

The logo for NERC (North American Electric Reliability Corporation) features the letters "NERC" in a bold, black, sans-serif font. A horizontal blue bar is positioned directly beneath the letters.

NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

A large, steel lattice transmission tower stands against a bright, hazy sky. The tower is positioned on the right side of the page, with its structure extending towards the center. The background is a light blue gradient with a faint map of North America.

Transmission Availability Data System Automatic Outage Metrics and Data

Region: WECC – 2009 Report

June 14, 2010

to ensure
the reliability of the
bulk power system

116-390 Village Blvd., Princeton, NJ 08540
609.452.8060 | 609.452.9550 fax
www.nerc.com

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1 Introduction

1.1 Contributors and Acknowledgements

The North American Electric Reliability Corporation (NERC) gratefully acknowledges the support of the Transmission Availability Data System Working Group (TADSWG), Open Access Technologies International (OATI), and in 2009 the 192 reporting Transmission Owners (TOs) in NERC. The 2009 “Reporting TOs” are TOs that own any TADS facilities, as described in Section 1.3 below, as of January 1, 2009.

- TADS Phase I participation is mandatory for all U.S. TOs on the NERC Compliance Registry, and all of the NERC TOs complied.¹
- Participation is voluntary for Mexican and Canadian TOs on the NERC Compliance Registry, and all non-U.S. TOs in NERC except one voluntarily provided data.

In addition to TOs, TADS Regional Entity coordinators (RECs) in NERC, and NERC TADS administrators supported the effort.

1.2 TADS History

The TADS effort began with the establishment of a task force (TADSTF) under the direction of NERC Planning Committee in October 2006. On October 27, 2007, the NERC Board of Trustees approved the collection of TADS Phase I data beginning in calendar year 2008. Phase I covers Automatic Outage data (and the reader is referred to Appendix 1 for the definition of capitalized Phase I terms).

Subsequently, on October 29, 2008, the NERC Board approved the collection of Non-Automatic Outage data that will begin in calendar year 2010 (Phase II). On July 1, 2009 the TADSTF was converted to the TADSWG by the NERC Planning Committee.

1.3 Scope

This report covers Phase I Automatic Outage data². The 2009 Report is based upon 2009 calendar year data submitted by Transmission Owners by March 1, 2010.

Phase I TADS includes Momentary and Sustained Automatic Outages of the following Elements:

- AC Circuits ≥ 200 kV (Overhead and Underground Circuits). Radial circuits are included;
- DC Circuits with $\geq +/-200$ kV DC voltage;
- Transformers with ≥ 200 kV low-side voltage; and
- AC/DC Back-to-Back (BTB) Converters with ≥ 200 kV AC voltage, both sides.

The following basic information is collected:

¹ For TADS, three U.S. companies in NERC that operate multiple NERC-registered TOs were allowed to submit one TADS set of data for their combined TOs. See *NERC ID Exceptions for TADS Data* posted at [NERC ID Exceptions](#).

² Phase II data will be reported next year with the Phase I data in the same report

- Automatic Outage Data:
 - Event ID & Event Type
 - Outage ID code
 - Fault Type
 - Outage Initiation Code
 - Outage Start Time
 - Outage Duration
 - Outage Cause Codes
 - Initiating
 - Sustained
 - Outage Mode
- Element Inventory Summary:
 - Number of Elements
 - For AC and DC Circuits, Circuit Miles
 - For AC and DC Circuits, AC and DC Multi-Circuit Structure Miles.

1.4 TADS Reports – NERC, Regional, and Transmission Owner

For calendar year 2009, one NERC-wide report and eight regional reports have been produced, using a common format, and these reports are posted on the TADSWG page on the NERC Web site. The definitions are a separate document that may be downloaded at [http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_\(All\).pdf](http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_(All).pdf).

These definitions were posted on September 11, 2008 for use during calendar year 2009 data collection.

In addition, each report has an associated Excel workbook that contains non-confidential data from webTADS as well as all of the associated tables and figures in the report that were developed from that data. Those workbooks are posted on the TADS Web site along with each report.

The purpose of this report is to provide the results of the annual 2009 data collection. Moving forward the TADSWG and other NERC groups may separately provide observations, interpretations of the annual results, and suggest further areas for study. It is recommended that readers of this report not draw conclusions based on the 2008 and 2009 calendar year data collection as it will take a number of years of data to provide interpretations with a high degree of confidence.

1.5 Confidential Data Not Publicly Reported

Per the data confidentiality policy, the report does not display performance data associated with a TADS Element in a Voltage Class or for circuits of a particular construction type (Overhead or Underground) if all of the Elements in that Voltage Class and applicable construction type are reported by one TO.³ In this report, confidential performance data has *not* been displayed for the following Elements, Voltage Classes, and construction types that are reported by one TO in WECC:

1. AC Circuits – one TO reported all of the Underground 400-599 kV AC Circuit performance data in WECC. Therefore, no Underground 400-599 kV AC Circuit

³ NERC will ask the impacted TOs for permission beginning with the calendar year 2010 report.

performance data is displayed in this report. Where Underground circuit performance data for the above voltage class has been excluded, that data is also excluded from the webTADS calculations to produce the combined total (Overhead plus Underground) performance data.

2. DC Circuits – one TO reported all the 200-299 kV and 500-599 kV DC Circuit performance data in WECC. Since these Voltage Classes contain all of the DC Circuits in WECC, no DC Circuit performance data is displayed in this report.

1.6 Report Organization

Section 2 has summary WECC metrics and data for each of the reported Elements while Section 3 has more detailed data for these same Elements, with separate subsections devoted to each Element (e.g., Section 3.1 for AC Circuits, Section 3.3 for Transformers, etc.).

1.6.1 Table and Figure Labeling

Table WECC 1-1 shows the assigned numbering scheme for the tables and figures in this report. The prefix “WECC” indicates the region covered by the report. The table and figure numbering scheme includes the major report section heading (e.g., Section 1, 2, 3.1, etc.) followed by a “dash” and then followed by a number (e.g., 1, 2, 3, etc.) that reflects the order that the table or figure appear in the report. Any tables or figures that are purposely omitted in this report are highlighted in the Table WECC 1-1. Tables or figures may be omitted because (i) they have no data because there are no Elements, or (ii) they contain confidential TO data, or (iii) there were no reported outages.

1.6.2 Tables and Figures Data Categories

The working group elected to use a common NERC-wide template for each of the tables and figures displaying performance data. The template only includes data categories (i.e., Voltage Class and construction type) for Elements that are found within NERC. The use of a common NERC-wide template allows for all reports (regional and NERC) to utilize a familiar format while making production easier. Table WECC 1-2 shows the categories included in the NERC template.

Performance data are not shown in Tables WECC 2-1 and WECC 2-2. These tables show, respectively, the Inventory of AC equipment and DC equipment within WECC. The working group felt that a complete snapshot of all TADS categories was needed, including categories with zero inventories in WECC.

1.6.3 Tables and Figures Data Display Conventions

Some regions do not have any Elements in a Voltage Class, but since those Elements exist elsewhere within NERC, the NERC template has a row or column for them. For example, only one region in NERC has DC Circuits in the 200-299 kV Voltage Class. That Voltage Class is contained in all DC Circuit tables in the NERC and all regional reports because the template is NERC-wide. However, the working group took these steps to assist the reader in viewing such tables:

1. Appendix 2 contains the metric definitions along with their acronyms. These acronyms are used frequently in tables and figures.

2. If there are no Elements of a particular Voltage Class and applicable construction type in a region, performance data in a table such as the number of Sustained Outages is shown as a “dash” and not a zero. Also, all calculations that would normally use that data are shown as a “dash.”
3. If there are Elements in a Voltage Class and applicable construction type, but the performance data displayed for that Element is equal to zero (for example, the number of Sustained Outages is equal to zero), a “0” is shown. In this case, if a computation using that data would result in a division by zero, a “tilde” (~) is shown for the results of that computation. This avoids the Excel “#DIV/0!” display.
4. If there are Elements in a Voltage Class and applicable construction type, but the performance data may not be displayed because it is confidential, all performance data for that Voltage Class and applicable construction type is removed and a “C” is displayed for that data. However, as explained in Section 2-3, Table WECC 2-3 (Event Types and Outages) generally includes all outage data because it does not reveal any confidential data; however, if it would reveal confidential performance data, that data would have a “C” displayed.
5. In each report subsection devoted to a specific Element (e.g., Section 3.1 for AC Circuits), separate tables display total (a) Element-Initiated Outages and (b) Other than Element-Initiated Outages for Sustained Outages by Voltage Class, and similar tables display the this data for Momentary Outages. These tables also compute metrics on a per Element basis, such as SOF. As described above, confidential performance data for a specific Voltage Class is displayed as a “C.” However, since these tables also compute per Element metrics for “All Voltages,” the “All Voltages” calculations would be incorrect if confidential performance data in a Voltage Class are excluded while non-confidential associated inventory data are included. Therefore, an “NC” has been displayed in the inventory data to ensure the correctness of the computations.⁴
6. If a cell is not supposed to contain data, a grayed pattern is inserted in that cell. For example, Circuit Miles are not applicable to Transformers.

1.7 Feedback and Comments

Readers may submit comments and feedback to tadscomments@nerc.net at any time. At present, NERC is interested in report content suggestions, such as (i) the way the report is organized (ii) the way data are displayed and (iii) the type of data that should be reported. If changes are requested, please describe the benefits of each suggested change. NERC will use this feedback to develop and improve future reports.

⁴ The Excel “SUM” function treats text such as “C” or “NC” as a zero.

Table WECC 1-1
TADS Report Tables and Figure Guide – WECC Report

Tables omitted because they have no data, contain confidential TO data, or have no reported outages are shaded as follows:

Section No. and Name	Table Title	Table No.	Figure No.
1. Introduction	TADS Report Tables and Figures Guide	WECC 1-1	
	Categories Displayed in Report Tables and Figures with Performance Data	WECC 1-2	
2. Summary WECC Metrics and Data	Inventory of AC Transmission Equipment	WECC 2-1	
	Inventory of DC Transmission Equipment	WECC 2-2	
	AC Circuit Outage Frequency by Outage Initiation Code		WECC 2-1
	AC Circuit Outage Duration by Outage Initiation Code		WECC 2-2
	DC Circuit Outage Frequency by Outage Initiation Code		WECC 2-3
	DC Circuit Outage Duration by Outage Initiation Code		WECC 2-4
	Transformer Outage Frequency by Outage Initiation Code		WECC 2-5
	Transformer Outage Duration by Outage Initiation Code		WECC 2-6
	AC/DC BTB Converter Outage Frequency by Outage Initiation Code		WECC 2-7
	AC/DC BTB Converter Outage Duration by Outage Initiation Code		WECC 2-8
	Event Types and Outages	WECC 2-3	
	3.1 AC Circuit Metrics and Data	AC Circuit Sustained Outage – Element-Initiated Only	WECC 3.1-1
AC Circuit Sustained Outage Metrics – Other than “Element-Initiated”		WECC 3.1-2	
AC Circuit Sustained Outages by Cause Code		WECC 3.1-3	
AC Circuit Sustained Outages – Other Attributes		WECC 3.1-4	
AC Circuit Momentary Outage Metrics – Element-Initiated Only		WECC 3.1-5	
AC Circuit Momentary Outage Metrics – Other than “Element-Initiated”		WECC 3.1-6	
AC Circuit Momentary Outages by Cause Code		WECC 3.1-7	
AC Circuit Momentary Outages – Other Attributes		WECC 3.1-8	
AC Circuit Metrics 1-16 per Appendix 2		WECC 3.1-9	
3.2 DC Circuit Metrics and Data	DC Circuit Sustained Outage Metrics and Data – Element-Initiated Only	WECC 3.2-1	
	DC Circuit Sustained Outage Metrics – Other than “Element-Initiated”	WECC 3.2-2	
	DC Circuit Sustained Outages by Cause Code	WECC 3.2-3	
	DC Circuit Sustained Outages – Other Attributes	WECC 3.2-4	
	DC Circuit Momentary Outage Metrics – Element-Initiated Only	WECC 3.2-5	
	DC Circuit Momentary Outage Metrics – Other than “Element-Initiated”	WECC 3.2-6	
	DC Circuit Momentary Outages by Cause Code	WECC 3.2-7	
	DC Circuit Momentary Outages – Other Attributes	WECC 3.2-8	
	DC Circuit Metrics 1-16 per Appendix 2	WECC 3.2-9	

