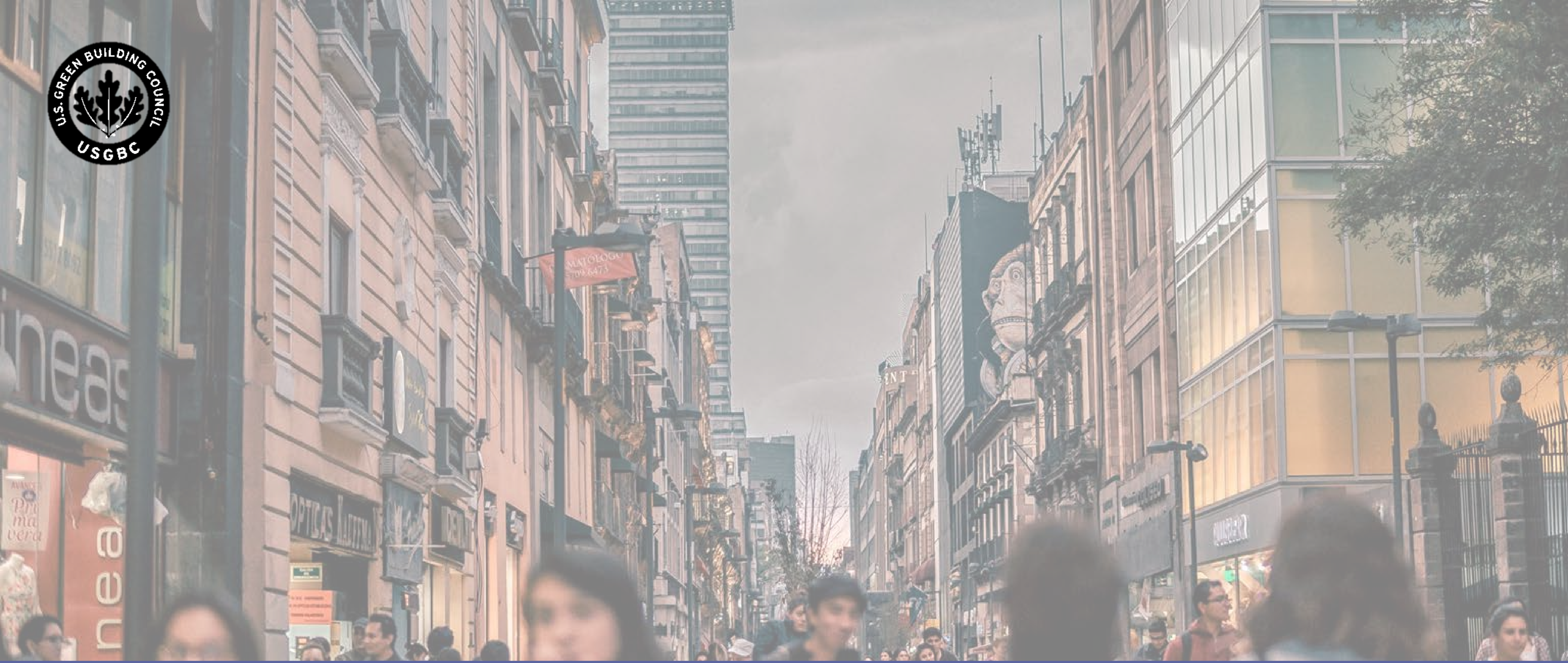
