BLOCK-CHAIN BASED ELECTRICITY POWER TRADING SYSTEM MECHANISMS AND OPERATING METHODS

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ABSTRACT

With a variety of distributed resources appearing in the power industry, the needs for many small power transactions are increasing. Many of these small quantities of electricity trading are not suitable for intermediating on the power exchange. However, operators that want to participate in power trading with such small distributed resources also want to trade their power through reliable systems and power trading intermediaries. For this reason, this paper presents examples of system development and demonstration where a number of disparate players can transact power through a trusted technology, block-chain.

I. INTRODUCTION

Nowadays, small scale power trading using DERs(distributed energy resources) such as renewable energy and EV(electric vehicle) is actively being done. So there are many small power generation companies include energy prosumer and EV charging service providers. These operators want to trade securely in electricity market. Therefore, a reliable and convenient security system is needed.

Blockchain is a technology that can meet these requirements. The definition of a blockchain is as ; High reliability for digital assets and data, processing distributed digital ledger on P2P(Peer-to-Peer) network rather than server of particular organization, new data structure technology (Frost & Sullivan).

This proposed technology in KEPCO utilizes the blockchain technology that is transparent and reliable in trading with electricity energy through distributed energy resources including renewable generators and energy storage systems, electric vehicles. This technology will be applicable to distributed energy transactions and virtual power plant, regulations for use of new distribution networks worldwide in the future.

KEPCO has already established an energy trading demonstration site in the company(KEPCO Human Resources Development Institute) to carry out actual verification. This paper is to propose a model for small-scale electricity trading for KEPCO and energy prosumer using blockchain technology.

II. BLOCK CHAIN BASED POWER TRADING MODELS AND TRADING PROCEDURES

The block chain-based power trading model that will be introduced in this paper is three models: electricity trading between commercial buildings, electricity trading between households, EV charging charge transactions.

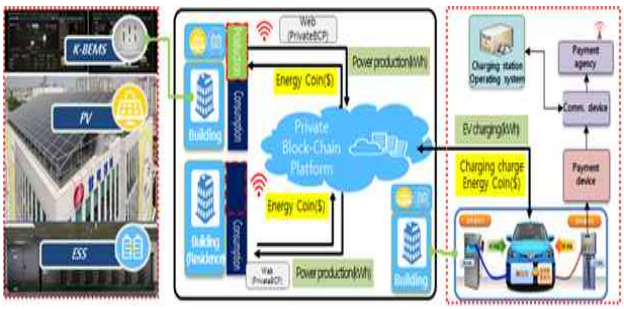

Figure 1. Building energy transaction & Charging EV using Block-chain

Power trading between buildings is a model of power trading between prosumers that sells surplus power from their distributed energy resources in building to neighboring buildings. In this paper, pilot projects were carried out for building-to-building(KEPCO buildings) electricity transactions and home-to-home(apartment) power transactions. As a result, prosumers who sell electricity can expect higher profits, and consumers who purchase electricity can save electricity costs by avoiding progressive fees.

In case of EV charging model, it is a model that has demonstrated charging service conveniently and reliably through blockchain without a need for credit card (financial fees) by applying blockchain payment function to existing EV rapid and slow chargers resceptively.

In this project, these three power trading models were developed by adopting Etherium. The representative block chain open sources are Bitcoin, Hyper Ledger, and Etherium. However, Etherium is used to use open source which has reliable operation and processing speed suitable for power trading service.

The following figure is a conceptual diagram of the block-chain based power trading proposed in this paper.

