DENTON MUNICIPAL ELECTRIC

2017 Distribution Reliability Report

May 8, 2018

IEEE 1366

Indices	Description
$SAIDI = \frac{\sum(r_i \times N_i)}{N_T}$	**System Average Interruption Duration Index** – the total duration of an interruption for the average customer during a given time period (minutes).
$CAIDI = \frac{\sum(r_i \times N_i)}{\sum N_i}$	**Customer Average Interruption Duration Index** – the average amount of time taken to restore service (minutes).
$SAIFI = \frac{\sum N_i}{N_T}$	**System Average Interruption Frequency Index** – the average number of times that a system customer experiences an outage during the time period being studied (number).
$ASAI = \left[1 - \left(\frac{\sum(r_i \times N_i)}{(N_T \times T)}\right)\right] \times 100$	**Average System Availability Index** - the total number of customer hours that service was available during the time period being studied to the total customer hours demanded and is calculated using the following formula (percent). [Note: r_i is in hours for this calculation]
$T_{MED} = e^{(\alpha + 2.5 \times \beta)}$	T_{MED} – a method to identify single day events which inclusion would skew the indices such that a true evaluation of the reliability indices would be imprecise.
Performance	SAIDI X SAIFI (not an IEEE 1366 calculation)

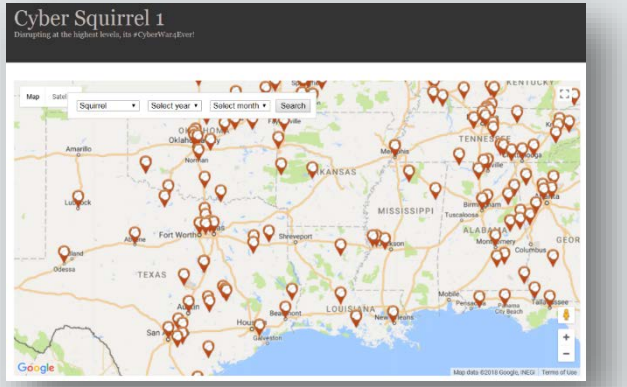
Where r_i is the restoration time in minutes, N_i is the total number of customers interrupted, N_T is the total number of customers served, T is the time period studied, α is the log-average of daily SAIDI values, and β is the log-standard deviation of the study data.

Study Baseline

- Study Period: Jan 1, 2017 to Dec 31, 2017
- 950 events(595 in 2017)
- Indices are calculated based on IEEE 1366 Standard for Reliability Indices after classification based on IEEE 1782 Standard by Cause Code and Equipment Code
- Reliability indices calculated on system, substation, and feeder service levels
- Top 5 cause and equipment codes were identified across system, substation, and feeder service levels

The #1 cause: Squirrels

Squirrels & Electric Distribution



"Wildlife near power equipment is the most common cause of outages at public power utilities and the failure of overhead equipment is the second most common cause, according to the American Public Power Association's latest annual survey on distribution system reliability."

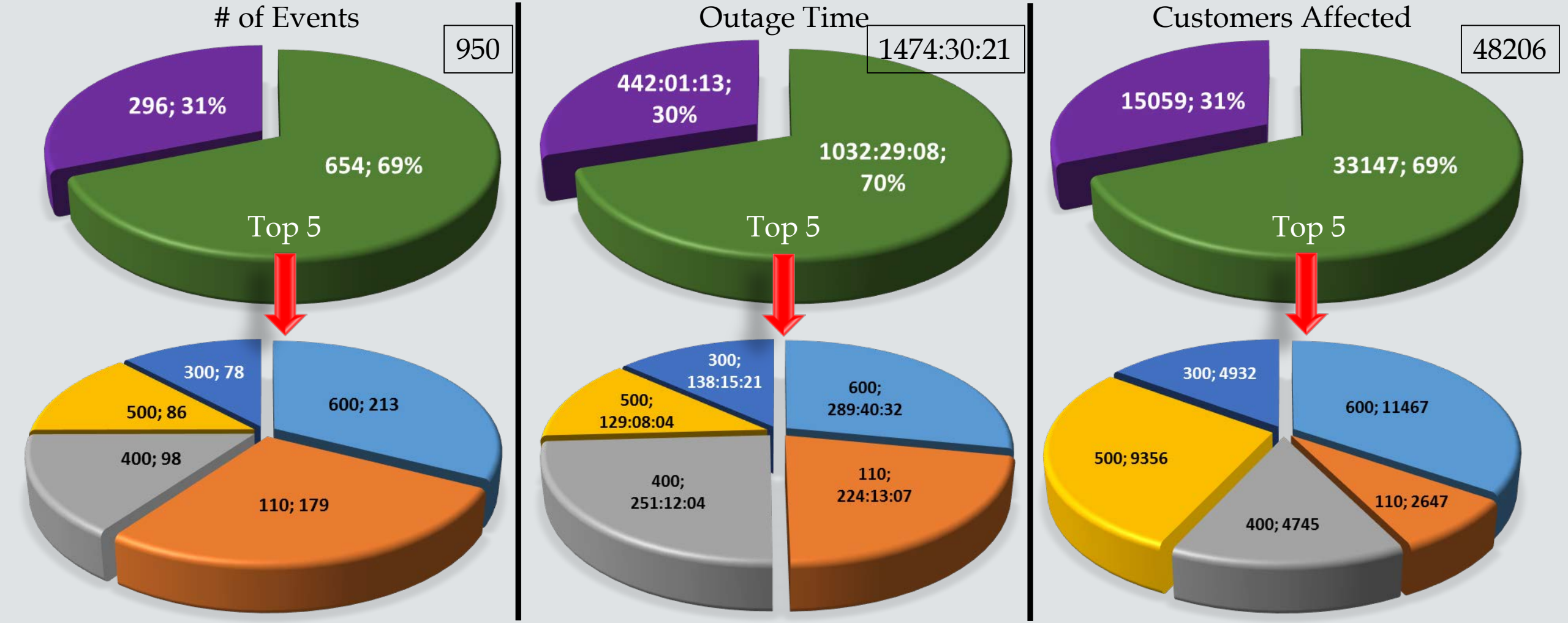
"Since a utility pole is similar to a tree, squirrels frequently climb poles." the report said. "The heat emitted by electric lines can attract a squirrel, particularly in cold weather."

