EPRI

TECHNICAL BRIEF

Key Insights: Interconnecting Behind-the-Meter (Facility-Scale) Microgrids

INTRODUCTION

The growing popularity of behind-the-meter (BTM) distributed energy resources (DER) is expanding the marketplace of commercial products with backup power and control systems. These offerings are packaged with microgrid interconnect devices (MIDs),[1] grid isolation devices, or backup interfaces that augment the functionality of energy storage and photovoltaic (PV) installations by enabling them to toggle between grid-following and grid-forming modes of operation. But although these systems provide significant customer benefit—that is, the ability to operate during grid outages—they also raise questions about their assessment during the interconnection process.[2]

In most jurisdictions, distribution system operators (DSOs) or authorities governing interconnection requirements (AGIR)[3] have established DER interconnection processes that define the protocols for evaluating customer requests to connect generation sources to the distribution system. To remain relevant, established interconnection review processes are continuously updated to accommodate technology advancements and evolving regulatory standards. This technical brief explores whether BTM facility microgrid systems challenge current interconnection processes and investigates potential changes that may help safeguard against any negative impacts that facility microgrids may cause to area system safety and reliability.

Background: Defining a Microgrid and Related Interconnection Challenges

A "microgrid" is defined as a group of interconnected loads and DER within a set electrical boundary that can operate both connected to and disconnected from the grid (see Figure 1).

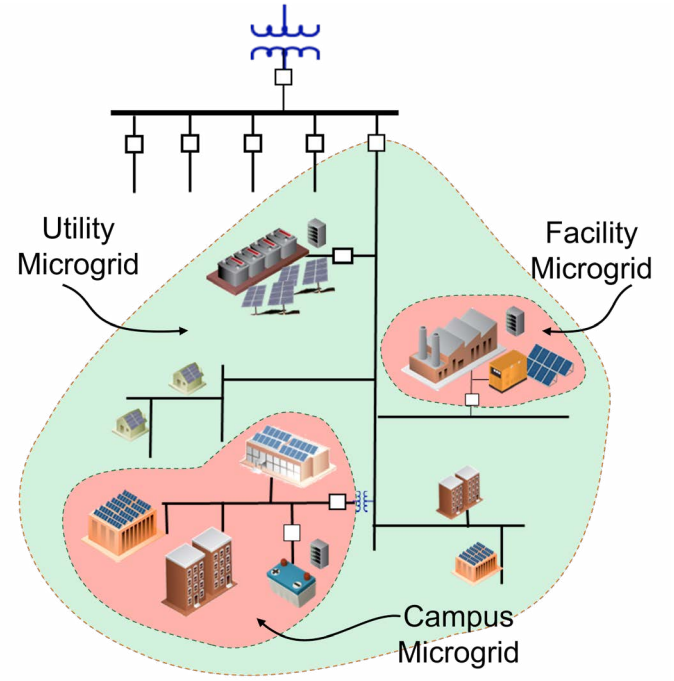

Figure 1. *Illustration of different microgrid types with BTM microgrids (facility, campus) shown in red*

1 NEC Article 705 defines microgrid interconnect device (MID) as 'a device that enables a microgrid system to separate from and reconnect to an interconnected primary power source'.

2 See DER Field Experience Interest Group #59 - Interconnecting Facility-level DER with Off-Grid Capability webcast recording https://www.epri.com/research/programs/067418/events/FC68533E-FBFF-4B8F-B233-E5F46598B6E8.

3 An authority governing interconnection requirements is an entity that sets and enforces the policies and procedures for connecting electrical systems to a local area. AGIRs can be regulatory agencies, public utility commissions, municipalities, or other organizations.

The microgrid concept is not new; it is simply a reformulation of power systems as they were originally designed. Like the traditional centralized electric grid, microgrids generate, distribute, and regulate the supply of electricity to consumers but do so locally and on a much smaller scale. They can comprise various footprints, ranging from a facility microgrid (potentially comprising a single residence) to a larger campus microgrid to a broader utility microgrid.

