Overview of Interconnection Issues

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Technical Interconnection Issues

- Personnel safety
- Equipment protection
- Service reliability
- Power quality

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Utility Interconnection Requirements

- IEEE 929-2000
- UL standard 1741
- Utility practice and requirements
- Public utility commission statues

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What are the common interests of Utilities and DG manufacturers?

- Provides predictable requirements for design and installation.
  - Utility protection departments need to reduce costs.
  - Inverter manufacturers need to standardize their designs to keep costs lower.
- Over 3000 utilities with a similar number of interconnection requirements.
  - Consensus IEEE standard makes it unnecessary for utilities to utilize an independent standard.
  - Inverter manufacturers can build one design that is widely applicable.

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Distributed Generation Codes and Standards

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Why do we look at codes and standards for PV systems?

- The U.S. Department of Energy has been supporting codes development for PV systems for over 20 years
- More concerted effort has been paid for PV codes and standards than all other DG combined
- The issues involved in other small inverter-based DG are quite similar to PV systems

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What are the applicable codes and standards for PV systems?

- NEC Article 690 - Solar Photovoltaic Systems - Building codes - UBC, SBC, BOCA, local codes
- UL Standard 1703, Flat-plate Photovoltaic Modules and Panels
- IEEE 929-2000, Recommended Practice for Utility Interface of Photovoltaic (PV) Systems (approved in January 2000)
- UL Standard 1741, Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems (published in May 1999-Required November 2000)

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IEEE 929-2000

- Passed by IEEE Standards Board in January, 2000.
- Represents an excellent primer on PV inverter interconnection issues.

P929
Recommended Practice for Utility Interface of Photovoltaic (PV) Systems

Prepared by the Utility Working Group of
Standards Coordinating Committee 21, on Photovoltaics

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Purpose of IEEE 929

"This recommended practice contains guidance regarding equipment and functions necessary to ensure compatible operation of photovoltaic systems which are connected in parallel with the electric utility. This includes factors relating to personnel safety, equipment protection, power quality and utility system operation."

- Power Quality
- Safety and Protection

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IEEE 929 Working Group Consists of Utilities and Industry

John Stevens, Chair
Sandia National Labs

Mike Behnke
Trace Technology

Bill Brooks
N. Carolina Sol. Center

John Bzura
New England Electric

Steve Chalmers (Ret.)
Salt River Project

Joe Chau
Florida Power & Light

Doug Dawson (Ret.)
Southern Cal Edison

Dick DeBlasio
Chair – IEEE SCC 21

Tom Duffy
Central Hudson G&E

Chris Freitas
Trace Engineering

D. Lane Garrett
Southern Co. Services

Steve Hester,
UPVG

John Hoffner, Planergy
(ex Austin Electric)

Barry Hornberger
PECO Energy

Bob Jones
Rochester G&E

Greg Kern
Ascension Technology

Leslie Libby
Austin Electric

Don Loweberg
IPP

Tron Melzl
Omnion

Miles Russell, Secr.
Ascension Technology

John Moriarty
Raytheon

Chet Napikoski
Arizona Public Service

Jean Posbic
Solarex

Jodi Smythe
Underwriters Labs

Chase Sun
Pacific Gas and Electric

Rick West
UPG

Chuck Whitaker
Endecon

Robert Wills
Advanced Energy Sys.

Tim Zgonena
Underwriters Labs

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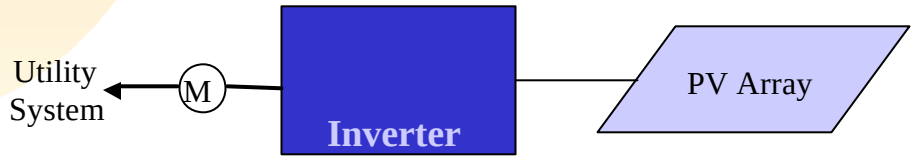
What Does IEEE 929 Really Impact?