Top 5 - 2017

Rank	Cause Code	Description	Events
1	600	Animals: Small animal/bird	213
2	110	Planned Outage: Maintenance	179
3	400	Maintenance: Decay/age of material/equipment	98
4	500	Weather: Lightning	86
5	300	Equip or Installation/Design: Material or equipment failure	78

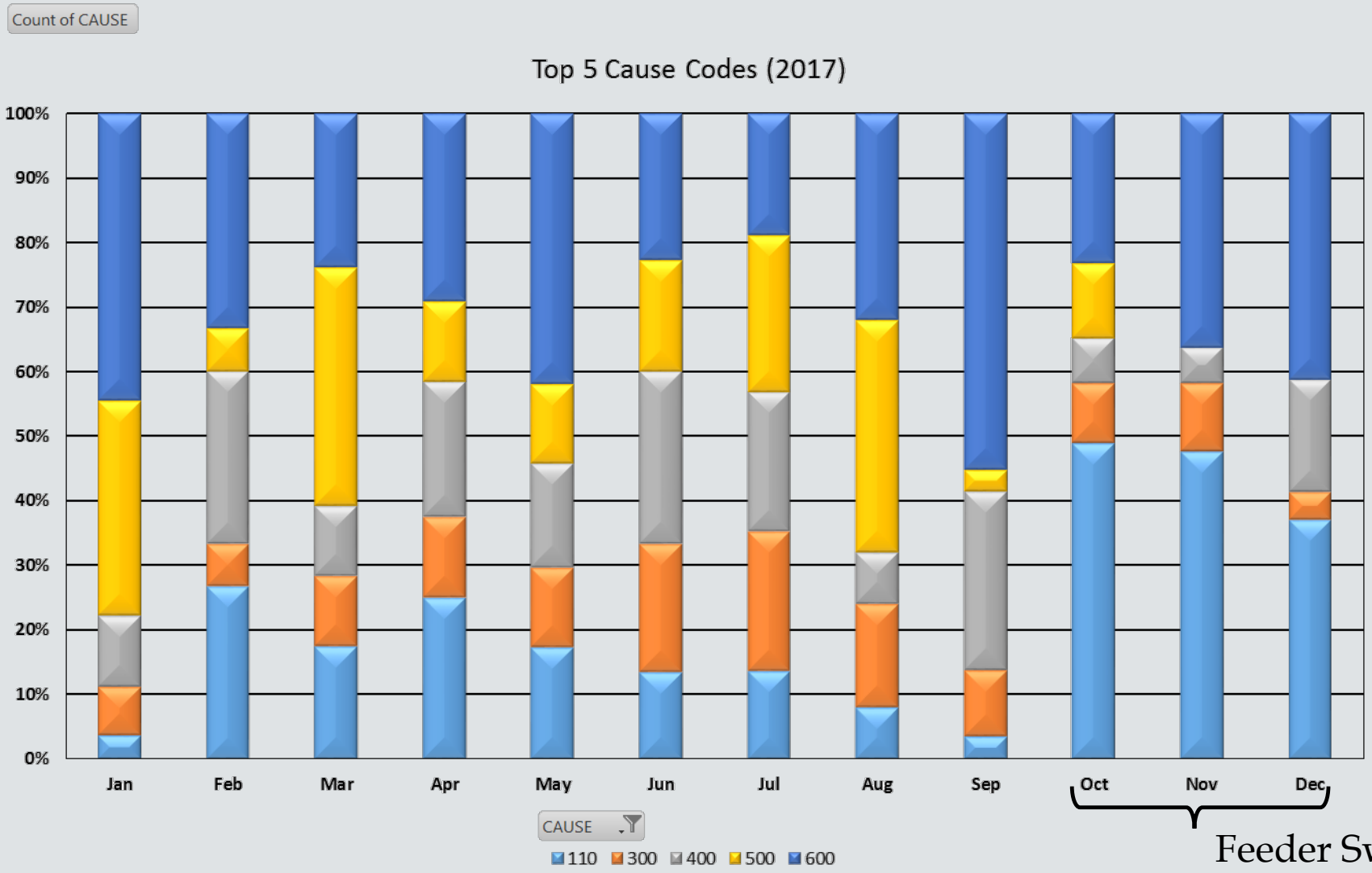
Rank	Equipment Code	Description	Events
1	999	No equipment damaged: No damaged equipment	283
2	360	OH Line Cond & Devices: Fuse cutout (damaged, malfunction, maintenance)	253
3	510	Line Transformer: Transformer fuse or breaker	119
4	600	Secondary & Services: Secondary or service conductor	50
5	500	Line Transformer: Transformer, bad	45

