Avoiding Main Panel Upgrades with SolarEdge Smart Energy Solutions

White Paper

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Introduction

SolarEdge is a leading global smart energy company that powers everyday life through clean, renewable resources. With its award-winning Energy Hub inverter, the market's most efficient, flexible solar & storage platform, SolarEdge meets the biggest homeowner demands of today and tomorrow in a single solution with connection to solar, batteries, EV charging and more.

The Energy Hub inverter integrates easily with the SolarEdge Backup Interface - a 200A microgrid interconnection device that enables users to back up the entire home or partial loads in case of a grid outage.

By leveraging a DC coupled architecture, SolarEdge has engineered integrated solutions that provide maximum value while decreasing installation costs. In particular the SolarEdge design approach significantly reduces the need for an expensive and time consuming main panel upgrade.

Background:

Today's residential renewable energy systems are mainly made up of grid-tied systems that connect to the home's main load panel. These include PV energy generation, stationary energy storage, emergency backup, EV Charging and even smart energy management. Other renewable resources include large loads that utilize local renewable generation or grid power, such as electric vehicles. In addition to managing stored power from batteries, these systems may also accept power from generation sources such as backup generators or even small wind generators.

As these residential systems evolve in flexibility and application, they begin to form a microgrid, rather than a traditional PV system. Microgrids are localized grids that can disconnect from the traditional grid to operate autonomously. They offer several advantages to the homeowner, grid operator, and society. During a power outage, homeowners have a reliable source of energy while contributing to the resiliency of the community and faster recovery. While connected to the grid, they can help mitigate grid disturbances, provide grid support resources, and reduce transmission losses, thus increasing the efficiency and reliability of the grid.

Renewable energy systems and energy storage systems have recently seen dramatic growth in deployment and have evolved in performance and complexity. Homes are increasingly becoming all electric with smart energy management systems as carbon infrastructure is phased out in some areas. Home electrical systems are relied on now more than ever for safe, reliable service.

On the other hand, electrical distribution systems within the home have not changed much in decades. This simple infrastructure was designed to receive energy from the distribution grid and safely deliver it to the home's loads. This is done typically at a main distribution panel that was traditionally intended as a one-way street for electricity. The panel was originally intended only to receive energy from the grid and distribute it to the home's loads.

However, innovations in equipment safety standards, and the National Electric Code in the past 20 years have creatively allowed renewable energy systems and residential microgrids to reliably and safely connect to these traditional distribution panels. Homeowners now have flexibility in how they choose to consume or generate energy as well as how their home interacts with the distribution grid without the need for expensive upgrades to the home's electrical system.

Avoiding a Main Panel Upgrade (MPU)

Solar plus storage systems may be connected to the home's distribution panel in a variety of ways. The most common way is to simply connect the inverter to a branch circuit breaker and apply NEC section 705. This type of connection is simple and inexpensive. However, the trade-off is that the allowed generation is limited by the size of the distribution panel's buss bar in NEC 2017 705.12 and NEC 2020 705.11. This is the traditional "120% rule" that ensures the existing buss bar will not be overloaded by the newly added second-generation source.

In addition, adding an AC coupled energy storage or EV charging equipment requires even more buss bar capacity with breaker space and often the installation of an entirely new larger main panel to make room for multiple new AC circuits. Figure 1 depicts how typical systems may be connected to an older 100A main panel – still popular in many older homes. The renewable generation in this example would be limited to about 16A, 3800 W. In order to install more generation, storage, or large AC loads using this method, an expensive main panel upgrade (MPU) may be needed with traditional AC coupled equipment.

