BEFORE
THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of the Commission's	)	
Review of Chapter 4901:1-22, Ohio	)	Case No. 12-2051-EL-ORD
Administrative Code, Regarding	)	
Interconnection Services	)	

COMMENTS OF METRO CD ENGINEERING, LLC
ON PROPOSED MODIFICATIONS
TO INTERCONNECTION SERVICES AND STANDARDS

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**COMMENTS OF METRO CD ENGINEERING, LLC
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TO INTERCONNECTION SERVICES AND STANDARDS**

Metro CD Engineering, LLC respectfully submits these comments on the proposed rule changes to Chapter 4901:1-22, O.A.C. (Interconnection Rule).

Metro CD Engineering is an engineering design and consulting firm with experience designing and implementing distributed renewable energy systems in Ohio. We commend the Public Utility Commission of Ohio's efforts to create a more stream-lined and clear process for interconnection with an electric distribution utility through this rule making process, and appreciate the opportunity to submit these comments.

The following reply comments are to address an issue raised in the 11/19/2012 filing "Initial Comments of Ohio Power Company electronically filed by Mr. Steven T Nourse on behalf of Ohio Power Company." In this filing, pertaining to **4901:1-22-05 Application requirements for interconnection,** it is stated "AEP Ohio prefers not to allow internal switching devices due to safety reasons, time delay issues of service restoration, and security issues" and a language addition to section **(E)(2)** is recommended. This issue relates to section **(D) Disconnect Switch**, which the proposed rule requires to be accessible by the EDU to isolate the distributed generation facility for the purposes of safety during EDU system maintenance and during emergency conditions. This disconnect switch is commonly referred to as a Utility External Disconnect Switch (UEDS.)

In the Common Sense Initiative – Business Impact Analysis for Case No. 12-2051-EL-ORD, the stated public purpose of the regulation (item #5) is “to make interconnection not unduly burdensome or expensive, to establish uniform requirements for nondiscriminatory technology-neutral interconnection to customers who generate electricity on the customer’s side of the meter, to apply in all commission jurisdictional areas, and to provide a process for expedient interconnection with the electric distribution utility.” It is the opinion of Metro CD Engineering, LLC that to best meet this purpose the requirement for a Utility External Disconnect Switch should be eliminated for small (25kW or under) inverter based systems and sections (D) and (E)(2) referenced above should not apply to such systems.

The existing and proposed rules require the use of inverter equipment certified for interconnection operation which has been certified by a nationally recognized testing laboratory and has been tested according to the IEEE 1547 standard. As such, the inverter will automatically de-energize its output within 2 seconds of a disturbance or loss of the utility source and will reconnect only after 5 minutes of normal utility conditions. This effectively addresses the issue of utility personnel safety during Electric Distribution Utility system maintenance and during emergency conditions, which is the underlying premise of requiring a Utility External Disconnect Switch.

It should be noted that the National Electric Code requires a disconnecting means for the system which may be located either outside of or inside a building or structure. Modern inverters typically integrate the disconnecting means inside the inverter equipment in order to reduce the amount of equipment and to simplify installations. This results in lower implementations costs and supports the adoption of distributed renewable energy generation systems which is a priority for the State of Ohio. By not allowing the use of internal switching devices (as preferred by AEP Ohio in their comments) unnecessary additional implementation costs will be incurred. In addition, unnecessary costs will be incurred by the Electric Distribution Utility by having to maintain a central database of the locations of Utility External Disconnect Switches, and incorporating their use by utility personnel during maintenance and emergency repair procedures.

The National Renewable Energy Laboratory (NREL) released a report in January 2008, "Utility-Interconnected Photovoltaic Systems: Evaluating the Rationale for the Utility-Accessible External Disconnect Switch" [http://www.nrel.gov/docs/fy08osti/42675.pdf] and concluded that "the utility-accessible EDS is increasingly viewed as redundant and unnecessary for residential and small-commercial PV systems with UL-listed inverters." It explores safety, cost, utility practices, and includes a survey of jurisdictions that have opted to eliminate the requirement for a utility-accessible disconnect switch which includes eight states and several large utilities with prolific PV deployments such as Pacific Gas & Electric and Sacramento Municipal Utility District. These jurisdictions accounted for more than 80% of total installed PV capacity in the United States in 2006. The Solar America Board for Codes and Standards released a report in September 2008, "Utility External Disconnect Switch: Practical, Legal, and Technical Reasons to Eliminate the Requirement" [http://www.solarabcs.org/about/publications/reports/ued/pdfs/ABCS-05_studyreport.pdf] which provides additional information and substantiation for eliminating utility external disconnect switches. These reports substantiate the position taken by Metro CD Engineering, LLC that it would be beneficial to stakeholders if the rules requiring a Utility External Disconnect Switch were eliminated for small (25kW or under) inverter based systems.

Metro CD Engineering, LLC appreciates the opportunity to offer these comments to the Public Utilities Commission of Ohio for consideration as the rules for interconnection standards are improved for the citizens and businesses in Ohio.

Respectfully submitted,

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A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

National Renewable Energy Laboratory
Innovation for Our Energy Future

Utility-Interconnected Photovoltaic Systems: Evaluating the Rationale for the Utility-Accessible External Disconnect Switch

M.H. Coddington, R.M. Margolis, and J. Aabakken

Technical Report
NREL/TP-581-42675
January 2008

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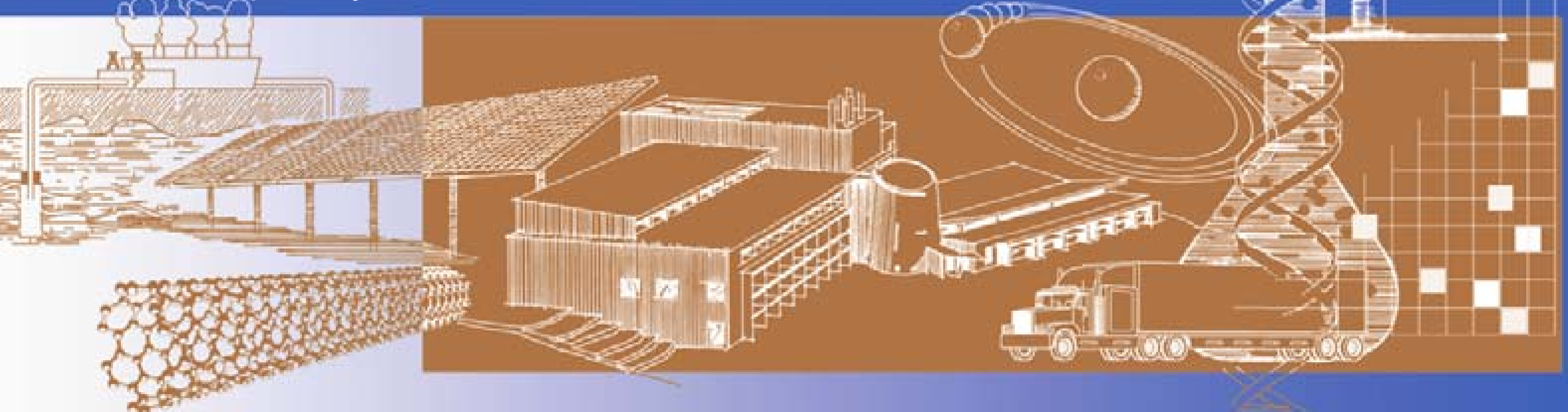

Utility-Interconnected Photovoltaic Systems: Evaluating the Rationale for the Utility-Accessible External Disconnect Switch

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List of Acronyms

AC	alternating current
EDS	external disconnect switch
IEEE	The Institute of Electrical and Electronics Engineers
NEC	National Electrical Code
NESC	National Electrical Safety Code
PG&E	Pacific Gas and Electric
PUC	public utility commission
PV	photovoltaic
SMUD	Sacramento Municipal Utility District
UL	Underwriters Laboratories

Executive Summary

The utility-accessible alternating current (AC) external disconnect switch (EDS) for distributed generators, including photovoltaic (PV) systems, is a hardware feature that allows a utility's employees to manually disconnect a customer-owned generator from the electricity grid. Proponents of the EDS contend that it is necessary to keep utility line workers safe when they make repairs to the electric distribution system. Opponents assert it is a redundant feature that adds cost without providing tangible benefits.

In this paper, we examine the utility-accessible EDS debate in the context of utility-interactive PV systems for residential and small commercial installations. We also evaluate the rationale for EDS requirements. In particular, we focus on the safety, reliability, and cost implications of the EDS. We observe that in a number of states in which public utility commissions (PUCs) and utilities have gained experience with PV systems, they have decided to eliminate the EDS requirement. These decisions typically require that utility-interactive PV systems use inverters that meet relevant Underwriters Laboratories (UL) and Institute of Electrical and Electronics Engineers (IEEE) standards. We argue that, going forward, a number of factors are likely to convince additional PUCs and utilities to eliminate the EDS requirement. These include demonstrated safety and effectiveness of UL- and IEEE-listed inverters, a need to re-evaluate safety practices and rules in light of technological advances and regulatory changes, a desire to reduce the administrative burden of requiring the EDS, and growing pressure to remove barriers to entry for PV systems.

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1. Introduction

Photovoltaic (PV) systems are a maturing technology. In the United States in 2006, the number of installed PV systems exceeded 30,000, and the number is continuing to grow. This paper focuses on residential and small-commercial PV systems that interconnect with the electricity grid. (See Figure 1.)

