

CI Number: 46587**Title: Metro Voltage Support - Add Capacitor Bank**

Start Date: 2015/06
In-Service Date: 2016/12
Final Cost Date: 2017/06
Function: Transmission
Forecast Amount: \$3,373,511

DESCRIPTION:

This work order provides the cost for design, supply, and installation of 50 MVAR capacitor banks, complete with breaker and associated protection, on the 138 kV busses at Sackville (90H) and Lakeside (103H) substations.

The purpose of this project is to increase the transfer limit on the Onslow South transmission corridor into the metro Halifax load centre. It will allow oil and natural gas fired generation in Halifax to be incrementally displaced by more economic power from coal plants in Eastern Nova Scotia or from New Brunswick imports.

This is the first phase of investment to address transmission system restrictions that limit the uneconomic dispatch of Tuft's Cove generation. Five additional capital items, listed in Summary of Related CIs, will be submitted in 2016.

Summary of Related CIs +/- 2 years:

2016 CI 48025 L7018 Upgrade to 345kV & Capacitor \$21,505,112

2016 CI 48022 Spider Lake Substation Addition \$6,354,458

2016 CI 48024 90H - Sackville: Capacitor Bank Addition & L-6010/L6005 Breaker Upgrades \$3,857,964

2016 CI 48023 103H - Lakeside: Capacitor Bank Additions & L-6003 Breaker Upgrades \$3,236,286

2016 CI 48026 L-6033/L6035 CT Ratio Changes at 1H - Water St. \$50,516

Depreciation Class: Transmission Equipment - Substation

Estimated Life of the Asset: 40 Years

JUSTIFICATION:

Justification Criteria: Transmission Plant

Why do this project?

Tuft's Cove generation in the metro Halifax area supplies reactive power to support steady state voltages during the combination of high transfer levels on the Onslow South transmission corridor and high system load (greater than 1600 MW). This isn't a concern when the Tuft's Cove fuel (gas or oil) is comparable to other fuel sources in the system, as these units would be dispatched economically. However, Tuft's Cove is occasionally required to be dispatched in order to provide reactive power capability in the metro Halifax area. Some of the reactive power is used for steady state voltage support while the rest is counted towards the reactive reserve which is needed for dynamic voltage support (required in the event of a transmission line trip). In this scenario, when gas or oil prices are higher than other fuel sources in the system, the cost of running Tufts Cove is uneconomic.

By installing capacitor banks, reactive power requirements to support steady state voltage from Tuft's Cove generators can be reduced. Additional static reactive power sources will release dynamic reactive power from generators and the Brushy Hill SVC. This additional reactive power can be counted towards reactive power reserve needed during contingency. In this way, higher Onslow South transfer can be achieved with reduced Tuft's Cove Generation. Another benefit of using capacitor banks over synchronous condensers is that capacitors banks have much lower real power losses.

Why do this project now?

System study has shown that, 100 MVAR of reactive power located on the power system south of Onslow substation increases the Onslow South corridor transfer capability by 70-90 MW. A study using the system planning simulation model Plexos has concluded that a reduction in must-run Halifax based generation improves the economics of system dispatch.

Why do this project this way?*Alternative A “Do Nothing”:*

This is a status quo option. There is no investment and no benefit. NPV is zero.

Alternative B “Install 50MVAR CAP Banks at both Sackville and Lakeside substations”:

This is the economic option – the capital investment avoids incremental uneconomic dispatch fuel costs at Tuft’s Cove. Please refer to the corresponding Economic Analysis Model.

Using the Plexos model, the optimum size of capacitor bank that would minimize the fuel cost was found to be 100 MVAR. Upgrading to higher than 100 MVAR will not have further significant fuel savings. NS Power transmission planning engineers consider the maximum size of a single capacitor bank in the metro area to be 50 MVAR for all possible operating conditions. Capacitor banks larger than 50 MVAR would change the system voltage significantly causing adverse impact on voltage sensitive customer equipment. More than two capacitor banks smaller than 50 MVAR each and totaling 100 MVAR would increase the capital investment significantly. Hence, it was decided to install two capacitor banks of size 50 MVAR each.

Five 138 kV substations in the metro were considered. It was found that Sackville and Lakeside substations can each accommodate a 50 MVAR capacitor bank. Physical space was a concern at other substations considered.

