The Combination of Electric Vehicle Energy Supply and the Application of Distribution Energy Resource in IEC 61850

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1. Research Background

In response to achieving net-zero emissions and energy transition, countries around the world are actively promoting the electrification of transportation. In addition to the share of electric vehicles, the construction of electric vehicle energy supply infrastructure is also a key aspect of vehicle electrification. To achieve a flexible energy supply, charging stations must have two capabilities. One is to control the energy supply of the equipment, and the other one is to communicate with the grid or aggregators to understand the real-time status and needs of the grid and assist in alleviating the pressure on the feeders. This study focuses on how to establish a standardized communication framework for information exchange between charging stations and the distribution grid.

2. Research Content

The general electric vehicle energy supply architecture is shown in Figure 1, which consists of two parts: electric power supply and market. At the lowest level, we have Electric Vehicle (EV) and Electric Vehicle Supply Equipment (EVSE). The information exchange between these two can be categorized into AC and DC charging. DC charging requires more information exchange than AC charging. In the future, there may also be a bidirectional energy supply, i.e., V2X. The communication between the Charging Point Operator (CPO) and EVSE refers to controlling the equipment's energy supply. The communication standards for this part usually use OCPP (Open Charge Point Protocol), and IEC has established IEC 63110 for this purpose. The green section represents roaming communication for the market. Taiwan has not established a global roaming system, though many manufacturers have attempted to do so. The red block represents the Distributed System Operator (DSO) with which the CPO needs to exchange information. There is no specific communication protocol for electric vehicle power supply here. Still, it can be referred to the information exchange for distributed energy, such as IEEE 2030.5 or SunSpec in the United States, IEC 61850 in Europe, and DNP 3 and IEC 61850 in Taiwan.

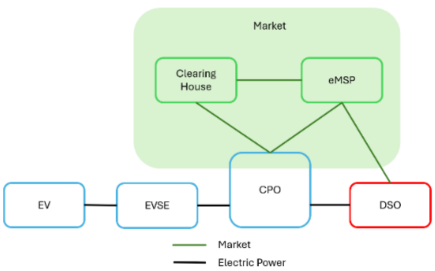

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Figure. 1 The Architecture of the electric vehicle energy supply

The full name of IEC 61850 is “Communication Networks and Systems for Power Utility Automation,” initially developed by TC 57 of the International Electrotechnical Commission (IEC) in 2001. The first version focused on communication and networking requirements within substations and was gradually expanded to cover the entire power system, including the upstream power plants and the distributed energy resources or loads at the end of the power grid. One of the key aspects of IEC 61850 is the definition of the parameters name used within the power system to ensure that devices from different manufacturers can exchange data without the need for a point table. IEC 61850-7-420[1] compiles past technical reports and defines related logical nodes for distributed energy resources, aiming for consistent information exchange while integrating distributed energy into the grid.

To implement a data model for the charging station in IEC 61850, it is necessary to understand the functions required by the power grid. According to IEC 63110[2], the communication use case between the CPO and the upper-level control system includes eight types, namely: smart charging management, charging with demand response, information exchange at the initiative of the CPO or control systems, power variation triggered by DSO, actors’ relations during a V2G session, information exchange required to ensure a dynamic energy transfer control, providing frequency regulation service through decentralized frequency measurements. The main types of information exchanged can be divided into three categories: static power and energy limits, Power Range Envelope (PRE), and Aggregated Energy Transfer Plan (AETP).

Static power and energy limits refer to the charging station's rated values, which the control systems use to establish the PRE. As shown in Table 1, these can be defined using the DSTO logical node for energy storage in IEC 61850-7-420.

PRE refers to the power limits for the charging station over time, which control systems determine. In IEC 61850, it can be described using scheduling logical nodes FSCH, FSCC, and the maximum charging and discharging power in DSTO, as shown in Tables 2, 3, and 4.

Table 1 The data objects used in DSTO for static power and energy limits

Data Object	Description
ChaWMaxRtg	Rated maximum charging power
DschWMaxRtg	Rated maximum discharging power
ChaWRmpRtg	Rated maximum charging power change rate
DschWRmpRtg	Rated maximum discharging power change rate
WhRtg	Rated battery capacity (Wh)
WhMaxRtg	Rated maximum storage capacity (Wh)
WhMinRtg	Rated minimum storage capacity (Wh)

Source: Made by authors

Table 2 The data objects used in DSTO for PRE

Data Object	Description
ChaWMax	Maximum charging power
DschWMax	Maximum discharging power

Source: Made by authors

Table 3 The data objects used in FSCH for PRE

Data Object	Description
ValMV	Value to be output for each entry
NumEntr	Number of scheduling entry
SchdIntv	Duration of each scheduling entry
StrTm	Start time of the schedule

Source: Made by authors

Table 4 The data objects used in FSCC for PRE

Data Object	Description
CtlEnt	Data object corresponding to the schedule

Source: Made by authors

AETP refers to the final overall charging profile determined by the charging station after receiving the PRE. Its description is similar to PRE but includes data objects indicating the scheduling targets, as shown in Table 5.

3. Conclusion

This study proposes a potential method and data model for information exchange between charging stations and control systems and maps them to the IEC 61850 logical nodes used by a smart grid of Taiwan Power Company. The control systems may refer to the distribution management system of Taiwan Power Company or an energy aggregator for power trading, which then transmits the data to the Taiwan Power system. However, the content of the data exchange is similar in the two cases. In the future, this study plans to use this communication architecture to build a data collection platform, connecting it with real sites to validate the feasibility of the proposed architecture.

Table 5 The data objects used in DSTO for AETP

Data Object	Description
WSpt	Power set points

Source: Made by authors

4. Reference

[1] IEC 61850-7-420: 2021, Communication networks and systems for power utility automation– Part 7-420: Basic communication structure– Distributed energy resources logical nodes.

[2] IEC 63110-1: 2022, Protocol for management of electric vehicles charging and discharging infrastructures– Part 1: Basic definitions, use cases and architectures.