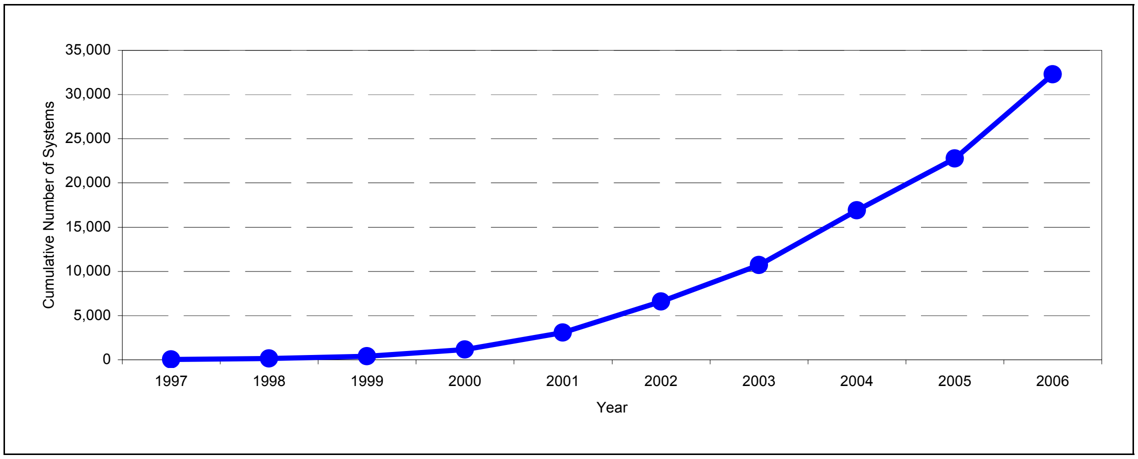

Figure 1. Utility-interactive PV systems installed in the United States, 1997–2006 [1]

Many electric utilities require a customer-owned, utility-accessible external disconnect switch (EDS), often within sight of the revenue meter. This requirement has been an issue of debate among utilities, state public utility commissions (PUCs), and PV system integrators/installers for several decades.

Some people ask: "Why is a utility-accessible EDS necessary? Is it worth the additional cost?" Others ask, "Why take a chance, even if it is remote, with issues of safety and reliability?" Having a utility-accessible EDS for each PV system on a distribution line may allow for maximum safety, but some people question the use of such a device in practical utility operations.

PV systems must meet a variety of codes and standards to be accepted by the local authority having jurisdiction. For example, the National Electrical Code® (NEC) covers all electrical installation requirements on the customer side of the utility revenue meter. Underwriters Laboratories (UL) Standard 1741 [2] covers inverters, which convert direct-current (DC) power to alternating-current (AC) power for use by the customer or utility. The Institute of Electrical and Electronics Engineers (IEEE) Standard 1547™ [3] provides interconnection requirements for PV systems at the point of common coupling and is referenced in the utility connection requirements of UL 1741. In addition, most electric utilities design and operate their electric distribution systems to meet the standards of the National Electrical Safety Code® (NESC), which does not address PV systems directly.

The development of IEEE 1547 and UL 1741 involved varied groups of balloters and contributors (known as working groups). Both standards were developed by groups that included significant utility representation. For example, for IEEE 1547, electric utility representatives comprised 34% of the 230 balloters [4]. UL 1741 also had a significant utility presence in standard development [5].

IEEE 1547, UL 1741, and the NEC do not address the use of customer-owned, utility-accessible EDSs for PV systems. IEEE 1547 does recognize that an EDS is not a universal requirement but that a utility may desire an EDS for its own use. These codes and standards require that PV systems automatically disconnect from the grid in the event of an electric outage. However, many utilities require a redundant utility-accessible EDS in the event of a grid-related problem.

In addition to the utility-accessible EDS, PV systems have several disconnect methods in the event of electric outages, fires, or maintenance. PV systems disconnect from the grid to prevent electricity generated by them from feeding into the grid when a problem occurs on it. Some disconnecting equipment, such as ground fault protection and inverter relays, is automatic. Others—including DC disconnects, inverter DC breakers, inverter AC breakers, EDSs, PV system circuit breakers in customer panels that are backfed, main breakers,[1] utility production meters,[2] and utility revenue meters—are manual. Although the NEC requires a disconnecting means in a readily accessible location, it does not specify that it be outdoors or accessible to utility personnel [6].

Clearly, if a utility-accessible EDS is required, it makes sense for utilities to integrate its use into their standard practices and procedures. Thus, it is worth examining the implications of using EDSs in utility service territories in which there are significant or growing numbers of PV systems and evaluating whether they are a practical tool for enhancing safety.

Several significant issues are involved. First, as the number of PV systems increases, the work and time needed to troubleshoot an outage on a distribution circuit with PV systems (and EDSs) will increase. Second, if utility line workers are required to use a group of EDSs on a line section, the EDSs must be incorporated into switching orders.[3] Third, the geographic information system departments at utilities will need to maintain accurate and timely maps to help dispatchers and line workers locate the EDSs during emergencies. And fourth, if line workers choose to ignore EDS requirements, utilities may face liability in the event of injury or equipment damage and must consider if disciplinary action will be taken.

[1] Not all homes and businesses have a main disconnect.
[2] Production meters are required by some utilities to track the total energy output of a system.
[3] Switching orders are used by utilities to plan and track the de-energization and re-energization of sections of lines and equipment in a safe manner

Pacific Gas and Electric (PG&E) and Sacramento Municipal Utility District (SMUD), both major electric utilities in California, changed their policies for inverter-based PV systems. Their decisions to eliminate utility-accessible EDS requirements for smaller PV systems were based on expected cost and time savings for the utilities and their customers. These utilities have a large and growing number of customer-sited PV systems to consider, and the EDS requirement was delaying installations and multiplying administrative costs.

It is worth noting that PG&E has the most interconnected PV systems in the United States and SMUD has been one of the most aggressive adopters of PV technology in the country. The fact that these utilities have eliminated their EDS requirements is likely indicative of a trend. As other electric utilities gain experience with PV technology and a better understanding of the safety features required by the UL and IEEE standards for PV inverters, they are likely to follow PG&E and SMUD and eliminate their utility-accessible EDS requirements.

2. Safety, Reliability, and Cost: Prime Focal Points for Utilities

Utilities have an "obligation to serve"[4] in a safe, reliable, and economical manner. The incorporation of utility-accessible EDSs into utility operations has implications for many of the utility's core considerations.

2.1. Safety

Electric utilities supply a commodity that has inherent danger. Line workers understandably believe that no task is more important than maintaining a safe workplace. In an emergency, all line workers are assigned duties to restore the system as quickly and safely as possible. As they work to restore power, they must be extremely cautious. U.S. electric utilities typically follow the NESC[5] for safe working practices to establish proper clearances and safeguard persons from hazards in the installation, operation, and maintenance of electric distribution systems.

Line workers must "consider the electric supply equipment and lines to be energized, unless they are positively known to be de-energized."[6] If a line worker determines that other sources are feeding the circuit, he must locate and open the source or work the line energized.

2.2. Reliability

There is an increasing demand on utilities and PUCs to reduce outage durations.[7] Some utilities face significant fines and penalties if they fail to meet standards set by their state PUCs. Public scrutiny is a driving factor as well. Prolonged outages cause repercussions for utility customers, and in turn the utility, which may result in an increase in complaints to PUCs.

Although safety is the highest priority for utility line workers, restoring power quickly and efficiently is also important. Although the presence of a utility-accessible EDS for PV systems on distribution lines may allow increased protection for utility personnel, it can be questioned if the device would be used by the utility, especially in the event of a large system outage.

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[4]A public utility's duty to serve has its origins in common law principles. See [8].
[5]The NESC is a publication of IEEE (Accredited Standards Committee C2-2007).
[6]Per the NESC Section 42 420.D "Energized Unknown Conditions."
[7]Two nationally recognized and published reliability indices are the System Average Interruption Duration Index and the Customer Average Interruption Duration Index. The System Average Interruption Duration Index is an index of the average system outage duration over a 12-month average. The Customer Average Interruption Duration Index is an index of the average outage duration per customer over a 12-month average.

2.3. Cost

Operating a distribution system in a cost-effective manner is a goal for all utilities. There is immense pressure from ratepayers and PUCs to keep costs down and rates reasonable while maintaining safety and reliability. Every procedure that a line worker must complete must be examined carefully, as it will affect the cost of service. The time expended operating a group of EDSs must be scrutinized, and a decision must be made regarding whether to use these devices.

If a utility or PUC requires the installation of an EDS and it is incorporated into the utility's operational procedures, there is a significant cost to the utility and ratepayers. This is true even if the full cost of the EDS equipment is paid for by the PV system owner. Additional utility operational costs translate into higher electricity rates because those expenditures are typically recovered from ratepayers.

Although beyond the scope of this paper, it would also be useful to evaluate the full cost of inspecting, mapping, and using the EDS from the utility perspective to provide a realistic estimate of its effect on rates/tariffs.

3. Integrating Customer Photovoltaics into a Utility Distribution System

Utilities have historically relied on power sources such as coal, water, nuclear energy, oil, and natural gas to generate electricity. Their generation stations tie directly into the utility transmission system, and power is then transported to area substations and distributed over local distribution feeders. (The entire system is commonly referred to as the "grid.") In the traditional model, power flows in one direction: from the substation to the customer location. The grid was designed to operate safely following this model. Careful supervision and operation helped the utility operate a relatively safe and reliable electricity delivery system.

PV and other distributed generation technologies, however, introduce two-way power flow onto the grid, which raises a number of potential issues for grid operation and maintenance. The UL and IEEE standards were developed to enable distributed generators to operate safely and reliably with the grid.

3.1. Interconnection Standards: UL 1741 and IEEE 1547

UL is a nationally recognized testing laboratory that tests to standards for electrical equipment, primarily to ensure safety of consumer products. The UL listing relevant to EDSs is UL 1741 (2005), Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources. UL 1741 was initially published May 7, 1999, and the latest version includes significant revisions.

UL 1741 applies to inverters, the devices that convert the DC electricity output from solar PV cells into AC, which is used in homes and businesses. Based on IEEE 1547 requirements, UL-listed inverters for PV systems require the inverter to disconnect automatically from the grid.

