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TRANSACTIONS

Many utilities and industries around the world were holding their breath for many years for publication of the new Arc-flash calculation guide. At the end of 2018, the Institute of Electrical and Electronics Engineers (IEEE) *voted and approved a new Arc-Flash calculation methodology that can be used to assess incident energy for three-phase, line-to-line, voltages between 208V and 15,000V.* Calculations for single-phase AC systems and DC systems are not part of the standard but it does offer some guidance and references for those applications.

Incident energy is the amount of thermal energy generated during an electric arcing event at any discrete distance from the source. It is extremely important to know these values to be able to equip electrical workers with the proper personal protective equipment (PPE). Changes in the calculation methodology can impact these values which could alter the level of PPE required or even require work to be done de-energized.

IEEE 1584-2002 vs. IEEE 1584-2018: WHAT CHANGED?

The new methodology completely overhauls the exposure energy calculation methodology and significantly complicates the analysis, although it does provide more granularity based on the inputs. The new method uses an iterative approach and many coefficients to find the final incident energy. As with the old method: fault current, clear time, gap and approach distance still play a major role in the incident energy calculation.

Extensive arc-flash testing by IEEE in collaboration with NFPA determined that the orientation of the electrodes (live parts) has a considerable effect on the incident energy. 1584-2002 claimed that there was no distinction between open and box configurations for high voltage faults. Arc-flash tests prior to the 2018 version of the

2020 Q2

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LOOK FOR US

Upcoming Conferences

Although current circumstances have kept us from attending the latest industry conferences, GDS has high hopes of attending the upcoming conferences starting in July

JULY 27-29
Texas Public Power Annual Meeting
Austin, TX

AUGUST 2-5
Texas Electric Cooperative Annual Meeting
San Antonio, TX

UPCOMING WEBINARS

JUNE 9
Designing Secondary and Services

JULY 7
Load Balancing on Wye Systems

Note *All webinars are recorded & are available for viewing post-presentation* standard concluded that the plasma cloud ejected by the arc has liquid properties, and that both the electrode configuration and confinement in a box will impact plasma movement and dissipation. The horizontal electrode arrangement will yield higher incident energy as the plasma cloud and arc will be expelled horizontally towards the electric worker. While in vertical electrode configuration the plasma cloud and arc will be expelled parallel to electrodes. Thus, incident energy exposure will be affected by the worker's location relative to the vertical electrodes. The general direction of plasma cloud is determined by the ends of the electrodes in relation to the worker.

The box cases of both configurations have a higher incident energy than their open-air counterparts, as the "box" will cause the plasma cloud to be more concentrated. The plasma cloud of an open-air case would dissipate faster, thus reducing the incident energy.

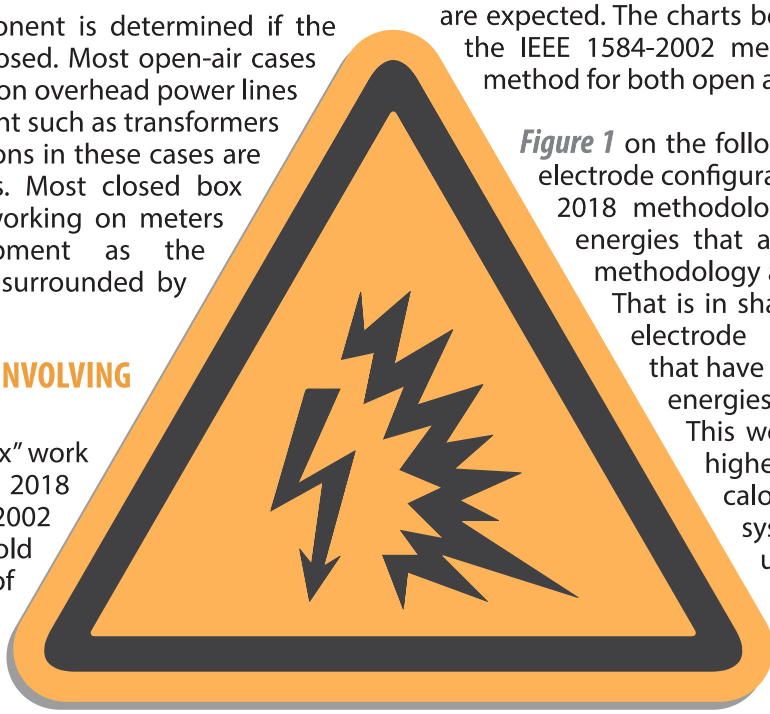
WHAT DETERMINES THE ELECTRODE CONFIGURATION?

