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Evaluating the Rationale for the Utility-Accessible External Disconnect Switch

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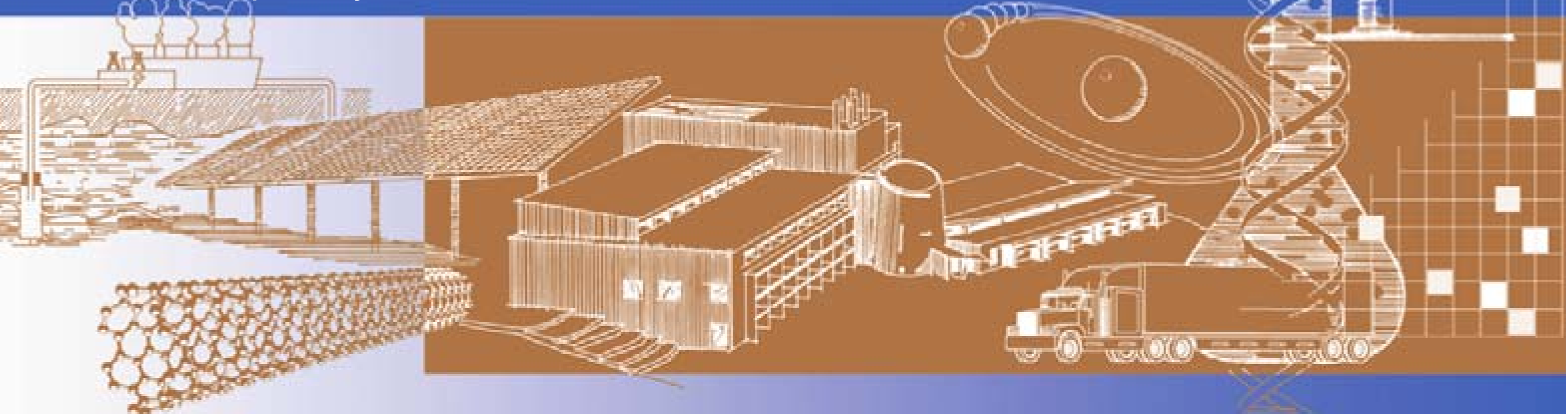

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EVALUATING THE RATIONALE FOR THE UTILITY-ACCESSIBLE EXTERNAL DISCONNECT SWITCH

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ABSTRACT

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.

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)

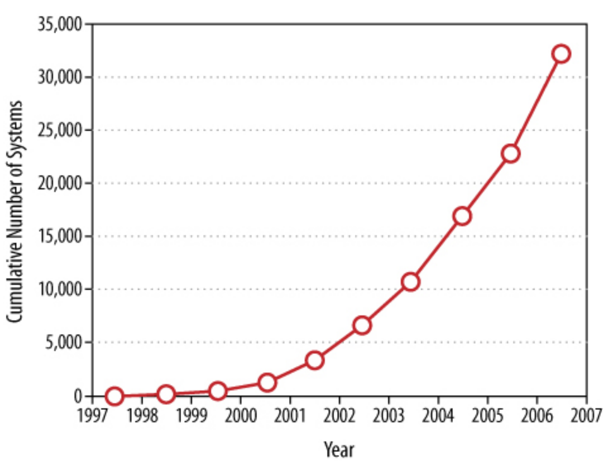

Figure 1. Utility-interactive PV systems installed in the United States, 1997–2006 (Interstate Renewable Energy Council 2007 and PV News March 2007)

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.

These issues and others are explored in greater detail in the NREL report available online. [1]

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).

It is important to note that there are at least six manual and automatic disconnect devices in a PV system. Any of these would allow an operator to disconnect power from the grid. In Figure 2, there are nine means of disconnecting the PV system from the grid:

- Ground fault protection at or near the PV array [1]
- 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

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

- 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.).

