

Design of a prosumer EMS for energy trading

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Abstract. We design a DER management system for energy trading based on OASIS EI and EMIX. With the spread of DERs, there is a growing need of a system for integrated management of DERs and customer loads. In this paper, we give a brief overview of a DER EMS for prosumer energy saving and trading. Based on the OASIS standards, we design a functional architecture of a DER EMS for energy trading. After showing communication protocols and operation sequences, we summarize our works.

1. Introduction

In recent years, there has been considerable interest in global warming. Many countries have introduced clean energy resources to reduce CO₂ emissions. However, the risk of investment in renewable energy generation facilities still exists. Thus, some countries are considering policies that mitigate the risk through government subsidies. The reduced investment cost of a Distributed Energy Resource (DER) is one of the reasons for the rapid proliferation of DERs. Low-cost DERs are attracting energy consumers to take an interest in power generation. It makes energy consumers require an advanced system that performs energy trading as well as peak demand reduction [1][2][3]. The existing Energy Management System (EMS) reduces the peak load of its customer. For that, it predicts power consumption patterns after measuring its customer's energy usage. It also schedules DER operations to reduce peak load based on the predicted data. Emerging energy prosumers require an EMS that performs DER integration and energy trading. Such a DER EMS should be able to control power generation facilities as well as customer loads. It should also be able to trade surplus energy stored in an Energy Storage System (ESS) through an energy market. Considering the requirements, we design a DER EMS system. It features the integrated management of energy generation, consumption, storing, and trading.

2. Related works

There has been a growing interest in power saving as well as generation. Demand Response (DR) programs for peak load shaving are divided into two categories: price based programs and incentive based. In the former, participants voluntarily reduce power consumption when the price is high. In the latter, available power reduction capacity is set in advance. Then, the power reduction is carried out according to the DR contract conditions. If DR participants fail to reduce the contracted peak load, penalties could be imposed on them. Otherwise, incentives would be given. Energy consumers could earn extra income by receiving incentives compensated for power reduction. They also could receive a capacity payment in return for keeping energy resources capable of responding to a DR request. OASIS standardized communication protocols between a DR market and market participants [4][5]. High volatility and low-reliability of DERs could lead to low profitability. The lack of a user's expertise could make it difficult to maintain DER facilities. To deal with that, a brokerage transaction



model for DER aggregation has been proposed. In this model, a resource broker collects its customer's energy resource information. It sets an optimal DER groups and sells the power aggregated from them on behalf of its customer through an energy market. Also, the system provides a function to settle sales revenue and commission based on the collected power metering data [6].

OASIS standardized the EI, EMIX, and WS-calendar specification for energy transaction services. EMIX defines energy products and specifies contract conditions between market participants. It also provides the information model for scheduling DER operations based on WS-Calendar [7]. EI defines various service interfaces for energy trading among power market participants. It also defines service descriptions for energy market participation, bidding, and trading [8]. Based on the OASIS standards, we design an energy sharing and trading system for energy prosumers.

3. Design of a prosumer EMS for energy trading

With the introduction of DERs, the number of energy consumers as a role of prosumer is increasing. Energy prosumers can reduce the maximum peak load through DER integration. They can also take a profit by selling surplus electricity to electric power markets.