CI Number : 46587-T856 - Metro Voltage Support Add Capacitor

Project Number T856

Parent CI Number : -

Cost Centre : 800 - 800-Services - Admin.

Budget Version 2016 ACE Plan

Capital Item Accounts

Acct	Actv	Account	Activity	Forecast Amount	Amount	Variance
092		092-Vehicle T&D Reg. Labour AO		114,767	0	114,767
094		094 - Interest Capitalized		99,521	0	99,521
095		095-COPS Regular Labour AO		171,133	0	171,133
095		095-COPS Contracts AO		182,217	0	182,217
012	003	012 - Materials	003 - TP - Bldg.,Struct.Grnd.	127,847	0	127,847
013	003	013 - COPS Contracts	003 - TP - Bldg.,Struct.Grnd.	382,620	0	382,620
001	022	001 - T&D Regular Labour	022 - TP - Elec Contr.Equip.	22,250	0	22,250
012	022	012 - Materials	022 - TP - Elec Contr.Equip.	124,200	0	124,200
013	022	013 - COPS Contracts	022 - TP - Elec Contr.Equip.	48,000	0	48,000
012	023	012 - Materials	023 - TP - Power Equip.-Station S	23,200	0	23,200
013	023	013 - COPS Contracts	023 - TP - Power Equip.-Station S	12,160	0	12,160
001	043	001 - T&D Regular Labour	043 - TP - Substn Dev.	3,450	0	3,450
012	043	012 - Materials	043 - TP - Substn Dev.	1,060,140	0	1,060,140
013	043	013 - COPS Contracts	043 - TP - Substn Dev.	256,880	0	256,880
033	043	033 - Rental and Maintenance of	043 - TP - Substn Dev.	10,500	0	10,500
001	085	001 - T&D Regular Labour	085 Design	102,137	0	102,137
011	085	011 - Travel Expense	085 Design	1,880	0	1,880
013	085	013 - COPS Contracts	085 Design	92,000	0	92,000
066	085	066 - Other Goods & Services	085 Design	255,079	0	255,079
001	086	001 - T&D Regular Labour	086 Commissioning	111,200	0	111,200
011	087	011 - Travel Expense	087 Field Super.& Ops.	2,800	0	2,800
013	087	013 - COPS Contracts	087 Field Super.& Ops.	83,280	0	83,280
041	087	041 - Meals & Entertainment	087 Field Super.& Ops.	12,000	0	12,000
028	088	028 - Consulting	088 Survey/Mapping	74,250	0	74,250
Total Cost:				3,373,511	0	3,373,511
Original Cost:						

Capital Project Detailed Estimate

Location: Transmission					Cost Support	Completed Similar
CI# : 46587					Reference	Projects (FP#'s)
Title: Metro Voltage Support-Add Capacitor Bank						
Execution Year: 2016						
Description	Unit	Quantity	Unit Estimate	Total Estimate		
001 Regular Labour						
Electrician	PD	320	\$ 358	\$ 114,650		
Engineering & Project Support Technologists	PD	252	\$ 405	\$ 102,137		
	PD	67	\$ 332	\$ 22,250		
			Sub-Total	\$ 239,037		
011 Travel Expense						
Travel to Site	Lot	1	\$ 4,680	\$ 4,680		
				\$ -		
			Sub-Total	\$ 4,680		
012 Materials						
Structural Steel	Lot	1	\$ 111,000	\$ 111,000		
Grounding Materials	Lot	1	\$ 16,847	\$ 16,847		
Protection Panels / Control Cables	Lot	1	\$ 124,200	\$ 124,200		
Distribution Panels	Lot	1	\$ 23,200	\$ 23,200		
138kV Switches, Insulators, Circuit Breakers & Reactors	Lot	1	\$ 640,140	\$ 640,140		
Capacitor Banks	Ea	2	\$ 210,000	\$ 420,000		
			Sub-Total	\$ 1,335,387		
013 Contracts						
Concrete Foundations / Conduit / Fencing	Lot	1	\$ 382,620	\$ 382,620		
Control Cable Installation	Lot	1	\$ 48,000	\$ 48,000		
Dist. Panel Installation	Lot	1	\$ 12,160	\$ 12,160		
138kV Equip. Installation	Lot	1	\$ 256,880	\$ 256,880		
Field Supervision - Electrical	hr	480	\$ 76	\$ 36,480		
Field Supervision - Civil	hr	520	\$ 90	\$ 46,800		
Survey and Mapping	Lot	1	\$ 4,000	\$ 4,000		
Project Management	hr	880	\$ 100	\$ 88,000		
			Sub-Total	\$ 874,940		
028 Consulting						
Engineering Design	Hrs	550	\$ 135	\$ 74,250		
				\$ -		
			Sub-Total	\$ 74,250		
033 Rentals						
Boom Truck Rental	Lot	1	\$ 10,500	\$ 10,500		
				\$ -		
			Sub-Total	\$ 10,500		
041 Meals & Entertainment						
Meals during Construction	Lot	1	\$ 12,000	\$ 12,000		
				\$ -		
			Sub-Total	\$ 12,000		
066 Other Goods & Services						
Contingency	%	10%	\$ 2,550,794	\$ 255,079		
				\$ -		
			Sub-Total	\$ 255,079		
092 Vehicle Overhead						
Vehicle T&D Labour Regular AO				\$ 114,767		
Vehicle T&D Labour Overtime AO				\$ -		
			Sub-Total	\$ 114,767		
094 Interest Capitalized						
				\$ 99,521		
				\$ -		
			Sub-Total	\$ 99,521		
095 Administrative Overhead						
COPS T&D Labour Regular AO				\$ 171,133		
COPS Contract AO				\$ 182,217		
Project Support Regular AO				\$ -		
			Sub-Total	\$ 353,350		
				SUB-TOTAL (no AO, AFUDC)	\$ 2,805,874	
				TOTAL (AO, AFUDC included)	\$ 3,373,511	
Original Cost						
				\$ 724,751		

