Transactive Energy Systems for Contingencies

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Transactive energy systems (TES) have been successfully demonstrated to achieve an economic market efficiency during normal grid operations. Current TES designs are based on marginal benefits to the buyer and marginal cost to the seller and are designed meet to the technical needs of the power system during normal economic operations. However, TES designs for contingency situations have not been adequately explored. Because power system operations involve risks and uncertainties ranging from forecast errors to natural disasters (e.g., hurricanes, tornados, cyber-attacks) which can potentially affect large portions of the system, TES approaches that can engage DERs during grid contingencies could add benefits to both DERs and system operators. In this study, we first investigate potential TES mechanisms to be used for contingency conditions. Presuming that contingency events cannot be avoided, we explore what must happen for a TES to change course to address contingencies. To understand the requirements of TES approaches for contingencies, we start with TES designs for blackstart (recovery from complete power outage).

The proposed TES for blackstart process conducts parallel negotiations - one to be used for normal economic operations and another failsafe alternative market to be used upon recognition of an event. This approach is based on commitment-restoration-compensation between retail TES market and blackstart service provider and it runs TES market ahead of time to acquire enough resources to position them for addressing potential contingencies. First, resources which are capable of providing blackstart service, called blackstart service providers, submit their bids to the retail TES market. Bids from blackstart service providers include additional attributes, such as type of resources (e.g., blackstart generating resources, no-blackstart generating resources, and flexible loads). For instance, blackstart generating resources (e.g., synchronous machines, grid-forming inverters) are the only resources that can initiate grid formation, while non-blackstart generating resources and flexible loads can only be used in subsequent steps of the restoration process. A blackstart service provider bid curve is constructed by extending bids for normal economic operations such that additional flexibilities can be exploited during the blackstart process. Once TES markets receive bid curves from blackstart service providers and the demand of blackstart resource from the system operator, the retail TES market will run to select enough resources with right composition (e.g., blackstart generators, non-blackstart generator, flexible loads) so as to enable blackstart process. When a blackout event occurs, the TES market issues dispatch instructions to committed blackstart service providers and the blackstart service providers should follow the dispatching signals from the resources. Overall, the blackstart recovery steps are:

1. Blackout and disconnection: Upon inception of blackstart event, all loads will be disconnected and the distribution system will be sectionalized immediately as a part of the blackout and disconnection step.
2. Jumpstart: As a jumpstart step all blackstart generators that were selected as jumpstart units from the commitment phase will start
3. Re-energize: Once the blackstart generating units has started, system operator reenergize different distribution system segments in steps and subsequently bring nonblackstart generating units online.

4. Reconnect and stabilize: The system operator directs the reconnection of loads as additional generator comes online, initially to help stabilize the generation and later to restore normal operation later.