An Analysis of Tornado-Induced Electrical System Damage in the Greater Tulsa Area (2023-2024): A Technical Report

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Quick Takeaway—Why This Report Matters to *You*

- **Developers & GCs:** *Think ahead or pay later. These case studies show exactly how six-figure change orders explode when tornado loads aren't baked into the electrical design. Use the data, spec tougher service entrances, and spare your budget the disaster-tax.*

- **Industrial & Commercial Engineers:** *Tornadoes took out entire substations and 100+ utility poles—yet a handful of plants stayed online. This report maps the difference: bulletproof grounding, layered surge protection, smarter panel locations. Steal the playbook and keep your facility humming while competitors scramble in the dark.*

- **Private Equity & REITs:** *Stop underwriting Tulsa assets on hope. We crunch EF3/EF4 loss figures—$25 M here, $40 M there—showing which properties bled cash after the storms. Use the numbers to price risk accurately, protect NOI, and avoid buying the next NuCera-style write-off.*

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For Developers & General Contractors: This report details multiple tornado events in the Greater Tulsa Area (2023-2024), some reaching EF3 and EF4 intensity, causing widespread power outages, downed power lines, and catastrophic damage to utility poles and substations. Understanding these real-world impacts on electrical infrastructure, including common failure points like service entrances and the requirements of Oklahoma's Appendix X for tornado resistance , can help you integrate resilience into your site plans from the outset. This proactive approach, informed by documented financial damages sometimes reaching tens of millions per event (e.g., $25 million for the Barnsdall EF4, $40 million for the Rogers County portion of the Claremore EF3) , can prevent costly, six-figure change orders and ensure greater project durability against predictable regional hazards.

For Industrial & Commercial Engineers: The analysis of recent Greater Tulsa Area tornadoes (2023-2024) reveals critical vulnerabilities in commercial electrical systems. Events like the May 2024 Claremore EF3, which knocked all four city substations offline , and the May 2024 Barnsdall EF4, which destroyed over 100 utility poles and inflicted high-end EF3 damage to the NuCera Solutions wax plant , highlight the severe operational risks. This report details common failure points, including main panels, internal wiring, and specialized equipment. It also underscores the importance of robust grounding systems and comprehensive surge protection —strategies that are crucial for maintaining plant operations and minimizing downtime when facing such severe weather events. Understanding these documented impacts and effective countermeasures can inform your designs to keep facilities online while others may go dark.

For Private Equity & REITs: This report provides a data-driven assessment of tornado-related risks to assets in the Greater Tulsa Area, based on events from 2023-2024. It documents the frequency of significant tornadoes (including EF3 and EF4 events) and their direct financial consequences, such as the $25 million in damages from the Barnsdall-Bartlesville EF4 tornado and the $40 million impact on Rogers County from the Claremore/Pryor EF3 tornado. The analysis details extensive damage to electrical infrastructure, including utility poles and substations , leading to significant business interruption and, in some cases, total loss of commercial properties like the NuCera Solutions plant. These hard numbers and documented impacts on commercial operations offer a clearer picture than gut feelings for evaluating current asset risk and potential future liabilities in this tornado-prone region.

I. Executive Summary

The Greater Tulsa Area experienced multiple significant tornado events during 2023 and 2024, leading to substantial impacts on both utility-scale electrical infrastructure and customer-owned residential and commercial electrical systems. These events, varying in intensity up to EF4, have repeatedly tested the resilience of the region's power grid and highlighted vulnerabilities inherent in electrical systems exposed to extreme weather.

Common consequences included widespread power outages, downed transmission and distribution lines, catastrophic damage to utility poles, compromised electrical substations, and extensive damage to service entrance equipment on homes and businesses.

Key findings from an analysis of these events reveal recurring patterns of electrical damage. Downed power lines and damaged utility poles were a near-universal outcome in affected areas, often complicated by fallen trees and debris. Service entrances on buildings—including masts, meter bases, and main panels—proved highly susceptible to damage from high winds and structural collapse. Internally, wiring systems were compromised by physical destruction and water ingress, leading to immediate failures and potential long-term hazards.

The response from utility companies, while systematic, often faced considerable logistical and technical challenges, resulting in restoration times spanning hours to several days depending on the severity and extent of the damage.[1] The critical role of qualified electricians in assessing damage, ensuring safety, and executing code-compliant repairs has been paramount in the recovery process.

These events underscore the persistent need for robust electrical safety protocols, diligent adherence to and potential enhancement of building codes, and the proactive implementation of resilient electrical installation practices throughout this tornado-prone region. The frequency of these events suggests that a forward-thinking approach, emphasizing system hardening and preparedness, is essential for mitigating future impacts on electrical infrastructure.

II. Overview of Tornado Activity and Electrical Impact

in the Greater Tulsa Area (2023-2024)

A. Summary of Significant Tornado Events Affecting the Region:

The Greater Tulsa Area, encompassing Tulsa, Broken Arrow, Owasso, Claremore, Bixby, Jenks, Catoosa, Sand Springs, Collinsville, Oologah, Sperry, Glenpool, Coweta, and Verdigris, has been subjected to numerous tornado events in 2023 and 2024. These events have varied in intensity and geographical scope, but collectively demonstrate the region's vulnerability.