Note 1: The labour figures noted above are an average of salaries across a variety of jobs within similar classifications including fringe, and are used solely for budgeting purposes.

Note 2: Small differences in totals are attributable to rounding.

Metro Voltage Support - Add Capacitor Banks Summary of Alternatives



Division : Transmission Planning
Department : T&D Engineering
Originator :

Date : 03-Dec-15
CI Number: 46587
Project No. :

	Alternative	After Tax WACC	PV of Revenue Requirement	PV of EVA / NPV	Rank (based on PV of RR)	IRR	Disc Pay
A	100 MVAR Capacitor Bank	6.11%	-25,880,327	19,125,442	1	87.51%	1.3 years
B	Test 2	6.11%	0	0	2	#NUM!	0.0 years
C	Test 3	6.11%	0	0	2	#NUM!	0.0 years
D	Test 4	6.11%	0	0	2	#NUM!	0.0 years

Recommendation :

Based on the analysis, installing these two capacitor banks is a more economical option due to the avoided fuel costs.

Notes/Comments :

100 MVAR Capacitor Bank
 This option compares the proposed option of installing two capacitor banks with a "do nothing" option. The revenue shown represents fuel savings from avoided out-of-merit generation due to system constraints. By removing these constraints, NS Power is able to generate electricity at a less costly generating station. The annual avoided fuel costs are estimated at \$3,394,930, which was calculated through NS Power's generation modelling tool, Plexos.

Test 2

Test 3

Test 4

Metro Voltage Support - Add Capacitor Banks Summary of Sensitivities



Division : Transmission Planning
 Department : T&D Engineering
 Originator :

Date : 03-Dec-15
 CI Number: 46587
 Project No. :

Alternative	After Tax WACC	PV of Revenue Requirement	PV of EVA / NPV	Rank	IRR	Disc Pay
A 100 MVAR Capacitor Bank	6.11%	-25,880,327	19,125,442	1	87.51%	1.3 years
B Test 2	6.11%	0	0	2	#NUM!	0.0 years
C Test 3	6.11%	0	0	2	#NUM!	0.0 years
D Test 4	6.11%	0	0	2	#NUM!	0.0 years

Alternative Variance on Capital Spend	Variance (%)	PV of Revenue Requirement	PV of EVA / NPV	Rank	IRR	Disc Pay
A 100 MVAR Capacitor Bank	10%	-25,613,006	18,900,022	1	79.54%	1.4 years
B Test 2	10%	0	0	2	#NUM!	0.0 years
C Test 3	10%	0	0	2	#NUM!	0.0 years
D Test 4	10%	0	0	2	#NUM!	0.0 years