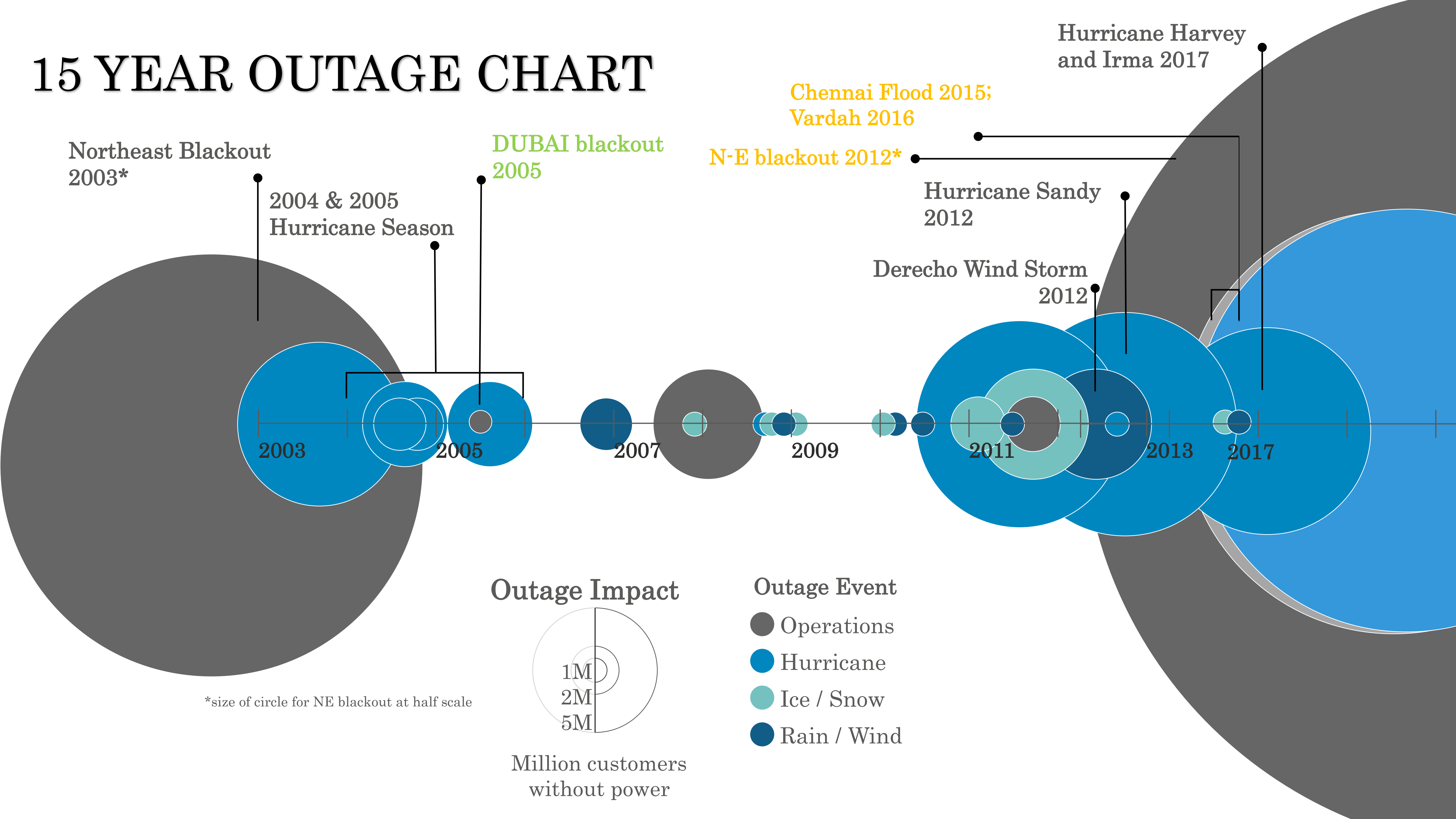