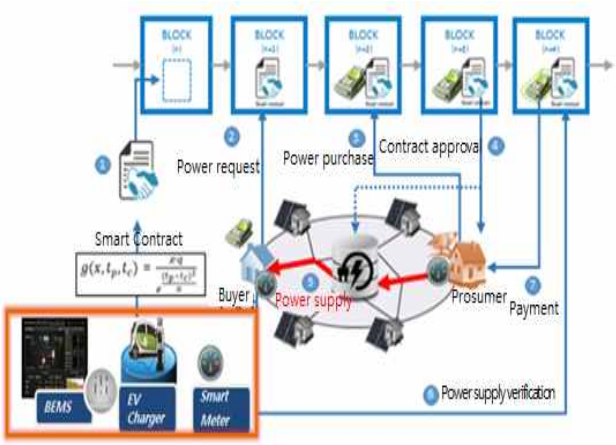

Figure 2. Block-chain based energy transaction procedure

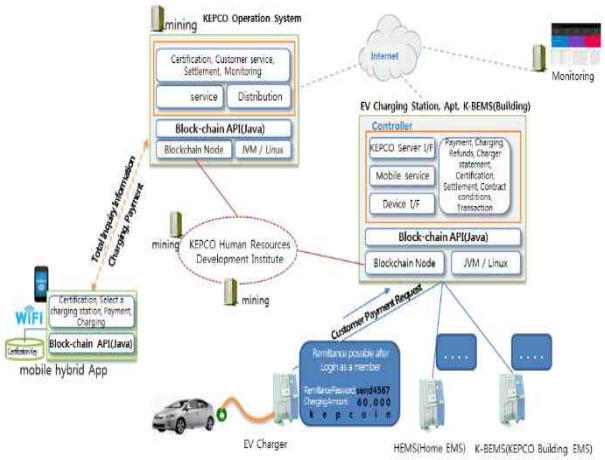

Figure 3. Node configuration for block-chain demonstration

As a small power generator and consumer with distributed energy resources, prosumer is able to sell its surplus power to its neighbors. In case of EV, electric power can be purchased from EV charging company. What is needed to proceed with these power transactions in a blockchain environment is the node that participates in the power transaction in the blockchain and the trading environment (such as device, program or system) of the entity that wants to sell or purchase power.

As shown above, the block-chain based power procedure through nodes with the functions to sell and purchase power is as follows. 1. The willingness of participants to trade power is entered into the smart contract of the block chain. 2. information to purchase power and 3. through the information to sell electricity, it is possible to identify the transactions that satisfy the power trading intention condition of each participant 3. the contract is approved. Based on the approved contract, 5. the electric power seller supplies electric power, 6. and if the electric power consumer confirms that the purchased electric power is supplied, 7. the final payment is made. Any changes to the power transaction process through the above blockchain can be identified by all consensus nodes within the block chain.

III. ELECTRICITY TRADING ENVIRONMENT

The power trading environment using the block - chain network was developed through the turing open language provided by Etherium to enable Etherium - based P2P energy trading. Through this language, we created smart contracts and distributed applications suitable for P2P energy trading, and created arbitrary rules on ownership, transaction formats, and state transformation functions.

The node configuration of the blockchain platform for power transactions is shown above. A static configuration file is applied for interworking between block chain nodes. Using the Local RPC method, three smart devices developed with a software programs and hardware system for demonstration operation were installed with only general nodes not performing mining. The nodes that perform mining are the KEPCO operating system, EV charging station, and KEPCO human resources development center.

In this paper, Smart Devices, which are participant nodes of participant in power trading, are k-BEMS for KEPCO building, HEMS for home, and fast-charger and slow charger for EV. That is, the electricity trading between the buildings and the electricity trading between the houses were developed by adding the electricity purchase function and the electric power sale function utilizing the installed energy operation system of each building.

A prosumer who sells electric power can input the amount of surplus power that is expected to be sold, and a consumer who wants to buy electricity can input the intention to buy electricity to purchase.

Figure 4. Power sales screen and trade entry window in k-BEMS

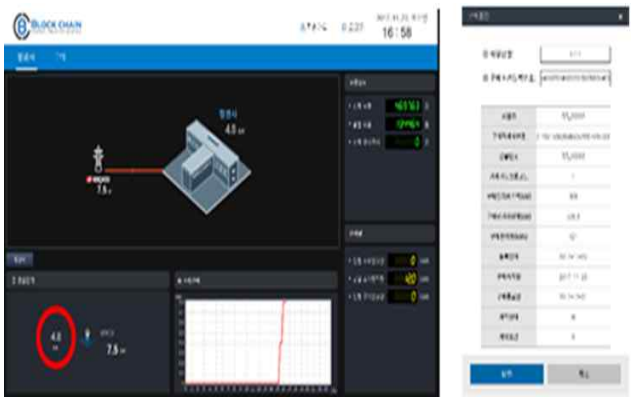

Figure 5. Power purchase screen and trade entry window in k-BEMS

In the case of EV charging system, the existing rapid EV charger and slow EV charger were developed by adding a function to charge electric power through a block chain.