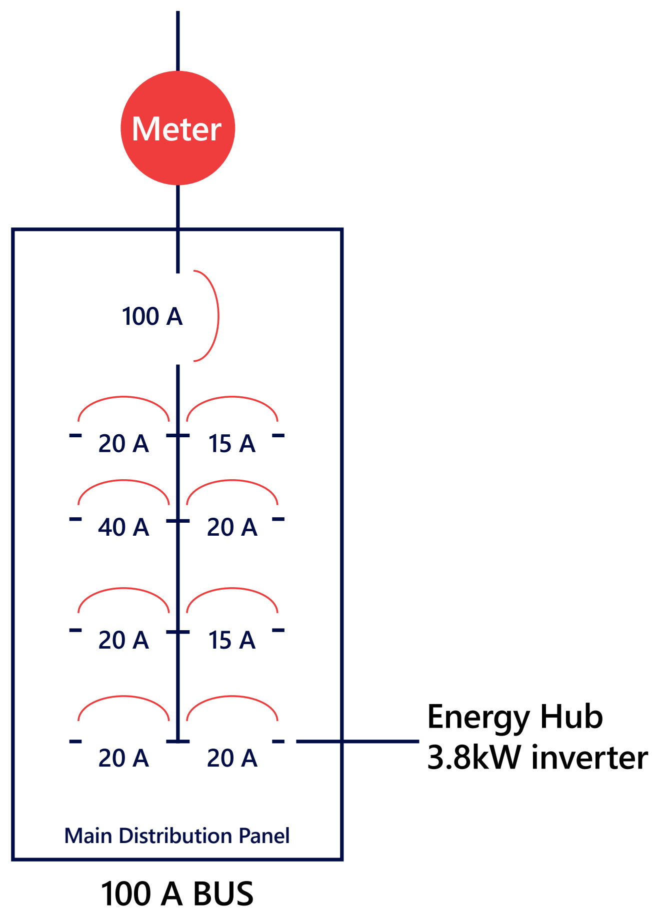

Figure 1 - 705.12 [705.12(B) in NEC-2017 and 705.12(D) in NEC-2014]

One alternative is to use a supply side connection, which can be inserted at point A in Figure 2. This directs renewable energy to the supply side conductors before the buss bar. As a result, energy may flow back to the utility or to the buss bar to serve loads. One advantage to this method is that more PV generation may be installed at this point. For example, a 40A breaker could be installed on a supply side tap that would allow 7600W of solar generation. However, this method has disadvantages also:

- The supply side tap cannot serve large loads. Use of many meter adaptor collars or renewable meter adaptors prohibit any loads at all
- Utility service must be interrupted, which adds delays and expense in the construction phase
- Perhaps the most impactful consequence is for energy storage and home backup systems that are considered large loads and cannot be served by the supply side tap.

When a supply side connection is not feasible, or when a homeowner wants to install an energy storage backup system, the next alternative to upgrading the main panel is to make a load side connection that feeds a new sub panel with a higher buss bar rating. The home's loads will need to be moved from the existing panel to the new sub panel. This is often referred to as a load side tap or load side feeder as shown in Figure 3 below.