From an interconnection perspective, microgrids and DER backup systems share technical characteristics as well as isolated operation and intentional islanding capability—but there are also distinctions. For example, NextEra Energy separates typical residential and commercial and industrial (C&I) customer backup systems from large-scale microgrids that serve a wider geographic area, such as government buildings, campuses, and small communities. Meanwhile, larger utility microgrids may serve entire towns, multiple feeders, and beyond. These distinctions clarify differences in ownership and system behavior responsibility during island operation. Residential and C&I facility microgrids are expected to be isolated from utility-owned equipment when operating as an island. Larger-scale community and utility microgrids incorporate multiple customers and utility-owned equipment during island operation; this mixed ownership structure creates different interconnection challenges.[4]

This technical brief examines single-customer, BTM microgrid interconnections (referred to as *microgrid* and *backup system* throughout the paper), which are commonly used to support the local facility during a grid outage. The DSO has limited to no involvement in the design of this scale of system and is primarily concerned with limiting potential impacts to the distribution system.

As BTM microgrids become more common in interconnection requests, utilities are seeking clarification in several areas, including the following:

- **Evolving standards:** How equipment listings and certifications apply to microgrid configurations
- **Operational practices:** Conditions when a customer facility can separate from the area electric power system (EPS)
- **Evolving customer relationships:** What the power quality and reliability expectations are for an islanded facility
- **New test points:** Whether additional commissioning tests should be considered

The remainder of this brief addresses each of the four pressing topics associated with BTM microgrid interconnection in a streamlined Q&A format. The content serves as a quick reference for informing relevant utility review practices.

PRESSING QUESTIONS

Q1: Certification Coverage—What does DER equipment certification cover related to BTM microgrids and off-grid behaviors impacting interconnection integrity?

UL 1741

UL 1741 serves as the certification standard for inverters, converters, controllers, and interconnection system equipment for use with DER. It defines safety and performance evaluation procedures to test and certify that devices conform to the IEEE Std. 1547-2018, which stipulates DER interconnection requirements. Related to microgrid operation, IEEE Std. 1547-2018 articulates DER performance **while operating in parallel** with the area power system, including power quality, voltage and frequency ride-through and trip (that is, area network conditions under which a DER should disconnect from the grid), and service reentry (that is, reentry delay, ramp rate, and synchronization range). If the DER in a BTM microgrid configuration are certified to UL 1741 SB,[5] the DER grid-connected behavior is covered by the certification.

Although IEEE Std. 1547-2018 stipulates that the DER should retain grid-interactive settings (utility required settings) when reconnecting for parallel operation, UL 1741 SA/SB **does not** explicitly include tests to verify DER settings retention when a system transitions to "island mode" and returns to "grid-connected mode." The existing certification process does verify settings retention after the DER returns to service following a trip event such as abnormal voltage and after power-cycling the DER.

4 See *Understanding Community Microgrids* EPRI, Palo Alto, CA: 2021. 3002021842 for details.

5 UL 1741 SB is an updated version of the UL 1741 standard that incorporates the testing requirements of IEEE 1547.1. It ensures that DER can comply with the required grid support functions stipulated in IEEE Std. 1547-2018 (for example, voltage regulation, frequency regulation, power factor correction).

UL 1741 Certification Requirement Decision for Power Control Systems/UL 3141

UL 1741 Certification Requirement Decision (CRD) for Power Control Systems (PCS) is an interim arrangement for certifying systems that can sense and control DER active power export to mitigate area system impacts.[6] BTM microgrid systems include local load centers that customers intend to serve wholly or partially with their own DER. If the desired generation capacity exceeds area power system limits, such as thermal or voltage criteria determined by the EPS operator, the customer may deploy a certified control system, such as a PCS,[7] to manage energy usage behind the meter while limiting excess export. However, limiting active power export is accomplished via signal monitored at the PCS external reference point of applicability (RPA) that directs the DER to reduce its output when it is an excess of a setpoint. No physical disconnection or area system isolation occurs. This enables a compromise wherein the proposed excess DER capacity may be interconnected if it is actively managed by the PCS.

DER in BTM microgrids may be sized to meet island-specific design criteria, such as black-start or long-duration renewable energy requirements, making their nameplate rating greater than typical operating rating. If this capacity is configured in a parallel operation and subject to area power system capacity limits, a certified PCS may be implemented to limit the microgrid's export behavior. It is important to note that a certified PCS has no bearing on island operation. Practically, during off-grid operation the external RPA should not sense any active power because of electrical isolation resulting in no active power curtailment of DER. This will allow DER to otherwise operate according to its logic to support the local power system.

