Bureau of
Energy Resources,
United States
Department of State

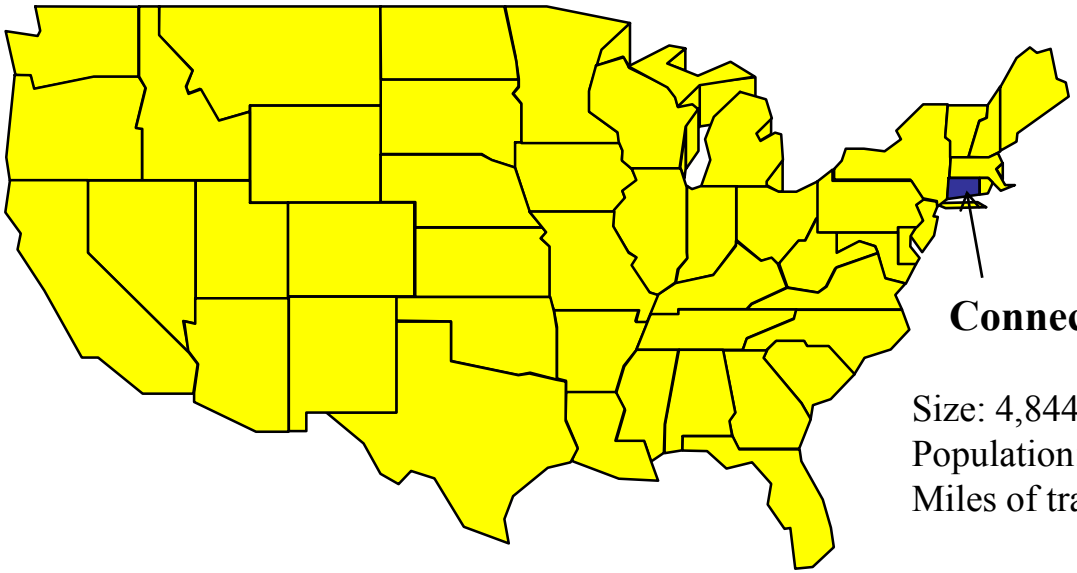
National
Association of
Regulatory
Utility
Commissioners

Scheduled Outages and Service Interruptions in Connecticut

Quat Nguyen
Connecticut Public Utilities Regulatory Authority
August 31, 2015

Topics

- Profiles of Connecticut EDCs
- SAIDI and SAIFI
- Interruptions of Service (including Scheduled Outages)



Connecticut

Size: 4,844 square miles (12,545 sq km)
Population: 3,483,372
Miles of transmission lines: 1,808+

Generation Resources

- With approximately 3.5 million residents, Connecticut represents about 25% of the population in New England region of the United States.
- There are six states in the New England region: Connecticut, Maine, Massachusetts, New Hampshire, Vermont and Rhode Island.
- The total capacity of existing generating plants located in Connecticut is about 8,700 MW. This is 27% of the total capacity in New England.

(Source ISO-NE)

There are two Connecticut electric distribution companies (EDCs)

- **The United Illuminating Company (UI)** engaged in the purchase, transmission, distribution and sale of electricity and related services to approximately 325,000 residential, commercial and industrial customers in the Greater New Haven and Bridgeport areas of Connecticut.
- In 2014, UI owned and maintained 27 bulk electric supply substations with a capacity of 1,886 MVA, and seven distribution substations with a capacity of 38.0 MVA. UI has approximately 3,283 pole-line miles of overhead distribution lines (single phase and three phase), 203 miles of underground conduit banks and 675 miles of underground primary cables (single phase and three phase) consisting of direct-buried as well as underground duct and splicing chamber construction.

Connecticut EDCs (cont.)

- **Eversource** is New England's largest energy delivery company, safely and reliably delivering energy to more than 3.6 million electric and natural gas customers in, Massachusetts, New Hampshire and Connecticut.

- Connecticut: Electric service territory includes 149 towns and covers 4,400 square miles. The Connecticut Light and Power Company is an EDC in Connecticut.
- Massachusetts: Electric service territory includes 140 towns and covers 3,192 square miles.
- New Hampshire: Electric service territory includes 211 towns and 5,628 square miles.

