MARKET PARTICIPATION MODELS FOR ENERGY STORAGE SYTEMS IN CHILE

Benjamin Maluenda, Consultant at inodú – Energy & Sustainability, +56 2 2502 0626, bmaluenda@inodu.com
Jorge Moreno, Partner at inodú – Energy & Sustainability, +56 2 2502 0626, jmoreno@inodu.com
Donny Holaschutz, Partner at inodú – Energy & Sustainability, +56 2 2502 0626, donny@inodu.com

Overview

The integration of wind and solar photovoltaic generation capacity in Chile is increasing rapidly. During some days of the month of November 2018, generation from these Variable Renewable Energy (VRE) sources exceeded 20% of the daily system-wide generation. The rapid integration of VRE in Chile is giving rise to a "middle market", which presents an increased need for intermediate generation that can adapt its output to variations in electricity demand and VRE production. The regional needs for intermediate generation will depend on the location of new VRE projects, the location of existing assets that provide flexibility, the evolution of the transmission system, and regulatory definitions [1].

Over the years, Chile has acquired experience using energy storage to operate and balance the power system. The utilization of Energy Storage Systems (ESS) in Chile has historically been determined by the Independent System Operator (ISO) based on audited operational costs of generation and storage units, with the purposes of minimization of operational costs and to maintain the balance between generation and demand. Almost 5 GW of hydroelectric capacity with stored water in reservoirs exists and, on a smaller scale, lithium-ion batteries have been operating for almost a decade. In 2009, the largest Battery ESS (BESS) in the world at that time was installed in the North of Chile to provide 12 MW of contingency reserves, and since then another 40 MW have been added. Other types of projects with storage capacity are currently under development. The first Concentrated Solar Power (CSP) facility in Latin America was developed without subsidies and is expected to begin operations in 2019. Additionally, new pumped storage projects which use ocean water are currently under development.

In the medium- to long-term, ESS are expected to play a more comprehensive role in the power sector. The integration of VRE coupled with emerging system constraints are creating new opportunities for the development of new projects and/or new market participation models for ESS. These projects can help the power system cope with increased variability and uncertainty in the operation of the power system and satisfy future needs to reduce the sector's carbon emissions. ESS projects will have to compete with other alternatives and have the capability to reduce the operational costs of the power system in order to be utilized by the ISO. Additionally, ESS can provide multiple services which include, but are not limited to, resource adequacy (capacity), energy arbitrage, different ancillary services, transmission upgrade deferrals, demand charge reductions, and others [2].

Traditional variables such as location, sizing, operational cost, and others are important elements in determining the value of ESS. The evaluation of the business case and viability of ESS projects will greatly depend on availability of real-time and ex-post data for key system variables, such as spot prices, forecasted demand, real demand, VRE generation, contingencies, and others. Access to such information should help investors conduct more robust evaluations of ESS projects and then ESS operators to develop market participation models which have a higher chance of maximizing the value created by the ESS considering their strategic priorities and market conditions. Additionally, market participation models are constrained by power sector regulation and knowledge gaps which may exist when implementing a particular scheme in a specific market.

In particular, greater data availability and regulation that governs the frequency of settlements in the energy markets have been found to be key for the estimation of the value of BESS projects [3]. BESS can provide services in shorter timescales than most other ESS . In this paper, the *energy arbitrage* service of a BESS to the Chilean power system, which consists on trading in the energy market by buying and selling energy at different prices in different times, will be analysed. As part of this paper the following key questions are addressed:

1. What modifications could be implemented to the Chilean power regulation in a short-term which can enable more accurate ESS project evaluations? In particular, how does the 1-hour time resolution of the energy market price affect the revenue of an ESS trader and how does this revenue change under a market with higher frequency of settlements?

2. What market participation models could be implemented in the Chilean wholesale electricity market with currently available data signals and what is the estimated revenue of a BESS project under each of them? What are the information gaps for implementing other participation models?

Methodology

The methodology used for the development of the paper has three parts. First, the emerging opportunities in the Chilean energy and ancillary service regional markets which can be addressed by ESS will be synthesised. Such analysis will consider power system operational and market data from 2017 and 2018. In addition, operations from existing BESS in the Chilean grid will be described, deviations between day-ahead programs and real-time operations will be statistically characterized, data availability will be mapped, and data quality will be analysed.

Secondly, multiple market participation models identified in [3] for valuation of the energy arbitrage service by a BESS will be described. The market participation models developed by MISO as part of FERC Order 841 will be reviewed [4]. Three market participation models will be selected for the analysis. These market participation models will be retroactively analysed using actual energy spot market results for 2017 and 2018. The 1-hour resolution historical spot price data will be used to estimate potential revenues from energy arbitrage considering a hypothetical 10 MW BESS project that could be located in two different regions of the Chilean power system. Additionally, historical data gaps will be identified for those models where historical data is missing in order to evaluate them.

Lastly, the three market participation models will be retroactively analyzed considering a higher frequency of spot energy market settlements available for 2018. The higher frequency spot energy prices are available at 15-minute and 5-minute resolution. The analysis should highlight the differences evaluating energy arbitrage services provided by a BESS project considering spot prices at a 1-hour time scale compared to lower time scales, such as has been shown in [3]. The analysis will derive in regulatory modification recommendations that could be implemented to enhance the value that ESS assets could capture in energy markets.

Expected Results

The following results will be presented as part of this paper:

1. A synthesis of emerging opportunities in the Chilean energy and ancillary service markets.

2. A review of the operation of grid-scale ESS projects in Chile, with a focus on BESS.

3. Regulatory and practical gaps between the ESS market participation models being implemented in other markets and those being defined in Chile.

4. The estimated revenue of a BESS project potentially located in 2 different regions that solely provides energy arbitrage services, considering 3 different market participation models.

5. The estimated revenue of a BESS project considering price setting mechanisms of 5-minute and 15-minute resolutions, and its comparison to the current 1-hour definition. The effect of the frequency of settlements in the energy market (frequency of pricing) consideres a BESS potentially located in 2 regions, considering 3 different participation models.

References

[1] B. Maluenda, J. Moreno, D. Holaschutz and E. Gil, “New market interactions in the chilean electricity system with high integration of variable renewable energy,” *41st IAEE International Conference*, Groeningen, 2018.

[2] P. J. Balducci, M. J. E. Alam, T. D. Hardy and D. Wu, “Assigning value to energy storage systems at multiple points in an electrical grid,” *Energy and Environmental Science,* vol. 11, pp. 1926-1944, 2018.

[3] Sakti, A., Gallagher, K.G., Sepulveda, N., Uckun, C., Vergara, C., de Sisternes, F.F., Dees, D.W., Botterud, A, “Enhanced representations of lithium-ion batteries in power systems models and their effect on the valuation of energy arbitrage applications” *Journal of Power Sources*, 2016.

[4] Midwest Independent System Operator, “Electric Storage Resource (ESR) Proposal Review,” MISO, 2018.