

IEEE 1547

IEEE 1547: *Standard for Interconnection **and Interoperability** of Distributed **Energy Resources** with **Associated** Electric Power Systems **Interfaces***

http://grouper.ieee.org/groups/scc21/1547_revision/1547revision_index.html

Index

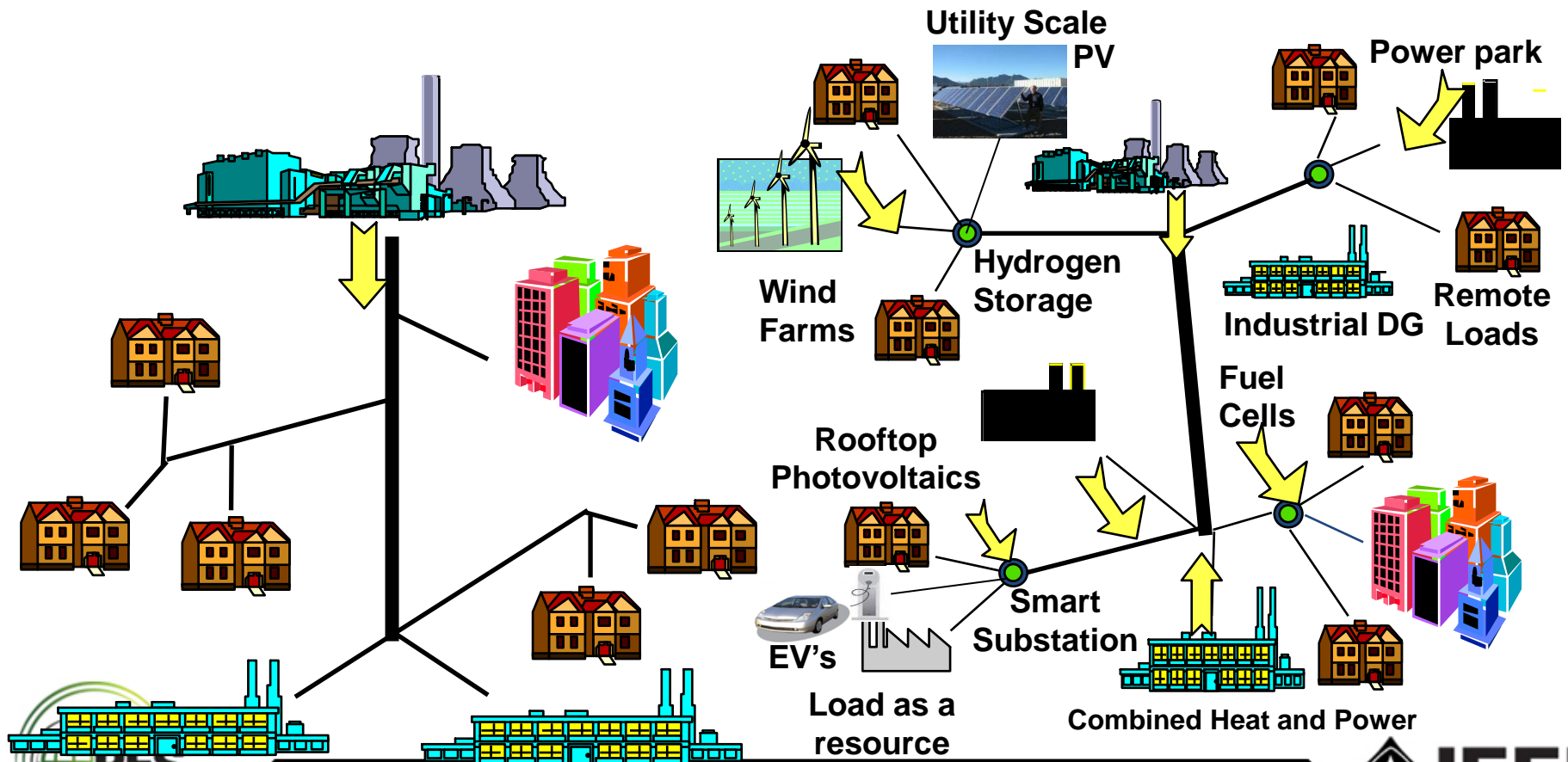
- What is IEEE 1547?
- Ride through
- Voltage regulation
- Power Quality
- Overview of interoperability, island systems, and testing

Challenges of Grid Modernization

Traditional Electric Grid...



