GRID RELIABILITY: FOCUS ON ‘WORST-PERFORMING FEEDERS’

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SUMMARY

“Worst-performing feeders,” “low-reliability feeders,” “worst-served customers”— a broad range of terminology is used in different regulatory jurisdictions across the globe, but the meaning is broadly the same. These terms all refer to parts of the electricity grid and thus, by definition, the customers served by those grids that experience markedly below-average levels of power reliability.

Detailed reliability reporting is embedded in most regulatory regimes worldwide, and it has been for some time. In many cases, utilities face reliability targets or are required to meet pre-defined standards, and in some jurisdictions performance is incentivized through the use of financial rewards or penalties. However, in the vast majority of cases the primary focus is on “average” performance, either on the feeder

or, most commonly, across the whole network. The result is a less direct regulatory focus on worst-performing areas. This is changing, and this paper explores the reason for the increased focus on the worst-performing parts of the grid.

First, the paper outlines the approaches used worldwide to monitor and measure "worst performance" and the implications of those arrangements on the actions distribution utilities take. It then considers the drivers behind the renewed focus on worst performance and why these may be evolving. Finally, it sets out the response to those challenges both in terms of the regulatory frameworks, including the use of metrics, standards and incentives, and in terms of technological solutions, with a particular focus on distribution automation and undergrounding. In doing so, the paper draws on evidence from regulatory regimes in the U.S., Canada, Australia, and the UK, including the actions of the regulators and some of the utilities operating in those jurisdictions.

INTRODUCTION

Utilities worldwide report reliability data. This is not surprising because, along with safety, customers consistently identify reliability as one of the most important aspects of utility performance. Most regulatory regimes continue to prioritize reporting "average" reliability. While important, this masks a subset of customers experiencing markedly lower levels of performance.

Historically, there was less focus on areas of "worst performance." This is changing. The reason is closely linked with aspects of reliability and resilience addressed in recent S&C Electric Company publications. In "Moving Beyond Average Reliability Metrics,"[1] S&C considered how reliability metrics are evolving and demonstrated changing customer needs were driving the use of more customer-centric metrics. In addition, in "Trends in Reliability & Resilience – the Growing Resilience Gap,"[2] S&C explored developments in reported reliability performance and, in doing so, highlighted the growing resilience challenges facing networks globally.

Building on our findings in those papers, this paper explores the increased focus on the worst-performing parts of the grid, how that focus is linked to wider trends in reliability and resilience, and why it is critical to the success of the energy transition.

DEFINING 'WORST PERFORMANCE'

A range of terminology is used for customers or parts of the grid that experience below-average levels of power reliability. For the most part, the terms used have a similar meaning, but there are some important differences.

1 "Moving Beyond Average Reliability Metrics." (S&C Electric Company, July 2021)

2 "Trends in Reliability & Resilience—the Growing Resilience Gap." (S&C Electric Company, August 2022)

In the U.S. and Canada, two terms are used interchangeably: “worst-performing feeders” and “worst-performing circuits.” In many U.S. states, utilities are required to report feeder-level information and, in cases such as in Texas, to outline investment plans for addressing underperformance. In Texas, no distribution feeder serving 10 or more customers should have a System Average Interruption Frequency Index (SAIFI) or System Average Interruption Duration Index (SAIDI) value for a year that is more than 300% greater than the system average of all feeders during two consecutive reporting years. Similarly, in Alberta, Canada, Rule 2[3] requires utilities to report annually on the 3% of circuits with the highest SAIDI values, identify the factors behind the poor performance, and describe the actions taken to improve reliability.

In Great Britain, the term “worst-served customers” (WSC) is used, and the definition has evolved over time. The present version defines a WSC as one experiencing on average at least four higher-voltage[4] interruptions per year over a three year period (i.e., 12 or more over three years, with a minimum of two interruptions per year). Distribution utilities receive a per-customer monetary allowance dependent on realizing a percentage improvement target.