Designing for Power Resilience

Honorable Katherine Hammack

15 YEAR OUTAGE CHART



The U.S. economy loses approximately

$24 Billion

a year from power quality events.

- *Source: Electric Power Research Institute*

RELIABILITY

RESILIENCE

QUALITY POWER

SAFETY

CRITICALITY

POWER SURETY

SMART

EFFICIENT

RENEWABLE

Source:
http://media.carbonated.tv/86809_story__6.JPG

To deliver sustainable, resilient and reliable power systems that adapt to the realities of human needs, finite resources and a changing climate.

PEER Guiding Principles

PEER's Applicability

Cities & Utilities

Campus

&

Transit

PERFORMANCE EXCELLENCE IN ELECTRICITY RENEWAL

PEER Scorecard

For Cities & Utilities, Campus, Transit

V2.0 | Scorecard

GBCI

April, 2020

CITIES & UTILITIES | U | Public Projects with large variety of customers
CAMPUS | C | Projects with one or more buildings
TRANSIT | T | Monorail, Metrorail, and Intercity or Intracity rail projects

Cities & Utilities	Campus	Transit	TYPE		POINTS: Cities & Utilities	POINTS: Campus	POINTS: Transit
				RELIABILITY AND RESILIENCY (RR)	30	30	30
U	C	T	Prereq	Prerequisite: Reliability Performance Monitoring	*Required*		
U	C	T	Credit 1	Credit: Reliability Performance Assessment	6	6	6
U	C	T	Credit 2	Credit: Momentary Interruption Tracking	1	1	1
U	C	T	Credit 3	Credit: Damage and Exposure Prevention	6	6	6
U	C	T	Credit 4	Credit: Distribution Redundancy and Auto Restoration	2	2	2
U	C	T	Credit 5	Credit: Alternate Sources of Supply	5	5	5
U	C	T	Credit 6	Credit: Power Surety and Resiliency	5	5	5
U	C	T	Credit 7	Credit: Power Quality Capabilities	5	5	5
				ENERGY EFFICIENCY AND ENVIRONMENT (EE)	25	27	30
U	C	T	Prereq 1	Prerequisite: Environmental Performance Disclosure	*Required*		
U	C	T	Prereq 2	Prerequisite: System Energy Efficiency Coefficient Disclosure	*Required*		
U	C	T	Credit 1	Credit: Environmental Perf. Improvement	10	10	10
U	C	T	Credit 2	Credit: System Energy Efficiency Coefficient Improvement	3	3	3
U	C	T	Credit 3	Credit: Renewable Energy and Carbon offset	4	4	4
U	C	T	Credit 4	Credit: Distributed Energy Resources	6	5	8
U	C	T	Credit 5	Credit: Environmental Impacts assessment, disclosure and management	2	5	5
				OPERATIONS, MANAGEMENT AND SAFETY (OP)	21	23	23
U	C	T	Prereq 1	Prerequisite: Triple Bottom Line Analysis	*Required*		
U	C	T	Credit 1	Credit: Risk Assessment & Mitigation	4	4	4
U	C	T	Credit 2	Credit: Emergency Response Planning	3	3	3
U	C	T	Credit 3	Credit: Safety Review Process	2	2	2
U	C	T	Credit 4	Credit: Operational Processes	4	4	4
U	C	T	Credit 5	Credit: Advanced Metering Infrastructure	3	3	3
U	C	T	Credit 6	Credit: Master Controller	3	3	3
U	C	T	Credit 7	Credit: Comm. Network & Info Processing	2	2	2
	C	T	Credit 8	Credit: Energy Management System	0	2	2

CITIES & UTILITIES | U | Public Projects with large variety of customers
CAMPUS | C | Projects with one or more buildings
TRANSIT | T | Monorail, Metrorail, and Intercity or Intracity rail projects

