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Subject: Calculation of Annual Distribution Loss Factors

DISTRIBUTION LOSS FACTOR CALCULATION

Texas New-Mexico Power (TNMP) is a Distribution Service Provider (DSP) in the ERCOT region and is subject to compliance with ERCOT Nodal Protocols Section 13.3¹ Distribution Losses and, as such shall calculate and provide ERCOT the annual Distribution loss coefficients to be applied to distribution voltage level Loads in its area of certification. The Distribution Loss Factors (DLF) calculations for TNMP's certificated regions have been updated per ERCOT Nodal Protocol Section 13.3.1 paragraph (1), and the associated calculations and methodology are summarized herein.

The equation below calculates the DLF based on information provided by each DSP.

$$SILF_i = F1 * \left(\frac{SIEL_i}{AAL} \right) + F2 + \frac{F3}{\left(\frac{SIEL_i}{AAL} \right)}$$

where:	<i>i</i>	=	Interval (15 minutes)
	<i>SILF_i</i>	=	Settlement Interval Distribution Loss Factor
	<i>SIEL_i</i>	=	Settlement Interval ERCOT System Load
	<i>AAL</i>	=	Annual Interval Average ERCOT System Load
	<i>F1, F2, F3</i>	=	Coefficients determined by the DSP to allow calculations of its <i>SILF_i</i> from the ERCOT System Load

Within the pages that follow is a summary of the calculations associated with DLF coefficients for each of TNMP's certificated regions.

ASSUMPTIONS AND APPROACH

ERCOT System Load

TNMP energy and demand data from calendar year 2022 were collected from meter data at each distribution substation power transformer. ERCOT load profiles from the same time period were collected from the ERCOT website². The analysis assumes that AAL, defined previously, and the peak for TNMP

¹ See <http://www.ercot.com/mktrules/nprotocols/current> for the most recent iteration

² See http://www.ercot.com/gridinfo/load/load_hist for 2022 ERCOT Hourly Load Data



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corresponds to the AAL and peak for ERCOT. The table below details the demand and energy figures utilized for this analysis.

	ERCOT	TNMP North TX	TNMP Central TX	TNMP Gulf Coast	TNMP West TX
1-Hr Peak (MW)	80,038	390.20	99.37	716.96	180.08
15-Min Interval (MWh)	20,009	97.55	24.84	179.24	45.02
Total Energy (MWh)	429,884,664	2,185,236	567,173	2,499,792	809,883
AAL (15-min)	12,268	62	16	71	23

Loss Analysis Methodology

A representative sample of the circuits within each TNMP region were selected for detailed analysis. The detailed analysis results of said sample circuits were extrapolated to develop loss factors at each level of the distribution system. System loss percentages are developed at each of the following levels of the distribution system: power transformers, primary line, distribution service transformers, and distribution services (secondary of service transformers). Due to system consistencies with respect to nominal operating voltages, circuit topology, and geographic proximity, the North Texas and Central Texas regions were consolidated in the analysis.

In each case, the following loss equation was utilized to calculate the total losses in TNMP's distribution system.

$$Losses = Ax^2 + B$$

where:

A	=	Constant
B	=	Constant (no-load losses)
x	=	Input to the system (MW)

The constants 'A' and 'B' were subsequently utilized to determine loss percentages at varying load levels. The analysis conducted at each distinct system level to determine the system input values is summarized further in the sections below.

Power Transformers

To compute no-load losses in TNMP power transformers, linear regression was utilized based on typical values from a Cooperative Research Network (CRN)³ report on distribution system losses. The expected transformer full load and a calculated load factor during the coincident peak month were utilized to calculate full-load losses. Typically observed load factor values were applied based on calculated values

³ CRN Report can be obtained at <https://www.cooperative.com/programs-services/bts/Pages/BTS-Reports/Electric-Distribution-System-Losses.aspx>

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using historical TNMP load data from the calendar year 2022. This methodology yields values consistent with power flow estimates.

Primary Conductor and Cable Systems

Computation of primary line losses was accomplished via extrapolation of the aggregate overhead and underground primary losses in the six (6) sampled circuits from each region. The six sample circuits were used to determine a representative loss factor for urban and rural classified circuits. Said loss factors were applied to the input to the distribution system derived after considering losses through the distribution power transformers. It was assumed that all circuits emanating from a power transformer would have consistent classification as either urban or rural.

