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Design of Open Framework Based Smart ESS Profile for PV-ESS and UPS-ESS

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***Abstract*—**In this paper, an open framework based smart energy storage system (ESS) profile for photovoltaic (PV)-ESS and uninterruptible power supply (UPS)-ESS is proposed and designed. An open framework based smart ESS is designed and developed for unifying the different interfaces among manufacturers. The smart ESS operates under the profile which provides the specifications of peripheral devices such as different interfaces and to the open framework. The profile requires well systemicity and expandability for addible peripheral devices. Especially, the smart ESS should provide the expansion with existing systems such as UPS and the linkage with new renewable energy technology such as PV. This paper proposes and designs an open framework based smart ESS profile for PV-ESS and UPS-ESS. The designed profile provides the existing smart ESS and also the expandability of additional peripheral devices on smart ESS such as PV and UPS.

***Keywords*—**ESS, open framework, profile, PV, UPS.

I. Introduction

AS the industrialization has grown rapidly in worldwide, the energy paradigm has changed to solve the electric power shortage phenomenon repeatedly and the unstable electric power supply phenomenon due to the deterioration of electric power facilities [1]. As illustrated in Fig. 1, the energy paradigm has changed from focus on supply to demand management.

New renewable energy technology such as wind power and water power has gotten the spotlight to supply extra the electric power on the overdemand, however, as the new renewable energy technology has the constraint implementation environment characteristic, the supply is unstable. In addition, both the supply and the consumption come at the same time. For those reasons, the interest of the large capacity battery such as ESS has increased and the study and development have been conducted [2], [3]. ESS is one of the solutions for electric power supply problems. It stores electric power when the power is supplied smoothly, so that the stored power can be used in case of electric power shortage.

In Korea, as the electrical grid is centralized control system, the supply grid to the central area is saturation now [4]. The overloaded supply grid to the central area has many problems. To solve this, the distributed electrical grid is proposed as illustrated in Fig. 2. The distributed electrical grid consists of the supply grid from centralized control system, ESS, and new renewable energy system. The distributed electrical grid is appropriate for unstable new renewable energy supply, prevention on the peak demand, and the sudden power outage. It provides the stable and efficient electric power supply and demand.

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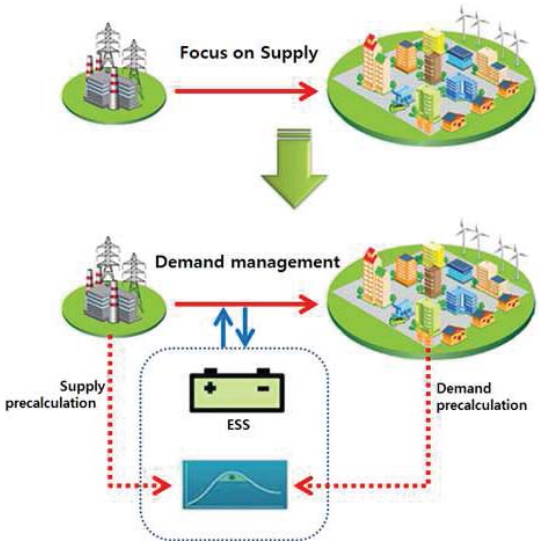

Fig. 1 Change of energy paradigm

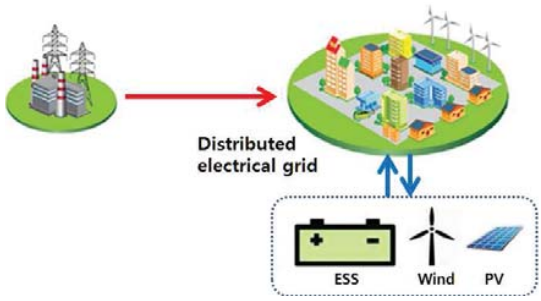

Fig. 2 Distributed electrical grid

ESS is the main key on the distributed electrical grid. However, as the standardization of the ESS compositions and interfaces among the peripheral devices has not been established, it faces many difficulties for users to set up and operate the ESS on the demands of users. Users must use fixed or specific devices to compose and expand the ESS or, the users have to conduct the additional implementation development such as embedded software (SW) about interfaces and operating applications.