Modern Electricity Choices ...



P1547 Revision: Draft *Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.*

Scope: This standard establishes criteria and requirements for interconnection of distributed **energy** resources (DER) with electric power systems (EPS), **and associated interfaces.**

Note: Interfaces defined in IEEE 2030: “a logical interconnection from one entity to another that supports one or more data flows implemented with one or more data links.

Purpose: This document provides a uniform standard for the interconnection **and interoperability** of distributed **energy** resources (DER) with electric power systems (EPS). It provides requirements relevant to the interconnection **and interoperability** performance, operation, and testing, and, safety, maintenance **and security considerations.**

IEEE SCC21 1547 Series of Standards*

IEEE Std 1547™(2003 and 2014 Amendment 1) Standard for Interconnecting Distributed Resources with Electric Power Systems

IEEE Std P1547™(full revision) Draft Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

IEEE Std 1547.1™(2005 and 2015 Amendment 1) Standard for Conformance Tests Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems

IEEE Std P1547.1 (full revision) Draft Standard for Conformance Tests Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces

IEEE Std 1547.2™(2008) Application Guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems

IEEE Std 1547.3™(2007) Guide for Monitoring Information Exchange, and Control of Distributed Resources with Electric Power Systems

IEEE Std 1547.4™(2011) Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

IEEE Std 1547.6™(2011) Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks

IEEE Std 1547.7™ (2013) Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection

IEEE Std P1547.8™ Draft Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Std 1547-2003

Guidelines &
Recommendations

* Colored background designates IEEE published standard; clear background is draft standard work in progress.

1547: Interconnection Is The Focus

IEEE Std 1547 covers:

- **INTERCONNECTION** TECHNICAL SPECIFICATIONS & REQUIREMENTS
- **INTERCONNECTION TEST** SPECIFICATIONS & REQUIREMENTS (IEEE 1547.1)

Distributed
Energy Resource
(DER) unit

Interconnection System

Note: P1547 full revision started in year 2015 is also addressing interoperability and interfaces

Area
Electric Power
System (EPS)

- A Technical Standard – Functional Requirements For the **interconnection** and **testing** of it
- Technology neutral, e.g., does not specify particular equipment nor type
- A single (whole) document of mandatory, uniform, universal, requirements that apply at the PCC or Point of DER Connection.
- Should be sufficient for most installations.

IEEE 1547 is **not**:

- a design handbook
- an application guide
- an interconnection agreement
- prescriptive, e.g., does not address DR self-protection, nor planning, designing, operating, or maintaining the Area EPS.

UL 1741 to certify inverters. Remaining test regiment to come with revised IEEE 1547.1

IEEE Std 1547a – Amendment 1, May 2014

(Amendment 1: revisions to 4.1.1, 4.2.3, and 4.2.4)

4.1.1 Voltage Regulation

... DER **allowed** to change its output of active and reactive power.

4.2.3 (Response to abnormal grid ...) Voltage

.... DER **allowed** to “**ride through**” abnormalities of grid voltage;

