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ENERGY CONVERSION TECHNOLOGY TREND AND COMMERCIAZATION CASE USING ENERGY-ICT CONVERGENCE TECHNOLOGY

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ABSTRACT

This study explains the development trend of Energy-ICT convergence technology in Korea and major countries that is being promoted based on the policy of expanding advanced ICT infrastructure and knowledge information services, and the trend of expanding P2P power transactions, which is becoming a representative energy-ICT convergence platform. Based on this, we will present a plan to activate an Energy-ICT convergence business model based on distributed resources, a profit model through energy conversion, such as commercialization of domestic Energy-ICT convergence technology, and overseas commercialization cases(USA, Germany). The establishment of an environment that activates P2P power trading will undergo a very big change in the current paradigm of change in the electricity market. Therefore, it is necessary to have optimal solutions to many pending issues(power load/power market participant competitive structure/trading system, etc.). Furthermore, it is necessary to focus on building a foundation that can maximize the value of small-scale distributed resources by differentiating integrated control of distributed resources and services that can be traded in the electricity market through the advancement of core technologies.

Keywords: *Energy-ICT convergence, P2P power transactions, Business model, Distributed resources, Electricity market, Power load, Power market, Trading system, Integrated control*

1. INTRODUCTION

P2P(Peer-to-Peer) power transactions using various distributed power sources(Solar Power, Fuel Cell(ESS : Energy Storage System), EV(Electric Vehicle), etc.) are expanding. Through this, the energy prosumer market concept and distributed resource power trading system are becoming Energy-ICT convergence profit models. In particular, as the unit cost of power generation using renewable energy decreases, the foundation for activating P2P power trading is being laid. In order to effectively enable this, i)How should the problem of increasing power distribution network costs be fairly shared? ii)Is there any impact on the distribution network? iii)How will it harmonize with the existing centralized power supply system in the new power trading environment? We need a policy that can satisfy these prerequisites[1][2].

P2P power trading is a method in which electricity consumers using various distributed power sources in a distributed energy system exchange the remaining electricity with each node(consumer) of the distributed energy system on the power grid. This means that electricity consumers become energy prosumers(energy producers and consumers) that produce electrical energy. However, the domestic energy market structure has not yet activated such P2P power trading. In particular, consumers' surplus power transactions for distributed power are more passive. An environment where P2P power trading is active will contribute to the current electricity market through significant positive changes in terms of power load, competitive structure of electricity market participants, and trading system. Therefore, it is necessary to discuss many pending issues that are still understudied.

This study explains the development trend of

Energy-ICT convergence technology in Korea and major countries that is being promoted based on the policy of expanding advanced ICT infrastructure and knowledge information services, and the trend of expanding P2P power transactions, which is becoming a representative energy-ICT convergence platform. Based on this, we will present a plan to activate an Energy-ICT convergence business model based on distributed resources, a profit model through energy conversion, such as commercialization of domestic Energy-ICT convergence technology, and overseas commercialization cases(USA, Germany).

2. ENERGY-ICT CONVERGENCE TECHNOLOGY AND P2P POWER TRANSACYION EXPANSION TREND

2.1 Energy-ICT Convergence Technology Development Trend

The development of domestic Energy-ICT convergence technology is being promoted based on the policy of upgrading information and communication infrastructure and expanding knowledge information services. Recently, by establishing a basic plan for building a foundation for IoT communication, it is promoting IoT-related policies in earnest. The ultimate goal is i)to increase the productivity of the economy and industry by more than 30% by 2020, ii)to achieve a domestic market size of 30 trillion won, 350 export companies, and 30,000 employees. To this end, the Action Plan is being implemented through various promotion strategies and R&BD tasks. The development of energy-ICT convergence technology abroad is actively progressing, mainly in the United States[1][3]. The development trend of energy-ICT convergence technology in major countries(US, EU, Germany, UK, Japan, China) is shown in Table 1.

Table 1. Development Trend of Energy-ICT Convergence Technology in major countries

	Development Trend
USA	- Promote sporadic and fragmented policies by ministries - The private sector is actively conducting IoT-related research. - Establish a minimum intervention strategy for the state due to raising privacy issues
EU	- Promote the revitalization of the EU IoT market through a pan-European R&D program - Adopt IoT as the EU's global core competency through Digital Single Market Strategy
Germany	- Industrie 4.0 strategy to build an automated production system for IoT-based manufacturing - Reorienting to the government-led Platform Industrie 4.0
UK	- Strengthen investment in smart city - Various attempts such as international cooperation to spread IoT
Japan	- Government support to strengthen national competitiveness through IoT - Focus on creating new markets that break away from dependence on component technology - Present 3 Visions (Digitalization/Networking/IoT Transformation)
China	- Establish IoT policies at the national level, and take the lead in technology development and activation - Laying the foundation for the development of top-down IoT - Strengthening industrial capacity by promoting market opening and private sector development

* Source : MOTIE(Ministry of Trade, Industry & Energy) of the Republic of Korea(No.20191210301820)_Business Plan, May 2019.
Wan-Ki Park et al., "System Improvement Measures of Energy Prosumer Industry and Business Cases", IICCC 2020, IPACT, July 16~18. 2020 / Reconstruction.