Table WECC 1-1 (cont'd)

3.3 Transformer Metrics and Data	Transformer Sustained Outage Metrics – Element-Initiated Only	WECC 3.3-1	
	Transformer Sustained Outage Metrics – Other than “Element-Initiated”	WECC 3.3-2	
	Transformer Sustained Outages by Cause Code	WECC 3.3-3	
	Transformer Sustained Outages – Other Attributes	WECC 3.3-4	
	Transformer Momentary Outage Metrics – Element-Initiated Only	WECC 3.3-5	
	Transformer Momentary Outage Metrics – Other than “Element-Initiated”	WECC 3.3-6	
	Transformer Momentary Outages by Cause Code	WECC 3.3-7	
	Transformer Momentary Outages – Other Attributes	WECC 3.3-8	
	Transformer Metrics 1-10 per Appendix 2	WECC 3.3-9	
3.4 AC/DC BTB Converter Metrics and Data	AC/DC BTB Converter Sustained Outage Metrics – Element-Initiated Only	WECC 3.4-1	
	AC/DC BTB Converter Sustained Outage Metrics – Other than “Element-Initiated”	WECC 3.4-2	
	AC/DC BTB Converter Sustained Outages by Cause Code	WECC 3.4-3	
	AC/DC BTB Converter Sustained Outages – Other Attributes	WECC 3.4-4	
	AC/DC BTB Converter Momentary Outage Metrics – Element-Initiated Only	WECC 3.4-5	
	AC/DC BTB Converter Momentary Outage Metrics – Other than “Element-Initiated”	WECC 3.4-6	
	AC/DC BTB Converter Momentary Outages by Cause Code	WECC 3.4-7	
	AC/DC BTB Converter Momentary Outages – Other Attributes	WECC 3.4-8	
	AC/DC BTB Converter Metrics 1-10 per Appendix 2	WECC 3.4-9	

Tables omitted because they have no data, contain confidential TO data, or have no reported outages are shaded as follows:

Table WECC 1-2
Categories Displayed in Report Tables and Figures with Performance Data
Based upon the WECC Inventory⁵

No categories of this type exist within NERC

Category	Voltage Class	Construction type (Overhead or Underground)	
		OH	UG
AC Circuit	200-299 kV	OH	UG
	300-399 kV	OH	UG
	400-599 kV	OH	UG
	600-799 kV	OH	UG
AC Multi-Circuit Structure Miles	200-299 kV		
	300-399 kV		
	400-599 kV		
	600-799 kV		
	Mixed Voltages		
DC Circuit	200-299 kV	OH	UG
	300-399 kV	OH	UG
	400-499 kV	OH	UG
	500-599 kV	OH	UG
	600-799 kV	OH	UG
DC Multi-Circuit Structure Miles	200-299 kV		
	300-399 kV		
	400-499 kV		
	500-599 kV		
	600-799 kV		
	Mixed Voltages		
Transformers	200-299 kV		
	300-399 kV		
	400-599 kV		
	600-799 kV		
AC/DC BTB Converters	200-299 kV		
	300-399 kV		
	400-599 kV		
	600-799 kV		

⁵ For performance tables and figures, only the categories above are shown. As noted in Section 1.6.2, Tables 2-1 and 2-2 have inventory data for all the Voltage Classes.

2 WECC Metrics and Data Summary

This section reports overall Element inventory data as well as two measures of Element performance - outage frequency for both Sustained and Momentary Outage Frequency (SOF and MOF) and Sustained Outage Duration Time (SODT) – on a per Element basis. The number of Elements shown in the inventory data was used to compute the “per Element” frequency and duration metrics. Figure WECC 2-1 through Figure WECC 2-8 show frequency and duration metrics on a different scale for each Element. The scale was dictated by the Element’s data. Finally, the report provides the number and percentage of Events for each Event Type.

2.1 Element Inventory Data

The inventory data, summarized in two tables, WECC 2-1 and WECC 2-2 shows the average Element inventory for calendar year 2009 for AC transmission equipment and DC transmission equipment respectively. All Voltage Classes available for collection are included in these tables. Because TADS uses an equivalent (or average) inventory, the number of reported Elements will generally not be a whole number. As an example, an AC Circuit that is added in the middle of a reporting period will be shown as 0.5 of an AC Circuit in the inventory. This accurately reflects the exposure of Elements to outages.

2.2 Element Outage Frequency and Duration Metrics

Two figures for each TADS Element (AC Circuits, DC Circuits, Transformers, and AC/DC Back-to-Back Converters) are shown in this section.

- The first figure shows the Sustained Outage and Momentary Outage Frequency (SOF and MOF) by Outage Initiation Code.
- The second figure shows the Sustained Outage Duration Time per Element (SODT) by Outage Initiation Code.

**Table WECC 2-1
Inventory of AC Transmission Equipment**

Name	200-299 kV		300-399 kV		400-599 kV		600-799 kV		Mixed Voltages		All Voltages	
	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles
AC Circuit - All	1606.9	44425	136.2	10488	253	16912	0	0			1996.1	71825
Overhead	1564.9	44204	136.2	10488	251	16826	0	0			1952.1	71518
Underground	42.0	221	0	0	2	85	0	0			44	306
AC Multi-Circuit Structure Miles*		6427		158		592		0		370		7547
Transformer	15		61.3		178.6		0				254.9	

* The data shown for AC Multi-Circuit Structure Miles is Multi-Circuit Structure Miles, not Circuit Miles.

**Table WECC 2-2
Inventory of DC Transmission Equipment**

Name	200-299 kV		300-399 kV		400-499 kV		500-599 kV		600-799 kV		All Voltages	
	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles
DC Circuit - All	2	92	0	0	0	0	4	2137	0	0	6	2229
Overhead	2	92	0	0	0	0	4	2137	0	0	6	2229
Underground	0	0	0	0	0	0	0	0	0	0	0	0
DC Multi-Circuit Structure Miles*		46		0		0		1068		0		1114
Name	200-299 kV		300-399 kV		400-599 kV				600-799 kV		All Voltages	
AC/DC BTB Converters**	5		2		0				0		7	

* The data shown for DC Multi-Circuit Structure Miles is Multi-Circuit Structure Miles, not Circuit Miles.

** AC/DC BTB Converter Voltage Classes are the highest AC Voltage Class of the two AC voltages on either side of the converter.