- **January 2, 2023 Event:** This early-year event brought multiple tornadoes to eastern Oklahoma. Notably, an EF0 tornado, with winds estimated at 80-85 mph, carved a 5.3-mile path (700 yards wide) from 3 miles north-northeast of Pryor to 3 miles southeast of Adair in Mayes County, damaging outbuildings and causing roof and siding damage to a home.[3] Another EF1 tornado, with winds of 85-95 mph on an 8.6-mile path, impacted McIntosh County (southwest of Texanna to northeast of Duchess Landing), causing damage to homes, destroying storage buildings, and uprooting trees.[3] While McIntosh County is slightly south of the immediate Greater Tulsa Area, its inclusion in "Eastern Oklahoma" event summaries provides regional context.
- **February 26, 2023 Outbreak:** This event was historically significant, producing 13 tornadoes in the NWS Norman forecast area alone, the highest number recorded for February in Oklahoma since record-keeping began in 1950.[5] While many of these tornadoes occurred west and southwest of the Greater Tulsa Area, their collective impact signals a widespread severe weather episode. An EF2 tornado, with winds of 125-130 mph, tracked for 27 miles from northeast of Cole through Goldsby and Norman to 2 miles northeast of Stella, affecting McClain and Cleveland Counties and causing 12 injuries.[4] Property damage from one EF2 in this outbreak was estimated at $50,000,000, illustrating the severe financial consequences.[6] Another EF1 tornado (95-100 mph winds) traveled from 2 miles south-southeast of Newalla to 2 miles north-northwest of Dale in Cleveland and Pottawatomie Counties.[4] These events touched the southern and western fringes of the specified area.
- **April 19, 2023 Outbreak:** This day is primarily known for the EF3 tornado in Cole, OK.[7] Data from the NWS Tulsa office indicated that by July 14, 2023, their area of responsibility (eastern Oklahoma and northwest Arkansas) had already experienced 10 tornadoes in 2023, including EF0 and EF1 rated storms.[3] Specific to April 19, records show an EF2 tornado with a 5.4-mile path causing $500,000 in damage, and an EF3 tornado with a 0.6-mile path resulting in $50,000

damage, although their precise locations within the Greater Tulsa Area require careful cross-referencing.[6]

- **June 17-18, 2023 Straight-line Wind & Tornado Event:** This event brought widespread thunderstorm wind damage, with gusts of 80-100+ mph, across northeastern Oklahoma. Tulsa International Airport recorded a peak gust of 77 mph.[3] Three tornadoes were confirmed along the leading edge of the squall line. The severity of this event prompted Oklahoma Governor Kevin Stitt to declare a State of Emergency for several counties, including Creek, Delaware, Mayes, Pawnee, Rogers, Tulsa, and Wagoner, all of which are within or directly adjacent to the specified Greater Tulsa Area.[3]
- **April 1, 2024 Tornadoes:** Several EF1 tornadoes directly impacted Osage and Washington Counties, affecting the northern parts of the Greater Tulsa Area:
  - An EF1 tornado tracked 7 miles from 4 miles north of Hominy to 2 miles southeast of Wynona in Osage County, snapping or uprooting numerous trees and downing power poles.[8]
  - Another EF1 tornado traveled 5.5 miles from 2 miles east-southeast of Wynona to 2 miles west of Barnsdall in Osage County, removing the roof from a garage and downing trees and power poles.[8]
  - A third EF1 tornado impacted Barnsdall, tracking 2.2 miles from the town to 2 miles east-northeast of Barnsdall (Osage County). This tornado damaged homes, destroyed outbuildings, and downed trees and power poles.[8] This event served as a precursor to the more devastating May 6th tornado in the same area.
  - An EF1 tornado also tracked 4.9 miles from 3 miles northwest to 4 miles northeast of Ochelata, crossing from Osage into Washington County, damaging outbuildings, uprooting trees, and downing power poles.[8]
- **April 27, 2024 Outbreak:** While the destructive Sulphur EF3 tornado occurred further south [11], this outbreak produced several tornadoes relevant to the Greater Tulsa Area:
  - An EF1 tornado tracked 6.9 miles from 3.1 miles northwest to 6.5 miles northeast of Okmulgee in Okmulgee County, which is adjacent to Tulsa County.[8]
  - An EF1 tornado traveled 9.8 miles from 2 miles east-southeast of Choska to 4 miles east-northeast of Porter in Wagoner County, part of the Greater Tulsa Area.[8]
  - Another EF1 tornado in Wagoner County had a 1.6-mile path from 3 miles southwest to 2 miles west-southwest of Wagoner.[8]
- **May 6, 2024 Barnsdall-Bartlesville EF4 Tornado:** This was a major and devastating event for the northern part of the Greater Tulsa Area.

- The tornado carved a 40.8-mile path, reaching a maximum width of 1,700 yards. It began southeast of Hominy, intensified as it moved through Barnsdall (Osage County), and continued to near Bartlesville before dissipating east-southeast of Dewey (Washington County).[8]
- This violent tornado resulted in 2 fatalities and 33 injuries. Barnsdall experienced extensive destruction, with homes suffering EF4 damage and the NuCera Solutions wax plant sustaining high-end EF3 damage. Southern Bartlesville also saw significant impacts, including damage to a Hampton Inn.[10]
- Critically for electrical infrastructure, the tornado destroyed over 100 utility poles and bent concrete poles, indicative of EF3-level wind forces acting on the grid.[10]

- **May 19-27, 2024 Outbreak (Greater Tulsa Area Impacts):**
    - **May 21, 2024:** Rogers County, within the Greater Tulsa Area, experienced tornadic activity.
        - An EF1 tornado tracked 5.3 miles from 2 miles north-northwest of Verdigris to 3 miles west-southwest of Tiawah.[8] Both Verdigris and Tiawah are located within the specified region.
        - A shorter EF1 tornado also occurred near Tiawah, with a 1-mile path from 2 miles west-southwest to 1 mile west-southwest of the town.[8]
        - Hail was also reported in Tulsa, Jenks, and Broken Arrow during this period.[15]
    - **May 25, 2024 Claremore/Pryor EF3 Tornado & Associated Activity:** This was a particularly damaging event for Rogers and Mayes Counties.
        - An EF3 tornado, with a path length of 23.9 miles and a width of 2,000 yards, tracked from 5 miles east-northeast of Owasso to 2 miles west-northwest of Pryor.[8] This tornado resulted in 2 fatalities (in Mayes County) and 23 injuries (19 of which were in Rogers County).
        - The tornado impacted areas near Owasso (Limestone area) and Keetonville before causing extensive damage in Claremore to homes, businesses, Will Rogers Downs, and an RV park. Significant damage also occurred in areas between Claremore and the Mayes County line.[18]
        - The electrical impact was severe: all four of Claremore's electrical substations were knocked offline, and numerous trees and power poles were downed throughout the damage path.[18] Widespread power outages affected the area.[17] Viewer images from storms around this date showed downed power lines in Sapulpa, Broken Arrow, Claremore, and Skiatook.[20]
- **November 4, 2024 Tornadoes:** Several tornadoes touched down in the northern parts of the Greater Tulsa Area.
    - An EF1 tornado tracked 2.2 miles from 5 miles west-southwest of Sperry to 3

miles west-southwest of Sperry in Osage County, damaging the roof of a metal building and trees.[8] Reports indicated homes damaged 3 miles west of Sperry.[22] Sperry is one of the specified localities.
  - An EF1 tornado northeast of Vera in Washington County had a 0.6-mile path, blowing the roof off an outbuilding and uprooting trees.[8]
  - A longer-track EF1 tornado traveled 9.6 miles from northeast of Vera (Rogers County) to west of Watova (Nowata County), causing tree damage and passing a Mesonet site that recorded a 94 mph wind gust.[8]
  - The Oklahoma Department of Emergency Management reported power poles snapped and electrical lines down in Wagoner from storms around this period.[23]