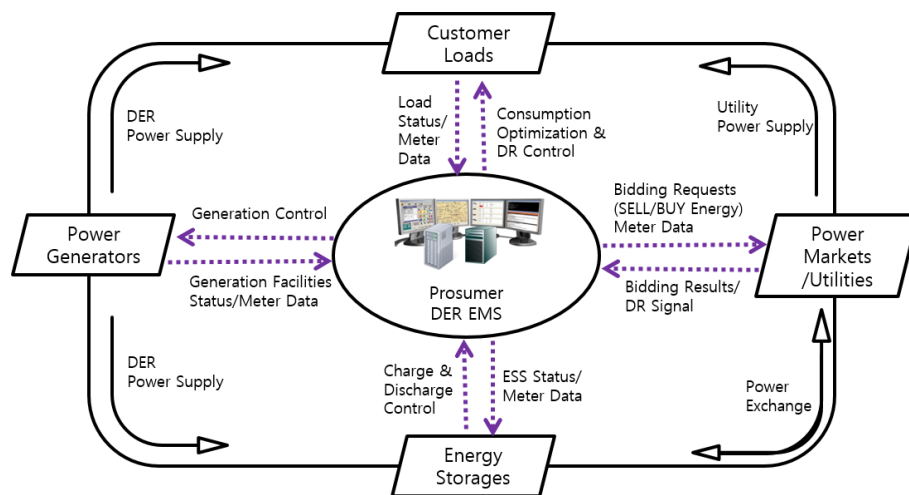


Figure 1. Overview of a Prosumer EMS for Energy Trading

Figure 1 shows a prosumer DER EMS for energy trading. It provides communication interfaces for connection to DERs, customer loads, and energy markets. Through the interfaces, it monitors power generation and transmits operation schedules to DERs. The power generated by the DERs is used to reduce peak power demand. The surplus power is stored in an energy storage system (ESS). Market participants can ask for auction bidding for the stored surplus power. Once receiving the bid result, the ESS is scheduled for discharge. The DER EMS measures the amount of power supplied to a power grid, and vice versa for processing revenue settlement.

3.1. System functional architecture

Depending on the type of the managed DER and loads, the DER EMS requires various subsystems. Figure 2 shows the configuration of a DER EMS for managing solar panels, ESSs, and customer loads. The configuration includes a consumer EMS, a Meter Data Management System (MDMS), and a Power Management System (PMS). The EMS manages power demand and supply in its management domain. It purchases electricity from energy markets when energy supply is insufficient. When surplus energy exists, it sells it through the markets. To do this, It collects the status of power generation and load facilities through an EMS Gateway. It also enables consumers to take part in an energy market.

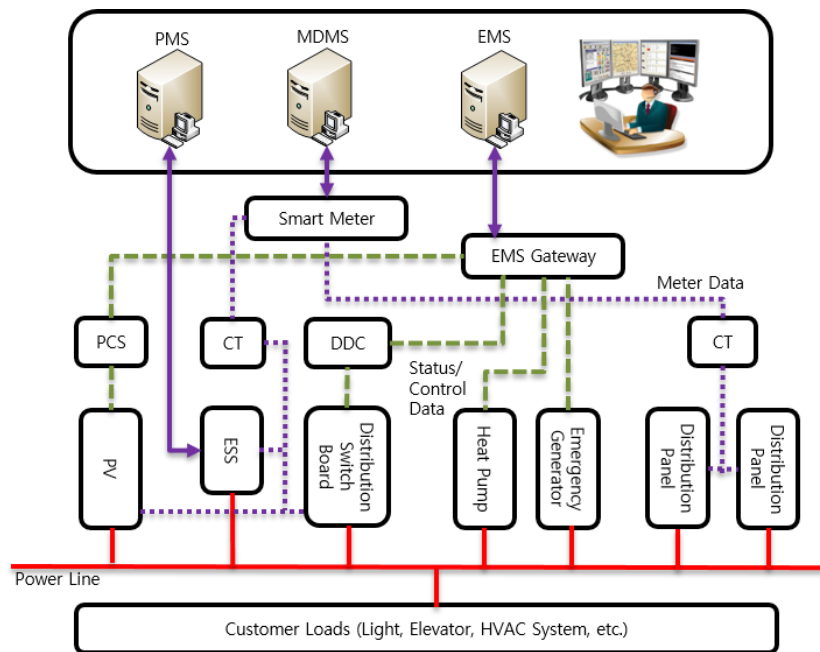


Figure 2. An Example of a Prosumer EMS

Considering the system components presented in Figure 2, we propose a three-layered DER EMS architecture as shown in Figure 3. First, the communication layer includes the SEP handler and the EI handler. The SEP handler performs protocol conversion from legacy protocols to SEP or vice versa. Through the SEP handler, legacy devices information is delivered to the core service layer. The EI handler supports OpenADR service interfaces [9]. Through the interfaces, it processes DR event signals from the DR management system (DRMS). It also provides reporting service interfaces for transmission of power metering data. The EI service interfaces are based on the EMIX model for party registration, bidding, and transaction.

