# Solar Wind Monitoring and Induction Modeling for GIC (SWIMIC)
British Geological Survey (BGS), UK

Geomagnetic storms and their associated ionospheric electrical currents induce surface electric fields in the Earth and these drive geomagnetically induced currents (GIC) through electrical power grids. GIC are significant because they affect the lifetime and performance of the voltage transformers in any grid. Thus, geomagnetic storm risk assessment, real-time activity monitoring, daily forecasting of geomagnetic activity in the UK, and surface electric field modelling have been the themes of various recent BGS scientific studies. These studies have been undertaken in association with the companies responsible for maintaining the high voltage power transmission grid in the UK.

As a result of these activities, a detailed 3D electrical conductivity model for the UK and its continental shelf has been developed and electric field modelling code written. Numerical simulations of geomagnetic storms have given an indication of the likely strength and locations of GIC in the Scottish part of the UK power grid.
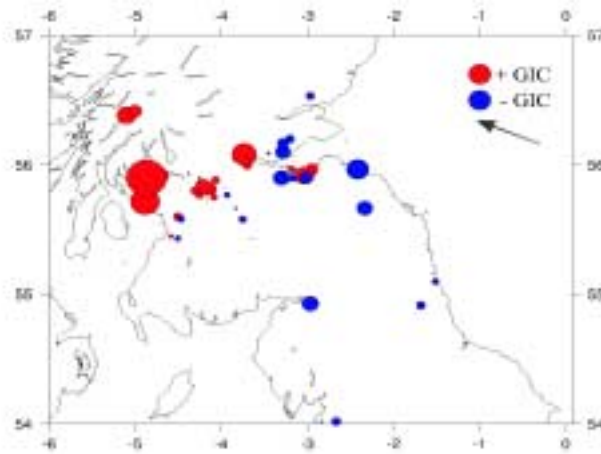
An example of estimated GIC flowing in a simplified model of the Scottish and Northern England high voltage grid (275 and 400 kV) as a result of a surface electric field of 1V/km in the direction of the arrow. This field is induced by a uniform ionospheric current distribution over the region, associated with a geomagnetic storm. The maximum GIC is 40A in this example, with spot sizes shown proportional to the GIC. Positive and negative currents flow into, or out of, the Earth, respectively, from the grid via the transformer earthing points.

Working with Scottish Power plc (SP), BGS has identified **new user needs**, which require the development of additional capabilities to improve the existing service that BGS provides for SP:

1) A **real-time geomagnetic storm warning service** will be developed using public domain, near real time, data primarily from the NASA/NOAA ACE spacecraft. Pattern recognition and event detection techniques will be used to identify shocks and coronal mass ejections in the solar wind as they pass ACE. Shock warnings will be communicated to SP together with a time frame for commencement (typically up to one hour later) of any subsequent geomagnetic storm.

2) An enhanced **power grid GIC model** will merge our induced surface electric field and conductivity models with a more detailed power grid network model to predict GIC in the Scottish power grid in near real time. At present SP monitor the Earth current at only four sites but larger GIC may be flowing elsewhere in the grid. The development of an accurate model will be more cost effective than installing monitoring equipment across the entire grid. The induction model will input magnetic variations: *a*) recorded at the UK observatories operated by BGS, or *b*) deduced from ACE solar wind data. Option *a*) will give an accurate diagnosis of real-time equivalent ionospheric currents that cause GIC, with real-time estimates of GIC. Option *b*) has the potential to give a longer warning of the time variations in the electrical currents in the ionosphere, and the resulting GIC. We will study how accurately ionospheric currents can be determined directly from solar wind measurements. The locations and strengths of predicted GIC will be provided to SP at all Earth points in the power grid.

These new developments will enable SP to manage the GIC risk to the transmission grid in a more reliable way and there is also the possibility that a service built on these developments will find application elsewhere in the world. At the end of the project, a full assessment of the usefulness of both the existing and the extended service to SP will be provided.