

Message

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Subject: Ryerson CUE white paper: Optimal Scheduling of Merchant-Owned Energy Storage Systems with Multiple Ancillary Services
Attachments: 5-White Paper 6 - Energy Storage.pdf

Hi,

Please find attached the latest white paper, *Optimal Scheduling of Merchant-Owned Energy Storage Systems with Multiple Ancillary Services*, from Bhanu Opathella, the IESO's Energy Storage Research Fellow at the Ryerson University Centre for Urban Energy. Please feel free to share internally.

Abstract: Energy storage systems can provide a set of benefits to improve the flexibility and reliability of electric power systems. They could supply a set of different services at the same time. In this context, this paper proposes a new linear profit-maximizing formulation for grid-connected merchant-owned energy storage systems with multiple ancillary services. All technical characteristics of ESS have been modelled including cycle life loss due to fast charge/discharge and low depth of discharge operations. A piece-wise linear model of an ESS converter's capability curve has been included. The proposed model of ESS could gain revenues from five services: voltage regulation, frequency regulation, energy arbitrage, reserve power and black start. The model was assessed considering a battery ESS, a flywheel ESS and a compressed air ESS using Ontario energy market price data, and the results demonstrate the benefits of the formulation. From the base case study and sensitivity studies, it is clear that the merchant-owned battery ESS and the flywheel ESS can generate profits, especially from voltage regulation and frequency regulation services. The compressed air ESS is not profitable for the considered price data. The case studies prove that the proposed model can be used as an optimal planning and operation tool for any type/size of ESS.

This white paper marks the completion of the current IESO-Ryerson contract; however, our team is currently working with Ryerson CUE on a proposal to continue the IESO Energy Storage Research Fellowship through the Conservation Fund. Below is the full list of papers produced by the various IESO Energy Storage Research Fellows and available to IESO staff:

6. *Optimal Scheduling of Merchant-Owned Energy Storage Systems with Multiple Ancillary Services*
5. *Sizing and Siting of Energy Storage in Distribution Systems*
4. *Sizing and Siting of Energy Storage in Transmission Systems*
3. *Capacity Auction Market Model with Energy Storage for Ontario*
2. *A New Storage Capacity Market Design for Renewable-Storage Grid Interaction*
1. *A Survey on Energy Storage Technologies in Power System*

All the best,

Tom Aagaard | Senior Specialist, Policy, Engagement and Innovation

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