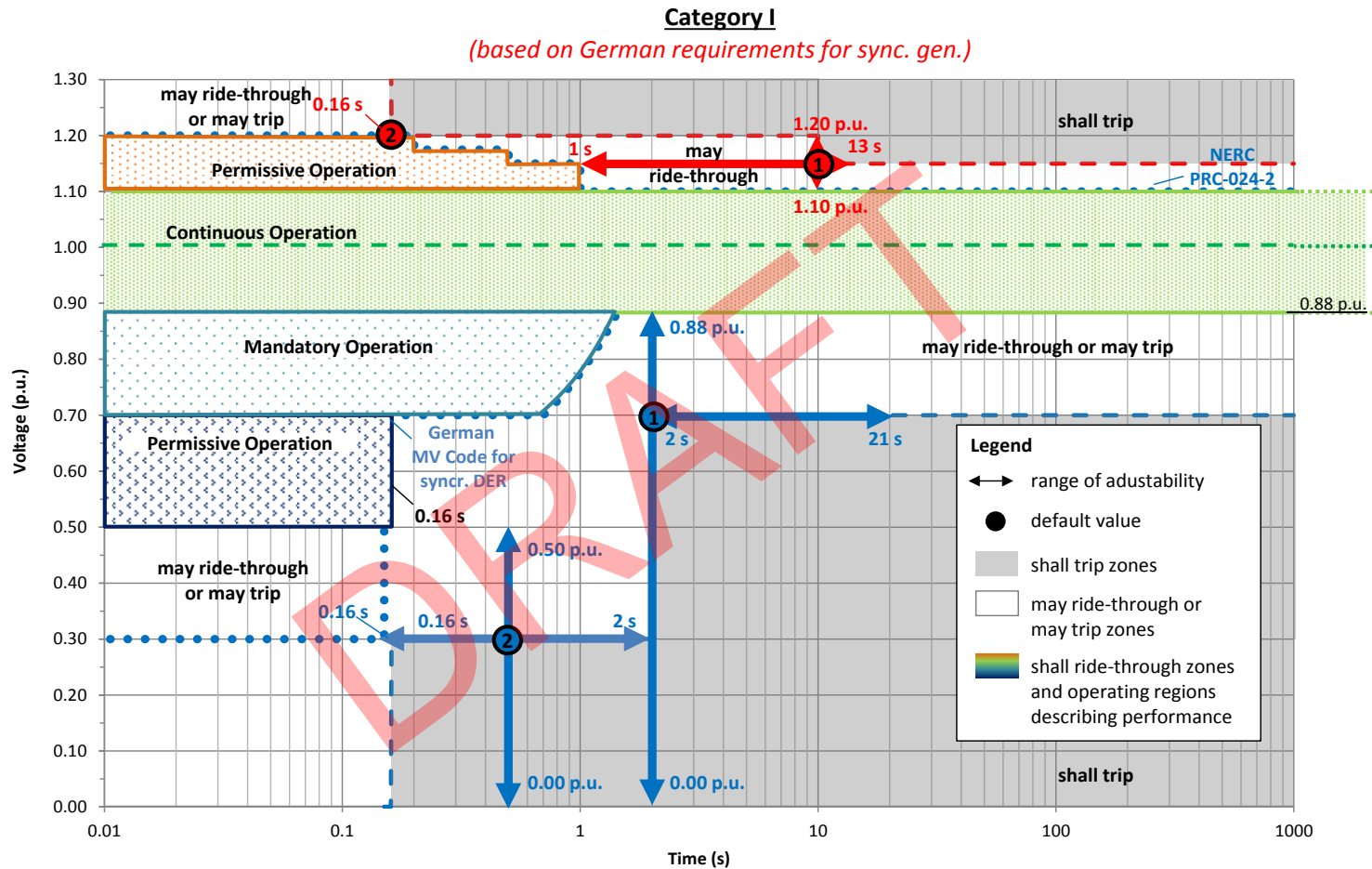
... grid and DER operators can mutually agree to other voltage trip and clearing time settings