The recurrence of significant tornadic events within Rogers, Mayes, Osage, and Washington counties over this two-year period is notable. This pattern suggests that certain portions of the Greater Tulsa Area, particularly its northern and eastern sectors, may lie within corridors more frequently susceptible to severe weather phenomena. Such a pattern implies a heightened need for robust preparedness strategies and targeted infrastructure resilience efforts in these specific zones. Furthermore, some communities, like Barnsdall, faced multiple tornado impacts within a very short timeframe—an EF1 on April 1, 2024, followed by a devastating EF4 on May 6, 2024.[8] This rapid succession of events severely compounds damage, stretches recovery resources, and places immense strain on affected residents and utility providers. It also brings into question the adequacy of initial repairs if they are unable to withstand subsequent, albeit stronger, tornadic events.

B. Documented Electrical Infrastructure Damage from These Events:

The tornado events of 2023-2024 inflicted substantial damage upon the electrical grid across the Greater Tulsa Area. This damage ranged from downed local distribution lines to the incapacitation of entire substations.

- **Downed Transmission and Distribution Lines & Utility Poles:** This was a common and widespread form of damage.
  - The May 6, 2024, Barnsdall-Bartlesville EF4 tornado was particularly destructive, destroying over 100 utility poles.[10] The extreme forces involved were evidenced by bent concrete poles, a testament to EF3-level winds impacting the infrastructure.[10] The loss of such a large number of poles indicates severe disruption to the backbone of the local distribution system.
  - The May 25, 2024, Claremore EF3 tornado resulted in numerous power poles being blown down in Claremore and along its path into Mayes County.[18]

Associated straight-line winds also contributed, with U.S. 69 being blocked by downed powerlines in Mayes County.[24]
  - The EF1 tornadoes in Osage and Washington Counties on April 1, 2024, also downed numerous power poles.[9]
  - The June 17-18, 2023, straight-line wind and tornado event likely caused significant power line damage given the widespread high winds and subsequent State of Emergency declaration.[3]
  - Storms around November 4, 2024, led to reports of snapped power poles in Wagoner.[23]
- **Impacts on Electrical Substations:** Substations are critical nodes in the power distribution network, and their failure leads to widespread outages.
  - The May 25, 2024, Claremore EF3 tornado critically impacted local infrastructure by taking all four of Claremore's electrical substations offline.[19] The loss of multiple substations guarantees extensive and prolonged power disruptions for the entire community they serve, as these facilities are essential for stepping down voltage and distributing power to local circuits.
- **Reported Power Outage Extents and Durations:**
  - Following the May 25, 2024, event, nearly 60,000 customers were without power statewide in Oklahoma, with over half of these outages concentrated in the Tulsa area.[25] Claremore experienced city-wide outages due to substation damage.[19] Skiatook also reported power disruptions.[25] Public Service Company of Oklahoma (PSO) reported that as of 10:00 AM on May 25 (likely 2024, despite a 2025 date in one source), 4,521 customers remained without power, with estimated restoration for the Tulsa district extending to the following Monday.[2]
  - The May 6, 2024, Barnsdall EF4 tornado, by destroying over 100 utility poles, undoubtedly caused extensive and prolonged outages in the Barnsdall and Bartlesville areas, though specific customer outage numbers for this single event are not detailed in the provided materials.[10]
  - The State of Emergency declared for several counties, including some on the fringe of the Greater Tulsa Area like Lincoln County, following storms around November 2-3, 2024, was associated with approximately 8,700 outages statewide.[23] During this period, a house fire in Tulsa County was attributed to a lightning strike.[26]
  - Generally, tornado-induced power outages can be expected to last from several hours to several days, contingent on the severity of damage to the electrical infrastructure.[1]

The destruction of a significant number of utility poles and the incapacitation of multiple substations are primary drivers of these widespread and prolonged power outages. While damage to individual service drops contributes to the overall number of customers affected, the failure of these higher-level backbone components of the electrical grid has a far more extensive and immediate impact, preventing power delivery to large segments of the community until substantial repairs or rebuilding efforts are completed. The declaration of a State of Emergency in several instances [3] highlights that the damage to critical infrastructure, including electrical systems, often overwhelms local resources, necessitating broader mobilization for repair and recovery. This elevates electrical restoration from a routine utility operation to a critical component of comprehensive disaster response.

III. Analysis of Residential and Commercial Electrical Damage

Tornadoes inflict a unique and often devastating combination of mechanical forces, debris impact, and water intrusion on electrical systems. Understanding common failure points is crucial for effective assessment, repair, and mitigation.

A. Common Failure Points in Customer-Side Electrical Systems:

Residential and commercial properties in the path of a tornado frequently experience severe damage to their electrical installations, starting from the point of utility connection and extending inwards.

- **Service Entrance Equipment:** This is often the first and most critically damaged part of a customer's electrical system.
    - *Overhead service drops* are highly vulnerable, easily torn down by high winds, falling trees, or airborne debris.
    - *Service masts (risers)*, which support the service drop conductors to the building, are frequently bent, broken, or ripped entirely from the structure. This occurs due to the immense tension placed on them when utility poles fall or when the building itself sustains structural damage.[2] The integrity of the weatherhead, which protects the point where conductors enter the mast, is also commonly compromised.
    - *Meter bases and main electrical panels* can be torn from walls, suffer direct impact from debris, or be exposed to severe water intrusion once the building

envelope is breached.[2] The structural failure of the wall to which these components are mounted often leads to their complete destruction.