Cities & Utilities	Campus	Transit	TYPE		POINTS: Cities & Utilities	POINTS: Campus	POINTS: Transit
				GRID SERVICES (GS)	24	20	17
U	C	T	Prereq 1	Prerequisite: Consumer and Load Survey	*Required*		
U	C	T	Credit 1	Credit: Customer Engagement	3	0	0
U	C	T	Credit 2	Credit: Load Duration Curve Optimization	3	4	4
U	C	T	Credit 3	Credit: Data Privacy and Cybersecurity	2	1	1
U	C		Credit 4	Credit: Access to Energy usage Data	4	4	0
U	C	T	Credit 5	Credit: Supply Choice	1	2	2
U	C	T	Credit 6	Credit: Demand-side management	3	3	5
U	C	T	Credit 7	Credit: Demand Response	2	2	2
U			Credit 8	Credit: Streamlined Interconnection & Net Metering Policies	4	0	0
U	C		Credit 9	Credit: Other Tools and Financial Incentives	1	1	0
U	C	T	Credit 10	Credit: Aggregation	1	1	1
	C	T	Credit 11	Credit: Advanced External Interface	0	2	2
				INNOVATION (IN)	6	6	6
U	C	T	Credit 1	Innovation 1	1	1	1
U	C	T	Credit 2	Innovation 2	1	1	1
U	C	T	Credit 3	Exemplary Performance	1	1	1
U	C	T	Credit 4	Exemplary Performance	1	1	1
U	C	T	Credit 5	Exemplary Performance	1	1	1
U	C	T	Credit 6	Education	1	1	1
				REGIONAL PRIORITY (RP)	4	4	4
U	C	T	Credit 1	Regional Priority 1	1	1	1
U	C	T	Credit 2	Regional Priority 2	1	1	1
U	C	T	Credit 3	Regional Priority 3	1	1	1
U	C	T	Credit 4	Regional Priority 4	1	1	1
				Certified 40. Silver 50. Gold 60. Platinum >80.	110	110	110

PEER Scoring

Total 31 Credits | No points for Prerequisites

Certification Levels	Minimum Points Required
Platinum	80+ points
Gold	60-79 points
Silver	50-59 points
Certified	40-49 points

The 6 credit categories of PEER are:

RELIABILITY AND RESILIENCY

ENERGY EFFICIENCY AND ENVIRONMENT

OPERATIONS, MANAGEMENT & SAFETY

GRID SERVICES

REGIONAL PRIORITY

INNOVATION & EXEMPLARY PERFORMANCE

Reliability and Resiliency

A **reliable** grid has minimized and shortened power interruptions.

A **resilient** grid is prepared to recover from adverse events like severe weather.

Reliability and Resiliency (RR)

1 Prerequisite

Reliability Performance Monitoring

7 Credits

- Reliability Performance Assessment
- Momentary Interruption Tracking
- Damage and Exposure Prevention
- Distribution Redundancy and Auto Restoration
- Alternative Source of Supply
- Power Surety & Resilience
- Power Quality Capabilities

RRp

Intent

To ensure data acquisition, reporting, and monitoring of interruptions.

Requirements

All Projects

- Install infrastructure and/or develop formal processes to continuously monitor and record interruptions for the complete project distribution network at high, medium, and low voltage levels.

Comply with **IEEE Standard 1782 – 2014**

RR$_{C-1}$

Reliability Performance Assessment

Intent

To give operators and customers greater transparency on interruption duration and frequency.

Requirements

All Projects

- Calculate the reliability indices - System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), based on the interruption data recorded by the project, as specified in IEEE 1366.

Comply with **IEEE Standard 1366 – 2012**

RR$_{C-1}$

Reliability Performance Assessment

- SAIDI - Average number of minutes that each customer is without power. The mathematical equation is as below:

$$\text{SAIDI (in minutes)} = \frac{\sum_{i=1}^{N} \text{Interruption duration}_i \times \text{Number of customers interrupted}_i}{\text{Total number of customers served}}$$

- SAIFI - Average number of outages that a customer experiences in one year. The mathematical equation is as below:

$$\text{SAIFI (in numbers)} = \frac{\sum_{i=1}^{N} \text{Number of customers interrupted}_i}{\text{Total number of customers served}}$$

In the above formulae, "i" is the ith occurrence of an interruption and "N" is the total number of interruption events in a specified time frame.

RR$_{C-2}$

Momentary Interruption Tracking

Intent

To support effective grid management and identify opportunities to improve reliability by tracking momentary interruptions.

Requirements

All Projects

- Calculate the project's annual momentary average interruption frequency index (MAIFI) as specified in IEEE 1366.