Figure WECC 2-1
AC Circuit Outage Frequency by Outage Initiation Code

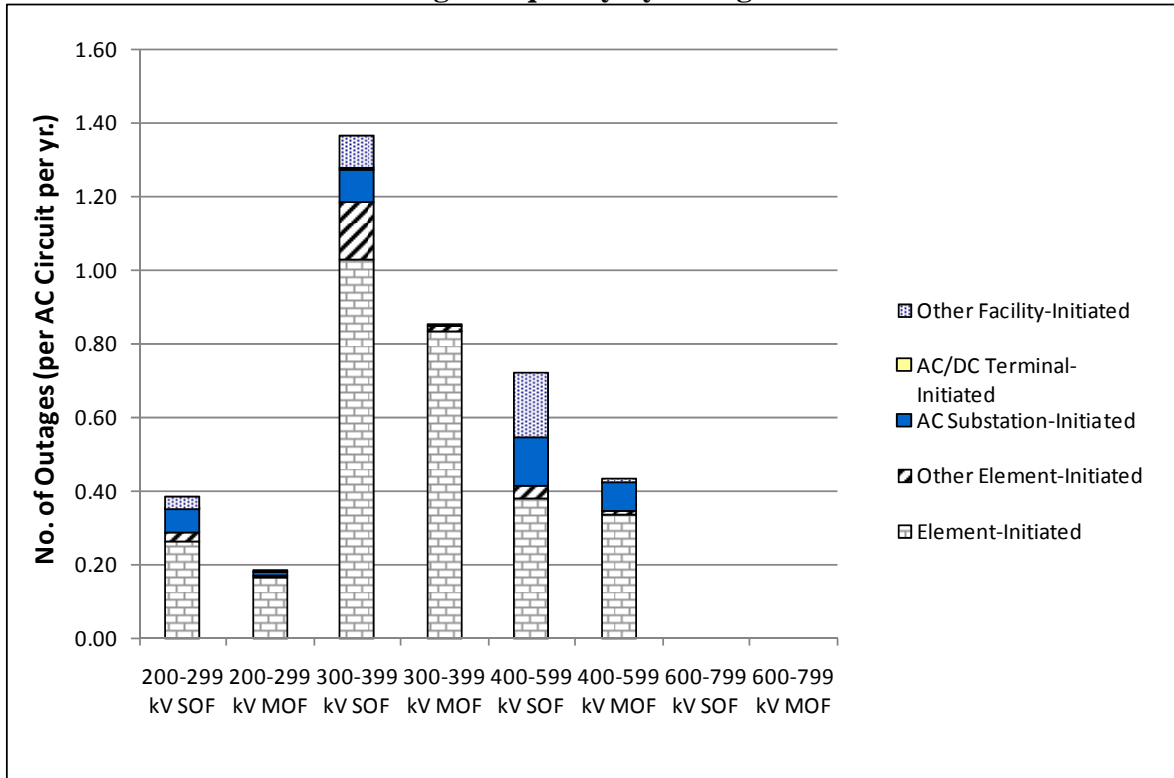


Figure WECC 2-2
AC Circuit Outage Duration by Outage Initiation Code

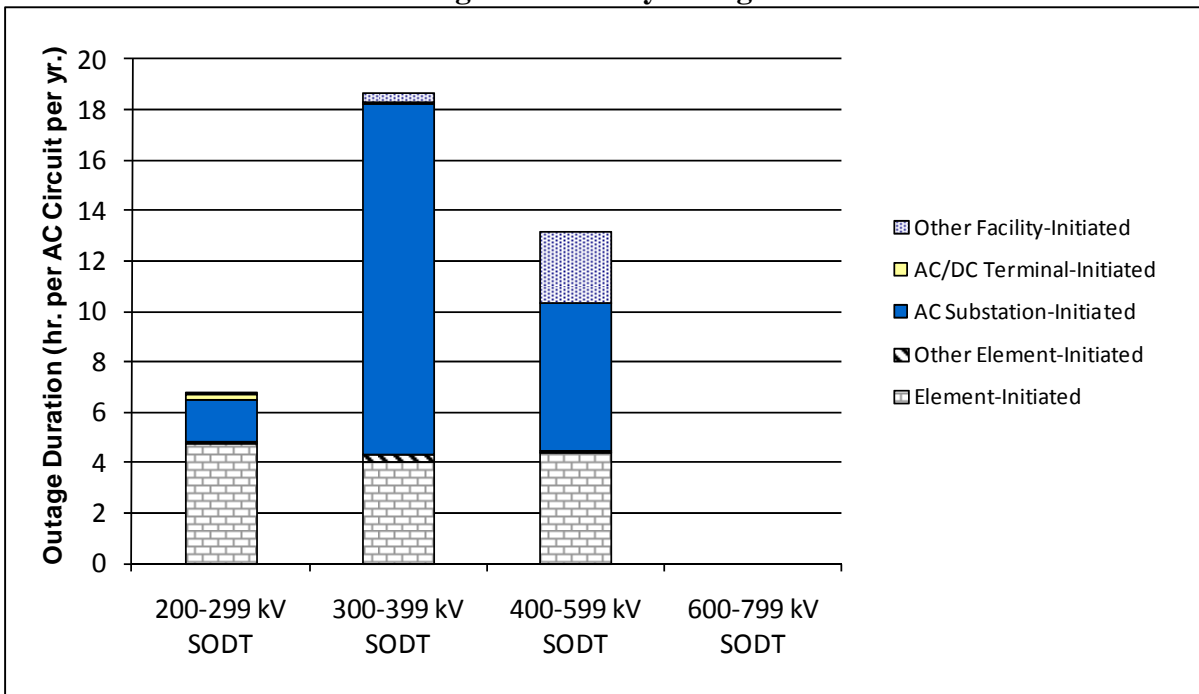


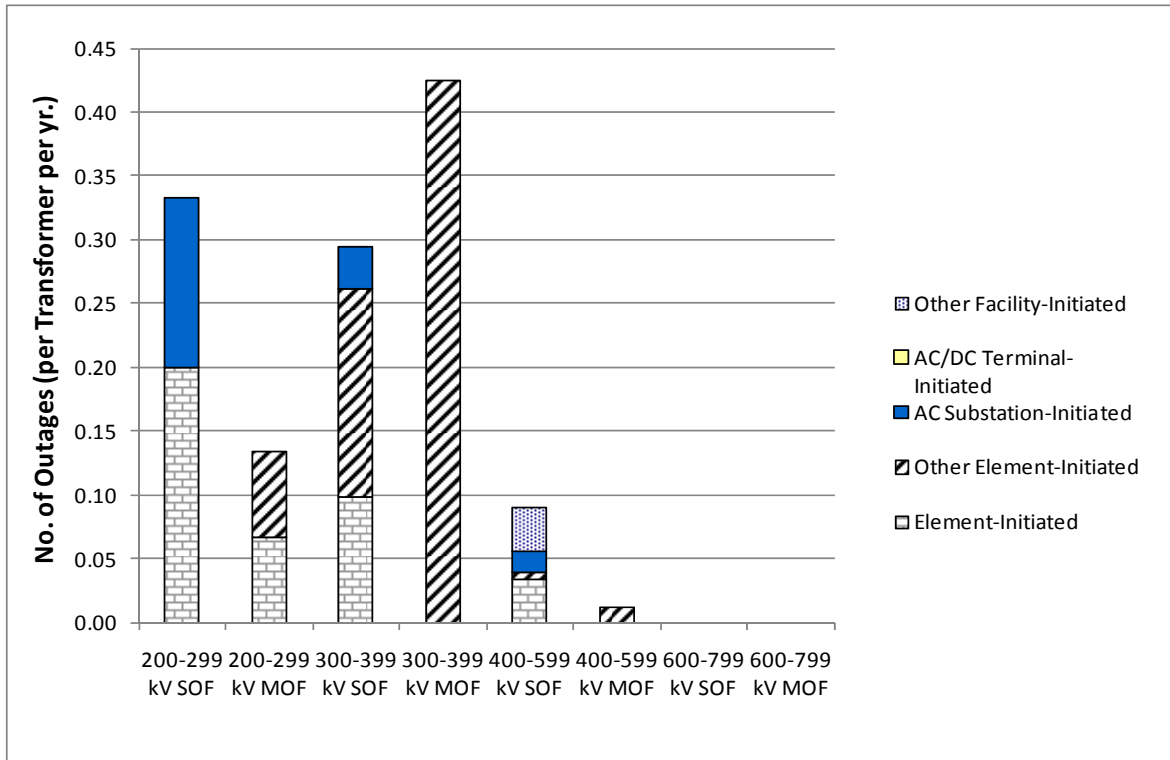
Figure WECC 2-3
DC Circuit Outage Frequency by Outage Initiation Code

This space intentionally left blank.
This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

Figure WECC 2-4
DC Circuit Outage Duration by Outage Initiation Code

This space intentionally left blank.
This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

**Figure WECC 2-5
Transformer Outage Frequency by Outage Initiation Code**



**Figure WECC 2-6
Transformer Outage Duration by Outage Initiation**

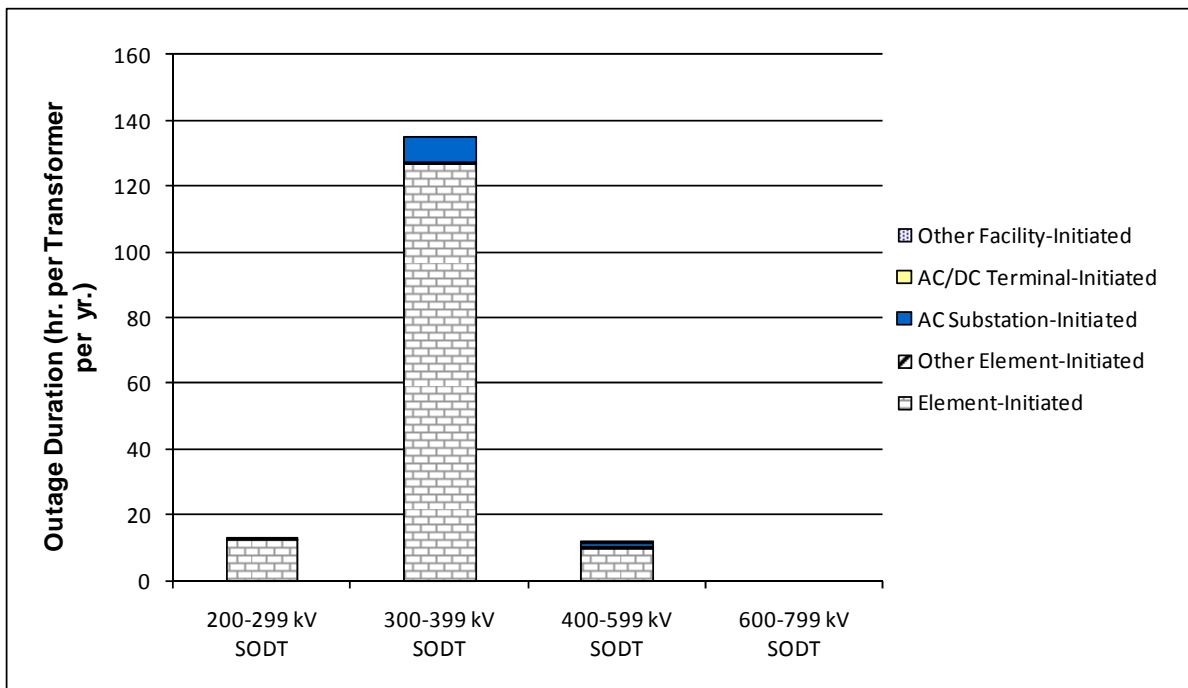


Figure WECC 2-7
AC/DC BTB Converter Outage Frequency by Outage Initiation Code

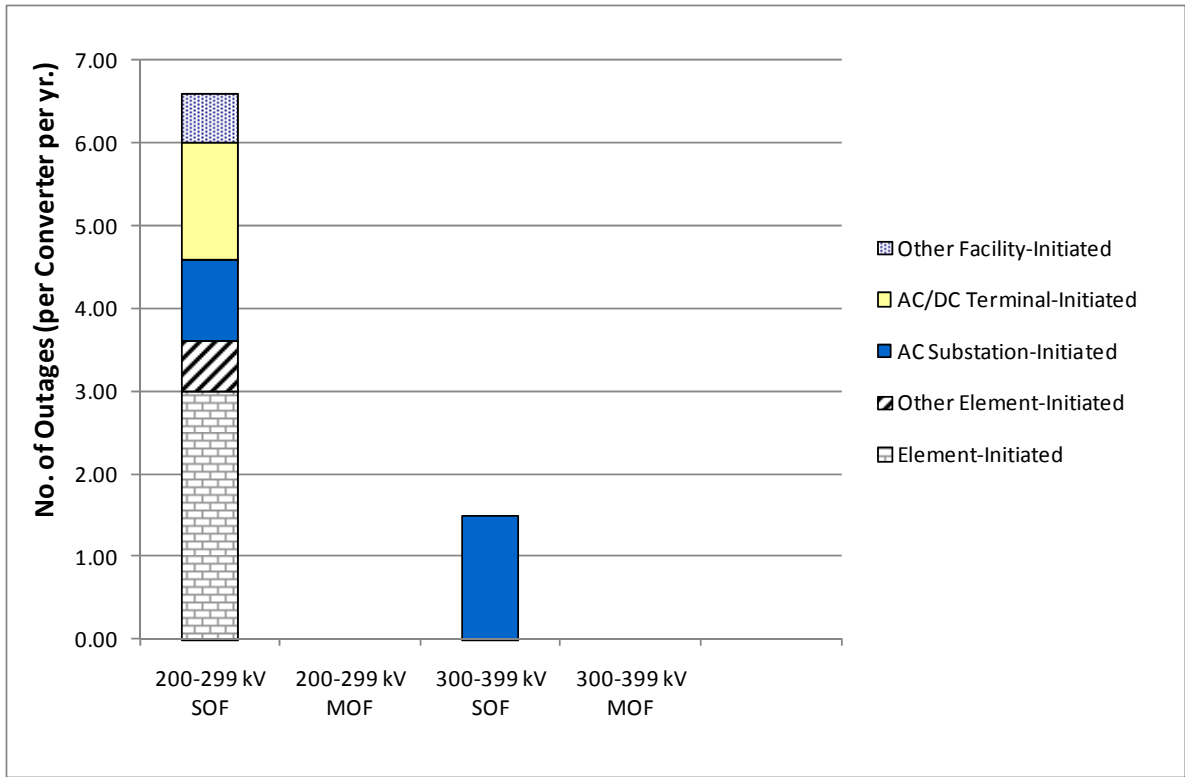
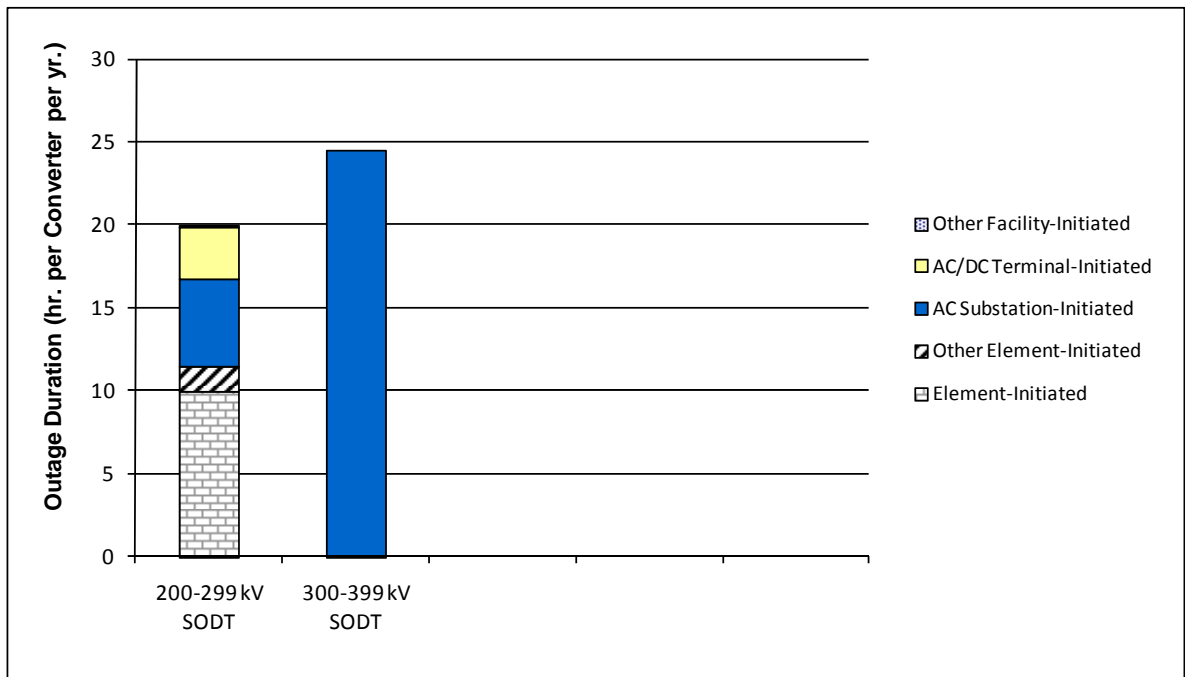


Figure WECC 2-8
AC/DC BTB Converter Outage Duration by Outage Initiation Code



2.3 Event Types

Event Type data, shown in Table WECC 2-3 below, provides the number and percentage of Events by Event Type as well as the number of outages associated with each Event. See the Event Type 10, 20, 30, 40, and 50 descriptions below.

Each Element outage, Sustained and Momentary, is assigned an Event Type. An Event may contain any number of Sustained and/or Momentary Outages and may include an outage from any type of Element; i.e. AC Circuit, DC Circuit, Transformer, or AC/DC BTB Converter. However, as defined, Event Types 10 and 20 involve only one Element outage, with Event Type 10 involving only an AC Circuit or a Transformer, and Event Type 20 involving a DC Circuit. Event Types 30 and 40 involve two AC Circuit and DC Circuit outages, respectively. Event Type 50 includes all other single or multiple outages not included elsewhere.

