Deconstructing Direct Transfer Trip

A Comprehensive Assessment of DER Islanding Risks, Safety Concerns, and Mitigations

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IREC builds the foundation for rapid adoption of clean energy and energy efficiency to benefit people, the economy, and our planet.

Regulatory Team

Mission:

Help U.S. states and territories regulate their electric utilities to ensure distributed energy resources can rapidly and equitably decarbonize the grid

Smart DER Siting

Hosting Capacity Analyses, Queue Reporting, Pre-Application Reporting

Innovative DER Integration

Smart Inverters, Energy Storage, Flexible Interconnection

Rapid Utility Approval

Model Procedures, Freeing the Grid, State Engagement

Utility Accountability

Utility Best Practices, Regulatory Compliance

Clean & Equitable Grid

Distribution Planning, Interconnection Equity, Grid Disparity

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PRESENTER

Brian Lydic

Chief Regulatory Engineer

IREC Regulatory Program

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AGENDA

1. **What Is Direct Transfer Trip (DTT)?**
   Overview of various DTT technologies
2. **Why Do Some Utilities Require DTT?**
   Examination of various utility justifications for DTT
3. **What Is the Risk of Unintentional Islanding (UI)?**
   Assessment of islanding risk posed by DERs
4. **How Do Utilities Screen for UI?**
   Overview of how utilities assess islanding risk today
5. **Key Findings**
   Summary of report findings

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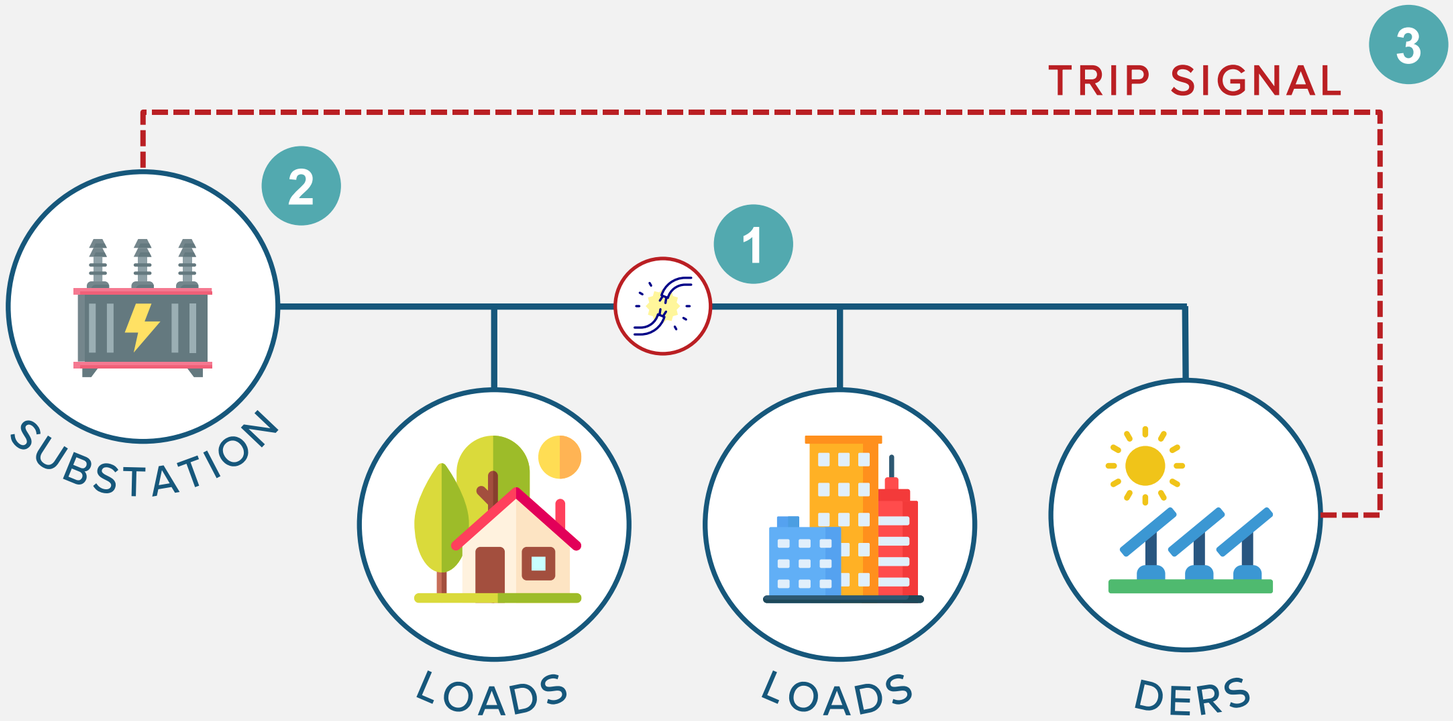
WHAT IS DIRECT TRANSFER TRIP (DTT)?