Distribution Service Transformers

An audit of the distribution service transformers from the circuits selected as part of the sample set were utilized in determining losses through the distribution service transformers. A typical transformer was assigned to each of the following:

- Single-phase overhead services
- Single-phase underground services
- Three-phase overhead services
- Three-phase underground services

Load and No-Load losses for TNMP distribution service transformers were derived utilizing typical loss magnitudes as depicted in the Cooperative Research Network (CRN) publication, "Electric Distribution System Losses," Project 13-01 from November 2014. Typical loss values associated with service transformers are found in Table 3.2 on page 18 of the CRN report (see footnote 3 for report location). Regression analysis was utilized to determine load and no-load losses for those transformers with ratings outside the range depicted in the table. Pad-mounted transformer load and no-load losses data were collected from manufacturer produced typical performance tables.

Distribution Secondary Service Drops

An analysis similar to that associated with the distribution service transformer audit was engaged in an audit of distribution services/service wires. Customers within each region's sample set were first subdivided into the following classifications:

- Residential (Rural) – assumes 150' 1/0 Triplex service drop
- Residential (Urban) – assumes 100' 1/0 Triplex service drop
- General Service (< 100 kW) – assumes 100' 4/0 Triplex service drop
- Large General Service (> 100 kW) – assumes 100' 500 MCM cable service

Average load magnitudes for customers falling within each stratum referenced above were determined using loads from the sampled circuits. Subsequently, these demand values were translated through the transformer to 240 V (or 480 V large three 3Ø services). The voltage drop through a typical service was

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calculated using cable impedance drawn from the WindMil EQDB. Line loss per service was extrapolated to capture anticipated total system losses through all system secondary service drops.

CALCULATED SYSTEM LOSSES

Found within the tables below are the calculated system losses at both peak and AAL for each of the TNMP certificated regions. These values were derived via the methodology described in the preceding sections.

Peak Loss %	TNMP CTX/NTX	TNMP Gulf Coast	TNMP West TX
Urban	4.0361	3.6149	N/A
Rural	5.3209	7.0255	3.9194

AAL Loss %	TNMP CTX/NTX	TNMP Gulf Coast	TNMP West TX
Urban	3.8085	3.4268	N/A
Rural	5.1367	6.0301	3.9638

DLF COEFFICIENTS

Calculated losses for each voltage levels analyzed were aggregated within each region and reported against corresponding load levels. Subsequently, the calculated system loss percentages were plotted against system load and the DLF coefficients were adjusted to “fit” the loss vs. load curve. The table below shows the DLF coefficients computed for each region of the system selected for analysis.

Classification	TNMP CTX/NTX		TNMP Gulf Coast		TNMP West TX	
	Urban (A)	Rural (B)	Urban (C)	Rural (D)	N/A	Rural (E)
F1	0.0172	0.0225	0.0100	0.0217	-	0.0126
F2	0.0004	0.0008	0.0000	-0.0007	-	0.0000
F3	0.0204	0.0272	0.0285	0.0424	-	0.0269

LOSS CALCULATIONS AND LOAD VS LOSS CURVES

The following pages summarize the loss calculations completed for each region and the load versus loss percentage curves for both the calculated values and the DLF coefficients.