Table WECC 2-3
Event Types and Outages

Event Type	Events		Outages	
	# Events	%	# Outages	%
10	1210	84.7%	1210	75.3%
20	C	C	C	C
30	58	4.1%	127	7.9%
40	C	C	C	C
50	160	11.2%	269	16.8%
TOTAL	1428	100.0%	1606	100.0%

Event Type	Description
10	Automatic Outage of an AC Circuit or Transformer with Normal Clearing.
20	Automatic Outage of a DC Circuit with Normal Clearing.
30	Automatic Outage of two ADJACENT AC Circuits on common structures with Normal Clearing.
40	Automatic Outage of two ADJACENT DC Circuits on the common structures with Normal Clearing.
50	Other

3 WECC Metrics and Data Details

3.1 AC Circuit Metrics and Data

AC Circuit metrics are displayed in three sections: Section 3.1.1 addresses Sustained Outages and Section 3.1.2 addresses Momentary Outages. In all cases, the metrics displayed in these two sections include *all* AC Circuits (Overhead and Underground). Additionally, Section 3.1.3 has AC Circuit metrics that are differentiated into Overhead and Underground categories. Data and metrics are displayed for the four AC Voltage Classes in the NERC template plus the total of all Voltages Classes.

3.1.1 AC Circuit Sustained Outages

3.1.1.1 AC Circuit Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage was initiated.

- Table WECC 3.1-1 on the next page shows metrics for AC Circuit Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table WECC 3.1-2 on the next page shows the metrics for AC Circuit Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

Table WECC 3.1-1
AC Circuit Sustained Outage Metrics - Element-Initiated Only

Voltage Class	Circuit Miles	No. of Circuits	No. of Outages	Total Outage Time (hr)	Frequency (SCOF) (per 100 CM per yr)	Frequency (SOF) (per circuit per yr)	MTR or Mean Outage Duration (hr)
200-299 kV	44425	1606.9	419	7634.3	0.9432	0.2608	18.2
300-399 kV	10488	136.2	140	545.9	1.3348	1.0279	3.9
400-599 kV	16912	253.0	96	1104.7	0.5677	0.3794	11.5
600-799 kV	0	0.0	-	-	-	-	-
All Voltages	71825	1996.1	655	9284.8	0.9119	0.3281	14.2

Table WECC 3.1-2
AC Circuit Sustained Outage Metrics - Other than "Element-Initiated"

Voltage Class	No. of Circuits	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per circuit per yr)	MTR or Mean Outage Duration (hr)
200-299 kV	1606.9	196	3256.9	0.1220	16.6
300-399 kV	136.2	46	1992.8	0.3377	43.3
400-599 kV	253.0	86	2229.6	0.3399	25.9
600-799 kV	0.0	-	-	-	-
All Voltages	1996.1	328	7479.3	0.1643	22.8

3.1.1.2 AC Circuit Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table WECC 3.1-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

Table WECC 3.1-3 (p. 1 of 3)
AC Circuit Sustained Outages by Cause Code

Outage Cause Code	200-299 kV						300-399 kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	105	17.1%	62	10.1%	687.2	6.3%	42	22.6%	25	13.4%	53.9	2.1%
Lightning	91	14.8%	40	6.5%	47.0	0.4%	12	6.5%	5	2.7%	2.7	0.1%
Environmental	4	0.7%	8	1.3%	695.8	6.4%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	10	1.6%	10	1.6%	98.8	0.9%	1	0.5%	1	0.5%	0.1	0.0%
Foreign Interference	27	4.4%	17	2.8%	130.1	1.2%	5	2.7%	1	0.5%	0.0	0.0%
Fire	58	9.4%	37	6.0%	2190.7	20.1%	5	2.7%	5	2.7%	63.3	2.5%
Vandalism, Terrorism, or Malicious Acts	3	0.5%	3	0.5%	16.9	0.2%	1	0.5%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	56	9.1%	60	9.8%	2338.5	21.5%	4	2.2%	10	5.4%	942.7	37.1%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	18	2.9%	26	4.2%	29.4	0.3%	4	2.2%	6	3.2%	10.2	0.4%
Failed AC Circuit Equipment	59	9.6%	69	11.2%	3048.8	28.0%	19	10.2%	23	12.4%	1177.7	46.4%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	5	0.8%	4	0.7%	16.4	0.2%	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	22	3.6%	39	6.3%	322.2	3.0%	2	1.1%	0	0.0%	0.0	0.0%
Human Error	52	8.5%	48	7.8%	14.7	0.1%	15	8.1%	12	6.5%	40.3	1.6%
Unknown	79	12.8%	152	24.7%	829.7	7.6%	69	37.1%	85	45.7%	243.0	9.6%
Other	26	4.2%	40	6.5%	425.1	3.9%	7	3.8%	13	7.0%	4.9	0.2%
TOTAL	615	100.0%	615	100.0%	10891.2	100.0%	186	100.0%	186	100.0%	2538.7	100.0%

Table WECC 3.1-3 (p. 2 of 3)
AC Circuit Sustained Outages by Cause Code

Outage Cause Code	400-599 kV						600-799 kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	21	11.5%	17	9.3%	83.6	2.5%	-	-	-	-	-	-
Lightning	23	12.6%	11	6.0%	17.7	0.5%	-	-	-	-	-	-
Environmental	1	0.5%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Contamination	2	1.1%	4	2.2%	18.8	0.6%	-	-	-	-	-	-
Foreign Interference	9	4.9%	5	2.7%	4.1	0.1%	-	-	-	-	-	-
Fire	7	3.8%	1	0.5%	0.1	0.0%	-	-	-	-	-	-
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Failed AC Substation Equipment	22	12.1%	23	12.6%	1231.9	36.9%	-	-	-	-	-	-
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Failed Protection System Equipment	13	7.1%	13	7.1%	14.7	0.4%	-	-	-	-	-	-
Failed AC Circuit Equipment	15	8.2%	24	13.2%	247.6	7.4%	-	-	-	-	-	-
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Power System Condition	12	6.6%	16	8.8%	73.4	2.2%	-	-	-	-	-	-
Human Error	25	13.7%	23	12.6%	921.1	27.6%	-	-	-	-	-	-
Unknown	29	15.9%	43	23.6%	696.9	20.9%	-	-	-	-	-	-
Other	3	1.6%	2	1.1%	24.4	0.7%	-	-	-	-	-	-
TOTAL	182	100.0%	182	100.0%	3334.2	100.0%	-	-	-	-	-	-

Table WECC 3.1-3 (p. 3 of 3)
AC Circuit Sustained Outages by Cause Code

Outage Cause Code	All Voltages					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	168	17.1%	104	10.6%	824.8	4.9%
Lightning	126	12.8%	56	5.7%	67.4	0.4%
Environmental	5	0.5%	8	0.8%	695.8	4.2%
Contamination	13	1.3%	15	1.5%	117.7	0.7%
Foreign Interference	41	4.2%	23	2.3%	134.2	0.8%
Fire	70	7.1%	43	4.4%	2254.0	13.4%
Vandalism, Terrorism, or Malicious Acts	4	0.4%	3	0.3%	16.9	0.1%
Failed AC Substation Equipment	82	8.3%	93	9.5%	4513.1	26.9%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	35	3.6%	45	4.6%	54.2	0.3%
Failed AC Circuit Equipment	93	9.5%	116	11.8%	4474.1	26.7%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	5	0.5%	4	0.4%	16.4	0.1%
Power System Condition	36	3.7%	55	5.6%	395.6	2.4%
Human Error	92	9.4%	83	8.4%	976.1	5.8%
Unknown	177	18.0%	280	28.5%	1769.6	10.6%
Other	36	3.7%	55	5.6%	454.4	2.7%
TOTAL	983	100.0%	983	100.0%	16764.1	100.0%

3.1.1.3 Other AC Circuit Sustained Outage Data

Table WECC 3.1-4 on the next page shows other AC Circuit Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type, and Outage Duration Interval.

Table WECC 3.1-4 (p. 1 of 3)
AC Circuit - Other Sustained Outage Attributes

Fault Type	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
No fault	163	26.5%	3309.2	30.4%	38	20.4%	1007.8	39.7%	65	35.7%	1706.1	51.2%	-	-	-	-
P-P fault	78	12.7%	986.4	9.1%	4	2.2%	28.4	1.1%	8	4.4%	3.2	0.1%	-	-	-	-
Single P-G fault	218	35.4%	3366.6	30.9%	93	50.0%	341.7	13.5%	78	42.9%	997.5	29.9%	-	-	-	-
P-P-G, 3 P, or 3P-G fault	58	9.4%	803.4	7.4%	3	1.6%	936.7	36.9%	8	4.4%	47.0	1.4%	-	-	-	-
Unknown fault type	98	15.9%	2425.7	22.3%	48	25.8%	224.1	8.8%	23	12.6%	580.5	17.4%	-	-	-	-
TOTAL	615	100.0%	10891.2	100.0%	186	100.0%	2538.7	100.0%	182	100.0%	3334.23	100.0%	-	-	-	-

Outage Initiation Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	419	68.1%	7634.3	70.1%	140	75.3%	545.9	21.5%	96	52.7%	1706.1	51.2%	-	-	-	-
Other Element-Initiated	41	6.7%	157.5	1.4%	21	11.3%	45.3	1.8%	8	4.4%	3.2	0.1%	-	-	-	-
AC Substation-Initiated	100	16.3%	2684.7	24.6%	12	6.5%	1895.7	74.7%	34	18.7%	997.5	29.9%	-	-	-	-
AC/DC Terminal-Initiated	1	0.2%	336.0	3.1%	1	0.5%	0.6	0.0%	0	0.0%	47.0	1.4%	-	-	-	-
Other Facility-Initiated	54	8.8%	78.7	0.7%	12	6.5%	51.3	2.0%	44	24.2%	580.5	17.4%	-	-	-	-
TOTAL	615	100.0%	10891.2	100.0%	186	100.0%	2538.7	100.0%	182	100.0%	3334.23	100.0%	-	-	-	-

Outage Mode Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Single Mode	446	72.5%	9038.5	83.0%	148	79.6%	545.9	21.5%	147	80.8%	2707.4	81.2%	-	-	-	-
Dependent Mode Initiating	19	3.1%	484.5	4.4%	7	3.8%	45.3	1.8%	4	2.2%	24.9	0.7%	-	-	-	-
Dependent Mode	55	8.9%	204.8	1.9%	16	8.6%	1895.7	74.7%	5	2.7%	11.8	0.4%	-	-	-	-
Common Mode	95	15.4%	1163.4	10.7%	12	6.5%	0.6	0.0%	22	12.1%	565.4	17.0%	-	-	-	-
Common Mode Initiating	0	0.0%	0.0	0.0%	3	1.6%	51.3	2.0%	4	2.2%	24.8	0.7%	-	-	-	-
TOTAL	615	100.0%	10891.2	100.0%	186	100.0%	2538.7	100.0%	182	100.0%	3334.23	100.0%	-	-	-	-

Table WECC 3.1-4 (p. 2 of 3)
AC Circuit - Other Sustained Outage Attributes

Event Type	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
10	438	71.2%	8897.2	81.7%	143	76.9%	609.3	24.0%	135	74.2%	2693.6	80.8%	-	-	-	-
30	89	14.5%	1527.9	14.0%	21	11.3%	1892.7	74.6%	1	0.5%	0.0	0.0%	-	-	-	-
50	88	14.3%	466.1	4.3%	22	11.8%	36.7	1.4%	46	25.3%	640.6	19.2%	-	-	-	-
TOTAL	615	100.0%	10891.2	100.0%	186	100.0%	2538.7	100.0%	182	100.0%	3334.2	100.0%	-	-	-	-

Outage Duration Interval	200-299 kV		300-399 kV		400-599 kV		600-799 kV	
	No. Sust.	%	No. Sust.	%	No. Sust.	%	No. Sust.	%
1-5 Minutes	172	28.0%	91	48.9%	72	39.6%	-	-
6-10 Minutes	66	10.7%	22	11.8%	22	12.1%	-	-
11-30 Minutes	67	10.9%	15	8.1%	32	17.6%	-	-
31-120 Minutes	77	12.5%	22	11.8%	12	6.6%	-	-
121 Minutes to 24 Hours	180	29.3%	25	13.4%	25	13.7%	-	-
> 24 Hours to 48 Hours	25	4.1%	6	3.2%	8	4.4%	-	-
> 48 Hours	28	4.6%	5	2.7%	11	6.0%	-	-
TOTAL	615	100.0%	186	100.0%	182	100.0%	-	-

Table WECC 3.1-4 (p. 3 of 3)
AC Circuit - Other Sustained Outage Attributes

Fault Type	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
No fault	266	27.1%	6023.0	35.9%
P-P fault	90	9.2%	1018.1	6.1%
Single P-G fault	389	39.6%	4705.7	28.1%
P-P-G, 3 P, or 3P-G fault	69	7.0%	1787.0	10.7%
Unknown fault type	169	17.2%	3230.3	19.3%
TOTAL	983	100.0%	16764.1	100.0%