The configuration of the bus and conductor primarily determine the electrode configuration. Any overhead pole with equipment can have multiple configurations. The key is to be able to identify the configuration when performing work. If electrical terminators, such as spade terminals, are configured such that they are perpendicular to the worker, the configuration will be horizontal. If electrical terminators are configured such that they are parallel to the worker, such as terminators on a riser pole, the configuration will be vertical.

The box or open-air component is determined if the electrodes are partially enclosed. Most open-air cases are apparent when working on overhead power lines and pole mounted equipment such as transformers and reclosers. The terminations in these cases are not surrounded by barriers. Most closed box cases are apparent when working on meters and pad-mounted equipment as the electrodes will typically be surrounded by the walls of the equipment.

WHAT ABOUT CHANGES INVOLVING ENCLOSED BOX WORK?

The concept of enclosed "box" work isn't unique to the 2018 methodology, as the 2002 method addresses it. The old approach used two sets of coefficients to distinguish between the open air and enclosed box calculations. The 2018 method also uses sets of coefficients distinguishing between open air and enclosed box calculations.



The major change with the IEEE 1584-2018 is the inclusion of the equipment box's dimension size and determining if the box is "typical" or "shallow". This would require obtaining the length (depth), width and height of any pad-mounted equipment or meter boxes to perform the 2018 calculations.

The incident energy values will also be different depending on if the box is shallow or typical. For the most part, any enclosed distribution equipment will be "typical", however, if all the following criteria are met, the box will be considered "shallow":

1. ***the voltage is less than 600V***
2. ***The height and width of the box are both less than 20 inches***
3. ***The enclosure depth is less than or equal to 8***

These additions to the standard can result in slightly different incident energies for different equipment, such as pad-mounted transformers and junction cabinets, at the same location having the same fault current.

WHAT ARE THE IMPACTS OF THE CHANGES IN IEEE 1584?

Using the new equations, higher incident energy levels are expected. The charts below show the comparison of the IEEE 1584-2002 method to the IEEE 1584-2018 method for both open air and closed box cases.

Figure 1 on the following page shows the vertical electrode configuration (VOA) calculations of the 2018 methodology result in similar incident energies that are slightly higher than 2002 methodology at 4,000 amps of fault current. That is in sharp contrast to the horizontal electrode configuration (HOA) results that have roughly 200% higher incident energies at 4,000 amps of fault current. This would require workers to wear higher calorie clothing, where a 4 calorie or 8 calorie clothing system would have sufficed under the old methodology.

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HOW DO WE MITIGATE EXPOSURE?

Since the calculated incident energies are higher under the new methodology, electric utilities may want to consider strategies to reduce incident energy exposure to line personnel.

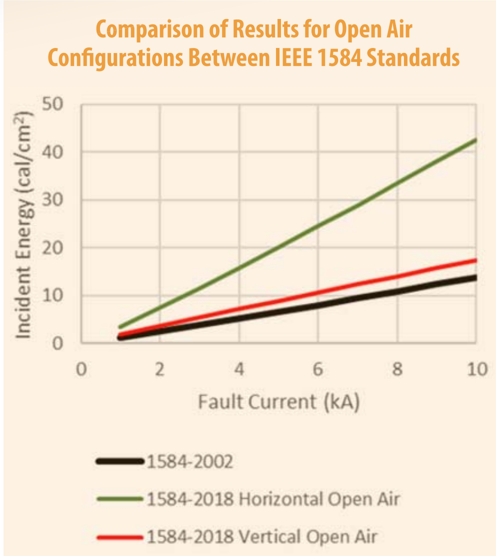
First and foremost, ***the safest way to work on a system without the threat of arc-flash is to work de-energized.*** Working a system de-energized eliminates the possibility of an arc-flash related incident.