In this paper, an open framework based smart ESS profile for PV-ESS and UPS-ESS is proposed and designed. The smart ESS is proposed for unifying the different interfaces among various manufacturers. The profile is designed by extensible mark-up language (XML) and to support not only peripheral devices such as smart meter, network interfaces, and battery racks but also added PV and UPS on smart ESS.

II. Overview

This section shows the existing ESS and open framework based smart ESS.

A. Energy Storage System

In worldwide, a study and development of ESS are conducted for stable electric power supply and efficient management of electric power. Many nations propose the ESS encouraging policies. In Japan, for example, the ESS for emergency electric power in case of nuclear accident and earthquake has been popularized and a government subsidy has been paid.

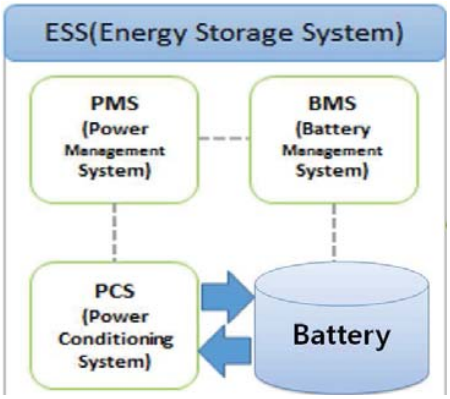

Fig. 3 Structure of general ESS

ESS consists of power conditioning system (PCS), power management system (PMS), battery management system (BMS), and other peripheral devices normally. Fig. 3 shows the structure of general ESS. Battery consists of several racks such as battery cells to store the electric power. BMS controls the battery. PCS and PMS to control the influx of the electric power.

The problem of general ESS is that there are no rules and standardizations about the interfaces of inside and outside devices. As a result, users must use fixed or specific devices to compose and expand the ESS. On the other hand, the users have to conduct the additional implementation development such as embedded software (SW) about interfaces and operating applications. Fig. 4 shows the interface and additional development problems of the general ESS.

B. Open Framework Based Smart Energy Storage System

Open framework based smart ESS is to unify the various ESS operating technologies depending on the manufacturers

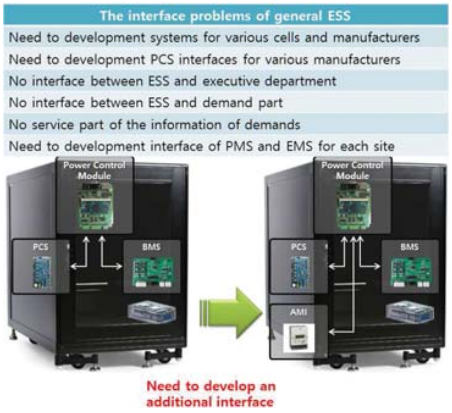

Fig. 4 Interface and additional development problems of the general ESS

and control the ESS even if the ESS consists of various interface devices.

The open framework for smart ESS provides the compatibility among the various smart ESS and the standardization interface for different device interfaces depending on the manufacturers. Fig. 5 shows the structure of open framework based smart ESS.

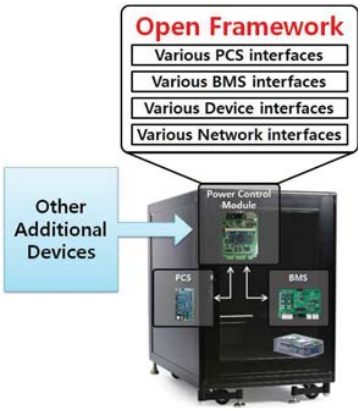

Fig. 5 Structure of open framework based smart ESS

The open framework consists of PCS adaptor, BMS adaptor, peripheral device adaptor, network adaptor, and ESS controller. Each PCS, BMS, and peripheral device adaptor provides various interfaces and The ESS controller communicates the other outside devices such as monitoring device with open application program interface (API).

