

STORM RESTORATION · OCTOBER 2026

Days to see, hours to act

After a major storm, a utility cannot plan its restoration until it knows what broke, and finding out still takes days. Drones and AI can compress that to hours, but programs stall on flight rules, on the missing record of the network, and on unwritten rules for turning a finding into a work order and a restoration estimate.

By the 6th Wave R&D team · 12 minute read

Winter Storm Fern reached Nashville on the weekend of January 24, 2026. Once it was safe to work, Nashville Electric Service began damage assessment on Monday, January 26. Some assessors could not reach their assigned circuits until the Tuesday or Wednesday. Each assessment crew was one driver and one assessor, and some line crews were sent ahead of them to do their own assessments, "resulting in potentially duplicative effort." By the time NES released its first global estimate of restoration time, on Day 7, about 80 percent of damage assessment had been completed.¹ Outages had peaked at 230,000 customers across 294 square miles; restoration reached 99.9 percent 13 days after the storm.² The independent review commissioned afterward found NES "could have restored power two to five days earlier" with faster outside help.²

The repair work in that storm was hard, but the first constraint was not repair. It was knowing what needed repairing. Until a utility knows which poles are down, which spans are on the ground and which transformers are gone, it cannot size its crews, assign the work or tell customers when the lights will come back. This paper sets out the evidence that damage assessment is the bottleneck in major-storm restoration, why drones and AI can compress it from days to hours, and why most utility programs have not yet done so. It is written for the COO, the head of distribution operations and the storm director who must decide what to build before the next season.

Restoration cannot be planned until damage is seen

The dependency is stated plainly by utilities and regulators alike. The Public Utility Commission of Texas, in its investigation of Hurricane Beryl, noted that "utilities may delay the deployment of work crews until damage is assessed."³ During Hurricane Francine, Entergy explained that "as damage assessments are completed," its utilities "can provide restoration time estimates."⁴ PA Consulting's review of Fern for NES concluded that "the accuracy and refinement of ETRs are highly dependent on the timeliness and quality of damage assessment information."¹

The scale of recent storms makes the dependency costly. In 2024, major events accounted for 80 percent of the hours US customers spent without power; Helene left 5.9 million customers without power across 10 states, Milton 3.4 million in Florida and Beryl 2.6 million in Texas.⁵ Georgia Power alone recorded more than 1.5 million outages in Helene, more than 12,300 broken poles and more than 1,500 miles of downed lines, and fielded 755 damage assessment teams alongside a workforce that grew to more than 20,000.⁶ Duke Energy mobilized more than 25,000 personnel to western North Carolina and set up 36 base camps, double its previous record.⁷ Days into that response, its Carolinas storm director said there were "stretches of damage that we still can't even assess," blocked by mudslides, flooding and closed roads.⁸ Florida Power & Light reported that flooding and closed roads were "delaying damage assessments and restoration efforts" after Milton.⁹

Every day spent seeing the damage is a day thousands of mobilized workers wait for assignments, and a day customers wait without an estimate. Florida regulators approved \$1.125 billion in final FPL restoration costs for Debby, Helene and Milton, \$774.4 million of it for Milton alone.¹⁰

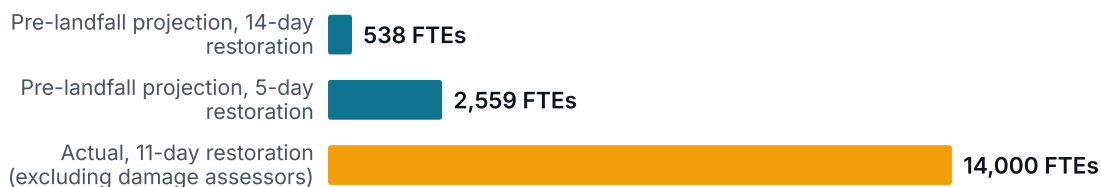
A blind estimate sizes the response wrong

When the damage is not seen, the response is sized by models and memory. Before Beryl made landfall, CenterPoint's damage prediction model, which the PUCT found "was largely ineffective and offered little value in decision-making," projected that restoration would need between 538 full-time-equivalent workers for a 14-day restoration and 2,559 for a 5-day restoration. The outcome was "14,000 FTEs who delivered an 11-day restoration," excluding damage assessors (Exhibit 1). The model "was limited to Hurricane Ike data (2008)."³ For the first two days of recovery, more than 2.2 million CenterPoint customers "lacked independent access to information about their outage statuses," and the PUCT recommended that the legislature codify "a customer's right to information about restoration times."³

EXHIBIT 1

Before Beryl, the damage model underestimated the restoration workforce by a factor of five or more

CenterPoint restoration workforce, full-time equivalents



Source: Public Utility Commission of Texas, *Investigation of Emergency Preparedness and Response by Utilities in Houston and Surrounding Communities*, Project No. 56822, November 21, 2024.