(OR)

- Have infrastructure to monitor the operation of all interrupting devices used in the project's distribution network.

Comply with IEEE Standard 1366 – 2012

RR$_{C\text{-}2}$

Momentary Interruption Tracking

The mathematical equation for calculation of MAIFI is as follows:

$$\text{MAIFI (in numbers)} = \frac{\sum_{i=1}^{N} (\text{Number of momentary interruptions x Number of affected customers})}{\text{Total number of customers served}}$$

Example:

Consider a feeder circuit with auto-reclosers providing power for 2000 customers. 2 momentary interruptions occur for all the customers.

No. of momentary interruptions

No. of customers affected

$$\text{MAIFI} = \frac{2 * 2000}{2000} = 2$$

Total customers

Note: The numerator is multiplied by 2 because the customers experience two momentary interruptions.

Under the definition of a momentary interruption event, this entire sequence qualifies as a single momentary interruption event.

RR$_{C-3}$

Damage and Exposure Prevention

Intent

To improve project reliability and power quality by protecting infrastructure from common external threats that may damage equipment, cause malfunctions, or interrupt service.

Requirements

All Projects

Option 1: External Damage Prevention:

Implement preventive measures to avoid infrastructure damage and/or service interruption from external risks like weather effects, tree or animal contact, vehicular or human interference, etc.

Comply with **NESC C2-2012 & IBC 2015 – Chapters 16 and 17**

RR C-3

Damage and Exposure Prevention

Option 2: Power System Hardening:

Have in place the following design considerations and/or infrastructure to harden power systems against flooding, storms, and other extreme events.

Flooding Avoidance	Storm Protection	Seismic Protection
• Permanent storm water drainage system to protect critical assets. (or) • Install a standalone pump to pump water from low-lying areas. (or) • Permanently relocate or increase height of critical assets – ASCE 7 & 24	• Ensure that the outdoor equipment can withstand three-second wind gusts up to 140 mph or equivalent.	• Seismic restraint–certified equipment for critical electrical systems

Comply with **ASCE Chapter 7 – 24, FEMA 413, IS 875 & 802, BIS National Electrical Code 2011**

$RR_{C\text{-}3}$

Damage and Exposure Prevention

Option 3: Undergrounding:

Bury electric cables underground or protect them in conduits or underground tunnels. PEER Thresholds for undergrounding is as below:

Network Protected (% of total length)		PEER points
Cities & Utilities	Campuses & Transit	
≥10	≥40	1
30	80	2

Comply with **NESC C2-2012**

RR$_{C\text{-}4}$

Distribution Redundancy & Auto Restoration

Intent

To improve reliability and resilience by ensuring that grid power can be supplied via multiple distribution pathways.

Requirements

All Projects

- Demonstrate the ability to sustain customer power with the use of redundant distribution and automated power restoration in case of an interruption within the project.

RR$_{C\text{-}5}$

Alternative Source of Supply

Intent

To improve reliability and resilience by providing an alternative source of electricity supply and transfer controls.

Requirements

All Projects

Option 1. Alternative Supply:

Have in place provisions for alternative sources of power supply for **at least 40% or 80%** of the critical project load in case the primary power supply fails. Choose either:

- Alternative (or secondary) feeder from bulk grid
- Generation outside the project boundary (at the neighbourhood level)
- Project-owned or project-operated backup power system

$RR_{C\text{-}5}$

Alternative Source of Supply

Calculate the fraction of the project load, including all critical loads that is protected by backup power supply options. PEER thresholds for alternate source provision is as below:

Project load with backup power supply (%)	PEER points
≥ 40	1
80	2

Option 2. Transfer Controls:

Demonstrate advanced capability to transfer control from grid-connected mode to complete or partial island mode and back again, either **automatic & quickly or seamlessly or with ride-through capability.**

Projects may earn points for either automatic and quick transfer capability or seamless transfer capability.