1. FAULT OR SWITCHING EVENT OCCURS
2. UTILITY PROTECTION EQUIPMENT RESPONDS
3. TRIP SIGNAL SENT TO DER SITE

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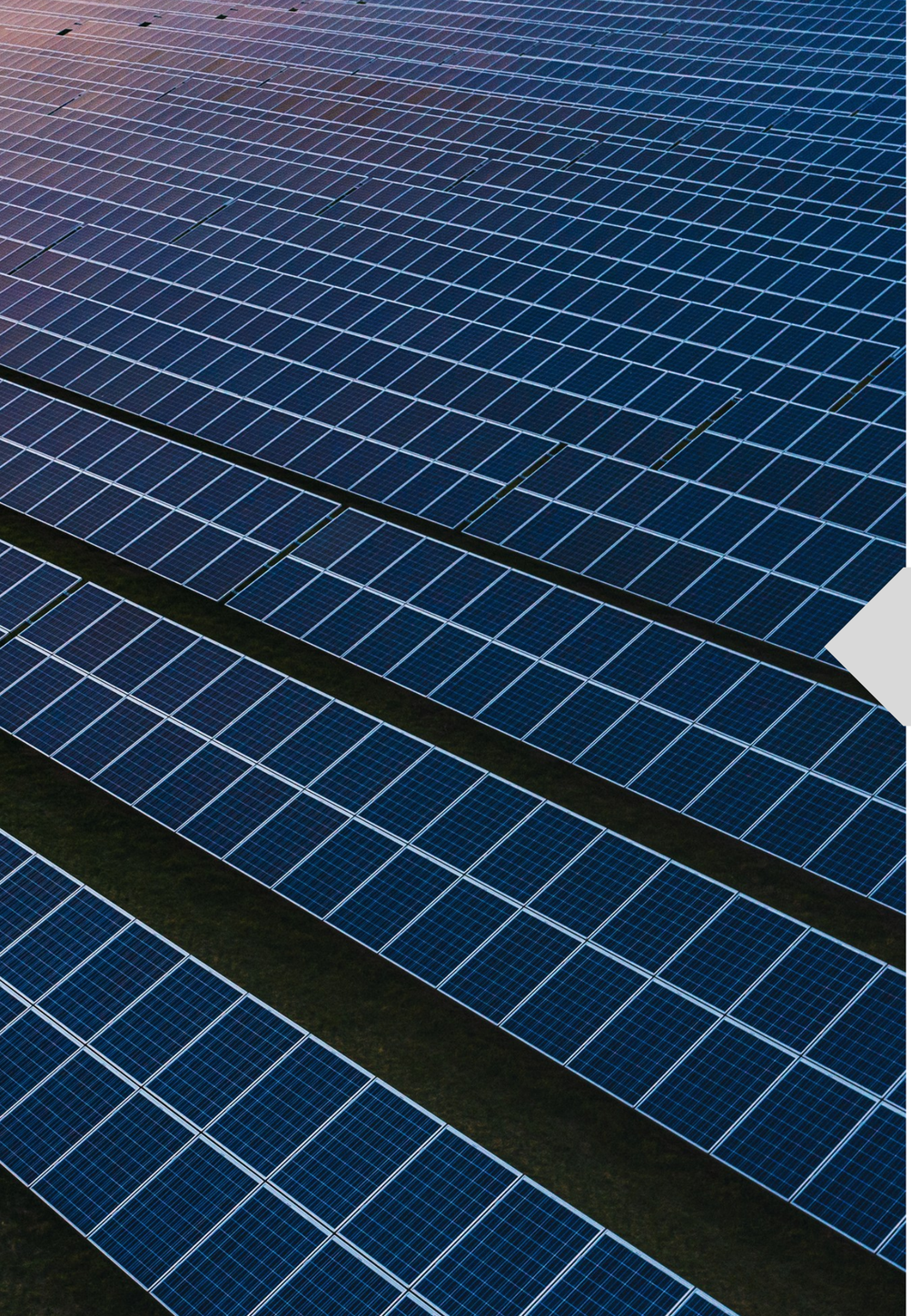

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WHY DO SOME REQUIRE DTT?

Electrocution risks to the public

Concerns that downed or manually disconnected conductors remain energized by DERs, increasing electrocution risk to the public or line workers.

- Exposure to live conductor sufficiently addressed by good utility practice
- DER-induced islands shown to not materially increase electrocution risk
- Near-zero probability of line worker encountering an island

Protection miscoordination

Delayed response of DERs to certain grid events may result in miscoordination of grid protection equipment, resulting in…

- Out-of-phase reclosing is very unlikely to occur for inverter DERs
- Any additional risks can be cost effectively mitigated
- Nuisance tripping is likely not an issue for inverter DERs

WHY DO SOME REQUIRE DTT?

Poor customer power quality

Customers may be exposed to unacceptable power quality deviations over the duration of a DER-induced unintentional islanding event.

- The extent and duration of power quality deviations are bounded during a UI and are unlikely to negatively impact equipment

Other less substantiated arguments

There is a wide range of less substantiated arguments that have been cited by utilities as justification for mandating DTT, including:

- Odessa Disturbance event at the transmission level (unrelated)
- Over-reliance on inverter protection misoperation anecdotes
- DER wildfire risk (unsubstantiated)
- Sub-transmission GFOV (otherwise effectively mitigated)

How can Tx GFOV be dealt with?