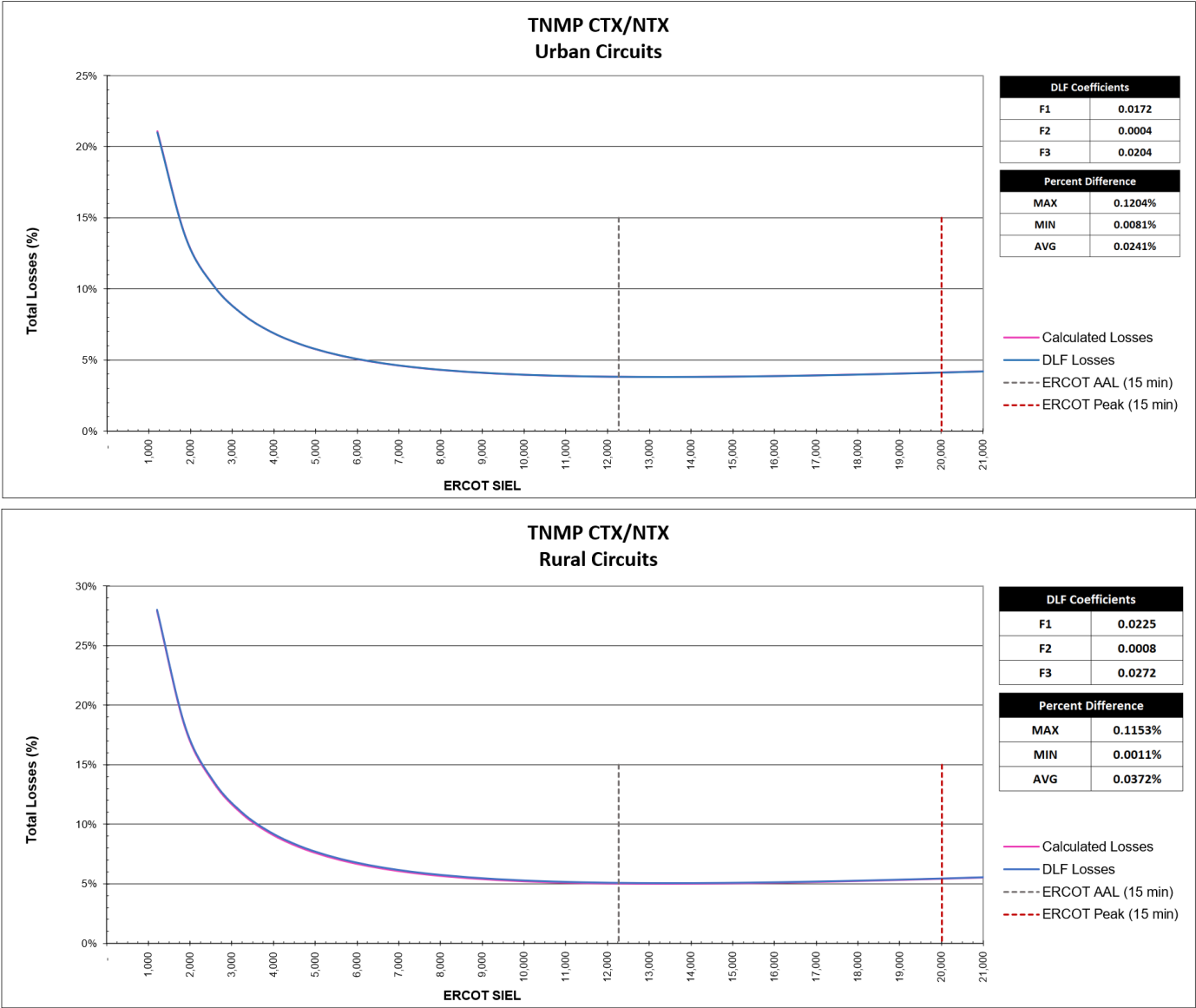
North Texas/Central Texas Regions

					Coincident Peak Loading (MW)	Coincident Peak Loading (kW)					
					382.323	382,323					
Substation Transformers	URBAN	Total Losses (MW)			No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000169	B	X	1.0953	2.4732	1,095.30	2,473.15	3,568	23.1%	
	B =	1.0953	Total No-Load Losses For Substation Transformers = 1.095 MW								
Primary Conductor	URBAN	Total Losses (MW)			No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000375	B	X	0.0000	5.3817	0.00	5,381.71	5,382	34.9%	
	B =	0.0000									
Distribution Transformers	URBAN	Total Losses (MW)			No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000056	B	X	4.0293	0.7824	4,029.26	782.39	4,812	31.2%	
	B =	4.0293	Total No-Load Losses For Substation Transformers = 4.029 MW								
Secondary Conductor	URBAN	Total Losses (MW)			No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000123	B	X	0.0000	1.6691	0.00	1,669.11	1,669	10.8%	
	B =	0.0000									
Total System Losses									15,431	kW	
Percent System Losses									4.04%		

					Coincident Peak Loading (MW)	Coincident Peak Loading (kW)						
					107.247	107,247						
Substation Transformers	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000622	1.169	0.0000622	0.4528	107.25	0.4528	0.7158	452.80	715.82	1,169	20.5%
	B =	0.4528	Total No-Load Losses For Substation Transformers = 0.453 MW									
Primary Conductor	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0001964	2.210	0.0001964	0.0000	106.08	0.0000	2.2100	0.00	2,209.98	2,210	38.7%
	B =	0.0000										
Distribution Transformers	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000260	1.728	0.0000260	1.4473	103.87	1.4473	0.2810	1,447.31	281.03	1,728	30.3%
	B =	1.4473	Total No-Load Losses For Substation Transformers = 1.447 MW									
Secondary Conductor	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000575	0.600	0.0000575	0.0000	102.14	0.0000	0.5995	0.00	599.54	600	10.5%
	B =	0.0000										
Total System Losses										5,706	kW	
Percent System Losses										5.32%		