Top 5 2017 Cause Codes



110-Maintenance | 300-Material or equipment failure | 400-Decay/age of material/equipment | 500-Lightning | 600-Small Animal/Bird

Top 5 2017 Cause Codes



110 Planned Outage/Maintenance
300 Material or Equipment Failure
400 Decay/Age of Material/Equipment
500 Lightning
600 Small Animal / Bird

Feeder Sweeps

5-Year System Performance

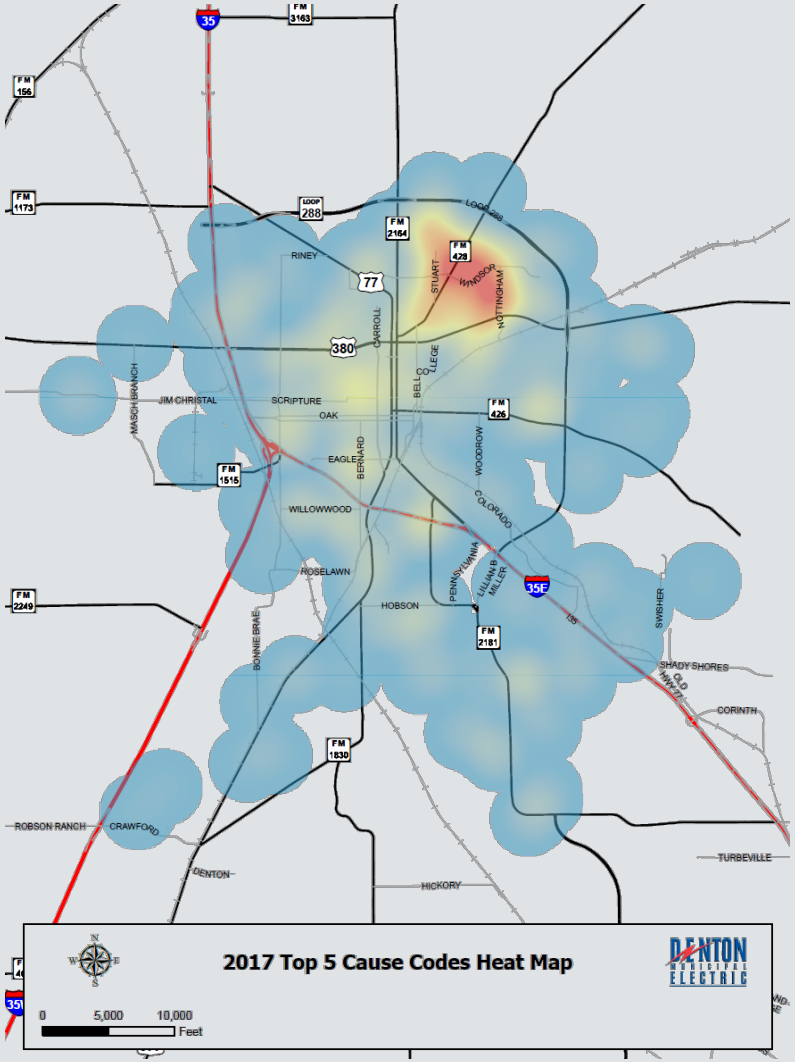
System Growth

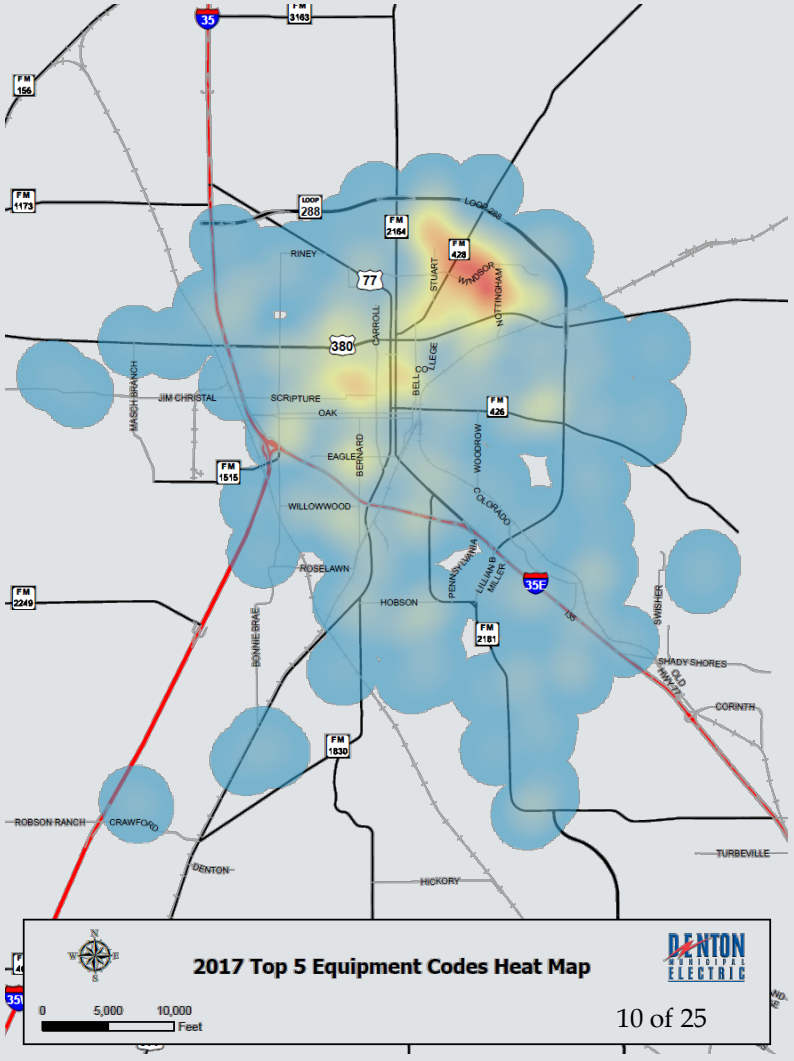
Year	% Distribution Expansion	Overhead$_{(miles)}$	Underground$_{(miles)}$	Total$_{(miles)}$	% Overhead	% Underground
2017	1.25%	346.30	476.61	822.90	42.08%	57.91%
2016	3.12%	353.61	459.17	812.78	43.51%	56.49%
2015	4.52%	344.98	443.18	788.16	43.77%	56.23%

Reliability Indices

Year	SAIFI	SAIDI	CAIDI	ASAI	Total Customers
2017	0.80	60.12	74.91	99.99%	53,355
2016	0.96	46.20	48.08	99.99%	52,222
2015	0.84	50.32	60.08	99.99%	51,240

Heat Map Analysis (System)
Top 5 - 2017





System Performance

Energy Information Administration (2016 Final Data)

Utility	$SAIFI_{2016}$	$SAIDI_{2016}$	Customers
Denton Municipal Electric	0.96	46.20	53,355
National	1.23	123.606	N/A
State of Texas	1.24	122.82	N/A
Oncor Electric	1.43	145.90	DNR
CoServ Electric	0.55	34.510	209,866
City of Garland (did not use IEEE 1366)	0.48	20.36	69,533
