DG Interconnection Systems

Interconnection systems are comprised of equipment, protection relays, controls, and programmable settings used to ensure the safe, reliable, and dependable interconnection of a distributed generation (DG) facility to a utility system. The complexity of a DG interconnection system can range from a very simplistic configuration of just a few devices to a sophisticated arrangement of many interacting components and programs.

For small residential-based DG facilities behind the meter, the interconnection systems and their configuration are fairly well-defined and are usually similar from installation to installation. Larger installations, however, require more careful consideration when determining the exact makeup, configuration, and components involved. Of particular importance is defining the exact location of the point of common coupling (PCC), commonly referred to as the point of interconnection (POI), which is the location where the utility and customer facilities meet.

All of the key factors below must be considered with every larger DG interconnection:

1. **Station Service** – Is a separate service desired for any onsite customer electrical loads, or will this be accomplished through the PCC? If the latter, consideration needs to be given to whether this service will be interrupted by needed protection schemes on the utility system such as a direct transfer trip (DTT) scheme tripping a utility-owned protection device installed near the PCC.

2. **Metering** – If service for onsite electrical loads will come through the DG PCC, then the metering needs to be able to maintain accuracy for both the full output of the DG facility and the onsite electrical consumption when the DG is not operating. If the DG facility output is significantly larger than the onsite electrical loads, then more expensive extended range current transformers may be required.

3. **Generator Step-Up (GSU) Transformer** – The winding configuration of the GSU will factor into whether onsite electrical loads can be served through the DG PCC. The DG facility and/or the utility may require a winding configuration for the interconnection that does not easily meet the needs of serving the on-site electrical loads.

4. **Disconnect** – a visible, lockable disconnect device is commonly required for DG interconnections. This device is used by the utility to ensure the DG facility is offline when work is being completed on the utility system. Onsite electrical loads may be interrupted when this device is operated. Typically, this device is also required to be gang operated and rated to interrupt the maximum generator output; however, if a means to drop load/generation via a protection device is available on the utility system, then these requirements may be relaxed, and single-phase disconnect switches may suffice.

Continued on page 2
Value of Solar Primer

The term “value” conveys worth. What is distributed solar photovoltaic (PV) energy worth? This is a question of costs versus benefits. But the question should also include alternatives: Are there other resource options that can provide the same, if not more benefits than distributed solar PV and could do so at a lower cost? And what about utility-scale solar? We should therefore be careful not to give distributed solar PV preferential valuation treatment that is not afforded other resources. Otherwise, what seems to be financially sound decisions could lead to an inefficient, unreliable, or sub-optimal resource mix.

Similar to how utility programs such as demand-side management are valued, the valuation of solar is commonly made using benefits, which are in turn based upon the utility’s avoided costs. The energy produced by a distributed solar PV system is obviously going to allow the utility to avoid having to procure that energy through other means, be it generation or purchase. The energy cost that is avoided therefore creates value. But wherever possible, in identifying and assessing potential avoided cost, the specific situation of the utility and of the fleet of distributed solar PV systems must be considered. If avoided generation capacity cost is to be included as a benefit of distributed solar PV, the analysis must consider the utility’s need for capacity, its load profile versus solar production profile, the resource being avoided, the method for costing the avoided resource, etc. Benefits such as externalities that are not easily quantifiable should not be included in determining utility rates or incentives. Similarly, benefits should generally not include avoidance of costs that are not otherwise directly borne by the utility. For example, although everyone has an interest in a healthy society, electric utilities do not directly incur or recover these types of costs in rates, and so there is nothing to be avoided.

Utilities, regulators, solar developers, consumer advocates, and various other stakeholders are looking closely at the value proposition of solar and, relatedly, at net metering policies. If or when these issues arise at your organization (and if they haven’t, perhaps you should initiate a conversation) it is important to clearly establish your organization’s perspective and strategic objectives, as this colors the lens through which these issues are viewed.

Submitted by Rich Macke – Vice President, Economics, Rates, and Business Planning – macker@powersystem.org

<table>
<thead>
<tr>
<th>Potential Benefits and Costs of Distributed Solar PV</th>
<th>+ Benefit</th>
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<td>Avoided Generation Capacity</td>
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<td>Avoided Transmission Capacity</td>
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<td>Avoided Losses</td>
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Submitted by Jeff Triplett, PE – Utility System Consultant – trippettj@powersystem.org

This article is based in part on assistance PSE provided to the National Rural Electric Cooperative Association (NRECA) in crafting its response to the United States Department of Energy Request for Information concerning Net Benefits and Costs of Distributed Solar Energy. The full comments submitted by NRECA can be found at: http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/NRECA_RFI_Comments.pdf
Distributed solar PV deployments are on the rise at both residences and businesses. The cost of distributed solar PV continues to decline rapidly and government subsidies are making it easier for customers to get on board. The value proposition from the perspective of the individual home owner or business is simple: the potential for a positive return on investment, hedging against future electric price increases, and the environmental rewards of going green.