3.2. Modern Electronic Inverters

Modern small-commercial and residential PV systems include UL-listed components that meet rigorous standards. Inverter technology has advanced considerably in the past decade, and new inverters are required to meet the stringent standards of UL 1741 and IEEE 1547. The NEC requires that an inverter de-energize its output upon loss of utility voltage and remain in that state until utility voltage has been restored [6]. Modern electronic inverters are reliable, intelligent, and comprehensively tested to ensure they do not backfeed to the grid during an outage.

Modern electronic inverters used in PV systems must meet UL 1741 standards to be "listed and labeled." UL 1741 incorporates IEEE 1547 requirements and IEEE 1547.1 [7] procedures for utility-interactive inverters. The NEC also requires that the system "shall automatically de-energize its output to the connected electrical production and distribution network upon loss of voltage in that system and shall remain in that state until the electrical protection and distribution network voltage has been restored" [6]. Numerous independent laboratories, including the National Renewable Energy Laboratory and Sandia National Laboratories, have tested and evaluated a variety of PV components and found that UL-listed inverters perform reliably, as specified.

In the case of an emergency when the grid is down, UL-listed inverters sense a situation known as “islanding”[8] and automatically disconnect if the utility source is absent. Under all abnormal or grid-outage conditions, a UL-listed inverter disconnects in 2 seconds or less and only reconnects after 5 minutes of normal utility conditions.

A manual utility-accessible EDS will require line workers to travel to homes and other buildings with utility-interactive PV systems and manually open the switches. In terms of response, a UL-listed inverter is obviously much faster because it disconnects from the grid quickly and without the need of human intervention.

[8] In this situation, islanding is unintentional. Islanding is a condition in which a portion of an area electric power system is energized by one or more local electric power systems while separated from the rest of the area electric power system. See [3] for additional information about islanding.

4. Defined Purpose of a Utility-Accessible External Disconnect Switch

The purpose of the utility-accessible EDS, from the utility perspective, is to enable line workers to lock out a customer source of power that could feed back onto the grid while utility line workers are working. In this context, a utility-accessible EDS could be used:

- When there is a specific customer-based problem and the utility wants to isolate that customer from the grid
- During the installation phase of new construction
- When line workers are replacing aged or damaged equipment on the utility's system
- During an unplanned electric outage (i.e., a "trouble" situation).

Figure 2. A typical residential PV installation includes (1) an EDS, (2) a DC disconnect, (3) an Inverter (with AC and DC breakers shown in the red circle), and (4) a revenue meter

Photo courtesy of Nicholas Lenssen.

Figure 2 illustrates the variety of equipment that could isolate the PV system from the utility grid. As shown, a typical PV installation has four options for a line worker to disconnect the system (in addition to the EDS). This is an example of a system with most of the system equipment installed outdoors, but some systems include equipment that is mounted indoors.

There are several means of disconnecting power in a typical PV system. The NEC requires (with some exceptions) that most systems have ground fault protection on the DC side of the inverter. The NEC also requires that the system have a means of disconnecting the system on the DC side of the inverter and the AC side of the utility-interactive inverter. In addition, the NEC states that a "disconnecting means shall be installed at a readily accessible location either outside of a building or structure or inside nearest the point of entrance of the system conductors." Ungrounded conductors may be disconnected by either a switch or circuit breaker, per the NEC [6].

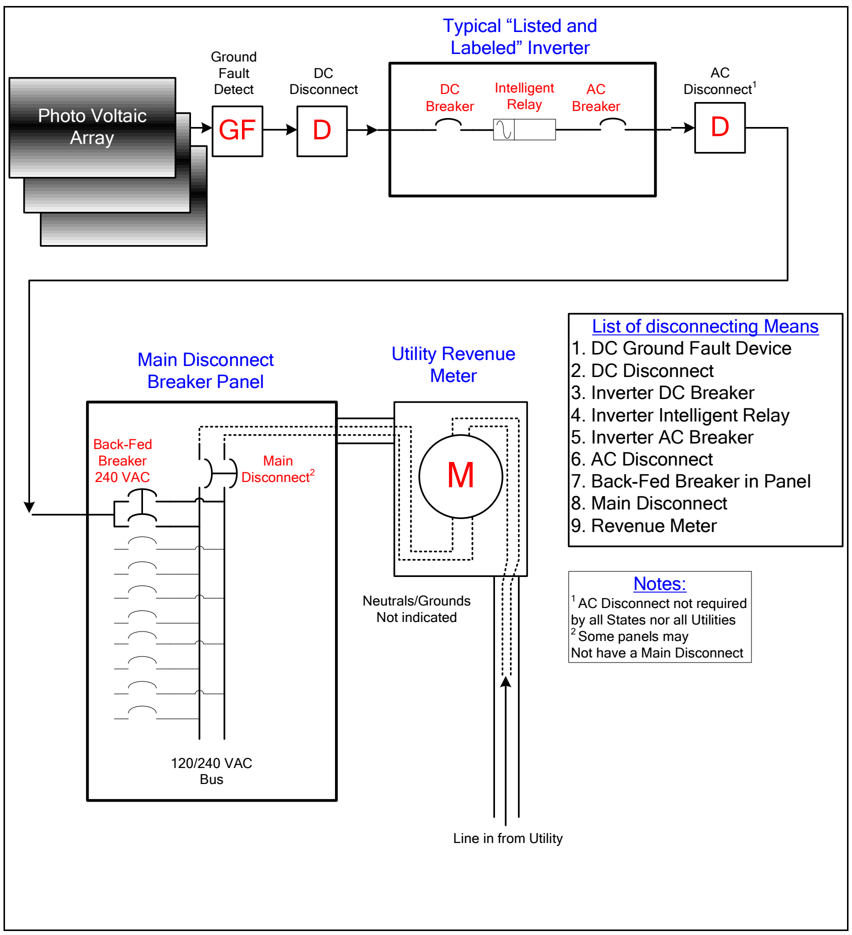

Figure 3. Typical residential/small commercial PV system schematic

It is important to note that there are at least six manual and automatic disconnect devices in a PV system. In Figure 3, there are nine means of disconnecting the PV system from the grid:

- Ground fault protection at or near the PV array[9]
- The DC disconnect switch between the PV array and the inverter
- The inverter DC breaker
- The inverter relay (This is an automatic device that disconnects the inverter if UL 1741 conditions are not met.)
- The inverter AC breaker
- The AC EDS
- The backfed circuit breaker (on the customer panel)
- The main disconnect (Not all buildings have a main disconnect.)
- The utility revenue meter (This historically has been used by utilities as a means of disconnecting customers for a variety of needs.).

Although the NEC contains specific requirements for a readily accessible disconnect switch, it does not require that it be installed outdoors.

[9] NEC-2008 690.5 "Ground Fault Protection" states requirements for ground fault protection.

5. Utility Line Practices

5.1. New Construction

New construction, whether it is overhead or underground, is usually performed while equipment is de-energized. Because there is a risk that a line could be energized during installation, equipment is grounded as a matter of procedure. Line workers are required to test and ground the line before they begin work to ensure they do not contact a live line and risk injury or death [9].

5.2. Customer-Related Problems

It is essential that utilities have the ability to isolate sources of problems on their systems, whether they are at the generation, transmission, or distribution level or a customer location. In normal business practice, if a utility worker believes there is a problem behind a customer's meter, the utility contacts the customer to resolve the problem. Only in unusual situations will utility personnel disconnect a customer by using the main disconnect or removing the revenue meter.

5.3. Trouble Situations

Utility line workers typically consider a line to be energized while working a "trouble" situation. This requires that they wear Occupational Safety and Health Administration- and American National Standards Institute-approved protective equipment, such as rubber gloves, fireproof clothing, eye protection, and insulated tools. Because all lines are considered energized during an outage, an EDS should not be necessary.

Utilities are aware that a small generator could be attached to a customer's service and, in error, create backfeed that places line workers in danger. But if a line crew works on an energized feeder, it will avoid injury if the proper procedures are followed. Similarly, when a crew works a line cold, the appropriate ground cables are installed, and the line is tested, it will avoid injury if the proper procedures are followed.

In the event of a feeder outage, a line crew will risk injury from a PV system only if *all* of the following events occur:

1. The inverter fails to disconnect automatically and somehow produces power without the necessary external voltage source present
2. The anti-islanding, voltage, and frequency methods fail in the inverter
3. The load at the output of the inverter matches the connected load of the PV owner and adjacent customers (This is statistically improbable.)
4. The line worker chooses to work the line energized but fails to follow procedures or;
5. The line worker chooses to work the line de-energized but fails to test and ground the line.

Therefore, a very unlikely series of events must occur to place a line worker at risk from a PV system installed without an EDS.

5.4. Normal Restoration of Outages and the Time Factor

In the event of an electric power outage, a utility will dispatch a line worker to:

- Troubleshoot the outage
- Clear the line or cause of outage
- Repair any damage
- Ensure the area that was damaged is now safe
- Restore power.

This process is expected to be completed as quickly as possible to restore power to affected customers. Average electric outage duration times in the United States are often under 2 hours.[10] However, keeping outage duration at less than 2 hours would be a commendable achievement if line workers had to visit each EDS on a feeder.

Because line workers are expected to troubleshoot and restore electric outages quickly, and because the restoration work is accomplished under the presumption that the lines are energized, it is unlikely that a line worker would use an EDS unless required to do so by documented utility switching procedures.

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[10] Based on published utility reliability data. For a detailed explanation of reliability indices and published data, see report by LaCommare, K.H.; Eto, J.H. *Understanding the Cost of Power Interruptions to U.S. Electricity Consumers*." LBNL-55718. Berkeley, CA: Ernest Orlando Berkeley National Laboratory, September 2004. Available at http://certs.lbl.gov/pdf/55718.pdf.

6. Work Practice Integration

When a utility requires a PV system owner to install an EDS, it must establish how the device will be incorporated into standard procedure. For example, if the EDS is tracked, will the utility use its customer information system and geographic information system, and will dispatchers use that information to resolve outages and write switching orders? If a line worker ignores the EDS installation, will the line worker or the utility face punitive damages or disciplinary action?