Three days after landfall, CenterPoint crews were still "completing damage assessment," with more than 8,500 miles of circuits examined.¹¹ The PUCT also found that "some utilities experienced delays issuing work orders to field crews due to the sheer number of field personnel."³ Seeing the damage late does not only slow the first crews. It degrades every downstream decision: how many crews to request, where to stage them, what to assign them, and what to tell the public.

The way most utilities see damage has not changed

The NES review is the most detailed public account of how assessment actually works in a large storm, and its findings will be familiar to any storm director. NES "only has one type of damage assessment," whereas peers such as FPL and Con Edison run a rapid feeder-level assessment first and a detailed one afterward. The process "relied on specialized knowledge, internally developed applications" that "could not be readily utilized by external contractors." Assessors "were not always sufficiently ahead of repair crews." NES explored drones and LiDAR only "several days into the event."¹

The finding that matters most is about rules, not tools. The review states: "The ERP does not dictate the timing of when to send damage assessment crews, nor does it specifically define how damage assessment information is to be utilized by Command Center personnel."¹ The emergency response plan said assessment should happen. It did not say when, in what sequence, or how its results should turn into decisions. Those choices were left to the people in the room, in the middle of the worst storm in the utility's history.

The table lists the five steps a damage finding must pass through before it becomes a restoration estimate. In most utilities only the first is well equipped.

From a damage finding to a restoration estimate	
Find	Someone or something observes the damage: a patrol, a helicopter, a drone, a customer call or a smart meter that stops reporting.
Locate	The finding is matched to the right pole, span, device and circuit in the utility's record of its network. Imagery that does not line up with that record has to be matched by hand.
Size	The damage is turned into a job: what crew type, what materials, how many hours. Usually an assessor's judgment.
Assign	Jobs are sequenced into work orders against restoration priorities and crew availability. The PUCT found work orders lagged the workforce in Beryl.
Estimate	Jobs roll up into a circuit and global restoration estimate. NES's first global estimate came on Day 7, with 80 percent of assessment done.

Drones can see in hours what crews see in days

The evidence that aerial assessment can compress the first step is now strong. After Helene, Georgia Power's aerial services team "received an FAA waiver to fly drones beyond visual line of sight" and completed more than 100 aerial patrols surveying more than 2,200 miles.⁶ Oak Ridge National Laboratory teams flew more than 100 drone flights in Florida, North Carolina and East Tennessee after Helene and Milton, collected more than 400 GB of data focused on poles and transmission lines, pushed it out within 10 minutes of landing, and produced a downed-pole map for a utility partner in a task that "normally would take days": "We had a map ready for him in an hour."¹² FPL reports that its aircraft and smaller drones have captured more than 1 million photos, and it is using vehicle cameras for "near real-time collection of our damage using AI."¹³

Docked drones that launch without a pilot on site are arriving too. In May 2025 AEP Texas deployed a docked drone at a substation, flown remotely under an FAA waiver from offices in other states, and plans 10 docks.¹⁴ The utility trade associations told the FAA that drones "assess damage even before crews arrive, speeding up restoration efforts," that their members report "cost reductions of up to 80% compared to legacy inspection methods," and that "delays in these inspections can significantly impede operational feedback and prolong restoration timelines."¹⁵ Xcel Energy says drones "eliminate the mobilization time of getting a lineman or a truck up to the site."¹⁶

Three things stall the programs

Flight rules are still exceptions

Under current rules, flying beyond visual line of sight requires a waiver or exemption granted case by case. The FAA's own data, published with its August 2025 proposed rule for normalizing such flights, counted 86,181 tracked beyond-line-of-sight flights in 2024. Package delivery accounted for 80,955. Linear infrastructure inspection, the category that includes power lines, accounted for 583, under 1 percent (Exhibit 2). About 230 operators held waivers indicative of such operations.¹⁷

EXHIBIT 2

Power-line inspection is under 1 percent of the beyond-line-of-sight flying the FAA tracks

Tracked BVLOS flights in 2024, by operation type



Source: FAA and TSA, *Normalizing Unmanned Aircraft Systems Beyond Visual Line of Sight Operations*, Notice of Proposed Rulemaking, 90 Fed. Reg. 38212, August 7, 2025, Table 9. Total tracked flights: 86,181.