2.2 P2P Power Transaction Expansion Trend

The domestic energy transition policy is being carried out as a 「Distributed Resource Power Trading System」 that is being built as an Energy-ICT convergence platform based on the 「2030 Energy New Industry Diffusion Strategy」 and the 「Second Basic Energy Plan」 to respond to the new climate system. The revenue model aims to increase the share of distributed power generation to 15% of total power generation by 2035. To this end, the 「Second Basic Energy Plan」 is promoting various policies such as inducing the installation of self-power generation, expanding collective energy, and distributing distributed new and renewable energy. As an Energy-ICT convergence platform, representative policies related to distributed resource power transactions in Korea include the P2P power transaction(Peer-to-Peer surplus power transaction between electricity consumers) system, the distributed resource intermediary market trading system, and the revision of the 「Guidelines for Trading Small-Scale New and Renewable Energy Power Generation Power」 etc. In particular, as the P2P power trading system is deregulated to foster a new energy industry in the government's 「Top 10 Projects in the Electric Power Sector(2016.01)」, prosumers are expected to generate additional revenue by selling surplus electricity from power produced by self-generating facilities to neighbors with high electricity bills through progressive systems[3][4]. Furthermore, the two-stage prosumer transaction measure is implemented to expand the target of prosumer P2P power transactions to large prosumers(schools/buildings/shopping malls, etc.), and is gradually expanding to power transactions between large prosumers and electricity consumers.

3. PROFIT MODEL AND COMMERCIALIZATION CASE THROUGH ENERGY CONVERSION

3.1 Profit Model through Energy Conversion

Based on ICT-based distributed resource operation technology, Energy-ICT convergence technology is being commercialized through related business models. In recent years, various technologies have been developed for the activation of distributed resources by integrating and operating them using ICT[1][5][6][7]. A plan for Activating Distributed Resources using ICT is shown in Table 2.

Table 2. A plan for Activating Distributed Resources using ICT

	Activation Scheme
V2G (Vehicle-to-Grid)	- Energy prosumer technology that uses energy efficiently - Utilize EV battery power as a grid during peak load - Expected to grow as a focus on new converged energy business
Micro-grid	- Based on the assumption that the amount of electricity supply can be reduced - Use of multiple small-scale power sources connected to the local power grid - Supplied through central power grid (transmission network and high voltage distribution network)
NZEB (Net-Zero Energy Building)	- Realization of high-efficiency and low-energy consumption through renewable energy facilities - Live without additional energy supply from the outside - Securing its own energy production facilities in the building and linking it with the power grid - Future expansion of grid-connected micro-grids and related business models - Expected to be highly dependent on development

VPP (Virtual Power Plant)	- Consolidate small-scale distributed resources into a single power generation profile - Visualize planned power generation, increase/decrease voltage control ability, reserve power, etc. - Evolve with the technology you have - Operational supply flexibility and controllability, such as central feed generators can be secured

* Source : New Energy Industry Domestic and International Industry Trends, Promotion Status by Business Model, and Technology Development Trend(IRS Global, May 14. 2020)
Energy Management, Improves Efficiency with Intelligent IoT(Journal of Engineering, April 4. 2020)
Soon-Ju Koh, "Evolution and Intelligence Direction of the Energy Prosumer Market," Insight Report 2019-24, Electronics and Telecommunications Research Institute, 2020 /
Reconstruction.