Outage Initiation Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	655	66.6%	9886.2	59.0%
Other Element-Initiated	70	7.1%	206.1	1.2%
AC Substation-Initiated	146	14.9%	5577.8	33.3%
AC/DC Terminal-Initiated	2	0.2%	383.5	2.3%
Other Facility-Initiated	110	11.2%	710.5	4.2%
TOTAL	983	100.0%	16764.1	100.0%

Outage Mode Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Single Mode	741	75.4%	12291.7	73.3%
Dependent Mode Initiating	30	3.1%	554.7	3.3%
Dependent Mode	76	7.7%	2112.3	12.6%
Common Mode	129	13.1%	1729.3	10.3%
Common Mode Initiating	7	0.7%	76.1	0.5%
TOTAL	983	100.0%	16764.1	100.0%

Event Type	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
10	716	72.8%	12200.1	72.8%
30	111	11.3%	3420.6	20.4%
50	156	15.9%	1143.4	6.8%
TOTAL	983	100.0%	16764.1	100.0%

Outage Duration Interval	All Voltages	
	No. Sust.	%
1-5 Minutes	335	34.1%
6-10 Minutes	110	11.2%
11-30 Minutes	114	11.6%
31-120 Minutes	111	11.3%
121 Minutes to 24 Hours	230	23.4%
> 24 Hours to 48 Hours	39	4.0%
> 48 Hours	44	4.5%
TOTAL	983	100.0%

3.1.2 AC Circuit Momentary Outages

3.1.2.1 AC Circuit Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage was initiated.

- Table WECC 3.1-5 shows metrics for AC Circuit Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table WECC 3.1-6 shows the metrics for AC Circuit Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

**Table WECC 3.1-5
AC Circuit Momentary Outage Metrics - Element-Initiated Only**

Voltage Class	Circuit Miles	No. of Circuits	No. of Outages	Frequency (MCOF) (per 100 CM per yr)	Frequency (MOF) (per circuit per yr)
200-299 kV	44425	1606.9	264	0.5943	0.1643
300-399 kV	10488	136.2	113	1.0774	0.8297
400-599 kV	16912	253.0	84	0.4967	0.3320
600-799 kV	0	0.0	-	-	-
All Voltages	71825	1996.1	461	0.6418	0.2310

**Table WECC 3.1-6
AC Circuit Momentary Outage Metrics -
Other than "Element-Initiated"**

Voltage Class	No. of Circuits	No. of Outages	Frequency (MOF) (per circuit per yr)
200-299 kV	1606.9	31	0.0193
300-399 kV	136.2	3	0.0220
400-599 kV	253.0	25	0.0988
600-799 kV	0.0	-	-
All Voltages	1996.1	59	0.0296

3.1.2.2 AC Circuit Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table WECC 3.1-7 on the next page reports Cause Code data for AC Circuit Momentary Outages.

**Table WECC 3.1-7
AC Circuit Momentary Outages by Cause Code**

Outage Cause Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Weather, excluding lightning	31	10.5%	9	7.8%	2	1.8%	-	-	42	8.1%
Lightning	126	42.7%	5	4.3%	47	43.1%	-	-	178	34.2%
Environmental	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Contamination	5	1.7%	4	3.4%	0	0.0%	-	-	9	1.7%
Foreign Interference	19	6.4%	4	3.4%	0	0.0%	-	-	23	4.4%
Fire	12	4.1%	0	0.0%	1	0.9%	-	-	13	2.5%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Failed AC Substation Equipment	3	1.0%	1	0.9%	1	0.9%	-	-	5	1.0%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Failed Protection System Equipment	1	0.3%	2	1.7%	1	0.9%	-	-	4	0.8%
Failed AC Circuit Equipment	8	2.7%	1	0.9%	8	7.3%	-	-	17	3.3%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Vegetation	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Power System Condition	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Human Error	12	4.1%	1	0.9%	1	0.9%	-	-	14	2.7%
Unknown	75	25.4%	88	75.9%	48	44.0%	-	-	211	40.6%
Other	3	1.0%	1	0.9%	0	0.0%	-	-	4	0.8%
TOTAL	295	100.0%	116	100.0%	109	100.0%	-	-	520	100.0%

3.1.2.3 Other AC Circuit Momentary Outage Data

Table WECC 3.1-8 on the next page shows other AC Circuit Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

**Table WECC 3.1-8
AC Circuit - Other Momentary Outage Attributes**

Fault Type	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
No fault	19	6.4%	3	2.6%	2	1.8%	-	-	24	4.6%
P-P fault	9	3.1%	2	1.7%	1	0.9%	-	-	12	2.3%
Single P-G fault	172	58.3%	73	62.9%	84	77.1%	-	-	329	63.3%
P-P-G, 3 P, or 3P-G fault	38	12.9%	0	0.0%	6	5.5%	-	-	44	8.5%
Unknown fault type	57	19.3%	38	32.8%	16	14.7%	-	-	111	21.3%
TOTAL	295	100.0%	116	100.0%	109	100.0%	-	-	520	100.0%

Outage Initiation Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Element-Initiated	264	89.5%	113	97.4%	84	77.1%	-	-	461	88.7%
Other Element-Initiated	5	1.7%	2	1.7%	3	2.8%	-	-	10	1.9%
AC Substation-Initiated	20	6.8%	1	0.9%	20	18.3%	-	-	41	7.9%
AC/DC Terminal-Initiated	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Other Facility-Initiated	6	2.0%	0	0.0%	2	1.8%	-	-	8	1.5%
TOTAL	295	100.0%	116	100.0%	109	100.0%	-	-	520	100.0%

Outage Mode Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Single Mode	280	94.9%	101	87.1%	104	95.4%	-	-	485	93.3%
Dependent Mode Initiating	3	1.0%	13	11.2%	1	0.9%	-	-	17	3.3%
Dependent Mode	3	1.0%	0	0.0%	1	0.9%	-	-	4	0.8%
Common Mode	9	3.1%	2	1.7%	3	2.8%	-	-	14	2.7%
Common Mode Initiating	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
TOTAL	295	100.0%	116	100.0%	109	100.0%	-	-	520	100.0%

Event Type	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	0	No. Mom.	0	No. Mom.	0	No. Mom.	%	No. Mom.	%
10	281	95.3%	99	85.3%	104	95.4%	-	-	484	93.1%
30	10	3.4%	2	1.7%	3	2.8%	-	-	15	2.9%
50	4	1.4%	15	12.9%	2	1.8%	-	-	21	4.0%
TOTAL	295	100.0%	116	100.0%	109	100.0%	-	-	520	100.0%

3.1.3 Total AC Circuit Metrics

Table WECC 3.1-9 on the next page displays AC Circuit metrics that are defined in Appendix 2.

**Table WECC 3.1-9
AC Circuit Metrics 1-16 per Appendix 2**

Voltage Class	OH/UG	Element Outage Duration, Repair Time, and Update Time (4-7)									Element Availability (8-10)		
		Element Outage Frequency (1-3)			SODT	MTRR	MTTR	MTTR	MdTTR	MTBF	APC %	PCZO %	PCDR %
		TOF	SOF	MOF		P(5%) <	MTTR 50/50	P(5%) >					
200-299 kV	Overhead	0.58	0.39	0.19	6.89	17.58	17.58	17.58	0.52	22345.43	99.92	68.12	0.88
300-399 kV	Overhead	2.22	1.37	0.85	18.64	13.64	13.65	13.65	0.10	6400.9	99.79	38.13	0.00
400-599 kV	Overhead	1.16	0.73	0.43	13.28	18.32	18.32	18.32	0.17	12062.8	99.85	52.38	0.69
600-799 kV	Overhead	-	-	-	-	-	-	-	-	-	-	-	-
200-299 kV	Underground	0.05	0.05	0.00	2.78	0.00	58.38	312.49	58.38	183901.63	99.97	95.24	0.00
300-399 kV	Underground	-	-	-	-	-	-	-	-	-	-	-	-
400-599 kV	Underground	C	C	C	C	C	C	C	C	C	C	C	C

Voltage Class	OH/UG	Circuit Outage Frequency (11-13)						Multiple Circuit Outage Frequency (14-16)			Outage Totals		
		TCOF		SCOF		MCOF		TMCOF	SMCOF	MMCOF	Momentary Outages	Sustained Outages	Sustained Outages Hours
		All	Elemt. Init.	All	Elemt. Init.	All	Elemt. Init.						
200-299 kV	Overhead	2.05	1.54	1.39	0.95	0.67	0.60	1.00	0.93	0.11	295	613	10774.5
300-399 kV	Overhead	2.88	2.41	1.77	1.33	1.11	1.08	7.59	6.96	0.63	116	186	2538.7
400-599 kV	Overhead	1.73	1.07	1.08	0.57	0.65	0.50	0.51	0.17	0.34	109	182	3334.2
600-799 kV	Overhead	-	-	-	-	-	-	-	-	-	-	-	-
Mixed Voltages	Overhead							0.00	0.00	0.00			
200-299 kV	Underground	0.91	0.45	0.91	0.45	0.00	0.00				0	2	116.8
300-399 kV	Underground	-	-	-	-	-	-				-	-	-
400-599 kV	Underground	C	C	C	C	C	C				C	C	C
TOTAL											520	983	16764.1

3.2 DC Circuit Metrics and Data

DC Circuit metrics are displayed in three sections: Section 3.2.1 addresses Sustained Outages and Section 3.2.2 addresses Momentary Outages. In all cases, the metrics displayed in these two sections include *all* DC Circuits (Overhead and Underground). Additionally, Section 3.1.3 has DC Circuit metrics that are differentiated into Overhead and Underground categories. Data and metrics are displayed for the three DC Circuit Voltage Classes in the NERC template plus the total of all Voltage Classes.

3.2.1 DC Circuit Sustained Outages

3.2.1.1 DC Circuit Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table WECC 3.2-1 shows metrics for DC Circuit Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (DC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table WECC 3.2-2 shows the metrics for DC Circuit Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

Table WECC 3.2-1
DC Circuit Sustained Outage Metrics

This space intentionally left blank.
This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

Table WECC 3.2-2
DC Circuit Sustained Outage Metrics – Other than “Element Initiated”

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This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

3.2.1.2 DC Circuit Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table WECC 3.2-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

**Table WECC 3.2-3
DC Circuit Sustained Outages by Cause Code**

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This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

3.2.1.3 Other DC Circuit Sustained Outage Data

Table WECC 3.2-4 shows other DC Circuit Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type, and Outage Duration Interval.

**Table WECC 3.2-4
DC Circuit – Other Sustained Outage Attributes**

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This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

3.2.2 DC Circuit Momentary Outages

3.2.2.1 DC Circuit Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table WECC 3.2-5 shows metrics for DC Circuit Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (DC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table WECC 3.2-6 shows the metrics for DC Circuit Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

Table WECC 3.2-5

DC Circuit Momentary Outage Metrics – “Element Initiated” Only

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This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

Table WECC 3.2-6

DC Circuit Momentary Outage Metrics – Other than “Element Initiated”

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This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

3.2.2.2 DC Circuit Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table WECC 3.2-7 reports Cause Code data for DC Circuit Momentary Outages.

Table WECC 3.2-7 DC Circuit Momentary Outages by Cause Code

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This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

3.2.2.3 Other DC Circuit Momentary Outage Data

Table WECC 3.2-8 shows other DC Circuit Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

Table WECC 3.2-8 DC Circuit – Other Momentary Outage Attributes

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This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

3.2.3 Total DC Circuit Metrics

Table WECC 3.2-9 displays DC Circuit metrics that are defined in Appendix 2.

Table WECC 3.2-9 DC Circuit Metrics 1-16 per Appendix 2

This space intentionally left blank.
This category of data is not displayed because there is no inventory in the voltage classes or it would reveal confidential Transmission Owner information. See Section 1.5 and Table WECC 2-2 of this report.

3.3 Transformer Metrics and Data

Transformer metrics are displayed in three sections: Section 3.3.1 addresses Sustained Outages, Section 3.3.2 addresses Momentary Outages, and Section 3.3.3 has Transformer metrics per the formulas in Appendix 2. Data and metrics are displayed for all four Transformer Voltages Classes in the NERC template plus the total of all Voltage Classes.

