PROTECTING THE UK POWER GRID FROM GEOMAGNETIC HAZARD

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
www.bgs.ac.uk

Allan McKay *and* ***Sarah Reay***
British Geological Survey
Murchison House
West Mains Road
Edinburgh, EH9 3LA

Geomagnetic storms, during which the Earth's magnetic field is disturbed, cause the beautiful natural phenomenon of the aurora borealis, or 'northern lights', but they also pose a threat to technological systems such as power transmission networks. For example, during the major geomagnetic storm of March 1989 the Canadian Hydro Québec power system failed. This power outage lasted for nine hours and affected six million people with damage and losses estimated at hundreds of millions of dollars. This massive disruption was due to equipment failure caused by induced electrical currents flowing in the power grid as a direct consequence of a severe geomagnetic disturbance. Operational mitigation is considered one of the best strategies to minimise this kind of risk. This poster describes recent developments towards a new, near-real-time, geomagnetic storm warning system based on spacecraft measurements of the solar wind, British Geological Survey (BGS) magnetic field measurements, and an integrated Earth-surface electric field and power grid network model. This system is being developed for use by Scottish Power plc, with support of the European Space Agency (ESA/ESTEC) to aid grid control management.

Geophysical Background

Large-scale eruptions on the Sun can eject massive energetic clouds of electrical plasma that collide with the Earth's magnetosphere causing a geomagnetic storm [Figure 1].

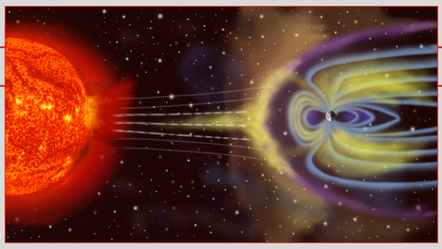

Figure 1

During a geomagnetic storm changes in the Earth's magnetic field happen more rapidly, and are larger, than on a normal 'quiet' day Example: during a magnetic storm on 30th October 2003 the compass direction at Eskdalemuir magnetic observatory changed by over 5 degrees in only 6 minutes [Figure 2].

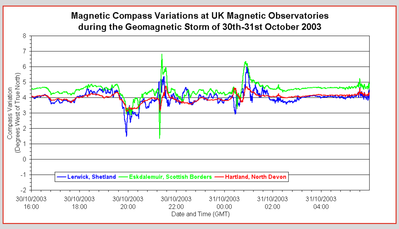

Figure 2

Large and rapid changes in the Earth's magnetic field induce an electric field in the Earth that can cause electrical currents to flow in conducting material grounded in the Earth [Figure 3].

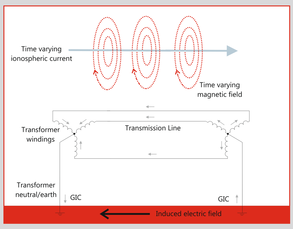

Figure 3

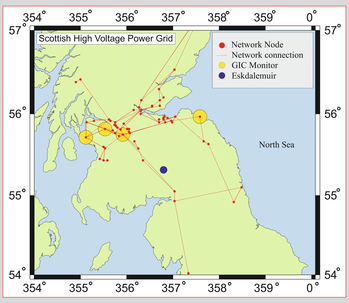

Figure 4

A power grid provides a wide network of good conductors which 'short-circuits' the induced geolectric field [Figure 4] and causes harmful currents, so-called Geomagnetically Induced Currents (GIC), to flow between the power grid and the Earth. Example: during the magnetic storm on 30th October 2003 the maximum GIC recorded at Strathaven station was approximately 40A [Figure 5].

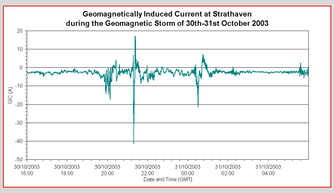

Figure 5

Response of Earth's Electric Field to a Geomagnetic Storm

To be able to predict GIC flow in the power grid we need to understand how the geoelectric field responds to a geomagnetic storm.

The geoelectric field is extremely sensitive to the electrical resistivity structure of the Earth. The geology of the UK is complex. BGS have developed a model to estimate the geoelectric field during geomagnetic storms [Figure 6].

Models of the electric field, and BGS measurements of the geomagnetic field, enable us to calculate GIC throughout the Scottish Power grid [Figure 7].

Figure 6

Figure 7

Continuous Real-time Warning of Geomagnetic Storms

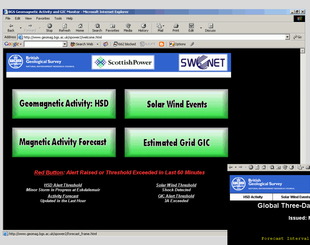

Figure 8

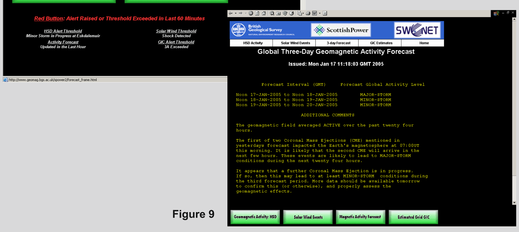

Figure 9

Reliable and robust advance warning of geomagnetic activity is required if power engineers are to take operational measures to mitigate the risk.

BGS have developed a geomagnetic storm and GIC warning and monitoring system, which includes a web interface and a continuous data supply to Scottish Power Plc in near real time. Figure 8 is the front-page of the interface where Scottish Power may access monitoring, analysis or forecast data.

The system includes a geomagnetic activity forecast for up to three days ahead, and a detector that monitors public domain NASA/NOAA near real-time solar wind measurements, to give up to one hour warning of the onset of geomagnetic activity. In addition, BGS geomagnetic data allow the progress of geomagnetic storms to be monitored. Calculated GIC throughout the power transmission network allow power engineers to assess the impact of geomagnetic activity. Figure 9 is an example of a recent forecast.

Impacts and Media Coverage

Geomagnetic activity has a worldwide impact.

During the major October 2003 storms, power grids in Canada and USA limited electricity production and distribution to cope with induced currents in their grids. In Sweden 20,000 homes were affected by an hour-long power cut most likely caused by GIC. The October storms generated huge media interest worldwide and, in the UK, many people were treated to fantastic auroral displays for three consecutive nights.

Acknowledgements

GIC data courtesy of Scottish Power plc.

Space weather 'Pilot Project' supported by ESA/ESTEC.

www.geomag.bgs.ac.uk