UL 1741 CRD for PCS tests include the following:

- Ability to detect step change in load or generation
- Unrestricted, export only, import only, and no-exchange operating modes
- Ability to export limit from all sources, export limit from energy storage system (ESS) only, or limit import to ESS within 30-second open loop response time[8]
- Loss of communication and component/control failure response

PCS CERTIFICATION IN DEVELOPMENT: UL 3141

The UL 1741 CRD for PCS is currently being formalized into the distinct UL listing, *UL 3141*. Following are several issues of note.

PCS are evaluated for at least one of three classifications:

- **Single-Source PCS** provides overload protection via load management (for example, opening a breaker or actively throttling controlled loads).
- **Multisource PCS** provides overload protection to feeders, branches, and busbars by direct control of sources or loads or indirectly by isolating uncontrolled sources or loads.
- **Power import limiting (PIL) and/or power export limiting (PEL) PCS** limits power flow measured at an external point, such as the point of common coupling (PCC) to or from generation sources or loads.

PCS can enable flexible interconnection.[9] PCS may respond to external commands or schedules provided by authorized third parties. A format for scheduling is defined, but communication backhaul, protocol, and so on are out of scope of UL 3141.

The "NEM Integrity Mode" ESS operating mode emphasizes system control. This configuration is intended to maintain area EPS export limit compliance when total site DER capacity is increased beyond the limits of the interconnection agreement.

6 A CRD approximates an upcoming standard for a novel product that does not currently have its own standard. UL is working to codify the majority of the CRD for PCS in a new certification, UL 3141.

7 A PCS manages the output of power production sources, such as batteries, PV systems, and electric vehicles. It limits the current and loading on conductors and busbars as well as the current to the busbar ratings or the ampacity of the conductors.

8 The open loop response time requirement is currently defined as less than 30 seconds. However, faster PCS response times may be necessary to meet specific AGIR requirements.

9 Flexible interconnection is a DER control strategy used to defer or avoid system upgrades and/or increase distribution system utilization typically by limiting DER active and/or reactive power at key times when transmission and/or distribution system constraints are binding.

UL 1741 CRD for Multimode

An additional conformance requirement decision has been attached to UL 1741 to certify "multimode" (MM) capable DER. The CRD for MM was originally published in 2018 and reissued for UL 1741, 3rd edition, in 2023. This documentation introduces multimode classification to UL 1741 and evaluates consistent grounding and isolation from the area EPS when a DER is intentionally islanding. Table 1 summarizes the tests in the CRD for MM.

Table 1. *CRD for MM Tests*

TEST	DESCRIPTION
Ground bond switch timing test	Evaluates devices that switch between multiple ground locations to verify that the system cannot become ungrounded and that any switching does not overlap with multiple service conductor ground for more than 0.1 seconds.
Synchronization device test	Tests for compliance with IEEE 1547, Section 4.1.3 Synchronization, and IEEE 1547.1, Section 5.4 Synchronization test.
Backfeed protection test	Verifies that no hazardous voltage or energy is present on the area EPS input within 1 second of disconnect. This test verifies that backfeed is prevented from power circuits and non-power circuits when non-EPS sources are generating power.

The CRD for MM testing is performed to certify products as a comprehensive system, so its value may be limited for bespoke microgrid designs. A collection of products installed and configured to work together may be perfectly suited to reliably isolate and operate an intentional island. But if the microgrid controller is not certified along with the other components of the DER system, the certification may be unreliable—and detailed commissioning evaluation is recommended.

Many commercial inverters with off-grid capabilities are designed with multiple ports, including a separate, dedicated port for backup power (see Figure 2). This configuration integrates the MID within the ESS, and the components are inherently tested together as part of the 1741 SB and CRD for MM certification.