3.3.1 Transformer Sustained Outages

3.3.1.1 Transformer Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table WECC 3.3-1 shows metrics for Transformer Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (Transformer in this case) being reported.
- Table WECC 3.3-2 shows the metrics for Transformer Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

Table WECC 3.3-1
Transformer Sustained Outage Metrics - Element-Initiated Only

Voltage Class	No. of Transformers	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per transformer per yr)	MTTR or Mean Outage Duration (hr)
200-299 kV	15.0	3	185.0	0.2000	61.7
300-399 kV	61.3	6	7773.2	0.0979	1295.5
400-599 kV	178.6	6	1757.3	0.0336	292.9
600-799 kV	0.0	-	-	-	-
All Voltages	254.9	15	9715.5	0.0588	647.7

Table WECC 3.3-2
Transformer Sustained Outage Metrics - Other than "Element-Initiated"

Voltage Class	No. of Transformers	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per transformer per yr)	MTTR or Mean Outage Duration (hr)
200-299 kV	15.0	2	6.3	0.1333	3.1
300-399 kV	61.3	12	486.1	0.1958	40.5
400-599 kV	178.6	10	283.2	0.0560	28.3
600-799 kV	0.0	-	-	-	-
All Voltages	254.9	24	775.6	0.0942	32.3

3.3.1.2 Transformer Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table WECC 3.3-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

Table WECC 3.3-3 (p. 1 of 3)
Transformer Sustained Outages by Cause Code

Outage Cause Code	200-299kV						300-399kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	0	0.0%	0	0.0%	0.0	0.0%	5	27.8%	5	27.8%	39.7	0.5%
Lightning	1	20.0%	1	20.0%	0.4	0.2%	2	11.1%	2	11.1%	4.3	0.1%
Environmental	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	0	0.0%	0	0.0%	0.0	0.0%	2	11.1%	2	11.1%	0.1	0.0%
Foreign Interference	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Fire	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	2	40.0%	2	40.0%	6.3	3.3%	4	22.2%	3	16.7%	460.2	5.6%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	2	40.0%	2	40.0%	184.6	96.5%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	1	5.6%	7752.0	93.9%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	0	0.0%	0	0.0%	0.0	0.0%	1	5.6%	1	5.6%	1.0	0.0%
Human Error	0	0.0%	0	0.0%	0.0	0.0%	2	11.1%	1	5.6%	1.5	0.0%
Unknown	0	0.0%	0	0.0%	0.0	0.0%	2	11.1%	2	11.1%	0.1	0.0%
Other	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	1	5.6%	0.4	0.0%
TOTAL	5	100.0%	5	100.0%	191.3	100.0%	18	100.0%	18	100.0%	8259.3	100.0%

Table WECC 3.3-3 (p. 2 of 3)
Transformer Sustained Outages by Cause Code

Outage Cause Code	400-599kV						600-799kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Lightning	1	6.3%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Environmental	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Contamination	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Foreign Interference	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Fire	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Failed AC Substation Equipment	6	37.5%	6	37.5%	2000.9	98.1%	-	-	-	-	-	-
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Failed Protection System Equipment	3	18.8%	3	18.8%	4.8	0.2%	-	-	-	-	-	-
Failed AC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Power System Condition	0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-	-	-
Human Error	4	25.0%	4	25.0%	0.6	0.0%	-	-	-	-	-	-
Unknown	1	6.3%	1	6.3%	7.9	0.4%	-	-	-	-	-	-
Other	1	6.3%	2	12.5%	26.4	1.3%	-	-	-	-	-	-
TOTAL	16	100.0%	16	100.0%	2040.5	100.0%	-	-	-	-	-	-

Table WECC 3.3-3 (p. 3 of 3)
Transformer Sustained Outages by Cause Code

Outage Cause Code	All Voltages					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	5	12.8%	5	12.8%	39.7	0.4%
Lightning	4	10.3%	3	7.7%	4.7	0.0%
Environmental	0	0.0%	0	0.0%	0.0	0.0%
Contamination	2	5.1%	2	5.1%	0.1	0.0%
Foreign Interference	0	0.0%	0	0.0%	0.0	0.0%
Fire	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	12	30.8%	11	28.2%	2467.4	23.5%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	5	12.8%	5	12.8%	189.4	1.8%
Failed AC Circuit Equipment	0	0.0%	1	2.6%	7752.0	73.9%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	1	2.6%	1	2.6%	1.0	0.0%
Human Error	6	15.4%	5	12.8%	2.1	0.0%
Unknown	3	7.7%	3	7.7%	8.0	0.1%
Other	1	2.6%	3	7.7%	26.8	0.3%
TOTAL	39	100.0%	39	100.0%	10491.1	100.0%

3.3.1.3 Other Transformer Sustained Outage Data

Table WECC 3.3-4 on the next page shows other Transformer Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type, and Outage Duration Interval.

Table WECC 3.3-4 (p. 1 of 3)
Transformer - Other Sustained Outage Attributes

Fault Type	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
No fault	4	80.0%	190.9	99.8%	16	88.9%	49.0	0.6%	13	81.3%	278.6	13.7%	-	-	-	-
P-P fault	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-
Single P-G fault	0	0.0%	0.0	0.0%	1	5.6%	458.3	5.5%	1	6.3%	1688.4	82.7%	-	-	-	-
P-P-G, 3 P, or 3P-G fault	0	0.0%	0.0	0.0%	1	5.6%	7752.0	93.9%	1	6.3%	24.2	1.2%	-	-	-	-
Unknown fault type	1	20.0%	0.4	0.2%	0	0.0%	0.0	0.0%	1	6.3%	49.3	2.4%	-	-	-	-
TOTAL	5	100.0%	191.3	100.0%	18	100.0%	8259.3	100.0%	16	100.0%	2040.5	100.0%	-	-	-	-

Outage Initiation Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	3	60.0%	185.0	96.7%	6	33.3%	7773.2	94.1%	6	37.5%	1757.3	86.1%	-	-	-	-
Other Element-Initiated	0	0.0%	0.0	0.0%	10	55.6%	26.2	0.3%	1	6.3%	24.2	1.2%	-	-	-	-
AC Substation-Initiated	2	40.0%	6.3	3.3%	2	11.1%	459.9	5.6%	3	18.8%	251.7	12.3%	-	-	-	-
AC/DC Terminal-Initiated	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-
Other Facility-Initiated	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	6	37.5%	7.3	0.4%	-	-	-	-
TOTAL	5	100.0%	191.3	100.0%	18	100.0%	8259.3	100.0%	16	100.0%	2040.5	100.0%	-	-	-	-

Outage Mode Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Single Mode	1	20.0%	0.4	0.2%	7	38.9%	8215.1	99.5%	7	43.8%	1693.7	83.0%	-	-	-	-
Dependent Mode Initiating	2	40.0%	184.6	96.5%	0	0.0%	0.0	0.0%	5	31.3%	68.9	3.4%	-	-	-	-
Dependent Mode	0	0.0%	0.0	0.0%	11	61.1%	44.2	0.5%	1	6.3%	2.2	0.1%	-	-	-	-
Common Mode	2	40.0%	6.3	3.3%	0	0.0%	0.0	0.0%	3	18.8%	275.8	13.5%	-	-	-	-
Common Mode Initiating	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	-	-	-	-
TOTAL	5	100.0%	191.3	100.0%	18	100.0%	8259.3	100.0%	16	100.0%	2040.5	100.0%	-	-	-	-

**Table WECC 3.3-4 (p. 2 of 3)
Transformer - Other Sustained Outage Attributes**

Event Type	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
10	1	20.0%	0.4	0.2%	5	27.8%	8213.1	99.4%	5	31.3%	1689.0	82.8%	-	-	-	-
50	4	80.0%	190.9	99.8%	12	66.7%	28.2	0.3%	11	68.8%	351.5	17.2%	-	-	-	-
TOTAL	5	100.0%	191.3	100.0%	18	100.0%	8259.3	100.0%	16	100.0%	2040.5	100.0%	-	-	-	-

Transformer - Sustained Outage Duration Intervals

Outage Duration Interval	200-299 kV		300-399 kV		400-599 kV		600-799 kV	
	No. Sust.	%	No. Sust.	%	No. Sust.	%	No. Sust.	%
1-5 Minutes	0	0.0%	6	33.3%	3	18.8%	-	-
6-10 Minutes	0	0.0%	0	0.0%	2	12.5%	-	-
11-30 Minutes	1	20.0%	2	11.1%	1	6.3%	-	-
31-120 Minutes	0	0.0%	3	16.7%	1	6.3%	-	-
121 Minutes to 24 Hours	3	60.0%	5	27.8%	5	31.3%	-	-
> 24 Hours to 48 Hours	0	0.0%	0	0.0%	1	6.3%	-	-
> 48 Hours	1	20.0%	2	11.1%	3	18.8%	-	-
TOTAL	5	100.0%	18	100.0%	16	100.0%	-	-

Table WECC 3.3-4 (p. 3 of 3)
Transformer - Other Sustained Outage Attributes

Fault Type	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
No fault	33	84.6%	518.5	4.9%
P-P fault	0	0.0%	0.0	0.0%
Single P-G fault	2	5.1%	2146.7	20.5%
P-P-G, 3 P, or 3P-G fault	2	5.1%	7776.2	74.1%
Unknown fault type	2	5.1%	49.7	0.5%
TOTAL	39	100.0%	10491.1	100.0%

Outage Initiation Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	15	38.5%	9715.5	92.6%
Other Element-Initiated	11	28.2%	50.4	0.5%
AC Substation-Initiated	7	17.9%	717.8	6.8%
AC/DC Terminal-Initiated	0	0.0%	0.0	0.0%
Other Facility-Initiated	6	15.4%	7.3	0.1%
TOTAL	39	100.0%	10491.1	100.0%

Outage Mode Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Single Mode	15	38.5%	9909.1	94.5%
Dependent Mode Initiating	7	17.9%	253.5	2.4%
Dependent Mode	12	30.8%	46.4	0.4%
Common Mode	5	12.8%	282.0	2.7%
Common Mode Initiating	0	0.0%	0.0	0.0%
TOTAL	39	100.0%	10491.1	100.0%

Event Type	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
10	11	28.2%	9902.5	94.4%
50	27	69.2%	570.6	5.4%
TOTAL	39	100.0%	10491.1	100.0%

Outage Duration Interval	All Voltages	
	No. Sust.	%
1-5 Minutes	9	23.1%
6-10 Minutes	2	5.1%
11-30 Minutes	4	10.3%
31-120 Minutes	4	10.3%
121 Minutes to 24 Hours	13	33.3%
> 24 Hours to 48 Hours	1	2.6%
> 48 Hours	6	15.4%
TOTAL	39	100.0%

3.3.2 Transformer Momentary Outages

3.3.2.1 Transformer Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table WECC 3.3-5 shows metrics for Transformer Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (Transformer in this case) being reported.
- Table WECC 3.3-6 shows the metrics for Transformer Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

**Table WECC 3.3-5
Transformer Momentary Outage Metrics -
Element-Initiated Only**

Voltage Class	No. of Transformers	No. of Outages	Frequency (MOF) (per transformer per yr)
200-299 kV	15.0	1	0.0667
300-399 kV	61.3	0	0.0000
400-599 kV	178.6	0	0.0000
600-799 kV	0.0	-	-
All Voltages	254.9	1	0.0039

**Table WECC 3.3-6
Transformer Momentary Outage Metrics -
Other than "Element-Initiated"**

Voltage Class	No. of Transformers	No. of Outages	Frequency (MOF) (per transformer per yr)
200-299 kV	15.0	1	0.0667
300-399 kV	61.3	26	0.4241
400-599 kV	178.6	2	0.0112
600-799 kV	0.0	-	-
All Voltages	254.9	29	0.1138

3.3.2.2 Transformer Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table WECC 3.3-7 on the next page reports Cause Code data for Transformer Momentary Outages.