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IEEE 929 Outline

- Introduction
- 1. Overview (scope & purpose)
- 2. References
- 3. Definitions (inverter, islanding, PCC, quality factor, etc…)
- 4. Power quality
- 5. Safety and protection functions
- Annexes

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Power Quality

- Power quality problems in general are rising because of proliferation of non-linear loads on utility systems -- all customers suffer
- PV should not add to that problem

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Power Quality

- Power Quality
  - 1. Service Voltage
  - 2. Voltage Flicker
  - 3. Frequency
  - 4. Waveform Distortion
    - *IEEE 519*
  - 5. Power Factor

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Safety and Protection Functions

- 1. Response to Abnormal Utility Conditions
  - ✓a. *Voltage Disturbances*
  - ✓b. *Frequency Disturbances*
  - ✓c. *Islanding Protection*
  - ✓d. *Reconnect After a Utility Disturbance*
- 2. Direct Current Isolation
- 3. Grounding
- 4. Manual Disconnect

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Response to Abnormal Utility Conditions

Voltage (at PCC)		Maximum Trip Time*
V< 60	(V<50%)	6 cycles
60≤V<106	(50%≤V<88%)	120 cycles
106≤V≤132	(88%≤V≤110%)	Normal Operation
132<V<165	(110%<V<137%)	120 cycles
165≤V	(137%≤V)	2 cycles

Frequency (at PCC)	Maximum Trip Time*
<59.3 Hz	6 cycles
59.3 - 60.5 Hz (normal)	--
>60.5 Hz	6 cycles

*"Trip time" refers to the time between the abnormal condition being applied and the inverter ceasing to energize the utility line. The inverter will actually remain connected to the utility to allow sensing of utility electrical conditions for use by the "reconnect" feature.

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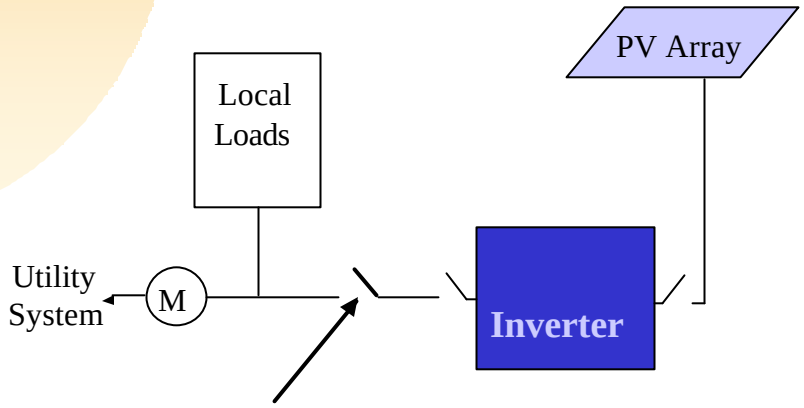
Manual Disconnect Switch



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IEEE 929 - Annexes

- Annex A (Normative) – Minimum Test Procedure for a Non-Islanding PV Inverter
- Annex B (Informative) - Bibliography
- Annex C - PV Inverters and the Utility Interface (Terminology)
- Annex D - Disconnect Switches & Utility Procedures
- Annex E - Islanding as it Applies to PV Systems
- Annex F - The PV Inverter Under Utility Fault Conditions
- Annex G - Dedicated Distribution Transformer

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How Does a Utility, or a PV-System Purchaser, Know If An Inverter Meets The Requirements of IEEE 929?

Require an inverter that meets the testing requirements of Underwriters Laboratories test standard UL 1741 and has the words “Utility-Interactive” printed directly on the listing label

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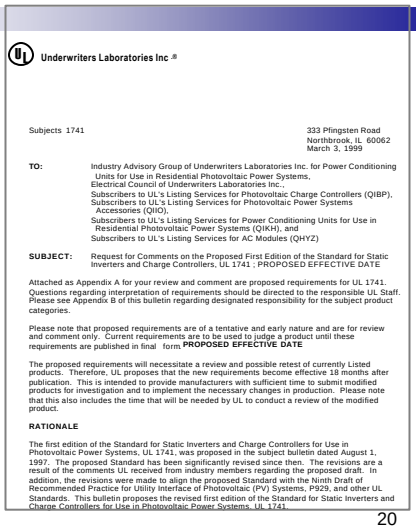
UL 1741 Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems

- First released in May of 1999
- Currently being revised to match IEEE 929-2000
- Compliance with revised document by November 7, 2000)
- New title reads “Standard for inverters, converters, and controllers for use in Independent Power Systems.”(Nov 8, 2000)