- **Main and Sub-Panels:** Beyond the initial service entrance, main and sub-panels within the structure are susceptible to physical damage from collapsing walls or roofs. Water ingress is a significant concern, leading to corrosion of busbars and breaker components, potentially causing short circuits, ground faults, or rendering overcurrent protective devices inoperable.
- **Internal Wiring:** The network of wiring within a building can be catastrophically affected.
  - Structural shifts, collapsing walls, and falling ceilings can sever, crush, or stretch conductors, compromising their integrity.[30]
  - Frayed wiring and damaged insulation resulting from these forces create immediate shock and fire hazards.[30]
  - Water infiltration into wall cavities, attics, crawlspaces, and conduits can saturate wiring systems, leading to short circuits and long-term corrosion issues, even if not immediately apparent.[30]
- **Outlets, Switches, and Fixtures:** These end-use devices are subject to direct physical damage, dislodgement from walls or ceilings, and water damage. Fixtures can be torn away, and internal components of switches and outlets can be compromised by moisture.
- **Connected Appliances and Electronics:** Appliances and sensitive electronics face a dual threat: direct physical damage from collapsing structures or debris, and electrical damage from power surges. These surges can occur during the initial event as lines clash or transformers fail, or upon power restoration if the system is unstable. Water damage can also render appliances irreparable.

The structural integrity of a building is inextricably linked to the survivability of its electrical system. When a tornado compromises a building's roof or walls, the electrical service entrance and internal wiring are almost invariably affected. This means that electrical repair and restoration efforts are often contingent upon prior or concurrent structural repairs, adding complexity and time to the recovery process.

B. Specific Challenges for Commercial Properties:

Commercial properties present unique and often more complex challenges for electrical damage assessment and restoration compared to residential structures.

- **Larger Load Centers and Complex Systems:** Commercial buildings typically feature larger electrical load centers, three-phase power systems, and more intricate distribution networks to support their operational needs.[32] Assessing damage to these systems requires a higher level of technical expertise due to the increased capacity and complexity of components like switchgear, transformers, and motor control centers.

- **Specialized Equipment:** A significant portion of a commercial property's value and operational capability lies in its specialized electrical equipment. Tornadoes can destroy or severely damage critical assets such as large HVAC systems, commercial refrigeration units, industrial manufacturing machinery, and extensive IT infrastructure including servers and communication systems. The cost of repairing or replacing such equipment is often substantial, and lead times for specialized components can be long, further extending business interruption.
- **Exterior Electrical Components:** Commercial properties often have extensive exterior electrical installations that are highly vulnerable to tornadic winds and debris. This includes illuminated signage, parking lot lighting systems, security cameras, and external power distribution for ancillary structures. Damage to these components not only incurs repair costs but can also impact safety and security around the property.
- **Business Continuity Impacts:** For commercial entities, electrical damage translates directly into significant business interruption. Prolonged power outages or the time required to repair or replace damaged electrical systems means lost revenue, potential loss of perishable inventory, inability to process transactions, and disruption to employee wages. The complete destruction of businesses, as observed in events like the May 2024 Claremore tornado [18], the April 2024 Sulphur tornado [11], and the May 2024 Barnsdall tornado [10], results in the total loss of their electrical systems and profound economic consequences for the owners and the local community. The failure of a major employer like the NuCera Solutions plant in Barnsdall due to tornado damage has lasting repercussions on local employment and the wider economy.[10]
- **Emergency and Backup Power Systems:** While many commercial facilities have backup generators, these systems themselves can be damaged by tornadoes. Ensuring the safe and proper functioning of transfer switches and generator connections post-event is critical, especially for facilities like hospitals or emergency operations centers.

The interconnectedness of electrical systems with nearly all aspects of commercial operations means that electrical damage is a primary driver of extended downtime and economic loss. The recovery of commercial properties often involves a more protracted and costly process than residential rebuilding due to these complexities.

C. Hidden Electrical Hazards Post-Tornado:

Beyond the immediately visible destruction, tornadoes often leave behind latent electrical hazards that can pose significant risks if not expertly identified and addressed. Initial assessments, particularly by those not professionally trained in electrical systems, may overlook these dangers, leading to a false sense of security and potential for future incidents.[28]

- **Compromised Wiring Integrity:** Conductors within walls, conduits, or raceways may suffer nicks, abrasions, stretching, or have their insulation compromised by the stresses of structural shifts or debris penetration.[30] Such damage might not cause an immediate fault but can lead to overheating, arcing, or ground faults over time, creating a serious fire or shock hazard.
- **Water Infiltration Effects:** Moisture is a pervasive enemy of electrical systems. Water can seep into electrical panels, junction boxes, conduit systems, and even the internal components of outlets and switches.[30] This can lead to delayed corrosion of metallic parts, degradation of insulating materials, intermittent faults, and eventual failure or dangerous arcing conditions, sometimes weeks or months after the storm.
- **Grounding System Damage:** The integrity of a building's grounding electrode system is vital for electrical safety. Tornadoes can cause foundation shifts, uproot grounding rods, or sever grounding electrode conductors due to debris movement or structural collapse. A compromised grounding system can leave the electrical installation without an effective path for fault currents, increasing the risk of electrocution and equipment damage.
- **Surge-Related Damage:** Voltage spikes and surges that occur during the chaotic conditions of a tornado (e.g., from clashing power lines, failing transformers, or lightning) can cause latent damage to sensitive electronics, appliances, and even wiring insulation. This damage may not be immediately apparent but can lead to premature failure of equipment days, weeks, or even months later.
- **Importance of Professional Inspection:** It is imperative that property owners understand that even if power is restored to their building or if visible damage appears minimal, a comprehensive inspection by a qualified and licensed electrician is crucial.[30] Such professionals possess the knowledge and tools (e.g., insulation resistance testers) to identify these hidden dangers and ensure the long-term safety and reliability of the electrical system. Attempting self-repair or relying on superficial assessments can have dire consequences.