Connecticut Light & Power (CL&P) d/b/a Eversource Energy

- CL&P electric system serves approximately 1.2 million customers with a peak load of 4,694 MW. CL&P's electric transmission system consists of approximately 1,630 circuit miles of overhead transmission and 137 miles of underground transmission.
- CL&P's distribution system consists of approximately 16,113 circuit miles of overhead primary construction, and 6,161 circuit miles of underground primary construction, including both direct-buried and underground duct and manhole primary construction.
- Primary distribution voltages range from 4.16kV to 34.5kV with the majority of circuits operated at 4.8kV, 13.2kV, 13.8kV and 23kV. CL&P uses over 290,920 distribution transformers to supply its customers.

Reliability

- Reliability is a major concern of the Connecticut Legislature and PURA. At the state level, reliability is maintained by protecting the integrity of the distribution system.

- Identifying and fixing trouble spots in the system – Indices such as SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) track performance of the system and its components.

SAIDI

- The **System Average Interruption Duration Index (SAIDI)** is a reliability indicator by electric power utilities. It is the average outage duration for each customer served.
- It is measured in units of time, minutes or hours, and over the course of a year.
- IEEE Standard 1366-1998, 2003 and 2012.

SAIDI

- SAIDI is calculated as:

$$\text{SAIDI} = \frac{\sum U_i N_i}{N_T}$$

- Where N_i is the number of customers and U_i is the annual outage time for location , and N_T is the total number of customers served.
- In other words,

$$\text{SAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customers served}}$$

SAIFI

- The **System Average Interruption Frequency Index (SAIFI)** is a reliability indicator by electric power utilities. It is the average number of interruptions that a customer would experience
- It is measured in units of interruptions per customer, and over the course of a year.
- IEEE Standard 1366-1998, 2003 and 2012.

SAIFI

SAIFI is calculated as

$$\text{SAIFI} = \frac{\sum \lambda_i N_i}{N_T}$$

where λ_i is the failure rate, N_i is the number of customers for location and N_T is the total number of customers served.

In other words,

$$\text{SAIFI} = \frac{\text{total number of customer interruptions}}{\text{total number of customers served}}$$

Lower SAIDI and SAIFI numbers reflect better reliability performance in terms of outage duration and frequency.

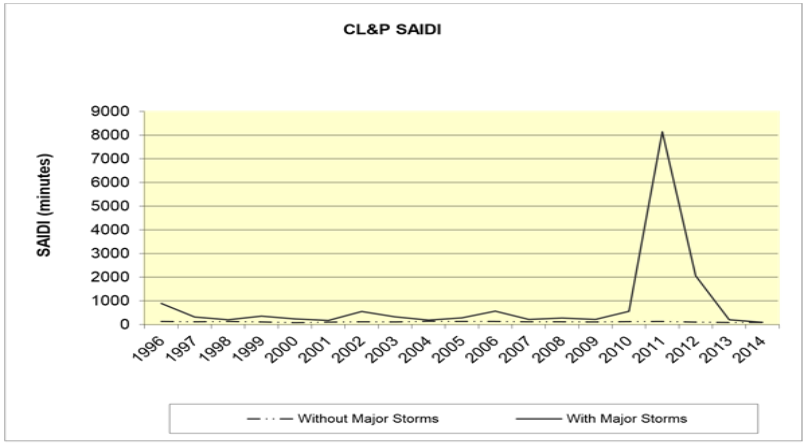
SAIDI Example

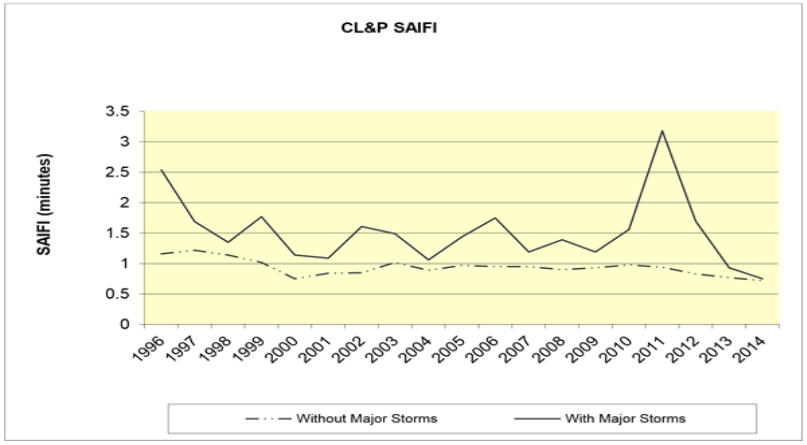
- 100 customers on the system
- 14 customers experienced a 3-hour outage
- 14 x 3 = 42 hours or 2520 minutes
- SAIDI = 2520/100 = 25.2
- Average of 25.2 minutes per customer