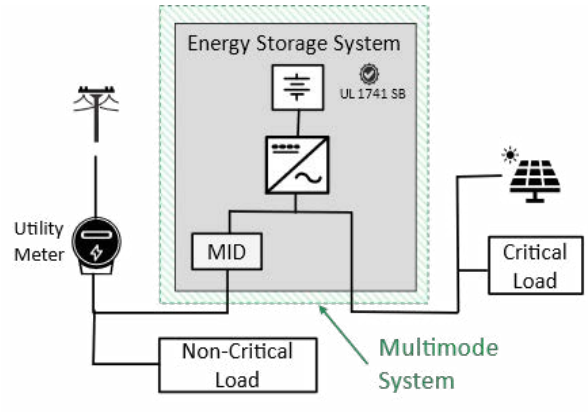

Figure 2. *Illustration of an MM ESS with an integrated MID*

Other BTM microgrid solutions incorporate an inverter with a single port for power supply both on- and off-grid. This configuration requires an external MID for off-grid operation, which must be tested in conjunction with the DER for MM certification (see Figure 3).

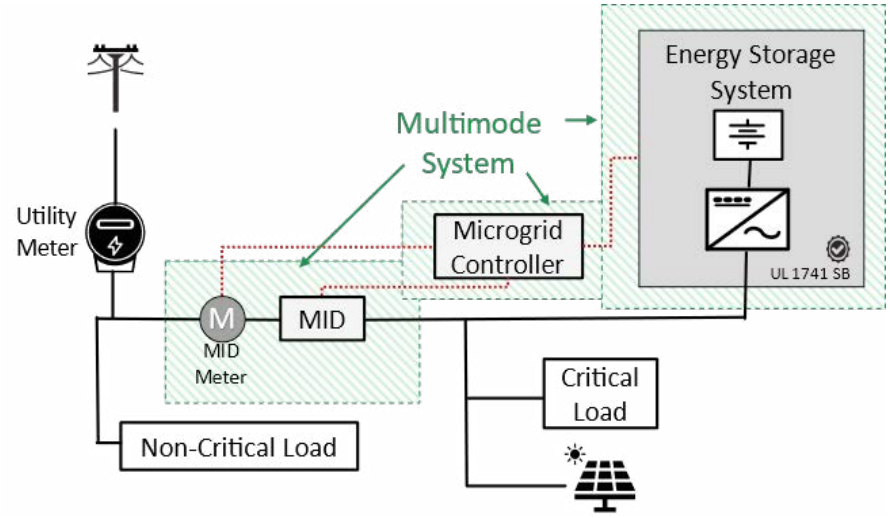

Figure 3. *Illustration of an MM system with an external MID*

Other Relevant Certifications

- UL 3010 – Single Site Energy Systems (for example, small facility microgrids) that can operate grid tied or islanded. In development; expected to be published in 2025.
- UL 1008 – Transfer Switch Equipment; several utilities reference this certification as a requirement for automatic transfer switch (ATS) equipment.
- NEC 705 – Interconnected Electric Power Production Sources. Specifies labeling requirements for microgrid systems and interconnected DER at the point of service.

Q2: Transitioning to Island—Who or what determines the circumstances when a BTM microgrid isolates from (and reconnects to) the area power system?

One of the concerns often raised with BTM microgrid interconnections is the impact these systems may have when transitioning to an intentional island state. Although DER interconnection standards, such as IEEE Std. 1547-2018, do allow this transition behavior, the timing and mechanisms to be considered for this transition operation are not entirely obvious. There are three general circumstances under which a BTM microgrid (and its DER) are allowed to isolate from the utility grid according to IEEE Std. 1547-2018:

1. A "cease to energize and trip" condition, for example, utility outage
2. A ride-though condition exception
3. A normal condition disconnection (for example, preemptive islanding)

These circumstances, along with example operational scenarios and related interconnection behavior requirements, are enumerated in Table 2. "Abnormal condition disconnection" is a commonly expected microgrid behavior in response to Circumstances 1 and 2, but "normal condition disconnection" may also be considered during interconnection review.

Table 2. *Common Island-Initiating Conditions and Related Interconnection Standard Requirements*

