Energy Storage and Decarbonization Analysis for Energy Regulators

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Abstract

This work presents methodologies developed and results obtained for determining the amount of ESS required to adequately serve load in a system where fossil fueled generators are being replaced by renewable energy generation over the next two decades. The Illinois MISO Zone 4 is used as a case study.

Motivation

- Electric power generation transitioning from fossil fuels to variable renewable energy (VRE) to reduce emissions and fight climate change
- Appropriate policies need to be enacted by energy regulators to guide this transition
- Energy regulators require tools to determine accurate amount of VRE and energy storage required to achieve the decarbonization goals of a certain jurisdiction and also reliably serve load

Method 1 – Boundary Conditions

- Capacity Adequacy Condition:

$$\sum_{i=1}^{n} P_i^{\max} \times CV_i \geq L_{\text{peak}}$$

- Energy Adequacy Condition:

$$\sum_{i=1}^{n} P_i^{\max} \times CF_i \times 8760 \geq L_{\text{total}}$$

- ESS power rating:

$$P_{\text{ESS}} = L_{\text{peak}} - \sum_{i=1}^{n} P_i^{\max} \times CV_i$$

- ESS Energy Capacity:

$$E_{\text{ESS}} = h \times \sum_{j=1}^{h} P_j$$

- These are necessary conditions that must be met in order to meet load.
- Satisfying these conditions helps specify the minimum amount of ESS and VREs.

Acknowledgement

The authors wish to thank Dr. Imre Gyuk, Director of Energy Storage Research in the U.S. Department of Energy Office of Electricity for his continued support.

Method 2 – Optimization + System Dynamic

- Given capacity expansion/retirement plans, load forecasts, VREs and ESS cost scenarios, renewable portfolio standards, reliability requirements as inputs, find the amount of Wind, PV, and short-term ESS, mid-term ESS, and long-term ESS that minimizes the total investment cost of those resources.
- Three types of ESSs are considered:
  - short-term (4-hour) ESS to maintain daily load variation.
  - mid-term (36-hour) to maintain monthly load variation.
  - long-term (100-hour) to maintain seasonal load variation.
- Round trip efficiencies, cycling requirements and cost scenarios are differentiating factors of the three types of ESSs.

Illinois MISO Zone 4 Test Case

- Technical analysis performed by Sandia in collaboration with Illinois Commerce Commission (ICC) using Illinois MISO Zone 4 as test case
- **Objective:** Determine resource adequacy and minimum amount of storage required to adequately serve load for the next two decades (2023 – 2042) as some fossil fueled units are retired and new VRE units are added