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National Association of Regulatory Utility Commissioners

Interconnection of Microgrids to the Distribution Grid: Challenges and State Solutions

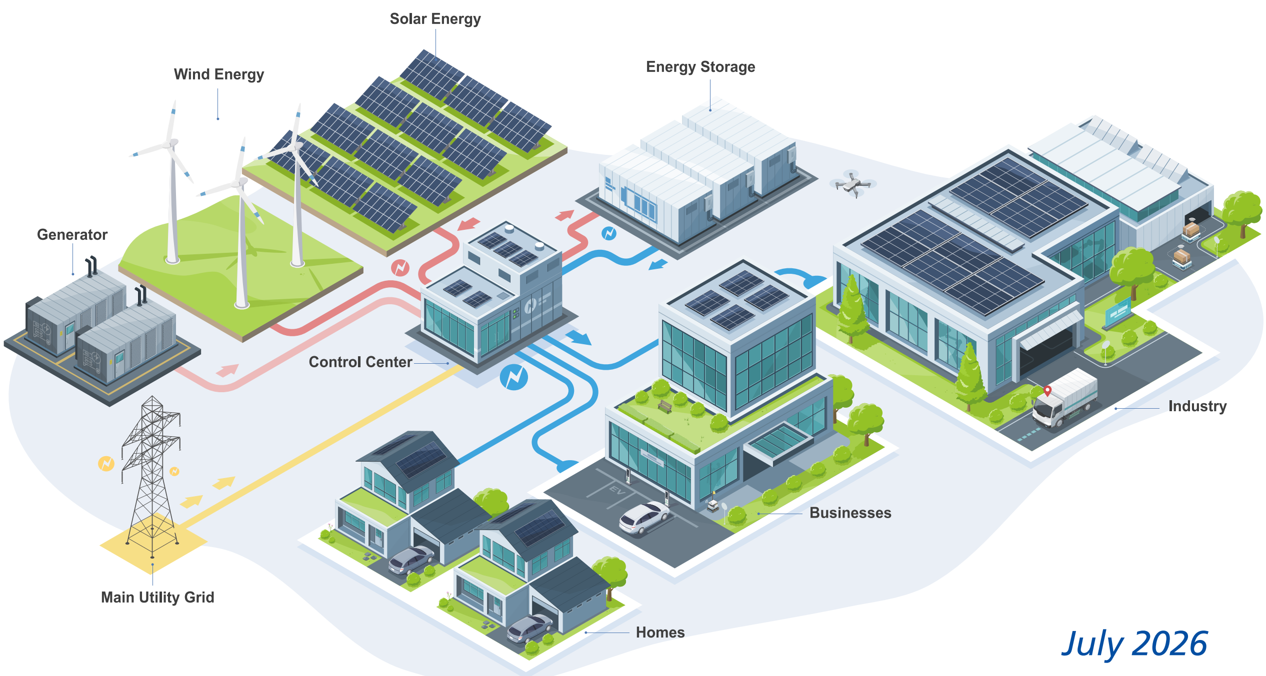

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Table of Contents

I. Introduction and Background Information

The increasing adoption of microgrids has coincided with increasing customer participation in the electricity system and interest in enhancing resilience to power disruptions. Microgrids, defined as localized grids capable of disconnecting from the traditional grid to operate autonomously, can play a pivotal role in improving energy reliability, flexibility, and security at a local level.[1] Further, increased use of local energy sources (e.g., onsite solar panels, biogas, battery storage systems) coupled with microgrid controls can reduce emissions while enhancing energy resilience. Some microgrids rely on natural gas or delivered fuels as a complement or alternative to renewable systems.

Regardless of fuel source, microgrids that will operate in conjunction with the grid at any time during their operations must be approved for interconnection by electric distribution utilities, which can be a complex and lengthy process. As explained by the U.S. Department of Energy (DOE) through the Interconnection Innovation e-Xchange (i2X™):[2]

> The process [of interconnection] involves a customer, like a microgrid developer, who submits an application to an electric service provider responsible for managing and operating the grid, to connect a new generating facility. The electric service provider must then evaluate the existing resources on the grid to determine whether the project can be built, connected, and operated in a safe and reliable way, without resulting in safety issues, equipment problems, or power outages.
>
> Because interconnection [for microgrids] is inherently a local, state, or regional process involving many stakeholder groups — an interconnection customer, an electric system provider or grid operator, and a regulatory body that establishes the rules — interconnection challenges vary depending on location. In addition, the challenges are multi-disciplinary and require expertise in electrical engineering, economics, regulation, and technology. Solving interconnection delays and streamlining processes requires an open, inclusive, and collaborative "all hands on deck" approach.

The purpose of this issue brief is to identify the key challenges microgrid developers and customers face in interconnecting with utility-owned distribution grids and to summarize how state public utility commissions (PUCs) and State Energy Offices (SEOs) are addressing these issues. By sharing some of the mechanisms implemented by states to establish interconnection process timelines, mitigate cost barriers, improve grid transparency, and remove cost allocation uncertainties, this paper provides concrete actions to streamline interconnection processes and accelerate the deployment of microgrids.

For discussions of other benefits, barriers, and opportunities in deploying microgrids, see recent NARUC and NASEO papers:

- NARUC and NASEO (2023) "State Microgrid Policy, Programmatic, and Regulatory Framework"[3]
- NARUC and NASEO (2023) "Clean Energy Microgrids: Considerations for State Energy Offices and Public Utility Commissions to Increase Resilience, Reduce Emissions, and Improve Affordability"[4]

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1 Kiera Zitelman, National Association of Regulatory Utility Commissioners, "User Objectives and Design Approaches for Microgrids: Options for Delivering Reliability and Resilience, Clean Energy, Energy Savings, and Other Priorities," January 2021. https://pubs.naruc.org/pub/E1F332D4-155D-0A36-31CB-889ABED753D5.

2 U.S. Department of Energy, "Interconnection Innovation e-Xchange (i2X™)," Office of Cybersecurity, Energy Security, and Emergency Response." https://www.energy.gov/cmei/i2x/interconnection-innovation-e-xchange.

3 National Association of Regulatory Utility Commissioners and National Association of State Energy Officials, "State Microgrid Policy, Programmatic, and Regulatory Framework." https://www.naruc.org/core-sectors/energy-resources-and-the-environment/microgrids/state-microgrid-policy-programmatic-and-regulatory-framework/.

4 National Association of Regulatory Utility Commissioners and National Association of State Energy Officials, "*Clean Energy Microgrids: Considerations for State Energy Offices and Public Utility Commissions to Increase Resilience, Reduce Emissions, and Improve Affordability,*" *May 2023.* https://pubs.naruc.org/pub/87CE4278-F947-EB1E-8337-1DD6799E6A5C.

- NARUC and NASEO (2022) "Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs"[5]
- NARUC and NASEO (2021) "User Objectives and Design Approaches for Microgrids: Options for Delivering Reliability and Resilience, Clean Energy, Energy Savings, and Other Priorities"[6]
- NARUC and NASEO (2021) "Private, State, and Federal Funding and Financing Options to Enable Resilient, Affordable, and Clean Microgrids"[7]

DOE Distributed Energy Resource Interconnection Roadmap

In September 2024, the U.S. Department of Energy (DOE) and National Laboratories published a **Distributed Energy Resource Interconnection Roadmap**, *Transforming Interconnection by 2035 Interconnection Innovation e-Xchange (i2x)*[8], following a multi-year analysis and engagement effort with experts and stakeholders across the country. The Interconnection Innovation e-Xchange envisions this roadmap as a collaborative resource to facilitate continued stakeholder discussions, problem-solving, and innovation as the U.S. works together to enable simpler, faster, and fairer interconnection of clean energy resources, including microgrids, all while enhancing the reliability, resiliency, and security of our electric grid.

The roadmap is organized around four goals, each critical to the overall mission of i2X: to enable a simple, fast, and affordable interconnection while enhancing the reliability and security of our electric grid. Developed through extensive stakeholder engagement, the roadmap outlines specific actions that each stakeholder group can take to improve interconnection. The solutions are categorized by time scale and deployment level to help stakeholders identify those that best meet regional needs.[9]

Adopting strategic reforms to distributed energy resource (DER) interconnection can help reduce interconnection delays, fairly allocate costs, improve transparency and equity, and support efficient and strategic investment in distribution and sub-transmission grids that can accommodate a rapidly evolving energy landscape.[10]

5 National Association of Regulatory Utility Commissioners and National Association of State Energy Officials, "*Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs," February 2022.* https://pubs.naruc.org/pub/1B571AB6-1866-DAAC-99FB-2509F05E4A67.

6 Kiera Zitelman, National Association of Regulatory Utility Commissioners, "*User Objectives and Design Approaches for Microgrids: Options for Delivering Reliability and Resilience, Clean Energy, Energy Savings, and Other Priorities," January 2021.* https://pubs.naruc.org/pub/E1F332D4-155D-0A36-31CB-889ABED753D5.

7 National Association of Regulatory Utility Commissioners and National Association of State Energy Officials, "*Private, State, and Federal Funding and Financing Options to Enable Resilient, Affordable, and Clean Microgrids," January 2021.* https://pubs.naruc.org/pub/E1D94D36-155D-0A36-3149-DFEB9D24715D.