Figure 6. Rapid(left) & Slow(Right) Charger with block-chain function

Like the existing EV charging environment, after connecting the charging cable to the vehicle, member certification is performed through the block chain log-in function of the charger. When the certification is completed, the amount to be charged is input. When the charging is completed, the settlement is completed.

IV. ELECTRICITY TRADING INTERMEDIATION METHOD

In a block-chain network environment, the person who wants to buy electric power and the person who wants to sell electric power can trade through the smart device for each environment. However, whether it is a transaction between buildings or EV charging transaction, each needs a place where it can meet in order to conduct a transaction. In this paper, we developed a system for integrated operation and management of power transactions so that each participant could gather their willingness to trade in their smart devices. The electric power transaction integrated operating system sorts these intentions and plays a role to set the appropriate pair for each transaction condition.

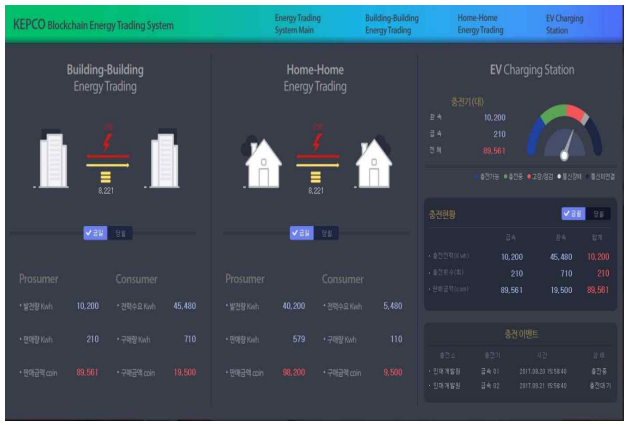

Figure 7. Electric power transaction integrated operating system

Among the electric power trading models proposed in this paper, the process for interbuilding electric power transactions, such as building-to-building transactions and home-to-home transactions, is as follows.

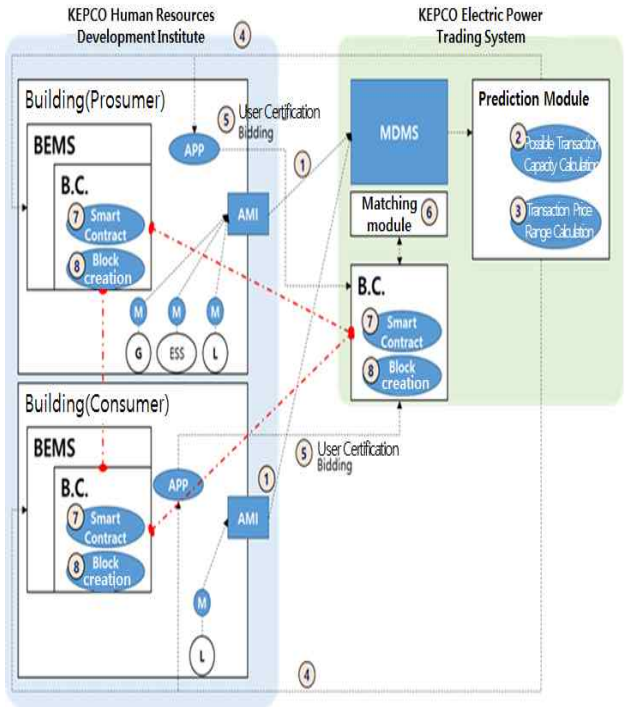

Figure 8. Process for building-to- building electric power transaction based on block-chain

The period of the transaction is one month, the same as Korea's electricity tariff system. Based on the measured values from the first of the month to the end of the month, the electricity transaction will be carried out on the first day of the following month and the postpaid electricity bill will be paid on the 18th day of next month.

On the first day of each month, the sales and purchasing buildings participating in the electric power transaction will receive information on the estimated power generation and demand of this month from the Electric power transaction integrated operating system for the

expected benefits or operational plans.