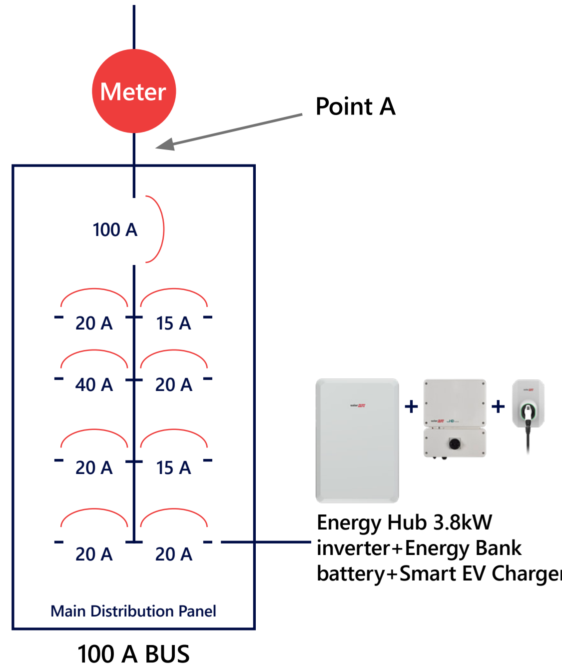

Figure 2

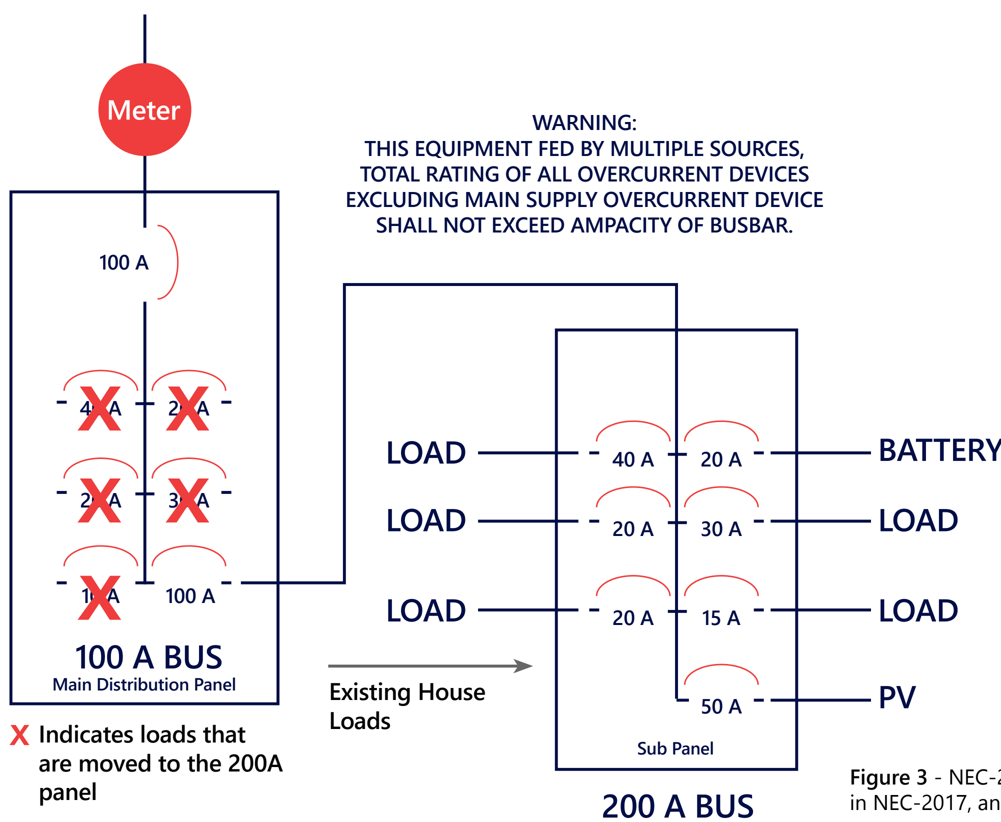

Figure 3 - NEC-2020 705.12(B) [705.12(B)(2)(1) in NEC-2017, and 705.12(D)(2)(1) in NEC2014]

Load-side tap advantages:

- Installing a subpanel has significant savings over a main panel upgrade
- Service interruption and coordination with the utility is avoided
- The maximum allowable PV generation on the new subpanel is a function of the new sub panel's increased buss bar capacity vs. the main panel's buss bar capacity

Load-side tap disadvantage:

- Existing loads need to be moved to the new subpanel and a larger new panel needs to be installed

Backup Interface design principle = "MPU avoidance" or "lower installed costs" by design:

The sophistication of renewable energy systems is rapidly evolving and changing. The previous examples show traditional approaches to installing typical PV and ESS systems.

SolarEdge solutions are uniquely engineered to avoid main panel upgrades by economically building upon existing electrical infrastructure rather than removing and replacing the entire main panel. This is primarily due to two design attributes of SolarEdge solutions.

The first is that SolarEdge solutions are based on DC coupling. By coupling the PV and battery on the DC side of the inverter, only half of the main panel space is required for the installation. In addition, the SolarEdge Energy Hub platform has the built-in capability for EV charging – which means main panel space is not needed. As a result of this, SolarEdge only needs one landing on the main panel for a complete system including solar, storage, and EV charging as shown on figure 2.

Though the equipment for replacing a main panel is relatively inexpensive (hundreds of dollars), the entire cost with labor can be thousands of dollars. And, the complexity of this task often means major permitting and installation challenges. First—typically, there is no upstream disconnect in the home for the main panel, which means the entire home must be disconnected by the local utility. So, not only is the home down during this upgrade, but the timing of this disconnect must be coordinated with the utility.

Also, the labor involved in an MPU is substantial. Each load circuit must be carefully inspected for prior work and renovations, and then disconnected from the old panel as represented in Figure 5.. Because the new panel is larger, construction work must also be done on the existing wall studs, sheetrock or other surrounding structures.

