From:
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Subject: MUSKRAT FALLS REVIEW- TNANSMISSION RELIABILITY
Date: Tue, 28 Feb 2012 23:32:57 -0300

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Attention C. Blundon

COMMENTS

1. Overhead transmission line reliability:

The studies I have seen filed by Nalcor uses reliability data from 230 kv AC lines [like ice , wind , snow loads] and applies it to the HVDC system. Nfld Hydro has considerable 230 kv AC lines and a lot of operating experience with them, so it might seem appropriate to use that data. However it states that the data "excludes" outages causes by "contamination". I assume contamination includes salt build up. As we live in a maritime region, salt air from the ocean blown by high winds is a problem for electrical systems often causing power transmission disruptions. Much of our 230 kv lines are inland and are less disturbed by salt contamination.

As an engineer with nfld hydro [from 1971-1975] I was involved in high voltage substation design as well as control and protection. My recollection is that transmission lines on the Northern Peninsula were "not" 230 kv. They were lower voltage of either 138 or 69 kv, more probably 69 kv. I recall that outages on that line were much more frequent and probably longer duration. the reason being: salt contamination. This is to be expected : it is a long and relatively narrow peninsula bounded on both sides by the ocean. High winds bringing salt laden air inland was not at all unusual, causing outages. The frequency of outages were much more than other lines , and in particular much more than the 230 kv lines, given much of those were inland.

While it might seem obvious to compare the risks of the DC line to that of the AC in that they are both high voltage, and may have somewhat similar steel structures, it appears to me that an important , if not most important comparison is as to the location: that troublesome Northern Peninsula with high winds and salt laden air. Manitoba Hydro Int. refers to the route as the Alpine region. The route is down and across the Long Range Mountains. It may be better or worse than the route of the 69 kv line. But the problem is the salt driven by the high winds.

When the salt builds up on the isolators it causes a flashover. A protective system would then shut off power momentarily, and after so many seconds it would reclose. If the salt contamination was not too severe, upon reclosure the system would continue to operate ok. It might trip again and do this a few times, and if it didn't stay energized, it would then stay off permanently causing a longer outage. I assume these conditions have not changed. So it seems strange: why not assess the risk from salt contamination: a serious problem whether the line in 69, or 230 kvac or 345kvdc. The location of the line and salt contamination seems to be a more important comparison for risk than using somewhat similar voltage but very different environmental conditions as to salt problems.

2. Cable reliability:

Data filed by MHI or Nalcor compares data of outage frequency with other cables installed around the world. They get average outages per 100 kilometers of cable. The average outage frequency is fairly high, but most other cables are fairly long. The cable across the Straits is relatively short. So they then devide the average outages by the shorter length of the Strait's cable and by this means get a very low expected outage rate for the Straits's cable. The method would certainly show a very low rate of outage for a very short cable. By this method , if the cable goes from 40 to 20 km you half the risk again , and so on . and so a 2 km cable is pretty well risk free! So, is this an appropriate method of calculating risk ?

And eliminated from the risk calculations is outages causes by "anchors". It took a little digging to find the signifinance of this. Anchors from fishing actavity is the largest source of damage to one of the cables in operation. It makes the overall average fairly high. If you eliminate that from the comparison, things look much more rosy. Perhaps there are no anchors in this Straits's region! Or do they intend to compensate fisherman, fish companies and communities for enforced fishery reductions or changed methods so as to eliminate or reduce anchor damage.

3. System reliability from GIC [geomagnetic induced currents]

Outages from this source peak during solar max, so they can be troublesome for about 3 years out of 11, but severe solar storms can occur at any time during the solar cycle. Outages are rare but can be severe. In 1989 , an outage knocked off 21,000 mw, 36 times the firm supply of Muskrat falls, and 4 times more than the full capacity of Churchill Falls. It took down the power systems from James Bay to the Northeast USA. Six million people were without power. Damage included a partial meltdown of a very large transformer at a 1000 MW nuclear generating plant in the coastal region of the Northeast USA. And that was a baby solar storm. Studies done since [by Metatech] predict that if we get one like hit earth in 1921 it would affect 130 million people and cause 2 Trillion dollars of economic damage,and that grid interconnectedness makes the power distribution network more susceptable to wide-ranging cascade failures . The 1921 storm was 10 times larger than that of 1989. The power grid is only one thing they can knock out: communications, satelites and railways and pipelines are also vulnerable. And the storm in 1859 was worst than the 1921 storm, estimated at 50 percent bigger. We had the telegraphs operating then across the Atlantic from Hearts Content. They were powered by DC batteries. During the storm the cables either didn't operate or operated poorly and sometimes operated even without batteries . The GIC's would sometimes power the cable!

High charged particles coming from the sun disturbs earth's magnetic field. A visual effect is the "northern lights". But they they also produce DC curents in the ground and oceans and these enter our AC power systems and pipelines etc.and can cause serious problems. Risk factors are:

a) being near the polar auroral zone , the zone extends from 55 to 70 degrees latitude.

b) high earth resistivity

c) coastal regions are especially susceptible to GIC', the effect is enhanced by charge accumulation at the coast, due to the earth's higher resistivity relative to water.

d) east-west running transmissions lines, cables , or pipelines. [North-south running lines are less vulnerable].

e) the longer the transmission line the more they are exposed to GIC's , they create voltages usually in the range of 1-6 volts per kilometer,but up tp 10 volts per kilometer in a more severe storm

f) significant power flow over the lines, by the year 2000 the vulnerability of North American power transmission lines increased by a factor estimated at 2 or 3 times that of 1989, and has grown since then, so the probability of a large storm coinciding with heavy power flow is much higher

g) long lines usually require voltage support devices. These can be prematurely tripped because their protective relays respond to harmonics created by transformer half-cycle saturation. Such saturation happens, caused by the quasi-dc nature of the GICs, with potential cascading effects on other system components, and can lead to voltage collapse, and blackouts.