The proposed rule, Part 108, would help utilities directly. It would treat airspace within 50 feet of power lines and substations as "shielded" when the owner grants permission, giving drones right-of-way there, and it notes that "traditionally, close-up inspection by manned aircraft... has been the method used by electrical transmission and pipeline utilities."¹⁷ FAA

Administrator Bryan Bedford called normalizing these flights "key to realizing drones' societal and economic benefits."¹⁸ But as of October 12, 2026, no final rule has been published. The FAA reopened comment in January 2026 on electronic conspicuity and right-of-way, the docket holds 3,929 comments, and an FAA official said in September that the agency hopes to have the final rule out before the end of the year.^{19,20} The trade associations have asked for utilities to be classed as "civic interest," for the cap of 25 aircraft to be removed, and for a two-year transition for existing waivers.¹⁵

The fleet itself is in question

Utilities fly largely foreign-made drones. In the trade associations' member survey, 26 percent of respondents fly all-foreign fleets and 59 percent fly fleets that are at least half foreign-made, although the survey's sample size was not disclosed (Exhibit 3).¹⁵ On December 22, 2025, the FCC added foreign-produced drones and critical components to its Covered List; new models cannot be authorized for import or sale, although the listing "does not affect any previously-purchased drone."²¹ In July 2026 the FCC proposed restricting continued imports of some previously authorized foreign drones.²² In a broader survey of 8,056 drone operators before the ruling, 56 percent of agriculture, utility and public-safety respondents said losing access to DJI could "potentially end" their operations.²³

EXHIBIT 3

Most utility drone fleets depend on foreign-made aircraft that new models can no longer replace

Share of surveyed utility trade-association members, %



Source: EEI, APPA, NRECA and LPPC, joint comments on FAA Docket FAA-2025-1908, October 6, 2025 (sample size not disclosed); FCC Covered List update, December 22, 2025.

Seeing more is not the same as knowing more

The third constraint is the least discussed and the most important. Drones multiply the images a utility collects, and someone has to turn them into findings. AEP Ohio's 2025 drone pilot covered about 4 percent of its distribution network, surfaced more than 150 "tier one" issues, and produced 400,000 to 500,000 images; one person "went through the entire year

spending 500 plus hours" reviewing them.²⁴ EPRI has collected more than 150,000 images of utility infrastructure for AI training, but only some are labeled and shared.²⁵

The published accuracy of AI on storm damage is real but modest. The clearest peer-reviewed benchmark, an Oak Ridge system that classified poles as damaged or undamaged on board the drone using Hurricane Ida imagery, scored an F1 of 0.65.²⁶ A June 2026 preprint reached an F1 of 0.92 from damage identification through repair scheduling, but on 1,700 synthetic hurricane scenarios, not field data.²⁷ A peer-reviewed audit of 15,814 buildings across three hurricanes found that satellite and drone damage labels disagreed 29 percent of the time, and that satellite labels under-reported damage by at least 20 percent.²⁸ Satellites can show where the power is out, from night lights, but not what broke.²⁹ We found no utility that has published precision and recall for AI damage detection on its own storm imagery.

The first operational drone-based machine-learning damage assessment, used at Hurricanes Debby and Helene, identified four failure modes that delayed or degraded its products. One of them was spatial misalignment between the imagery and existing geospatial data.³⁰ A finding has to land on the right asset in the utility's record of its network to become a job. The most recent multi-utility survey of GIS accuracy we could find, from 2019, reported that only 23 percent of utilities had high confidence in their GIS data and that 25 percent took more than 30 days to post updates.³¹ The NES review found its assessment tool and outage management system were not integrated.¹ Without a current record of the network to compare against, an image of a broken pole is a picture, not a work order.