III. Design

This section proposes a design of open framework based smart ESS profile for PV-ESS and UPS-ESS. Open framework based smart ESS can not handle the different interface devices automatically. For this reason, a XML based profile is proposed [5]. The XML based profile contains the information of the interfaces of devices composing a smart ESS and device specifications. As shown in Table I, the profile consists of four parts.

TABLE I
STRUCTURE OF THE SMART ESS PROFILE

Profile	Contents
System	System identification, user information, subsystem information
PCS	PCS identification, PCS specification, protection information, communication parameter
BMS	BMS identification, rack information, communication parameter
Device	Additional peripheral devices information and communication parameter

TABLE II
XML TAG FOR SYSTEM PROFILE

SYSTEM_IDENTITY
.....
/SYSTEM_IDENTITY
CONSUMER_INFO
.....
/CONSUMER_INFO
SUBSYSTEM_ID
.....
/SUBSYSTEM_ID

TABLE III
XML TAG FOR PCS PROFILE

IDENTITY
.....
/IDENTITY
SPECIFICATION
.....
/SPECIFICATION
PROTECTION
.....
/PROTECTION
COMMUNICATION_PARAM
.....
/COMMUNICATION_PARAM

TABLE IV
XML TAG FOR BMS PROFILE

IDENTITY
.....
/IDENTITY
RACK_INFO
.....
/RACK_INFO
.....
RACK_INFO
.....
/RACK_INFO
COMMUNICATION_PARAM
.....
/COMMUNICATION_PARAM

TABLE V
XML TAG FOR DEVICE PROFILE

METER_DEVICE
.....
/METER_DEVICE
SENSOR_DEVICE
.....
/SENSOR_DEVICE
.....
XXX_DEVICE
.....
/XXX_DEVICE
.....

TABLE VI
ADDIBLE XML TAGS FOR PV-ESS

Profile	Contents
System	SUBSYSTEM_ID
PCS	SPECIFICATION, COMMUNICATIOIN_PARAM
BMS	COMMUNICATION_PARAM, PV_INFO
Device	PV_DEVICE

TABLE VII
ADDIBLE XML TAGS FOR UPS-ESS

Profile	Contents
System	SUBSYSTEM_ID
PCS	SPECIFICATION, COMMUNICATIOIN_PARAM
Device	UPS_DEVICE

System profile consists of the smart ESS composition information and interworking information with energy management system (EMS) and total operating center (TOC). Table II shows the XML tag for system profile. PCS profile contains the PCS identification, PCS specification, protection information, and PCS communication parameter. Table III shows the XML tag for PCS profile. BMS profile is with the rack information of battery and cell information, and BMS communication parameter. Table IV shows the XML tag for BMS profile. Device profile consists of additional peripheral devices information and communication parameter. Table V shows the XML tag for device profile.

A. Open Framework Based Smart ESS Profile for PV-ESS

PV is an electric power charging system basically. To expand the smart ESS with PV, PV-ESS has an effect on system, PCS, BMS, device profiles. Table VI shows the additional XML tags for PV-ESS.

B. Open Framework Based Smart ESS Profile for UPS-ESS

UPS is a popularized system instead of ESS typically. To expand the smart ESS with UPS, UPS-ESS has the concept of main-sub. The smart ESS would be a main and the UPS would be a sub. UPS-ESS has an effect on system, PCS, device profile. Table VII shows the additional XML tag for UPS-ESS.

IV. CONCLUSION

In this paper, an open framework based smart ESS profile for PV-ESS and UPS-ESS is proposed and designed. It is expected that the implementation of PV-ESS and UPS-ESS profile would be conducted and the implementation results would contribute to the development of smart ESS.

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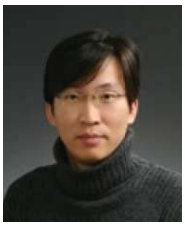

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