h) only a few utilities monitor GICs

Some utilities are members of Sunburst- a consortium of utilities who measure the harmonics in the currents and voltages and use internet links to their sites, the goal being to collect data from many sites during a GIC event. And the ACE satellite now observes local particle and magnetic perturbations from outside the earth's magnetosphere., so computer model warnings about large GICs are issued to member groups about half an hour before they they occur. Devices to block GICs from entering the power systems are seldom used , as they are complex and expensive. Most utilities follow no specific guidelines, showing a lack of interest or resources. A few follow some general rules. A proper process would involve: performing system studies to determine the grid's vulnerability to GIC effects; an evaluation of the risk of harmonic resonances; an assessment of the risk of of system voltage collapse , as well as the harmonic responce of relays; transformers that are more immune to GICs; and to design the power system to withstand larger voltage swings. The Sunburst project has developed a monitoring program that is needed and a step -by-step procedure that involves an analysis of the major power system components as they are affected by the GIC or related harmonics.

An IEEE paper in 2009 indicates that GICs at a China nuclear plant was 75.5 amps in 2004, which was larger than the neutral DC current caused by the HVDC monopole operation; suggesting that longer transmission lines and other factors, the influences of GICs on the ultra -high voltage power grid being constructed in China need to be studied more urgently.

Unlike wind or snow storms , magnetic storms can cause damage to transformers very quickly: in 1972 , in Minnesota , the GIC current increased from 0 to 60 amps in 3 minutes. Following the 1989 blackout , considerable research was done, including the report titled "ELECTRIC UTILITY INDUSTRY EXPERIENCE WITH GEOMAGNETIC DISTURBANCES" ,published in 1991, and sponsored by the US Defence Nuclear Agency and the US Department of Energy, and included input from some Canadian power companies and including Nfld and Labrador Power. Of interest is the information from Hydro Quebec on

1. the speed that damage can occur fro GIC: from tests by injecting DC current into transformers- the transformers can saturate in 1 minute or less, and
2. the effect on HVDC systems: this test done in may 1988, before the storm, DC currents were injected into Hydro Quebec's AC transmission system near the electrode of the Hvdc converter. A DC current of 780 amps was injected at the HVDC converter electrode, which resulted in neutral currents of avout 16 amps in several transformers. Harmonic currents were measured that had an amplitude of about 1.5 times the phase DC current.
3. system response during the actual blackout of March 13 ,1989 : At 2:44 a.m. ,an intense storm was underway. Hydro Quebec operating staff were experiencing some difficulties in controlling voltage. Harmonics due to GICs were causing problems with HVDC converters, voltage regulation, and generator excitation. Total generation was 21,500 MW with 9500 MW supplied from the LaGrande Complex near James Bay, Quebec. Some of the harmonic currents generated by saturated transformers flowed to ground through shunt cappacitors associated with the SVCs. At 2:44:17 a.m. an SRV tripped at Chibougamau because of overcurrent . this started a sequence of events : within 70 seconds 5 different transmission lines tripped off, 3 static VAR compensators, and 4 SVCs. Within 2 minutes of the first SCV trip, most of the Hydro- Quebec system was down. Once the last SVC was tripped, the HQ system collapsed in less than 30m seconds!

Today ,some utilities place emphasis on minimizing and mitigating the risk and to make the equipment more resilient and to provide for rapid system restoration.

Of local significiance is the chart on page 27 of the report, as it indicates how we can be affected by geomagnetic storms and these GICs invading our power system. The chart shows 22 locations, all except one being readings recorded in transformer neutrals in the United States substations from 1969 to 1972. They are in order from the lowest GIC amp , being 16 amps to the highest , being 100 + amp , meaning over 100., at the very top of the list. This ranking of Number 1 was at Corner brook substation in Nfld, as recorded by Nfld and Labrador Power.

A Manitoba Hydro engineer,Tom S. Molinski, in the year 2000 paper " Sheilding grids from solar storms" [from which much of this information is found] reports that the highest measured GIC in North America is 184 amps. It doesn't say if this was at Corner Brook. But if we are not the bulls eye for GICs , we are close. And we have all the risk factors.

When I worked at Nfld Hydro , we communicated with Boulder ,Colo., Usa , a part of NOAA's Space Environment Centre. We would get advance warnings of the solar flares. Unlike Scotie , the engineer on Star Trek, [who would give orders "activate the deflector shields" , we could do little but observe and have our operations department maybe trip out parts of our power system in advance ,if we were lucky. Our operations probably haven't changed much.

We are now entering solar max again.

Most people are aware of the risks of wind , salt , and ice build up on our transmission lines. Most know little of solar max or GICs. But engineers with the local power companies know , or should know. And Manitoba Hydro engineers certainly know. And some say we have spent over half a billion dollars on studies ,etc already on the Muskrat falls project. And while damage from GICs is currently of very low risk , this new line could and would , it seems, increase that risk. By how much ? Who can tell? Has'nt there been an analysis done? I haven't had time to read all of Nalcor's and MHI's material, but I've looked for reports of risk assessment for this and can't find them. From ice bergs, to salt contamination, fishermans anchors, ice build up on the lines, high winds, heavy snows- we get it all. And don't forget GICs.

The reliability risks for this system requires an analysis of a whole number of risks. Important risks as to possible anchor damage to cables, salt contamination on line insulators, GIC issues,etc seems to be overlooked.

Winston Adams