**Table WECC 3.3-7
Transformer Momentary Outages by Cause Code**

Outage Cause Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Weather, excluding lightning	0	0.0%	10	38.5%	0	0.0%	-	-	10	33.3%
Lightning	2	100.0%	8	30.8%	1	50.0%	-	-	11	36.7%
Environmental	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Contamination	0	0.0%	8	30.8%	0	0.0%	-	-	8	26.7%
Foreign Interference	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Fire	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Failed AC Substation Equipment	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Failed Protection System Equipment	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Failed AC Circuit Equipment	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Vegetation	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Power System Condition	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Human Error	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Unknown	0	0.0%	0	0.0%	1	50.0%	-	-	1	3.3%
Other	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
TOTAL	2	100.0%	26	100.0%	2	100.0%	-	-	30	100.0%

3.3.2.3 Other Transformer Momentary Outage Data

Table WECC 3.3-8 on the next page shows other Transformer Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

Table WECC 3.3-8
Transformer - Other Momentary Outage Attributes

Fault Type	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
No fault	1	50.0%	26	100.0%	2	100.0%	-	-	29	96.7%
P-P fault	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Single P-G fault	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
P-P-G, 3 P, or 3P-G fault	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Unknown fault type	1	50.0%	0	0.0%	0	0.0%	-	-	1	3.3%
TOTAL	2	100.0%	26	100.0%	2	100.0%	-	-	30	100.0%

Outage Initiation Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Element-Initiated	1	50.0%	0	0.0%	0	0.0%	-	-	1	3.3%
Other Element-Initiated	1	50.0%	26	100.0%	2	100.0%	-	-	29	96.7%
AC Substation-Initiated	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
AC/DC Terminal-Initiated	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Other Facility-Initiated	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
TOTAL	2	100.0%	26	100.0%	2	100.0%	-	-	30	100.0%

Outage Mode Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Single Mode	1	50.0%	0	0.0%	0	0.0%	-	-	1	3.3%
Dependent Mode Initiating	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Dependent Mode	1	50.0%	26	100.0%	2	100.0%	-	-	29	96.7%
Common Mode	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
Common Mode Initiating	0	0.0%	0	0.0%	0	0.0%	-	-	0	0.0%
TOTAL	2	100.0%	26	100.0%	2	100.0%	-	-	30	100.0%

Event Type	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
10	1	50.0%	0	0.0%	0	0.0%	-	-	1	3.3%
50	1	50.0%	26	100.0%	2	100.0%	-	-	29	96.7%
TOTAL	2	100.0%	26	100.0%	2	100.0%	-	-	30	100.0%

3.3.3 Total Transformer Metrics

Table WECC 3.3-9 on the next page displays Transformer metrics that are defined in Appendix 2.

**Table WECC 3.3-9
Transformer Metrics 1-10 per Appendix 2***

Voltage Class	Element Outage Frequency (1-3)			Element Outage Duration, Repair Time, and Update Time (4-7)						Element Availability (8-10)		
	TOF	SOF	MOF	SODT	MTRR	MTRR	MTRR	MdTTR	MTBF	APC %	PCZO %	PCDR %
					P(5%) <	MTTR 50/50	P(5%) >					
200-299 kV	0.47	0.33	0.13	12.75	28.97	38.26	47.55	3.50	26241.74	99.85	86.67	0.00
300-399 kV	0.72	0.29	0.42	134.74	447.87	458.85	469.83	1.23	29373.82	98.44	75.76	0.00
400-599 kV	0.10	0.09	0.01	11.42	124.25	127.53	130.81	2.88	97655.97	99.87	91.62	5.56
600-799 kV	-	-	-	-	-	-	-	-	-	-	-	-

***Note: Metrics 11-16 only apply to AC Circuits or DC Circuits**

Voltage Class	Outage Totals		
	Momentary Outages	Sustained Outages	Sustained Outages Hours
200-299 kV	2	5	191.3
300-399 kV	26	18	8259.3
400-599 kV	2	16	2040.5
600-799 kV	-	-	-
TOTAL	30	39	10491.1

3.4 AC/DC BTB Converter Metrics and Data

AC/DC BTB Converter metrics are displayed in three sections: Section 3.4.1 addresses Sustained Outages, Section 3.4.2 addresses Momentary Outages, and Section 3.4.3 has AC/DC BTB Converter metrics per the formulas in Appendix 2. Data and metrics are displayed for the two AC/DC BTB Converter Voltages Classes in the NERC template plus the total of all Voltage Classes.

3.4.1 AC/DC BTB Converter Sustained Outages

3.4.1.1 AC/DC BTB Converter Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table WECC 3.4-1 shows metrics for AC/DC BTB Converter Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC/DC BTB Converter in this case) being reported.
- Table WECC 3.4-2 shows the metrics for AC/DC BTB Converter Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

Table WECC 3.4-1

AC/DC BTB Converter Sustained Outage Metrics - Element-Initiated Only

Voltage Class	No. of Converters	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per converter per yr)	MTTR or Mean Outage Duration (hr)
200-299 kV	5.0	15	49.8	3.0000	3.3
300-399 kV	2.0	0	0.0	0.0000	~
All Voltages	7.0	15	49.8	2.1429	3.3

Table WECC 3.4-2

AC/DC BTB Converter Sustained Outage Metrics - Other than "Element-Initiated"

Voltage Class	No. of Converters	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per converter per yr)	MTTR or Mean Outage Duration (hr)
200-299 kV	5.0	18	49.4	3.6000	2.7
300-399 kV	2.0	3	48.9	1.5000	16.3
All Voltages	7.0	21	98.2	3.0000	4.7

3.4.1.2 AC/DC BTB Converter Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table WECC 3.4-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

Table WECC 3.4-3 (p 1 of 2)

AC/DC BTB Converter Sustained Outages by Cause Code

Outage Cause Code	200-299kV						300-399kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	4	12.1%	2	6.1%	7.4	7.4%	0	0.0%	0	0.0%	0.0	0.0%
Lightning	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Environmental	1	3.0%	1	3.0%	0.7	0.7%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	2	6.1%	2	6.1%	3.0	3.0%	0	0.0%	0	0.0%	0.0	0.0%
Fire	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	3	9.1%	4	12.1%	19.6	19.8%	3	100.0%	3	100.0%	48.9	100.0%
Failed AC/DC Terminal Equipment	6	18.2%	4	12.1%	14.5	14.6%	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Circuit Equipment	8	24.2%	7	21.2%	40.5	40.8%	0	0.0%	0	0.0%	0.0	0.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	3	9.1%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Human Error	2	6.1%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Unknown	3	9.1%	12	36.4%	13.3	13.4%	0	0.0%	0	0.0%	0.0	0.0%
Other	1	3.0%	1	3.0%	0.2	0.2%	0	0.0%	0	0.0%	0.0	0.0%
TOTAL	33	100.0%	33	100.0%	99.2	100.0%	3	100.0%	3	100.0%	48.9	100.0%

Table WECC 3.4-3 (p 2 of 2)
AC/DC BTB Converter Sustained Outages
by Cause Code

Outage Cause Code	All Voltages					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	4	11.1%	2	5.6%	7.4	5.0%
Lightning	0	0.0%	0	0.0%	0.0	0.0%
Environmental	1	2.8%	1	2.8%	0.7	0.5%
Contamination	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	2	5.6%	2	5.6%	3.0	2.0%
Fire	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	6	16.7%	7	19.4%	68.5	46.3%
Failed AC/DC Terminal Equipment	6	16.7%	4	11.1%	14.5	9.8%
Failed Protection System Equipment	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Circuit Equipment	8	22.2%	7	19.4%	40.5	27.3%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	3	8.3%	0	0.0%	0.0	0.0%
Human Error	2	5.6%	0	0.0%	0.0	0.0%
Unknown	3	8.3%	12	33.3%	13.3	9.0%
Other	1	2.8%	1	2.8%	0.2	0.1%
TOTAL	36	100.0%	36	100.0%	148.0	100.0%

3.4.1.3 Other AC/DC BTB Converter Sustained Outage Data

Table WECC 3.4-4 on the next page shows other AC/DC BTB Converter Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type, and Outage Duration Interval.

Table WECC 3.4-4**AC/DC BTB Converter - Other Sustained Outage Attributes**

Fault Type	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
No fault	27	81.8%	85.5	86.3%	0	0.0%	0.0	0.0%	27	75.0%	85.5	57.8%
P-P fault	0	0.0%	0.0	0.0%	1	33.3%	1.8	3.7%	1	2.8%	1.8	1.2%
Single P-G fault	3	9.1%	4.4	4.5%	2	66.7%	47.1	96.3%	5	13.9%	51.5	34.8%
P-P-G, 3 P, or 3P-G fault	3	9.1%	9.2	9.3%	0	0.0%	0.0	0.0%	3	8.3%	9.2	6.2%
Unknown fault type	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
TOTAL	33	100.0%	99.2	100.0%	3	100.0%	48.9	100.0%	36	100.0%	148.0	100.0%

Outage Initiation Code	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	15	45.5%	49.8	50.2%	0	0.0%	0.0	0.0%	15	41.7%	49.8	33.6%
Other Element-Initiated	3	9.1%	7.5	7.5%	0	0.0%	0.0	0.0%	3	8.3%	7.5	5.1%
AC Substation-Initiated	5	15.2%	26.3	26.5%	3	100.0%	48.9	100.0%	8	22.2%	75.2	50.8%
AC/DC Terminal-Initiated	7	21.2%	15.3	15.5%	0	0.0%	0.0	0.0%	7	19.4%	15.3	10.3%
Other Facility-Initiated	3	9.1%	0.3	0.3%	0	0.0%	0.0	0.0%	3	8.3%	0.3	0.2%
TOTAL	33	100.0%	99.2	100.0%	3	100.0%	48.9	100.0%	36	100.0%	148.0	100.0%

Outage Mode Code	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Single Mode	24	72.7%	68.2	68.8%	3	100.0%	48.9	100.0%	27	75.0%	117.1	79.1%
Dependent Mode Initiating	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
Dependent Mode	6	18.2%	30.7	30.9%	0	0.0%	0.0	0.0%	6	16.7%	30.7	20.7%
Common Mode	3	9.1%	0.3	0.3%	0	0.0%	0.0	0.0%	3	8.3%	0.3	0.2%
Common Mode Initiating	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
TOTAL	33	100.0%	99.2	100.0%	3	100.0%	48.9	100.0%	36	100.0%	148.0	100.0%

Event Type	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
50	33	100.0%	99.2	100.0%	3	100.0%	48.9	100.0%	36	100.0%	148.0	100.0%
TOTAL	33	100.0%	99.2	100.0%	3	100.0%	48.9	100.0%	36	100.0%	148.0	100.0%

Table WECC 3.4-4 (continued on next page)

Table WECC 3.4-4 (continued)

**AC/DC BTB Converter
Sustained Outage Duration Intervals**

Outage Duration Interval	200-299 kV		300-399 kV		All Voltages	
	No. Sust.	%	No. Sust.	%	No. Sust.	%
1-5 Minutes	4	12.1%	0	0.0%	4	11.1%
6-10 Minutes	3	9.1%	0	0.0%	3	8.3%
11-30 Minutes	2	6.1%	0	0.0%	2	5.6%
31-120 Minutes	12	36.4%	2	66.7%	14	38.9%
121 Minutes to 24 Hours	12	36.4%	0	0.0%	12	33.3%
> 24 Hours to 48 Hours	0	0.0%	1	33.3%	1	2.8%
> 48 Hours	0	0.0%	0	0.0%	0	0.0%
TOTAL	33	100.0%	3	100.0%	36	100.0%

3.4.2 AC/DC BTB Converter Momentary Outages

3.4.2.1 AC/DC BTB Converter Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table WECC 3.4-5 shows metrics for AC/DC BTB Converter Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC/DC BTB Converter in this case) being reported.
- Table WECC 3.4-6 shows the metrics for AC/DC BTB Converter Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by Other Facilities.

Table WECC 3.4-5
AC/DC BTB Converter Momentary Outage
Metrics - Element-Initiated Only

Voltage Class	No. of Converters	No. of Outages	Frequency (MOF) (per converter per yr)
200-299 kV	5.0	0	0.0000
300-399 kV	2.0	0	0.0000
All Voltages	7.0	0	0.0000

Table WECC 3.4-6

AC/DC BTB Converter Momentary Outage
Metrics - Other than "Element-Initiated"

Voltage Class	No. of Converters	No. of Outages	Frequency (MOF) (per converter per yr)
200-299 kV	5.0	0	0.0000
300-399 kV	2.0	0	0.0000
All Voltages	7.0	0	0.0000

3.4.2.2 AC/DC BTB Converter Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table WECC 3.4-7 on the next page reports Cause Code data for AC/DC BTB Converter Momentary Outages.