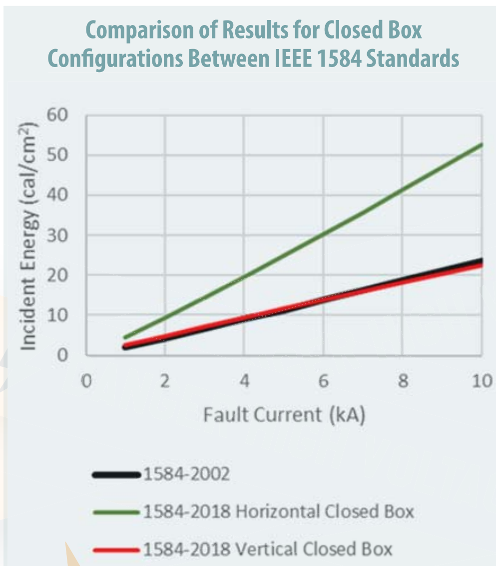
If work can't be performed de-energized, reducing the time duration of the fault can reduce the incident energy. A common method is to utilize hot-line tags (HLT) that implement near instantaneous tripping on electronic reclosers that result in clearing times of 5-10 cycles. This reduction can greatly reduce the incident energy. An added benefit when using HLT is that a worker downline is protected from multiple recloser operations.

If the upline device is not capable of using HLT, then use of the non-reclose function is recommended. This would default to tripping on the first curve of the device's operation sequence. With this option, the clearing time is dependent on the curve used in the device for coordination. If a utility primarily uses delay curves for feeder protection, an alternate "maintenance" profile should be considered where a faster curve can be implemented in conjunction with the non-reclose feature to reduce incident energy.

Figure 1 ***Representation of VOA Calculations of the 2018 Methodology Result***

Analysis performed using 5.98" arc/electrode gap, 15" working distance, and 0.5s clearing time at 12.47 kV





Another way to decrease incident energy is to increase the working distance from the arc. This can be achieved by utilizing live-line tools.

FINAL THOUGHTS

Appendix E to Subpart V of Part 1926 discusses the need for electric industry employers to assess the workplace for electric-arc hazards. The document provides acceptable methods for the calculation which includes IEEE 1584-2002 and the 2017 NESC. Since OSHA specifically does not endorse any methodology, it is the onus of the employer to determine the incident energy and the new IEEE 1584-2018 may be the tool to use.