Currently, solar PV installation levels represent only about two percent of total electricity generated in the United States, but market penetration is trending upward. This growth benefits the distributed solar PV developers but can place new risks on the electric utility and its customer base. For decades, most customers simply looked to their electric utility for power. But now, with solar PV, many customers are being presented with another choice. Solar PV distributors are not just competing for your utility customers’ energy dollars; they are also interested in providing services such as battery storage and home security. Major players such as Google and Apple are getting into the game, launching new initiatives and acquiring substantial technologies and companies in the home energy market.

There are a lot of unknowns at this time, such as the rate impact of EPA’s emission rules, the pace and extent of distributed solar PV cost reductions, the viability of commercialized, mass market battery storage, and others. While some of these industry events are out of a utility’s direct control, it is essential for your organization to identify, assess, and implement strategic initiatives in the areas of customer service, customer wants/needs, customer relationships, staff training, service offerings, rate structures and policies in order to ensure opportunities are pursued to enhance the utility’s value proposition to its customers. One such initiative might be to evaluate the introduction of community solar gardens to provide a cost-effective solar option to customers. Although results are mixed, many utilities are seeing positive results and customer interest in community solar gardens.

These are still the early days of the solar market, and they are also the most pivotal. Is your utility ready?

The valuable experience he gained can be applied to utilities dealing with the rise of distributed solar PV today. Below, Rick offers some insight into these lessons learned.

Your career began at a start-up long-distance carrier in the early 1980s. What was the culture there?

That start-up grew at an incredible pace, becoming the country’s fourth largest long-distance provider. I also worked for a regional fiber optic carrier that faced significant competition. The management culture at both these young companies was fresh, aggressive, market-share focused, and confident. Frankly, we viewed AT&T and the local telephone companies as old-fashioned, with no capability or interest to defend themselves or compete. If you’ve heard from representatives from the big solar companies of today, I think you’d agree that they—like any eager new business—share this similar culture.

Of course, infinitely more important than what a potential competitor thinks of you is how your customers think of you and truly what or who you are as an organization. Organizations that capture the mind of the customer and deliver superior value stand the best chance of success. In some ways this might require us to take a fresh and honest look at our core strategies and how they measure up to future opportunities and threats.

Early in my career, I learned that given the opportunity, customers will make choices based on price and functionality. If we had a better product, we could win some of the competitive battles and we were surprised by the lack of loyalty the customers had to their incumbent phone company.

You also worked at a telephone company monopoly. How was that different?

That’s right; I gained experience on both sides of the coin. I worked for a holding company of about 75 independent rural phone companies with local service territory monopolies. We felt the pressure of competition and dealt with it reactively (rather than proactively) by taking a strong regulatory stance at both the state and federal levels to prevent it.

Eventually, of course, the various regulatory bodies allowed local exchange competition, and even though we had known it was coming and we did our best to prepare for competition, we lost customers. In the rural markets, losing two or three of the largest customers could represent 10% of the revenues for a given
independent phone company. It was challenging to make up those revenues with new services, which at the time included caller ID, caller name, voicemail, and others. With local service competition, in some situations we were completely bypassed by competitors, and we lost nearly all revenue. I would caution that this is much less likely with distributed solar, and complete grid bypass has a much higher hurdle to clear, even with improved battery storage, but electric service revenue erosion of some level is still a real threat.

At the telephone monopoly, we did our best to quickly evolve and add new services, but our culture presented a low tolerance for risk, so in hindsight, we didn’t adopt new services quickly enough. Once the competition entered the market, it was already pulling customers away simply because they offered services the local phone companies didn’t.

What is the lesson learned?

Be proactive and go on the offensive. Keep in mind that it’s not just the face of competition that’s changing, but also the face of the customer. Competition, such as solar PV, empowers customers to be more educated and involved in their energy choices.

Positioning your utility as a future-minded and evolving service organization will ensure that your customers’ needs are being identified and met early. This likely means investing time and money to understand the wants and needs of your customer groups. Practically, it may mean considering the adoption of new technologies and services such as community solar, prepaid metering, energy storage, various forms of home automation, and web portals, or new products such as broadband internet, etc.

Why would an electric utility get into the solar business?