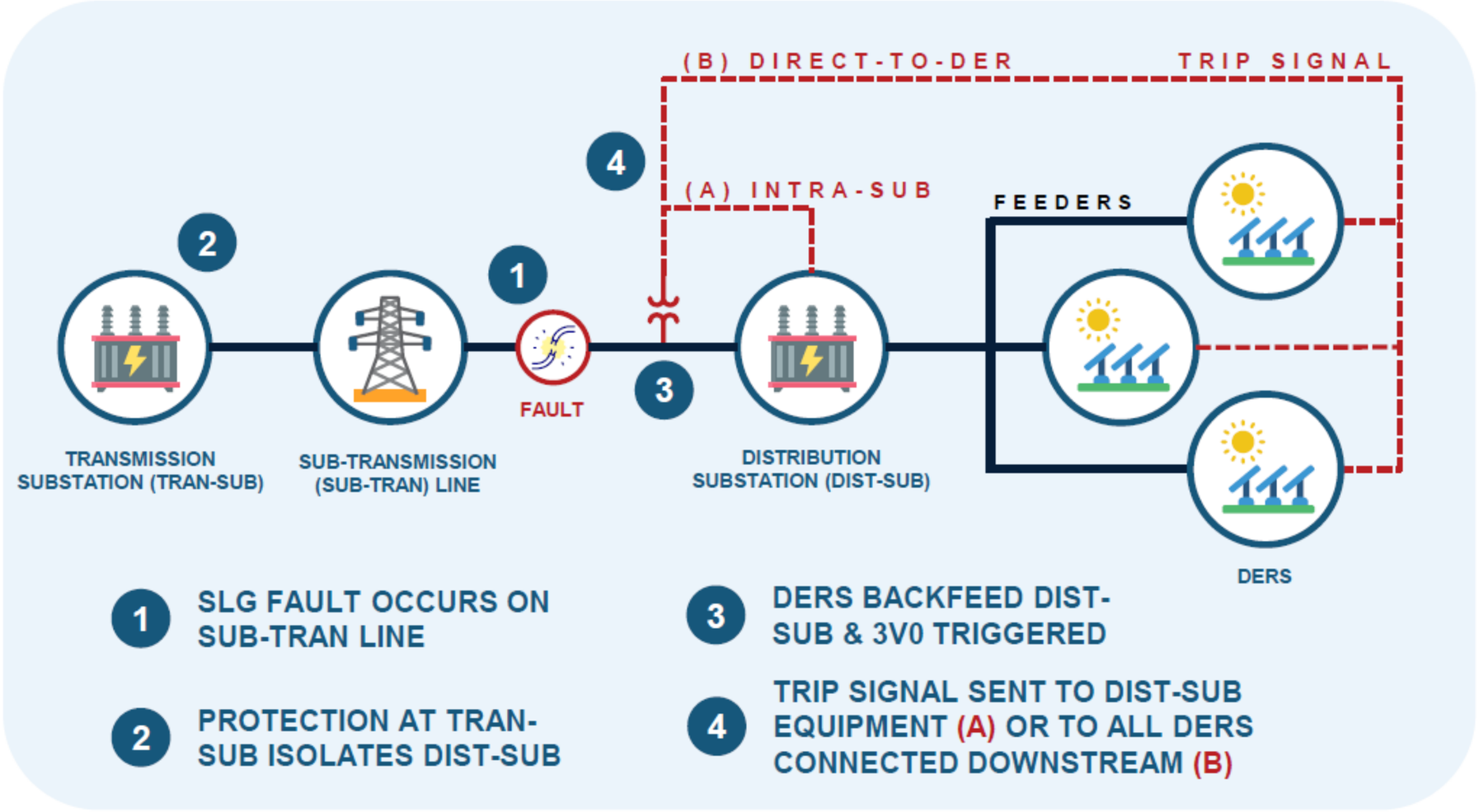
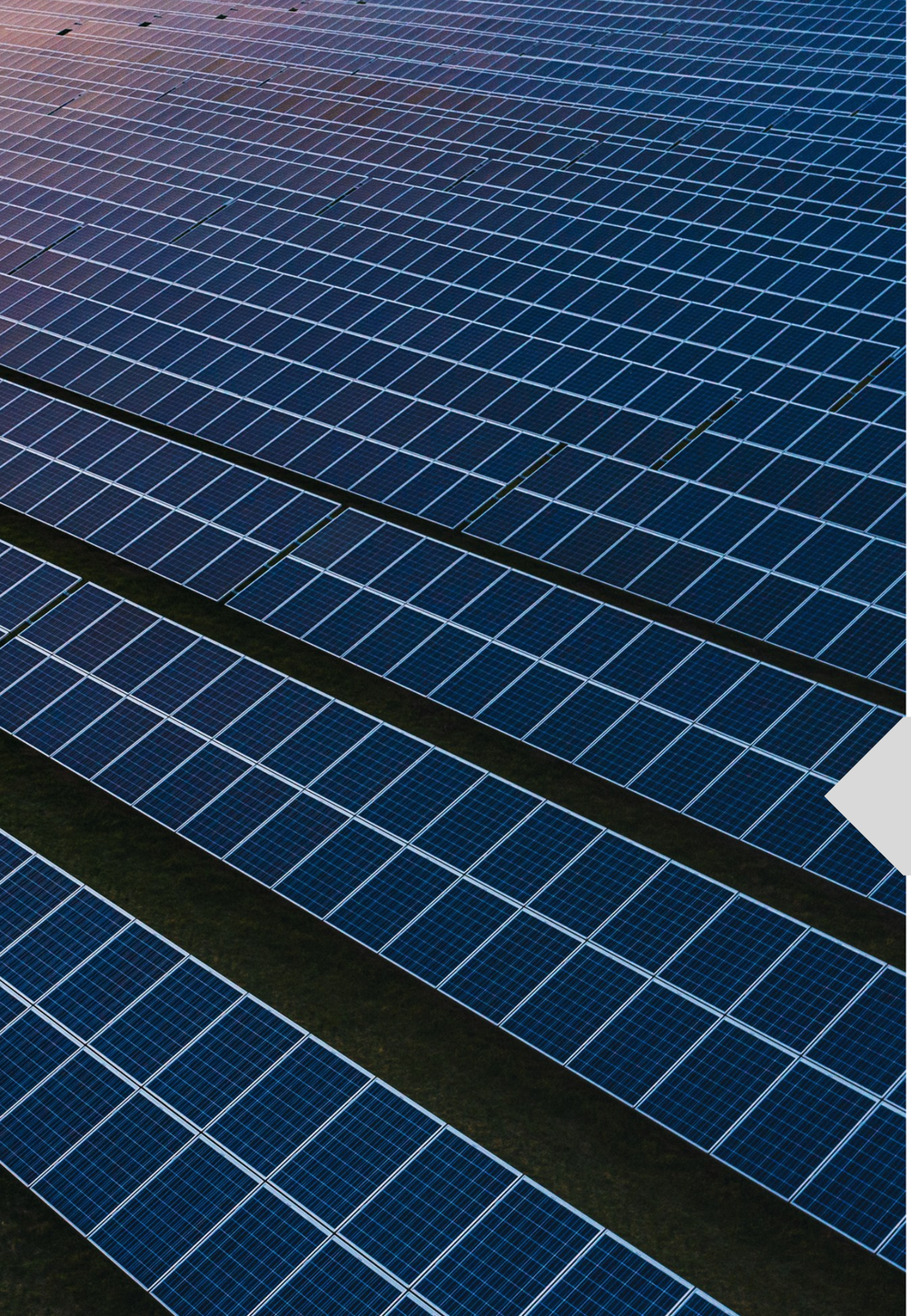


Figure 4: Simple Diagram of 3V0 to Prevent Sub-Transmission GFOV



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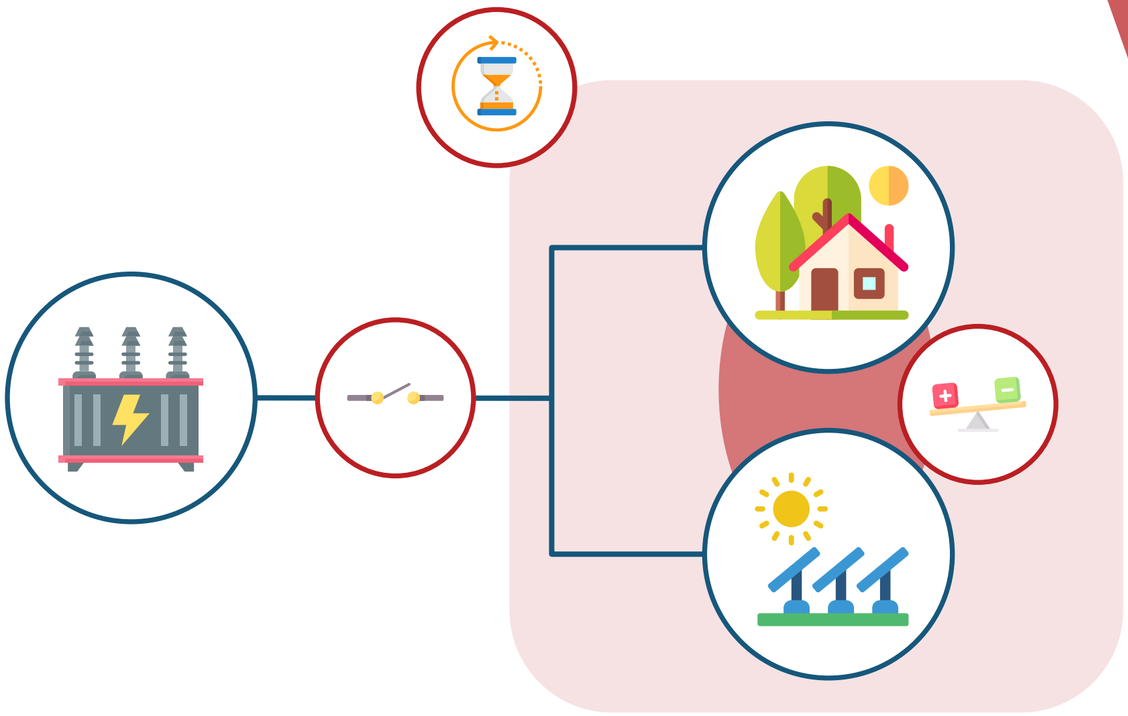
Risk of Unintentional Islanding

When can UIs occur?