Finally, in Australia the terminology varies by jurisdiction. In South Australia, distribution utility SA Power Networks is required to report annually on “Low-Reliability Feeders” (LRFs), including actions to improve performance. The scheme defines LRFs as feeders within a particular region that have exceeded twice the mean unplanned SAIDI for two consecutive years. In Northern Territory, the Utility Commission’s Electricity Industry Performance Code[5] requires Power & Water to report annually on the five “worst-performing feeders” and that it provide details on associated remedial actions. Other states and territories in Australia use similar mechanisms.

MEASURING RELIABILITY PERFORMANCE

Traditionally, IEEE SAIFI and SAIDI measures have been favored for measuring reliability performance. While useful, both measures consider “average” performance. They reveal nothing about the experience of individual customers, including those on the worst-performing parts of the network.

3 “Rule 002: Service Quality and Reliability Performance Monitoring for Owners of Electric Distribution Systems and for Gas Distributors.” (Alberta Utilities Commission, December 2020)

4 In this context, the term higher voltage interruptions refers to interruptions originating on the medium-voltage network or higher voltages up to and including 132 kV.

5 Electricity Industry Performance Code—Standards of Service and Guaranteed Service Levels (Utilities Commission. (Northern Territory of Australia—July 2017)

As demonstrated in S&C’s “Moving Beyond Average Reliability Metrics” paper, this picture is changing. Customers Experiencing Multiple Interruptions (CEMI) is used increasingly throughout the U.S., while Florida Power and Light (FPL) is using the Customers Experiencing Multiple Momentaries (CEMM) metric to drive performance improvements for customers most affected by momentary interruptions. A number of utilities in Ontario, Canada, use the Feeders Experiencing Sustained Interruptions (FESI) metric, while Sweden and Finland use Customers Experiencing Long Interruption Durations (CELID).

These are just examples of approaches to measuring performance, but even this limited overview reveals something about how to approach “worst performance:”

- **“Worst performance” can be measured in different ways:** Across all jurisdictions studied we found differences in measurement. Some were absolute measures, i.e., an aggregate position, whereas others were relative measures comparing to other feeders or customers or to a point in time. Such differences make sense because performance challenges will vary, but it makes comparisons between jurisdictions difficult.
- **“Worst performance” is a not static measurement:** Different challenges can emerge over time, such as population migration or changes in weather patterns, where performance levels improve in some areas and decline in others. Utilities will have varying levels of control over those factors.
- **There are different ways to support those experiencing “worst performance:**” In some jurisdictions, the emphasis has been on monitoring and reporting. In others, utilities are required to have action plans for areas with lower levels of performance. Some have specific targets linked directly to funding. The approaches vary, but we have observed an increasing trend toward using incentive-based regulation in this area.
- **The number of jurisdictions focusing on “worst performance” has increased:** While the approaches to measuring “worst performance” and regulatory responses may vary, the attention being given to “worst performance” is greater than it was 10 years ago. More regulators also have signaled their intention to consider introducing metrics in this area in the future.

WHY ATTENTION IS TURNING TO ‘WORST PERFORMANCE’

As with many aspects of energy policy, views on addressing the challenges associated with “worst performance” have been evolving. There are three main drivers of this change.

Driver 1: Climate Change

Our energy grids face an increasing threat from climate change. In some parts of the world, the challenges are hurricanes and high winds. In others, they are ice storms and heavy snow. Flooding and wildfires are also increasing in prevalence. The risks vary, but what these incidents have in common is they often have a disproportionately greater impact on areas already experiencing relatively poor performance.

In 2019, SA Power Networks in Australia identified long rural feeders made up 122 of the 156 low-reliability feeders.[6] Similarly, in Great Britain, Western Power Distribution (WPD) noted those experiencing high numbers of faults are "generally located on the end of long rural circuits or on remote parts of the network."[7] This is not surprising because many of the areas most exposed are at the grid edge. Investment in grid hardening is, therefore, likely to improve performance for many of the worst-performing feeders.