SAIFI Example

- 100 customers on the system
- 60 customers had a sustained interruption
  (or 30 customers had two interruptions: 30 x 2 = 60)
- SAIFI = 60/100 = 0.6

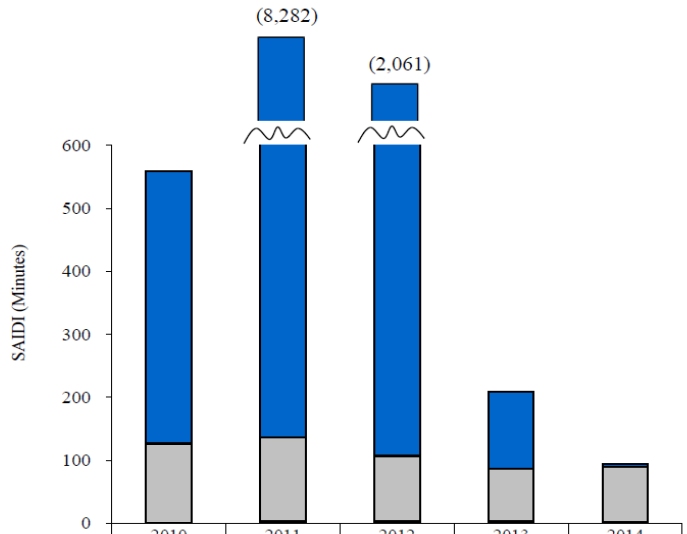
The Connecticut Light and Power Company d/b/a Eversource Energy





CL&P SAIDI Performance

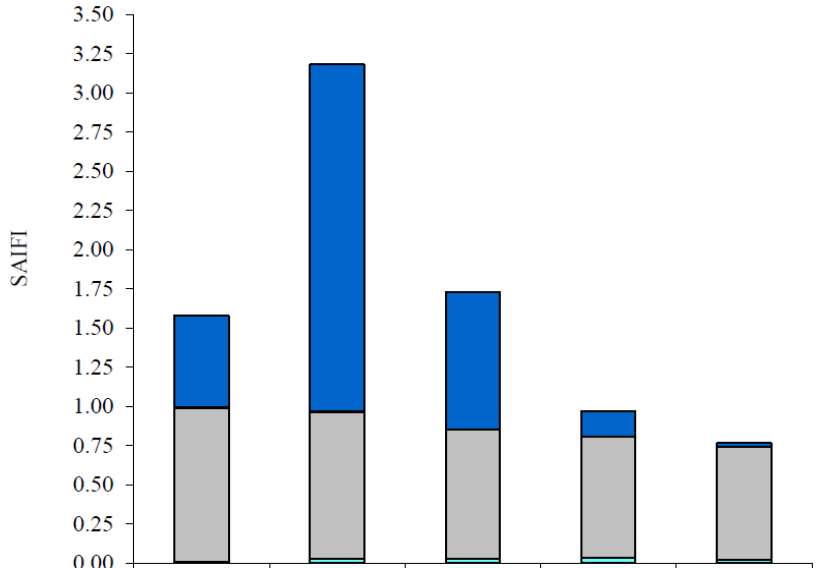
System Average Interruption Duration Index
(Including Major Storms)
2010-2014



	2010	2011	2012	2013	2014
MAJOR STORM	432.5	8,145.9	1,953.7	122.5	4.8
CUSTOMER CAUSED	0.5	0.2	0.1	0.0	0.0
DISTRIBUTION SYSTEM	124.8	133.1	104.4	83.2	86.7
SCHEDULED	1.3	3.0	2.7	3.1	2.1
TRANS/POWER SUPPLY	0.00	0.00	0.00	0.00	0.01
Grand Total	559.2	8,282.3	2,061.0	208.8	93.7

