

From Risk to Resilience

Extreme Weather Events



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Extreme weather events and low-probability occurrences drastically impact the network, causing significant economic damage and protracted loss of supply to customers. These events include flooding, heatwaves, snowfall and high winds. Heatwaves can cause line sagging and conductor derating, as well as the potential for fires where sagging lines contact vegetation, and flooding can inundate substations. In the UK, the most common and drastic of these events are winter storms. These cause significant disruption through high winds and heavy rainfall, which damage electricity cables both directly and through treefall, and can flood transformers and other ground mounted assets.

The majority consensus expects storms to become more intense with heavier rainfall in the future, as the UK climate shifts towards hotter, drier summers and rainier winters^{10,11}. Changing patterns of rainfall and wind direction may introduce vulnerabilities and require the siting of assets, management of vegetation and orientation of electricity lines to be reconsidered. Changing rainfall and climate patterns have seen a consistent increase in vegetation growth rates, increasing the risk of tree damage from storms. Increasing electricity dependency due to the Net Zero transition will also increase customer vulnerability to power cuts.

The period from 2021 to 2025 has seen an increasing frequency and severity of storms testing the resilience of the distribution network:

- *Storm Arwen (Nov 2021)*: Left 1 million homes without power, some for over a week. It exposed the inability of DNOs to identify “nested faults”, secondary damage on lines that had already tripped.
- *Storm Babet (Oct 2023)*: Unlike the wind-driven Arwen, Babet brought exceptional rainfall, causing extensive flooding in the Midlands and Scotland. Substations were inundated, and physical access for repair crews was blocked for days, highlighting the vulnerability of ground-mounted assets to sudden flooding.
- *Storm Darragh (Dec 2024)*: Impacting 2.3 million customers and causing widespread damage across Wales and the West, this storm demonstrated the compounding effect of high winds on sodden ground, leading to higher rates of tree fall.
- *Storm Éowyn (Jan 2025)*: The first Red Warning storm for Northern Ireland in years, leaving over 1 million customers without power across Northern Ireland and Scotland. It reinforced the “long tail” of restoration, where complex, nested faults delay the final 1-2% of reconnections.