Finally, the loads must individually be reconnected to the new panel. Given the time, effort, electrician costs, utility coordination, and permitting it is no surprise that this one task can increase the cost of an installation enough to make the project no longer viable.

Key reasons to avoid a main panel upgrade when at all possible:

- **Costs** - Electrical material, labor as well as other trades (wall repair)
- **Service interruption** – Coordination with the utility, homeowner impact
- **Increased time on sit**e - More truck rolls and site visits
- **Delays** - Utility and special inspection scheduling
- **Lost opportunity** - The financial risk may kill the project

Supply side taps also share some of these hurdles.

How SolarEdge Smart Energy Solutions Help Avoid MPU

SolarEdge's system architecture is uniquely designed to build upon existing electrical infrastructure like older or newer main panels. Aside from the advantages of using DC coupled architecture to reduce the need for AC breakers in the first place, the Energy Hub system utilizes a top-down architecture to create a residential micro grid as shown in Figure 4 below. This approach reduces dependencies on the main panel and provides a new platform to build larger and more sophisticated renewable energy systems.

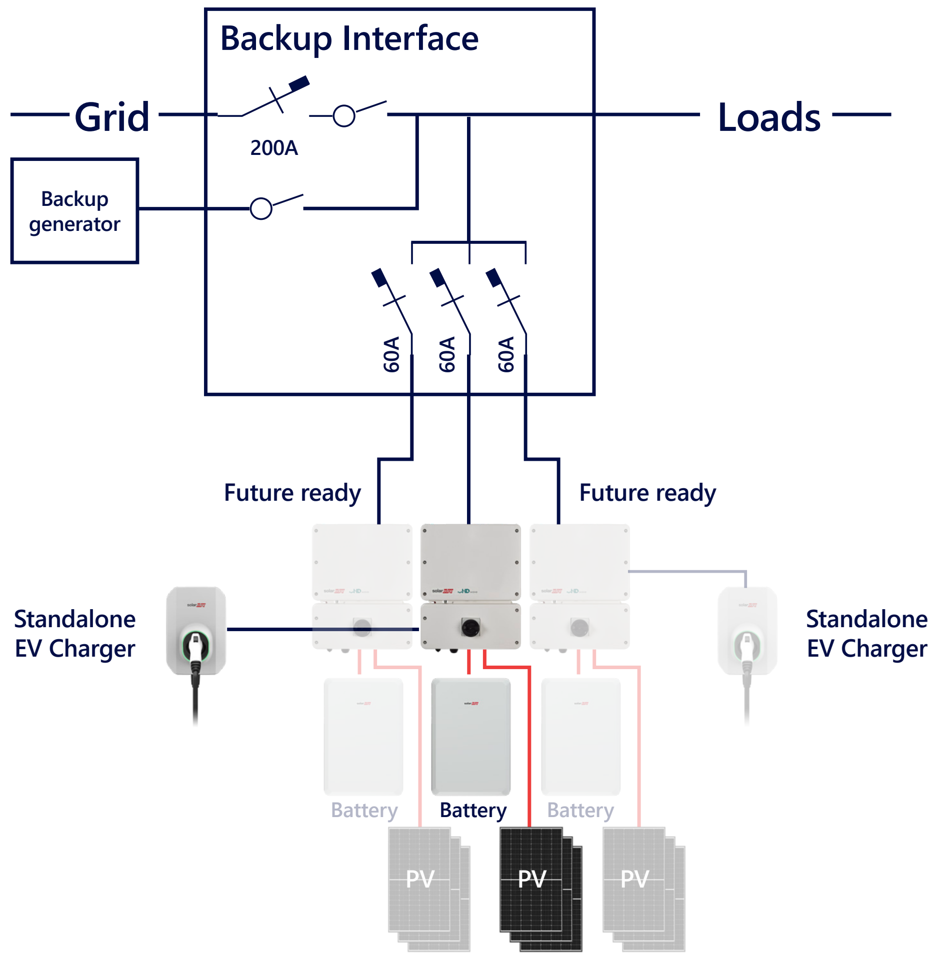

Figure 4

As shown in Figure 4 above, the Backup Interface is an important part of the architecture with a single point grid connection to the Energy Hub platform. It provides flexibility and future proofing with connections for combinations of PV, ESS, EV charging and generator combined with the intelligence of a micro grid interconnect device. It is listed to UL 869A as well as UL 1741 to be used as service equipment with an integrated service disconnect or simply as load-side equipment.