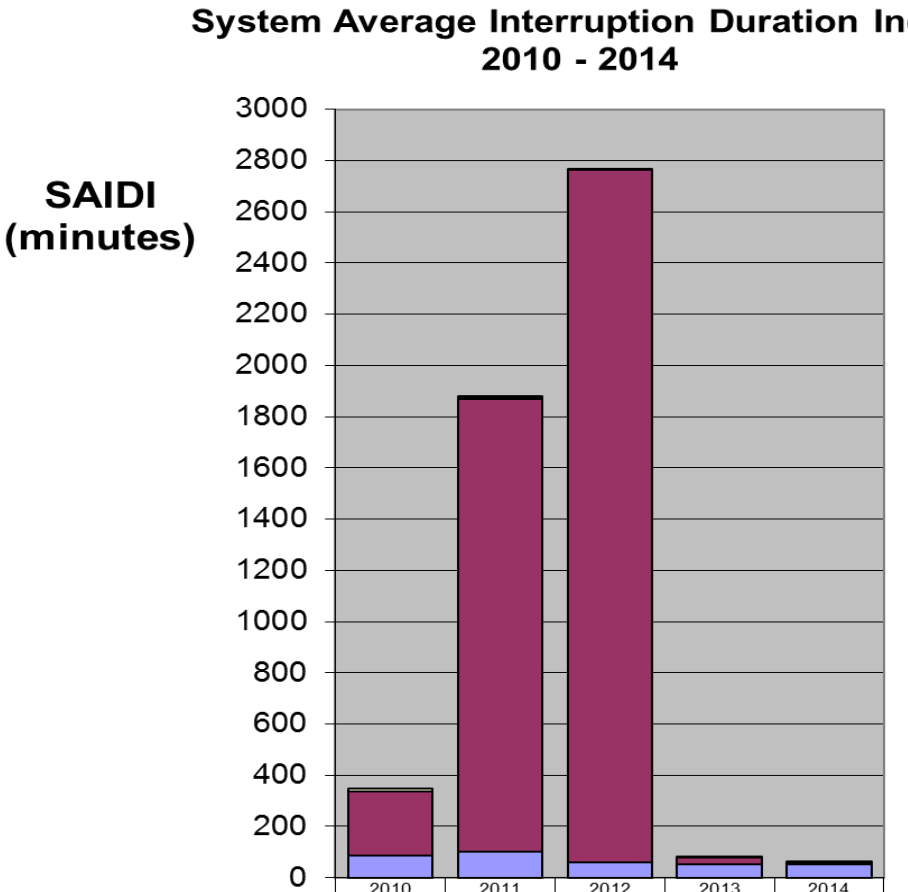
CL&P SAIFI PERFORMANCE

System Average Interruption Frequency Index
(Including Major Storms)
2010-2014



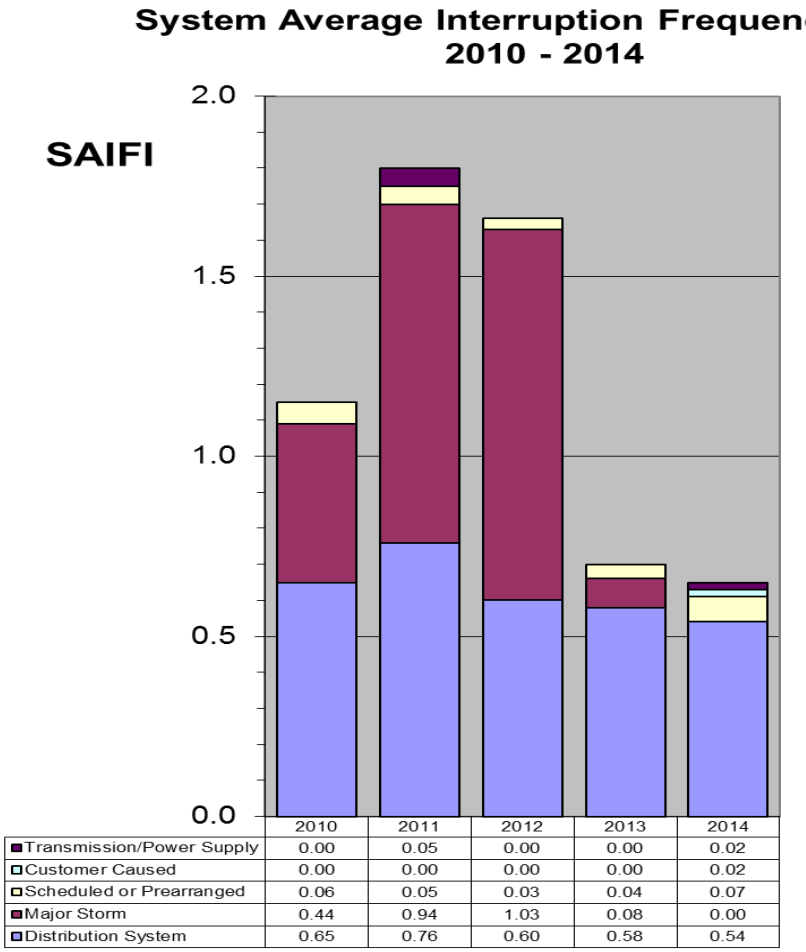
	2010	2011	2012	2013	2014
MAJOR STORM	0.58	2.21	0.87	0.16	0.02
CUSTOMER CAUSED	0.01	0.00	0.00	0.00	0.00
DISTRIBUTION SYSTEM	0.98	0.94	0.83	0.77	0.72
SCHEDULED	0.01	0.03	0.03	0.04	0.02
TRANS/POWER SUPPLY	0.00	0.00	0.00	0.00	0.00
TOTAL SAIFI	1.58	3.18	1.73	0.97	0.77