Table WECC 3.4-7
AC/DC BTB Converter Momentary Outages
by Cause Code

Outage Cause Code	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
Weather, excluding lightning	0	~	0	~	0	~
Lightning	0	~	0	~	0	~
Environmental	0	~	0	~	0	~
Contamination	0	~	0	~	0	~
Foreign Interference	0	~	0	~	0	~
Fire	0	~	0	~	0	~
Vandalism, Terrorism, or Malicious Acts	0	~	0	~	0	~
Failed AC Substation Equipment	0	~	0	~	0	~
Failed AC/DC Terminal Equipment	0	~	0	~	0	~
Failed Protection System Equipment	0	~	0	~	0	~
Failed AC Circuit Equipment	0	~	0	~	0	~
Failed DC Circuit Equipment	0	~	0	~	0	~
Vegetation	0	~	0	~	0	~
Power System Condition	0	~	0	~	0	~
Human Error	0	~	0	~	0	~
Unknown	0	~	0	~	0	~
Other	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

3.4.2.3 Other AC/DC BTB Converter Momentary Outage Data

Table WECC 3.4-8 on the next page shows other AC/DC BTB Converter Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

**Table WECC 3.4-8
AC/DC BTB Converter
Other Momentary Outage Attributes**

Fault Type	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
No fault	0	~	0	~	0	~
P-P fault	0	~	0	~	0	~
Single P-G fault	0	~	0	~	0	~
P-P-G, 3 P, or 3P-G fault	0	~	0	~	0	~
Unknown fault type	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

Outage Initiation Code	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
Element-Initiated	0	~	0	~	0	~
Other Element-Initiated	0	~	0	~	0	~
AC Substation-Initiated	0	~	0	~	0	~
AC/DC Terminal-Initiated	0	~	0	~	0	~
Other Facility-Initiated	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

Outage Mode Code	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
Single Mode	0	~	0	~	0	~
Dependent Mode Initiating	0	~	0	~	0	~
Dependent Mode	0	~	0	~	0	~
Common Mode	0	~	0	~	0	~
Common Mode Initiating	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

Event Type	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	0	No. Mom.	0	No. Mom.	%
50	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

3.4.3 Total AC/DC BTB Converter Metrics

Table WECC 3.4-9 on the next page displays AC/DC BTB Converter metrics which are defined in Appendix 2.

Table WECC 3.4-9

AC/DC BTB Converter Metrics 1-10 per Appendix 2*

Voltage Class	Element Outage Frequency (1-3)			Element Outage Duration, Repair Time, and Update Time (4-7)						Element Availability (8-10)		
	TOF	SOF	MOF	SODT	MTRR	MTRR	MTRR	MdTTR	MTBF	APC %	PCZO %	PCDR %
					P(5%) <	MTTR 50/50	P(5%) >					
200-299 kV	6.60	6.60	0.00	19.83	3.00	3.00	3.01	1.13	1324.27	99.77	20.00	0.00
300-399 kV	1.50	1.50	0.00	24.44	0.00	16.29	34.57	1.87	5823.71	99.72	50.00	0.00

*Note: Metrics 11-16 only apply to AC Circuits or DC Circuits

Voltage Class	Outage Totals		
	Momentary Outages	Sustained Outages	Sustained Outages Hours
200-299 kV	0	33	99.2
300-399 kV	0	3	48.9
TOTAL	0	36	148.0

Appendix 1 TADS Definitions

The definitions are a separate document that may be downloaded at [http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_\(All\).pdf](http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_(All).pdf). These definitions were posted on September 11, 2008 for use during calendar year 2009 data collection.

Appendix 2 Metric Definitions

The TADS Metric definitions are contained on the table below, which is divided into two sections: the first page has metrics 1-10 that apply to *all* Elements. The second page has metrics 11-16 that only apply to AC Circuits or DC Circuits.

- Metric 5: Mean-time-to-repair (MTTR) has the same meaning as mean outage duration. Since this calculation may be based upon a limited number of outages for smaller Regions or individual Transmission Owner organizations, the computed value is an *estimate* of the “true” MTTR for the Element. Using statistical methods, one can estimate the uncertainty in the mean calculation. The tables in the main report provide a range of MTTR values:
 - The value that is calculated straight from the data is labeled “MTTR 50/50.”
 - The MTTR labeled “P(5%) >” means the true MTTR has a 5 % chance of being greater than this value, and the MTTR labeled “P(5%)<” means the true MTTR has a 5% chance of being lower than this value

When a fairly large number of outages are used to calculate the MTTR 50/50 value, the range of uncertainty is fairly low. See the Overhead AC Circuit MTTR values on WECC 3.1-9. When only a few outages are used, the range is very large, indicating a high degree of uncertainty between the calculated MTTR and the “true” MTTR.

- Metrics 11, 12, and 13: Circuit outage frequency on a per 100 Circuit Mile basis - Total Circuit Outage Frequency (TCOF), Sustained Circuit Outage Frequency (SCOF), and Momentary Circuit Outage Frequency (MCOF), are calculated twice – one calculation includes *all* outages while a second calculation only includes Element-Initiated outages. The second calculation more correctly relates outages initiated on the circuit (the Element in this case) to total circuit exposure measured by mileage.

No.	Metric	Formula	Units	Acronym
<i>Element Outage Frequency</i>				
1	Element Total Automatic Outage Frequency	Total Automatic Outages / Total Elements	No. Automatic Outages per Element per year	TOF
2	Element Sustained Outage Frequency	Total Sustained Outages / Total Elements	No. Sustained Outages per Element per year	SOF
3	Element Momentary Outage Frequency	Total Momentary Outages / Total Elements	No. Momentary Outages per Element per year	MOF
<i>Element Outage Duration, Repair Time, and Up Time</i>				
4	Element Sustained Outage Duration Time	Total Sustained Outage Hours / Total Elements	No. Sustained Outages hours per Element per year	SODT
5	Element Sustained Outage Mean Time to Repair. Also referred to as Mean Outage Duration	Total Sustained Outage Hours / Total Sustained Element Outages	Average no. of Sustained Outage Hours per outaged Element	MTTR
6	Median Time to Repair Sustained Element Outage Failures	The time when 50% of the Sustained Outage Duration hours per outaged Element are greater than this figure	Median no. of Sustained Outage Hours per outaged Element	MdTTR
7	Mean Time Between Sustained Element Outages (Mean "Up Time"). Also referred to as Mean Time Between Failures.	(Total Element Hours - Total Sustained Outage Hours) / Total Sustained Element Outages	Mean (average) no. of hours of operation of an Element before it fails	MTBF ¹
<i>Element Availability</i>				
8	Element Availability Percentage	1- (Total Sustained Outage Hours / Total Element Hours) * 100	Percentage	APC ¹
9	Percentage of Elements with Zero Automatic Outages	Total Elements with Zero Automatic Outages / Total Elements	Percentage	PCZO
10	Percent of Element Automatic Outages associated with a Disturbance Report (EOP-004)	Total Automatic Outages associated with a Disturbance Report / Total Automatic Outages	Percentage	PCDR

1 Since Non-Automatic Outage data are not collected, these metrics will be overstated from industry definitions.

	Metric	Formula	Units	Acronym
<i>Circuit Outage Frequency, per 100 Circuit Miles (Applies to AC and DC Circuits Only)</i>				
11	Circuit Total Outage Frequency, Mileage Adjusted	$(\text{Total Circuit Automatic Outages} * 100) / \text{Total Circuit Miles}$	No. Automatic Outages per 100 Circuit Miles per year	TCOF _{100CM}
12	Circuit Sustained Outage Frequency, Mileage Adjusted	$(\text{Total Circuit Sustained Outages} * 100) / \text{Total Circuit Miles}$	No. Sustained Outages per 100 Circuit Miles per year	SCOF _{100CM}
13	Circuit Momentary Outage Frequency, Mileage Adjusted	$(\text{Total Circuit Momentary Outages} * 100) / \text{Total Circuit Miles}$	No. Momentary Outages per 100 Circuit Miles per year	MCOF _{100CM}
<i>Multiple Circuit Outage Frequency per 100 Multi-Circuit Structure Miles (For AC Circuits, multi circuit outages are Event Type 30 outages; for DC Circuits, they are Event Type 40 outages.)</i>				
14	Multi Circuit Total Outage Frequency, Mileage Adjusted	$(\text{Total Multi-Circuit Automatic Outages} * 100) / \text{Total Multi-Circuit Structure Miles}$	No. Automatic Outages per 100 Multi-Circuit Structures Miles per year	TMCOF _{100SM}
15	Multi-Circuit Sustained Outage Frequency, Mileage Adjusted	$(\text{Total Multi-Circuit Sustained Outages} * 100) / \text{Total Multi-Circuit Structure Miles}$	No. Sustained Outages per 100 Multi-Circuit Structure Miles per year	SMCOF _{100SM}
16	Multi-Circuit Momentary Outage Frequency, Mileage Adjusted	$(\text{Total Multi-Circuit Momentary Outages} * 100) / \text{Total Multi-Circuit Structure Miles}$	No. Momentary Outages per 100 Multi-Circuit Structure Miles per year	MMCOF _{100SM}

Appendix 3 TADS Working Group Members as of April 23, 2010

Chair and TO-TRE Member	Michael J. Pakeltis, P.E. Manager, Reliability Analysis & Technical Support, Transmission Operations	CenterPoint Energy P.O. Box 1700 Houston, Texas 77251-1700	(713) 207-6714 (713) 207-9122 Fx michael.pakeltis@centerpointenergy.com
Vice Chair and TO-NPCC Member	Julian Cox, C.Eng. Director, Operational Planning and Review	National Grid 40 Sylvan Road Waltham, Massachusetts 02451	(781) 907-2399 (781)907-5707 Fx julian.cox@us.ngrid.com
Secretary	Ronald J. Niebo Reliability Assessment Coordinator	North American Electric Reliability Corporation 116-390 Village Boulevard Princeton, New Jersey 08540-5721	(609) 452-8060 (609) 452-9550 Fx ron.niebo@nerc.net
RE Member	Adam Flink Engineer	Midwest Reliability Organization 2774 Cleveland Ave Roseville, Minnesota 55113	(651) 855-1705 (651) 855-1712 Fx ad.flink@midwestreliability.org
RE Member	Rao Somayajula, P.E. Senior Engineer	ReliabilityFirst Corporation 320 Springside Drive Suite 300 Akron, Ohio 44333	(330) 247-3061 (330) 456-3648 Fx rao.somayajula@rfirst.org
TO-RFC Member	Steven J. Hedden Principal Engineer	Commonwealth Edison Co. 1N301 Swift Road Lombard, Illinois 60148	(630) 691-4594 (630) 691-4414 Fx steven.hedden@comed.com
TO-WECC Member	Brian K. Keel Manager, Transmission System Planning	Salt River Project MS POB100 PO Box 52025 Phoenix, Arizona 85072	602-236-0970 (602) 236-3896 Fx brian.keel@srpnet.com
TO-SPP Member	Jake Langthorn, P.E. Transmission Tariff Coordinator	Oklahoma Gas and Electric Co. 320 N Harvey Oklahoma City, Oklahoma 73101	405-553-3409 (405) 553-3165 Fx langthjs@oge.com
TO-SERC member	Ronald Carlsen System Security Manager	Georgia Power Company 241 Ralph McGill Blvd NE Bin 10024 Atlanta, Georgia 30308	(404) 506-2958 (404) 506-1240 Fx rlcarlse@southernco.com
TO-FRCC Member	G. Brantley Tillis, P.E. Manager, Transmission Planning Florida	Progress Energy Florida 3300 Exchange Place Lake Mary, Florida 32746	407-942-9569 407-942-9797 Fx brantley.tillis@pgnmail.com

TO-MRO Member	Kurt Weisman Reliability Performance Project Manager	American Transmission Company W234 N2000 Ridgeview Pkwy. Ct. Waukesha, Wisconsin 53187-0047	(262) 506-6920 (262) 832-8650 Fx kweisman@ atcllc.com
At-Large Member	Michael S. Clemons, P.E. System Engineer	Tennessee Valley Authority 1101 Market Street Mailstop: MR-5K-C Chattanooga, Tennessee 37402	423-751-7098 423-751-4442 Fx msclemons@ tva.gov
At-Large Member	Jeff Schaller Performance Manager	Hydro One Networks, Inc. 483 Bay Street TCT14 Toronto, Ontario M5G 2P5	(416) 345-5268 (416) 345-5401 Fx jeff.schaller@ HydroOne.com
NERC Staff	Jim K. Robinson, P.E. TADS Manager	North American Electric Reliability Corporation 116-390 Village Boulevard Princeton, New Jersey 08540-5721	(610) 841-3362 jim.robinson@ nerc.net
	Mark G. Lauby Director of Reliability Assessment and Performance Analysis	North American Electric Reliability Corporation 116-390 Village Boulevard Princeton, New Jersey 08540-5721	(609) 452-8060 (609) 452-9550 Fx mark.lauby@ nerc.net