4.2.4 (Response to abnormal grid ...) Frequency

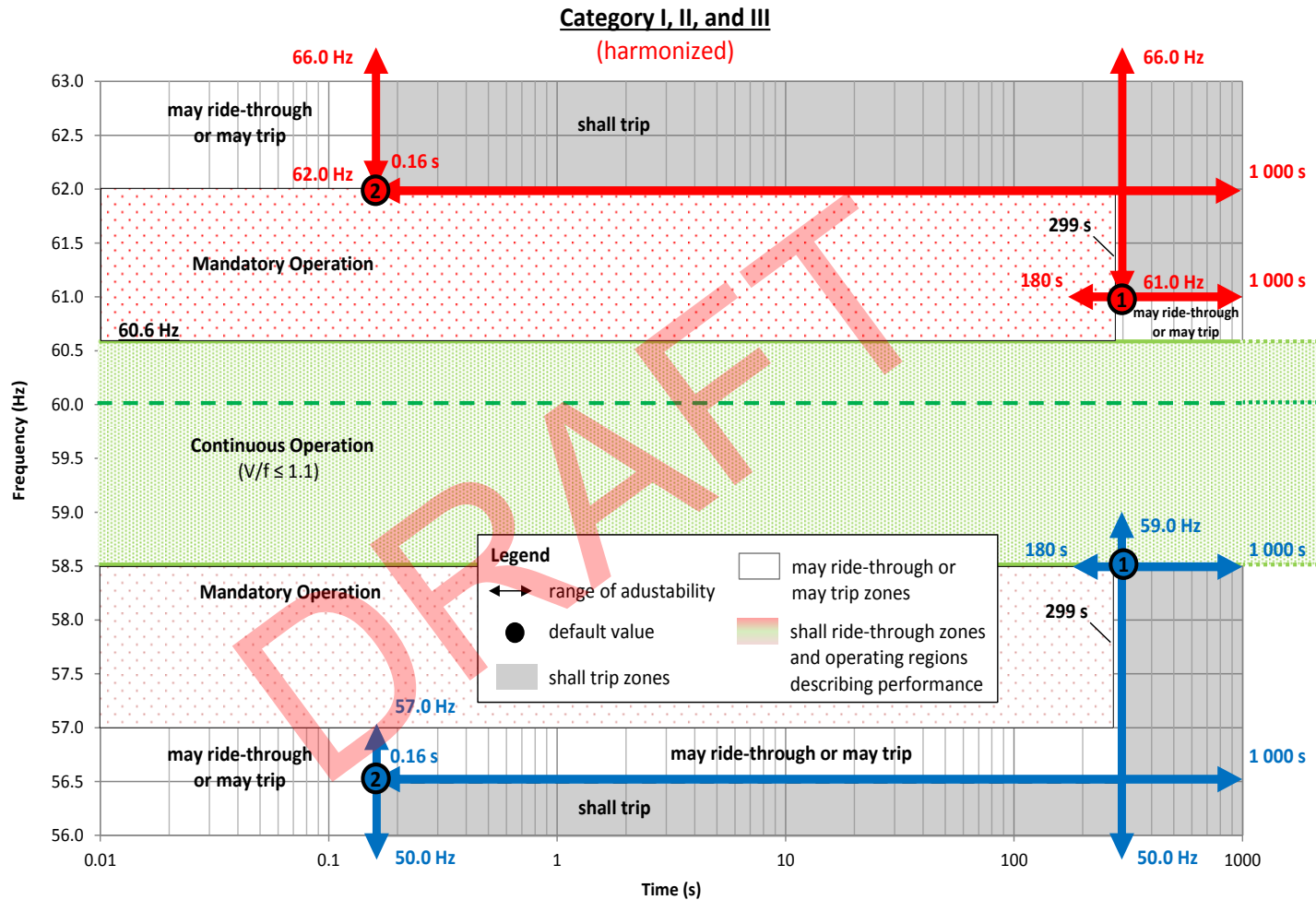
... DER **allowed** to provide **modulated power output** as a function of frequency

... grid and DER operators can mutually agree to other frequency trip and clearing time settings

P1547 Example New Requirements for **voltage** Ride Through (work in progress)



P1547 Example New Requirements for **frequency** Ride Through (work in progress)



P1547 voltage regulation

(Work In Progress)

Two performance categories are defined for DERs with voltage regulation capabilities:

- a) Category A covers minimum performance capabilities needed for Area EPS voltage regulation and are reasonably attainable by all state-of-the-art DER technologies
- b) Category B covers all requirements within Category A and specifies additional requirements to mitigate voltage variations due to resource variability

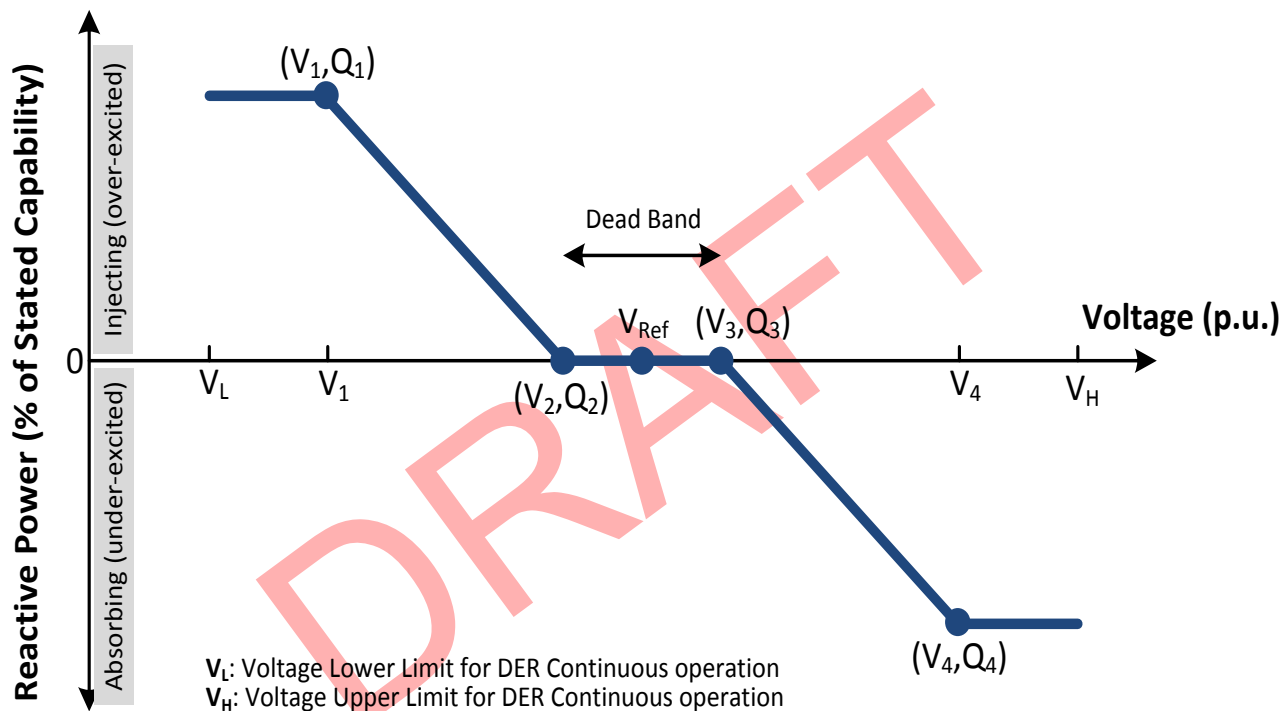
**Will be able to support Voltage Regulation
if wanted by Utility!**

Voltage and Reactive Power Control

The DER shall provide the capabilities of the following modes of reactive power control functions:

1. Adjustable Constant Power factor mode – The capability is mandatory for categories A and B
2. Voltage-reactive power (Volt-var) mode – The capability is mandatory for categories A and B
3. Active power-reactive power mode (watt-var) – The capability is optional for category A and mandatory for categories B
4. Reactive power mode – The capability is mandatory for categories A and B

P1547 Example New Reactive Power Requirements (Work In Progress)



Transition from abnormal to normal voltage conditions

The requirements of the voltage regulation clause (4.1) apply to normal voltage range when the voltage is between **0.88 and 1.1** times the nominal voltage (V_N). The voltage conditions outside of this range are defined to be abnormal. The DER shall return to its pre-disturbance operating mode after the system voltage returns to its normal range.