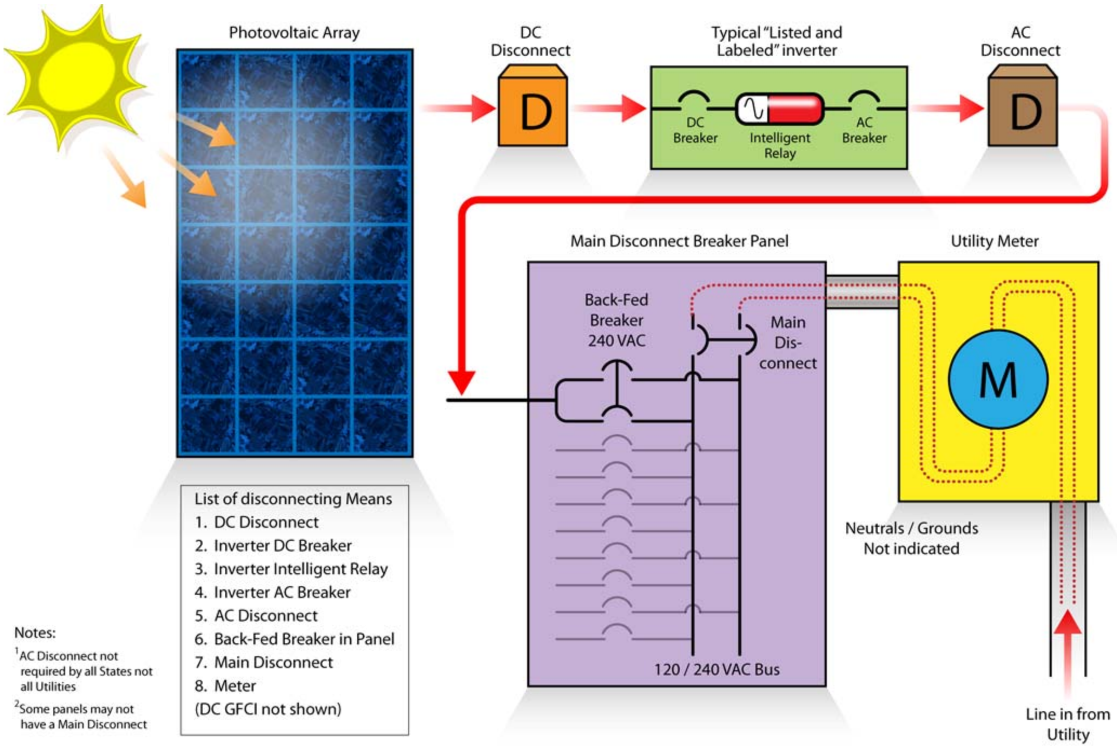

Figure 2. Typical residential/small commercial PV system schematic

STANDARDS AND CODES

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, 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 its 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, and 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, are automatic. Others—including DC disconnects, inverter DC breakers, inverter AC breakers, EDSs, PV system circuit breakers in customer panels that are backfed, main breakers,[2] utility production meters,[3] 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.

Clearly, if a utility-accessible EDS is required, it makes sense for utilities to integrate their 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.[4] Third, the geographic information system departments at utilities will need to maintain accurate and timely maps to help dispatchers and linemen 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.

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 was 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] Not all homes and businesses have a main disconnect.

[3] Production meters are required by some utilities to track the total energy output of a system.

[4] 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

SAFETY, RELIABILITY, AND COST: PRIME FOCAL POINTS FOR UTILITIES

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 follow the NESC [6] for safe working practices to establish proper clearances and safeguard persons from hazards in the installation, operation, and maintenance of electric distribution systems.

Linemen must "consider the electric supply equipment and lines to be energized, unless they are positively known to be de-energized.[5] If a lineman determines that other sources are feeding the circuit, he must locate and open the source or work the line energized.

Reliability

There is an increasing demand on utilities and PUCs to reduce outage durations.[6] 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.

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

[5] Per the NESC Section 42 420.D "Energized Unknown Conditions."

[6] 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.

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.

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 [7]. 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[8] procedures for utility-interactive inverters. The NEC also requires that the system "shall automatically de-energize its output to the connected electrical projection 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" [9]. 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" [7] 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 re-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.

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 [10]. As the PV industry grows, it will likely begin to play a stronger role in policy debates at the state and federal levels.

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.

[7] 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.

Both PG&E and 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 [11] and PG&E [12]). 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.

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.

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.

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