8 U.S. Department of Energy and National Laboratories, "*Transforming Interconnection by 2035: Distributed Energy Resource Interconnection Roadmap," September 2024.* https://www.osti.gov/servlets/purl/2997033.

9 U.S. Department of Energy, "DOE Distributed Energy Resource Interconnection Roadmap," Office of Cybersecurity, Energy Security, and Emergency Response, April 2024. https://www.energy.gov/cmei/i2x/doe-distributed-energy-resource-interconnection-roadmap.

10 U.S. Department of Energy and National Laboratories, *Transforming Interconnection by 2035: Distributed Energy Resource Interconnection Roadmap, September 2024,* https://www.osti.gov/biblio/299703.

II. Interconnection Challenges

Integrating microgrids into the distribution grid remains a complex process with challenges for investors, developers, customers, and utilities.[11] Because microgrids are grid-connected and capable of operating isolated from (i.e., black-sky operation) or integrated into (i.e., blue-sky operation) the distribution grid, these projects must go through interconnection processes with distribution utilities. Microgrids with renewable generation can be subject to stricter interconnection requirements, such as intermittent resources. Delays, high costs, and regulatory uncertainties impede progress, which can discourage private sector participation. Interconnection is dictated by a complex network of laws, regulations, and administrative processes that have been developed at the regional, state, or utility-territory level,[12] further complicating the interconnection process.

This section summarizes key issues associated with the interconnection of microgrids. The rest of the paper explains opportunities and state examples for overcoming these common challenges.

A. Lengthy Interconnection Process Timelines

Challenge: Microgrid interconnection can pose significant complexity for utility engineers to evaluate, as every component of the microgrid environment must be part of the engineering evaluation for grid impacts, grid upgrades, and safety, given that the microgrid will operate in conjunction with the main distribution grid at times. State PUCs often establish timelines for processing interconnection applications to ensure timely responses from utilities. Despite these statutory requirements, utilities frequently miss deadlines, citing insufficient resources, staff shortages, and backlogs of interconnection requests. These delays cause significant project slowdowns, undermining investor confidence and increasing development costs.

Impact: Extended delays in interconnection approval lead to higher costs for developers and customers due to financing and operational uncertainties. For instance, developers may face penalties for project delays or lose access to tax credits tied to specific timelines.

Opportunities: In addition to utilities expanding staff capacity and leveraging technology tools, some states have responded to utility delays with additional reforms that may be useful models for microgrid interconnection.

- California requires interconnection timeline tracking and reporting under Rule 21;[13]
- Oregon has proposed or adopted a 600-day construction timeline with a self-build fallback;[14]
- Colorado uses a tiered, standardized interconnection framework that improves process predictability.[15]

B. Outdated or Inaccessible Distribution System Data

Challenge: Hosting capacity analysis (HCA) and other distribution system data are essential for developers to determine grid readiness for new DER projects such as microgrids. However, in many states, this data is either unavailable or outdated, leaving developers relying on incomplete or inaccurate information.

Impact: The lack of actionable data can result in developers conducting costly and time-consuming feasibility studies, increasing project timelines and costs. Additionally, unexpected grid constraints discovered late in the process can derail projects after expenditures have already been made on design, planning, and regulatory tasks.

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11 Kelsey Jones, Will McCurry, and Kiera Zitelman, National Association of State Energy Officials and National Association of Regulatory Utility Commissioners, "State Microgrid Policy, Programmatic, and Regulatory Framework," August 2023. https://www.naseo.org/data/sites/1/documents/publications/Final%20Microgrid%20Framework.pdf

12 U.S. Department of Energy, "Interconnection Innovation e-Xchange (i2X™)," Office of Cybersecurity, Energy Security, and Emergency Response. https://www.energy.gov/cmei/i2x/interconnection-innovation-e-xchange.

13 California Public Utilities Commission. "Rule 21: Interconnection." https://www.cpuc.ca.gov/Rule21/.

14 Oregon Public Utility Commission. *Order No. AR 683 (Interconnection / Construction Timeline Filing).* https://edocs.puc.state.or.us/efdocs/HAC/ar683hac344461111.pdf.

15 American Council for an Energy-Efficient Economy (ACEEE). "State Interconnection Standards." https://database.aceee.org/state/interconnection-standards.

Opportunities: One response that states have increasingly been taking is expanding the availability and timeliness of hosting capacity data within or outside the context of integrated distribution system planning proceedings.

- California's public hosting-capacity and integration-capacity tools show that utilities can update distribution system data on a regular cadence, sometimes monthly or quarterly, and can refresh analyses when grid conditions change.[16]
- Other states have public hosting-capacity maps and utility portals such as Colorado, Minnesota, New York, and New Jersey.[17] These practices can help developers screen sites earlier, reduce the need for expensive feasibility studies, and avoid late-stage surprises.

In addition, utilities can leverage modern data analytics and advanced tools to make more informed decisions about grid upgrades and new facility integration. Tools such as the Least-Cost Optimal Distribution Grid Expansion (LODGE) Model from DOE are available for such tasks.[18]

C. High Costs and Cost Uncertainty

Challenge: Interconnection costs can include fees for grid upgrades, interconnection studies, and other processes. Regulators and utilities may require developers to fund grid upgrades necessary for interconnection, but these costs can be unpredictable and allocation of these costs can be inconsistent across states and utilities. In some cases, developers may be charged for upgrades that also benefit other customers, raising concerns about cross-subsidization.

Impact: High and uncertain costs disproportionately affect smaller microgrid projects, which lack the financial resources to absorb unexpected expenses. This situation creates a competitive disadvantage for small-scale developers and can hamper efforts to expand microgrid-related access to local energy sources, particularly in traditionally underserved areas.

Opportunities: Some states have taken steps to reduce interconnection cost uncertainty by improving upfront visibility, adopting clearer cost-allocation rules for upgrade costs, distinguishing between project-specific costs and upgrades that benefit the wider system, and capping exposure to unexpected upgrades.

- California PUC's interconnection process provides published cost guidance on common upgrades.[19]
- New York's Cost Sharing 2.0 framework similarly moves away from a pure cost-causer-pays model.[20]
- Massachusetts is now using a capital investment project structure that allows utility-owned upgrades to be recovered through rates with customer charges based on pro rata participation.[21] Additionally,

16 St. John, Jeff. "How California's Utilities Are Mapping Their Grids for Distributed Resources." *Utility Dive*. https://www.utilitydive.com/news/how-californias-utilities-are-mapping-their-grids-for-distributed-resource/436899/.

17 U.S. Department of Energy, "U.S. Atlas of Electric Distribution System Hosting Capacity Maps," Office of Cybersecurity, Energy Security, and Emergency Response. https://www.energy.gov/cmei/us-atlas-electric-distribution-system-hosting-capacity-maps.

18 U.S. Department of Energy, "Least-Cost Optimal Distribution Grid Expansion (LODGE) Model," https://www.energy.gov/cmei/systems/least-cost-optimal-distribution-grid-expansion-lodge-model.

19 Lori Bird et al., *Review of Interconnection Practices and Costs in the Western States (Golden, CO: National Renewable Energy Laboratory, April 2018)*, https://docs.nlr.gov/docs/fy18osti/71232.pdf.

20 Janique Williams, "Interconnection Cost-Causer-Pays Model: Is It Fair or Antiquated in the Era of Grid Modernization," *POWER Magazine, February 1, 2024*, https://www.powermag.com/interconnection-cost-causer-pays-model-is-it-fair-or-antiquated-in-the-era-of-grid-modernization/.

21 Richard McAllister et al., *New Approaches to Distributed PV Interconnection: Implementation Considerations for Addressing Emerging Issues (Golden, CO: National Renewable Energy Laboratory and Western Interstate Energy Board, February 2019)*. https://www.westernenergyboard.org/wp-content/uploads/2019/02/02-2019-nrel-wieb-emerging-interconnection-issues-joint-report-1.pdf.

the state's process includes pre-application and system study steps that provide applicants with earlier visibility into potential upgrade costs and grid impact.[22]

- Maine revised its interconnection rules to allow some distribution upgrade costs to be pooled or capped for smaller projects.[23]

III. State Options for Addressing Microgrid Interconnection Challenges

PUCs and SEOs play a pivotal role in addressing barriers in the interconnection process for microgrid developers and investors. Although some of the actions and state examples provided are based on general DER interconnection, the insights are directly relevant to microgrid integration. This is because, in most cases, microgrid interconnections are not regulated separately and are subject to the same DER interconnection standards as other local energy sources.

By implementing proactive policies, fostering collaboration among stakeholders, and leveraging advanced planning tools, states can ensure that interconnection standards improve grid transparency as well as ensure adherence to interconnection process timelines and cost-effectiveness. This section explores how PUCs and SEOs can work independently or in tandem to address these barriers. Drawing on tools such as integrated distribution system planning and regulatory innovation, it examines how states can facilitate microgrid integration while ensuring grid reliability, safety, affordability, and resilience.