1. Opening of a power grid circuit, islanding a segment containing DERs and loads

2. Balance between both active and reactive power of generation and load

3. No disruption to the island by protection or detection algorithms



Risk of Unintentional Islanding

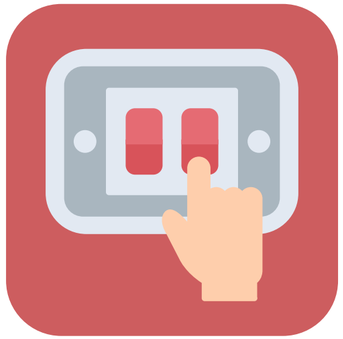
1. Opening of a power grid circuit…

Caused by a fault…

Highly unlikely to sustain an island as fault conditions disrupt power balance and trigger protection devices and internal protection functions

Caused by a manual switching…

Good utility practice and proper protection coordination can ensure that such events do not create islands

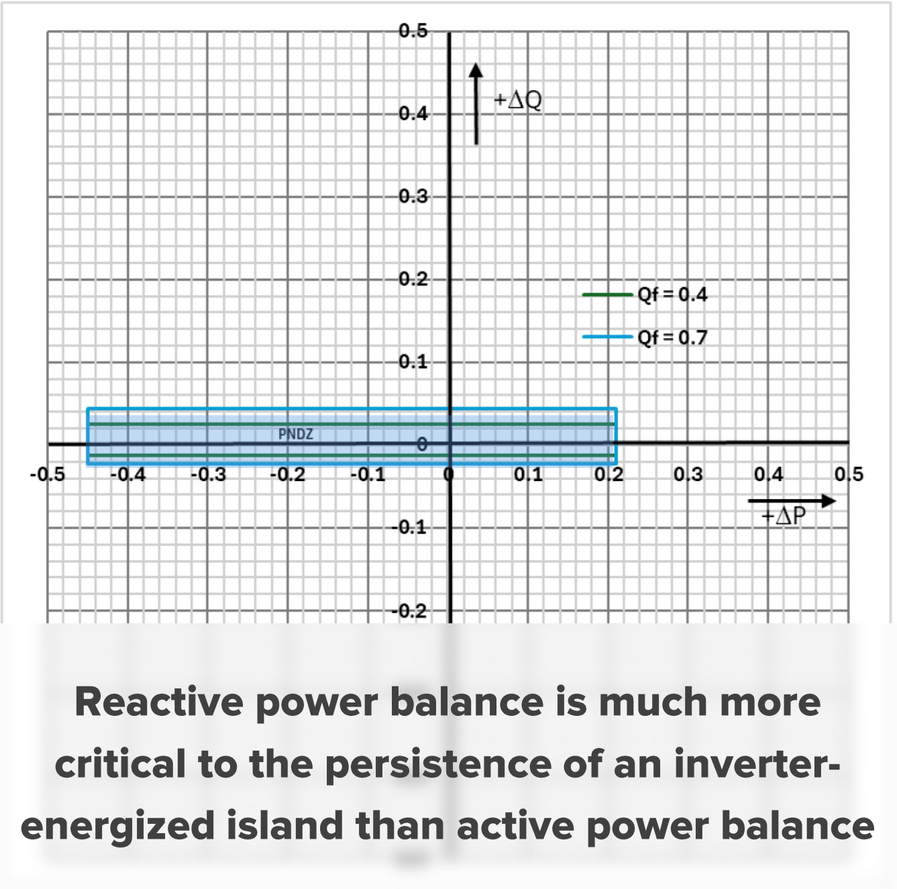


Risk of Unintentional Islanding

2. Balance between both active and reactive power…

Passive Non-Detection Zone (PNDZ):
A set of system operating conditions under which passive anti-islanding detection methods (i.e., voltage or frequency deviation) fail to detect the formation of an unintentional island.

Defining PNDZ Boundaries (right)



Reactive power balance is much more critical to the persistence of an inverter-energized island than active power balance

Risk of Unintentional Islanding

2. **Balance** between both active and reactive power…

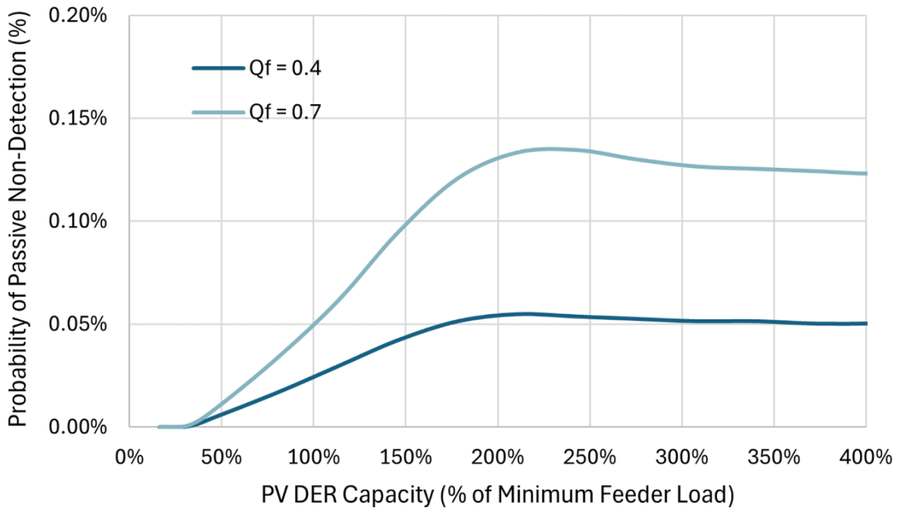


Figure 6: Probability of Passive Non-Detection Zone as a Function of PV DER Capacity Relative to Minimum Load