PRE-ISLAND CONDITION	EXAMPLE SCENARIO	ALLOWABLE ISLAND TRANSITION BEHAVIOR (ACCORDING TO IEEE STD. 1547-2018)
Cease to Energize Condition	Upstream fault or loss of utility power; isolate microgrid and stay powered	Generally, a BTM microgrid can transition to island under conditions that would otherwise require DER to cease to energize and trip. This includes faults external to the microgrid, open phase conditions, and under-/overvoltage trip conditions. See IEEE Std.1547-2018 Clause 8.2 for details.
Abnormal Condition (DER ride-through time)	Bulk system fault; prefer to island instead of ride-through and possibly experience a disturbance	The IEEE Std. 1547-2018 "Response to Area EPS abnormal conditions" Clauses 6.4.2 and 6.5.2 provide abnormal condition ride-through exceptions that allow BTM microgrids to transition to island without limitation if the pre-disturbance DER output is similar to local load.[8] These exceptions are often informally referred to as the "take your load with you" clause.
Normal Condition	Upcoming public safety power shutoff event warning; anticipated system maintenance outage warning	DER are expected to comply with the induced power quality phenomena requirements of IEEE Std. 1547 when a BTM microgrid executes a "normal condition disconnection" transition. If this requirement is met, the DER are not required to remain online during normal operating conditions unless separately obligated through contractual service agreements. The DER owner may be contractually penalized if the DER in the microgrid were providing a grid service and the BTM microgrid transitioned to island under normal operating conditions

10 Two exception conditions specified in IEEE Std. 1547-2018 Clauses 6.4.2 and 6.5.2 allow an island transition to occur while the applicable voltage and frequency are in a ride-through state. To meet the exception condition (a), the pre-disturbance microgrid dispatch scheme must limit the active power imported or exported across the PCC to under 10% of the aggregate microgrid DER rating. Exception condition (b) requires local load shedding equivalent to 90% of the pre-disturbance microgrid DER output. These exceptions are typically met when a BTM microgrid transitions to island because the DER are sized to match local load and opening the microgrid isolation point effectively sheds the entire microgrid load from the distribution operator's perspective. This assumes that the BTM microgrid island isolation and import/export control point is the same point as the DER PCC.

IEEE 1547.4 REVISION (GUIDE FOR DESIGN, OPERATION, AND INTEGRATION OF DER ISLAND SYSTEMS WITH EPS): DRAFT DEFINITIONS OF DISCONNECTION CIRCUMSTANCES

- **Abnormal condition disconnection:** A transition in which an intentional island system disconnects from the external EPS while the voltage or frequency conditions on the external EPS side of the intentional island isolation point are outside the normal operating range defined by the area EPS operator. **Contrast:** normal condition disconnection.
- **Normal condition disconnection:** A transition in which an intentional island system disconnects from the external EPS while the voltage and frequency conditions on the external EPS side of the intentional island isolation point are within the normal operating range defined by the area EPS operator. **Contrast:** abnormal condition disconnection.

Impending system events, such as scheduled public safety power shutoffs (PSPS) or extreme weather-induced rolling load shed events, may signal BTM microgrid systems to preemptively disconnect from the distribution grid to maintain local reliability. This behavior may also be leveraged as an aggregate resource by a distributed energy resource management system (DERMS) or advanced distribution management system (ADMS), though no certification test explicitly covers this capability; IEEE Std. 2030.8-2018 does require a high-level "planned islanding" transition test case. If expected for future use, EPRI recommends evaluating this type of remote dispatch control as part of the BTM microgrid interconnection witness test and considering it part of future product certification.

Q3: Evolving Customer Relationships—Who owns or manages energy optimization and power quality when a BTM microgrid is isolated from the area power system?

For customers privately pursuing microgrid development, it is important to establish that the distribution network has been designed to provide electric service to serve customer demand and that they are responsible for maintaining resource adequacy and power quality within their facilities while in islanded operation. When isolated from the primary distribution grid service, the BTM microgrid system is still subject to local jurisdiction code and requirements, such as NEC 705 or the United Facilities Criteria for Resilient Installation Microgrid Design. Key accounts or premium customers[11] may collaborate with the electric service provider to increase their reliability through the provisioning of dedicated distributed generation and facility islanding capability. In these cases, the service provider may have an obligation for resource adequacy and power quality within the facility. In both cases, the microgrid designer must identify facility power and energy requirements and size the distributed generation sources to meet customer needs during island mode.

Relevant parties should consider reviewing electric service rules and regulations and DER interconnection agreements for clauses establishing the responsibility for facility power quality and limitations of impact to the distribution system. This may include conditions where separation is allowed and the area network could experience impacts from switching transients.

Although the utility may not be explicitly responsible for facility power quality during islanded operation, EPRI recommends that distribution operators provide customer education tools such as power and energy calculators or infographics on appliance-over-time energy capacity. For highly reliable networks, general awareness of the quality of service provided while grid connected as well as equivalent microgrid capacity may also help customers determine both appropriate costs and when investment in an islanding system may be appropriate.