In addition, state legislatures can play a critical role in creating a fair and enabling environment for microgrid development. Statutory changes can address structural barriers, such as outdated regulatory frameworks, discriminatory grid access policies, or prohibitive interconnection costs, which often disadvantage microgrid developers. Some states have taken important legislative actions to ensure a level playing field for microgrid investors and developers, including policies that standardize interconnection processes, allow third-party ownership models, and provide equitable access to grid services. Many regulations, laws, and policies are discussed throughout the four sections in this chapter.

State Legislation to Support Microgrids

In Hawaii, Act 200 Relating to Resiliency was passed in 2018, establishing a legal framework to promote microgrids as tools for resilience and clean energy integration, particularly crucial for Hawaii's islanded energy system. Utilities are required to work with developers to ensure efficient and equitable interconnection of microgrid projects. Also in Hawaii, Act 266 was passed in 2025, establishing a goal for customer-sited DERs, including microgrids, and also exempting a microgrid from being considered as a public utility.[24]

A. Approaches to Reduce Interconnection Process Timelines

Specifying Interconnection Standards

A direct approach to reducing interconnection timelines is to specify clear interconnection standards so that developers know what to expect and can prepare before approaching a utility. When requirements are well-defined and publicly available, developers can complete technical design work, gather required

22 Richard McAllister et al., *New Approaches to Distributed PV Interconnection: Implementation Considerations for Addressing Emerging Issues (Golden, CO: National Renewable Energy Laboratory and Western Interstate Energy Board, February 2019).* https://www.westernenergyboard.org/wp-content/uploads/2019/02/02-2019-nrel-wieb-emerging-interconnection-issues-joint-report-1.pdf.

23 Janique Williams, "Interconnection Cost-Causer-Pays Model: Is It Fair or Antiquated in the Era of Grid Modernization," *POWER Magazine, February 1, 2024.* https://www.powermag.com/interconnection-cost-causer-pays-model-is-it-fair-or-antiquated-in-the-era-of-grid-modernization/.

24 Hawaii State Legislature, *Act 266, Relating to Energy (2025)*, https://www.capitol.hawaii.gov/slh/Years/SLH2025/SLH2025_Act266.pdf.

documentation, and anticipate costs in advance. In multiple states that have examined opportunities to better support microgrids, stakeholders have noted that having microgrid-specific interconnection standards is far more helpful than relying solely on general DER interconnection requirements.[25] Several states have taken steps toward standardizing microgrid interconnection requirements, with varying levels of specificity and scope.

In 2014, The **New York** Public Service Commission held a Reforming the Energy Vision Proceeding and the Future of Microgrid Interconnection in New York (REV) proceeding, where a Microgrids Working Group was tasked with identifying several issues, including those related to microgrid interconnection. The Working Group identified various potential recommendations for the PSC to consider.

Pervasive issues affecting microgrid development identified by the working group included:

- Microgrids with multiple utility tie points generally do not conform to existing utility requirements.
- Microgrids installed in urban areas may need to interconnect with secondary network distribution systems, which can present unique challenges because network protectors may not be compatible with the reverse power flow that microgrids produce.
- Due to the lack of standardized interconnection requirements for the interconnection of microgrid projects over 2 MW, timely processes for interconnection design, approval, and construction needed to be reviewed and addressed.
- Existing utility interconnection requirements do not incorporate newer technologies, such as smart inverters, ride-through, voltage regulation schemes, and energy storage.
- Planning the operation and integration of microgrids interconnecting to the distribution grid may require sophisticated models that have not been fully tested and/or used in the industry at this time.
- There is a lack of mature microgrid controller technology.
- There may be ambiguity on who has the obligation to maintain or repair microgrid infrastructure interconnecting with the utility system.
- Communications infrastructure will be required between the microgrid and the distribution grid.

The Working Group identified several potential solutions to these issues including:

- Most interconnection issues could be resolved by the creation of a unified set of interconnection standards applicable both to utilities and microgrid developers.
- Expansion of the Standardized Interconnection Requirements from the existing 2 MW threshold or the adoption of FERC Order 792 for smaller (2 to 20 MW) generator interconnections needs to be reviewed and addressed to simplify and ensure speedy completion of the interconnection application and review process.
- The topic of allocating the cost of interconnection needs to be reviewed and addressed to determine the economics of such interconnection/microgrid projects on the utility grid.
- The (Institute of Electrical and Electronics Engineers) IEEE 1547-2018 Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces provides technical specifications for interconnection and interoperability between DERs and utility distribution systems, addressing some of the issues identified above.[26]

Since the 2014 REV proceeding, the New York Public Service Commission has continued moving the state from broader microgrid policy identification toward more practical DER interconnection rules, which include

25 Colorado Energy Office, *Colorado Microgrid Roadmap.* https://energyoffice.colorado.gov/microgrid-roadmap.

26 New York State Energy Research and Development Authority, *Microgrids for Critical Facility Resiliency in New York State* (Albany, NY: NYSERDA, n.d.). https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Electic-Power-Delivery/Microgrids-for-Critical-Facility-NYS.pdf.

expanded standardized interconnection treatment for smaller projects and newer cost-sharing and queue-management approaches. In 2021, the PSC adopted Cost-Sharing 2.0 to address upgrade-cost allocation and reduce barriers to interconnection.[27] In 2026, the PSC issued an Order on Interconnection Queue Management to accelerate the interconnection of tax-credit-eligible projects.[28]

Publishing Utility Expectations for Microgrid Interconnection

Consolidated Edison (Con Ed), one of the major electric distribution utilities in New York, publishes technical requirements for microgrid interconnection (Specification EO-2161) so developers know what to expect. While EO-2161 is Con Edison's own engineering specification rather than a direct regulatory mandate, it operates within the framework of tariff rules filed with and approved by the New York State Public Service Commission, making compliance effectively mandatory for any developer seeking to interconnect with the Con Edison grid. Published in 2017 and still active in 2026, the rules specify what the developer will need to provide to the utility:

- Describe the general technical requirements and considerations for interconnecting and operating a microgrid system safely and effectively in the Con Ed Electrical Power System (EPS).[29]
- Identify the specific interconnection issues and technical requirements of a microgrid interconnected with the electric power system (EPS) under the following conditions:
  - Operating the microgrid system in parallel with the EPS;
  - Separating from and operating the microgrid system in island mode when the EPS is lost or placed in a contingency condition or in anticipation of a power system disturbance due to an inclement weather situation; and
  - Putting the microgrid system back to parallel operation with the EPS when normal service conditions are restored.[30]

In 2019, the **Puerto Rico** Public Service Regulatory Board / Energy Bureau published an order titled "Generating Facility and Microgrid Interconnection Regulation" that serves to provide the rules and procedures for the interconnection of generating facilities and microgrids to the Puerto Rico electric power system. The order lays out four processes for microgrid systems to interconnect:

1. **Simplified Process:** available to small inverter-based systems[31] that interconnect to the distribution system.
2. **Fast Track Process:** available to an interconnection customer proposing to interconnect a certified system with the distribution system, if the proposed interconnection does not exceed certain size limits and other eligibility requirements.
3. **Study Process:** for applicants that do not meet certain eligibility requirements for interconnection.

27 New York Solar Energy Industries Association, "PSC Cost Sharing 2.0 Order." https://www.nyseia.org/policydocuments/psc-cost-sharing-2.0-order.

28 Schiff Hardin LLP, "NY Public Service Commission Adopts Interconnection Queue Management Framework in Light of New ITC Deadlines." https://sprlaw.com/ny-public-service-commission-adopts-interconnection-queue-management-framework-in-light-of-new-itc-deadlines/.

29 Consolidated Edison Company of New York, *Specification EO-2161: Technical Requirements for Microgrid Interconnection (New York: Con Edison, 2017).* https://www.coned.com/-/media/files/coned/documents/save-energy-money/using-private-generation/specs-and-tariffs/eo-2161.pdf.

30 Consolidated Edison Company of New York, *Specification EO-2161: Technical Requirements for Microgrid Interconnection* (New York: Con Edison, 2017). https://www.coned.com/-/media/files/coned/documents/save-energy-money/using-private-generation/specs-and-tariffs/eo-2161.pdf.

31 Small inverter-based systems are described in: Puerto Rico Energy Bureau, *Resolution and Order, Case Nos. NEPR-MI-2019-0009 and CEPR-MI-2018-0008 (July 13, 2021),* https://energia.pr.gov/wp-content/uploads/sites/7/2021/07/20210713-MI20190009-20180008-Resolution-and-Order-and-Draft.pdf.

4. **Transmission Interconnect:** This process applies to microgrids with an export capacity above 5 MW that must connect to the transmission grid.[32]

Since Puerto Rico's 2019 microgrid interconnection regulation, the framework has continued to be implemented. In July 2021, PREB issued a Resolution and Order confirming a comprehensive "Generating Facility and Microgrid Interconnection Regulation," which provides the rules and procedures for interconnecting generating facilities and microgrids to the Puerto Rico Electric Power System.[33] By 2023, Puerto Rico was already seeing real-world deployments, including the Vieques Microgrid Network's 15+ resilient solar-plus-storage systems serving more than ten critical community facilities and six single-family homes on the island.[34]

The **Hawaii** Public Service Commission established a microgrid services interconnection tariff for the Hawaii Electric Company service territory. The Microgrid Services Tariff applies to two types of microgrids:[35]

- Customer microgrids where a customer's infrastructure is exclusively used to supply all their own electricity needs during emergencies (*most common for residential and small commercial situations*).
- Hybrid microgrid in which an operator may combine utility infrastructure and customer infrastructure to supply electricity to microgrid members during an emergency (*more common for large commercial or government agency customers*).