Underwriters Laboratories Inc ®

Subjects 1741

333 Pfingsten Road
Northbrook, IL 60062
March 3, 1999

TO: Industry Advisory Group of Underwriters Laboratories Inc. for Power Conditioning Units for Use in Residential Photovoltaic Power Systems,
Electrical Council of Underwriters Laboratories Inc.,
Subscribers to UL’s Listing Services for Photovoltaic Charge Controllers (QIBP),
Subscribers to UL’s Listing Services for Photovoltaic Power Systems Accessories (QIIO),
Subscribers to UL’s Listing Services for Power Conditioning Units for Use in Residential Photovoltaic Power Systems (QIKH), and
Subscribers to UL’s Listing Services for AC Modules (QHYZ)

SUBJECT: Request for Comments on the Proposed First Edition of the Standard for Static Inverters and Charge Controllers, UL 1741 ; PROPOSED EFFECTIVE DATE

Attached as Appendix A for your review and comment are proposed requirements for UL 1741. Questions regarding interpretation of requirements should be directed to the responsible UL Staff. Please see Appendix B of this bulletin regarding designated responsibility for the subject product categories.

Please note that proposed requirements are of a tentative and early nature and are for review and comment only. Current requirements are to be used to judge a product until these requirements are published in final form.

PROPOSED EFFECTIVE DATE

The proposed requirements will necessitate a review and possible retest of currently Listed products. Therefore, UL proposes that the new requirements become effective 18 months after publication. This is intended to provide manufacturers with sufficient time to submit modified products for investigation and to implement the necessary changes in production. Please note that this also includes the time that will be needed by UL to conduct a review of the modified product.

RATIONALE

The first edition of the Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems, UL 1741, was proposed in the subject bulletin dated August 1, 1997. The proposed Standard has been significantly revised since then. The revisions are a result of the comments UL received from industry members regarding the proposed draft. In addition, the revisions were made to align the proposed Standard with the Ninth Draft of Recommended Practice for Utility Interface of Photovoltaic (PV) Systems, P929, and other UL Standards. This bulletin proposes the revised first edition of the Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems, UL 1741.

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What is UL 1741 and how does it relate to IEEE 929?

- UL 1741 is the UL test standard that is used for the listing of PV inverters, charge controllers, and other BOS equipment.
- "Final" version released last year. It will be revised as all new standards are over the first several years of implementation.
- 1741 incorporates the testing required by IEEE 929 (frequency and voltage limits, power quality, non-islanding inverter testing)
- 1741 testing includes design (type) testing and production testing.

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IEEE P1547

- Entitled: *IEEE Draft Standard for Interconnecting Distributed Resources with Electric power Systems*

  (*http://grouper.ieee.org/groups/scc21/1547*)
- Draft 7 was balloted in April (received 66% approval, need 75%)
- Draft 8 was recirculated in September (similar results)
- Negative votes and other comments are currently being addressed

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IEEE P1547 Section 4.0

INTERCONNECTION TECHNICAL SPECIFICATIONS AND REQUIREMENTS

- 4.1 General Requirements
- 4.2 Response to Area EPS Abnormal Conditions
- 4.3 Power Quality
- 4.4 Islanding

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IEEE P1547 Section 5.0

TEST SPECIFICATIONS AND REQUIREMENTS

- 5.1 Interconnection Test
- 5.2 Production Tests
- 5.3 Interconnection Installation Evaluation
- 5.4 Commissioning Tests
- 5.5 Periodic Interconnection Tests

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IEEE P1547 Benefits

- Consistent national requirements that help manufacturers develop universal products
- Broad buy-in from diverse stakeholders

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IEEE P1547 Limitations

- Only solves a portion of interconnection issues
- Does not adequately address site-specific interconnection concerns

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Technical Requirements for Distribution System Integration

Distribution System
Capacity Constraints and
Interconnection Study Requirements

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California Rule 21

Technical Aspects of the California
Interconnection Review Process
for all Distributed Generation

(www.energy.ca.gov/distgen)

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Basic Interests of Stakeholders

- Need to streamline the process. Especially to make smaller installations (under 500 kW) easier.
- Need for a set of requirements that allow "plug-and-play" of DG for as many installations as possible.
- Process should focus on what can be solved within the given timeframe.
- Result should be broadly transferable to other states, regions, municipalities, IEEE P1547

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Recommendations of the Strawman Team

- Keep requirements 'performance-based' rather than 'prescriptive-based.'
- Make the requirements size-independent. Remove references to system size.
- Establish "screening process" to address individual technical issues that must be addressed for each installation.
- Begin developing specific language for testing and certification process to support simplified interconnections.