The presence of these hidden hazards underscores the fact that post-tornado electrical recovery is not merely about restoring power quickly; it is fundamentally about restoring power *safely*. This necessitates a meticulous approach to inspection and repair by trained professionals.

IV. Utility Response and Restoration Challenges

The restoration of electrical service following a tornado is a complex, hazardous, and resource-intensive undertaking. Utility companies in the Greater Tulsa Area employ established protocols but face significant hurdles in the aftermath of severe tornadic events.

A. Key Electric Utility Providers in the Region:

Several electric utility providers serve the 14 specified localities within the Greater Tulsa Area. Understanding their service territories is important for coordinating response and understanding outage patterns.

- **Public Service Company of Oklahoma (PSO):** As a major investor-owned utility, PSO serves a significant portion of the region, including key urban centers like Tulsa and Broken Arrow, and likely extends its services to many of the other 13 listed communities.[2] PSO has been actively involved in large-scale restoration efforts, such as those following the May 2024 storms [2], and undertakes ongoing infrastructure improvement projects, exemplified by the Catoosa-Verdigris transmission line rebuild, aimed at enhancing grid resilience.[37]
- **Verdigris Valley Electric Cooperative (VVEC):** VVEC is a member-owned cooperative headquartered in Collinsville. Its service territory primarily covers Collinsville and surrounding rural areas within Rogers, Tulsa, Washington, Nowata, and Osage counties.[35]
- **Indian Electric Cooperative (IEC):** IEC, another member-owned cooperative, provides electrical service to parts of Tulsa, Pawnee, Osage, Creek, Payne, Noble, and Kay counties.[36] Its headquarters are located in Cleveland, Oklahoma.
- **Northeast Oklahoma Electric Cooperative:** This cooperative is listed as being price-regulated by the Oklahoma Corporation Commission (OCC) and likely serves portions of the northeastern Greater Tulsa Area.[36]
- **Other Cooperatives:** Depending on the precise boundaries of their service areas, other electric cooperatives listed by the OCC, such as Lake Region Electric Cooperative or East Central Oklahoma Electric Cooperative, might serve some of the fringe areas within the 14 specified localities.[36]

The presence of both investor-owned utilities and rural electric cooperatives means a varied landscape of operational structures and service areas, which can influence coordination during widespread disaster recovery.

B. Power Restoration Protocols and Priorities:

Electric utilities follow a structured approach to power restoration after major storm events, prioritizing safety and the re-energization of critical services and major infrastructure components.

- **Damage Assessment:** The immediate post-storm phase involves a comprehensive assessment of the damage to the electrical system. This includes identifying the location and extent of downed power lines, damaged poles, compromised substations, and other affected equipment.[1] This assessment phase is critical for allocating resources and planning the restoration sequence. It often involves both ground crews and, where feasible, aerial surveillance.
- **Safety Operations:** A primary and immediate concern is public and worker safety. This involves making affected areas safe, primarily by identifying and isolating downed power lines to ensure they are de-energized.[42] Utilities emphasize that the public should assume any downed line is live and maintain a safe distance.[2]
- **Prioritization Sequence:** The restoration process typically follows a well-defined hierarchy:
    1. **Critical Infrastructure:** The highest priority is given to restoring power to essential community services. This includes hospitals, police and fire departments, emergency operations centers, water and wastewater treatment plants, and key communication facilities.[1] The restoration of power to Claremore's hospitals and water treatment plant after the May 2024 tornado exemplifies this priority.[19]
    2. **Transmission Lines:** These high-voltage lines are the arteries of the power grid, carrying electricity from generation plants to substations. Repairing any damage to transmission infrastructure is essential for system-wide recovery.
    3. **Substations:** Substations are critical nodes that step down transmission voltage for local distribution. Damage to substations, such as that experienced in Claremore [19], can affect thousands of customers. Their repair is a high priority after transmission lines are secured.
    4. **Main Distribution Lines (Feeders):** These are the primary circuits that carry power from substations to large groups of customers within communities. Repairing main feeders allows for the restoration of service to the largest number of customers in the shortest amount of time.[1]
    5. **Tap Lines (Lateral or Smaller Lines):** Once main distribution lines are

energized, crews move to repair tap lines, which serve smaller groups of customers within neighborhoods or along rural routes.[29]

6. **Individual Service Drops:** The final step involves restoring power to individual homes and businesses. However, utilities cannot reconnect service if the customer's own electrical service entrance equipment (such as the weatherhead, service mast, or meter base) is damaged. Property owners are responsible for having these repairs made by a qualified, licensed electrician before the utility can safely restore power.[2]

- **Communication with Customers:** Throughout the restoration process, utilities typically provide updates to affected customers through various channels, including their websites, social media platforms, automated phone systems, and text or email alerts.[1]

This systematic approach aims to restore service in a manner that is both safe and efficient, addressing the most critical needs first and progressively working towards full restoration.

C. Logistical and Technical Hurdles in Post-Tornado Electrical Rebuilding:

Restoring electrical infrastructure after a tornado is fraught with significant logistical and technical challenges that can impede the speed and efficiency of recovery efforts.

- **Safety for Line Crews and the Public:** The work environment post-tornado is inherently hazardous. Line crews must navigate areas with downed and potentially re-energized power lines, unstable or collapsed structures, extensive debris, and the risk of gas leaks or hazardous material spills.[2] Ensuring the safety of both the restoration crews and the general public is a paramount concern that dictates the pace and methods of repair.
- **Accessibility Issues:** Tornadoes often leave a trail of destruction that blocks roadways with fallen trees, utility poles, building debris, and sometimes localized flooding.[1] This can severely restrict or delay the access of utility crews and their heavy equipment to the damaged sections of the electrical grid, particularly in rural or heavily wooded areas.
- **Scale of Component Replacement:** High-intensity tornadoes can cause catastrophic damage to the physical components of the electrical distribution system. The destruction of over 100 utility poles during the May 6, 2024, Barnsdall EF4 event [10] or PSO's replacement of 36 poles and nearly 15,000 feet of wire after another storm [2] illustrates the sheer volume of materials and labor

required. This often involves not just repair but complete replacement of poles, transformers, conductors, and associated hardware.

