[AGM] Space Weather Mitigation Planning

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Timeline: FY2023 – present

Challenge:

Geomagnetic disturbances (GMDs), resulting from intense solar activity caused by coronal mass ejections, pose risks to the electric grid by generating geomagnetically induced currents (GICs) through interaction with the Earth's magnetic field, resulting in the flow of ionospheric electrojet sources. The resulting time-varying fields generate currents within the earth, resulting in surface electric fields that couple into transmission lines, which in turn causes quasi-dc GICs to flow through those lines. The GICs modify the ac behavior of transmission network by causing half-cycle saturation of transformers, drawing harmonic currents and a net increase in reactive power consumption.

To protect against these threats, dc-current blocking devices may be included into the network. These blockers, however, are expensive; additionally, dynamic measures to deal with GICs include controls, such as generator dispatch, load-shedding, and line switching. Developing a GIC-aware optimal power flow (OPF) that includes ac physics, transformer reactive losses, small-signal stability etc., is a challenging computational problem for the community and requires advanced algorithmic techniques.

Technical Approach:

This project integrates the individual elements developed by past Los Alamos projects into a planning problem formulation that supports the placement of dc-current blocking devices to mitigate the effects of GICs on the bulk electrical system (BES). This complete formulation creates the basis for resilience planning based on uncertainty associated with future GIC, the dynamics of the GIC events over time, and the combined physics of ac power and GIC. The project is developing novel prototype algorithms tested on BES GIC models of increasing complexity and network size and building to an ISO relevant optimal planning problem. It also includes a unique partnership with the DOE Office of Science, leveraging the expertise and technology of the "Scientific Discovery through Advanced Computing" (SciDAC) centers.

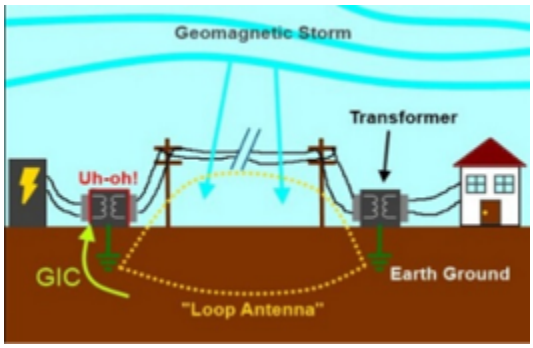

Figure 5-6: Schematic of interactions between power systems and geomagnetic storms.

Impact:

When GMDs occur on large energy systems, the resulting power outages may be catastrophic. For example, the 1989 event in Quebec led to the shutdown of the Hydro-Quebec system, as a consequence 6,000,000 people suffered power outage for nine hours; a report estimated that the net cost of this event was $13.2 million, with damaged equipment accounting for $6.5 million of the cost. Potential GMD impacts to transformers motivate research that will improve our understanding of such events and identify strategies to mitigate impacts. Without these advancements to optimization-based planning, future infrastructure designs are vulnerable to GIC induced voltage collapse and transformer failure, which this project seeks to address.