Driver 2: Changing Customer Needs

Energy customers are relying more on the power grid. This was acutely demonstrated during the Covid-19 pandemic, when our working, shopping, and schooling patterns changed, placing a greater strain on different parts of our grids because of a load shift from cities and office buildings to homes. Environmental goals also have a significant impact. Decarbonization of the power sector means a greater emphasis on electrifying heat and transport. As levels of electrification rise, it will further reinforce reliance on the grids.

Meeting the increased demands on the grid and thereby supporting the energy transition means a greater emphasis on grid resilience. Because the parts of the grid with worst-performing feeders is where the challenge will be most acute, performance-level improvements in these areas will ultimately determine success.

Driver 3: The Importance Of 'Equity'

The energy transition presents many opportunities, but an important consideration is to ensure all customers can benefit from those opportunities. This means no one should be excluded because of where they are connected to the grid.

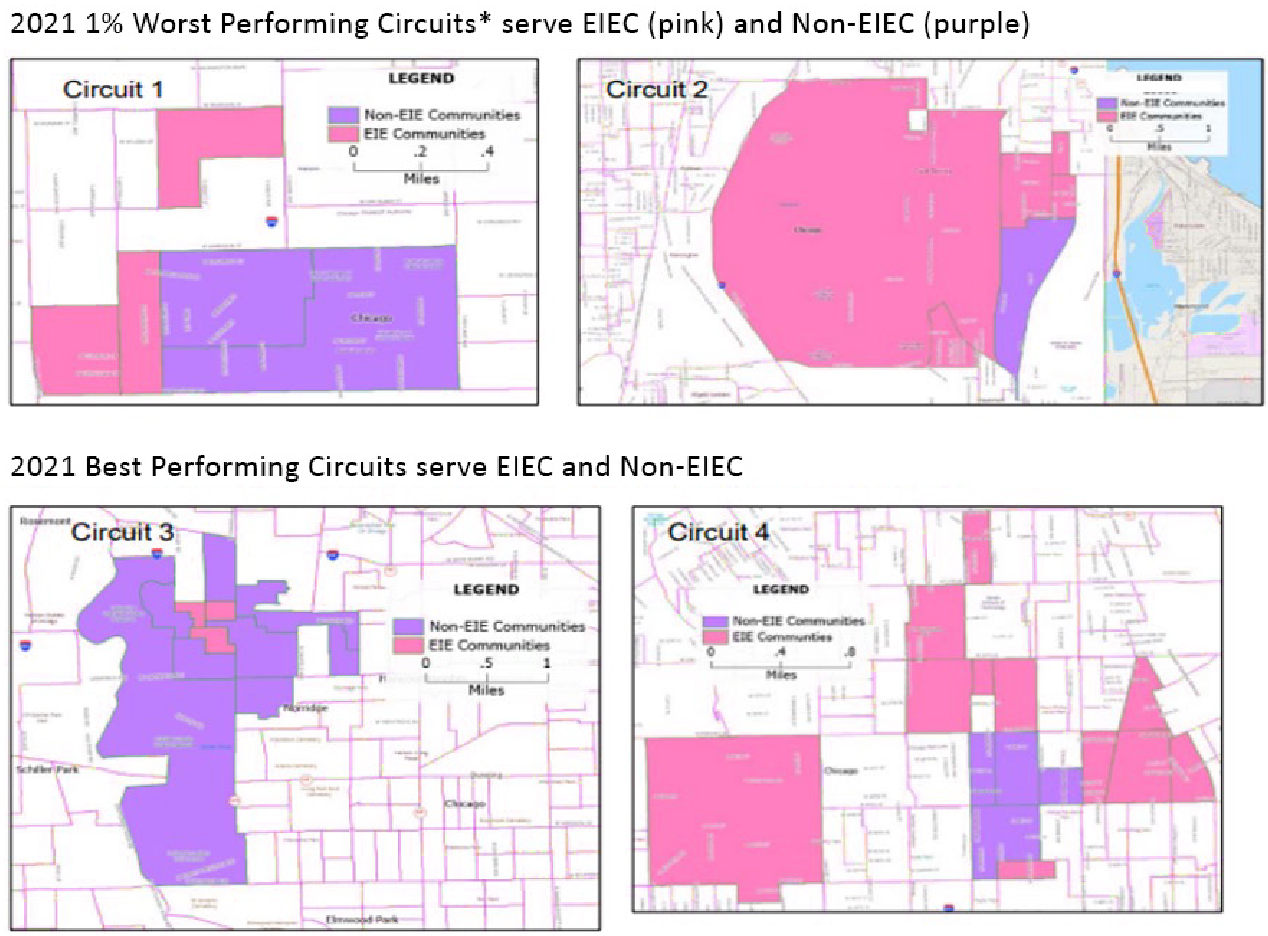
A greater focus on economically and environmentally disadvantaged customers is evident in the U.S. For example, in a recent presentation, Illinois utility ComEd highlighted its worst- and best-performing circuits for 2021 in the context of performance in areas deemed as Equity Investment Eligible Communities (EIEC), i.e., communities that would most