- **Specialized Equipment Requirements:** The process of replacing utility poles, stringing new conductors, and repairing substation equipment necessitates the use of specialized heavy machinery, including bucket trucks, derrick diggers, cranes, and tension stringing equipment.[42] Mobilizing and deploying this equipment to numerous damage sites can be a complex logistical operation.
- **Manpower and Mutual Assistance:** The scale of damage from a significant tornado can quickly overwhelm the internal resources of the local utility provider. In such cases, utilities activate mutual assistance agreements, bringing in line crews, forestry personnel, and support staff from other utility companies, often from neighboring states.[29] For instance, PSO reported mobilizing over 500 of its own personnel plus an additional 460 workers from external sources during one major restoration effort.[2] While vital, coordinating these external resources adds another layer of logistical complexity.
- **Debris Removal and Site Preparation:** Before electrical repair work can commence, significant debris removal is often necessary. This may involve specialized vegetation management crews to clear fallen trees and branches from power lines and rights-of-way, as well as coordination with emergency management for the removal of structural debris.[45]
- **Rebuilding versus Repairing:** In areas subjected to the most intense tornadic winds, electrical infrastructure is often not just damaged but entirely destroyed. This necessitates a complete rebuilding of sections of the grid, which is far more time-consuming and resource-intensive than simply repairing damaged components.[45]
- **Adverse Weather Conditions:** Restoration efforts can be hampered or temporarily halted by ongoing severe weather, such as continued high winds, heavy rain, or lightning, which pose safety risks to crews working outdoors.[2]
- **Supply Chain Considerations:** In the event of very large-scale disasters affecting multiple regions, the availability of specific electrical components, such as transformers or certain types of utility poles, can sometimes become a limiting factor, potentially leading to delays in acquiring necessary materials.

These multifaceted challenges underscore why power restoration after a major tornado can be a lengthy process, requiring extensive coordination, resources, and a persistent focus on safety. The interdependency of various recovery operations also plays a role; for instance, roads must be cleared before utility trucks can access damaged areas, and structural assessments of buildings may be needed before individual electrical services can be safely reconnected.

Table 2: Major Electric Utilities in the Greater Tulsa Area and Primary Service Regions

Utility Name	Type (Investor-Owned/Cooperative)	Known Service Areas/Cities within GTA (based on snippets)	Key Contact/Outage Reporting Info (General from Snippets)	Snippet ID(s)
Public Service Company of Oklahoma (PSO)	Investor-Owned	Tulsa, Broken Arrow, Catoosa, Verdigris (and likely others among the 14 specified localities)	Website (psoklahoma.com/outages), Phone (1-833-PSO-OUTG for outages, 1-833-PSO-POWR for customer service), Mobile App	2
Verdigris Valley Electric Cooperative (VVEC)	Cooperative	Collinsville, Rogers Co., Tulsa Co., Washington Co., Nowata Co., Osage Co.	Website (vvec.com), Phone (918-371-2584 or 1-800-870-5948 for outages)	35
Indian Electric Cooperative (IEC)	Cooperative	Parts of Tulsa Co., Pawnee Co., Osage Co., Creek Co. (among others outside GTA)	Website (iecok.com), Phone (855-940-3844 for outages, 918-295-9500 for office)	36
Northeast Oklahoma Electric Cooperative	Cooperative	Likely northeastern parts of the GTA	(Specific contact info not in snippets, but listed as OCC regulated)	36

The requirement for property owners to arrange for repairs to their own service entrance equipment (meter loop, weatherhead, mast) before utilities can safely reconnect power is a critical interface point.[2] This customer-side responsibility can become a significant bottleneck in individual power restoration, especially when qualified electricians are in high demand following a widespread disaster. It adds another layer of complexity and financial burden for residents already grappling with other forms of tornado damage.

V. Technical Considerations and Recommendations for Electrical Professionals

As a Master Electrician, your expertise is invaluable in the aftermath of tornadic events, not only for restoring power but also for ensuring the long-term safety and resilience of electrical installations. This section outlines key technical considerations and recommendations pertinent to your work in the Greater Tulsa Area.

A. Adherence to and Interpretation of Relevant Electrical and Building Codes:

Navigating the complex landscape of codes and standards is fundamental to safe and compliant electrical work, particularly in a post-disaster rebuilding scenario.

- **National Electrical Code (NEC, NFPA 70):** The NEC serves as the foundational standard for electrical installations in the United States. Key articles relevant in a post-tornado context include those governing service installations (Article 230), grounding and bonding (Article 250), wiring methods and materials (Chapter 3), and overcurrent protection (Article 240). Adherence to these provisions is critical for ensuring the safety and operational integrity of repaired or newly installed systems. For example, proper grounding is essential to protect against electrical shock and stabilize voltage, aspects that can be compromised by storm damage. Oklahoma City, for instance, has adopted the 2017 Edition of the NEC, though it's crucial to verify the specific edition and any local amendments adopted by each of the 14 jurisdictions within the Greater Tulsa Area, as these can vary.[48]
- **Oklahoma Uniform Building Code Commission (OUBCC) Standards:** The OUBCC adopts and amends building codes for the state. Of particular relevance is **Appendix X, Residential Tornado Provisions**, which is based on the International Residential Code (IRC) 2018.[50] This appendix provides prescriptive

requirements for new residential construction designed to withstand wind speeds up to 135 mph, corresponding to an EF-2 tornado rating. While not exclusively an electrical code, its mandate for achieving a "continuous load path from the roof to the foundation" directly impacts how electrical service entrances and exterior components are secured and protected.[50] Electricians should be cognizant of these structural requirements, as they influence the mounting locations and protection strategies for electrical equipment. A structurally sound building provides inherent protection to the electrical systems housed within it.

