OPTIMISING THE MIX AND STRUCTURE OF POWER GENERATION MARKET: EX-ANTE ANALYSIS OF SUMATRA POWER SYSTEM

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Overview

This research optimise the mix and structure of Generating Companies in Sumatra power system. Market power, indicating the ability to raise prices profitably above the competitive level, tends to be a significant problem in the aftermath of electricity market restructuring. In the process of regulatory reform and the development of competitive electricity markets, it is desirable and practical to establish an efficient number of competitors GenCos. Simulations of a power system account for multi-plant mergers of GenCos subject to a regulatory measure of Residual Supply Index and the influence of direct current load flow and the topology of the system.

This research will answer the following research question: What is the optimal market structure and generation technology mix in the oligopoly electricity market model in objective to minimise market power exercise from the potential pivotal player? This research question will be answered by implementing perfect competition and Cournot competition and applying Residual Supply Index (RSI) as market power mitigation. This research simulates the effect of electricity market restructuring in the Indonesia power generation market. Therefore, this study focusses on determining the optimal market structure, efficient generation mix in the GenCos, and an efficient number of competitive GenCos by using the Sumatra power system as a case study. The Indonesia power system consists of two primary power systems, i.e. Sumatra and Java-Bali power system. This research adopts the 10 nodes stylised model for the Sumatra power system, by incorporating generation, transmission and power system stability constraint.

This study implements the concept of preventive approach in electricity market restructuring which contributes to the current body of literature on electricity market modelling and market power studies, which is essential for Indonesia, when the market restructuring occurs.

Methods

The research methodology in this paper following the cascading optimisation algorithm developed by (Hakam 2019) that has an objective to formulate the optimal structure of successor companies on the basis of market power index RSI. The market structure optimisation in (Hakam, 2019) consist of four steps as follows: Firstly, we modelled the Sumatra power system into perfect and imperfect (Cournot) competition models by considering the generation and transmission constraints. The perfect competition modeling is based on the studies by (Macatangay, 1998), (Berry, Hobbs, Meroney, Neill, & Stewart, 1999), (Green, 2007), (Leuthold, Weigt, & von Hirschhausen, 2012) and (Hakam, 2018) while the Cournot competition modelling is based on the research by (Borenstein, Bushnell, & Wolak, 2002), (Cunningham, Baldick, & Baughman, 2002), and (Willems, Rumiantseva, & Weigt, 2009). The generation constraints including generation capacity, energy mix, and reserve margin, while transmission constraints cover DC load flow, transmission limit, and line connection. Secondly, we calibrated the stylised modelling according to the real condition of Sumatra load flow at non-coincident peak load year 2015, i.e. 3rd September 2015 19.30 for North Sumatra subsystem and 18th August 2015 19.00 for Mid-South Sumatra subsystem (P3BS, 2016). Thirdly, we conducted horizontal addition of marginal cost for combined power plants. We assume company that owned multi power plants behave as multi-plant monopolist (Dahl, 2015). Lastly, we screened the optimisation result and determined the optimal market structure for each configuration based on RSI threshold 110 % following the empirical study by (Sheffrin, 2001) and (Sheffrin, 2002). Please note that each cascading optimisation calculates nodal price, nodal demand, nodal supply, nodal consumer surplus, nodal producer surplus, and power flow for each configuration. However, we focus on the RSI calculation for each market setting by opting for the highest RSI for every possible market setting.

Results

Three case studies were simulated in this chapter. The first case study is the simulations to optimise the Sumatra power system considering virtual IPP nodes under perfect competition as in normal operation (unconstrained). The second case study performed simulation under under perfect competition and contingency N-1 (constrained), and the third case study applied Cournot competition in the model (unconstrained). The modelling of large-scale power system under constrained transmission is very hard to solve (Hakam, 2019; Leuthold et al., 2012). Therefore, the modelling of Indonesia power system under Cournot constrained is left for future separated study. However, the three case studies in this paper already reflecting the substantial comparisons between perfect and Cournot competition, and between unconstrained and constrained transmission.

Conclusions

This study provides guidelines for competition policy regulator in electricity market on how to configure the mix and structure (portfolio) of successor companies. The portfolio optimisation applied in this study is based on preventive law approach using recursive optimisation, power system modelling and market power mitigation to create the optimal market structure ex-ante. The optimal mix and structure of electricity market was varied according to the characteristic of power system. This study extends the application of preventive competition policy in Hakam (2019) by applying the cascading optimisation in stylised Sumatra power system. This study also extends the study of Sumatra power system modelling in (Hakam 2018b) by applying imperfect (Cournot) competition in Sumatra system. Therefore, the contributions of this study are as follows: First, this research is the first to analyse the Sumatra power system using imperfect (Cournot) competition modelling. Second, this study is the first kind to optimise the mix and structure of Sumatra generation power market.

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