What the people shaping the next four years expect

- **The flight rules will change.** The FAA describes Part 108 as close to final, and the utility associations expect most utility flying to become automated; 68 percent of their surveyed members plan for at least 80 percent of beyond-line-of-sight operations to be automated within ten years.^{20,15}
- **Docks will make drones a standing asset, not a storm rental.** EPRI is installing docks at its own lab because "there is little experience with these technologies."³²
- **Regulators will demand faster information.** The PUCT has recommended a customer's right to information about restoration times, and the NES review's recommendations call for drones, remote sensing and "advanced analytics to accelerate damage identification."^{3,1}
- **The workforce will not grow fast enough to see everything on foot.** The Bureau of Labor Statistics counts 131,900 line installer and repairer jobs, growing 10 percent over a decade.³³ Beryl alone drew 14,000 FTEs.³

Our own expectation follows from the evidence. Within two storm seasons of a final Part 108, aerial damage assessment will be standard at large utilities, and the bottleneck will move. Seeing the damage will take hours. The constraint will become everything after the image: matching it to the right asset, sizing the job, sequencing the work and publishing an estimate. Utilities that have a current record of their network, written rules for when assessment launches and how its findings flow into work orders and restoration estimates, and AI that is measured on their own imagery will release credible restoration estimates in the first day. Those that buy drones without those things will collect more pictures and publish their estimates no sooner.

A decision framework for the COO and the storm director: four moves

1. Write the assessment rules into the plan

Fix what the NES review found missing: when assessment crews and aircraft launch, in what sequence circuits are assessed, who receives the findings, and how command staff use them.¹ Adopt a two-stage approach, a rapid feeder-level pass followed by detailed assessment, as FPL and Con Edison do. Set the clock for the first global restoration estimate in the plan rather than waiting for assessment to finish.

CONCRETE MARKER

The emergency response plan states the launch trigger, sequence and owner for ground and aerial assessment.

CONCRETE MARKER

The first global restoration estimate is due at a set time after the storm passes, with a stated confidence.

2. Keep a record of the network that a finding can land on

Before investing further in aircraft, make sure each finding can be matched to a pole, span and device automatically. Measure the accuracy and update lag of the network record on the circuits most exposed to storms, and fix them first. Pre-storm imagery of those circuits is the baseline that turns a post-storm image into a change.

CONCRETE MARKER

For the highest-risk circuits, the network record is verified against current imagery before each season.

CONCRETE MARKER

Aerial findings are matched to assets without manual re-keying, and unmatched findings are counted.

3. Measure AI on your own storms before trusting it

The published benchmarks are good enough for triage, not for unattended work orders.²⁶ Run AI detection in parallel with human review on real storm imagery, record precision and recall by asset type, and use AI first to rank images for review, which addresses the 500-hour review problem.²⁴ Promote it to drafting work orders only when its record justifies it.

CONCRETE MARKER

Precision and recall for each AI detection model are measured on the utility's own storm imagery and reported by asset type.

CONCRETE MARKER

Every AI-drafted work order is traceable to the image and the asset it came from.

4. Prepare the fleet and the flight authority now

Inventory the drone fleet against the FCC Covered List and plan replacement of aircraft that cannot be resupplied.²¹ Secure the waivers available today and be ready to transition to Part 108 the day it is final.^{17,15} Pre-agree flight areas and owner permissions for shielded operations near lines and substations, so aircraft can fly the first morning after a storm.

CONCRETE MARKER

The drone fleet has a documented replacement path that does not depend on newly authorized foreign models.

CONCRETE MARKER

Flight authority for storm assessment over the highest-risk circuits is in place before the season.

The leadership test

Leaders can locate their utility by asking six questions:

1. On our last major storm, how many hours after the all-clear did we know what broke on 80 percent of the system, and how many hours after that did we publish a global restoration estimate?
2. Does our emergency plan say when assessment launches, in what order, and how command uses what it finds, or does the storm director decide in the moment?
3. If a drone photographed a broken pole tonight, could we match it to the right asset and circuit without someone re-keying it?
4. How accurate is our network record on the circuits most likely to fail in a storm, and when was it last checked?
5. What precision and recall does our AI damage detection achieve on our own storm imagery?
6. If Part 108 were final tomorrow, and our current drones could not be replaced, could we fly the morning after the next storm?

Utilities that can answer these questions will see their damage in hours and act on it the same day. Those that cannot will add aircraft and still wait days to tell customers when the lights come back.

Restoration is limited by what a utility can see, and how quickly it can turn what it sees into work. The aircraft are ready and the flight rules are close. What most utilities still lack is the record to compare against and the written rules for what happens after the picture is taken. The drone is the easy part. Turning a picture into a restoration estimate is the work.

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About 6th Wave R&D

6th Wave R&D is the research and development team of 6th Wave Ventures. It publishes independent analysis on how utilities forecast, assess and act on their hardest days, and what that means for AI and autonomy on the grid. Every figure in this paper is drawn from public sources, listed in the notes.