- **National Electrical Safety Code (NESC, ANSI C2):** This code primarily governs the installation, operation, and maintenance of electric utility systems, including overhead and underground lines.[48] While your work as a contractor is primarily on the customer side of the service point, understanding NESC principles related to clearances, grounding of utility systems, and service drop installations can inform the interface between your work and the utility's infrastructure, ensuring a safe and compatible connection.
- **Local Jurisdictional Amendments and Interpretations:** It cannot be overstated that each municipality or county (the Authority Having Jurisdiction, or AHJ) may have its own specific amendments to the adopted state codes or unique interpretations and enforcement practices. Verifying these local requirements for each of the 14 localities in the Greater Tulsa Area is essential before commencing any repair or installation work. This proactive engagement with local code officials can prevent costly rework and ensure compliance. Resources like OneClick Code aim to provide up-to-date local code information, recognizing that requirements can change even between adjacent streets.[51]

While existing codes like Appendix X provide a baseline for structural resilience to EF-2 level events, electrical systems often face unique stresses during tornadoes that may not be fully addressed by general code provisions. Debris impact, extreme pressure changes, and pervasive water ingress can compromise electrical components even if a structure remains largely intact, particularly in tornadoes exceeding EF-2 intensity. This points to a potential need for specialized electrical installation techniques or material specifications—such as impact-resistant enclosures for exterior components or enhanced methods for securing service masts beyond standard NEC requirements—that could improve the survivability of electrical systems.

B. Best Practices for Damage Assessment and Repair of Electrical Systems Post-Tornado:

A systematic and thorough approach to damage assessment and repair is crucial to ensure safety and reliability.

- **Prioritize Safety:** Always de-energize electrical systems at the main disconnect before beginning any inspection or work. Utilize appropriate Personal Protective Equipment (PPE), including insulated gloves, safety glasses, and hard hats. Be acutely aware of the surrounding environment, including structurally unstable buildings, sharp debris, potential for gas leaks, and the presence of water near electrical equipment.[31] Treat all downed lines as energized until confirmed otherwise by the utility.
- **Comprehensive Service Entrance Inspection:** The service entrance is a common point of failure. Meticulously inspect the service mast for bends, breaks, or insecure attachment. Examine the service entrance conductors for damage to insulation or signs of arcing. Check the weatherhead for integrity and proper sealing. Inspect the meter base for physical damage, water entry, secure mounting, and any signs of overheating or corrosion.[2]
- **Thorough Panel Inspection:** Open and inspect all main and sub-panels. Look for any physical damage to the enclosure, signs of water intrusion (rust, corrosion, mineral deposits), melted or discolored insulation on conductors, loose or damaged breakers, and evidence of arcing on busbars or terminals. If water intrusion is suspected, especially in critical panels, consider insulation resistance testing (megger testing) of main breakers and feeder conductors.
- **Wiring Integrity Checks:** Visually inspect all accessible wiring and conduit runs for physical damage, such as crushing, severing, or kinking. Pay close attention to areas where the building structure has shifted or been penetrated by debris.[30] For critical circuits, or in areas known to have been exposed to significant water, insulation resistance testing of branch circuit wiring can help identify compromised insulation that may not be visually apparent.
- **Grounding and Bonding System Verification:** The grounding and bonding system is essential for safety. Verify the integrity of the grounding electrode conductor(s), connections to grounding electrodes (ground rods, water pipes, etc.), and all bonding jumpers. Ensure that connections are tight and free of corrosion. Tornado-induced structural shifts can easily compromise these critical safety pathways.
- **Appliance and Equipment Checks:** Advise clients that connected appliances, particularly sensitive electronics and major motor-driven equipment (HVAC units, pumps), may have sustained damage from power surges or direct physical impact/water intrusion. Recommend they have these items checked by qualified technicians if malfunction is suspected.

- **Meticulous Documentation:** Thoroughly document all observed damage with high-resolution photographs and detailed written notes before beginning any repairs.[30] This documentation is invaluable for property owners when filing insurance claims and provides a record of the conditions found.
- **Adherence to Manufacturer Instructions:** When replacing damaged equipment, always follow the manufacturer's installation instructions and specifications.

The post-tornado environment often presents an opportunity to not just repair but to upgrade. When systems are heavily damaged, the incremental cost of incorporating more resilient components or installation methods can be relatively small compared to the benefit of enhanced future protection.

C. Recommendations for Enhancing Electrical System Resilience in New and Existing Constructions:

Proactive measures taken during new construction or significant renovations can substantially improve the resilience of electrical systems against tornado impacts.

- **Service Entrance Reinforcement:**
  - Utilize stronger materials for service masts (e.g., rigid steel conduit of appropriate size) and ensure they are securely braced to the building structure, potentially exceeding minimum code requirements in high-wind areas.
  - Ensure all penetrations for service entrance conduits are properly sealed with weather-tight fittings to prevent water ingress.
  - Where feasible and economically viable, consider underground service laterals. While underground systems have their own vulnerabilities (e.g., to flooding or excavation damage), they are generally protected from high winds and falling debris.[42] However, the decision to underground involves significant cost and coordination with the utility.
- **Panel Location and Protection:**
  - Avoid locating main electrical panels and critical sub-panels in areas prone to flooding, such as basements, if the building is in a flood-risk zone.
  - Utilize NEMA-rated enclosures appropriate for the installation environment. For example, NEMA 3R enclosures are suitable for most outdoor applications, offering protection against rain, sleet, and external ice formation. For interior panels that might be exposed to water spray or debris in a damaged structure, consider enclosures with higher NEMA ratings if deemed necessary.
- **Comprehensive Surge Protection:**

  - Install a Type 1 or Type 2 whole-house surge protective device (SPD) at or near the main service panel to protect the entire electrical system from externally generated surges (e.g., lightning, utility switching) and some internally generated surges.
  - Recommend Type 3 point-of-use SPDs for sensitive electronic equipment (computers, entertainment systems, etc.) as a secondary layer of protection.
- **Robust Wiring Methods and Support:**
  - In new construction or major renovations, consider using robust wiring methods such as electrical metallic tubing (EMT), rigid metal conduit (RMC), or intermediate metal conduit (IMC) in areas where wiring might be subject to physical damage.
  - Ensure all cables and conduits are securely strapped and supported according to NEC requirements, and consider exceeding minimum support requirements in areas vulnerable to structural movement.
- **Backup Power Readiness:**
  - Facilitate the safe use of portable generators by installing a manual transfer switch or, at minimum, a generator interlock kit on the main panel.[2] This prevents dangerous backfeeding onto utility lines, protecting line workers. TL Davis Electric & Design's service offerings include generator inlet box installations, indicating local demand and expertise.[53]
  - For critical facilities or homeowners desiring seamless backup, recommend professionally installed standby generator systems with automatic transfer switches.
- **Elevation of Components in Flood-Prone Areas:** For properties susceptible to localized flooding that can accompany severe storms, consider elevating electrical outlets, switches, and critical appliance connections above anticipated flood levels.
- **Collaboration with Builders and Structural Engineers:** In new construction projects, early collaboration between the electrical contractor, builder, and structural engineer is beneficial. This ensures that electrical pathways, service entrance locations, and equipment mounting are considered within the context of tornado-resistant structural designs, such as those outlined in OUBCC Appendix X.[50] For instance, reinforcing the wall section where the meter base and panel are mounted can improve their survivability.