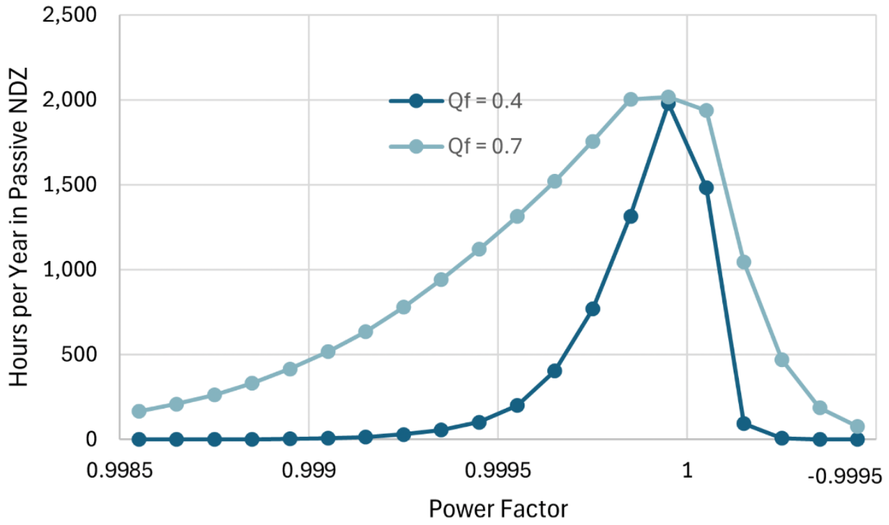


Figure 8: Hours in the Passive Non-Detection Zone as a Function of Power Factor and Quality Factor, with DER Capacity 1.46 Times Minimum Load

Risk of Unintentional Islanding

3. No disruption to the island…

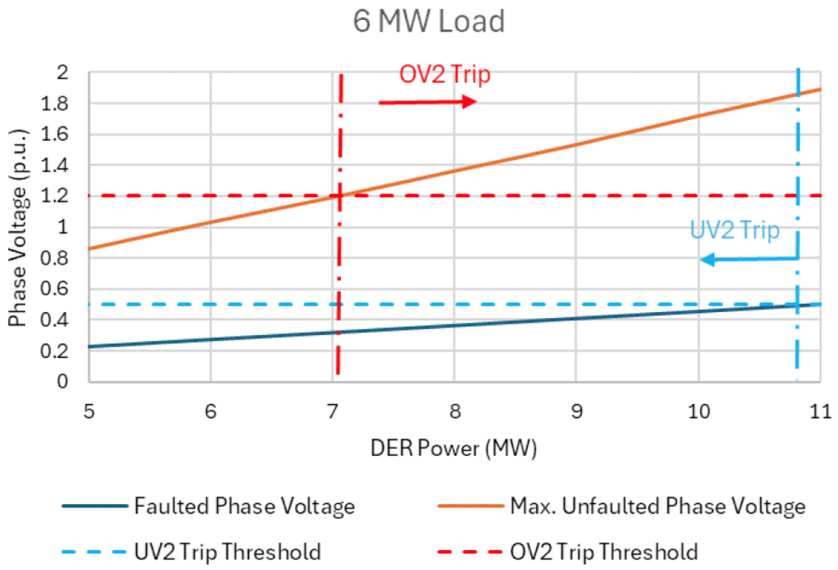


***Figure 11**: Phase Voltages at DER for Single-Phase Fault 8.6 Miles Away as a Function of DER Power with 6 MW Distributed Load*

There is no gap where neither under- nor over-voltage protection would eliminate any potential islands, and the full range of DER capacities will result in DER cessation of energization within no longer than 0.083 seconds for Category III inverters and 0.16 seconds for Category II inverters.

Risk of Unintentional Islanding

Question:

Given these preconditions and assuming anti-islanding is ineffective, what is the probability that an inverter-DER-induced persistent island will occur?

Once every 3,800 to 10,000 years

Risk of Unintentional Islanding

But what about anti-islanding functions and their effectiveness when…

- Using Advanced Grid Support Functions
- There Are Various Other Interconnected Inverters
- Connected to Circuits with Rotating Generators

Research shows that inverters with Advanced Grid Support Functions still adhere to the two-second disconnection requirement, as such functions often help to destabilize the island rather than support persistence.

Risk of Unintentional Islanding

But what about anti-islanding functions and their effectiveness when…

- Using Advanced Grid Support Functions
- There Are Various Other Interconnected Inverters
- Connected to Circuits with Rotating Generators

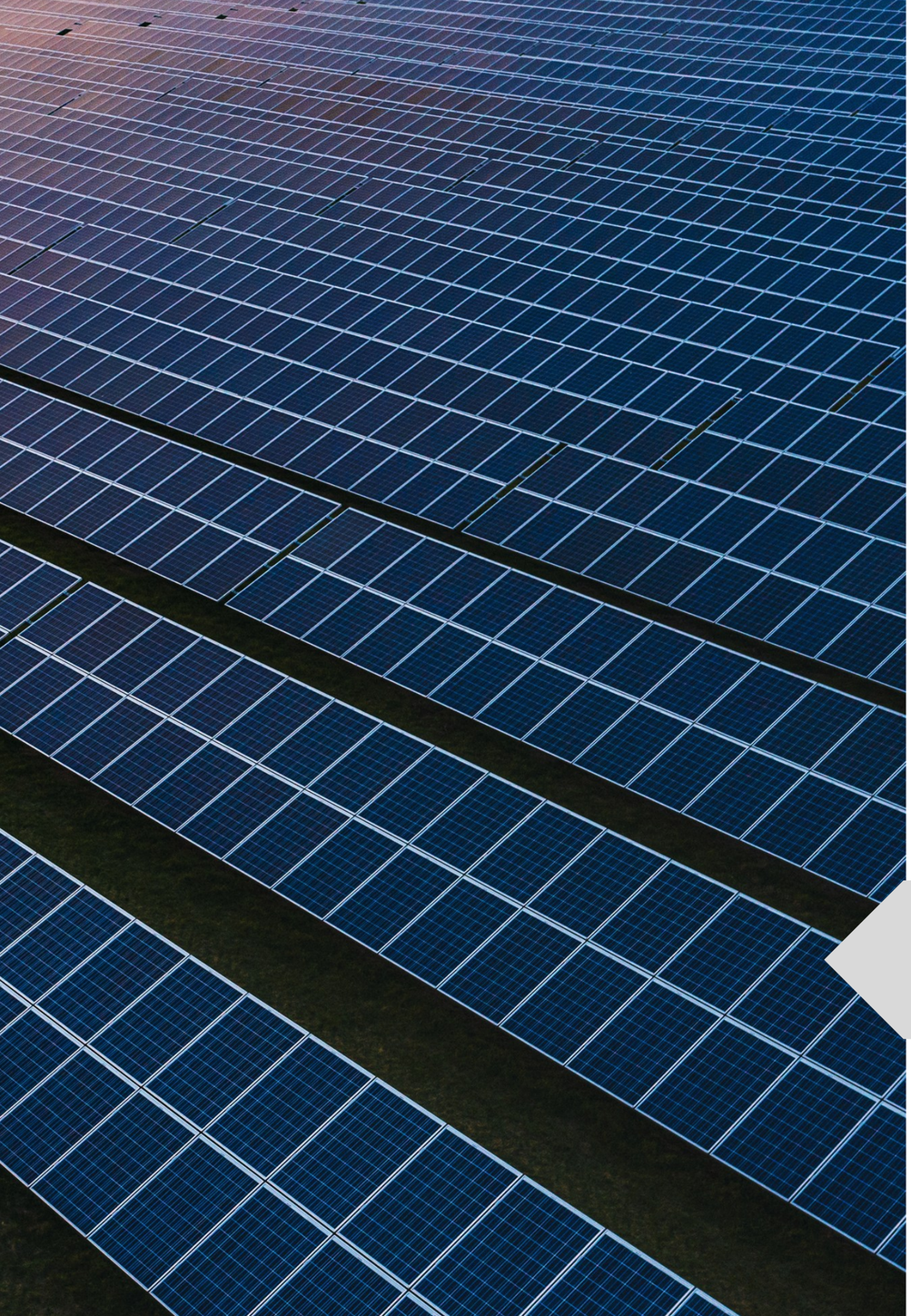
Research shows that even when various other inverters are interconnected, if most of those inverters use highly effective anti-islanding methods (i.e., Frequency Shift), disconnection within two seconds is still achieved under worst-case loading scenarios.