3.2 Commercialization of Energy-ICT Convergence Technology at Domestic and Global

3.2.1 Domestic Commercialization Cases

Domestic Eeergy-ICT convergence technology is gradually becoming a power trading system between neighbors through the revision of small-scale electricity trading guidelines and the distributed resource brokerage market trading system. 「Prosumer Small-scale Power Trading Guidelines」 are being implemented as a two-stage prosumer transaction promotion measure to expand the target of power transactions between neighbors from housing units to large prosumers such as schools, buildings, and shopping malls. It is gradually expanding to power transactions between large prosumers and large electricity consumers. In addition, the discovery of prosumers and consumers that meet the requirements of power trading is creating new business opportunities such as energy consulting by making full use of the capabilities of private companies. In addition, electricity trading is being attempted in the form of recruiting electricity produced by a large number of energy prosumers through intermediaries and then selling them to the wholesale electricity market. Unlike power transactions between neighbors, which sell electricity produced by energy prosumers directly to other consumers, this project is being promoted as a 「Top 10 Project in the Power Field」 to expand the participation of small-scale distributed resources in the electricity market and strengthen the flexibility of grid operation through efficient management. In January 2016, the government implemented deregulation measures to foster a new energy industry through the 「Top 10 Projects in the Power Sector」. In other words, it allowed power transactions between prosumers and neighbors within a certain area [8]. Unlike the existing fee offset transaction, the prosumer system is a system that can generate additional revenue by selling the electricity produced by the power generation facilities owned by the company to neighbors who are burdened with high electricity bills through a progressive system.

3.2.2 Global Commercialization Cases

As a representative example of the US TPO model NEM(Net Energy Metering), 'Sunrun' is attracting attention. Through this, grid parity is implemented to solve customers' needs such as reducing initial costs. 'Sunrun' is positioned as a model to resell electricity produced through solar power generation facilities in houses to customers. 'Sonnen', which is attracting attention as a representative example of the German cloud community, is estimated to increase the consumption rate of self-generation to 70% by using the electricity stored by self-generators during the day and stored at night through the sonnen community. As a result, when power is scarce, SonnenFlat(Sonnen's virtual power generation system) is used to become a system where members of the community can trade power. The transaction price of surplus electricity is around 23 cents/kWh up to 2,000KW[1][4].

4. DISCUSSION

The P2P power trading system, which is the core of this research, is clearly different from the

existing P2P on the Internet. Internet P2P is a B2C type of commerce in which a small number of suppliers deliver information to a large number of consumers by sharing information while acting as clients/servers among equal peer nodes. On the other hand, P2P power trading is a platform for sharing energy resources among energy prosumers within a network. The structure of the platform consists of a server/client distributed processing method that stores, processes, and transmits excess data from one node. The advantages of P2P power trading include:

- You can use the remaining amount of electricity you produce and turn it into a profit without throwing it away.

- Resource utilization can be optimized by free movement of power through transactions between users.

- Stable power supply is possible through cooperative networking between producers and consumers.

5. CONCLUSION

The role of ICT in the paradigm shift in the energy industry is becoming more important. In particular, Energy-ICT convergence technology induces changes in consumers' behavior by analyzing and visualizing consumers' energy consumption patterns. This contributes to the integration of small-scale distributed resources and the energy consumption of end consumers into one coherent system, optimizing the overall energy supply and demand flow. Through sustainable energy sources and efforts to reduce greenhouse gas emissions, the structure of the energy industry is being transformed into a distributed resource-centered, bidirectional, regional distributed form. The expansion of the spread of renewable energy sources(wind power/solar power, etc.) may cause a decrease in the stability and power quality of power supply, so institutional mechanisms are needed to monitor and maintain power quality[2]. To this end, ICT technology is applied to enable the construction of a flexible distributed energy supply chain that can be distributed and independently operated according to scale by linking various small-scale distributed resources[9][10]. The establishment of an environment that activates P2P power trading will undergo a very big change in the current paradigm of change in the electricity market. Therefore, it is necessary to have optimal solutions to many pending issues(power load/power market participant competitive structure/trading system, etc.). Furthermore, it is necessary to focus on building a foundation that can maximize the value of small-scale distributed resources by differentiating integrated control of distributed resources and services that can be traded in the electricity market through the advancement of core technologies.

In addition, in order for Korea's P2P power transactions using V2G(Vehicle-to-Grid Interworking Technology) to be activated, it is necessary to focus on equipping various infrastructures such as EV and charging systems, and electricity markets, which meet international standards. In particular, in the V2G business, the spread of EVs is the most important key point. Therefore, for collective generators composed of small-scale distributed resources that meet certain conditions, a strategy to provide incentives to improve predictability and output stability is also required. Through this, it is expected to build a foundation for utilizing small-scale distributed resources as more strategic resources that can compete with existing power generation resources and promote related technology development.

Through this study, a new business model in K orea's P2P electricity trading market and a shift in a two-way power structure using blockchain techn ology were proposed. As a result, P2P power tradi ng using solar power became possible in Korea, re alizing the purpose and objectives of the research. However, it is a regrettable part that there is a ma jor shift in consumer perception regarding the eco -friendliness of energy consumption and the activa tion of electricity trading between individuals, and it is a limitation of the study. In order for the P2P power trading system to become more stable in th e future, legal and institutional support is essential . In addition, joint efforts are needed among relev ant stakeholders for energy transition and eco-frie ndliness.

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