City of Bryan (did not use IEEE 1366)	0.26	17.47	55,336
City of Greenville (did not use IEEE 1366)	0.28	10.10	14,089
City of Austin	0.72	50.21	453,000
City of San Antonio	0.82	57.401	767,821
Average of Public Power Respondents (National)	1.23	122.94	N/A
Average of Public Power Respondents (State of Texas)	1.24	122.91	N/A

2017 Substation Performance (Worst to Best)

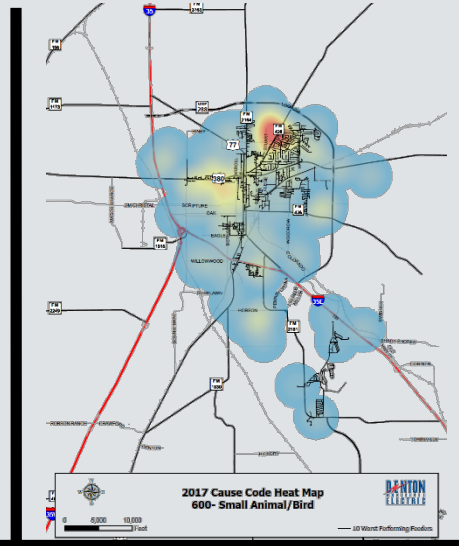
Substation	SAIDI	CAIDI	SAIFI	ASAI	Performance	2017 Rank	2016 Rank
Denton North	281.183	78.145	3.598	99.947%	1011.764	16	7
Kings Row	251.991	64.765	3.891	99.952%	980.459	15	16
Locust	352.743	139.445	2.530	99.933%	892.307	14	9
McKinney	111.159	33.958	3.273	99.979%	363.865	13	15
Teasley	126.826	66.452	1.909	99.976%	242.050	12	11
Cooper Creek	91.119	43.752	2.083	99.983%	189.769	11	4
Fort Worth	99.017	77.854	1.272	99.981%	125.933	10	8
North Lakes	81.250	58.791	1.382	99.985%	112.289	9	14
Bonnie Brae	96.751	85.981	1.125	99.982%	108.870	8	12
Pockrus	68.115	51.718	1.317	99.987%	89.711	7	6
Hickory	68.509	78.787	0.870	99.987%	59.571	6	10
Arco	33.626	42.368	0.794	99.994%	26.687	5	3
Woodrow	22.218	65.867	0.337	99.995%	7.495	4	1
Jim Christal	13.631	39.558	0.345	99.997%	4.697	3	2
Industrial	20.184	96.125	0.210	99.996%	4.238	2	5
R D Wells	9.642	84.707	0.114	99.998%	1.097	1	13