6.1. Prompt Restoration of Service Imperative

When a utility's distribution network is down, the utility is under intense pressure to restore power to customers as quickly as possible. Yet, if the utility relies on EDSs as part of its safety protocol, then its line workers must use these switches in an emergency or repair to the distribution network. Thus, the line workers must travel to each location with a utility-accessible EDS to lock the switch in the open position before starting repairs. After the repairs have been completed, the line workers must travel to each location and manually close the switch (to restore PV power to that customer). This would add considerable time to the process of restoring power to the grid.

In addition, such emergencies may take place under severe weather conditions, such as freezing rain, high winds, or flooding. Requiring line workers to navigate these conditions to travel to each location may pose additional risk to their safety. They could lose control of a vehicle while driving on ice, be forced to navigate flood waters, or have to contend with fallen tree limbs.

6.2. Other Sources of Power

Line workers must consider a line energized unless it is positively known to be de-energized, per Rule 420 of the NESC [9]. This critical rule takes into consideration that customers may have gas-powered generators tied to their home and businesses. All building supply stores sell gasoline-powered electrical generators and the electrical equipment necessary to properly isolate and power a home or business. However, because it is not mandatory that these systems be registered with the utility—and they are often not inspected by the appropriate authority having jurisdiction—utility line workers must assume they are energized during an electric outage. These generators are designed for standalone use, but they are simple to interconnect without provisions to avert backfeed into the grid.

7. Relative Cost of a Customer-Owned External Disconnect Switch

The installation of a utility-accessible EDS for PV systems has been a contentious issue for several years. Although some utilities and PUCs require an EDS for PV systems, most PV system installers and owners view the EDS as unnecessary in the era of modern inverter-based interconnection. For PUCs, the decision to require—or allow a utility to require—a utility-accessible EDS is a matter of balancing safety, reliability, and cost (to the utility, rate payers, and the PV system owner).

The cost of an EDS, which is typically several hundred dollars, is not insignificant to PV system owners. It is a particularly unwarranted cost if EDSs are required but not incorporated into utility operating procedures. If a utility requires its customers to install utility-accessible EDSs, it should incorporate the devices into its working rules and operations as practical procedure. Further, if EDSs are required for customer-owned PV systems, the utility should validate any problems with customer-owned systems and determine whether the EDSs are beneficial and thus justify their cost.

An illustrative case is documented in a study conducted by Cassandra Kling, a leader in the New Jersey Million Solar Roof Partnership and renewable energy program manager for the New Jersey Board of Public Utilities at the time, and Christopher Cook, a consultant [10]. Kling and Cook found that none of the EDSs studied had been used by utility maintenance staff. Furthermore, despite their lack of use, no safety incidents had been reported.

8. Review of Past Utility Commission Decisions Regarding External Disconnect Switches

The Energy Policy Act of 2005 calls for state PUCs (and various "non-regulated" utilities) to consider adopting certain standards for electric utilities. Under Section 1254 of the act, "Interconnection services shall be offered based upon the standards developed by the Institute of Electrical and Electronics Engineers: IEEE Standard 1547" and "shall be established whereby the services offered shall promote current best practices in interconnection" [11].

Because Federal Energy Regulatory Commission Order 2006 [12] for the interconnection of distributed generators does not require EDSs, there is no federal policy governing this issue. If a state elects to set policy on interconnection, it usually delegates the authority to create rules to the PUC or similar authority. Each state's PUC has the option to create its own rules.

Some states have ruled that inverter-based interconnections do not need EDSs, while others have ruled that inverter-based interconnections must have utility-accessible EDSs. And finally, some states leave the decision to the electric utilities, which often take the most conservative approach and require EDSs.

8.1. States' Stands on External Disconnect Switches

In the United States, 35 states have interconnection rules for distributed generation systems such as the inverter-based PV systems discussed in this paper. Among these states, 18 require an EDS for all systems, 8 specifically waive the requirement for small systems (that meet specific technical requirements), and 9 leave the decision to utilities. Table 1 provides a detailed overview of interconnection rules by state.

Table 1. Interconnect Requirements by State

State	Year	Comments
Alabama	NA	No state rules in effect
Alaska	NA	No state rules in effect
Arizona	2007	No state EDS requirement; utility discretion http://www.azcc.gov/utility/electric/dg.htm
Arkansas	2007	No EDS required for systems that meet conditions (see link) http://www.apscservices.info/rules/net_metering_rules.pdf
California*	2000	No state EDS requirement; utility discretion (SMUD and PG&E have waived the requirement for systems with self-contained meters that meet IEEE 1547, UL 1741, and NEC.) http://www.energy.ca.gov/distgen/interconnection/california_requirements.html

State	Year	Comments
Colorado	2005	No state EDS requirement; Utility discretion http://www.leg.state.co.us/clics/clics2007a/csl.nsf/fsbillcont3
Connecticut	2004	EDS required http://www.dsireusa.org/documents/Incentives/CT06R.doc
Delaware	2000	No EDS required for systems <25 kW http://depsc.delaware.gov/orders/6983.pdf
Florida	2002	No EDS required for systems ≤10 kW http://www.psc.state.fl.us/agendas/archive/071218cc/071218.html
Georgia	2001	No state EDS requirement; utility discretion http://www.dsireusa.org/documents/Incentives/GA04R.htm
Hawaii	2002	EDS required http://www.dsireusa.org/documents/Incentives/HI01Rc.pdf
Idaho	NA	No state rules in effect
Illinois	NA	No state rules in effect (Com Ed has decided that EDSs are not required for systems <40 kW.)
Indiana	2005	No state EDS requirement; utility discretion http://www.in.gov/legislative/iac/iac_title?iact=170&iaca=4
Iowa	2007	EDS required http://www.legis.state.ia.us/Rules/Current/iac/199iac/19915/19915.pdf
Kansas	NA	No state rules in effect
Kentucky	NA	No state rules in effect
Louisiana	2005	EDS required; utility may waive the requirement http://www.dsireusa.org/documents/Incentives/LA03Rb.pdf
Maine	NA	No state rules in effect
Maryland	2007	No EDS required for systems that meet IEEE, UL, and NEC http://mlis.state.md.us/2007RS/chapters_noln/Ch_119_sb0595E.pdf
Massachusetts	2006	No state EDS requirement; utility discretion http://masstech.org/DG/02-38-C_Attachment-B_Tariff-Recs_Clean_June-30-2006.pdf
Michigan	2003	EDS required http://www.michigan.gov/mpsc/0,1607,7-159-16377_43420---,00.html
Minnesota	2004	EDS required http://www.puc.state.mn.us/docs/orders/04-0131.pdf
Mississippi	NA	No state rules in effect

State	Year	Comments
Missouri	2007	EDS required http://www.sos.mo.gov/adrules/csr/current/4csr/4c240-20.pdf
Montana	1999	No state EDS requirement; utility discretion http://www.deq.state.mt.us/energy/Renewable/NetMeterRenew.asp
Nebraska	NA	No state rules in effect
Nevada	2003	No EDS required for systems <10 kW that meet IEEE, UL, and NEC http://www.leg.state.nv.us/Nrs/NRS-704.html#NRS704Sec774
New Hampshire	2001	No EDS required for systems <10 kW http://www.puc.state.nh.us/Regulatory/Rules/puc900.pdf
New Jersey	2004	No EDS required for systems <2 MW http://www.dsireusa.org/documents/Incentives/NJ11R2.htm
New Mexico	2007	EDS required; utilities may allow meter to serve as EDS http://www.nmcpr.state.nm.us/NMAC/parts/title17/17.009.0570.htm
New York	2004	EDS required http://www.dsireusa.org/documents/Incentives/NY02Rc.pdf
North Carolina	2005	EDS required http://www.dsireusa.org/documents/Incentives/NC04Rb.pdf
North Dakota	NA	No state rules in effect
Ohio	2007	EDS required http://dis.puc.state.oh.us/TiffToPDf/A1001001A07C28B45049D31500 .pdf
Oklahoma	NA	No state rules in effect
Oregon	2007	No state EDS requirement; utility discretion http://apps.puc.state.or.us/orders/2007ords/07-319.pdf
Pennsylvania	2006	EDS required (can be inside and accessed using a lock box) http://www.dsireusa.org/documents/Incentives/PA07Rb.doc
Rhode Island	NA	No state rules in effect (Narragansett Electric does not require EDSs.)
South Carolina	2006	EDS required http://www.dsireusa.org/documents/Incentives/SC05R.pdf
South Dakota	NA	No state rules in effect
Tennessee	NA	No state rules in effect
Texas	2007	EDS required http://www.puc.state.tx.us/rules/subrules/electric/25.211/25.211ei.cfm

State	Year	Comments
Utah	2002	No EDS required (unless the public service commission deems it necessary) http://le.utah.gov/~code/TITLE54/54_11.htm
Vermont	2006	EDS required http://www.state.vt.us/psb/rules/OfficialAdoptedRules/5500_Electric_Generation_Interconnection_Procedures.pdf
Virginia	2000	No state EDS requirement; utility discretion http://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+20VAC5-315-40
Washington	2006	EDS required; utilities may waive the requirement http://www.wutc.wa.gov/energy
West Virginia	NA	No state rules in effect
Wisconsin	2004	EDS required http://www.legis.state.wi.us/rsb/code/psc/psc119.pdf
Wyoming	2001	EDS required http://legisweb.state.wy.us/statutes/statutes.aspx?file=titles/Title37/T37CH16.htm
Washington DC	2003	No jurisdictional EDS requirement; utility discretion http://dceo.dc.gov/dceo/cwp/view,a,3,q,601821.asp

*California does not require EDSs for very small systems (<1 kW). Because most utility-interactive PV systems are larger than 1 kW, the EDS requirement for PV systems is left to utility discretion, for all practical purposes.

Source: Database of State Incentives for Renewable Energy (www.dsireusa.org), accessed during December 2007. Additional information was collected from state utility commission Web sites and utility Web sites.