The United Illuminating Company - SAIDI



	2010	2011	2012	2013	2014
Transmission/Power Supply	0	1	0	0	0
Customer Caused	0	0	0	0	1
Scheduled or Prearranged	8	5	4	4	8
Major Storm	253	1769	2704	26	0
Distribution System	85	101	58	51	53

The United Illuminating Company - SAIFI



	2010	2011	2012	2013	2014
Transmission/Power Supply	0.00	0.05	0.00	0.00	0.02
Customer Caused	0.00	0.00	0.00	0.00	0.02
Scheduled or Prearranged	0.06	0.05	0.03	0.04	0.07
Major Storm	0.44	0.94	1.03	0.08	0.00
Distribution System	0.65	0.76	0.60	0.58	0.54

Scheduled Outages

Sec. 16-11-101 of the Regulations of Connecticut State Agencies:

- *Every utility shall make all reasonable efforts to prevent interruptions of service, and when such interruptions occur shall endeavor to reestablish service with the shortest possible delay.*

- *Whenever the service is necessarily interrupted or curtailed for any significant length of time for the purpose of working on equipment, such work should be done at a time which will cause the least inconvenience to customers, and those customers who will be affected shall be notified in advance to the extent practicable except in cases of emergency.*

The causes of service interruptions have been classified into five categories:

1. Forced Transmission & Power Supply Related Outages
2. Scheduled or Prearranged Outages for Maintenance & Construction
3. Major Storm Related Outages
4. Customer Caused Outages
5. Distribution System

Forced Transmission and Power Supply

- Power supply outages caused by the operation of the system in conjunction with other companies such as ISO-NE imposed load shedding or loss of an external transmission line supplying the company.

Scheduled or Pre-Arranged Outages

- Planned or intentionally de-energizing facilities serving customers for the purpose of apparatus change out, conversion, maintenance, relocation/extension, permanent repair, or customer request.
- Scheduled outages for maintenance and construction are often arranged in conjunction with the affected customer(s) in order to provide them with advanced notice and lessen their inconvenience.

Major Storm-Related Outages

- A major storm will be declared when the number of restoration steps exceeds the 98.5 percentile of all days in the most recent four years. All reliability data associated with interruptions beginning on that qualifying day would be excluded, even if the interruptions extend into subsequent days.