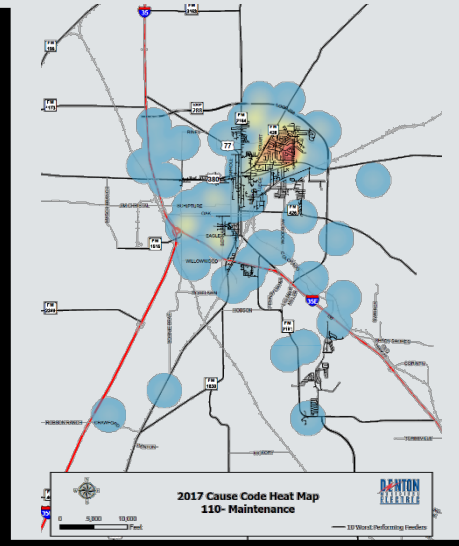
2017 Feeder Performance (10 Worst Performing)

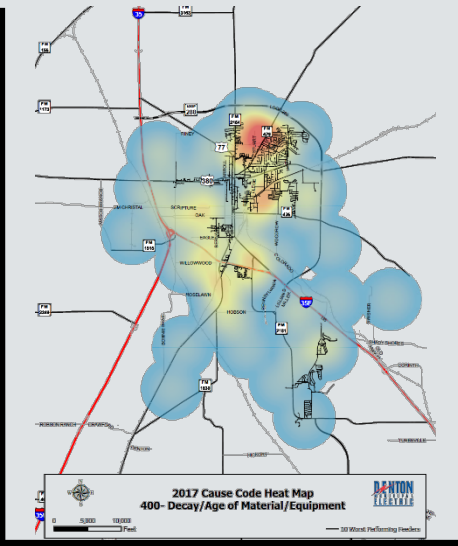
Feeder	SAIDI	CAIDI	SAIFI	ASAI	Performance	2017 Rank	2016 Rank
DN212	217.887	70.338	3.098	99.959%	674.950	85	22
MK211	96.106	31.870	3.016	99.982%	289.816	84	75
KR222	92.465	50.917	1.816	99.982%	167.917	83	63
LC221	230.971	346.366	0.667	99.956%	154.021	82	65
CC222	68.605	35.302	1.943	99.987%	133.323	81	11
KR212	97.704	72.524	1.347	99.981%	131.626	80	74
TS221	93.482	94.913	0.985	99.982%	92.073	79	37
LC223	56.025	61.949	0.904	99.989%	50.667	78	64
BB211	61.036	82.700	0.738	99.988%	45.048	77	48
DN213	62.014	133.611	0.464	99.988%	28.783	76	62

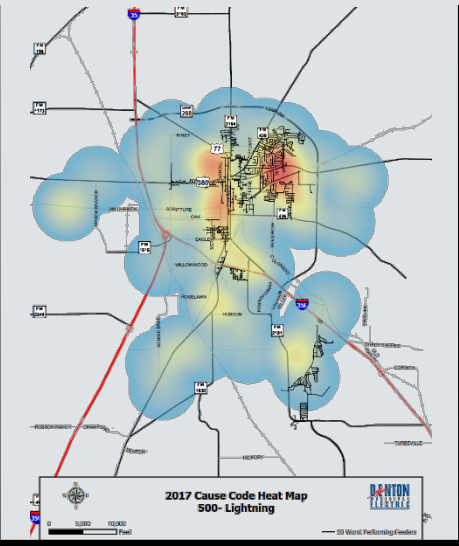
2017 10 Worst Performing Feeders
Heat Map Analysis (Top 5 Cause & Equipment)