The following summarizes the status of the EDS issue in select states:

- **Arkansas**
  The Arkansas Public Service Commission decided in 2002 that a “redundant visible, manual, lockable disconnect switch” was not required for customers that meet the IEEE 1547 standard, have installed the system properly, and operate the system as designed. Commission staff and each utility present asked for the switch, but the commission ruled the IEEE requirements were sufficient [13].

- **Colorado**
  Colorado passed HB07-1169 in 2007 and left the decision of utility-accessible EDSs up to the utilities. (This applies to investor-owned utilities, municipal utilities, and cooperatives). The largest utility in the state, Xcel Energy, requires EDSs for systems of all sizes.

- **Delaware**
  Delaware enacted a rule in July 2007 that allows inverter-based systems of 25 kW or less to be exempt from utility-accessible EDS requirements:

  > All inverter-based systems with a generating capacity of 25 kilowatts (kW) or less must comply with IEEE 1547 and UL 1741, in addition to Delmarva's technical guidelines. These installations are exempt from the pre-interconnection study. Furthermore, an EDS is not required for smaller inverter-based systems. (In emergencies, the utility reserves the right to disconnect the system without notification.) The customer accepts full responsibility for any risks involved with disconnecting the system" [14].

- **Florida**
  On Dec. 7, 2007, the Florida Public Service Commission ruled that inverter-based systems 10 kW or smaller are not required to have an EDS installed if they meet IEEE 1547 and UL 1741 requirements. However, if a utility insists on an EDS, the utility must pay for the full cost of the EDS. Systems larger than 10 kW are required to have an EDS.

- **Nevada**
  The Nevada PUC ruled in 2003 that if IEEE, NEC, and UL requirements are followed, the utility may not require additional devices such as an EDS. The commission's rule states that a "utility is prohibited from requiring certain customer generators to meet additional requirements" [15]. If customers abide by IEEE 1547, UL 1741, and NEC requirements, no additional controls, tests, or insurance are required.

- **New Jersey**
  In New Jersey, utilities contended that EDSs should be required for safety. The New Jersey Board of Public Utilities took great interest in the issue and invited several line workers to testify [16]. When asked if they had ever used an EDS, not one line worker said yes. Although utilities in New Jersey advocated for required EDSs, the board ruled against the requirement.

- **Virginia**
  The Virginia State Corporation Commission ruled that each electric distribution utility could make its own decision about EDS requirements. The commission ruled that PV systems that meet the NEC, IEEE 1547, and UL 1741 requirements are not required to have any additional safety equipment. However, a utility's net-metering tariff may require that customer generators include a utility-accessible EDS. The commission provided no criteria to the utilities with which to make the decision [17].

8.2. Forces That Shape External Disconnect Switch Policy

A combination of forces and stakeholders—including utilities, PUCs, solar-focused policies, and the solar industry itself—shape the direction of EDS-related policies.

In the past, PUCs have frequently been closely aligned with utilities with respect to the EDS issue and therefore have required utility-accessible EDSs based on the perceived need for additional safety. However, PUCs and utilities are changing their positions as they become more informed about existing interconnection standards, modern inverters, and real-world experience with utility-interactive PV systems. The accumulation of knowledge from utilities' experiences, such as that of PG&E and SMUD, will likely influence additional PUCs and utilities to consider different policies going forward. Given the pace of the state regulatory process, it is not surprising that standards and technology have evolved more rapidly than regulatory policy in many states.

Another factor that could hasten elimination of the EDS is government support for expanding PV markets. The most prominent example is the California Solar Initiative. Reaching the California Solar Initiative's goal of installing 3 GW of distributed PV systems in California by 2016 will require increasing emphasis on removing barriers to entry for PV at all levels, reducing installed system costs, and improving program administration. All of these pressures point toward removing the EDS requirement. As other states develop initiatives focused on expanding PV markets, whether to meet renewable portfolio standards or other policy purposes, similar pressures will likely emerge.

Finally, the solar industry's stance is that the utility-accessible EDS is redundant, adds unnecessary cost, increases operational complexity, and hampers market deployment of PV. Solar stakeholders argue that modern UL-listed inverters have virtually eliminated risk for utility line workers and that with the more than 30,000 interconnected PV systems in the United States, there has not been a single line worker injury caused by an inverter-based PV system [18]. As the PV industry grows, it will likely begin to play a stronger role in policy debates at the state and federal levels.

8.3. Implications for Utilities

The combination of well-developed standards, improved technology, and market experience is modernizing regulatory and utility policy with respect to the EDS issue. It is providing an open, technical-based, fresh look at decision-making. Over the next 5–10 years, additional utilities and PUCs will likely eliminate their requirements for utility-accessible EDSs for relatively small (i.e., tens to hundreds of kilowatts) utility-interactive PV systems. At least three factors will push utilities in this direction: a desire to streamline business processes, pressure to remove barriers to entry, and a need to re-evaluate safety practices and rules in light of technological and regulatory changes.

Because of the increasing number of interconnections involving distributed PV systems, utilities will need to streamline their interconnection business processes. Although interconnecting a few installations annually requires limited utility resources, as the number of installations grows—from dozens to hundreds and then to thousands annually—the administrative burden and associated costs will increase quickly. Depending on the regulatory arrangement, the additional costs of processing and approving the installation of an EDS may be borne by the customer (increasing the PV system cost) or the utility (increasing electricity rates for all customers). As the number of systems grows, there will be increasing pressure from rate payer interest groups and regulators to reduce or eliminate utility costs associated with the installation and tracking of EDSs in the service territory.

9. Changing Policy Climate

Although many states require utility-accessible EDSs for PV systems, the policy climate may be changing. As previously noted, two major utilities in California—which have significant installed bases of interconnected PV systems—changed their policies by removing their requirements for utility-accessible EDSs for utility-interactive PV systems.

Both Pacific Gas & Electric (PG&E) and Sacramento Municipal Utility District (SMUD) have been pioneers by adopting significant levels of PV generation into their distribution systems for more than a decade. Based on their experience with PV systems, both utilities changed their EDS rules. (See press releases for SMUD [19] and PG&E [20].) In short, they see EDSs as redundant safety features that add cost to PV installations and may act as a barrier to entry for PV systems. In addition, SMUD and PG&E have become confident that the listed and labeled systems operate properly when there are system problems. Finally, and one of the largest benefits of eliminating the EDS for the utilities, was the administrative cost savings realized from the utilities not having to check plans, validate installation locations, and track the devices in customer information systems and geographic information systems.

10. Conclusion

In this paper, we have examined the interplay between evolving technology and standards and changing perceptions of the need for utility-accessible EDSs and related regulations. Although utility arguments for requiring utility-accessible EDSs for grid-connected PV systems may have been justifiable 5 or 10 years ago, today the EDS issue is effectively addressed by UL and IEEE standards.

Going forward, at least four factors are likely to convince additional utilities and PUCs that EDSs are redundant and unnecessary:

- Increasing utility experience with utility-interactive PV systems that demonstrates the effectiveness and safety of UL-listed inverters
- Re-evaluation of safety practices and rules in light of technological advances and regulatory changes
- A desire to reduce or eliminate the administrative burden and associated cost of requiring utility-accessible EDSs
- Growing pressure to remove barriers to entry to meet growing state-level targets for PV installations.

Put simply, the utility-accessible EDS is increasingly viewed as redundant and unnecessary for residential and small-commercial PV systems with UL-listed inverters. Eight state PUCs (i.e., Arkansas, Delaware, Florida, Maryland, Nevada, New Jersey, New Hampshire, and Utah) have reached this conclusion and eliminated their EDS requirements for systems that meet criteria, and nine state PUCs have decided to leave the EDS decision up to individual utilities. In the states with utility choice, at least five utilities have eliminated the EDS requirement. These states and utilities accounted for more than 80% of total installed PV capacity in the United States in 2006.

If states and utilities deem renewable energy systems viable and desirable, then these entities must minimize economic barriers to system deployment while maintaining safe, reliable, and cost-effective utility service. Eliminating the economic and operational burdens of redundant equipment will encourage greater consideration of renewable energy systems by customers. Because many states have aggressive renewable energy goals, they must examine all potential barriers closely and make informed decisions regarding expensive and redundant equipment.

11. References

[1] Prometheus Institute. "US Grid-Tied Installations Grow 60%." *PV News*. Cambridge, MA: Prometheus Institute. Vol. 26, No. 3, Pg. 3, (March 2007).

[2] UL 1741 (2005), Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources. 2007.

[3] IEEE 1547 (2003), IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.

[4] Basso, T. Personal communication. IEEE Standards Coordinating Committee 21 secretary, IEEE 1547-2003, Nov. 26, 2007.

[5] "Underwriters Laboratories: Streamlining Interconnection." NREL/FS-560-35051. Golden, CO: National Renewable Energy Laboratory, October 2003.

[6] National Fire Protection Association. NEC (2008).

[7] IEEE 1547.1 (2005), IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.

[8] Rossi, Jim. "Universal Service in Competitive Retail Electric Power Markets: Whither the Duty to Serve?" *Energy Law Journal*; Vol. 21, 2000; pp. 27–49. Available at http://ssrn.com/abstract=220374.

[9] IEEE. NESC C2-2007.

[10] "Overcoming Net Metering and Interconnection Objections." DOE/GO-102005-2192. Golden, CO: National Renewable Energy Laboratory, September 2005. Available at http://www.state.co.us/oemc/presentations/060222/status/NJ_Case_Study.pdf.

[11] U.S. Congress. *Energy Policy Act of 2005*. 119 Stat. 594. 109th Cong., Public law 109-58-Aug. 8, 2005. Available at http://www.doi.gov/iepa/EnergyPolicyActof2005.pdf.

[12] Federal Energy Regulatory Commission. *Standardization of Small Generator Interconnection Agreements and Procedures*. Docket No. RM02-12-000; Order No. 2006, May 12, 2005. Available at http://ferc.gov/EventCalendar/Files/20050512110357-order2006.pdf.