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Results of Technical Working Group

- Technical requirements identified under three main headings:
  - General Interconnection and protection requirements
  - Prevention of interference
  - Control, protection and safety equipment requirements

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General Interconnection and protection requirements

- This section deals with those requirements that are generic to all distributed generators.
- It addresses such requirements as
  - not reenergizing deenergized lines,
  - not contributing to an Unintended Island, and
  - the fact that Certified equipment is acceptable to all California Electrical Corporations.

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Prevention of interference

- Deals primarily with the limits of operation of the DG so as to prevent interference on Customers and the operation of the Distribution System.
- It addresses
  - Voltages limits and voltage flicker
  - Frequency limits
  - Power Quality (harmonics, DC injection, and, power factor)

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Control, protection and safety equipment requirements

- This section covers the control requirements related to the protection and safety functions of the DG.
- It addresses
  - Basic Requirements
  - Technology Specific Requirements
  - Initial Review process
  - Supplemental DG Requirements
  - Generating Facility types and conditions not identified

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Initial Review process

- It evaluates the specific characteristics of the Interconnection, including those specific to the location of the Generating Facility, and whether additional requirements are necessary.
- It includes a screening process which is a series of pass/fail criteria that help identify the simple cases for interconnection.
- The screening process does not eliminate any DG from interconnecting.

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Possible Outcomes of the Initial Review Process

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Initial Review Process Outcomes

- **Simplified** Interconnection Requirements
- **Supplemental Review** to Establish Interconnection Requirements
- **Interconnection Study** to Establish Interconnection Requirements

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Initial Review Process Questions and Issues Addressed

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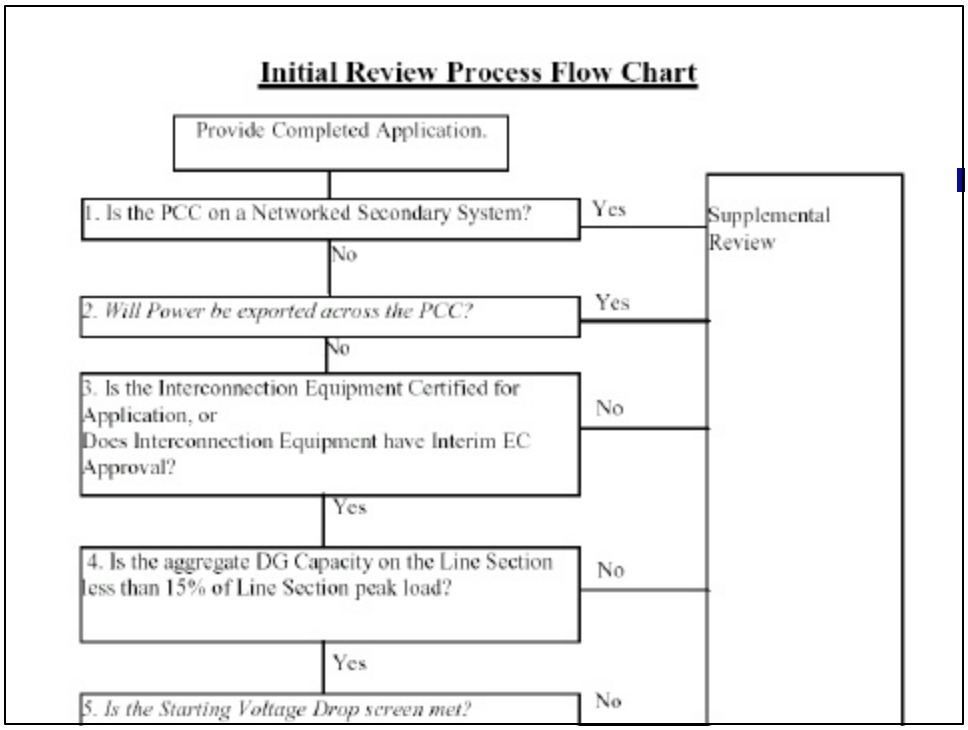
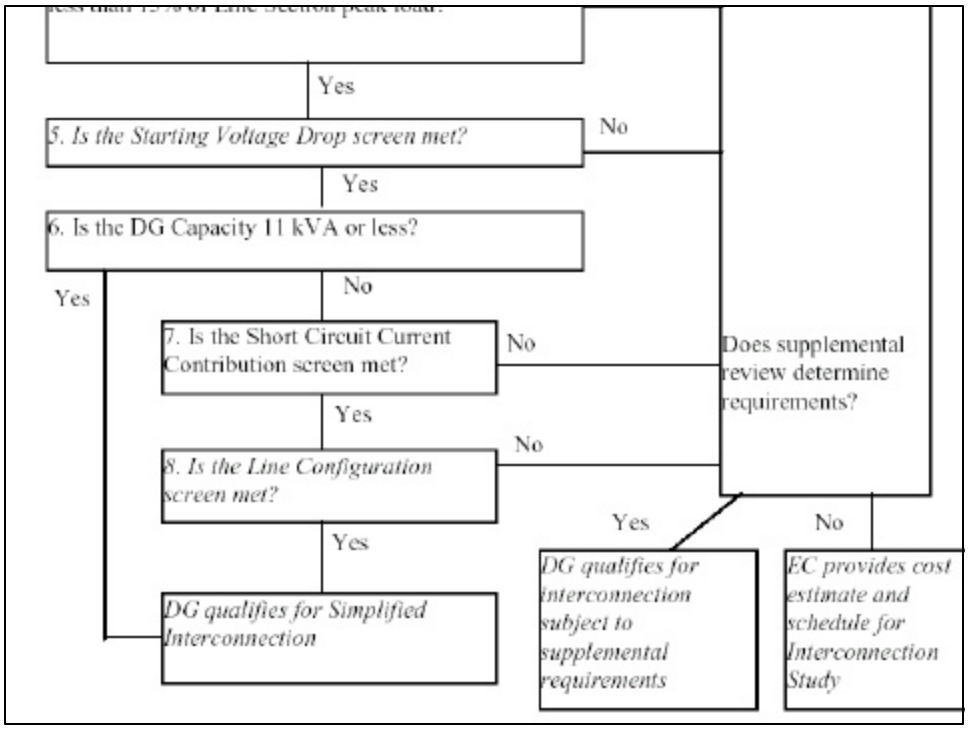