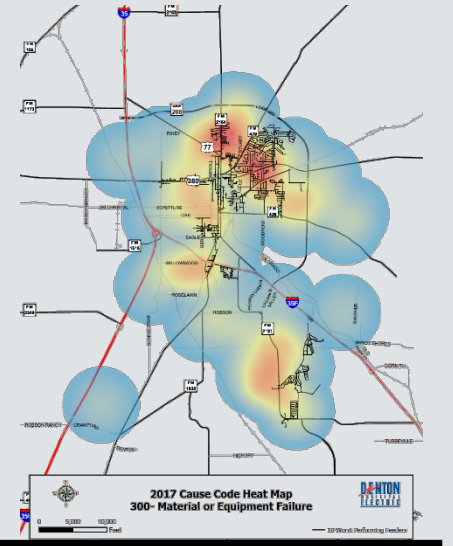
Cause Codes



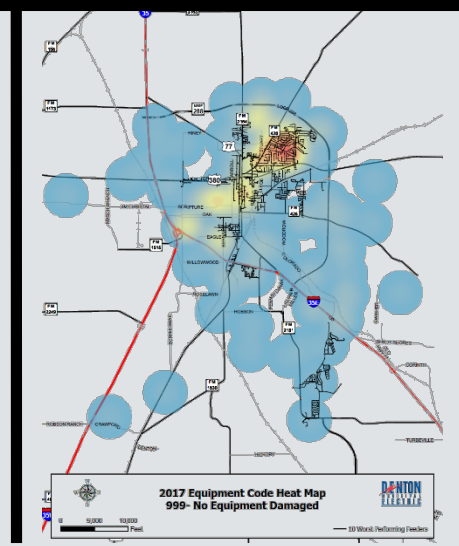


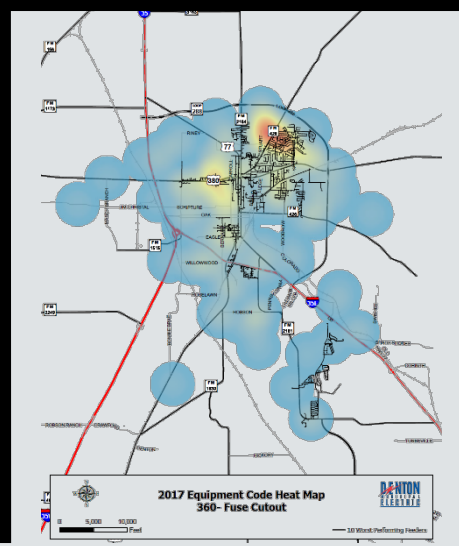


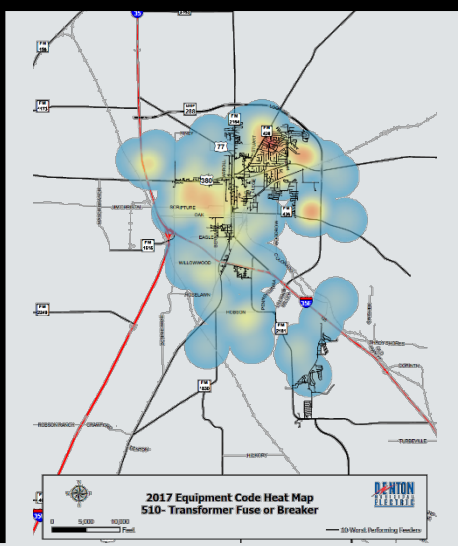


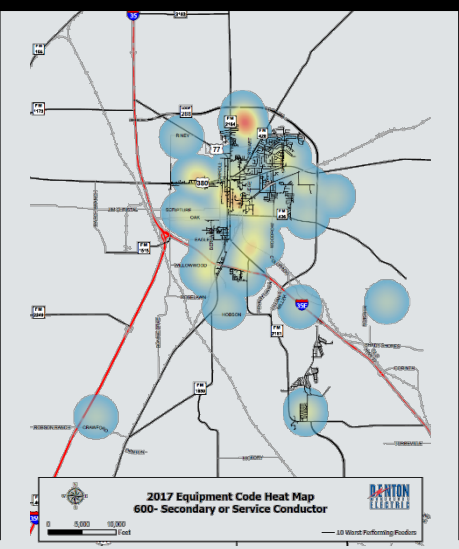


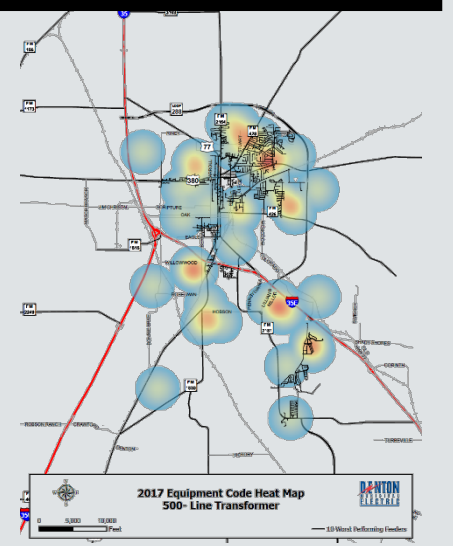
Equipment Codes







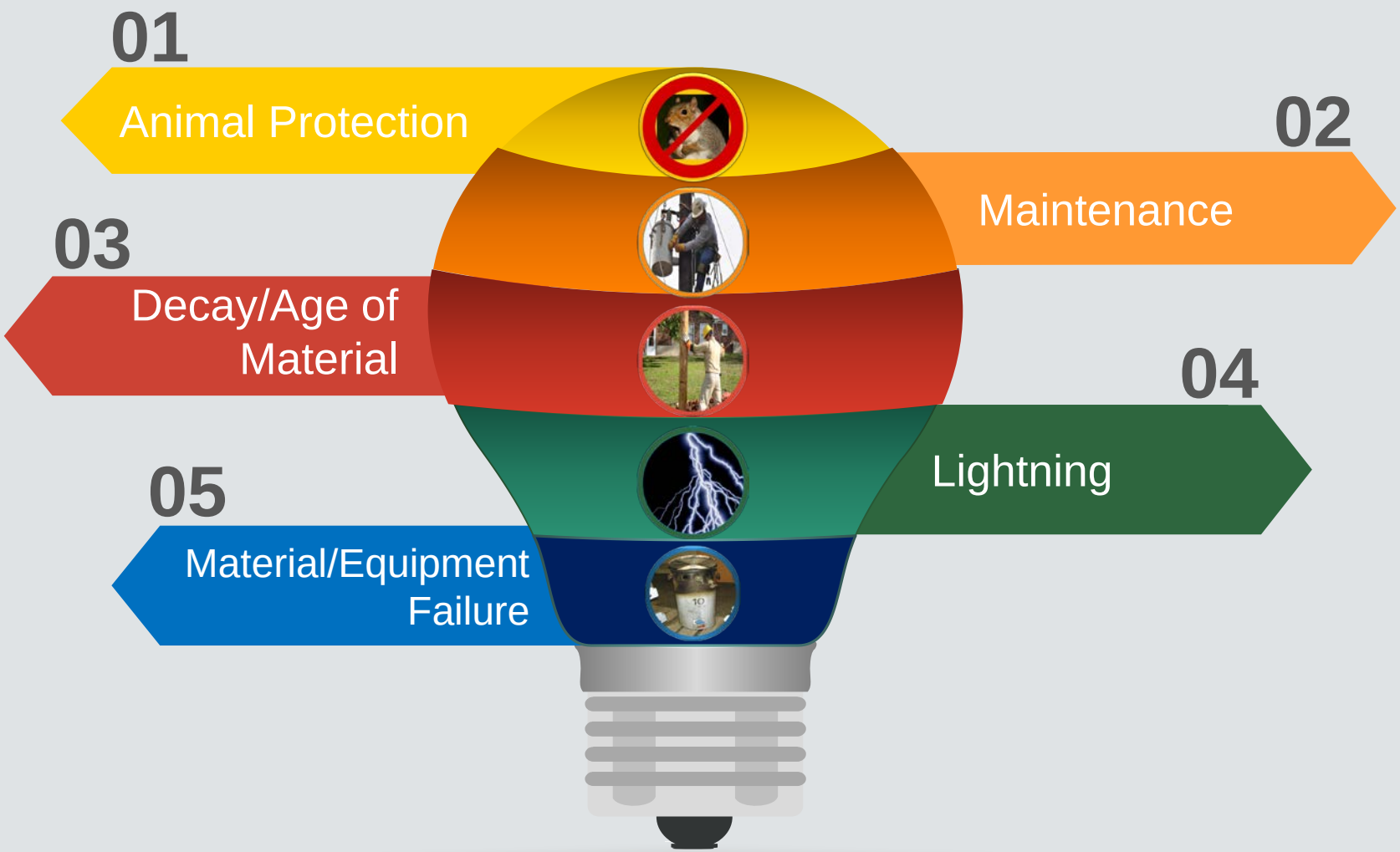




2017 Findings

- The Top 5 Cause and Equipment Codes were identified as factors in over 60% of the recorded events at every service level (System, Substation, Feeder)
- North Lakes Substation is the worst performing substation
- Kings Row Substation has moved from the worst performing substation, but still has 2 of the 10 worst performing feeders

Action Plan (System)



Action Plan (System)

01

Standardized

Standardized

Standardized

Continues

As needed

In progress

Animal Protection

- Use of Reliaguard products
  - Actively inspect and install animal protection where identified
- Change design standards to install animal protection on transformers, air switches, and capacitor banks.
- Use duct plugs instead of air seal on pole risers
- Continue tree trimming program
  - Quarterly inspection
  - Hot spot trimming when needed
- Consider use of taller poles so wires are above tree canopy
- Evaluate use of “non-conventional” approaches such as fox urine

Action Plan (System)

02

Sweeps

Sweeps

RFP

Standardized & Sweeps

Maintenance

- Replace damaged or missing lightning arrestors
- Replace damaged or missing grounds and down guys
- Cable testing
- Infrared testing
- Strategic placement of fault indicators