The service entrance—comprising the mast, meter base, and connection to utility lines—is a consistently identified point of failure. Its exposed nature makes it vulnerable to direct wind forces and cascading failures when utility poles and lines are downed.[2] Enhancing the structural integrity and secure attachment of these components is a key area for improving individual property resilience.

D. The Role of Master Electricians in Safe and Effective Community Recovery:

Master Electricians and their teams play a pivotal and multifaceted role in the aftermath of tornadoes, extending far beyond simple repairs. Their expertise is fundamental to restoring normalcy and ensuring the long-term safety of affected communities.

- **Providing Technical Expertise and Guidance:** Homeowners and business owners are often overwhelmed and unsure how to proceed after a disaster. Master Electricians provide essential guidance on the scope of electrical damage, the necessary repairs, and the importance of adhering to safety standards and electrical codes.
- **Identifying Hidden Dangers:** As detailed previously, tornadoes can cause latent electrical hazards that are not immediately obvious.[28] A key role for the electrician is to conduct thorough, professional inspections to uncover these hidden issues—such as compromised wiring insulation, water-damaged components, or faulty grounding—thereby preventing potential future fires or electrical shock incidents.
- **Facilitating Timely and Efficient Individual Restoration:** Once utility power is restored to an area, electricians are crucial in addressing the "last mile" of restoration to individual properties. This involves repairing or replacing damaged service entrance equipment (masts, meter bases, panels), which is the customer's responsibility, before the utility can safely reconnect power.[2] In a post-disaster scenario with high demand, efficient work by electrical contractors is vital to minimize the time residents and businesses remain without power.
- **Advising on Resilience Upgrades:** The rebuilding phase presents a unique opportunity to enhance the resilience of electrical systems. Electricians can advise clients on upgrades such as whole-house surge protection, generator interlocks, more robust service entrance installations, and improved wiring methods, helping them build back stronger and safer than before.
- **Community Education and Awareness:** Electricians can contribute to community preparedness by sharing information on electrical safety during and after storms, the importance of professional inspections, and safe generator use. This can be done through local workshops, informational materials, or community group engagement.
- **Coordination with Authorities Having Jurisdiction (AHJs) and Utilities:** Ensuring that all repair work meets current electrical codes and passes inspection

by the local AHJ is a fundamental responsibility. Effective communication with utility companies is also necessary to coordinate the reconnection of service once customer-side repairs are completed and approved.

- **Upholding Ethical Practices:** In the chaotic aftermath of a disaster, property owners can be vulnerable to unscrupulous or unqualified individuals posing as contractors. Reputable Master Electricians uphold ethical standards by providing honest assessments, fair pricing, and high-quality, code-compliant work, thereby protecting consumers from contractor fraud.[31] Companies like TL Davis Electric & Design, with positive customer reviews emphasizing professionalism, honesty, and quality work, exemplify this role.[53]

The contribution of skilled electrical professionals is thus indispensable not only for the immediate technical tasks of repair and restoration but also for safeguarding the community against future risks and promoting a more resilient built environment.

VI. Conclusion

The analysis of tornado activity in the Greater Tulsa Area during 2023 and 2024 reveals significant and recurring vulnerabilities within both utility-scale and customer-side electrical systems. Utility infrastructure, including transmission and distribution poles, conductors, and even substations, has repeatedly suffered extensive damage, leading to widespread and often prolonged power outages.[10] On the customer side, service entrance equipment has proven to be a frequent failure point, with subsequent damage to internal wiring and connected equipment due to structural collapse and water ingress.[29] The financial costs associated with this damage are substantial, impacting homeowners, businesses, and utility providers alike.

The critical role of skilled and licensed electrical professionals, such as Mr. Terry Davis and the team at TL Davis Electric & Design, cannot be overstated in the context of tornado recovery. Our expertise is essential for conducting accurate and thorough damage assessments, identifying both overt and hidden electrical hazards, and performing safe, code-compliant repairs that are fundamental to restoring power and ensuring the safety of occupants.[30] Furthermore, electricians are uniquely positioned to advise property owners on measures to enhance the resilience of their electrical systems against future tornadic events, transforming the rebuilding process into an opportunity to build back stronger and safer.

Looking forward, a multi-faceted approach is necessary to mitigate the impact of future tornadoes on the region's electrical infrastructure. This includes continued investment by utility companies in hardening their systems, such as PSO's Catoosa-Verdigris transmission line rebuild project [37], which aims to strengthen key parts of the grid. The adoption and stringent enforcement of robust building codes, including provisions like Oklahoma's Appendix X for residential tornado resistance [50], are vital for protecting the building envelope and, by extension, the electrical systems within.

Emerging technologies, such as AI-driven damage assessment models [54], may offer new tools for speeding up post-disaster evaluation. However, the foundational elements remain skilled workmanship, adherence to evolving best practices, and a collective commitment from utilities, contractors, code officials, and property owners to prioritize electrical safety and resilience.

The consistent pattern of tornadic activity in the Greater Tulsa Area underscores that proactive planning and continuous improvement in electrical system design and installation are not merely advisable but essential for the long-term safety and well-being of its communities.

Disclaimer:

TL Davis Electric & Design put this report together for informational purposes only. It’s not legal, financial, or engineering advice, and we’re not on the hook for any investment moves, construction choices, or design tweaks you make after reading it. Always run big decisions past your own pros before you break ground—or break the bank.

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