By looking into possible opportunities in the solar PV business, it’s possible that the utility will be better positioned to address grid stability and safety for its customers and employees, as well as capture some of the revenues that would have otherwise been lost. In some cases, it may make sense from an overall power supply portfolio perspective. Solar PV may even offer some utilities opportunities for market expansion by reaching outside their present service area to new geographic areas.

How can a utility stay proactive?

Start by creating a long-range strategic plan for your utility that consist of a variety of future scenarios regarding sales, regulations, market conditions, etc. Identify and potentially test strategic initiatives across the entire organization including the potential of adding new products and services over the planning horizon. Some initiatives may actually turn into actionable items to be implemented and monitored annually. I think that one way to keep the long-range strategic plan fresh is to re-evaluate it every 3-5 years; otherwise, it is too easy to get bogged down by short-term goals and become reactionary.

What’s the risk of waiting?

A utility’s infrastructure remains, even if its customers do not. Even losing a portion of the load for a few larger-load customers, or if as little as five percent of residential customers purchase distributed solar PV, the remaining customers will have to pay the fixed costs of the grid. As these costs are spread over fewer sales, rates will have to increase. If rates are not adjusted in a way that properly reflects the recovery of fixed costs, more customers may find it beneficial to self-supply a portion of their energy needs. This would be a future that is not in anyone’s best interest over the long-term.

Competition is already here. Now is the time to develop a strong plan for action.

Comments or questions regarding the interview?
Feel free to contact Rick Schmidt – Vice President, Utility Automation and Communications – schmidtr@powersystem.org
Most of the time, a transformer is involved in interconnecting a distributed resource (DR) to an electric system. Usually the voltage generated by the DR is lower than that of the utility. This is true of small- or medium-sized systems that are connected to a distribution line, or medium and large systems that are connected to a transmission system. This article will focus on three-phase DR interconnected to distribution systems, although the same basic principles apply to transmission interconnections and also wind farm collector systems.

In choosing a transformer winding configuration for an interconnection, the utility usually favors the transformer model that is kept in stock for ease of replacement, but that model may not be the best fit for the particular installation. Utilities usually prefer the wye-wye winding-configured transformers for distribution systems because they easily integrate with the four-wire distribution systems with a grounded neutral and single-phase loads connected phase-to-neutral. However, this is sometimes not the best arrangement for a three-phase generator if the loads are very unbalanced, as the generator may take on too much of the unbalanced load and trip off at certain times. This should be worked out between the generator owner and the utility.

Having a transformer with a wye high-side winding configuration will match to the utility system, and a delta low-side winding configuration will usually match to the generator, even if the generator has an internal wye connection. The delta connection will improve the balance in load seen by the generator; however, consideration should be made with regard to the installation acting as a grounding bank. A generator having a neutral can be grounded directly or through a resistor, the latter being valuable in limiting the line-to-ground fault current on the low-voltage side.

Having a transformer with a delta connection on the utility side is not recommended when the distribution system is four-wire wye. This is because the opening of a circuit-breaking device on the utility side will cause the line-to-neutral reference voltage to be lost. In this scenario, the neutral can float, subjecting equipment to overvoltages until the anti-islanding relaying operates. The level of overvoltage is particularly magnified for a line-to-ground fault during an islanding event.

In cases where the DR is an inverter, which is common for solar systems, the DR is sometimes three-wire delta. In these installations, a delta winding connection on the DR side of the transformer is recommended. Utilizing a wye-wye transformer would present an unstable neutral when a circuit-breaking device opens up on the utility side, resulting in high-voltage situations until anti-islanding relaying operates. Merely grounding the low-side neutral point on the wye-wye transformer has no effect because the DR source does not find a low-side line-to-neutral reference voltage by merely connecting to ground.

When the transformer cannot provide a needed neutral, a separate grounding bank could be installed. The grounding bank will require its own protection. A similar type of protection is required on the wye side of wye-delta transformers because they too act as grounding banks on the wye side. An engineer should be part of this process from the beginning to ensure that all DR and utility equipment is compatible.

Submitted by Duane Craig, PE – Senior Project Engineer – craigd@powersystem.org

PSE Contributes to Local Communities

Madison Office

Our Madison office participated in a Spring Food Can Drive to support the River Food Pantry. Besides making a monetary donation, our staff donated several boxes of much-needed food to help the Pantry’s clients.

Minnesota Offices

- Last quarter, our Blaine office assisted with a benefit and silent auction to help raise funds for the Drew Macke Foundation. Drew, the 14-year-old son of PSE’s Rich Macke, has a rare medical condition that has required ongoing medical procedures and dozens of surgeries.

- Our Prinsburg office helped to sponsor the 2014 Freedom Run/Walk & Adam’s Race. The annual 4th of July event benefits the Central Minnesota Christian School.