The tariff includes the PSC's rules for customer and hybrid microgrids. It defines the two microgrid types, sets the interconnection application and review process, and specifies eligibility limits, forms, and operating requirements for connecting to the Hawaiian Electric grid. It also clarifies that the tariff is focused on emergency use and does not yet provide additional financial incentives, with unresolved issues such as non-emergency operation and compensation deferred to the next phase of the proceeding.

California's interconnection framework is built around Electric Rule 21, which the California Public Utility Commission (CPUC) describes as the tariff governing the interconnection, operating, and metering requirements for generation facilities connected to an investor owned utility's (IOU's) distribution or transmission system under CPUC jurisdiction.[36] Rule 21 provides customer-sited generation and storage access to the grid while protecting safety and reliability, and the CPUC says it has continued revising the tariff to facilitate distributed generation and address interconnection barriers.

Since the 2019 microgrid rulemaking under Senate Bill 1339, the Commission has adopted multiple decisions to reduce barriers to microgrid deployment, including D.21-01-018 in 2021, D.23-04-034 in 2023, and D.24-11-004 in 2024, which adopted implementation rules for a ratepayer-oriented multi-property microgrid tariff and stated that non-utility-owned microgrids in the Microgrid Incentive Program must use that tariff.[37] The CPUC's 2022 Resiliency and Microgrids Working Group materials also show the Commission actively examining interconnection process improvements, including microgrid-specific study processes, timeline certainty, and

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32 Puerto Rico Energy Bureau, *Motion Submitting Complete Version of Technical Interconnection Requirements Document* (NEPR-MI-2019-0009). https://energia.pr.gov/wp-content/uploads/sites/7/2022/05/Motion-Submitting-Complete-Version-of-Technical-Interconnection-Requirements-Document-NEPR-MI-2019-0009.pdf.

33 Puerto Rico Energy Bureau, *Resolution and Order, Case Nos. NEPR-MI-2019-0009 and CEPR-MI-2018-0008 (July 13, 2021),* https://energia.pr.gov/wp-content/uploads/sites/7/2021/07/20210713-MI20190009-20180008-Resolution-and-Order-and-Draft.pdf.

34 Clean Energy Group, "Vieques Microgrid Network," Technical Assistance Fund Featured Installations. https://www.cleanegroup.org/initiatives/technical-assistance-fund/featured-installations/vieques-microgrid-network/.

35 The Microgrid Services Tariff currently does NOT cover the following types of microgrids: hybrid microgrids with peak demand over 3 MW on Oahu, 1 MW on Maui and Hawaii Island, and 0.5 MW on Lanai and Molokai; hybrid microgrids that operate in island mode under non-emergency conditions; utility or utility-private partnership microgrids; remote or virtual microgrids. These excluded configurations are generally more complex from a regulatory standpoint, so the Commission left them for later phases rather than folding them into the initial tariff.

36 California Public Utilities Commission, "Rule 21: Interconnection." https://www.cpuc.ca.gov/Rule21.

37 California Public Utilities Commission, *Decision 24-11-004 (November 2024).* https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M546/K650/546650794.PDF.

automation, with proposals aimed at faster review and clearer technical requirements.[38] SB 100 also remains a key policy backdrop because it sets California's clean energy target by 2045, shaping the state's broader push toward cleaner distributed resources and grid modernization.[39]

California's Multifaceted Microgrid Tariff Approach

California SB 1339, a bill enacted in 2018, directed the California Public Utilities Commission, in consultation with the California Energy Commission and California Independent System Operator, to undertake several activities to develop further policies related to microgrids. The Commission issued an order instituting rulemaking regarding microgrids pursuant to Senate Bill 1339 and resiliency strategies that established multi-property microgrid tariffs and addressed other microgrid issues before the Commission.

This microgrid tariff, the rules for which were adopted in Decision 24-11-004, applies to Pacific Gas & Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company.[40] The tariff addresses the statute of SB 1339, which required the Commission to develop methods to reduce barriers for microgrid deployment without shifting costs to non-participating ratepayers.

The order also set forth guiding principles for the electric distribution companies to follow for drafting their multi-property microgrid tariffs. In particular, the order aligned the microgrid multi-property tariff with existing electric service rules (Rule 2) and existing interconnection processes (Rule 21).[41] This multi-property microgrid tariff is now operating, and compliments the active Microgrid Incentive Program, a competitive grant program providing $200M in funding to communities facing outages, power shutoffs, and other events driven by climate change.[42]

The **Minnesota** legislature passed Statute §216B.1611 in 2001, requiring utilities to adopt uniform interconnection standards and empowering the MN PUC to oversee and update these standards to improve efficiency and transparency, aligning with best practices like those in the Interstate Renewables Energy Counsel (IREC) model interconnection procedures and IEEE 1547-2018.[43] Docket No. E-999/CI-16-521 supported this implementation, which included creating a process and schedule for the establishment of statewide requirements (2017).[44] The MN PUC process included convening and facilitating a working group of utilities, DER industry, and consumer stakeholders to contribute insights to the Commission as it worked through the development of statewide standards.

The process produced two key outputs. Phase I resulted in the Minnesota Distributed Energy Resource Interconnection Process (MN DIP), approved in 2019, which replaced the state's outdated 2004 standards with a streamlined application process modeled on FERC's Small Generator Interconnection Procedures, which includes

38 California Public Utilities Commission, *Resiliency and Microgrids Working Group Stakeholder Perspectives Slide Deck (January 6, 2022).* https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/resiliency-and-microgrids/resiliency-and-microgrids-events-and-materials/2022-01-06_rmwg_stakeholder_perspectives_slidedeck.pdf.

39 California Energy Commission, "SB 100 (100 Percent Clean Energy Act of 2018)." https://www.energy.ca.gov/sb100.

40 Also referred to as the "Joint IOUs" in the Order.

41 For the full order, please use this link:https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M546/K650/546650794.PDF In addition, for Rules 2 and 21, respectively, please use the following links for more details on California's existing electric service request and interconnection rules. https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_RULES_2.pdf https://www.cpuc.ca.gov/rule21/

42 Southern California Edison, "Microgrid Incentive Program." https://www.sce.com/partners/3rd-party-energy-providers/microgrid-incentive-program.

43 Minnesota Legislature, "Minnesota Statutes §216B.1611 (2001)." https://www.revisor.mn.gov/statutes/2001/cite/216B.1611.

44 Minnesota Public Utilities Commission, "Phase II Interconnection Standards Update." https://mn.gov/puc/activities/economic-analysis/distributed-energy/interconnections/phase-ii-standards-update/.

a tiered review pathway that allows smaller and mid-sized projects to avoid full study requirements.[45] Phase II produced the Minnesota Technical Interconnection and Interoperability Requirements (TIIR), effective July 1, 2020, which established statewide technical standards for DER systems covering protection systems, voltage and frequency trip settings, anti-islanding requirements, and smart inverter capabilities.[46]

Establishing Interconnection Process Timelines

A streamlined and efficient interconnection process is crucial for enabling the timely deployment of microgrids and other DERs. To address issues such as lengthy approval processes or unclear procedural steps, states are increasingly turning to innovative solutions and best practices. These practices include adopting measures to monitor interconnection performance, such as tracking processing timelines and identifying bottlenecks. Some have begun establishing performance targets and incentives for utilities to improve efficiency and accountability in processing applications. For more complex grid areas, group studies are emerging as a collaborative approach to evaluating interconnection requests, optimizing system upgrades, and distributing costs more equitably among applicants. This section explores these strategies and highlights how some states are utilizing these tools to enhance interconnection processes.

IREC Model Interconnection Procedures

The Interstate Renewable Energy Council (IREC) model interconnection procedures, developed through DOE-funded work led by IREC in partnership with EPRI and other stakeholders, provide a comprehensive framework for modernizing interconnection processes, emphasizing transparency, standardization, and fairness. The Model Interconnection Procedures are a widely applicable set of best practices for DER interconnection. The model is not microgrid-specific in the narrow sense, but several of its features, including hosting-capacity analysis, pre-application data sharing, streamlined screening, simplified procedures for small systems, and group studies, are particularly relevant to microgrid projects that often involve multiple DERs and more complex grid interactions.[47, 48, 49]

IREC Model Interconnection Procedures can serve as guiding principles for states to develop clear interconnection rules that are transparent and fair. The key features of IREC's model include:[50]

- Defining timeliness and interconnection process transparency
- Cost allocation transparency
- Standardized technical screenings
- Hosting capacity analyses and pre-application data sharing
- Simplified procedures for small DER projects
- Dispute resolution mechanisms
- Measuring performance
- Establishing performance targets and incentives
- Group studies

45 Minnesota Public Utilities Commission, Distributed Energy Resources Interconnection Process (MN DIP), Version 2.4 (April 24, 2025), https://mn.gov/puc/assets/MN%20DIP%202025%20Clean%20April%2024%202025_tcm14-623149.pdf.