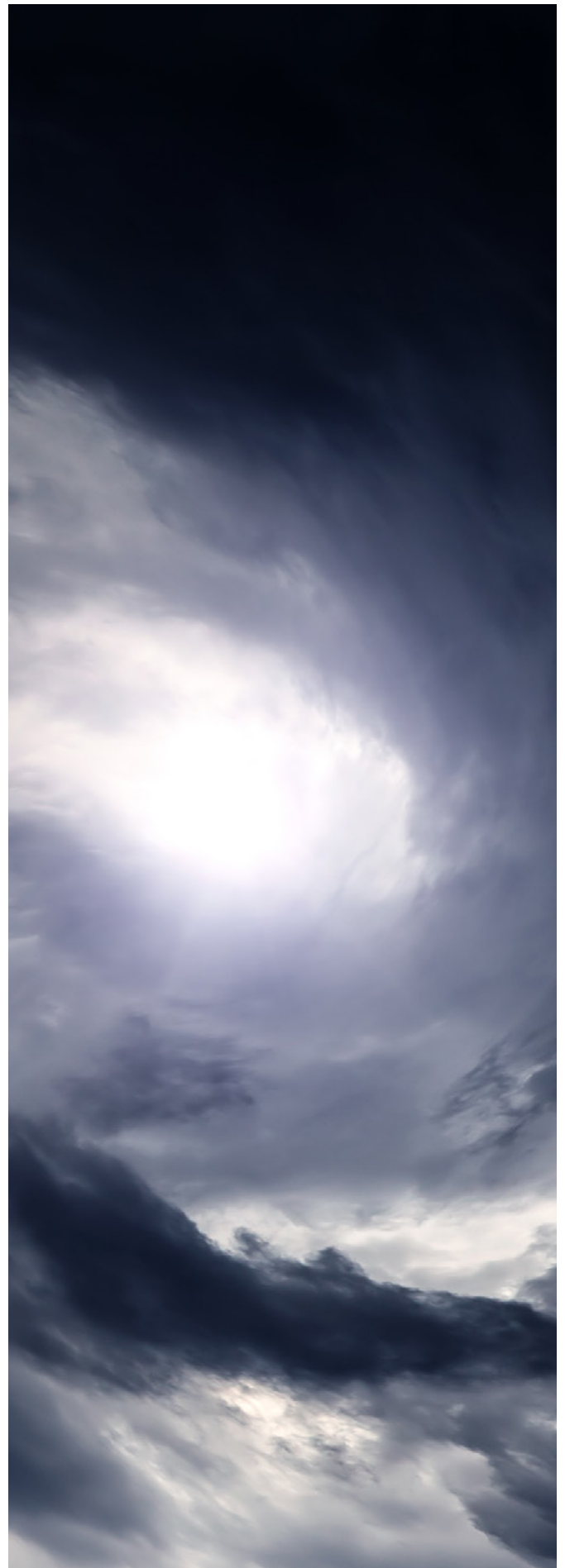


Table 1: Major UK Storm Events and Electricity Network Impacts (2020–2026)

Storm	Date	Max Wind	Worst-Affected Areas	Customers Disconnected	Max Duration
Arwen	Nov 2021	~100 mph (NE Scotland)	NE England, Scotland (esp. Aberdeenshire, Northumberland)	~1,000,000	Up to 13 days (worst cases)
Eunice	Feb 2022	122 mph (IoW — England record)	S. England, Wales, SE England	~1,400,000 (record)	Up to ~5 days (some SE England)
Dudley / Franklin	Feb 2022	~75 mph (Dudley); ~80 mph (Franklin)	N. England, Scotland, W. Scotland	~200,000 (combined)	Up to ~24 hrs
Darragh	Dec 2024	~93 mph	Wales, SW England, Midlands	~2.3 million (cumulative events in 24 hrs); ~260,000 at peak	Up to 4 days (mid-Wales rural)
Eowyn	Jan 2025	~100 mph (NI/Scotland)	N. Ireland (~283,000 peak), Scotland (~22,000+), N. England	~621,000 GB; +283,000 N. Ireland = ~904,000 total	Up to 10 days (N. Ireland rural)
Goretti	Jan 2026	~99 mph (SW England)	SW England, S. Wales, W. Midlands (also heavy snow)	~247,000 (National Grid ESO area); ~65,000 at 8am 9 Jan	Several days in worst-affected rural areas

Key vulnerabilities exposed by reviews into the impact of storms such as Arwen included the difficulty of detecting and fixing 'nested faults' - several faults in sequence on the same line - in the lower-voltage levels. These faults often are not picked up until the first breakage on a line is fixed and the line is attempted to be re-energised. Traditionally, these faults would require inspection of the entire affected line, a time- and resource- consuming process. Communications failures caused by disruption of mobile network coverage and overwhelmed DNO call centres also meant that many customers could not report a lack of supply, a key source of information for DNOs attempting to fix faults¹².

Digital line-monitoring technologies can detect nested faults and other advanced fault conditions, as well as providing information on line health and tree proximity in remote and difficult-to-access locations. This can provide a much more effective alternative method to relying on customer reports to track power outages and cable faults, as well as potentially reducing repair times by allowing teams to see the location of all faults including difficult to locate nested faults with greater precision as well as providing information on nested faults.

Case Study: Storm Arwen

Storm Arwen is widely regarded as the most consequential windstorm to affect UK electricity networks in at least fifteen years. The storm tracked unusually from the north, bringing sustained northerly gales, peaking at over 100mph, and snow across east Scotland and North-East England. This northerly wind direction was critically important: UK distribution network overhead lines are designed and orientated primarily for westerly and south-westerly storm loading conditions, meaning that line spans were loaded at their weakest orientation and vegetation was inadequately cleared on the windward (northern) side.

Storm Arwen resulted in approximately one million customers losing supply, with approximately 40,000 losing supply for over three days. Northern Powergrid described Arwen as the largest storm to impact their network since 2005. The Energy Networks Association characterised the event as at least three times as damaging as the 'Beast from the East' winter storm of 2018.





