

# [DOUBLE AUCTION DESIGN FOR P2P ENERGY TRADING BETWEEN MICRO-GRIDS WITH DEMAND-SUPPLY IMBALANCE]

[Ji-su Sim, Department of Industrial Engineering, Seoul National University, +82-2-880-7223, [jisu.sim22@snu.ac.kr](mailto:jisu.sim22@snu.ac.kr)  
[Deok-joo Lee, Department of Industrial Engineering, Seoul National University, +82-2-880-7223, [leedj@snu.ac.kr](mailto:leedj@snu.ac.kr)  
[Kiho Yoon, Department of Economics, Korea University, +82-2-3290-2222, [kiho@korea.ac.kr](mailto:kiho@korea.ac.kr)]

## Overview

Micro-grid is the concept of small power community independent from the existing main power system. It aims to meet the supply and demand generated internally by itself. Participants constituting the micro-grid can be divided into producers, consumers, and prosumers. Producers and prosumers have their own distributed resource units to generate renewable energy. Especially, prosumers play a role in production and consumption at the same time. When there are participants with surplus power and participants who lack power to use in the micro-grid, surplus and deficiency can be resolved through direct power transactions between participants, which is called peer-to-peer(P2P) energy trading. However, P2P energy trading in a micro-grid may not be easy, since the demand-supply imbalance problems frequently occur in a micro-grid. This is because renewable energy not only has a high variability, but also electricity demands and generation facilities are concentrated in specific regions. Most of the existing studies tend to solve the demand-supply imbalance problem in a micro-grid through power transactions with main grid. Then participants should trade at the fixed price. Moreover, they should sell electricity at a low price and buy it at a high price. Also, power transactions from micro-grid with low voltage to main grid with high voltage cause high power loss. Therefore, if it becomes possible to trade electricity with other micro-grids which are nearby or interconnected each other, it would be more efficient in terms of participants' profit and the volume of power loss.

The paper considers micro-grids with demand-supply imbalance which are connected to main grid. In each micro-grid, there are buyers and sellers and there is a difference between the total volume of electricity demands and supplies. The paper introduces P2P energy trading scheme between a micro-grid with excess supply and a micro-grid with excess demand. Notice that sellers and buyers in micro-grids feel their own value for the electricity that they buy or sell. Also, they compete not only with participants in the same micro-grids but also with participants in other spatially distributed micro-grid as transactions between micro-grids become possible. Thus, the multi-unit double auction is an appropriate mechanism for this problem. Reliable double auction should satisfy individual rationality, budget balance, and incentive compatibility. Since the paper considers P2P energy trading scheme which solves demand-supply imbalance, minimizes power loss and satisfies economic properties at the same time, it is difficult to apply the existing double auction models directly [1], [2]. The paper designs a truthful multi-unit double auction mechanism that enables two micro-grids with demand-supply imbalance to trade electricity each other. The performance of the auction mechanism is validated by analyzing the social welfare and the transaction rate through various simulations. The simulation results show that the proposed double auction mechanism for P2P energy trading increases social welfare and the transaction rate, and decreases the volume of power loss caused by transactions. In order to evaluate the validity of the investment connecting two different micro-grids, the performances of the double auction when the interconnection between two micro-grids exists and when it does not exist are compared.

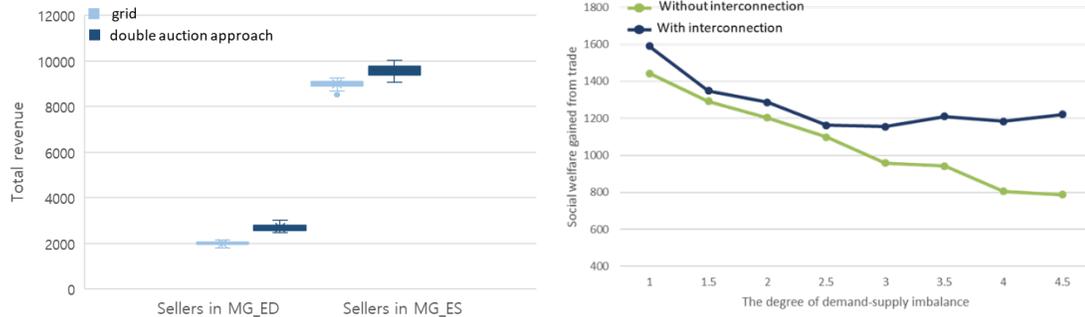
## Methods

The paper assumes that there are two interconnected micro-grids, that is, a micro-grid with excessive demand(MG\_ED) and a micro-grid with excessive supply(MG\_ES). Also, the paper assumes that double auction consists of auctioneer, sellers, and buyers. Each buyer and seller has the amount of electricity that they have or need, and the price at which they want to buy or sell. The amount of demand and supply are public information and the price is a private information which is called a type. Buyers and sellers bid for the amount of electricity and the price. When the auction terminate, the auctioneer informs the agents of trading price and allocation. Specific description of the proposed double auction mechanism will be introduced at the conference presentation.

## Results

Through various simulations, I would like to conduct the following analysis.

1. Comparison of the results of transactions through grid and results of the P2P transactions through proposed double auction (example : Figure 1.)
2. The effect of the presence of micro-grids interconnection (example : Figure 2.)
3. Comparison of the results from the variants of the proposed double auction mechanism
4. Sensitivity analysis for power loss rate



[Figure 1. Comparison of sellers' total revenue] [Figure 2. Comparison of social welfare gained from trade]

## Conclusions

The paper addresses the demand-supply imbalance issue in micro-grids. The framework for P2P energy trading between interconnected micro-grids is proposed to resolve the imbalance issue. The framework utilizes a multi-unit double auction with transaction cost. Moreover, the study considers power loss cost incurred by power transactions between spatially distributed micro-grids and treats the loss costs as transaction costs. By analyzing theoretically, the study shows that the proposed double auction mechanism satisfies properties such as individual rationality, budget balance, strategy-proofness and asymptotically efficiency. Simulation results show that the proposed double auction mechanism increases participants' profit, social welfare gained from trade, transaction rate, and decreases the volume of power loss compared to proposed existing transaction methods. Also, by simulation results, the paper shows that the proposed double auction mechanism is effective when the degree of demand-supply imbalance in each micro-grid is above 2.5 times. For evaluating the validity of investment connecting the power systems of two different micro-grids, the paper presents the reference value which is the difference between social welfare when interconnection exists and does not exist.

## References

- [1] P. U. Huang and A. Scheller-Wolf, "DESIGN OF A MULTI-UNIT DOUBLE AUCTION E-MARKET," 2002.
- [2] D. An, Q. Yang, W. Yu, X. Yang, X. Fu, and W. Zhao, "SODA: Strategy-Proof Online Double Auction Scheme for Multimicrogrids Bidding," *IEEE Trans. Syst. Man, Cybern. Syst.*, vol. 48, no. 7, pp. 1177–1190, 2018, doi: 10.1109/TSMC.2017.2651072.