Risk of Unintentional Islanding

But what about anti-islanding functions and their effectiveness when…

- Using Advanced Grid Support Functions
- There Are Various Other Interconnected Inverters
- Connected to Circuits with Rotating Generators

Research shows that even when connected alongside rotating generators at high penetrations, inverters equipped with the most effective anti-islanding methods (i.e., Frequency Shift), disconnected within two seconds.



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UI SCREENING PRACTICES

PENETRATION LEVEL
(e.g., "where load to generation is less than 3:1 …")

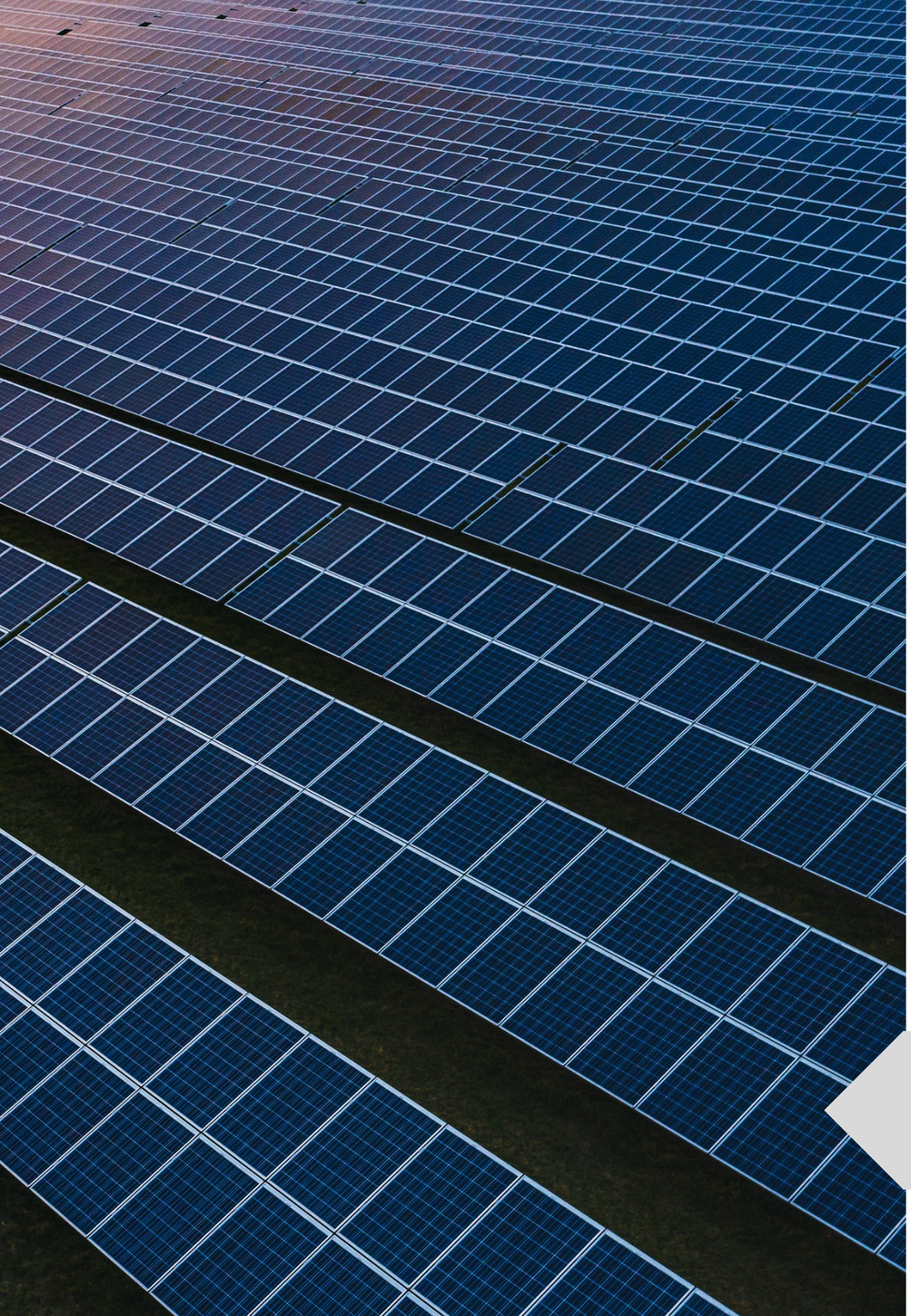
APPLICANT PROJECT SIZE
(e.g., "for systems ≥ 40 kW and ≤ 1 MW…")

VOLTAGE CLASS
(e.g., "connected to a line < 5 kV…")

ANTI-ISLANDING FUNCTION GROUP
(e.g., "if less than 33% of inverters on feeder are Group 1 or 2A…")

OTHER SYSTEM CHARACTERISTICS
(e.g., "If the substation transformer is ungrounded and…")

DETAILED ISLANDING STUDY
(e.g., "project fails a risk of islanding study…")



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KEY FINDINGS ON PROBABILITY

When can inverter DER-induced unintentional islands occur?

- Mostly manual switching events would cause separation without passive tripping of DER (once in several years).
- Reactive power balance must occur coincidentally, which is only balanced for several hours per year.
- Active anti-islanding would have to fail for the island to persist.
- The utility personnel doing the switching can check for an island after switching to ensure anti-islanding did not fail.