[13] Arkansas Public Utility Commission. Docket No. 02-046-R, Order No. 3.

[14] Summary of S.B. 8, enacted July 2007. Dsireusa.org library. Available at http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=DE05R&state=DE&CurrentPageID=1&RE=1&EE=1.

[15] Nevada Revised Statutes, Section 704.774. Available at http://law.onecle.com/nevada/energy/704.774.html.

[16] Cook, C. Personal correspondence. Sun Edison, April 26, 2007.

[17] Virginia Register, Vol. 21, Issue 18, eff. April 26, 2005; Vol. 23, Issue 3, eff. Sept. 26, 2006. Available at http://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+20VAC5-315-40.

[18] Cook, C.; Haynes, R. "Industry Interview." *PV News*, November 2006.

[19] SMUD. "SMUD Waives Switch Requirement for Solar Systems: Move Makes Solar Installations Easier." Feb. 21, 2007. Available at http://www.smud.org/news/releases/07archive/02_21solar.pdf.

[20] PG&E. "AC Disconnect Switches for Inverter-Based Generation." Pacific Gas and Electric Co. online. Available at http://www.pge.com/suppliers_purchasing/new_generator/solar_wind_generators/disconnect_switches/.

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The utility-accessible alternating current (AC) external disconnect switch (EDS) for distributed generators, including photovoltaic (PV) systems, is a hardware feature that allows a utility's employees to manually disconnect a customer-owned generator from the electricity grid. This paper examines the utility-accessible EDS debate in the context of utility-interactive PV systems for residential and small commercial installations. It also evaluates the rationale for EDS requirements.

15. SUBJECT TERMS

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Executive Summary

Some states and utilities require that a utility external disconnect switch (UEDS) be installed between a photovoltaic (PV) power system and the utility grid as a device necessary for safety. Adding the UEDS provides a utility worker with an additional means of disconnecting a customer's system.

However, thousands of PV systems in many jurisdictions have been connected to the utility grid both safely and effectively without a UEDS. Indeed, there is increasing evidence that UEDSs are seldom, if ever, used. The history of safety recorded from these jurisdictions demonstrates that when PV hardware meeting Underwriters Laboratories (UL) and Institute of Electrical and Electronic Engineers (IEEE) standards is installed in compliance with the *National Electrical Code® (NEC)* and operated according to procedures mandated by OSHA and in accordance with recognized Best Practices, the UEDS is not needed to ensure safe operation of a PV system. In fact, for properly designed and installed Code-compliant PV systems, the UEDS provides little, if any, additional safety, beyond what is already present. Indeed, utilities increase their risk of liability when they require the UEDS for safety during maintenance or emergency.

Currently, eight states—Arkansas, Delaware, Florida, Nevada, New Jersey, New Hampshire, North Carolina, and Utah—have incorporated provisions into their interconnection procedures that appear to waive the requirement for a UEDS for small, inverter-based systems. Although the precise application of these provisions may be subject to debate, it is clear that an increasing number of states have decided to do away with the requirement for a UEDS for small, inverter-based systems. In addition, many utilities around the country have also eliminated the requirement for the UEDS on systems less than 10 kW. This list of utilities includes Pacific Gas and Electric and Sacramento Municipal Utility District (SMUD) in California and National Grid USA in the northeast United States. Importantly, more than half of all small, inverter-based photovoltaic systems installed in 2007 were in these jurisdictions with no UEDS requirement.

This report documents the safe operation of PV systems without UEDSs in several large jurisdictions and explains why, increasingly, the Best Practice is to eliminate the UEDS requirement. As described in this report, the UEDS fails to provide the "fail safe" protection that is its justification, is functionally redundant to the traditional practice of "pulling the meter," and adds unnecessary cost to a PV system. This report recommends adherence to established Best Practices for PV system interconnection because they provide safety without the UEDS or its unfavorable impacts.

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Interstate Renewable Energy Council Web site:

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The Solar America Board for Codes and Standards (Solar ABCs) is a collaborative effort among experts to formally gather and prioritize input from the broad spectrum of solar photovoltaic stakeholders including policy makers, manufacturers, installers, and consumers resulting in coordinated recommendations to codes and standards making bodies for existing and new solar technologies. The U.S. Department of Energy funds Solar ABCs as part of its commitment to facilitate widespread adoption of safe, reliable, and cost-effective solar technologies.

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Introduction

What is a Utility External Disconnect Switch?

Photovoltaic (PV) systems are designed to operate as electric power generators, connected in parallel with the utility grid, and to meet stringent equipment and interconnection standards. A utility-interactive inverter serves as the interface for the PV system providing voltage and frequency synchronization and serving as the system controller. The inverter converts the DC power produced by the PV array into AC power in harmony with the voltage and power quality requirements of the utility grid. This harmonious voltage and frequency synchronization requires the existence of the utility AC power as a reference signal. The grid-interactive inverters are designed to shut down in the absence of utility power.

In the United States, the *National Electric Code® (NEC)* and authorities having jurisdiction (AHJ) require that grid-interactive PV inverters meet the safety and operational requirements of Underwriters Laboratories (UL) standard 1741[1] in addition to the interconnection requirements of Institute of Electrical and Electronic Engineers (IEEE) standard 1547-2003[2]. These standards describe the safety, system protection, and power quality requirements that the inverter must meet. As noted above, these standards also specify operational requirements for safe operation when the inverter is connected to the grid. UL 1741 test standard evaluates inverters for compliance with the IEEE 1547 interconnection requirements to automatically prevent the PV source from supplying power to the grid when the utility grid is not energized.

Figure 1: Typical location of Utility External Disconnect Switch, marked with a yellow caution label, below the production meter. The revenue meter is to left.

A Utility External Disconnect Switch (UEDS) is a disconnect device that the utility uses to isolate a PV system to prevent it from accidentally sending power to the utility grid during routine or emergency maintenance. The UEDS is installed in an accessible location for operation by utility personnel. Figure 1 shows the UEDS in a typical installation. However, meter locations on buildings vary, depending upon local zoning law and utility practices, and line workers seeking to disconnect PV systems in an emergency, may find it difficult to locate the meter and the UEDS. For example, they could be mounted on a wall behind bushes or other obstructions. Also, emergencies often occur during inclement weather or at night.

Historical Background on Distributed Generation

Utilities have historically treated customer-sited generation equipment connected to the grid with similar scrutiny as their large central power plants. Since there is a wide variety of generator types and installations, this common approach may cause excessive interconnection requirements for small, inverter-based generating systems. Central power plants are synchronous generators that export large amounts of power on high-voltage transmission lines. In contrast, small renewable energy systems are inverter-based sources that connect relatively small generators of power to the low-voltage side of the distribution transformer. Some utilities require distributed resources to provide direct-transfer trip, Supervisory Control And Data Acquisition (SCADA), and redundant relay protection devices such as those used by central power plants. Over the past decade, standards and codes have been updated to facilitate the safe operation of small distributed energy systems. Inverters and other equipment meet these newer standards. Many utilities now have different rules and procedures for small distributed systems than they have for central power plants.

1 UL 1741(2005) Inverters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources

2 IEEE 1547 (2003), IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems

Current Status of the Utility External Disconnect Switch Requirements

Several utilities (such as National Grid[3], Pacific Gas and Electric[4] (PG&E) and Sacramento Municipal Utility District[5] (SMUD)) and eight states (Arkansas, Delaware, Florida, Nevada, New Jersey, New Hampshire, North Carolina, and Utah)[6] have waived the requirement for a UEDS for small, inverter-based systems. Increasingly, utilities such as PG&E and SMUD are taking advantage of self-contained meters as the means for facilitating the desired accessible/visible break/lockable functions without requiring a UEDS. As a result, more than half of all photovoltaic installations in the US in 2007 were installed without a UEDS[7].

Utility testimony indicates that, for properly designed and installed Code-compliant PV systems, the UEDS provides little, if any, additional safety, when a self-contained meter is already present[8]. There remain state and utility interconnection rules and guidelines that still require an accessible, lockable, visible-break safety-disconnect switch (for example[9,10]). Some utility companies are reluctant to accept the growing body of evidence that this additional safety device is unnecessary.

Review of Literature, Standards, and Operations

Safety, OSHA, and ANSI

Safety, in all aspects of PV system installation, interconnection, and operation, is of paramount concern to the Solar ABCs and the continued growth of connecting renewable energy sources to the grid. The Occupation Safety and Health Administration (OSHA) provides the law of the land for electrical safety regulations although utilities may interpret this law in various ways. The OSHA Act of 1970 requires employers to provide employees with a workplace free from recognized hazards known to cause serious physical harm. Sub part S of OSHA 29CFR part 1910, "Standards for General Industry," contains requirements that deal with protection from electrical hazards. Switching and tagging, and lockout/tagout are the primary methods of hazardous energy control. OSHA rules direct utilities to follow three general steps in switching and tagging procedures: first, check to be sure the circuit is dead; second, ground the circuit conductors; and third, work with gloves.

OSHA 1910.269 and provisions of 1910.331 through 1910.335 cover electrical safety work practices. As part of the three-step process to lockout/tagout a line section, OSHA Section 1910.333(b)(2)(iv)(B) states that:

A qualified person shall use test equipment to test the circuit elements and electrical parts of equipment to which employees will be exposed and shall verify that the circuit elements and equipment parts are de-energized. The test shall also determine if any energized condition exists as a result of inadvertently induced voltage or unrelated voltage backfeed, even though specific parts of the circuit have been de-energized and presumed to be safe. If the circuit to be tested is over 600 volts, nominal, the test equipment shall be checked for proper operation immediately after this test.

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3 John J. Bzura PhD. email correspondence. *M.D.T.E. No. 1116-A Canceling M.D.T.E. No. 1088 Effective: April 2, 2007*. February 2008.