46 Minnesota Public Utilities Commission, Technical Interconnection and Interoperability Requirements (TIIR), with Corrected Interim Implementation Guidance (January 22, 2020), https://mn.gov/puc/assets/TIIR%20w%20CORRECTED%20Interim%20Implementation%20Guidance_tcm14-431321.pdf.

47 Interstate Renewable Energy Council, "IREC Model Interconnection Procedures (2023)." https://www.irecusa.org/resources/irec-model-interconnection-procedures-2023/.

48 Interstate Renewable Energy Council, "Connecting to the Grid." https://irecusa.org/our-work/connecting-to-the-grid/.

49 Interstate Renewable Energy Council, *IREC Model Interconnection Procedures: 2023 Edition (August 2023)*, https://irecusa.org/wp-content/uploads/2023/08/IREC-Model-Interconnection-Procedures-2023-FINAL-8.23.23.pdf.

50 Interstate Renewable Energy Council, Model Interconnection Procedures: 2023 Edition, August 2023, https://irecusa.org/wp-content/uploads/2023/08/IREC-Model-Interconnection-Procedures-2023-FINAL-8.23.23.pdf.

Hawaii was one of the early adopters of IREC's framework. Hawaii's integrated grid plan has adopted practices that align with IREC model framework and streamlined the interconnection process. In 2011, HI PUC approved updates to the interconnection rules of distributed generating facilities.[51] The updates included a standardized technical screening, called a Supplemental Review, to identify projects requiring detailed studies — preventing utilities from needing to conduct comprehensive studies automatically without an assessment of need. Furthermore, Hawaii offers a simple interconnection procedure for small projects, namely inverter-based systems up to 10 kilowatts (kW) in capacity, and simplified procedures for net metered systems up to 50 kW.

Monitoring Interconnection Processes

State utility regulators and energy offices are increasingly focusing on measuring the performance of utilities in managing interconnection processes for DERs, including microgrids. By tracking performance metrics, such as application processing times, interconnection costs, and project approval rates, states aim to identify inefficiencies, set benchmarks, and ensure accountability. Many are implementing performance monitoring frameworks, establishing reporting requirements, and leveraging data to improve utility practices and streamline the interconnection process.

Massachusetts has established clear timelines for utility responses to interconnection requests as part of its efforts to streamline the interconnection process to the distribution grid. The state's approach is primarily outlined in Standards for Interconnection of Distributed Generation (DG Interconnection Tariff), which applies to the three investor-owned electric utilities in the state.[52] The timelines and performance metrics for various stages of the interconnection process include:

1. **Pre-application report requests:** Utilities must respond within ten business days.
2. **Application completeness review:** Utilities have ten business days to determine if an application is complete.
3. **Simplified process review:** For eligible small-scale projects, following notice of application completeness, utilities must complete the review within fifteen business days.
4. **Expedited process review:** following notice of application completeness, utilities have thirty business days to complete this review for qualifying projects.
5. **Standard process initial review:** following notice of application completeness, utilities must complete this within twenty business days.

The Massachusetts Department of Public Utilities (MA DPU) requires utilities to adhere to these timelines and report their performance regularly. This reporting requirement enhances transparency and allows for ongoing assessment of utility compliance and process efficiency. Each of the three investor-owned electric utilities submits a monthly interconnection report by the 15th of each month, with aggregated data made publicly available by the Massachusetts Department of Energy Resources (DOER).[53]

Similarly to Massachusetts, the **Nevada** Public Utilities Commission (NV PUC) approved changes to the NV Energy's interconnection requirements, known as Rule 15, clarifying the application and interconnection

51 Hawaii Public Utilities Commission, Public Utilities Commission Approves New Rules for Interconnection to the HECO Companies' Distribution System, November 29, 2011, https://puc.hawaii.gov/wp-content/uploads/2013/04/2011-11-29-PUC-Press-Release-HECO-Rule-14h-Approval.pdf.

52 The MA DPU-approved DG Interconnection Tariff for the three electric distribution companies are: Massachusetts Department of Public Utilities, Distributed Generation Interconnection Tariffs, M.D.P.U. No. 474 (Fitchburg Gas and Electric Light Company d/b/a Unitil), M.D.P.U. No. 55C (NSTAR Electric Company), and M.D.P.U. No. 1620 (Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid).

53 Massachusetts Department of Energy Resources, "Utility Interconnection in Massachusetts," https://www.mass.gov/info-details/utility-interconnection-in-massachusetts

process as well as defining timelines.[54] NV PUC set timelines for initial review, system impact or feasibility studies review timeline, interconnection agreement issuance deadline, and deadlines for construction and implementation.

Conducting Group Studies

Traditional interconnection processes often struggle to keep pace with the growing volume and complexity of applications as microgrid deployment accelerates. Group studies for interconnection requests have emerged as a possible solution to streamline this process, particularly in areas with high DER penetrations. By evaluating multiple interconnection applications collectively rather than individually, group studies should optimize grid upgrades, reduce costs, and shorten timelines for developers. For these reasons, states are advancing group studies, but it is important to examine the benefits of coordinated assessments as well as the challenges associated with balancing stakeholder needs in a collaborative framework.[55]

In 2023, IREC conducted an assessment of group studies, concluding that while these studies can help alleviate queue challenges in certain situations, they are not a comprehensive solution to all interconnection-related issues. Their effectiveness may be limited in states where the penetration of microgrids and DERs have reached a level that requires extensive and widespread distribution system upgrades to support the increasing volume. Furthermore, IREC highlighted the importance of states overseeing the process because designing a group study process is a complex and context-dependent task. States must thoroughly assess the various elements of the process and customize them to meet their specific needs. This process involves balancing trade-offs to ensure the safety and reliability of the distribution system and address the priorities of interconnection customers and utilities.[56]

Improving Utilization of Data Analytics and Advanced Technologies

With pressure from state decision makers and customers, utilities are leveraging data analytics to make more informed decisions about grid upgrades and new facility integration while improving process efficiency. Utilities are increasingly adopting software platforms to automate and streamline interconnection applications, track project status, and generate performance reports. These tools not only improve the customer experience but also provide valuable data for utility commissions to assess utility performance and identify areas for improvement.

It is valuable for PUCs and SEOs to closely monitor developments around data analytics and advanced technology solutions and seek ways to incorporate use of these tools through the regulatory framework. The DOE DER Interconnection Roadmap reviews tiered options for incorporating more advanced analytics and machine learning into interconnection processes.[57] Below is an overview of how utilities are using these technologies, with examples from various states:

Automated Interconnection Platforms

Some utilities are adopting software platforms to streamline or automate the interconnection process for distributed generation.

California's experience with automated interconnection platforms also reflects an earlier regulatory and technical foundation. The CPUC's Rule 21 framework helped establish smart inverter requirements and settings

54 Nevada Power Company, Rule No. 15: Generating Facility Interconnections, March 20, 2018, https://www.nvenergy.com/publish/content/dam/nvenergy/brochures_arch/about-nvenergy/rates-regulatory/electric-rules-south/Rule_15_South.pdf.

55 Interstate Renewable Energy Council, Thinking Outside the Lines: Group Studies in the Distribution Interconnection Process, October 2023, https://irecusa.org/wp-content/uploads/2023/10/IREC-Group-Studies-Paper-Final.pdf.

56 Ibid.

57 Diane A. Baldwin et al., Distributed Energy Resource Interconnection Roadmap, September 2024, https://www.osti.gov/biblio/2997033.

for inverter-based distributed energy resources, creating a standardized basis for evaluating whether advanced inverter functions could address local grid constraints. This framework includes smart inverter settings and standards for inverter-based DER interconnection in California, which established the technical foundation for tools to automate interconnection review.

The PRECISE Tool was developed by the National Laboratory of the Rockies (NLR) and the Sacramento Municipal Utility District (SMUD — a public power utility in California). PRECISE (PREconfiguring and Controlling Inverter SEt-points) is an automation tool for interconnecting customer solar to the grid that could have applicability for solar-powered microgrids.[58] PRECISE builds on the foundation of Rule 21 by automating the technical interconnection review process and using smart inverter functionality to determine whether a proposed solar project can be accommodated safely and efficiently. Key capabilities of PRECISE include:

- Fast performance and automated interconnection assessments
- Seamless integration with existing business interconnection workflows
- Automatic inclusion of data when a customer's interconnection application is created
- Updates for downstream business teams once calculations are complete

This tool has significantly reduced the time and costs associated with interconnection requests, allowing SMUD to handle the increasing volume of solar applications more efficiently.[59] NLR is now exploring applying PRECISE's automated evaluations to other inverter-based distributed energy resources, such as battery energy storage, and offers the PRECISE tool for licensing. Other AI-supported interconnection tools have also been entering the electric utility industry recently and might offer similar advantages.