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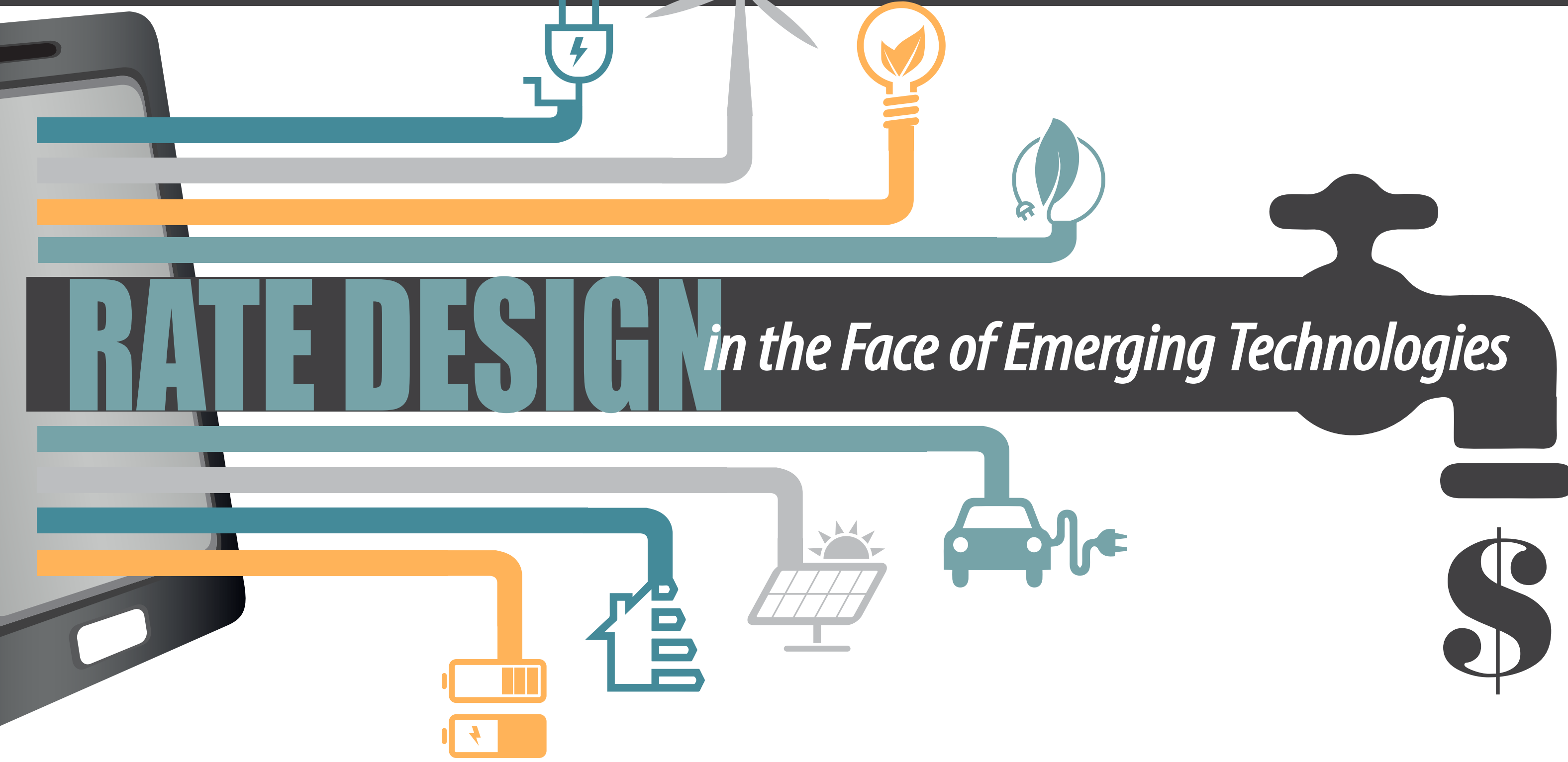
> ***...the safest way to work on a system without the threat of arc-flash is to work de-energized***



RATE DESIGN *in the Face of Emerging Technologies*

Ten years ago, if someone told a room full of electric utility personnel that energy sales and the economy were highly correlated and that sales would increase year after year, most people would nod their head in agreement. With steady and predictable energy sales, recovery of fixed costs based on these sales was generally not subject to significant risk. Even though the economy has been strong over the past ten years, ***this correlation no longer holds true and residential consumption has been flat or decreasing every year.*** New technology has resulted in higher energy efficiency in the everyday products used by customers and some consumers have also turned to using alternatives such as rooftop solar panels and are generating their own energy, impacting sales even further. One major concern is with sales unable to recover costs like they once did, externalities like fluctuations in the weather, causing either much higher consumption due to excessive AC or much lower consumption due to mild weather, have a much greater impact on utility margins. Finding unique and adaptive solutions is essential to this new era of electric sales because traditional methods don't always recover fixed costs in a reliable fashion.

*Even though the economy has been strong over the past ten years, this correlation no longer holds true and **residential consumption has been flat or decreasing every year***

It has been a standard practice to recover fixed costs from residential customers through a two-part rate design consisting of a low fixed customer charge and an energy charge that recovered the remaining portion of the utility's fixed costs. Now, with energy sales across the residential class either flattening or in some markets declining, the traditional rate design is not recovering fixed costs as it once did. One of the first lines of defense for utilities to combat declining sales trends is to raise the customer charge. Although a good alternative, raising the customer charge may not always be the best solution, and utilities can look to advanced technology to help. Real time interval load data from AMI helps provide the information that enables utilities to create dynamic rate designs that can result in improved recovery of fixed costs. But new rate alternatives and strategies have to be developed and implemented to complement existing ones.