11 Premium customers are those who contract separately with a service provider for especially high levels of reliability and/or power quality.

Q4: Additional Witness Testing Requirement—Should a BTM microgrid be subject to additional witness or commissioning tests?

Although the grid-connected behavior of the DER that comprise BTM microgrids may be certified, additional acceptance testing of BTM microgrids is recommended to address the certification gaps highlighted in this brief. For example, Consolidated Edison specifies a minimum set of site acceptance testing for customer microgrids as part of the "ConEd *Microgrid Technical Specification*."[12] Southern California Edison requires BTM microgrid applications to include CEC-listed[13] DER along with a relay and disconnection device design and certified test reports that must be reviewed by an engineer.[14]

As noted previously, even the UL 1741 CRD for multimode DER does not currently reverify grid-parallel behavior **after** the DER has transitioned to and from an off-grid operation. It is common during island operation for the independent-operation-capable DER to receive new settings or configuration to support the operation of the islanded system. Although IEEE Std. 1547-2018 requires that the grid-connected DER settings be reactivated upon reconnection to the grid, this represents a current gap in the certification test procedure. It would, however, be difficult for BTM microgrids with an integrated MID (as shown in Figure 2) to pass existing certification procedures for grid-connected operation without adhering to this requirement.

Small-scale laboratory testing of certified, commercial inverter systems has indicated that the settings are retained through the island transition and reconnection cycle.[15] EPRI advises caution when reviewing products with limited deployment or solutions that are highly customized with external MID and off-grid control components (as shown in Figure 3). Commissioning tests may consider including a verification that the appropriate settings are active in the DER following an intentional island event until this gap is addressed by a certification procedure. A similar verification is recommended for PCS systems, if used, to ensure that the appropriate active power limit is maintained at the DER PCC after reconnecting to the grid.

EPRI recommends open phase response testing for C&I customers with a BTM microgrid interconnection to ensure that appropriate isolation occurs if the system transitions to island. According to IEEE Std. 1547-2018, the DER are required to cease to energize and trip for open phase conditions; a BTM microgrid system may isolate and transition to island under this scenario. This response should be tested during commissioning to ensure that the appropriate three-phase isolation is applied after detecting the open phase condition and continuing to energize the island. Additional commissioning tests for response to open phase condition are recommended for C&I customer BTM microgrid installations in cases where zero-sequence continuity is not maintained across the interconnection transformer. Commissioning guidance is provided in *DER Performance Verification and Commissioning Guideline*.[16]

Proper electrical isolation during island operation is a key component of microgrid design, and the isolation device may require review during witness testing. Typically, a backup power solution with an ATS requires the transfer switch to be UL 1008 tested. The UL 1741 CRD for multimode does include a backfeed protection test for island operation and requires that "switching devices that transfer between sources … shall not lose their intended functionality" after abnormal condition testing. The isolation equipment installed in the BTM microgrid should be evaluated for appropriate failure behavior if it is not listed to a utility-approved certification standard.

EPRI recommends evaluating microgrid behavior for island transition behavior under both "normal condition disconnection" and "abnormal condition disconnection." BTM microgrid systems are primarily designed to handle "abnormal condition disconnection" (for example, provide reliability upon sensing a grid disruption). Although most microgrids

12 Final inspection tests to be witnessed by the utility include operation of the protection and control system, status indicators, alarm and trip circuits, interlocks, telemetry, switchgear, and grounding. Consolidated Edison Co., "Technical Requirements for Microgrid Systems Interconnected with the Con Edison Distribution System." New York, 2017.

13 The California Energy Commission (CEC) publishes a list of preapproved inverters and PCS combinations that meet CA Rule 21 requirements: https://solarequipment.energy.ca.gov/Home/PowerControlSystem.

14 https://www.sce.com/partners/partnerships/Microgrids-for-Developers.

15 *IEEE 1547-2018 Smart Inverter Evaluations: UL 1741SB Certified Energy Storage System (ESS)*. EPRI, Palo Alto, CA: 2023. 3002028375.