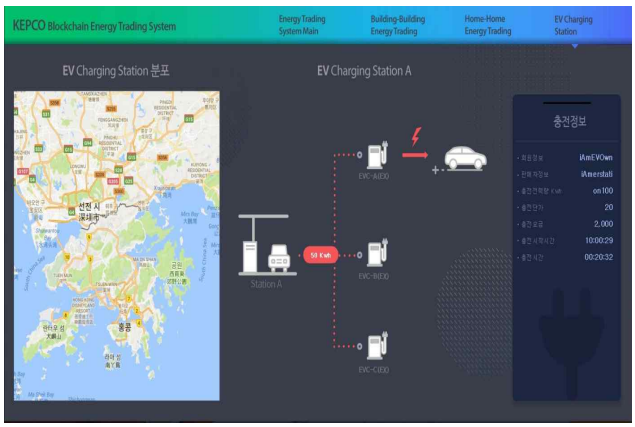

Figure 9. EV charging management screen in Electric power transaction integrated operating system

In the case of EV charging transactions, competition among EV charging companies is not considered. This service model is a model that can charge EV without credit cards through a block-chain network environment. Therefore, the effectiveness of this service is to save financial fees.

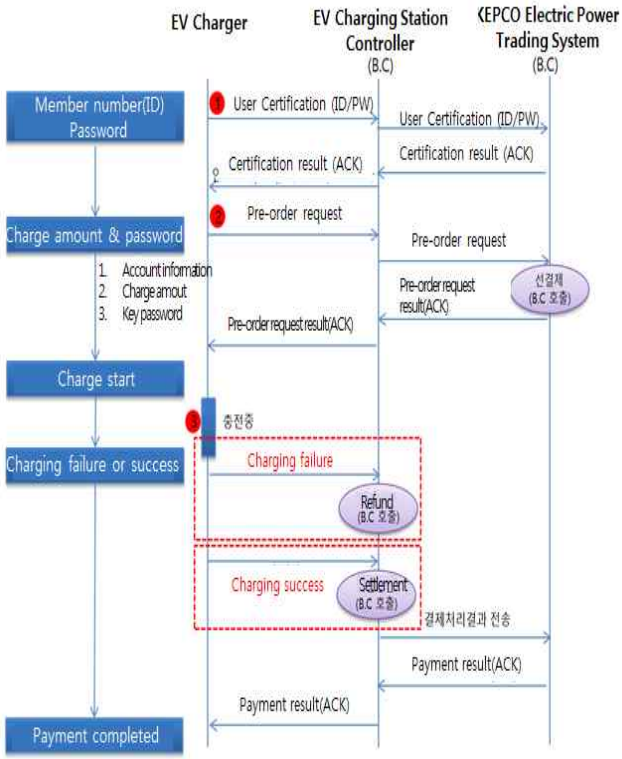

Figure 10. Process for EV charging transaction based on block-chain

Anyone who wants to use a block-chain based EV charging system has to sign up for the system in advance, enter the member number and password directly into the charger, and the KEPCO Electric power transaction integrated operating system sends the certification result to the charger. A user who has completed the authentication process checks the information in the virtual currency account from the charger and enters the charge amount and password. The payment process using a general credit card is made in the order of prepayment, cancellation of prepayment, and actual settlement. However, since the payment can not be canceled in the block chain, the transaction consists of three transactions within the block chain such as prepayment, cancellation, and settlement.

V. CONCLUSTION

P2P power trading between prosumer and neighbors and EV charging transaction can be fully serviced through existing internet environment and IT technology. However, in this paper, it is very important to construct a real service infrastructure by using a block-chain network environment and technology based on reliability that everyone can easily and safely participate in transactions without having a large server in the center. This will play a major role in expanding and disseminating renewable energy, which is eco-friendly energy. In case of EV, anyone can easily and securely charge at EV charging stations without a credit card fee, saving money.

KEPCO's next project needs to apply block chains to various transactions and increase the speed of operations inside the block chain for transactions. It is also necessary to develop IoT-based smart devices so that smart devices can participate in transactions even if people do not participate in transactions every time.

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