While NLR developed PRECISE with SMUD, a municipal utility, the tool's capabilities are directly relevant to investor-owned utilities also, where PUCs could play a role in incentivizing or approving the adoption of automation tools as a practical means of achieving required interconnection process timelines.

B. Approaches to Anticipate Distribution System Capacity

Requiring Hosting Capacity Maps

A lack of grid transparency is a significant hurdle for microgrid developers and investors seeking to connect their projects to the distribution system. This issue not only delays project timelines but also increases costs and uncertainty, deterring investment in microgrids.

Recognizing these barriers, PUCs and SEOs are implementing measures to improve grid transparency and streamline the interconnection process. Many states are requiring utilities to develop hosting capacity maps, improve interconnection portals, and provide detailed data on grid capabilities and constraints. By addressing grid transparency issues, states aim to reduce project costs, accelerate deployment timelines, and support the growth of microgrids as a key component of a modernized and resilient energy system. These practices can help developers screen sites earlier, reduce the need for expensive feasibility studies, and avoid late-stage surprises.

The U.S. Department of Energy maintains an atlas of states in which utilities have published hosting capacity maps and notes that, as of May 2024, 58 utilities and state agencies have published maps in 26 states, DC, and Puerto Rico.[60] DOE tracks maps that include a variety of information types to support visibility into distribution grid assets, distributed generation or DER capacity, and load with varying levels of granularity.

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58 Jess Townsend, "NREL and SMUD Launch Groundbreaking Automation Tool for Interconnecting Customer Solar to the Grid," National Renewable Energy Laboratory, November 9, 2022, https://www.nlr.gov/news/detail/program/2022/nrel-and-smud-launch-groundbreaking-automation-tool-for-interconnecting-customer-solar-to-the-grid.

59 Ibid.

60 U.S. Department of Energy, U.S. Atlas of Electric Distribution System Hosting Capacity Maps, May 2024, https://www.energy.gov/cmei/us-atlas-electric-distribution-system-hosting-capacity-maps.

In 2023, NARUC published a Grid Data Sharing Framework[61] — following nearly two years of collaborative effort with state utility commissions, DER developers, utilities, cybersecurity experts, and others — that outlines key considerations and information needs that a PUC might want to weigh as it decides whether to require utilities to make more distribution grid data, such as hosting capacity maps, available. NARUC's Framework specifies seven categories of likely relevant information and offers use cases to demonstrate applicability, including one for DER interconnection that includes discussion of hosting capacity information. DOE's DER Interconnection Roadmap builds from these resources to offer tiered approaches to advancing interconnection speed and efficacy with recommendations and technical details for state utility regulators, utilities, and others.

In **California**, the CPUC has required the three large investor-owned utilities in the state to host data portals with integration capacity analysis tools and information, and have routinely added requirements (such as data validation expectations) to ensure the maps are accurate and usable.[62] The data portals hosted by PG&E, SCE, and SDG&E provide extensive geospatial mapping data to the public about the electric distribution grid. Among the data hosted are Integration Capacity Analysis (ICA), which are designed to help contractors and developers identify project sites where existing grid infrastructure has capacity available to interconnect new DERs.[63]

In **New York**, investor-owned utility National Grid maintains numerous different types of 'hosting capacity' data in its New York System Data Portal, including: distribution assets overview, PV hosting capacity, electrification capacity, ESS hosting capacity, LSRV/VDER, DG cost sharing, non-wires alternatives, and more.[64] Multiple layers of these data could be valuable for microgrid developers.

Conducting Integrated Distribution System Planning (IDSP)

In order to plan for DERs, rather than react to them, states can work together with utilities to examine current and planned projects and distribution system spending to meet future needs. By projecting distributed generation growth and customer needs, utilities can predict capacity needs and upgrade infrastructure to accommodate expected growth through IDSP. According to the U.S. Department of Energy, IDSP is a holistic planning process that determines grid requirements, develops a technology roadmap for modernization, and supports staged investment strategies for integrating technologies like storage, microgrids, and electric vehicles.[65] After publication, adjustments can be made to the process before beginning again on a predetermined cycle to ensure results are reflective of current grid conditions.[66]

Relying on IDSP and hosting capacity analyses, locational value analyses, interconnection studies, and grid modernization plans, states can work with utilities to plan for DERs and share transparent data with microgrid developers and investors to better support a smooth interconnection process.

LBNL has created a comprehensive, filterable database and mapping tool that describes state electric distribution system planning practices, in addition to multiple publications that highlight best practices.[67] Below

61 National Association of Regulatory Utility Commissioners (NARUC), Grid Data Sharing Playbook (2023), https://pubs.naruc.org/pub/E2E50FD7-CD1B-62D5-1071-8D8362AD1E6D

62 California Public Utilities Commission, Data Portals and Integration Capacity Analysis, last updated March 7, 2025, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/distribution-planning/data-portals-and-integration-capacity-analysis.

63 California Public Utilities Commission, Data Portals and Integration Capacity Analysis, last updated March 7, 2025, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/distribution-planning/data-portals-and-integration-capacity-analysis.

64 National Grid, Distributed Generation System Data Portal (New York), https://systemdataportal.nationalgrid.com/NY/.

65 U.S. Department of Energy, Integrated Distribution System Planning, December 2024, https://www.energy.gov/oe/integrated-distribution-system-planning.

66 See the NARUC-NASEO Comprehensive Electricity Planning roadmaps (2021). The Jade Cohort roadmap shows this process. National Association of Regulatory Utility Commissioners, Task Force Cohort Roadmaps, Feb 2021, https://www.naruc.org/committees/task-forces-working-groups/retired-task-forces/task-force-on-comprehensive-electricity-planning/resources-for-action/roadmaps/.

67 Lawrence Berkeley National Laboratory, State Electric Utility Distribution Planning Practices, updated May 2026, https://emp.lbl.gov/state-electric-distribution-system-planning-practices

is an overview of state engagements in integrated distribution system planning that incorporated microgrids in recent years.

- Hawaiian Electric's Integrated Grid Planning (IGP) process combines distribution, transmission, and resource planning.[68] The main objective is for the **Hawaii** Public Utilities Commission (HI PUC) to work collaboratively with stakeholders to utilize their input along with advanced modeling to forecast DER growth and optimize grid investments.
    - For example, in docket 2018-0165,[69] in 2021, Hawaiian Electric began working with the HI PUC using the IGP process to identify specific geographic areas where microgrid installations provide the most value, such as a community microgrid concept for North Kohala.[70]
- In 2018, the **Massachusetts** Department of Public Utilities (MA DPU) approved, with modification, the first grid modernization plans submitted by investor-owned electric distribution utilities (IOUs) operating in the state.[71] These filings were informed by a working group process that commenced in 2012. As part of their plans, utilities identified areas for system upgrades geared towards facilitating the interconnection of DERs (e.g., implementation of DER management system, advanced SCADA, and volt-VAR optimization investments) and integrating these resources into the utilities' planning and operations processes.[72] In 2022, the Massachusetts Legislature enacted M.G.L. c. 164, § 92B, requiring the IOUs to start filing Electric Sector Modernization Plans (ESMPs) once every five years, commencing in 2024. State law requires the ESMPs to address a broad array of requirements, including the identification of investments to enable increased, timely adoption of renewable energy and DERs, improve grid reliability and resiliency, and accommodate increased transportation and building electrification efforts. The IOUs must develop their ESMPs and proposed investments using five- and ten-year forecasts, as well as a demand assessment of estimated system needs through 2050.

    In their first ESMPs, the Massachusetts IOUs relied on their existing five- and ten-year forecast processes and inputs, which are updated annually, but incorporated the demand assessment and additional elements and electrification projections identified by the state to propose ESMP-specific investments beyond the IOUs' existing five- and ten-year capital plans. The MA DPU approved the first ESMPs as strategic plans on August 29, 2024, and directed procedural and filing requirements for a separate proceeding involving the establishment of a long-term system planning process (LTSPP) for the interconnection of DERs.[73] The ESMPs will enable greater transparency and understanding of system upgrades needed to facilitate accelerated DERs and electrifications efforts within Massachusetts and requires the IOUs to work with stakeholders to identify and consider the equitable distribution of the benefits and costs associated with the investments required .

68 Hawaii Public Utilities Commission, "Integrated Grid Planning Docket for Hawaiian Electric (2018-0165)," May 2024. https://puc.hawaii.gov/energy/integrated-grid-planning-docket-for-hawaiian-electric-2018-0165/

69 Hawaii Public Utilities Commission, North Kohala Microgrid RFP Proceeding, Docket No. 20220012, filed January 2022, https://hpuc.my.site.com/cdms/s/puc-case/a2G8z0000007fKBEAY.

70 Hawaiian Electric, North Kohala Microgrid, last updated March 19, 2024, https://www.hawaiianelectric.com/about-us/our-vision-and-commitment/investing-in-the-future/north-kohala-microgrid.

71 In Massachusetts, one of three IOUs provide electric service in a majority of the state. More than 50 municipalities, however, are not served by IOUs but, rather, by one of more than 40 municipal lighting plants that operate in the state. The MA DPU has limited jurisdiction over these municipal utilities.Massachusetts Department of Public Utilities, Massachusetts Municipally-Owned Electric Companies, https://www.mass.gov/info-details/massachusetts-municipally-owned-electric-companies.