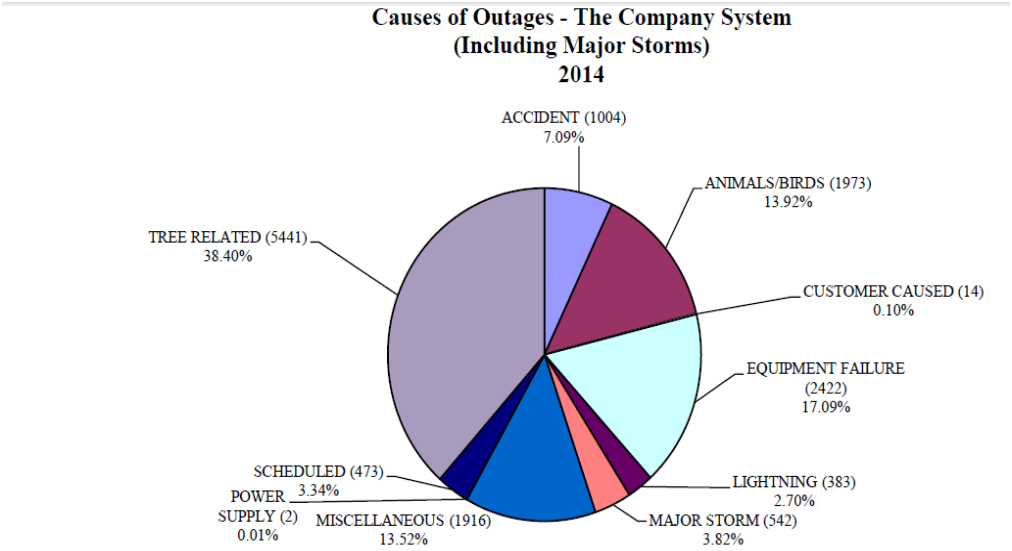
Customer-Caused Outages

- Any interruption caused by customer-owned equipment failure or customer operation.

The components of the "Distribution System" category are as follows:

- Animal/Bird Contact
- Lightning
- Tree Contact
- Accident: Vehicle, Foreign Objects or Employee Error
- Equipment Failure: Overhead System, Underground Cable, Direct-Buried Cable, Transformer, Substation, Transmission, Other Equipment.
- Miscellaneous: Overload, Other or Unknown.

CL&P 2014 Outages by Categories



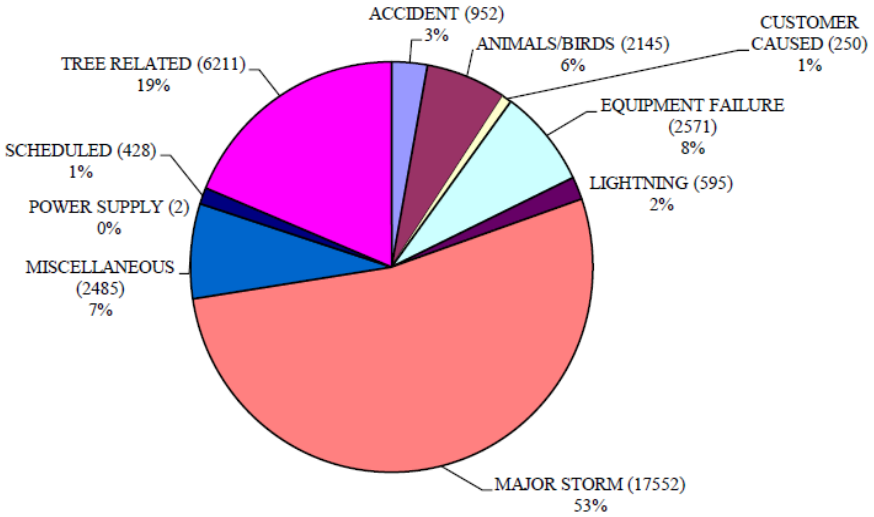
Note: The number of interruptions is included in the parentheses next to each cause.

Accident	**7.09%**
Vehicle	5.38%
Foreign Objects	1.11%
Employee Error	0.59%

Equipment Failure	**17.09%**
Overhead System	6.09%
Underground Cable	0.71%
DB Cable	5.70%
Transmission	0.00%
Substation	0.08%
Transformer	4.52%
Other	0.00%

Miscellaneous	**13.52%**
Overload	1.19%
Other	2.61%
Unknown	9.72%

CL&P Outages – Four-Year Average



Note: The average annual number of interruptions is included in parentheses next to each cause.
The average annual number of interruptions for 2010-2013 was 33,191.

Accident	**2.87%**
Vehicle	2.13%
Foreign Objects	0.50%
Employee Error	0.25%

Equipment Failure	**7.75%**
Overhead System	2.97%
Underground Cable	0.28%
DB Cable	2.73%
Transmission	0.01%
Substation	0.03%
Transformer	1.73%

Miscellaneous	**7.49%**
Overload	2.13%
Other	1.26%
Unknown	4.10%