How utilities can combat diverse threats to decentralised grids

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Energy generation and storage is rapidly being moved from the centre to the edges of the network, with far-reaching consequences for grid management and oversight. Across the world, the policy direction is increasingly towards distributed generation with the UN 2030 Agenda for Sustainable Development, the EU Framework 2030, European Green Deal, and an EU Directive all championing self-sufficient energy communities. UK community energy organisations have already delivered over 30MW of renewable power with community groups funding 175 new renewable energy schemes ranging from solar to hydroelectric, while the EU predicts that energy cooperatives could own 17% of its installed wind capacity within a decade.

Pioneering projects include Germany's Energy Cooperative Heilbronn-Franken, the Orkney Community Windfarm Project, the Bright Tucson Community Solar Program in the US, and UK initiatives to exploit ground-source heat pumps in hundreds of urban parks.

'Interconnection', which allows small-scale renewable energy projects to connect to the electric grid, will mean that national grids increasingly draw on these local, community-run power sources. Home energy storage and vehicle-to-grid technology are similarly decentralising energy storage, transforming homes and cars into batteries that share power with the grid. Experts predict that renewable electric grids will have to draw on a mix of centralised and decentralised power to remain flexible and resilient. In theory, a diverse and decentralised array of local and central power sources will improve resilience by enabling grids to adapt to sudden local fluctuations in wind, sunshine, or consumer demand. This also creates growing interdependence between local power sources and regional or even national grids.

A little-known consequence of the decentralisation of energy is the consequent fragmentation of the geospatial network data traditionally used to capture, monitor, and protect electric grids. With generation and storage capacity splintered among far more people and places, vulnerabilities will be more widely dispersed and difficult to manage. Distributed generation can blur visibility over all the subtle dependencies between a network's local assets and the potential for many systemic vulnerabilities to natural hazards.

Learning the lessons of Winter Storm Uri in Texas

This comes at a time when studies show extreme weather events are increasing in frequency and 83% of utility companies expect high-impact extreme weather events to affect future grid stability. The potential effect of extreme weather on diverse and decentralised grids was recently illustrated by events in the United States. Texas prides itself on a diverse mixed energy grid that includes abundant solar power and the country's largest wind

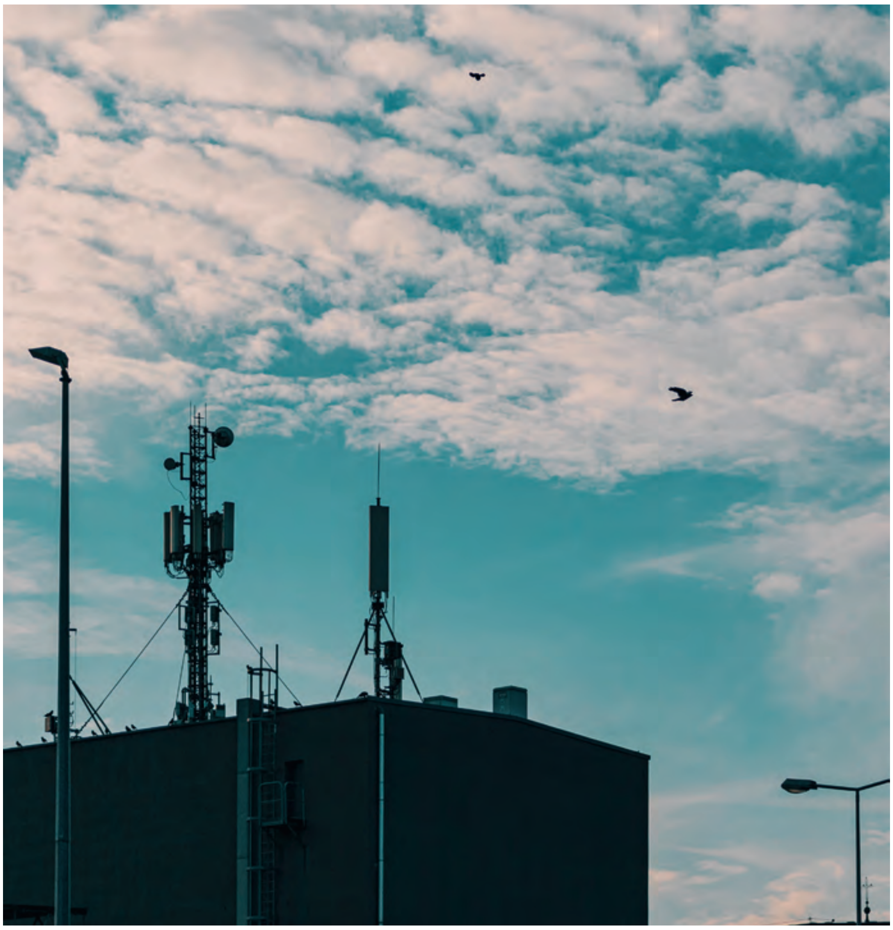
energy production capacity. Yet Storm Uri exposed a 'single point of failure' across these interconnected power sources with ice simultaneously freezing wind turbines and affecting other power sources from solar to nuclear and natural gas, costing $130 billion and leaving 4 million people in the cold and dark. The move away from centralised generating capacity towards local power sources means that what happens in one place increasingly matters everywhere else. An ice storm affecting a community solar project and a neighbouring wind farm are no longer merely local problems when those projects are connected to the electric grid.

