

1 Q. Reference PUB-NLH-241: What design changes would have to be made to the ac
2 switchyard at Muskrat Falls and the ac switchyard at Soldiers Pond to prevent a
3 stuck breaker resulting in the need for under frequency load shedding? In the
4 response provide an estimate of the cost of such a change at each ac switchyard.
5 Also, please provide a list of breaker failure events on the IIS during the past 20
6 years, and a brief description of the impact of each of these events.

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9 A. As per Hydro's response to PUB-NLH-241, the worst case contingency would involve
10 a stuck circuit breaker in the ac network near Muskrat Falls. Preliminary analysis
11 indicates that if a three-phase fault was applied at the 315 kV bus and not cleared
12 for 300 ms, the Labrador Island Link would sustain multiple commutation failures
13 and would be unable to recover¹. This blocking of the LIL would result in scheduled
14 load shedding on the Island Interconnected System.

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16 It is noted that the commutation failures do not result from the configuration of the
17 ac terminal station,² but rather from the extended suppression of system voltage
18 due to the sustained fault. The addition or reconfiguration of circuit breakers would
19 therefore not resolve the issue.

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21 Integration studies were performed to ensure that that the system can withstand
22 normal fault clearing, as specified in Table 1 of Hydro's response to PUB-NLH-241.

23 As per Hydro's response to PUB-NLH-283, the system can withstand a temporary

¹ The application of a three-phase fault for 300 ms at Soldiers Pond also results in instability.

² Soldiers Pond Terminal Station and Muskrat Falls Terminal Station are each designed with a breaker-and-a-third configuration. The interconnections of system elements at each of these terminal stations are arranged to minimize the impact of a stuck circuit breaker. For example, connections to system elements including units, transmission lines, HVdc converters, and HVdc filters, are alternated.

1 bipole block for up to 250 ms (or 467 ms with three high inertia synchronous
2 condensers in service at Soldiers Pond Terminal Station).

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4 For the system to be able to withstand a sustained three-phase fault in the range of
5 300 ms as discussed in Hydro's response to PUB-NLH-241, significant inertia and
6 reactive support would be required at both Muskrat Falls and Soldiers Pond to
7 assist with voltage and frequency recovery. Preliminary analysis indicates that
8 stability cannot be maintained, even with three high-inertia synchronous
9 condensers³ installed at Muskrat Falls Terminal Station and three additional
10 synchronous condensers installed at Soldiers Pond Terminal Station. Such a solution
11 would therefore not be practical.

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13 A list of breaker failure events on the IIS during the past 20 years are provided in
14 the table below.

³ For simulation purposes, synchronous condensers were assumed to be equivalent to Soldiers Pons units.

Newfoundland & Labrador Hydro Circuit Breaker Failures from 1996 to 2015			
SurgeID	Date/Time	HYDRO_ID	Notes
2496	Feb 16, 1997 09:00	Hardwoods B7C1	Breaker operating arm broken. No customer Impact
2540	Jul 02, 1997 10:00	Sunnyside B3T4	Breaker pole failed on opening. Customer outage to all of the Burin Peninsula, Sunnyside, Come By Chance and Arnolds Cove for to up 383 mins
2635	Feb 17, 1998 09:35	Massey Drive B5L11	Breaker failed to close on all three phases during switching. No customer impact
2814	Apr 06, 1999 05:42	Holyrood B12L17	Breaker failed during line trip. No customer impact.
2970	Jan 07, 2000 12:49	Sunnyside L03L06	A-Phase support stack failed on opening. No customer impact.
3181	Dec 07, 2000 07:42	Hardwoods B7C1	Breaker operating arm broken. No customer Impact
3247	May 15, 2001 15:32	Springdale B1L23	Low oil in breaker. No customer impact.
4077	Jun 03, 2004 15:39	Stony Brook L05L31	Breaker phase failed. No customer impact.
4456	Jan 15, 2006 16:52	Hardwoods B7T2	Breaker failed and required to be replaced. Outage to 9,204 Newfoundland Power customers.
5187	Aug 13, 2008 10:32	Upper Salmon L34L63	Breaker failed to close. No customer Impact.
5202	Sep 04, 2008 18:35	Western Avalon B1L37	Air leak on breaker. No customer Impact
5205	Sep 30, 2008 01:15	Oxen Pond B5C1	Breaker failed to open. Stuck contact. No customer impact.
5487	Sep 04, 2009 08:13	Bottom Brook L11L33	Closed coil burnt out. No customer impact
5628	Mar 11, 2010 16:17	Bottom Brook B3L50	Breaker failed and had to be replaced. No immediate customer impact. Emergency planned outage of nine minutes for switching. Customers affected were Burgeo, Newfoundland Power customers in Codroy Valley, Port Aux Basque areas.
5618	Jun 04, 2010 07:04	Stony Brook B1C1	Broken linkage in breaker. No customer impact
6021	May 25, 2012 19:00	Bay d'Espoir B10B11	Stuck contact, failed to close during switching. No customer impact
6034	Jun 05, 2012 09:11	Bottom Brook B1L09	Air leak on breaker. No customer Impact

6071	Jul 06, 2012 13:27	Bottom Brook L09L33	Air leak on breaker. And failure during line trip. No customer Impact
6064	Jul 12, 2012 13:00	Holyrood B1L17	Oil leak on grading capacitors. No customer Impact
6082	Aug 14, 2012 06:41	Bay d'Espoir B2T3	Air leak on breaker. No customer Impact
6158	Jan 11, 2013 06:42	Holyrood B1L17	Flash over on breaker resulted in the loss of the Holyrood Plant and System Wide power interruptions. Affect Newfoundland Power and NL Hydro customers.
6324	Jan 04, 2014 09:05	Sunnyside B1L03	Breaker failed to open during transformer fire. Resulted in an outage to all customers on the Avalon Peninsula.
6324	Jan 04, 2014 09:05	Sunnyside B2T1	Breaker damaged during a transformer fire.
6326	Jan 05, 2014 21:27	Holyrood B1L17	Contact broken in breaker. Customer outage resulted during attempt to synch on-line Holyrood Unit 1 with this damaged breaker (unknown at the time). All customers on Avalon experienced an interruption.
6364	Apr 11, 2014 14:19	Hardwoods B1L01	Oil leak on grading capacitors. No customer Impact
6366	Apr 18, 2014 14:32	Holyrood B1L17	Air leak on breaker. No customer Impact
6454	Aug 05, 2014 15:16	Peter's Barren B1L41	Breaker faulted internally and had to be replaced. Resulted in customer outage to NI Hydro customers in Plum Point, Bear Cove, Main Brook, Roddickton, and St Anthony.
6525	Mar 05, 2015 11:15	Bay d'Espoir B5B6	Opened during switching. No customer impact.
6688	Mar 05, 2015 11:15	Bay d'Espoir B5B6	Air leak on breaker. No customer Impact
6571	Aug 06, 2015 12:49	Bottom Brook B3L50	Breaker failed during a lightning storm. Customer outage to Burgeo for 91 mins.