Initial Review Process Flow Chart
Provide Completed Application.
1. Is the PCC on a Networked Secondary System?
Yes
Supplemental Review
No
2. Will Power be exported across the PCC?
Yes
No
3. Is the Interconnection Equipment Certified for Application, or
Does Interconnection Equipment have Interim EC Approval?
No
Yes
4. Is the aggregate DG Capacity on the Line Section less than 15% of Line Section peak load?
No
Yes
5. Is the Starting Voltage Drop screen met?
No


Yes
5. Is the Starting Voltage Drop screen met?
No
Yes
6. Is the DG Capacity 11 kVA or less?
Yes
No
7. Is the Short Circuit Current Contribution screen met?
No
Does supplemental review determine requirements?
Yes
8. Is the Line Configuration screen met?
No
Yes
Yes
No
DG qualifies for Simplified Interconnection
DG qualifies for interconnection subject to supplemental requirements
EC provides cost estimate and schedule for Interconnection Study

The Screens

- Export Screen
  - If power is not exported, utility voltage regulators are not affected and reverse-power functions can be used to mitigate Unintended Islanding.
- Certification Screen
  - If equipment is Certified, it does not need to be separately reviewed and tested by each utility.

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Fault Current Contribution Screen

- If fault contribution is minimal, then there is no impact on the Electrical Corporation's:
  - equipment short circuit duty
  - fault detection sensitivity
  - relay coordination
  - fuse-saving schemes

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Line Configuration Screen

- If the primary system is three-wire or the DG interconnection transformer is single-phase (line-to-neutral), then there is no concern about overvoltages to the Electrical Corporation's or Customer's equipment caused by loss of system neutral grounding during brief Unintended Islands.

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Importance of the Screening Process

- It provides a standardized, methodical procedure for addressing the individual technical issues of interconnection.
- It leads the way to identifying the greatest concerns with a specific DG installation and the degree of review necessary to develop the interconnection requirements.
- It is the shortest near-term path to the "plug-and-play" world that we all want for DG.

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