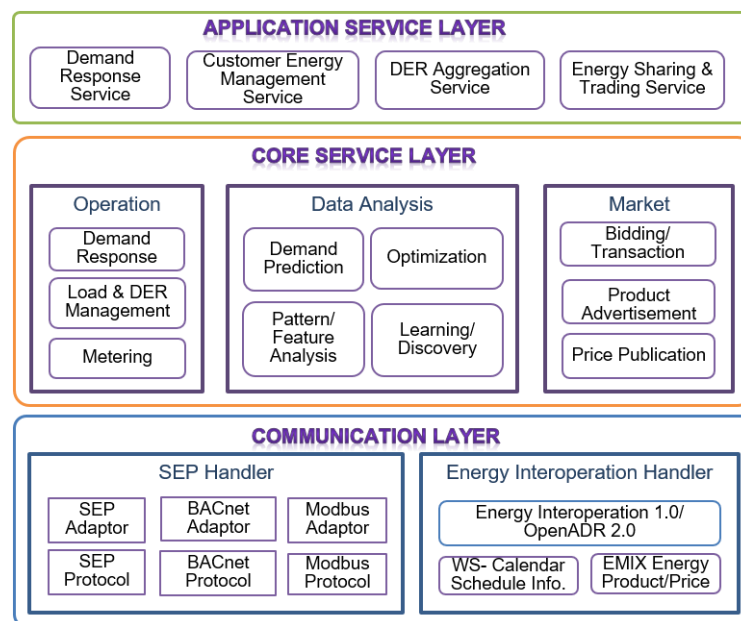


Figure 3. System Functional Architecture

The core service layer includes essential functions for DER operation and energy trading. With the measured data, energy consumption patterns are calculated. It is used to optimize DER operations. The layer supports functions for energy price announcement, product advertisement, and contract management. The application service layer provides specific features for DR and DER services.

3.2. Communication protocols

The DER EMS interconnects with various prosumer devices through the protocols depicted in Figure 4. OpenADR is applied as service interfaces for DR event and meter data handling. The designed system supports service interfaces with electricity markets for energy trading. It provides functions to enroll energy resources and to make a contract based on EI and EMIX. The DRMS and the DER market are operated as a Virtual Top Node (VTN) and the prosumer DER EMS as a Virtual End Node (VEN). The designed EMS supports the SEP protocol for integration of DERs, loads, and ESSs. It also supports SEP protocol conversion for legacy devices through a SEP gateway. The DER EMS functions as a SEP server, and the SEP gateway as a SEP client.

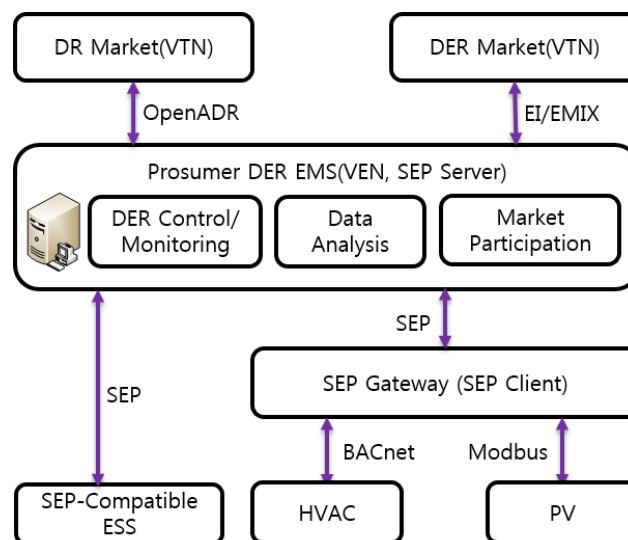


Figure 4. Communication Protocols between System Components

3.3. Interaction between prosumer EMS and energy market

The VENs as a prosumer DER EMS take part in an energy market and register their energy resources in the market system. Among the registered VENs, the EMS acting as a seller creates a bid for sale of energy generated from the registered DERs. If the bid is approved, the market system sends the bid to VENs registered. Then, the EMSs acting as a buyer take part in the bid. Winning bidder finally confirms transaction for the bid. The winner's EMS updates its DER programs and end device control information according to the contract condition. The DER operation schedule is confirmed through the bidding. If the controlled DERs do not support SEP, a SEP gateway receives the DER operation schedules from the EMS on behalf of them. It controls the SEP-incompatible DERs only supporting legacy communication interfaces through protocol conversion.

4. Conclusion

We designed a prosumer DER EMS based on the OASIS EI specification. It features the integrated management of energy generation, consumption, storing, and trading. The designed system consists of 3 layers: communication, core service, and application. Each layer provides several functions for DER integration and energy trading. Based on the architecture, we explained system components and communication protocols. Last, we described operation sequences for DER integration and energy trading in detail.

5. References

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Acknowledgments

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning(KETEP) and the Ministry of Trade, Industry & Energy(MOTIE) of the Republic of Korea (No. 20161210200310).