Going forward, one of the main concerns for every utility will be *understanding how emerging technologies will impact energy consumption patterns and how that changed consumption will further impact rate design.* With newer technologies becoming more common and available in all areas of the country, investor owned utilities, municipalities, and cooperatives are all having to find ways to adjust with improved product efficiency and changing consumption patterns. ***Potential widespread use of smart devices, EVs, advanced batteries should spur utilities to consider alternative rate designs that may better recover costs.***

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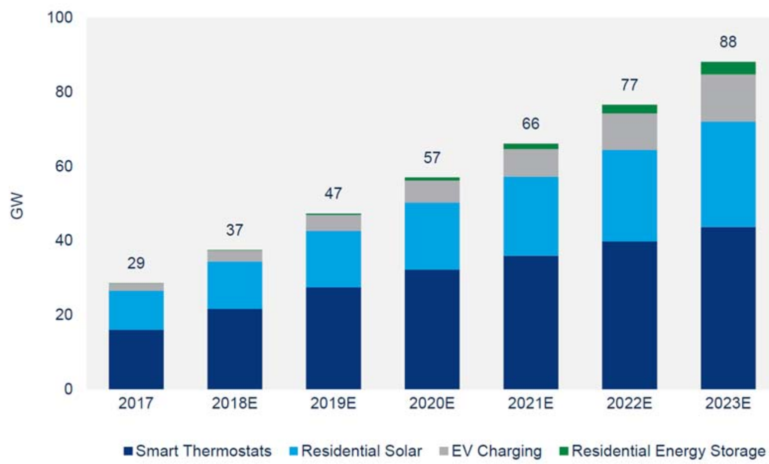
SMART THERMOSTATS & OTHER SMART DEVICES

One of the leading emerging technologies in the residential market is the smart thermostat. There are varying degrees to just how smart a thermostat must be in order to garner the "smart" moniker. A true smart thermostat uses advanced algorithms to learn a person's schedule and adjust the temperature in order to most effectively condition the home using the least amount of energy. Such true smart thermostats are becoming increasingly standard on new construction homes. A case in point is Austin, TX which requires homebuilders to install smart thermostats on all new homes and apartment buildings.[1] As building codes are changed and efficiency standards are updated, smart thermostats will continue to gain market share, similar to how more efficient alternatives to incandescent lighting such as CFL and LED bulbs did beginning a decade ago. Smart thermostats were projected to account for nearly 20 million installed units nationwide by 2020 in a report from the Northeast Energy Efficiency Partnerships published in 2019.[2]

Other smart appliance technology is still developing, but some of the same benefits that smart thermostats supply could be achieved for dishwashers, washing machines, clothes dryers, ranges, lighting, and more. As consumers become more accustomed to the smart home and realize the benefits market share for other connected appliances is expected to grow[3]. All of these advancements in the Internet of Things will allow customers to understand their home's energy use and respond to price signals from their electric utility much more easily. A side-effect of the increasing popularity of the connected smart home that the utility needs to consider is the ***potential for lower energy consumption***. However, innovative time-of-use (TOU) or critical peak pricing (CPP) rate designs coupled with AMI meters could encourage consumers to reduce consumption during peak hours when energy costs are their highest. The average consumer may be much more willing, or even desire to be billed on a TOU, CPP, or other dynamic pricing rate if the consumer believes their smart home can help them reduce their energy bill (see *Figure 2*).

FIGURE 2 ***Projected Cumulative US Potential for BTM Residential Flexibility***



Source: *Wood McKenzie Power Renewables*

"We will not stop until every car on the road is electric," Elon Musk proclaimed in 2014. The International Energy Agency's latest report shows 2018 the United States had approximately 1.1 million EVs, which represents 2.4% of the total car market share. Musk's goal still has a way to go, but with lithium batteries becoming cheaper and charging stations more prominent throughout the country, utilities in most regions of the nation are feeling the influence EVs as manufacturers have extended the mileage achieved per charge.