A microgrid interconnect device or MID is defined in NEC article 705 as a premises wiring system that has generation, energy storage, and load(s), or any combination thereof, that includes the ability to disconnect from and parallel with the primary source. The back-up interface was designed from the ground up as an integrated MID, intended to reduce installation equipment, labor, and main panel upgrades.

One of the key advantages to this approach is that the microgrid system can be inserted on either the supply side or the load side of the main panel to increase overall load and generation capacity without increasing the main panel size. The following section will show real world approved, installed, and inspected examples of how to avoid main panel upgrades with this approach.

Example 1

An existing 100A combination panel that does not have capacity to support breakers for a 7.6kW PV system (32A), 7kW AC battery (30A), and 7.6kW EV charger (32A). With this configuration, a main panel upgrade is not feasible and may jeopardize the entire project.

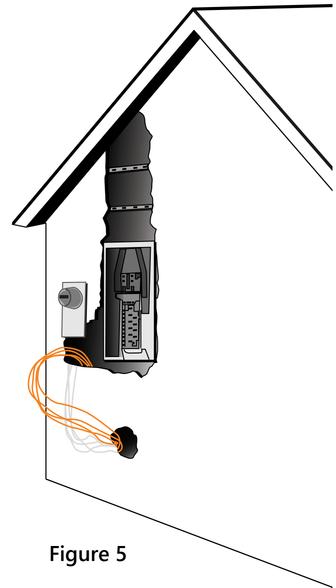

Figure 5

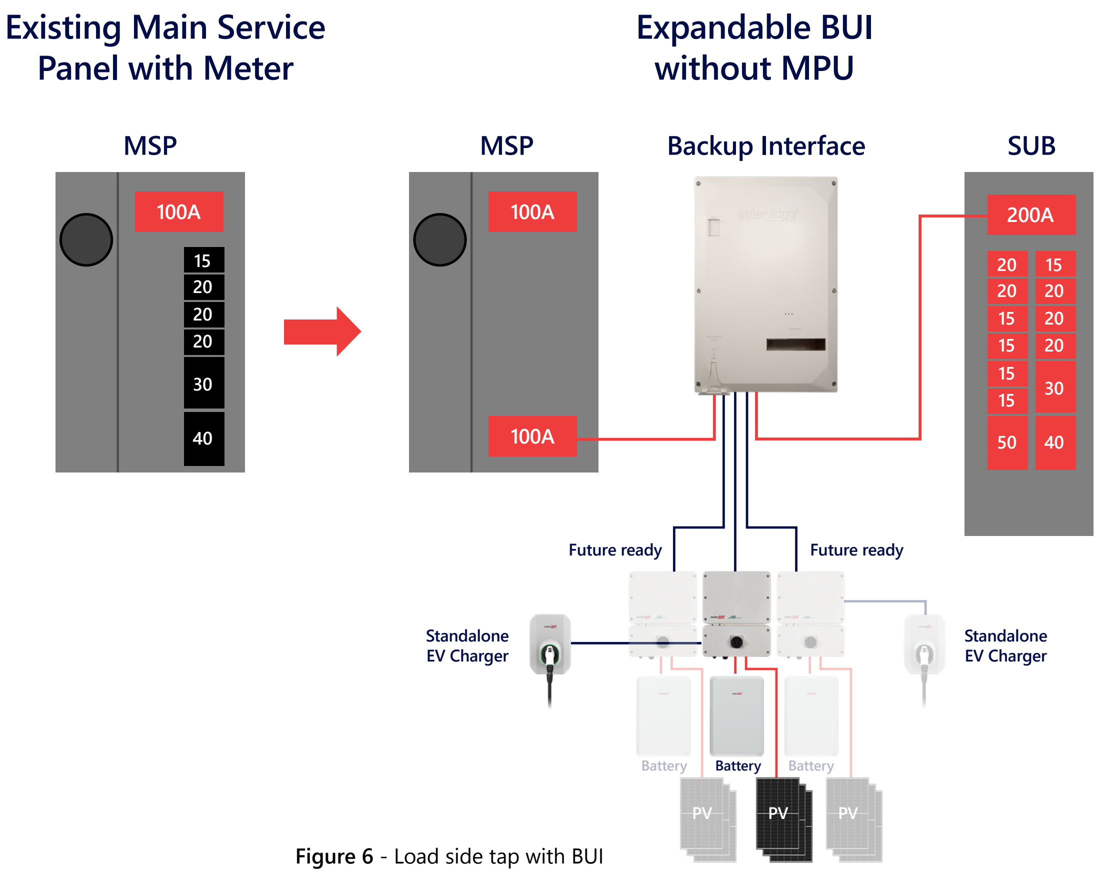

Figure 6 - Load side tap with BUI

Figure 6 shows a robust platform in place that provides the following:

1. Full backup of the entire home via the new sub panel
2. Maximized space in the sub panel by connecting PV, ESS, EVSE circuits to the Energy Hub platform
3. Room for future expansion of PV, ESS, EVSE, and other loads

Note: All equipment does not need to be added on day one. Once the Energy Hub platform is in place, equipment, like ESS or EVSE, can be added as customer needs grow. This also presents a unique opportunity for recurring business with the homeowner.

Example 2

A customer with an existing 200A fully populated main panel wants PV, ESS, EVSE and a whole home backup solution that would trigger a main panel upgrade. In addition, the customer wants to back up selected loads during an outage, but does not want to install a new sub panel as in the example before.

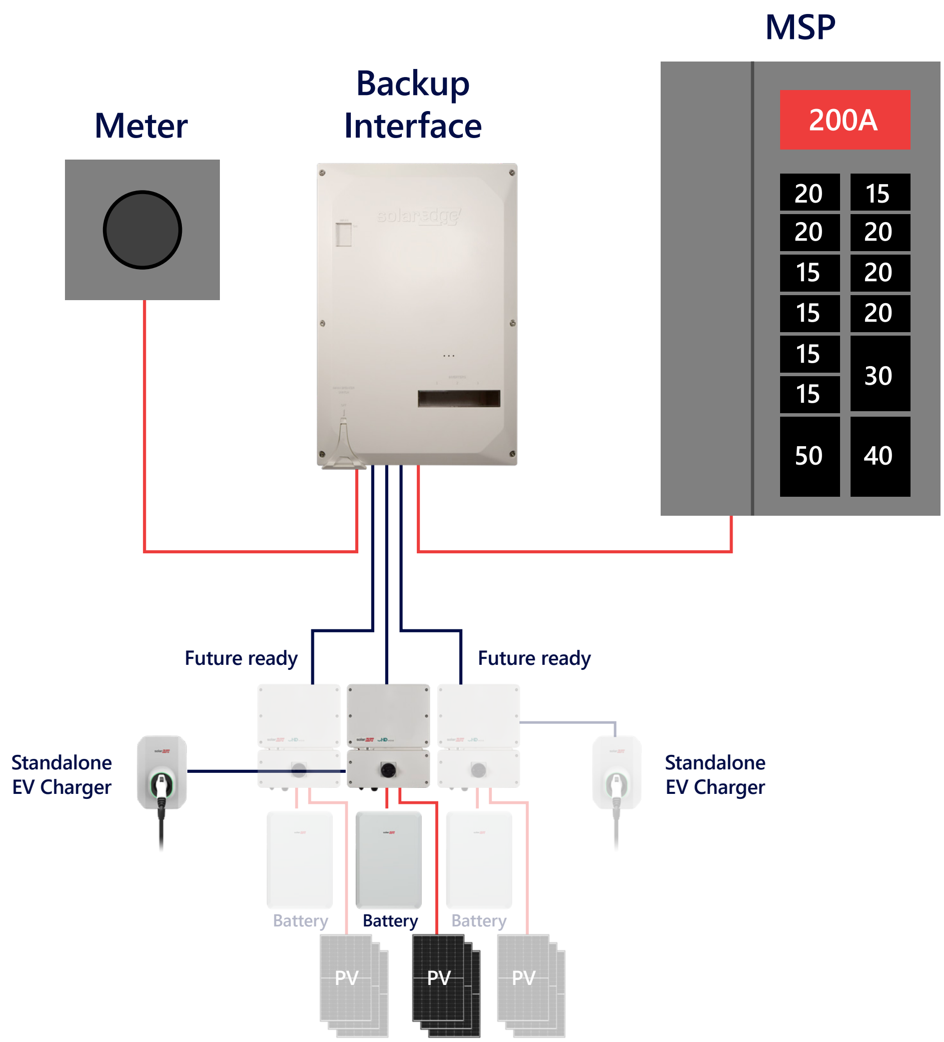

Figure 7

Figure 7 shows a robust platform in place that provides the following:

1. Full backup of the entire home
2. Room for PV, ESS, EVSE circuits using the Energy Hub platform (up to 60kWh backup)
3. Room for future expansion of PV, ESS, EVSE on the Energy Hub platform

Compliance with Codes and Standards

The examples given above are compliant with National Electric Code (NEC) and have been deployed and approved in many jurisdictions throughout the United States. However, it is important to understand how the NEC and equipment standards and listings support these applications.

NEC 2020 705.12 allows for load side connections and B(3)(3) uses the sum of the overcurrent devices to protect the buss bar. In example one above, the load side of the main panel is now protected by a single 100A load/generation breaker. Neither load nor generation may exceed this limit without tripping the breaker, therefore the buss bar is protected. It is important to note that in this scenario there are no other load or generation breakers on the buss bar. In some cases, it may be useful to keep some non-backed up loads on the MSP buss. This is acceptable under NEC. However, those breakers would now need to be considered in B(3)(3) and the 100A breaker in this example would need to be reduced. In both cases, it is imperative to place the field warning signs, required in 705.12 B (3), so that users do not re-locate loads and are aware that panels are fed by multiple sources.

So, how can one use a larger subpanel and add more loads and generation when the main service panel is limited to 100A? NEC 705.12 B(3)(3) does not prohibit a subpanel that is larger than the main panel. The 200A rated subpanel may be fed by multiple sources, as long the buss bar ampacity is not exceeded. In example number one, the load side subpanel can receive up to 100A from the MSP. It could, in theory receive another 100A from the PV, ESS, or EVSE connected to the BUI, without exceeding its ampacity or violating 705.12B(3)(3).

Because the main service panel and subpanel are protected in accordance with NEC, energy derived from multiple sources can be exchanged as needed to suit generation and load profiles safely and reliably. In essence, the buss bar infrastructure has been expanded in compliance with NEC, without a main service panel upgrade.

Example number two shows an installation of the Backup Interface interconnection equipment between the meter box and the main panel. The Backup Interface has been evaluated to UL 869A as service equipment and may be connected directly to the load side of the conductors leaving the service meter. It contains a 200A main breaker and integral disconnecting means that may be used to isolate the home from the service conductors.

In some applications, a load-side tap may involve “tapping the buss bar” or using a lug kit on the main panel buss bar, rather than a breaker to provide a load-side connection to the Backup Interface. In most cases this is acceptable, but only if the main service panel manufacturer supports it. The main service panel’s listing and instructions may require that only approved accessories and lug kits be used in order to maintain the panel’s listing. Going the extra mile to ensure that all NEC sections are met, all warnings signs are applied, and all equipment listings are maintained before inspection time, will help avoid costly delays and rework.

The key takeaways from this paper are:

1. Installers can save time, money and headaches with utilities by avoiding main panel upgrades when possible, with SolarEdge’s smart energy technology design
2. SolarEdge’s smart energy technology is designed from the ground up to eliminate expensive electrical system upgrades
3. This enables the installation of more solar, more energy storage, and future-proofing for more loads
4. Load-side and supply-side connections with listed SolarEdge equipment are NEC compliant and have been widely accepted throughout the market

Household electrification will continue to play a critical role in the way homeowners consume and manage energy. SolarEdge’s smart energy technology is designed to eliminate expensive electrical system upgrades by utilizing existing distribution panels, while enabling more grid services, more PV, more backup power, installation of EV Chargers and other future loads.

Glossary of Terms Used:

- BUI: Backup Interface
- NEC: National Electric Code
- MPU: Main Panel Upgrade
- MID: Microgrid Interconnection Device
- PV: Photovoltaic
- ESS: Energy Storage Systems
- EVSE: Electric Vehicle Supply Equipment
- MDP: Main Distribution Panel
- MSP: Main Service Panel
- MCB: Main Circuit Breaker