4 Pacific Gas and Electric Company. (Nov 2006). AC disconnect switches for inverter-based generation. Retrieved June 12, 2008 from http://www.pge.com/b2b/newgenerator/solarwindgenerators/disconnectswitches

5 "SMUD Waives Switch Requirement for Solar Systems: Move Makes Solar Installations Easier." SMUD, Feb. 21, 2007. http://www.smud.org/news/releases/07archive/02_21solar.pdf

6 Coddington, M.H., Margolis, R.M., & Aabakken, J. (2008). *Utility-interconnected photovoltaic systems: Evaluating the rationale for the utility-accessible external disconnect switch* page 23

7 Larry Sherwood, IREC personal communication July 6, 2008.

8 Public Service of Colorado testimony in Docket 07R-166E that its policy provides field personnel of either pulling the meter or utilizing the EUDS if they choose to disconnect a customer's system page 88

9 Ohio PUCo. Technical Requirement and Parallel Operation of Distributed Generation. page 1.4.2.

10 Exelon Energy Delivery Interonnection Guideslines for Generators 2 MVA or Less.Original: October 31, 2006. Page 8.

In contrast, utility standards for lockout/tagout usually reference the older, less rigorous American National Standards Institute (ANSI) standard Z244.1-2003 procedures. Where OSHA requires that a circuit be measured and verified as de-energized from all sources before servicing, the ANSI standard does not require this. The lack of a requirement to manually check for safe conditions has often been cited as the necessity for an accessible, lockable UEDS. However, OSHA procedures explicitly require the line section to be verified as de-energized prior to all service actions[11].

It is important to note that all grid interactive inverters installed in the U. S. have been tested to the UL 1741 and IEEE 1547 standards (explained below) that include passing the Unintentional Islanding Test, which verifies that the inverter does not operate independent of the utility. This evaluation also tests that these inverters cease to export power when the utility is de-energized.

Since the OSHA procedure must be performed *before* starting any maintenance or emergency work, a line determined to be de-energized and made safe via the OSHA safety procedures by a worker can not become energized by a grid-interactive inverter under any circumstances without reapplication of line voltage from the utility. Hence, since workers must determine that a line is de-energized and attach equipotential grounding before servicing, presence of the UEDS provides little additional protection for line workers.

National Electrical Code Requirements

The *National Electrical Code® (NEC)* requires all buildings or structures to have switches or breakers capable of disconnecting them from all sources of power[12]. The switches must be manually operable without exposing the operator to contact with live parts and must be readily accessible[13]. *NEC* 690.13 states: "Means shall be provided to disconnect all current-carrying conductors of a photovoltaic power source from all other conductors in a building or other structure." In addition, the switches must be permanently marked to identify them as PV system disconnects. In the case of solar generators, the *NEC* requires at least two manual disconnects on the inverter (one AC disconnect switch and one DC disconnect switch). In section 690.64, the *NEC* specifies that PV system inverters must have means for disconnecting AC, either with breakers in distribution panels or fusible switches. The *NEC* does not require that these disconnects be lockable or that they provide a visible-break separation, conditions placed on the UEDS.

More significant is the difference between the *NEC* and the utility in their working definition of the term "readily accessible." From the *NEC* perspective, a circuit breaker panel in the laundry room in a residence is readily accessible to the electrician who would come to repair a PV system (or general house wiring, electric range, etc.). So is the disconnect switch next to the inverter inside of the garage. If the house is locked and no one is home, then the electrician can't get to the breaker or the disconnect—or the inverter—and therefore can't work on the PV system, wiring, range, etc.

Utilities have a different perspective on *readily accessible*—their stated use of the utility disconnect would potentially require emergency access 24 hours a day, 7 days a week. It cannot be locked in a garage or laundry room. Since the utility usually has access to the customer's revenue meter, they typically want or require the PV utility disconnect switch to be located near the meter. Even though the meter may be located inside the house or building (in an area where the utility has 24-hour access), utility accessible locations are usually (though not always) on the building exterior, leading to the PV industry misnomer, *External* Disconnect Switch, rather than the more correct, Utility Accessible Switch designation.

11 OSHA standard interpretations: Recognition of ANSI ASSE Z244.1-2003 "Control of hazardous energy-lockout tag-out and alternative methods" consensus standard. Washington, D.C.: Occupational Safety & Health Administration.

12 National Fire Protection Association, *National Electrical Code (NEC)* 2008 section 690.13

13 ibid section 690.17 (1)

While in some cases the meter location may be a convenient point to connect the PV system—and thus a single switch could serve *NEC* and utility needs—in many cases it can be complicated and expensive to route. At times, it can be difficult to route PV output wires from a location that is both convenient and acceptable under *NEC* requirements (such as inside a garage) to a point acceptable to utilities. Meter locations on buildings vary depending upon local zoning law and utility practices, and line workers seeking to disconnect PV systems in an emergency may find it difficult to locate the meter and the UEDS. For example, they could be mounted on a wall behind bushes or other obstructions. Also emergencies often occur during inclement weather or at night. In those many cases where the *NEC* disconnect located near the inverter does not meet the utility's needs for readily accessible, the UEDS represents a redundant means to disconnect the system from the grid. In addition, this additional wire and equipment also contributes to system losses and potential maintenance concerns.

UL 1741 and Product Safety Evaluations

Safety of Inverter based system Subject to UL Testing under IEEE Standards 1547

The UL 1741 standard covers inverters, multi-mode inverters, converters, controllers, and interconnection systems for use with Distributed Energy Resources (DER). UL 1741 combines product safety requirements with the interconnection system test requirements developed in the IEEE 1547 standard to delineate the specific procedures and criteria for evaluating and certifying distributed generation products. UL 1741 goes beyond IEEE 1547 requirements to include product safety aspects. Rigorous tests must be passed for any inverter to obtain UL 1741 listing.

IEEE 1547 and IEEE 1547.1 were written to become the basis for DER interconnection of 60 Hz systems (i.e., North America voltage and frequency) and were based upon existing criteria for evaluating utility interconnection relays, and upon utility interconnection certification requirements from individual state and local public utility commissions (PUCs). Relays perform the protective functions that are integrated into an inverter. UL 1741 was revised in 2005 to directly reference the IEEE 1547 requirements and IEEE 1547.1 test procedures. IEEE 1547 references IEEE C37.90 and IEEE C62.41, standards that are normally applied to "utility grade" protection relays.

The combination of the UL 1741 and IEEE 1547 standards help to harmonize the utility interconnection requirements and equipment conformance validation across the United States. The IEEE 1547-compliant UL 1741 requirements became effective on May 5, 2007. Underwriters Laboratories Inc. and other Nationally Recognized Testing Laboratories (NRTLs) perform quarterly unannounced manufacturing inspections on the UL 1741 Listed equipment to verify that products continue to be produced in the same manner as when they were originally evaluated and tested. This process is intended to prevent variations in the critical components (hardware and software) that could affect the critical utility interconnection performance of the product.

Traditional Utility Protection Practices Not Evaluated as Rigorously as Inverter Based Interconnection

Unfortunately, utilities have not required that interconnection protection relays be Listed to UL 1741. Utility protection equipment is only required to meet the IEEE 1547.1 testing requirements and lacks the additional safety afforded by product testing and oversight of critical hardware and software that a NRTL listing provides.

PV system inverters today are UL 1741 Listed with anti-islanding feature. Islanding is a situation in which a portion of the electrical grid that contains loads and generation source remains energized even after it is isolated from the remainder of the electrical grid. The traditional utility concern is that the islanded system will suddenly and unexpectedly connect to the grid and re-energize it—or remain energized when the utility believes the portion of the grid in question to be completely de-energized. To be UL 1741 Listed, inverters must pass tests to "successfully demonstrate that their anti-islanding protection methods operate in less than two seconds under a range of conditions expected on the feeder[14]."

There are distributed generation systems designed to operate site loads during utility outages. However, these are for service institutions such as hospitals and other sites that have stand-by generation that is energized during a utility outage. All of these systems have specially designed power transfer systems that prevent the system from energizing the utility grid during an outage.

IEEE Standard Isolation Device Requirement

Some utilities cite the IEEE Standard 1547 Isolation Device clause 4.1.7 as justification for the UEDS[15]. Clause 4.1.7 in IEEE-2003 states: "When required by the Area Electric Power System (EPS) operating practices, a readily accessible, lockable, visible-break isolation device shall be located between the Area EPS and the DER unit." In other words, under IEEE 1547, an isolation device is not a universal requirement, but IEEE 1547 recognizes that utilities could require a redundant disconnect that could be on the utility side of the meter in addition to the many utility methods already available to isolate a circuit. Unless the local jurisdiction rules otherwise, this isolation device clause in IEEE 1547 is not a mandatory equipment requirement.

Operational Issues

Non-Use of the UEDS

Where the UEDS is required for renewable energy systems, discussions with utility personnel show that few utilities have used the switch during maintenance or emergency situations. One research project found that none of the external disconnect switches studied had been used by utility maintenance staff[16].

We will review some of the reasons why utility workers have not operated the UEDS for safety during either maintenance or emergency conditions. First, most residential PV systems are less than 10 kW. Residential customers have a potential connected load above 20 kW. Motor loads in particular tend to trip off isolated PV systems because motors have an in-rush current in the range of 5-12[17] times normal load. Typical motor loads are air conditioning units, washing machines, and refrigerators. If the grid is de-energized, then the PV alone cannot supply the motor load for the residence, and the inverter will shut off.

Second, according to Coddington et al.[18], on the UEDS a line worker can only be injured by a PV system if several failures occur at the same time. Similarly, the California Rule 21 Supplemental Review Guideline[19] states that a number of specific conditions must exist for unintentional islanding to take place. Public Service of Colorado's expert witness on this subject[20] has confirmed that a very unlikely series of events must occur to place a line worker at risk from a PV system installed without a UEDS.