KEY FINDINGS ON CONSEQUENCES

If a manually induced unintentional island were to occur…

- Damage to customer or utility equipment will not occur.
- Inverter GFOV is generally mitigated by load (if not, a small ground bank is used).
- LROV is fully mitigated by inverter testing.
- I.e., an unintentional island that might occur on a feeder once in thousands of years (if anti-islanding happens to fail) is not consequential. Additional protection is not required.

REPORT CONCLUSIONS

Screening based on anti-islanding groups, rotating machines, reactive power balance (capacitors) will ensure anti-islanding protection does not fail, and even inconsequential islands will not occur

DTT is unnecessary for inverter DERS

Further mitigations, such as reclose blocking, can generally be avoided as well

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THANK YOU

To download the paper, go to:

irecusa.org/resources/deconstructing-direct-transfer-trip

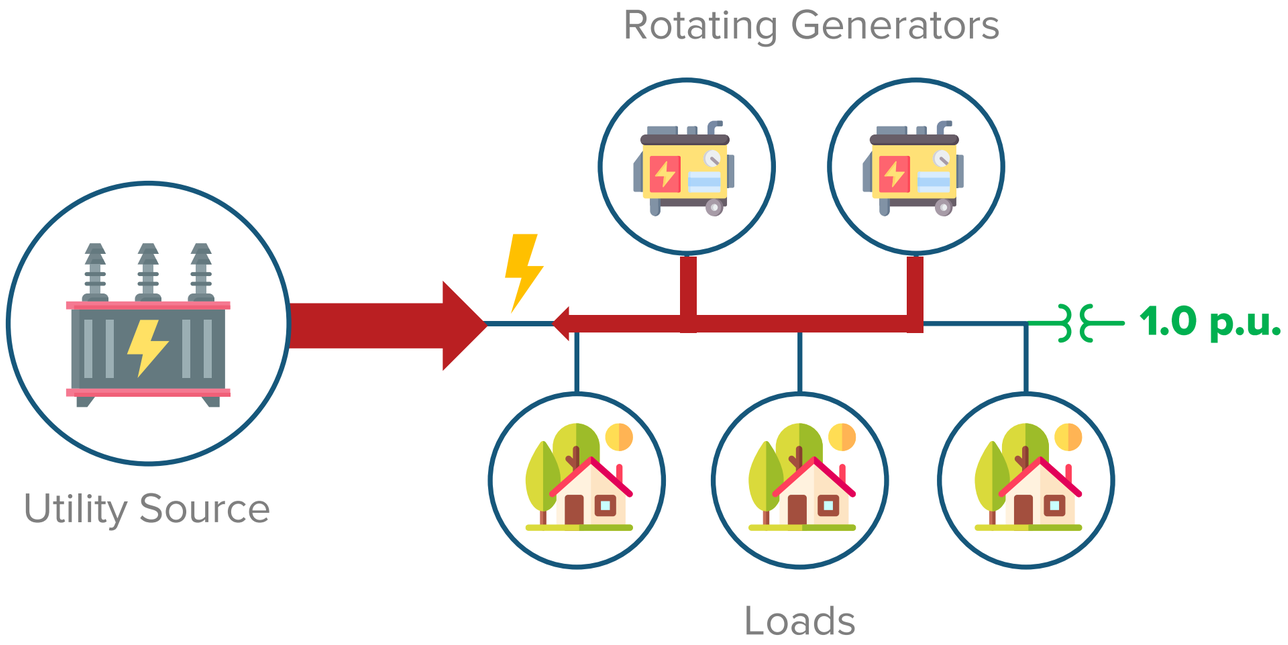
If you have any questions, contact:

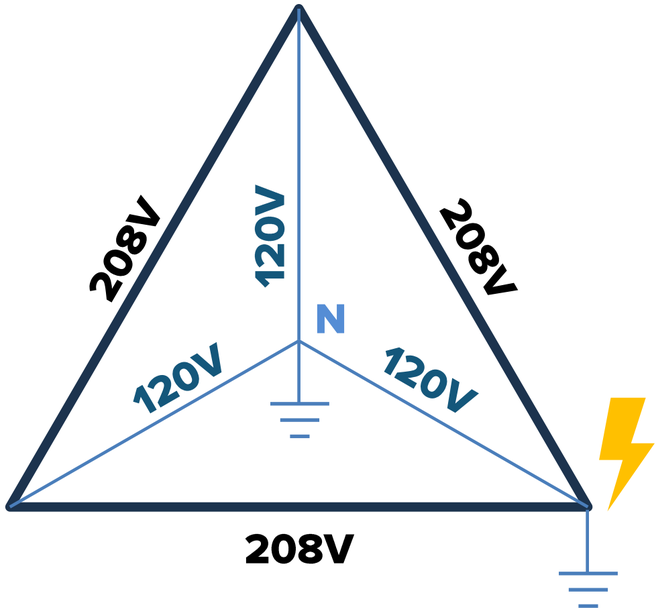
Brian Lydic

Chief Regulatory Engineer

brian@irecusa.org

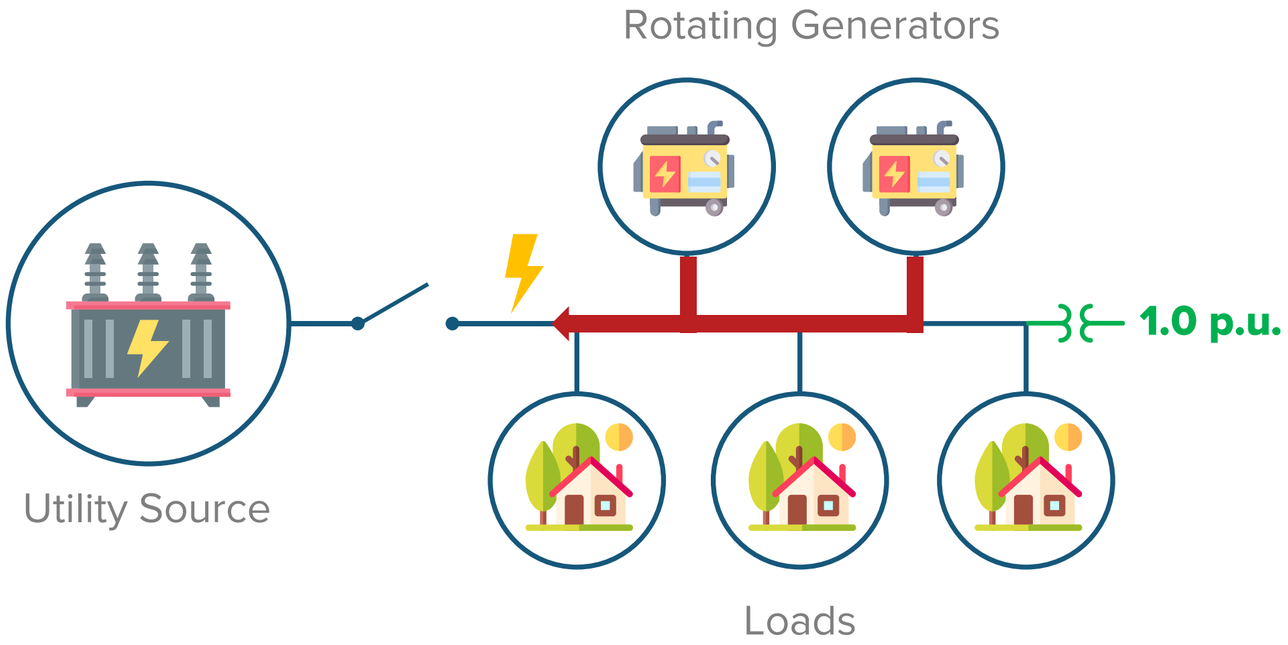
DER Impact on GFOV

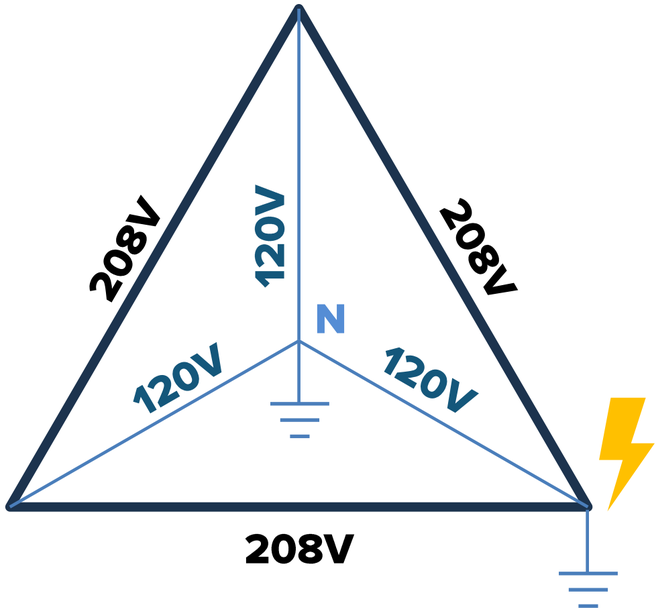




1 **Fault Occurs on Segment**

DER Impact on GFOV



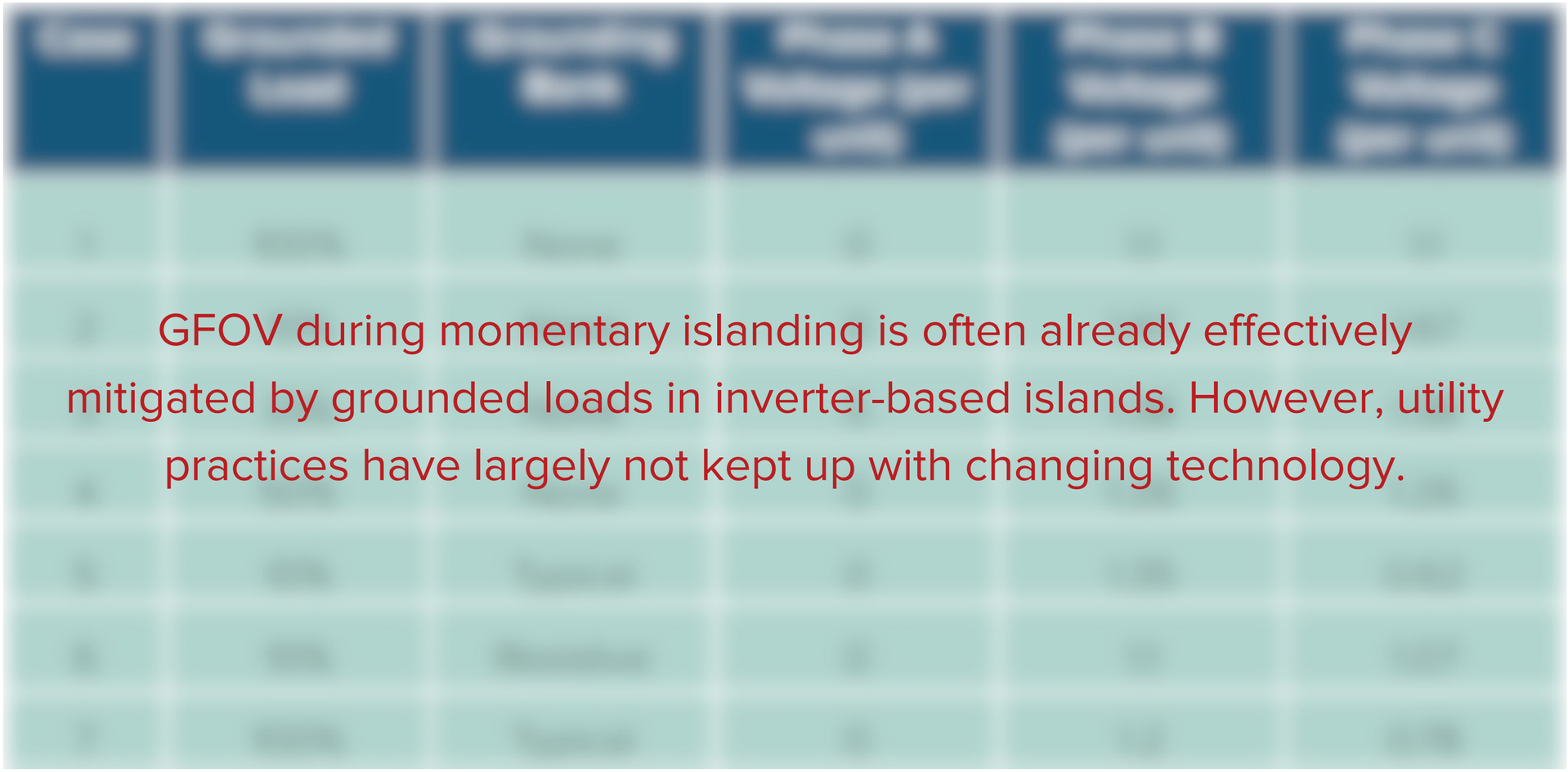


1. **Fault Occurs on Segment**
2. **Utility Protection Isolates Segment**

DER Impact on GFOV

What about inverter DERs?

Inverter Impact on GFOV



GFOV during momentary islanding is often already effectively mitigated by grounded loads in inverter-based islands. However, utility practices have largely not kept up with changing technology.