ELECTRIC VEHICLES

Most EVs come with a standard home installed charger, but when exactly a consumer charges their vehicle has become a point of emphasis for utilities. If there were no adjustments to standard rates for EV owners and they plugged their vehicles into the charger when they arrived home, it could increase electric load during peak load conditions, which in turn would increase cost to the utility. By offering special EV/TOU rates with lower prices during off-peak hours, usually during the middle of the night, the consumer is incentivized to charge during hours that do not negatively impact the peak load. The higher energy consumption during these usually quiet "off peak" hours greatly improves a utility's load factor, which can lead to greater fixed cost recovery. With the reduction in the peak load by the consumer and the reduction in energy bill for the consumer, the configuration of a specific time of use rates for EVs can be seen as a "win-win" for both parties.

BATTERY STORAGE TECHNOLOGY

Battery storage technology is a maturing field and will likely begin to impact residential rate design soon. While the current market share of retail-battery storage is far from that of smart thermostats, it is a growing segment of the market. As residential solar installations continue to grow and battery storage technology matures and costs decline, the benefits of coupling battery storage with a solar installation will begin to outweigh the costs of installation and maintenance (see *Figure 3* on the following page).

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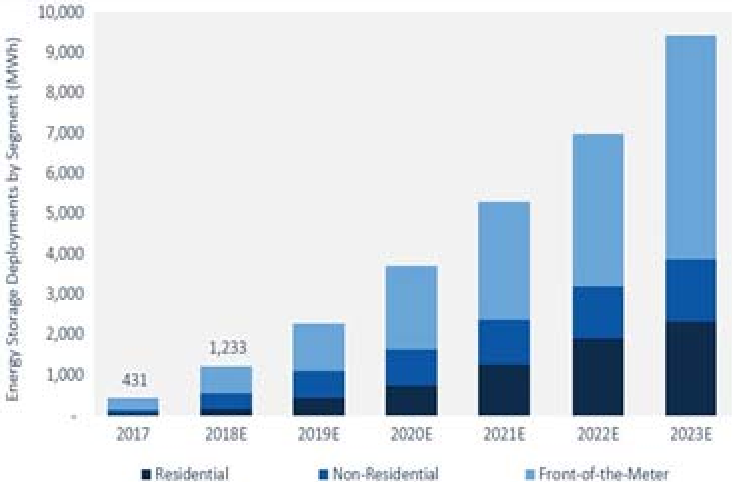
Forward thinking utilities should begin to gather data and consider how increasing consumer adoption of retail-scale batteries combined with solar PV panels will affect cost recovery. Retail rates must be designed with consideration for a variety of issues a battery-solar panel combination could pose, including changes in energy consumption patterns, decreased energy purchases, purchases of excess customer energy, or the redundancy of certain traditional demand response (DR) programs.

FIGURE 3 ***US Annual Energy Storage Deployment Forecast by Installation Type***



One significant benefit of retail batteries is the potential for the batteries to be deployed as a DR measure; by charging a battery during off-peak hours and discharging during on-peak hours a utility can easily shift costs from higher on-peak periods to lower off-peak periods. These savings can be achieved without inconveniencing residential customers, such as shutting off their AC systems, can easily increase the amount of load control available to a utility. When combined with rooftop solar, a retail battery will allow a customer to store solar power for use during peak periods, reducing consumption from the utility and lowering the utility's peak demand requirements. If desired, a utility can bill customers under rates that require the customer to allow the utility to discharge the battery a certain number of hours per year, using the battery as a de facto peak shaving DR measure. This type of rate design would still allow the retail customer to benefit from their solar/battery installation, while also allowing the utility to realize extra benefit during critical peak hours.

CONCLUSION

The energy landscape is continually changing and evolving in countless ways. Smart thermostats and devices, EVs, and batteries are just a few of the emerging technologies primed to alter the market in the near future. The typical two-part residential rate design may not effectively recover fixed costs as customer energy usage patterns change. More innovative rate designs could be the answer to ensuring better cost recovery in a changing landscape so that customers can take advantage of emerging technologies and more effectively manage consumption and their bill. In doing so, utilities could benefit in a number of ways, including better cost recovery, reduced peak loads, increased consumption during lower energy cost times, and of course happier customers.

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