72 Additional information and Orders regarding the first Grid Modernization Plans in Massachusetts are available through this website: https://www.mass.gov/info-details/grid-modernization-and-ami-resources. Massachusetts Department of Public Utilities, Grid Modernization and AMI Resources, Last updated November 2024, https://www.mass.gov/info-details/grid-modernization-and-ami-resources.

73 Massachusetts Department of Public Utilities, Long-Term System Planning Process (LTSPP) Procedural Guidance Memo, March 4, 2025, https://fileservice.eea.comacloud.net/V3.1.0/FileService.Api/file/iidcadie?QpP9F6QPaQX3DKYnr%2FJPxsEmiDhMBXK0ednWT8WFP5Ok9v9pxUxyG6LkaCeWBSjqbmMlNqhcSkxPf0qUr1gASPKrYE1qejvebf677PtCVStUdHoHpEGELGLGjR%2BZpYgt.

- Massachusetts ESMP and related grid-modernization materials focus on DER and non-wires planning broadly, with microgrids fitting as one potential DER resource that can advance those objectives.[74]

- In 2016, the **Maryland** Public Service Commission (MD PSC) launched Public Conference 44 (PC44) to explore grid modernization strategies with objectives of enhancing DER integration, improving interconnection processes, and supporting innovative grid technologies and energy efficiency. MD PSC launched the Distribution System Planning (DSP) Work Group in 2021 (leveraging the NARUC-NASEO Comprehensive Electricity Planning Jade Roadmap), which works to develop a distribution planning framework for all utilities in Maryland that incorporates planning for the entire distribution network and takes into account DER forecasts.[75]
  - In 2016 Pepco was required to file a report addressing legal, financial, and practical issues regarding microgrid planning and development, including ownership and operational structures. Order No. 88836, issued on September 17, 2018, by the MD PSC found that Pepco's microgrid proposals (filed September 25, 2017, and supplemented February 15, 2018) satisfied the filing requirements.[76]

- In 2016, the **New York** State Public Service Commission (NY PSC) required utilities to submit Distributed System Implementation Plans (DSIPs) that forecast DER adoption and plan upgrades accordingly. In April 2024, the NY PSC launched the "New York Grid of the Future Plan" to establish targets for flexible resource deployment and identify enabling utility investments.[77] The NY PSC and New York State Energy Research and Development Authority (NYSERDA) issued a grid flexibility study in January 2025 estimating the potential for flexible grid technologies to deliver clean, reliable, and affordable energy to New Yorkers. The proceeding remains open as of February 2026 following a November 2025 request from PSC staff to allow more time to finish an updated grid of the future plan.
  - NYSERDA High Performing Grid Initiative (May 7, 2021) describes grid modernization efforts under the REV initiative. It states that the adoption of new technologies will enable community-based energy systems such as microgrids to improve environmental performance and energy system resiliency. The report details how the High Performing Grid initiative moves beyond DER interconnection to facilitate the development of microgrids through enhanced grid visualization, diagnostics, and dynamic management.[78]
  - Central Hudson Gas and Electric Benefit-Cost Analysis Handbook (June 30, 2023) was filed in accordance with the NYPSC order establishing the benefit-cost analysis (BCA) framework under the REV proceeding (Case 14-M-0101). The document lists microgrids as a key component of community-based energy systems that the REV initiative aims to enable through grid transformation.[79]

74 Massachusetts Department of Public Utilities, Grid Modernization and AMI Resources, last updated November 19, 2024, https://www.mass.gov/info-details/grid-modernization-and-ami-resources.

75 Maryland Public Service Commission, "Case No. 9665, Administrative Docket PC44, Order No. 90777: In the Matter of Transforming Maryland's Electric Distribution Systems to Ensure that Electric Service is CustomerCentered, Affordable, Reliable and Environmentally Sustainable in Maryland: Distribution System Planning for Maryland Electric Utilities," August 24, 2023, https://www.psc.state.md.us/wp-content/uploads/Order-No.-90777-DSP-Work-Group-Relaunch-1.pdf.

76 Maryland Public Service Commission, Case No. 9361, May 2024, https://webpscxb.psc.state.md.us/DMS/maillogpdfview/Case/9361/593/0/0.

77 New York State Public Service Commission, "Case No. 24E0165: Proceeding on Motion of the Commission Regarding the Grid of the Future," last updated January 9, 2026, https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=24-e-0165.

78 New York State Department of Public Service, Case 14M0094, Proceeding on Motion of the Commission to Consider a Clean Energy Fund, Last updated June 2026, https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=44959&MNO=14-M-0094.

79 New York State Department of Public Service, Case 14M0101, Reforming the Energy Vision, Last updated May 2026, https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=44991&MNO=14-M-0101.

C. Approaches to Tackling High and Uncertain Costs

Balancing Cost Causation with the Public Interest

In an era of load growth with many technology choices for customers that want to maintain access to the grid for both import and export, high grid upgrade costs are an increasing challenge for DERs including microgrid projects. Ensuring appropriate allocation of these costs while supporting state policy goals and affordability is a key challenge that PUCs and SEOs are working through.

Existing frameworks for allocating interconnection costs typically rely on the cost causation principle, where the cost of an upgrade lies with the entity responsible for the cost being incurred. This approach can support efficient siting, but can also create significant barriers for development of smaller projects. Most states and utilities use this approach to allocating grid updates that might be triggered by a new microgrid project.

In contrast, some advocates have recommended cost allocation approaches that would alleviate financial pressure on individual developers or customers and encourage collaboration and investment in grid improvements that support broader energy resilience and energy policy goals.[80] These recommendations include implementing multi-beneficiary cost sharing or setting a market-based grid access fee. Grid access fees are still being examined by states and utilities[81] while at least a handful of states have begun implementing new approaches to cost sharing that could support microgrid and other DER development in ways that spread costs and encourage development.

In **New York**'s Cost Sharing 2.0, the NY Public Service Commission approved a defined mechanism for qualifying distribution upgrade costs that are shared among projects benefiting from the same upgrade.[82] Under the PSC order, the mechanism uses a pro rata concept, includes a cap on unrecovered project costs equal to 2% of each utility's annual distribution and sub transmission capital budget, and applies over a six-fiscal-year period. This approach can reduce the financial burden on the first developer to trigger an upgrade while still preserving utility oversight and cost recovery.

Massachusetts DPU Docket No. 20-75 designed a provisional framework for system planning that allows distribution utilities to plan and fund essential upgrades to their electric system to allow timely connections. Under the provisional framework, distribution utilities are able to file capital investment projects (CIPs) after completing a group impact study and demonstrating that the upgrade(s) will enable the interconnection of several facilities with a cost to interconnecting customers of $500 per kilowatt or less.[83] Once a CIP proposal is approved by the MA DPU, ratepayers will help fund the upgrades with the goal of being partially reimbursed over time and to benefit from a more resilient system in the future. MA DPU Docket No. 25-20 will establish the transition from the provisional framework to a long-term system planning process for proactive system upgrades to allow for more cost effective and timely interconnection of future distributed generation.

Building on this framework, the MA DPU is also in the process of reviewing a 2026 proposal for a Common System Modification Fee.[84] If approved, DG systems that interconnect under the Simplified Process — generally smaller-scale facilities — would be charged a flat fee, proposed at $225. As a result, they will avoid

80 Janique Williams, "Interconnection CostCauserPays Model: Is It Fair or Antiquated in the Era of Grid Modernization," POWER Magazine, February 1, 2024, https://www.powermag.com/interconnection-cost-causer-pays-model-is-it-fair-or-antiquated-in-the-era-of-grid-modernization/.

81 Coalition for Community Solar Access, Integrating Distributed Solar and Storage: The Keystones of a Modern Grid, February 2022, https://communitysolaraccess.org/wp-content/uploads/CCSA_BRO-White-Paper_20220214-1.pdf.

82 PSEG Long Island, Summary of NYS SIR Cost Sharing 2.0 Proposal, n.d., https://www.psegliny.com/aboutpseglongisland/ratesandtariffs/sgip/-/media/B63F65D2682E4669844F4D18965612E6.ashx.

83 Massachusetts Department of Public Utilities, Provisional System Planning Program Guide, December 2021, https://www.mass.gov/guides/provisional-system-planning-program-guide.

84 Massachusetts Department of Public Utilities, Investigation into the Interconnection Implementation Review Group's Proposed Revisions to the Model Standards for Interconnection of Distributed Generation Tariff, D.P.U. 25-48, opened May 27, 2025, https://eeaonline.eea.state.ma.us/dpu/fileroom/ (search docket "25-48").

or experience significant reduction in the cost of any common system modification upgrades that may be triggered by the interconnection of their solar or battery facility.

The **Maryland** PSC's PC44 Interconnection Work Group designed the Maryland Cost Allocation Model (MCAM) in 2021, where upgrade costs will be shared among developers / investors and ratepayers.[85] Under the MCAM proposal, ratepayers cover the costs of upgraded hosting capacity while investors or developers using the upgraded capacity would pay their proportional share of the costs based on the share of the upgraded capacity attributable to them, which would reduce the amounts needed to be recovered through rates.