RR$_{C\text{-}6}$

Power Surety and Resilience

Intent

To ensure power for critical loads and essential services during emergencies and to support community recovery after catastrophic events and power grid outages.

Requirements

- Identify the project’s essential services and critical loads, with their minimum daily runtimes. For each critical load and essential service, provide backup power source to support during widespread outages.

Comply with **NFPA 110 & NFPA 70.**

RR$_{C-7}$

Power Quality Capabilities

Intent

To assess and mitigate poor power quality events through detection, prevention, and corrective actions.

Requirements

All Projects

Option 1: Power Quality Assessment

Assess the project's existing level of power quality. Demonstrate compliance with the standard power quality audit process. **The audit should:**

- Assess the power quality
- Identify locations for permanent power quality monitoring
- Identify and troubleshoot the causes of poor power quality, and
- Verify the performance of corrective measures

$RR_{C\text{-}7}$

Power Quality Capabilities

Option 2: Continuous Power Quality Monitoring

Install permanent, integrated infrastructure to continuously monitor and record power quality events such as:

- Voltage Sag & Swell
- Voltage & Current Harmonics
- Voltage Unbalance, etc.

RR$_{C-7}$

Power Quality Capabilities

Option 3: Power Quality Improvement

Cities & Utilities:

- Have in place infrastructure for improving voltage profile and reactive power support at the substation or feeder level.
- Implement a volt-VAR control program for the project's distribution network.

Campuses & Transit:

- Have in place infrastructure that improves the power factor at all points of common coupling .
- Demonstrate that the project has automated infrastructure and controls to maintain unity power factor and zero harmonic injection at all points of common coupling.

Comply with **European Quality Standard EN 50160 & IEEE 519-2014, IEEE 1159, IEEE 1346**

City of Chattanooga EPB

Case Study based on Reliability & Resiliency Measures

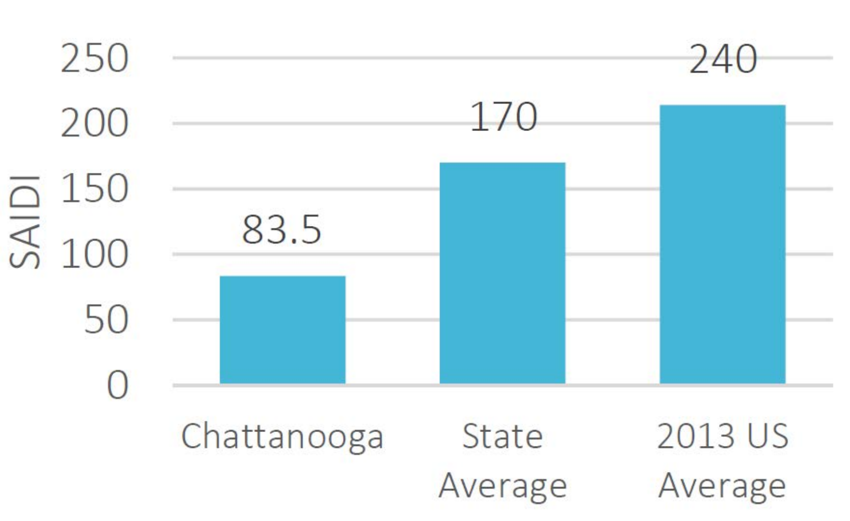
PEER
CERTIFIED

- Annual cost savings of $ 5.5 million
- Self-healing grid network
- Reliability metrics better than State of Tennessee