75,000

of customers remained off supply beyond 48 hours

4,000

customers experienced outages lasting more than one week

DNOs paid

£29.6m

in mandatory and voluntary compensation

While 82–83% of disconnected customers had their supply restored within 24 hours, approximately 75,000 remained off supply beyond 48 hours and nearly 4,000 customers, predominantly in remote rural areas of Scotland and Northumberland, endured disconnections of more than one week. Hundreds of distinct faults were recorded across the DNO networks, many requiring the complete replacement rather than repair of overhead line sections. Limited remote monitoring on lower-voltage networks (11 kV and LV) initially prevented DNOs from accurately assessing the scale and geographic distribution of damage by failing to pick up ‘nested faults’, causing delays in recovery and resource deployment.

The severity and prolonged nature of the Arwen outages prompted a formal review from The Energy Emergencies Executive Committee (E3C)¹³. Concurrently, Ofgem conducted a six-month regulatory review¹⁴. The E3C final report contained 45 recommended actions across five categories: network resilience, planning and preparation, incident management, communications and customer support, and post-incident support. Key actions included reviewing overhead line design standards and vegetation management corridors for atypical wind directions; introducing outcomes-based physical resilience standards; improving remote fault-detection capability; reforming GSOP compensation arrangements; and stress-testing DNO websites and call centres. Ofgem’s review concluded that staff had worked hard in challenging conditions but that thousands of customers received an unacceptable level of service, particularly regarding restoration timescales and communications. The three worst affected DNOs, Northern Powergrid, SSEN, and Electricity North West, agreed to pay £10.3 million into consumer resilience funds in addition to £29.6 million in mandatory and voluntary compensation. This event clearly illustrates both the challenges faced by DNOs attempting to rely on historic storm management techniques, and the increasing performance expectations of customers and the regulator.

Conclusions

The UK's distribution networks face the modern challenges of ageing assets coupled with more expensive replacements due to a congested supply chain, an ambitious electrification and net-zero programme which leads to greater network loads and bi-directional flows, high customer expectations of stable supplies and substantial economic damages in the case of outages, and frequent extreme weather events increasing in both intensity and variability – with downed lines also causing potentially deadly public safety hazards.

The challenge for DNOs is to ensure the highest level of supply availability possible at an affordable cost to the consumer. This may entail a reconsideration of the current resilience paradigm – potentially from a “fix-on-fail” approach to a “predict-and-prevent” strategy underpinned by pervasive sensor deployment and real-time data analytics.

Digital technologies to enable this will be explored in the next section.



Key takeaways:

Ambitious policy targets requiring a step change in pace and scale of network investment: Government is four years away from its Clean Power 2030 targets and 25 years (or five RIIO price control periods) away from legally enshrined Net Zero targets. The primary Clean Power target is that by 2030, 95% of the UK's generation comes from clean sources¹⁸. In 2023, Ofgem was accordingly given duties related to sustainable economic growth and Net Zero.

Transformation of the energy system: System-wide electrification, decarbonisation and electricity demand growth putting pressure on the grid. Higher risk of cascading and compounding impacts through increased interdependencies between sectors. Challenges around the actual rate and pace of electricity demand growth. According to NIC, £37-50 billion of investment in the distribution network (a doubling of current annual allowances) could be needed to support additional demand and generation between today and 2050¹⁹.

Transformation of social and economic energy-use patterns: More people are working from home, running businesses from home, shopping from home etc. Heat, light and power are increasingly reliant on electricity.

Anticipated increase in climate-change related risks and challenges such as extreme weather events: Previous years' extreme weather events (e.g. Storm Eowyn, Storm Arwen) expose vulnerabilities in outage emergency response, particularly where Critical National Infrastructure (CNI) is concerned.

The interconnectedness of networks presents increased vulnerability due to cyberattacks and power grid blackouts as seen in April 2025 in Spain and Portugal with cascading impacts on critical infrastructure such as mobile and internet services and the broader economy.