Improving the prediction model of Spanish power grid's vulnerability in solar storms
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Apart from the beauty of auroras in polar latitudes, the disturbances of Earth's magnetic field caused by the solar cycle can generate huge economic losses in many sectors. When the solar wind's particles interact with the Earth's magnetic field, a geomagnetic storm results. This storm can generate geomagnetically induced currents (GIC) in the subsoil, which are dangerous to electrical networks and transport systems (oil pipelines, gas pipelines, railway lines, etc.).

These low-frequency continuous currents depend on the region's geoelectrical structure, that is, the regional geology, and on the electric conductivity of rocks. Regarding electrical lines, geomagnetically induced currents couple with the distribution network through the transformer's dams.

Alex Marcuello, lecturer from the Department of Earth and Ocean Dynamics of the University of Barcelona, says, "The applied methodology in this new study allows a simulation of different situations for the network, according to different magnetic storm conditions. Therefore, modeling can estimate the highest values of GIC for different substations, finding out their effect in different elements of the grid –connected or not- and identifying the most vulnerable ones."

Improving predictions with the study of electric conductivity

This scientific article, with Joan Miquel Torta as its first author, sets as a study model an electricity substation in Vandellòs, Tarragona. To study the vulnerability of the electric grid, the study analyzes the comprehensive elements of the grid and its length, apart from the geoelectrical structure of the subsoil using in situ measurements in the territory.

"In general, the most vulnerable high voltage lines are the ones with voltages higher than 200 kV" says Alex Marcuello. "The most GIC-sensitive components are the transformers in the
substations. These GIC cause a half-cycle saturation in the nucleus of the transformers, and its consequence is tripled—the transformer warms up and can even burn, the current and voltage stop being sinusoidal (50 Hz) and become unstable. Finally, the grid's inductive power increases. As a final result of the three situations, a partial or total blackout can take place."

A more realistic diagnosis on the country's power grid

The study published in the journal *Space Weather* creates a realistic prediction model based on simplified approaches. In this context, the experts of the Geomodels Research Institute have characterized the conductivity of subsoil in the region of the Vandellòs substation using the magnetotelluric method.

"This methodology enabled a substantial improvement in the former predictions for GICs. Also, we have proposed a model that can add three factors on which the GIC depend: the magnetic storm, the subsoil geoelectrical structure, and the electricity grid characteristics," says Marcuello.

Satellite meteorology: anticipating the effects of solar storms

The importance of technological impacts of magnetic storms have prompted the design of global warning protocols that alert systems managers in a minimum time interval, even hours before a GIC, to set the proper preventive measures. Situations such as the Quebec blackout on March 13, 1989 are extreme cases that encourage the research process in satellite meteorology to prevent and palliate the magnetic effects of solar activity in the planet.


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