6 "2020-25 Reliability & Resilience Programs—Low Reliability Feeders: 2020-25 Revised Regulatory Proposal." (SA Power Networks, December 10, 2019, p 20)

7 "Business Plan 2023-2028: SA02 Supplementary Annex Our Commitments." (WPD, December 2021, p175)

benefit from investments to combat historic inequities. **Figure 1**[8] shows a portion of the 1% worst-performing circuits could be found in both EIEC and non-EIEC areas on ComEd’s network. The utility also outlined its plans to target poor-performing circuits for improvements.

FIGURE 1. ComEd overview of worst- and best-performing circuits.



Reliability is particularly important for vulnerable customers. This is recognized in the distribution utility investment plans in Great Britain. Both Scottish & Southern Energy Networks (SSEN)[9] and WPD[10] indicated their intention to prioritize WSC based on the proportion of vulnerable customers per feeder.

8 “Perspectives on the Previous & Next 6 Months for Grid Planning.” (ComEd Presentation, Illinois Commerce Commission Website, May 20, 2022, p8)

9 “Powering Communities to Net Zero: Our Business Plan for RIIO-ED2 2023-2028.” (Scottish & Southern Energy Networks, December 2021, p84)

10 “Business Plan 2023-2028: SA02 Supplementary Annex Our Commitments.” (WPD, December 2021, p176)

RESPONDING TO THE CHALLENGE: THE ROLE OF TECHNOLOGY

Technology plays a key role in addressing the increasing challenges to the reliability and resilience of our networks. Utilities are adopting various approaches, but we consider two areas that merit particular mention: automation and undergrounding.

INSTALLING AUTOMATED FEEDER AND LATERAL SWITCHES AND RECLOSERS

Distribution automation is forming an increasing part of rate-case applications. The solutions vary but generally involve the installation of assets that enable the grid to instantly respond to outage events through reconnection and grid reconfiguration. When outages occur, distribution automation devices enable the grid operator to pinpoint areas of damage so trucks can roll directly to the problem.

