Energy Metering for Electric Vehicle Charging Stations

With the growing popularity of electric vehicles (EV), the need for metering EV charging stations has grown. According to a Wikipedia article, "As of October 2023, there are 69,222 charging stations across the US and Canada."[i] Accurately monitoring energy consumption and power quality calls for the use of advanced energy meters. While a simple energy consumption meter can be used, there are several advantages to using a more advanced energy meter with power quality analysis, especially for certain types of EV charging stations. This paper discusses the advantages of using a high accuracy power and energy meter that can provide data logging and power quality.

EV charging stations allow the driver to "fill up" the EV car's batteries in a similar way to a driver's using a gas pump to fill a traditional vehicle's tank. Since EV charging stations enable the supply of energy, rather than gasoline, there are several specific considerations. There are three levels of charging stations. Level 1 and Level 2 EV charging stations use AC power to charge the vehicle. This is the power that is supplied by the electrical grid. Since the EV car's batteries use DC power only, the vehicle has an AC to DC converter.[ii] Level 3 EV charging stations supply DC power directly to the EV vehicle. In this case, the grid's AC power is converted to DC at the charging station before it is supplied to the vehicle. An advantage to DC charging stations is that the charging process is much quicker; in fact, they are referred to as DCFC - DC fast charging - stations. Since the AC to DC conversion necessitates "more bulky and expensive equipment and requires a high-voltage connection to the power grid," DC power stations generally charge a higher rate.[iii] They need to assure adequate supply from the utility and accurate billing for their energy use. They also need to monitor power quality, as explained in the following sections.

Regardless of the type of power being used to charge the EV, the charging station needs an energy meter to measure the energy consumption of charging the EV. This allows the charging station operator to bill the customer accurately for the energy used to charge their EV. Often, the meter used for Level 1 and Level 2 charging is incorporated into the charger itself. This makes sense both from an economic standpoint and from their relatively simple billing requirements. Level 3 charging stations can benefit from a separate, high accuracy meter that can also supply power quality data. There are multiple reasons for this.

The conversion of the grid's AC current to the EV battery's DC current introduces power quality issues such as damaging harmonic distortion. "High harmonic currents contribute to distribution circuit losses, voltage fluctuations on power distribution networks — and ultimately, faulty EV chargers."[iv] A comprehensive study conducted by the Electric Power Engineering Group at Luleá University of Technology in Skellefteá, Sweden, looked at multiple power quality issues associated with EV charging stations: voltage dips from the grid that can reduce the charging station's efficiency and reduce EV battery life cycles; the potential effect on the grid of multiple charging stations going offline due to undervoltage protection; and fast voltage fluctuations and their effect on flicker; in addition to waveform distortion - harmonics, interharmonics, and supraharmonics due to the charging infrastructure. The study discusses the power quality issues in depth and raises the need for additional information on the effects of EV charging. It also discusses steps to minimize the negative impact on the grid of increasing EV usage.[v]

Installing an advanced power and energy meter with power quality capabilities gives the DCFC charging station operator the ability to monitor the quality of the power coming from the grid and being

transferred to the EV. A meter with programmable alarms can notify the operator of voltage and current sags/surges, low power factor, voltage and current unbalance, and other power quality conditions. This alerts an operator to problems with the charging station or its grid connection, so that timely action can be taken to mitigate the problem. A meter with waveform recording capability allows the charging station operator to analyze power quality events.

A power and energy meter with memory for data logging enables the operator to analyze their charging station's use. This can be helpful in planning for expansion or modifying hours of service. Knowledge of patterns of usage is also essential to long term planning for the electric grid's capacity to meet growing EV usage. California has recently adopted a set of regulations for charging station operators that receive state funding. It requires record keeping for "reporting the uptime of publicly funded charging stations and collecting data to help inform state policy."[vi] In DCFC charging stations that utilize solar panels to supply part of the energy for charging EVs, a submeter can also be used to measure the amount of energy generated, the amount of energy consumed, and the status of the storage batteries.

The power quality revenue accurate meter needs software to manage the metered data and produce required reports, bills, and data for analysis. Either a cloud-based application or a robust energy management software application is needed. A cloud-based application enables charging station operators to access data through any web browser, on any device. A cloud-based energy management system that allows the operator to determine the location of power quality events – whether they are from the utility or from the DCFC charging station, is of great benefit. An energy management application used with meters that support WiFi, cellular communication, or Ethernet can also be used to access metered data and power quality remotely. A high-accuracy, revenue grade meter, with 0.2% or better energy metering accuracy, will ensure that billing both from the utility and to the customer is accurate.

EIG offers a full line of high accuracy, revenue meters with power quality, such as the Shark® 270 cyber secure power and energy meter, which is an ideal choice for metering a Level 3 EV charging station. It has ANSI C12.20 0.1 Accuracy Class energy measurements. Its power quality features include 512 samples per cycle waveform recording, harmonic analysis, and programmable alarms. It has six independent historical logs of 64+ parameters each. It also has an anti-tampering system events log to record actions in the meter, a power quality log that provides timestamped magnitude and duration of up to 2048 events, and an alarms log that records out-of-limit events for up to 16 programmed limits. It offers extensive I/O for control and has multiple communication ports, including an optional underglass Verizon-certified cellular modem card. It is compatible with both the EnergyPQA.com® AI driven cloud-based energy management system and the CommunicatorPQA® energy management software application.

To learn more about the Shark® 270 meter and EIG's software applications, click here.

Notes

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[i] "Charging Station," accessed 1/23/2024 from https://www.wikiwand.com/en/Charging_station
[ii] "EV Charging: the difference between AC and DC, accessed 1/23/2024 from https://blog.evbox.com/difference-between-ac-and-dc#:~:text=When%20it%20comes%20to%20electric,is%20used%20for%20fast%20charging.
[iii] *ibid*

[iv] "Power Quality: the First Mile in EV Charging," Powerside, accessed 1/23/2024 from https://powerside.com/wp-content/uploads/2024/01/Power-Quality-The-First-Mile-in-EV-Charging.pdf
[v] "Impact of Electrical Charging on the Power Grid," Shimi Sudha Letha and Math Bollen, Luleá University of Technology, accessed 1/23/2024 from www.diva-portal.org/smash/get/diva2:1530550/FULLTEXT02.pdf
[vi] "Electrical Vehicle Charging Infrastructure Reliability reporting and Data Standards," California Energy Commission, accessed 1/23/2024 from https://www.energy.ca.gov/proceedings/active-proceedings/electric-vehicle-charging-infrastructure-reliability-reporting-and