Grid impacts that need to be carefully reviewed
by the utility engineer !!

- Anti-islanding protection
- Reactive Power coordination amongst existing DERs and utility assets i. e. capacitor banks, etc.
- Prioritizing the voltage regulation schemes

Are voltage regulation and ride-through requirements proposed to be mandatory?

- The ride-through capability and performance is proposed to be mandatory.
- The voltage regulation capability is proposed to be mandatory but the performance is proposed to be at the utility's discretion (The DER will provide this capability and the utility will decide to enable/disable it and choose the proper operating modes).

Rapid voltage changes (RVC)

- Rapid voltage changes are considered to be changes in fundamental frequency voltage less than one second. The DER shall not cause the $\Delta V/V$ voltage variations to go outside the limits specified in table X. (Ref. IEEE 1453)

Number of Changes (moving window)	$\Delta V/V$
$n \leq 4$ per day	6 %
$n \leq 2$ per hour and > 4 per day	4 %
$2 < n \leq 10$ per hour	3 %

For the one-day moving window of Table X, each new RVC event shall be assessed separately using a sliding one-day window. The new RVC event and all RVC events that occurred in the preceding 24 hours shall be counted together to determine if the new RVC event exceeds the maximum number of rapid voltage changes allowed in one day. For the one-hour moving window of Table X, each new RVC event shall be assessed separately using a sliding one-hour window. The new RVC event and all RVC events that occurred in the preceding 60 minutes shall be counted together to determine if the new RVC event exceeds the maximum number of rapid voltage changes allowed in one hour.

Flicker

Flicker- Flicker is the subjective impression of fluctuating luminance caused by voltage fluctuations. Assessment methods for flicker are defined in IEC 61000-3-7.

- $P_{st99\%}$ (99th percentile value) shall not be greater than 0.9. If not specified differently, the P_{st} evaluation time is 10 minutes.
- $P_{lt99\%}$ (99th percentile value) shall not be greater than 0.7. If not specified differently, the P_{lt} evaluation time is 2 hours.

P1547 Example New Power Quality Requirements (Work in progress)

Harmonics:

- When the DER is serving balanced linear loads, harmonic current injection into the Area EPS at the Point of DER interconnection shall not exceed the limits stated below.
- The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in the Area EPS without the DER connected.

Table 3—Maximum odd harmonic current distortion in percent of rated current (I)_a

Individual odd harmonic order h	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h$	Total demand distortion up to the h=50 harmonic (TDD)
Percent (%)	4.0	2.0	1.5	0.6	0.3	5.0

Table 4—Maximum even harmonic current distortion in percent of rated current (I)_a

Individual even harmonic order h	$h=2$	$h=4$	$h=6$	$8 \leq h$
Percent (%)	1.0	2.0	3.0	Associated range specified in Table 3

P1547 Example New Power Quality Requirements (Work in progress)

Any aggregated interharmonic current distortion between $h \pm 5\text{Hz}$ shall be limited to the associated harmonic order h limit in Tables 3 and 4. Any aggregated interharmonics current distortion between $h + 5\text{Hz}$ and $(h + 1) - 5\text{Hz}$ shall be limited to the lesser magnitude limit of h and $h + 1$ harmonic order.

DRAFT

Interoperability and interfaces

Significant New Additions to IEEE 1547

- Interoperability requirements will be included
- Additional interfaces addressed – not only the PCC
- Informative material to be included

Interoperability deals with compliance/certification to multiple common utility protocols such as DNP or 61850

Other areas being discussed in P1547

- Voltage Ride-Through requirements for consecutive temporary voltage disturbances
- Voltage regulation during ride through
- Island systems
- Interoperability
- Testing
-

Thank you!

Questions?