How Solar Storms Affect Manitoba Hydro

*<caption> Submission by **Andrew Campbell** (Project Services) of the Northern Lights near the Keeyask project.*
<alt text> Landscape image featuring blue hued aurora borealis over a forest. Snowy terrain in the foreground.

Between May 10-12 this year, an extreme solar storm had many folks in Canada, the United States and even Europe looking up to see a light show.

Though this storm didn't knock out our grid, there was a chance it could have. In March 1989, six million Quebecois were without power after a similar storm hit the region. The same storm melted power transformers in New Jersey.

"Our studies have pinpointed the area of concern — long transmission lines. Long transmission lines act as an antenna for the energy in the upper atmosphere. Transformers at the end of these long lines, if they are grounded, complete the circuit providing a path for currents to flow," said **Steve Shelemy** (Grid Infrastructure Planning) who has been working with Hydro on geomagnetic interference since 2007.

Severe solar storms effectively make a long transmission line act like a battery by inducing a "large

voltage drop" between the two ends of the line and if there is a path to ground geomagnetically induced currents (GIC) flow through the transmission system.

"Large voltage drops between two points is basically a battery. Like your standard AAA battery, one end has a higher voltage than the other, which is known as a voltage drop. If you connect a wire between the ends of the battery (provide a path) current will flow. Electricity must travel in a closed circuit. I tell my kids, electrons always want to get back home but the roads are all one-way streets, so they need two paths (or a closed loop)," said Steve.

Even though transformers are designed to handle currents of electricity, the GIC created by severe solar weather impacts the transformer's ability to maintain standard voltage, resulting in voltage collapse and in extreme cases, transformer burnout (which is what happened in New Jersey in 1989).

But what is solar weather exactly?

Solar weather originates from the sun — a super-hot ball of swirling hydrogen, helium, and plasma. Solar weather is constantly spreading across the universe, and the radiation it emits is a big reason space exploration is so dangerous. NASA Goddard scientist Holly Gilbert said the sun is 'beautifully dynamic' with magnetic field lines that dance with each other. This dance starts in the center of the sun, where extremely hot, electrically charged particles create mini nuclear fusions which generate powerful, chaotic and invisible magnetic field lines.

Arnad Choudhuri, from the Indian Institute of Science, explains how the power of these magnetic field lines is so intense that the lines get squished and kinked, like a tangled, bent garden hose. When the "hose" gets overwhelmed by the pent-up energy, it bursts out from sunspots, spewing radiation and plasma out into the universe. Depending on the level of intensity, the waves of radiation and plasma become solar winds, solar flares, coronal mass ejections (CME), or solar hurricanes – all together referred to as solar weather.

Last year, during a routine SpaceX satellite launch, an unexpected solar storm rolled in and downed around 40 Starlink satellites. Thankfully, our magnetic field – we call it the magnetosphere – protects life on Earth from solar radiation. The magnetic field is generated by the kinetic energy from the planet's rotation against the rotation of the molten iron core at its center. So long as the planet spins, the energy field will be in a feedback loop, sustaining an invisible, polarized shield that surrounds Earth. Without this protective bubble, solar winds would erode our atmosphere, ending life as we know it.

What does Manitoba Hydro do to mitigate risks?

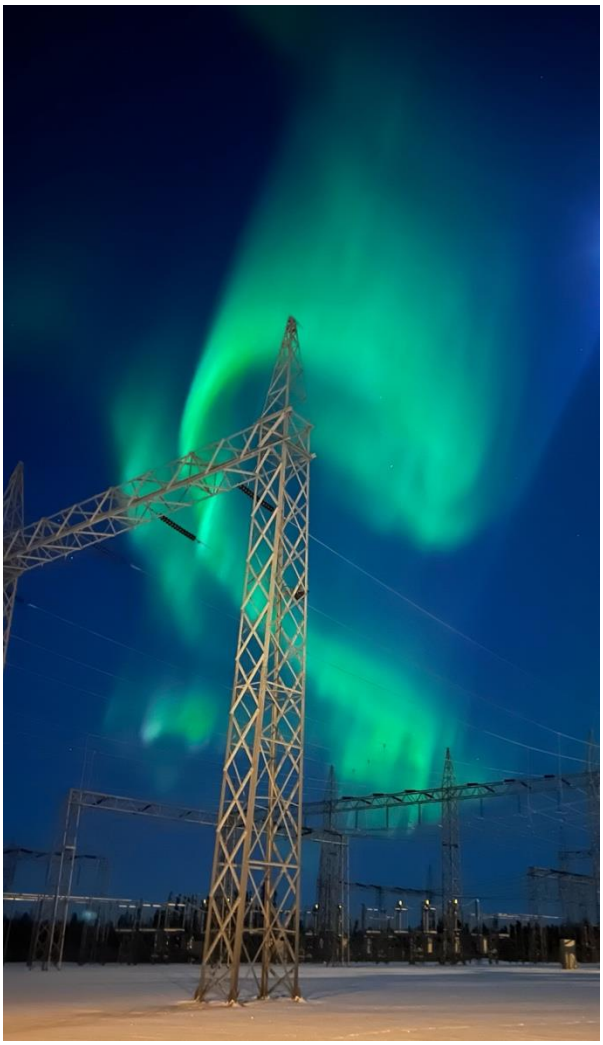
"The biggest threat to our customers from a solar storm is a blackout," Steve said. "From our research, we know the risk of damage is on the transmission system, not the distribution system. Though a severe solar storm may damage a transmission transformer, this will not happen to distribution transformers.

