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Storage allocation and investment optimisation for transmission-constrained networks considering losses and high renewable penetration

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Abstract-

This study investigates the effects of transmission losses, constraints and increased renewable energy penetration on planning energy storage allocation and investment. By modifying a DC optimal power flow model using a linearised approximation for ohmic losses, the authors were able to understand which network characteristic or inhibitor drives the most change in expanding utility-scale storage. Four different storage technologies were explored: compressed air energy storage, pumped hydro storage, lithium-ion battery and fly wheel. Each had different charging, capacity and cost characteristics. The results of the storage allocation trials revealed that network congestion was a more influential network inhibitor than were line losses. Losses only had substantial effects on a free-flowing network but produced marginal changes in allocation in congested ones. The conclusion of the investment trials revealed two things: (i) storage investment is not significantly affected by transmission constraints so long as renewable generation stays constant and relatively low; (ii) more flexible technologies like flywheels are favoured at lower volumes of renewable penetration for their load balancing capabilities while cheaper technologies are best as the volume of renewable power generated increases.

Index Terms- optimisation; flywheels; load flow; compressed air energy storage; renewable energy sources; power transmission economics; secondary cells

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