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Optimal Allocation of Battery Energy Storage Considering Stiffness Constraints

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Abstract : Around the world, many countries have committed to a decarbonization of their electricity system. Under this global drive, converter-interfaced generators (CIG) such as wind and photovoltaic generation appear as cornerstones to achieve these energy targets. Despite its benefits, an increasing use of CIG brings several technical challenges in power systems, especially from a stability viewpoint. Among the key differences are limited short circuit current capacity, inertia-less characteristic of CIG, and response times within the electromagnetic timescale. Along with the integration of CIG into the power system, one enabling technology for the energy transition towards low-carbon power systems is battery energy storage systems (BESS). Because of the flexibility that BESS provides in power system operation, its integration allows for mitigating the variability and uncertainty of renewable energies, thus optimizing the use of existing assets and reducing operational costs. Another characteristic of BESS is that they can also support power system stability by injecting reactive power during the fault, providing short circuit currents, and delivering fast frequency response. However, most methodologies for sizing and allocating BESS in power systems are based on economic aspects and do not exploit the benefits that BESSs can offer to system stability. In this context, this paper presents a methodology for determining the optimal allocation of battery energy storage systems (BESS) in weak power systems with high levels of CIG. Unlike traditional economic approaches, this methodology incorporates stability constraints to allocate BESS, aiming to mitigate instability issues arising from weak grid conditions with low short-circuit levels. The proposed methodology offers valuable insights for power system engineers and planners seeking to maintain grid stability while harnessing the benefits of renewable energy integration. The methodology is validated in the reduced Chilean electrical system. The results show that integrating BESS into a power system with high levels of CIG with stability criteria contributes to decarbonizing and strengthening the network in a cost-effective way while sustaining system stability. This paper potentially lays the foundation for understanding the benefits of integrating BESS in electrical power systems and coordinating their placements in future converter-dominated power systems.

Keywords : battery energy storage, power system stability, system strength, weak power system
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