Secured interoperable fibre optic network

&

Auto-restoration switches



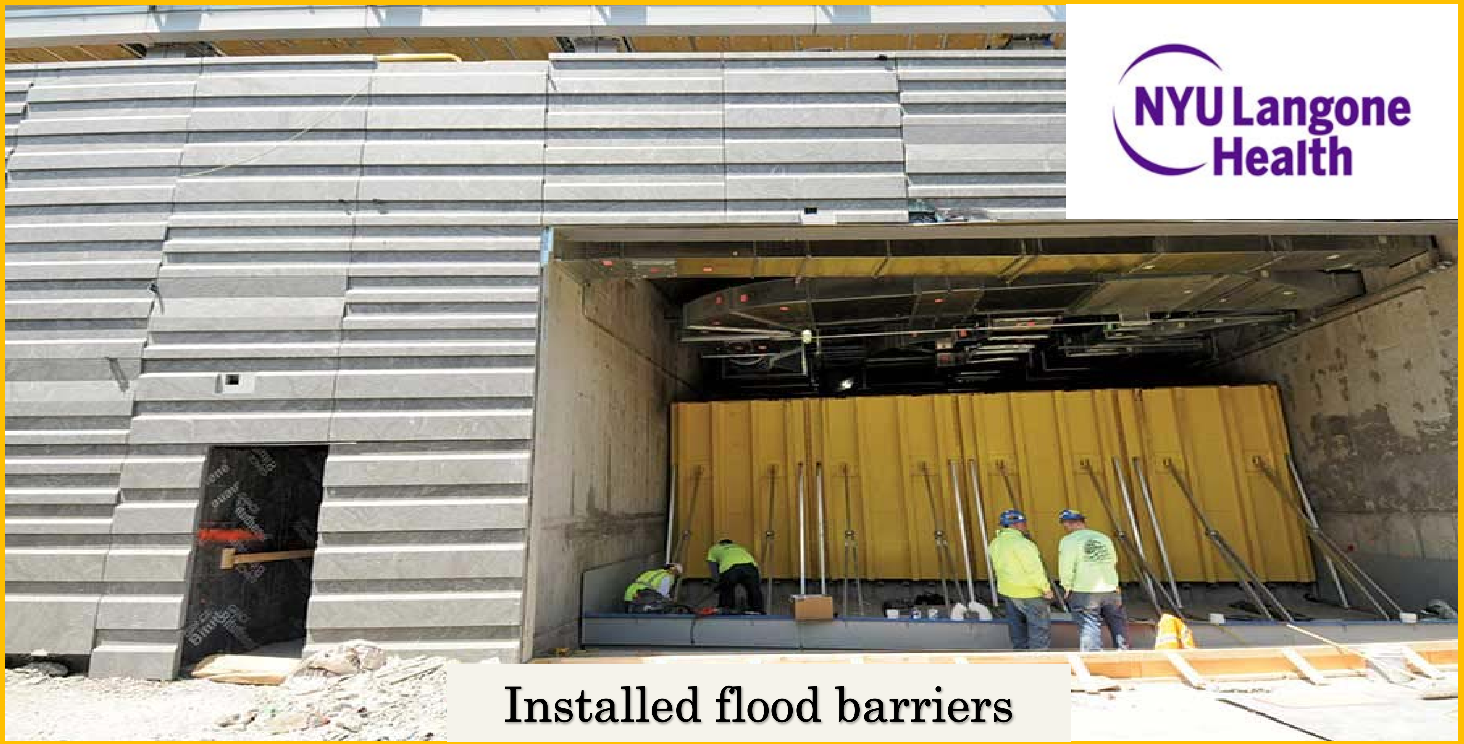
Chattanooga EPB's SAIDI compared with state average

NYU Langone Health

Case Study based on Reliability & Resiliency Measures

PEER
PLATINUM

- Campus with ability to withstand 500-year flood level
- Zero sustained interruptions
- Trained resources to manage emergency conditions



Installed flood barriers

&

Undergrounded power lines

Cogeneration Plant – Alternative Power Supply

Energy Efficiency and Environment

Operations, Management and Safety

Grid Services

GLOBAL PEER PROJECTS

POWER UTILITES

CAMPUS & TRANSIT

PEER Online Resources at peer.gbci.org/resources

- Guide to PEER Certification
- PEER v2 Reference Guide
- Technical Reports on Certified Projects
- Articles on PEER Strategies