16 *DER Performance Verification and Commissioning Guideline: Utility Current Practices and EPRI Recommendations*. EPRI, Palo Alto, CA: 2023. 3002028376.

will remain grid-connected most of the time the grid is available, BTM microgrid systems may also island as part of a "normal condition disconnection" (for example, as a preemptive action in anticipation of PSPS disruptions). EPRI advises testing both disconnection types when applicable during commissioning to ensure that the BTM microgrid behavior still complies with the power quality phenomena requirements of IEEE Std. 1547-2018 on the grid side of the microgrid isolation point. Potential impacts to assess during commissioning include rapid voltage change and flicker when the DER are exporting power prior to normal condition disconnection.

Table 3 summarizes the certification coverage of critical functions, potential risks with existing certifications, and witness testing considerations for interconnecting BTM microgrids.

Table 3. *Summary of microgrid DER functional coverage, per listing and witness testing considerations, to address gaps in interconnecting BTM microgrids*

BTM MICROGRID FUNCTIONS AND INTERCONNECTION CONCERN		CERTIFICATION ADDRESSING CONCERN	RISK (WITH RESPECTIVE CERTIFICATION)	COMMISSIONING IMPLICATION
Reapply grid-connected settings	After islanding	None	Low[a]	May waive
	After DER trip or power cycle	1741 SB		
PCS limits reapplied after islanding	After islanding	None	Low[a]	May waive
	After DER trip or power cycle	CRD for PCS		
Open phase detection response		1741 SB	Medium; type tested at DER point of connection	Verify response for 3Φ microgrids
MID failure response under abnormal conditions		CRD for MM or UL 1008	Low-medium	Verify failure testing of MID equipment
Island detection and trip		1741 SB	Low	May waive
Intentional island trip response		CRD for MM	Low	May waive
Backfeed protection		CRD for MM or UL 1008	Low-medium	Verify that certification is applicable to microgrid system[b]
Normal condition disconnection:[c] power quality during intentional island transition		None	Low-medium	Verify grid-side impact during normal condition transition

a Low-risk test gap: Return from islanding is not explicitly tested; however, DER are continuously power cycled and disconnected from the grid during testing. DER would have difficulty passing certification testing if unable to retain grid-connected settings and limits.

b Commissioning implications are intended when relevant certification has been acquired. In cases where relevant certification testing has not been performed, verification of the BTM function at commissioning is recommended. See discussion in CRD for MM section on microgrid system configuration details.

c See Table 3 for details of normal condition disconnection.

CONCLUSIONS

This technical brief provides an overview of the current state and challenges associated with behind-the-meter (facility) microgrid interconnections, emphasizing the need for updated standards and certifications to ensure intended performance. The landscape of certification requirements, such as the UL 1741 CRD for PCS and related standards, is evolving; these requirements are receiving feedback from both EPRI and the industry, and are expected to mature to address gaps. In the meantime, EPRI recommends that additional witness testing and commissioning procedures be considered – particularly for 3-phase customer systems – to ensure that BTM microgrids can operate safely and effectively during grid outages while maintaining compliance with power quality standards. Overall continued collaboration, feedback, and field experiences are needed to refine interconnection processes for BTM microgrids and enhance the reliability and safety of their operations.

RECOMMENDED READING

Considerations for Application of Export Limiting Power Control Systems. EPRI, Palo Alto, CA: 2020, 3002019736.

DER Interconnection Standards and Certifications in North America: Overview and Status Update. EPRI, Palo Alto, CA: 2023. 3002028288.

DER Performance Verification and Commissioning Guideline: Utility Current Practices and EPRI Recommendations. EPRI, Palo Alto, CA: 2023. 3002028376.

Energy Storage System Taxonomy of Operating Behaviors. EPRI, Palo Alto, CA: 2023. 3002027416.

Generic Technical Interconnection and Interoperability Requirements, 2nd Edition. EPRI, Palo Alto, CA: 2024. 3002030551.

Grid Considerations for Microgrids. EPRI, Palo Alto, CA: 2021. 3002020344.

IEEE 1547-2018 Smart Inverter Evaluations: UL 1741SB Certified Energy Storage System (ESS). EPRI, Palo Alto, CA: 2023. 3002028375.

Toolkit and Guidance for the Interconnection of Energy Storage and Solar-Plus-Storage. DOE, EERE, Washington, D.C.: 2022. https://energystorageinterconnection.org/.

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