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North Texas/Central Texas Regions (continued)



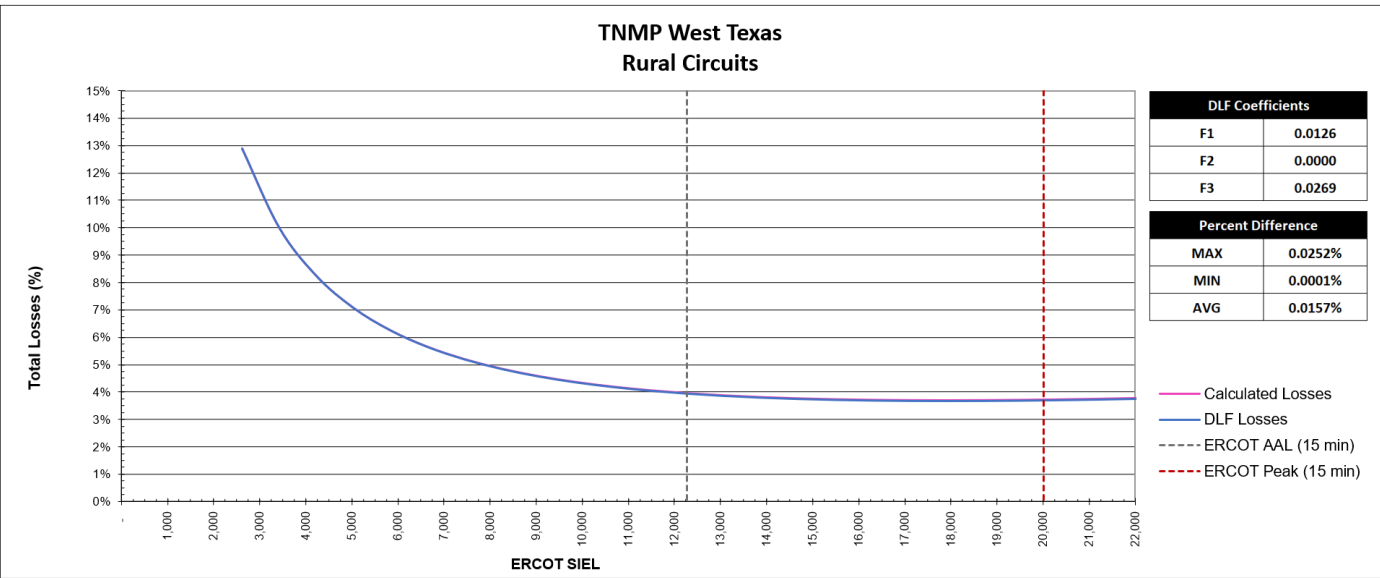
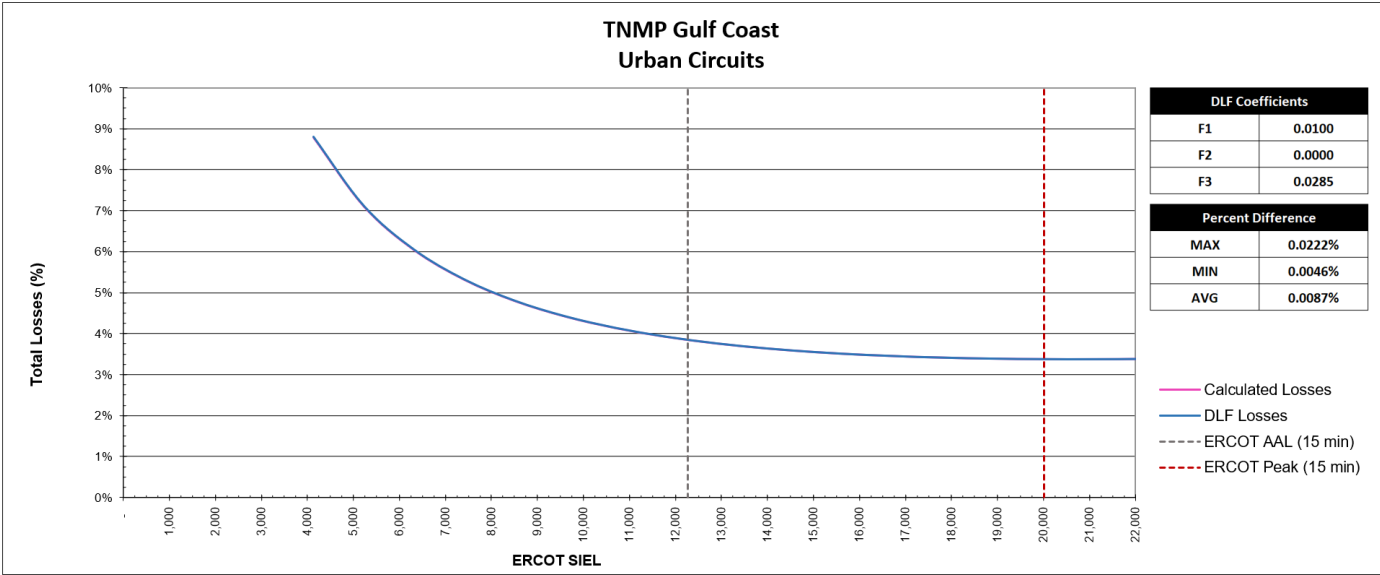
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Gulf Coast Region