Action Plan (System)

RFP

03

Sweeps

RFP

Decay/Age of Material

- RFP for system-wide inspection and inventory
  - Pole inspections
  - Joint use attachments
- Replace deteriorated insulators and other equipment
- Infrared testing to identify hot connections in the distribution system

Action Plan (System)

04

Sweeps

Sweeps

Lightning

- Replace damaged or missing lightning arrestors
- Replace damaged or missing grounds and down guys

Action Plan (System)

Standardized

Sweeps &
CIP Process

Material & Equipment Failures

- Use contingency analysis to minimize number of customers affected and outage time
- When working in an area that has dated facilities, actively replace aged equipment

Video

APPA RP_3

An RP_3 designation signifies leadership in reliability, safety, workforce development and system improvement. It shows your commitment to keeping the lights on for your customers. An RP_3 designation can also indicate good financial health.

2017 Gold

APPA RP_3

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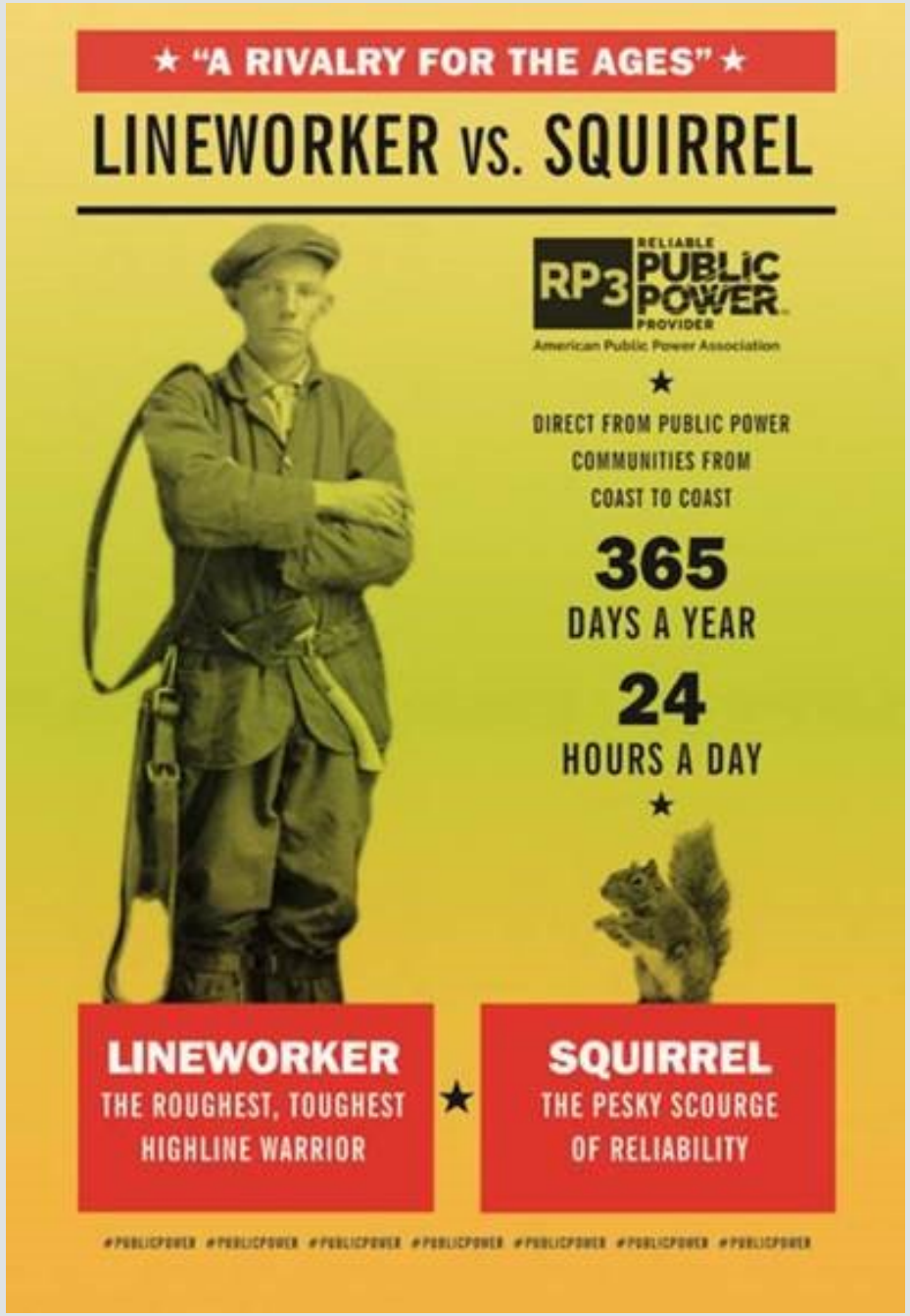
2018 Platinum



Questions?

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