"Our main defense against blackout or damage is to relieve stress on our system. Either by reducing exports or, if it were to get severe enough, reducing power to large local enterprises. We could also power up any unused transformers to help spread out the flow of energy, and we can install capacitors in the transmission line to block the flow of current."

Solar storms can be intense but rest assured: scientists are diligently watching the sun to give us a heads up in the event of any activity. The European Space Agency is also launching Vigil in 2025, a monitoring satellite that detects activity on the hidden side of the sun.

But even with current technology, Steve says we get ample notice before solar storms.

“Though we have yet to experience a massive storm with extreme destructive power, we get around four hours' notice of solar activity, which is enough for Manitoba Hydro to implement mitigation measures,” Steve said.



*<caption> Submission by **Crystal Cook** (Transmission Ops & Maintenance) of the Northern Lights swirling around a transmission tower at the Birchtree Station in Thompson.*
<alt text> A hydro-electric transmission tower stands in the foreground while a swirl of green-hued aurora shines behind it.

Manitoba Hydro is prepared for solar weather

Manitoba Hydro was one of the first utilities to take part in the Electric Power Research Institute's (EPRI) SUNBURST program following the Quebec storm of '89. Meant to monitor geomagnetically induced currents (GIC), the SUNBURST program kickstarted Hydro's history as a world leader in GIC monitoring.

Long before most countries were concerned, Manitoba Hydro worked on a research and development project with the Finnish Meteorological Institute (FMI) in 2007 to assess the data gathered from SUNBURST, which was monitoring the Dorsey 500 kV transformer, then Ridgeway and finally Grand Rapids.

In 2010, Natural Resource Canada (NRCAN) reached out to Manitoba Hydro to develop a new GIC simulator to help us understand the effects of solar weather. (See our 2014 Hydrogram story about it here.)

The North American Reliability Corporation (NERC) established the Geomagnetic Disturbance Task Force (GMDTF) in 2011 to set clear guidelines and procedures for energy providers. By 2018, the GMDTF's new standard came into effect for Manitoba. It outlines transmission performance requirements that ensure our infrastructure will operate reliably in the event of severe solar weather.

"The sun has an 11-year cycle, which tends to lull people into a false sense of security," Steve said. "We're currently installing many new GIC monitors prior to the 'solar maximum' NASA predicts for July 2025."

"It's interesting how we've observed the most severe storms happen at the tail-end of the supposed solar maximums. I'm hoping to install one of the new monitors at the Brandon station since NRCAN also has a magnetometer there. This would give us some really interesting and innovative data."

These new GIC monitors utilize our existing transmission system monitors – all you need to do is add a simple component. Who doesn't love a cost-effective solution?

<TIMELAPSE VIDEO>

*<caption> Submission by **Brendan Mazurik** (former employee) Northern Lights timelapse near the Keeyask project.*
<alt text> Timelapse video showing the aurora borealis over a winter landscape.

The greatest light show on earth: how solar weather creates the Northern Lights

Commonly known as Northern Lights, aurora borealis is just leftover sun plasma that spent 2-4 days hurtling through space at unimaginable speeds before crashing into our magnetosphere. As coronal mass ejection waves attempt to escape the Earth's magnetism, they stretch outward like the tail of a comet before snapping back like an elastic. The electrically charged plasma particles are then drawn toward the poles, squeezing through layers of the magnetosphere until the remaining particles fall through our atmosphere. This process creates breathtaking colours and patterns that have mystified humans for generations.

According to Steve, the aurora are also referred to as “electric jets” that act much like air or water currents. It’s difficult to pinpoint where these currents will lead, or what influences them. Their erratic behaviour is why the May 10-12 solar storm didn’t affect our grid.

“The strange behaviour of the electric jet moved the storm further south, allowing a lot of people to witness the show but also saving our transformers from the brunt of the storm,” said Steve.

It wasn’t until the invention of the telegraph that we realized the threat imposed by solar weather, after telegraphs sparked and failed worldwide. Back in 1859, auroras could be seen around the world, shining so brightly that night turned into day. We refer to this as the Carrington Event and it remains the most intense solar storm in recorded history. The city of Malmo, Sweden had its satellites, radio waves, and electrical grids blacked out by a CME in 2003. This same storm also disrupted hundreds of flights and 59 per cent of NASA’s space missions reported effects on their equipment.

Since Manitoba Hydro does such an excellent job of keeping our grids safe from geomagnetic interference, the greatest threat from solar weather remains in space — outside of Earth’s magnetic field. Though a severe storm has a chance of affecting things such as GPS and communication satellites, we can feel confident that watching a display of breathtaking aurora won’t mean a province-wide blackout.