		Coincident Peak Loading									
		Peak Loading									
		(MW)									
		(kW)									
		648.018		648,018							
Substation Transformers	URBAN	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
	A = 0.0000048	3.226	0.0000048	1.2230	648.02	1.2230	2.0031	1,223.01	2,003.08	3,226	13.8%
	B = 1.2230	Total No-Load Losses For Substation Transformers = 1.223 MW									
Primary Conductor	URBAN	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
	A = 0.0000235	9.766	0.0000235	0.0000	644.79	0.0000	9.7659	0.00	9,765.92	9,766	41.7%
	B = 0.0000										
Distribution Transformers	URBAN	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
	A = 0.0000053	8.379	0.0000053	6.2267	635.03	6.2267	2.1527	6,226.75	2,152.70	8,379	35.8%
	B = 6.2267	Total No-Load Losses For Substation Transformers = 6.227 MW									
Secondary Conductor	URBAN	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
	A = 0.0000052	2.054	0.0000052	0.0000	626.65	0.0000	2.0538	0.00	2,053.79	2,054	8.8%
	B = 0.0000										
Total System Losses										23,425	kW
Percent System Losses										3.6149%	

		Coincident Peak Loading										
		Peak Loading (MW)		Peak Loading (kW)								
		58.338		58,338								
Substation Transformers	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000807	0.467	0.0000807	0.1917	58.34	0.1917	0.2748	191.70	274.81	467	11.4%
	B =	0.1917	Total No-Load Losses For Substation Transformers = 0.192 MW									
Primary Conductor	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0006841	2.291	0.0006841	0.0000	57.87	0.0000	2.2911	0.00	2,291.15	2,291	55.9%
	B =	0.0000										
Distribution Transformers	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000896	1.077	0.0000896	0.8003	55.58	0.8003	0.2767	800.28	276.67	1,077	26.3%
	B =	0.8003	Total No-Load Losses For Substation Transformers = 0.800 MW									
Secondary Conductor	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio	
	A =	0.0000889	0.264	0.0000889	0.0000	54.50	0.0000	0.2640	0.00	263.96	264	6.4%
	B =	0.0000										
Total System Losses										4,099 kW		
Percent System Losses										7.0255%		

Gulf Coast Region (continued)



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West Texas Region

Coincident Peak Loading (MW)	Coincident Peak Loading (kW)
189.377	189,377

Substation Transformers	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
		A	B	X							
		2.402	0.0000453	0.7791	189.38	0.7791	1.6228	779.10	1,622.84	2,402	32.4%
		Total No-Load Losses For Substation Transformers = 0.779 MW									
Primary Conductor	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
		A	B	X							
		1.859	0.0000532	0.0000	186.98	0.0000	1.8589	0.00	1,858.85	1,859	25.0%
Distribution Transformers	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
		A	B	X							
		2.229	0.0000151	1.7096	185.12	1.7096	0.5190	1,709.64	518.97	2,229	30.0%
		Total No-Load Losses For Substation Transformers = 1.710 MW									
Secondary Conductor	RURAL	Total Losses (MW)				No Load Losses (MW)	Load Losses (MW)	No Load Losses (kW)	Load Losses (kW)	Total Losses (kW)	Loss : Total Loss Ratio
		A	B	X							
		0.933	0.0000279	0.0000	182.89	0.0000	0.9331	0.00	933.07	933	12.6%

Total System Losses 7,422 kW

Percent System Losses 3.92%