One of the possible failings behind the Texas energy crisis pinpointed by investigators was the failure to institutionalise insights from previous severe weather events which had already exposed its vulnerability to extreme cold. Decentralised grids need to learn what happens in each location and cross-pollinate that knowledge across the grid to avert similar future hazards so that the entire grid grows collectively stronger from each failure. Yet energy operators struggle to collect vital insights from decentralised assets because they often still use centralised Geographic Information Systems (GIS), paper-based network maps, and Excel spreadsheets. These are relics of centralised fossil fuel grids and cannot easily incorporate new information from the abundant array of local sources in the field.

The risk from grid data fragmentation

Despite the fact grids increasingly generate power at the edge of the grid, they are not collecting information from the edges effectively. This means they lack an integrated overview of local vulnerabilities, defects, or hazards from local field technicians or communities running local power sources. These maps can only be amended by specialist GIS cartographers in central offices and are thus not fit for purpose in a world of diverse and decentralised grids that rely on widely dispersed power sources. There is a gap between network maps and the reality on the ground and this gap is growing as grids are expanded through new local renewable energy generators and interconnection with community renewable projects.

Complex network assets are often still represented in non-interactive ways, which means they are neither timely nor accurate and do not respond efficiently to the needs of mobile field teams that need to see and capture real-time information on local hazards. This compromises the ability to manage our increasingly dispersed and fragmented networks and exacerbates field update backlogs that can already take weeks or months to capture important field as-built data. We have worked with utility companies where as many as 50% of their



as-builts are wrong and we have spoken to another with 50,000 updates stuck in their as-built queue. Records of damage, degradation, or repairs are similarly out of date. This is a major potential threat when modern mixed grids must monitor damage or hazards across a much more widely distributed web of power sources both local and central, large and small.

Outdated, inaccurate and inaccessible network data can hinder disaster resilience and response both in the office and the field. They delay vital repairs and upgrades as technicians on the ground cannot quickly access accurate data on the position and condition of nearby assets or their proximity to hazards.

Another key failing in Texas is that it took several days to get their grid back online due to delays restoring affected generators, something that is often exacerbated if network data is not easily accessible or up to date.

Even worse, the central office cannot get the comprehensive, current overview needed to proactively identify and pre-empt critical vulnerabilities or risks to grid stability. Crucially, this impedes the ability of operators to learn lessons from damage or disruption in one part of the network and incorporate these into best practice across the grid. It means that grids fail to get 'smarter' over time.

Applying the lessons from Typhoon Faxai in Japan

Some countries with long experience of extreme weather events are providing valuable lessons on how to develop geospatial strategies and systems that make distributed grids more disaster resilient. Japanese power giant TEPCO recently responded to damage from storms and typhoons by decentralising its network data so that information on hazards, damage or degradation can be seen and sent by everyone, from operations centre staff to local field engineers or local producers.

They made their network data more user-friendly, open, and accessible to every mobile device or web browser so it can be rapidly updated by workers in the field to create a comprehensive and current overview of utility grid damage and hazards. Field workers can quickly record recent new builds, repairs, or upgrades as well as damage, degradation, or risks.

When Typhoon Faxai damaged their network, the system was used to allow both central managers and field crews to rapidly view and update critical network information, blackout locations, and damage in any location. Their system is integrated with Google Maps to make it easy for field technicians and construction teams to find unfamiliar locations and identify facility characteristics.

This helps target resources efficiently and effectively and incorporates valuable insights from damage to one asset that could inform risk management strategies to protect other assets. Companies can use this kind of integrated, updated network data to model the impact of future extreme weather events or other worst-case scenarios and implement strategies such as weatherising grids, having reserve margins, or making generators weather-resistant. Accessible and integrated geospatial data enables field crews to continuously correct or update the network overview for all other users creating a virtuous circle where grids become progressively more disaster resilient from each incident. Ultimately, geospatial network data can be integrated with other datasets such as local hazard or weather trend data to create proactive and 'predictive' grids continually anticipating and averting hazards before they arise.

The decentralisation and digitalisation of utility grids means that utilities now face a more complex, distributed, diverse array of threats and vulnerabilities. They must respond by creating an equally distributed and diverse overview of their network's assets, dependencies, and vulnerabilities.

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