There are clear examples of utilities using distribution automation to address worst-performing circuits. EPCOR Distribution & Transmission Inc. in Alberta identified this approach as a core part of its plan "to sustain or improve the performance of its worst-performing circuits."[11] Similarly, ComEd highlighted its own DA Lateral Program as improving reliability on the worst-performing taps by preventing sustained outages from temporary overhead faults.[12]

UNDERGROUNDING

While not a realistic solution in all cases, undergrounding can be a way to eliminate the susceptibility of parts of the grid to some of the more extreme risks posed by the environment. In Florida, both FPL and Duke Energy have invested in undergrounding to improve grid reliability and reduce outage times. FPL's "Storm Secure Underground Pilot Program" uses historic storm data and its reliability metrics to identify areas that would most benefit from undergrounding.[13] Duke's performance analysis found specific grid segments incurred significantly more events than did some of the best-performing segments. Consequently, these areas formed part of the company's Targeted Undergrounding (TUG) program.[14]

Historical analysis in the U.S. suggests a cost of five to 10 times greater for undergrounding compared with overhead installation. However, when including the growing risks climate change posed and the significant annual repair costs on the worst-performing overhead lines, the economics is changing and the case for undergrounding is strengthening.

11 2023 Phase 1 Distribution Tariff Application. (EPCOR, January 17, 2022)

12 Capital Investment Proposal. (ComEd, Illinois Commerce Commission Website, December 15, 2021)

13 "Improving Through Undergrounding: Storm Secure Underground Program." (FPL Website, www.fpl.com)

14 "Targeted Undergrounding: Undergrounding lines, improving reliability." (Duke Energy Website, www.duke-energy.com)

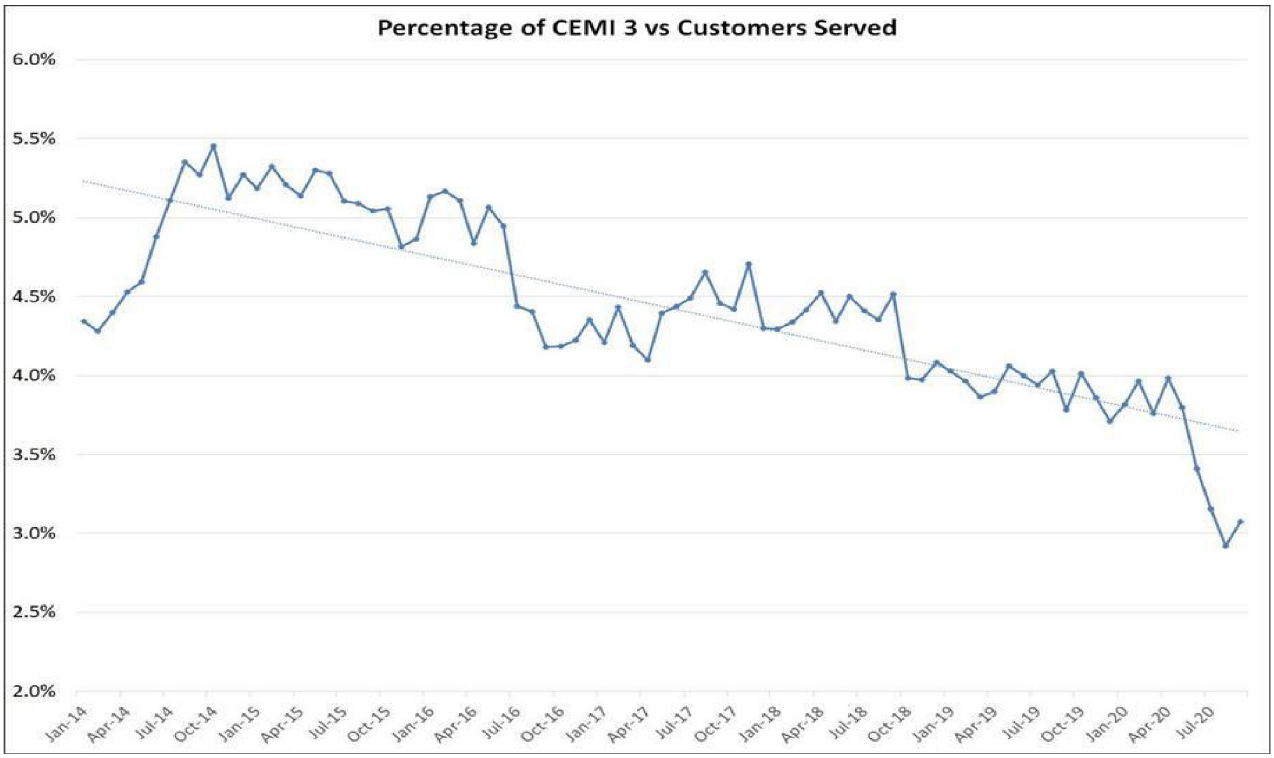
RESPONDING TO THE CHALLENGE: THE ROLE OF REGULATION