In November 2023, the **Maine** Public Utilities Commission (ME PUC) revised its interconnection policies to adjust cost allocation for projects under 25 kW. Costs related to installing new single-phase transformers are socialized and recovered from all ratepayers. Additionally, these small projects pay a flat fee of $150 for other distribution upgrades not exceeding $5,000.[86]

In December 2022, the **Minnesota** PUC implemented a policy for small DER projects up to 40 kW. Where upgrade costs are $15,000 or less, the utility company covers the costs, with the interconnecting party paying only a $200 fee.[87]

These examples demonstrate a trend towards cost allocation approaches that aim to reduce upfront costs for small-scale microgrids. By addressing grid upgrade cost barriers, states can foster a more favorable environment for microgrid deployment, enabling these systems to deliver their full potential in terms of reliability, resilience, and grid modernization.

Reducing Uncertainty by Providing Visibility into Potential Costs

In addition to establishing standard or maximum costs for interconnection of small systems and associated grid upgrades, a few states have attempted to reduce cost uncertainty through rules for cost envelopes for distributed generation.

A cost envelope limits developer cost responsibility to a certain percentage above a utility cost estimate, either for interconnection studies or upgrades. If costs exceed the envelope, a utility's shareholders bear the costs if they are not deemed prudently incurred by the PUC, strengthening the utility incentive to contain costs or ensuring their estimate will be within the envelope and providing developers with greater certainty about potential costs.[88]

California, **Massachusetts**, **Oregon**, and **Utah** have established cost envelopes where a developer's liability is limited to 25% more than the utility's study cost estimate.[89] The entity responsible for cost overruns varies by state from shareholders to ratepayers or a combination. An analysis of the impact of these provisions is lacking in the literature, though in California, a pilot evaluation found that few developers selected to participate, likely because there was a higher upfront interconnection application fee to participate in the program.

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85 Maryland Public Service Commission, Distribution System Planning (DSP) Interim Report 2023, December 21, 2023, https://www.psc.state.md.us/wp-content/uploads/Final-2023-DSP-Report.pdf.

86 Janique Williams, "Interconnection Cost-Causer-Pays Model: Is It Fair or Antiquated in the Era of Grid Modernization," POWER Magazine, February 1, 2024, https://www.powermag.com/interconnection-cost-causer-pays-model-is-it-fair-or-antiquated-in-the-era-of-grid-modernization/.

87 Janique Williams, "Interconnection Cost-Causer-Pays Model: Is It Fair or Antiquated in the Era of Grid Modernization," POWER Magazine, February 1, 2024, https://www.powermag.com/interconnection-cost-causer-pays-model-is-it-fair-or-antiquated-in-the-era-of-grid-modernization/.

88 Lori Bird et al., Review of Interconnection Practices and Costs in the Western States (Golden, CO: National Renewable Energy Laboratory, April 2018), https://docs.nlr.gov/docs/fy18osti/71232.pdf.

89 Richard McAllister et al., New Approaches to Distributed PV Interconnection: Implementation Considerations for Addressing Emerging Issues (Golden, CO: National Renewable Energy Laboratory, February 2019), https://www.westernenergyboard.org/wp-content/uploads/2019/02/02-2019-nrel-wieb-emerging-interconnection-issues-joint-report-1.pdf

One approach to reducing cost uncertainty has been well established and maintained in California. In 2016, the California PUC required the three investor-owned utilities to each publish a Unit Cost Guide, which provide the estimated cost of various common types of equipment required for upgrades.[90] The guides are revised annually to reflect current construction and equipment costs and can serve as a reference point for microgrid and other DER developers.

D. Approaches to Reinforce Interconnection Best Practices

Establishing Performance Targets and Incentives

To ensure that utilities forecast capacity, upgrade the grid, and streamline microgrid interconnection processes, multiple states are establishing performance targets and incentives to ensure utilities prioritize transparency and timeliness. By linking utility performance to measurable outcomes — such as streamlined interconnection timelines, adoption of advanced grid technologies, or increased hosting capacity — states can encourage utilities to plan and invest strategically in their distribution systems. This section explores how states are leveraging performance-based regulation (PBR) and other incentive frameworks to ensure utilities actively support customer resilience and grid modernization while maintaining efficient interconnection processes.

In "Demand Flexibility within a Performance-Based Regulatory Framework",[91] NARUC (2024) explores how PBR can align utility profit motivations with public policy goals like demand flexibility. To design an effective PBR framework, the report outlines a staged implementation process centered on three primary components. The first is the determination of quantitative objectives, such as emissions reductions or peak demand savings. The second is the selection of reliable performance metrics categorized as activity, program, or outcome-based, which are supported by benchmarking and historical data. These elements culminate in the third component: the development of specific performance targets tied to performance incentive mechanisms (PIMs), which provide financial rewards or penalties based on the utility's demonstrated progress toward the stated goals.[92]

While there are PIMs for reliability and DERs more broadly across some states and utilities, there are no PIMs established specifically for microgrids as of June 2026.[93] States seeking to develop resilience-focused PIMs that support microgrid deployment could look to the NARUC Resilience Framework (2025) as a foundational resource to determine objectives and metrics that align with state goals and priorities.[94]

In 2021, the **Hawaii** PUC (HI PUC) issued Order No. 37787 that outlined the design of a new PBR framework. This framework includes metrics and PIMs that incentivize utilities to proactively engage in grid forecasting and development. PIMs reward utilities for achieving specific performance metrics tied to state policy goals. HI PUC's PBR framework includes incentives for integrating renewable energy resources into the grid, rewards for increasing the adoption and effective use of customer-sited DERs, such as rooftop solar and energy storage, incentives for reducing the time required to process interconnection requests for renewable energy and DER projects, and metrics tied to improving customer satisfaction and equitable access to renewable energy programs.[95] Many of these performance incentives could apply to and incentivize microgrid deployment in Hawaii.

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90 Richard McAllister et al., New Approaches to Distributed PV Interconnection: Implementation Considerations for Addressing Emerging Issues (Golden, CO: National Renewable Energy Laboratory, February 2019), https://www.westernenergyboard.org/wp-content/uploads/2019/02/02-2019-nrel-wieb-emerging-interconnection-issues-joint-report-1.pdf

91 Elliott J. Nethercutt, Demand Flexibility within a Performance-Based Regulatory Framework (Washington, DC: National Association of Regulatory Utility Commissioners, January 2023), https://pubs.naruc.org/pub/2A466862-1866-DAAC-99FB-E054E1C9AB13

92 Elliott J. Nethercutt, Demand Flexibility within a Performance-Based Regulatory Framework (Washington, DC: National Association of Regulatory Utility Commissioners, January 2023), https://pubs.naruc.org/pub/2A466862-1866-DAAC-99FB-E054E1C9AB13.

93 Rocky Mountain Institute (RMI). 2026. "PIMs Database." https://pims.rmi.org/?tab=0. [pims.rmi.org]

94 National Association of Regulatory Utility Commissioners (NARUC), NARUC Resilience Framework (February 2025), https://pubs.naruc.org/pub/1037E2EB-D1FE-747C-C0DD-2A78CF3ECDE3.

95 Ibid.

To ensure that utilities identify and implement steps to streamline the interconnection process, states have the option of applying penalties or more closely monitoring their utilities when they underperform. Some of HI PUC's performance incentives are symmetrical--with incentives available for achieving or exceeding performance targets and downside risk (financial penalties) for failing to meet targets. As discussed in the previous section, several states set clear timelines on the application, agreement, construction, and implementation process by assessing penalties when the deadlines are not met. The other option is to tie penalties to quality-of-service metrics. In 2020, the **Minnesota** Public Utilities Commission (MN PUC) received many complaints about the delays in the interconnection process with one of their utilities. MN PUC penalized their utility during a quality-of-service plan review and instructed them to streamline the interconnection process.[96]

NARUC tracks state utility commission efforts around PBR, including which states have PBR frameworks, performance incentive mechanisms, decoupling, and multi-year rate plans — any of which could be used to support utility focus on streamlining interconnection, and ultimately supporting microgrid development.[97]

IV. Conclusion

As the energy landscape continues to evolve with increasing customer and utility interest in microgrids, it is likely that states and utilities will continue to refine their interconnection processes. Ongoing improvements will be crucial in supporting grid resilience and integration of local energy resources while maintaining grid reliability, safety, and affordability. Despite the challenges of delays, high costs, data limitations, and cost allocation uncertainties, state-level initiatives to integrate microgrids into distribution grids offer promising solutions. By standardizing interconnection processes, leveraging technology, and fostering collaboration among industry stakeholders, state utility regulators and State Energy Offices can create a supportive environment for microgrid development.

96 Ibid.

97 National Association of Regulatory Utility Commissioners (NARUC), "Performance-Based Regulation," Last updated March 2025, https://www.naruc.org/core-sectors/energy-resources-and-the-environment/valuation-and-ratemaking/performance-based-regulation/.

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