14 Email and conference call with Tim Zgonena, Principal Engineer, Underwriters Laboratories, Inc.

15 Potomac Electric Power Company's Reply Comments Case No 1050,41 May 2,2008 Response to MD-DC-VA Solar Energy Industry Association page 6

16 U.S. Department of Energy, *Million Solar Roofs Case Study: Overcoming Net Metering and Interconnection Objections,* September 2005

17 How to Make Accurate Inrush Current Measurements Mar 1, 2003 , By Bob Greenberg, Fluke Corp

18 ibid Coddington page 11

19 www.energy.ca.gov/distgen/interconnection/SUP_REV_GUIDELINE_20050831.PDF Section 7.1 5a-c

20 Public Utilities Commission State of Colorado Docket 07A-462E Volume 4 page 102

Third, operation of multiple UEDSs is onerous for the utility. Utility companies may be reluctant to follow the number of steps necessary to document the required information necessary to properly switch and tag each PV system. This includes recording the location and size of each PV system on the utility's circuit maps and making this information available to system operators, engineers, line workers, and all non-utility employee crews working on the utility facilities. This is simply not practical in utility operations. In order to do this, information with details of the interconnect agreement must be communicated from the commercial side to the operational side of the utility. In addition, if the UEDS is to be operated for safety during maintenance and emergency situations, then the appropriate switching orders need to be generated for each work group, and all switching and tagging orders for small PV systems need to be posted and incorporated into existing switching and tag-out orders. Finally, although the utility must ensure access to the UEDS just as it does for all metering, utility metering personnel and service personnel are not the same. Service outages on the distribution system come at night or in bad weather conditions when metering personnel are not available to help with locating a UEDS. Thus, some utilities allow the practice of "pulling the meter" to isolate the system[21,22] if the need for isolation is found to be necessary.

Cost

Several PV installers have estimated the typical incremental cost of installing a UEDS to be in the range of $200 to $400. In response to a question from the Florida Public Utilities Commission, Progress Energy estimated the cost of the UEDS to be $1,253.13 per customer[23]. Whether the lesser or the higher estimate, on small systems, the UEDS is a burden that will have long-term impacts with no clear benefits. The national interest requires that our renewable energy installations be completed in as cost effective a manner as possible, consistent with Best Practices including safety concerns.

Legal and Jurisdictional Issues

There are two legal issues that arise from the utilities' claim that the UEDS is necessary for safety. The first issue is the exposure that utilities accept when they "require" the UEDS and then fail to operate it during maintenance or emergency situations. A utility that fails to incorporate the use of the UEDS into its standard operating procedures could as a result be faced with the prospect of additional source of liability or even punitive damages in case of injury[24].

The second issue arises from the fact that the utility requires the line worker to operate the UEDS even though it is located outside the utility's jurisdiction, i.e., it is not utility property and is located on the customer side of the meter. The legal concern arises because utility line workers are considered not "qualified"[25] under *NEC* requirements to work outside the utility's jurisdiction. The utility is exposed to liability if the line worker becomes injured attempting to operate the UEDS.

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21 Pacific Gas and Electric Company. (Nov 2006). AC disconnect switches for inverter-based generation. Retrieved June 12, 2008 from http://www.pge.com/b2b/newgenerator/solarwindgenerators/disconnectswitches/

22 Transcript of cross examination of Public Service of Colorado expert witness on this subject in 2008 Public Utility Commission of Colorado Docket 07R-166E page 88

23 Florida Public Utilities Commission (2007). Docket 070674-EI. Tallahassee, FL.

24 ibid Cook

25 National Fire Protection Association. (2007). Report on proposals A2007 NFPA 70. Quincy, MA:

Conclusions

This report highlights how a number of progressive state regulatory commissions and utilities with jurisdiction over a large portion of the country's inverter-based renewable energy systems have eliminated the UEDS requirement traditionally required for interconnection of Distributed Energy Resource generation and how the growing evidence indicates that the UEDS requirement can be eliminated from state and utility requirements for PV systems without compromising the safety of these systems or of personnel working near them.

The disadvantages of the UEDS requirement are:

- The lack of any measurable benefit to safety
- The additional cost of UEDS
- The potentially detrimental impact on PV system losses and reliability
- The possible liability incurred to federal sanctions and penalties as well as to punitive damages.

Furthermore,

- Utilities rarely, if ever, use the installed UEDS
- PV systems installed without a UEDS have had a clean safety record
- More than half of the small PV systems installed in 2007 did not have a UEDS
- A growing number of utility and regulatory commissions have decided to eliminate the UEDS requirement.

Recommendation

The recommendation is to eliminate the requirement for UEDS for all small, inverter-based systems in all jurisdictions. With the inherent safety features built into all UL-listed PV inverters, the UEDS is functionally unnecessary and provides little, if any, additional safety.

For customers with self-contained meters (including almost all residential and small commercial customers), the meter itself is already fully capable of providing the functions required of the switch (i.e., a visible, physical, lockable separation of the system from the utility). At the very minimum, these customers should be excluded from any UEDS requirement.

References

Bzura, John J., PhD. email correspondence February 2008.. M.D.T.E. No. 1116-A Canceling M.D.T.E. No. 1088 Effective: April 2, 2007.

Coddington, M.H., R. M. Margolis, and J. Aabakken. (2008). *Utility-interconnected photovoltaic systems: Evaluating the rationale for the utility-accessible external disconnect switch*, (TP-581-42675). Golden, CO: National Renewable Energy Laboratory.

Cook, C. "Interconnected PV - The utility accessible external disconnect switch," page 3. www.puc.state.pa.us/electric/pdf/NMIC_SunEdison_Comments_Att2.pdf. 2004.

Email and conference call with Tim Zgonena, Principal Engineer, Underwriters Laboratories, Inc. February 2008.

Exelon Energy Delivery Interconnection Guidelines for Generators 2 MVA or Less, page 8. Original: October 31, 2006.

Florida Public Service Commission. (December 7, 2007). Docket 070674-EI Attachment B, page 40. Author Progress Energy Florida

Greenberg, Bob, "How to Make Accurate Inrush Current Measurements." Fluke Corp., March 1, 2003.

IEEE 1547 (2003), IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems (EPS).

National Fire Protection Association. (2007). "Report on proposals A2007 NFPA 70." Quincy, MA.

National Fire Protection Association. *National Electrical Code (NEC)* 2008.

Ohio PUCo. "Technical Requirement and Parallel Operation of Distributed Generation," page 1.4.2.

OSHA standard interpretations: Recognition of ANSI ASSE Z244.1-2003 "Control of hazardous energy-lockout tag-out and alternative methods" consensus standard, page 3 or 4. Washington, D.C.: Occupational Safety & Health Administration. Nov 10, 2004.

Pacific Gas and Electric Company. (Nov 2006). "AC disconnect switches for inverter based generation." Retrieved from http://www.pge.com/b2b/newgenerator/solarwindgenerators/disconnectswitches/

Pennsylvania Public Utility Commission. (2005). Docket M-00051865. Harrisburg, PA.

Potomac Power Company, Reply Comments to MD-DC-VA Solar Energy Industry Association, Public Utility Commission of DC Case No. 1050,41, May 2, 2008.

Public Service of Colorado testimony in Docket 07R-166E that its policy provides field personnel of either pulling the meter or utilizing the EUDS if they choose to disconnect a customer's system.

Public Utilities Commission State of Colorado Docket 07A-462E Volume 4, page 102.

Sherwood, Larry. IREC phone correspondence July 6, 2008.

SMUD Waives Switch Requirement for Solar Systems: Move Makes Solar Installations Easier. SMUD, Feb. 21, 2007. http://www.smud.org/news/releases/07archive/02_21solar.pdf.

Transcript of cross examination of Public Service of Colorado expert witness on this subject in 2008 Public Utility Commission of Colorado Docket07R-166E.

UL 1741(2005) Inverters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources.

U.S. Department of Energy, *Million Solar Roofs Case Study: Overcoming Net Metering and Interconnection Objections*, September 2005.

www.energy.ca.gov/distgen/interconnection/SUP_REV_GUIDELINE_20050831.PDF Section 7.1 5a-c

Acronyms

AC	Alternating current
ANSI	American National Standard Institute
AHJ	Authorities Having Jurisdiction
DC	Direct current
DOE	Department of Energy
DER	Distributed Energy Resource
EPS	Electric Power Systems
FERC	Federal Energy Regulatory Commission
IEEE	The Institute of Electrical and Electronic Engineers
IREC	Interstate Renewable Energy Council
NEC	*National Electrical Code®*
NFPA	National Fire Protection Association
NREL	National Renewable Energy Laboratory
NRTLs	Nationally Recognized Testing Laboratories
OSHA	Occupational Safety Health Administration
PG&E	Pacific Gas & Electric
PV	Photovoltaic
SMUD	Sacramento Municipal Utility District
Solar ABCs	Solar America Board for Codes and Standards
UL	Underwriters Laboratories
UEDS	Utility External Disconnect Switch

Glossary of Terms

Best Practice: A technique or methodology that, through experience and research, has proven to reliably lead to a desired result. A commitment to using the Best Practices in any field is a commitment to using all of the knowledge and technology at one's disposal to ensure success.

De-energized: Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the Earth.

Intentional Islanding: Intentional islanding is the purposeful sectionalization of the utility system during widespread disturbances to create power "islands." These islands are designed to maintain a continuous supply of power during disturbances of the main distribution system.

Self-Contained Meter: A utility revenue meter that contains all sensing elements within the casing and meter base connections. All power to the facility must pass directly through the meter in order for the facility to receive service. Should the meter be removed, a physical separation will occur between the meter-base blade sockets, and the facility will be isolated from the utility. Nearly all residential customers are served by self-contained meters.

Unintentional Islanding: An unplanned condition where one or more DERs and a portion of the electric utility grid accidentally remain energized through the point of interconnection.

Utility External Disconnect Switch: An isolation device, accessible to utility personnel, used to provide a physical separation between a customer-generator and the utility system. This device must have a visibly-verifiable separation, be lockable in the open position, but does not need to be load-break rated or even be a switch.

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