***Batteries at the crossroads of electricity grid expansion and load balancing problems***

Adrienne de Bazelaire, LGI CentraleSupelec, adrienne.de-bazelaire@centralesupelec.fr

Yannick Perez, LGI CentraleSupelec, yannick.perez@centralesupelec.fr

Olivier Massol, LGI CentraleSupelec- IFP School, olivier.massol@ifpen.fr

## Overview

Transmission Expansion Planning (TEP) is often the responsibility of the grid operator. Even in nodal markets, market-based expansion is not sufficient to reach optimal grid investments (Hogan et al., 2010; Joskow, 2005). Historically, when the electricity industry was more centralized, Generation Expansion Planning (GEP) was followed by future grid investments planning... With the deregulation of the electricity industry, the two exercises are no longer coordinated by the same entity (Wu et al., 2006). Along with the de-integration of the industry, new challenges have opened up for TEP. They involve the management of intermittent decentralized energy sources and new technological solutions to include to the grid planning.

Battery Electrical Storage System (BESS) is a good example showcasing a new means to address such challenges, because they are decentralized, adaptable and de-integrated assets. They may emerge either for load balancing (by shifting consumption throughout the day for example), or as a complement to traditional grid lines investments (it can allow the grid operator to defer line reinforcement by resorbing local congestion). BESS’ versatility makes it a powerful tool for both GEP and TEP. BESS turns out to be a new opportunity as well as a new challenge to overcome in grid expansion modelling.

The current solution issued by grid operators when planning their future investments is to proceed with a two-stage approach. First, the grid operator tries to forecast future levels of generation and consumption according to public policies and scenarios. The grid operator makes assumptions on the production and load spatial location, all within a given time horizon. Second, the operator models the grid expansion and renewal investments needed to optimize social welfare.

## Methods

This two-stage optimization solution comes up short when capturing the full value of BESS. The BESS value when participating in the system operation (energy arbitrage, frequency and tension reserves, capacity mechanism if any) can be stacked with the network operation value (lines investments deferral, congestion resorption). Although both values partially overlap, when it comes to modelling, the two-stage approach doesn’t fully grasp BESS’ multifaceted value. Previous works regarding BESS in generation-transmission co-optimization concern mostly nodal prices markets (Xu and Hobbs, 2020), focus on market considerations (Gonzalez-Romero et al., 2019) or adopt a simplified grid (Mallapragada et al., 2020).

In this paper, a unique price market is considered, in that there are no economic locational signals. We want to propose a joint optimization of transmission, generation and storage expansion that would capture both BESS’ system operation value and network operation value. Arbitraging over time raises the question of the stored battery energy’s use value. With a joint optimization, we could answer several questions regarding BESS: the optimal sizing and siting, future expected volumes, how the two values add to or cannibalize one another. Eventually, it could help grid operators contracting grid services from third parties.

## References

Gonzalez-Romero, I.-C., Wogrin, S., Gomez, T., 2019. Proactive transmission expansion planning with storage considerations. Energy Strategy Reviews 24, 154–165. https://doi.org/10.1016/j.esr.2019.02.006

Hogan, W., Rosellón, J., Vogelsang, I., 2010. Toward a combined merchant-regulatory mechanism for electricity transmission expansion. J Regul Econ 38, 113–143. https://doi.org/10.1007/s11149-010-9123-2

Joskow, P.L., 2005. Transmission policy in the United States. Utilities Policy 13, 95–115. https://doi.org/10.1016/j.jup.2004.12.005

Mallapragada, D.S., Sepulveda, N.A., Jenkins, J.D., 2020. Long-run system value of battery energy storage in future grids with increasing wind and solar generation. Applied Energy 275, 115390. https://doi.org/10.1016/j.apenergy.2020.115390

Wu, F.F., Zheng, F.L., Wen, F.S., 2006. Transmission investment and expansion planning in a restructured electricity market. Energy, Electricity Market Reform and Deregulation 31, 954–966. https://doi.org/10.1016/j.energy.2005.03.001

Xu, Q., Hobbs, B.F., 2020. Transmission Planning and Co-optimization with Market-Based Generation and Storage Investment, in: Hesamzadeh, M.R., Rosellón, J., Vogelsang, I. (Eds.), Transmission Network Investment in Liberalized Power Markets, Lecture Notes in Energy. Springer International Publishing, Cham, pp. 201–236. https://doi.org/10.1007/978-3-030-47929-9\_7