of Common Coupling) as extended per the CEA Power Quality Protocol 220 D 711 ○ Cannot lead to Voltage flicker (luminance changes in lighting systems) at the PCC exceeding Pst = 0.9 ○ Cannot lead to a voltage sag at the transmission substation exceeding 5%
EPCOR Distribution Inc	<ul style="list-style-type: none"> • IEEE Standard 519 Flicker Curve • Maximum 5% allowable. Measurable on primary of single customer transformer and on secondary of multiple customer transformer
ENMAX Distribution	<p>ENMAX's "Power Quality Specifications and Guidelines for Customers" includes:</p> <ul style="list-style-type: none"> ○ In house flicker curve with values dependent on frequency of occurrence. ○ Maximum 4% allowable. Measurable on primary of single customer transformer and on secondary of multiple customer transformer.
FortisAlberta	<ul style="list-style-type: none"> • In house flicker curve with values dependent on frequency of occurrence. The same curve as the AESO uses. • Maximum 5% allowable. Measurable on primary of customer transformer.

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<u>DFO</u>	<u>Standards</u>
Lethbridge Distribution	<ul style="list-style-type: none">• In house flicker curve with values dependent on frequency of occurrence.• Maximum 4% allowable. Measurable on primary of a dedicated customer transformer and on secondary of shared customer transformer.
Red Deer Distribution	<ul style="list-style-type: none">• IEEE Standard 519 Flicker Curve• IEEE Standard 1159-1995• Maximum 4% allowable. Measurable on primary of customer transformer.

4.4 Other Power Quality Standards

The standards for point of delivery substations are currently in development as part of the Interconnection Standards Upgrade.

5.0 Definitions

The following definitions are the basis for the terms used in this document unless otherwise defined herein. The application of these definitions is intended solely for the purpose of this guideline and is not necessarily intended to represent the definitions used by the AESO in other documents.

“Momentary Outage” means interruptions less than one minute in duration

“Sustained Outage” means interruptions one minute or more in duration

“System Average Interruption Duration Index (SAIDI)” is defined as the system average interruption duration for customers served per year.

- The formula to calculate SAIDI for distribution systems is:

$$\text{SAIDI} = \frac{\text{Total Customer-Hours of Interruptions}}{\text{Total Customers Served}}$$

- The formula to calculate SAIDI for point of delivery substations is:

$$\text{SAIDI} = \frac{\text{Total Duration of all Delivery Point Interruptions in Minutes}}{\text{Total no. of Delivery Points monitored}}$$

“System Average Interruption Frequency Index (SAIFI)” is defined as the system average number of interruptions per customer served per year.

- The formula to calculate SAIFI for distribution systems is:

$$\text{SAIFI} = \frac{\text{Total Customer-Interruptions}}{\text{Total Customers Served}}$$

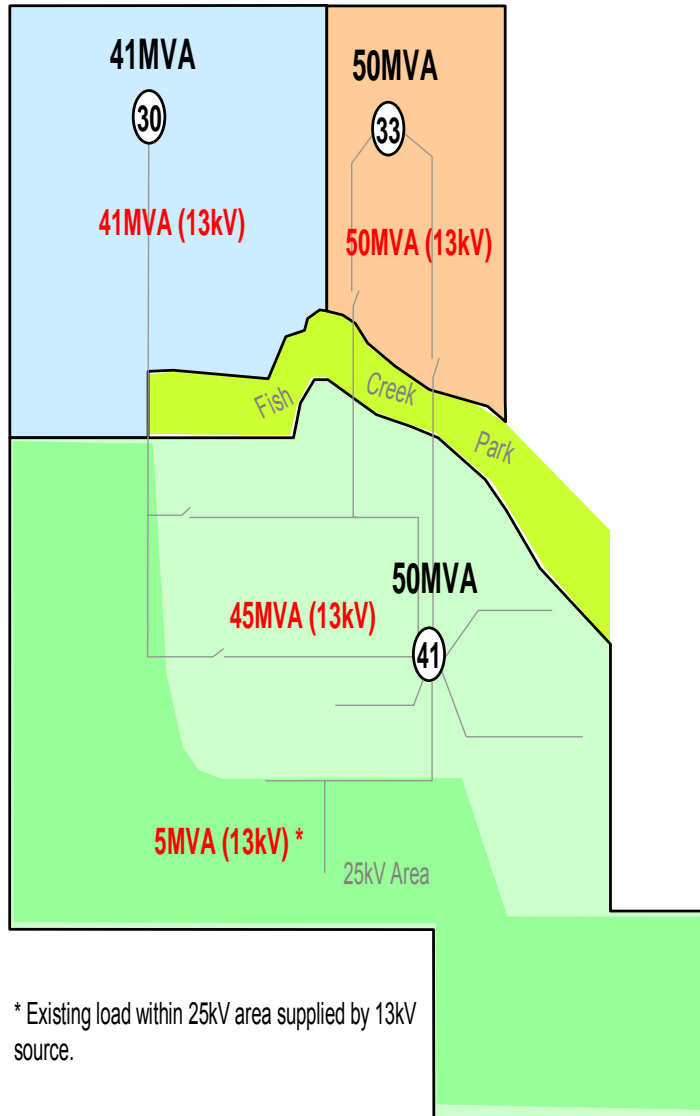
- The formula to calculate SAIFI for point of delivery substations is:

$$\text{SAIFI} = \frac{\text{Total no. of Delivery Point Interruptions}}{\text{Total no. of Delivery Points monitored}}$$

“Unsupplied Load” means the load not served after any automatic or manual switching operations have been carried out after the occurrence of a first contingency.

APPENDIX I. Load Density Map Example

**Southwest Calgary Loading Without #6 Substation
(2004/2005 Winter Peak)**



APPENDIX II. FORTIS and ATCO DEFINED URBAN AREAS

Distribution Point-of-Delivery Interconnection Process Guideline - Standards of Service

DFO	Urban Area
ATCO Electric Distribution	<ul style="list-style-type: none"> • A large urban is any community with a population greater than 5000. • Urban Areas: <ul style="list-style-type: none"> ○ Bonnyville ○ Drumheller ○ Ft. McMurray ○ Grand Center/Cold Lake ○ Grand Prairie ○ Lloydminster ○ Peace River ○ Slave Lake ○ St. Paul ○ Stettler ○ Vegreville ○ Vermilion
Fortis Alberta	<ul style="list-style-type: none"> • A large urban is any community with a: <ul style="list-style-type: none"> ○ population greater than 5000; or ○ distribution system with a total load greater than 10 MW • FortisAlberta Urban areas are: <ul style="list-style-type: none"> ○ Airdrie ○ Beaumont ○ Banff ○ Brooks ○ Camrose ○ Canmore ○ Coaldale ○ Cochrane ○ Edson ○ Fort Saskatchewan ○ High River ○ Innisfail ○ Lacombe ○ Leduc ○ Okotoks ○ Olds ○ Ponoka ○ Rocky Mountain House ○ Sherwood Park ○ Spruce Grove ○ St. Albert ○ Stony Plain ○ Sylvan Lake ○ Taber ○ Wetaskiwin