Designing for Power Resilience

Honorable Katherine Hammack
Outage Impact

Million customers without power

Outage Event

- Operations
- Hurricane
- Ice / Snow
- Rain / Wind

15 YEAR OUTAGE CHART

Northeast Blackout 2003*
2004 & 2005 Hurricane Season
DUBAI blackout 2005

Outage Event

- Hurricane Sandy 2012
- Derecho Wind Storm 2012
- Chennai Flood 2015; Vardah 2016
- N-E blackout 2012*

*size of circle for NE blackout at half scale
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

- Credible and Consensus Driven
- Verifiable
- Systems Thinking
- Leverage Existing Standards
- Transparency
- Outcomes and Capabilities
PEER’s Applicability

Cities & Utilities

Campus

Transit
# PEER Scorecard

For Cities & Utilities, Campus, Transit

## V2.0 | Scorecard

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TYPE</th>
<th>POINTS</th>
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## GRID SERVICES (GS)

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## INNOVATION (IN)

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## REGIONAL PRIORITY (RP)

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<th>CATEGORY</th>
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</tbody>
</table>

Certified 40, Silver 50, Gold 60, Platinum >80.

110 | 110 | 110
### PEER Scoring

Total 31 Credits | No points for Prerequisites

<table>
<thead>
<tr>
<th>Certification Levels</th>
<th>Minimum Points Required</th>
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<tbody>
<tr>
<td>Platinum</td>
<td>80+ points</td>
</tr>
<tr>
<td>Gold</td>
<td>60-79 points</td>
</tr>
<tr>
<td>Silver</td>
<td>50-59 points</td>
</tr>
<tr>
<td>Certified</td>
<td>40-49 points</td>
</tr>
</tbody>
</table>
The 6 credit categories of PEER are:
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
To ensure data acquisition, reporting, and monitoring of interruptions.

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

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
Reliability Performance Assessment

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

  \[
  \text{SAIDI (in minutes)} = \sum_{i=1}^{N} \text{Interruption duration}_i \times \text{Number of customers interrupted}_i \]

  Total number of customers served

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

  \[
  \text{SAIFI (in numbers)} = \sum_{i=1}^{N} \text{Number of customers interrupted}_i \]

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

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
Momentary Interruption Tracking

The mathematical equation for calculation of MAIFI is as follows:

\[ \text{MAIFI} = \text{(in numbers)} \sum_{i=1}^{N} \left( \frac{\text{Number of momentary interruptions} \times \text{Number of affected customers}}{\text{Total number of customers served}} \right) \]

**Example:**

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

\[ \text{MAIFI} = \frac{2 \times 2000}{2000} = 2 \]

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

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
### 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.

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

Comply with **ASCE Chapter 7 – 24, FEMA 413, IS 875 & 802, BIS National Electrical Code 2011**
**Option 3: Undergrounding:**

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

<table>
<thead>
<tr>
<th>Network Protected ( % of total length)</th>
<th>PEER points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cities &amp; Utilities</td>
<td>Campuses &amp; Transit</td>
</tr>
<tr>
<td>≥10</td>
<td>≥40</td>
</tr>
<tr>
<td>30</td>
<td>80</td>
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</tbody>
</table>

Comply with **NESC C2-2012**
To improve reliability and resilience by ensuring that grid power can be supplied via multiple distribution pathways.

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

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
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:

<table>
<thead>
<tr>
<th>Project load with backup power supply (%)</th>
<th>PEER points</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 40</td>
<td>1</td>
</tr>
<tr>
<td>80</td>
<td>2</td>
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</table>

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

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

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
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.
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.

City of Chattanooga EPB

Case Study based on Reliability & Resiliency Measures

- 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

![Graph showing SAIDI values for Chattanooga, State Average, and 2013 US Average.](attachment:graph.png)
NYU Langone Health

Case Study based on Reliability & Resiliency Measures

- 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
PEER Online Resources at peer.gbcia.org/resources

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