Just as technology is adapting and driving different approaches to improving performance on worst-performing circuits, regulation is also evolving. Various measures commonly used to support improvements in reliability performance are being adapted to reflect changing customer needs.

REFINING METRICS

Metrics have a growing role as part of rate-case submissions to support targeted reliability investment. For example, FPL has driven significant improvements in performance in CEMI-3 (customers experiencing more than three sustained interruptions in a year) through investment in distribution automation and lateral protection. This is highlighted in **Figure 2**.[15]

FIGURE 2. FPL performance improvements in CEMI-3.



Setting Standards

Standards generally take two forms. The first is technical standards to which assets should be built, including the ability to withstand threats. The other is standards of performance. The latter is an area where regulatory incentives are often set, and in Great Britain there have been Guaranteed Standards of Performance[16] (GSoP) in place for some time. These detail the performance levels required of distribution utilities and the associated payments to be made to customers if standards are not met.

15 PowerUp S&C Webinar Series: "Moving Beyond Average Reliability Metrics." (S&C Electric and FPL, November 17, 2020)

16 The Electricity (Standards of Performance) regulations 2015: SI 2015 No.699. (Ofgem/ Department of Energy and Climate Change, March 2015)

In its recent review of the distribution utilities' responses to a major storm, the standards were one area where the British regulator turned its attention. Ofgem has identified plans to review the GSoP "to identify amendments that will better acknowledge the impact of extended power cuts on customers."[17] This is important because it indicates a particular emphasis on those customers that experience the worst impacts of prolonged weather events.

Using Incentives

Finally, one consistent feature of regulation with respect to reliability performance is the tendency to strip out major-event days from both reporting and the processes by which any rewards or penalties are determined. The reason is regulators view such events as "exceptional" and thus beyond utility control. However, as the frequency and severity of significant weather events increase, it raises questions about the treatment of such events.

In a recent guidance document on network resilience, the Australian Energy Regulator (AER) suggested there was scope to consider incentives in relation to major events, albeit the first stage should be to better understand the value of reliability in such events.[18] This is not an isolated view, and it can be seen as part of a trend toward a willingness to use incentives as a way to protect those areas of the network with the worst-performing circuits.

CONCLUSION: MORE FOCUS ON 'WORST PERFORMANCE' IS INEVITABLE AND IS A SIGNAL OF PROGRESS

A common theme in recent rate cases is that, even where investment plans are based on maintaining already high levels of reliability, utilities indicate a focus on worst-performing circuits. The British distribution utilities have sought £111 million (US$136 million) to invest on supporting worst-served customers, while Hydro One in Ontario has requested C$209.4 million (US$163 million) from 2023 to 2027.

This trend should not be surprising. As the importance of reliability and resilience grows, distribution utility attention has turned to improving service in all parts of the network. Regulators have also driven this trend by increasing reporting requirements along with a greater use of performance-based regulation directing more attention on the issue.

The potential benefits of the energy transition are significant, but they will only be fully realized if all customers have the opportunity to benefit. This requires utilities and regulators to continue to address head-on the challenges for those on worst-served circuits.

17 Final report on the review into the networks' response to Storm Arwen. (Ofgem, June 9, 2022)

18 Network Resilience: A note on key issues. (AER, April 2022)