Change:	A	B	C	D	IRR	Disc Pay
	267,321	0	0	0	-7.97%	0.1 years
	0	0	0	0	#NUM!	0.0 years
	0	0	0	0	#NUM!	0.0 years
	0	0	0	0	#NUM!	0.0 years

Alternative Variance on Avoided Expenses	Variance (%)	PV of Revenue Requirement	PV of EVA / NPV	Rank	IRR	Disc Pay
A 100 MVAR Capacitor Bank	-10%	-25,880,327	19,125,442	1	87.51%	1.3 years
B Test 2	-10%	0	0	2	#NUM!	0.0 years
C Test 3	-10%	0	0	2	#NUM!	0.0 years
D Test 4	-10%	0	0	2	#NUM!	0.0 years

Change:	A	B	C	D	IRR	Disc Pay
	0	0	0	0	0.00%	0.0 years
	0	0	0	0	#NUM!	0.0 years
	0	0	0	0	#NUM!	0.0 years
	0	0	0	0	#NUM!	0.0 years

Alternative Variance on Avoided Expenses - Change in Revenue Requirement		PV of Revenue Requirement	PV of Revenue Requirement	PV of Revenue Requirement	Delay?
	Yrs Delay:	1	2	3	
A		126,635	2,976,906	5,543,463	No
B		0	0	0	No
C		0	0	0	No
D		0	0	0	No

Metro Voltage Support - Add Capacitor Banks Avoided Cost Calculations



Division :	Transmission Planning	Date :	03-Dec-15
Department :	T&D Engineering	CI Number:	46587
Originator :		Project No. :	

100 MVAR Capacitor Bank

Year	Avoided Replacement Energy Costs		Avoided Unplanned Repair Costs		Total Annual Avoided Costs	
	2016	2017	2016	2017	2016	2017
Replacement Energy Cost (\$/MWh)	0.00	0.00				
Repair Cost (\$)			0	0		
Events/Outages (#)	0	0	0	0		
Probability of Occurrence (%)	0%	0%	0%	0%		
Capacity Factor (%)	100%	100%				
Energy Replaced (MW)	0.0	0.0				
Duration (Hours)	0	0				
Totals	\$0	\$0	\$0	\$0	\$0	\$0
Total Capital Cost of Alternative						\$3,373,511

Test 2

Year	Avoided Replacement Energy Costs		Avoided Unplanned Repair Costs		Total Annual Avoided Costs	
	2016	2017	2016	2017	2016	2017
Replacement Energy Cost (\$/MWh)	0.00	0.00				
Repair Cost (\$)			0	0		
Events/Outages (#)	0	0	0	0		
Probability of Occurrence (%)	0%	0%	0%	0%		
Capacity Factor (%)	100%	100%				
Energy Replaced (MW)	0.0	0.0				
Duration (Hours)	0	0				
Totals	\$0	\$0	\$0	\$0	\$0	\$0
Total Capital Cost of Alternative						\$0

Test 3

Year	Avoided Replacement Energy Costs		Avoided Unplanned Repair Costs		Total Annual Avoided Costs	
	2016	2017	2016	2017	2016	2017
Replacement Energy Cost (\$/MWh)	0.00	0.00				
Repair Cost (\$)			0	0		
Events/Outages (#)	0	0	0	0		
Probability of Occurrence (%)	0%	0%	0%	0%		
Capacity Factor (%)	100%	100%				
Energy Replaced (MW)	0.0	0.0				
Duration (Hours)	0	0				
Totals	\$0	\$0	\$0	\$0	\$0	\$0
Total Capital Cost of Alternative						\$0

Test 4

Year	Avoided Replacement Energy Costs		Avoided Unplanned Repair Costs		Total Annual Avoided Costs	
	2016	2017	2016	2017	2016	2017
Replacement Energy Cost (\$/MWh)	0.00	0.00				
Repair Cost (\$)			0	0		
Events/Outages (#)	0	0	0	0		
Probability of Occurrence (%)	0%	0%	0%	0%		
Capacity Factor (%)	100%	100%				
Energy Replaced (MW)	0.0	0.0				
Duration (Hours)	0	0				
Totals	\$0	\$0	\$0	\$0	\$0	\$0
Total Capital Cost of Alternative						\$0

Metro Voltage Support - Add Capacitor Banks

100 MVAR Capacitor Bank

Year	Total Revenue	Operating Costs	Avoided Expenses	Capital	CCA	UCC	CFBT	Applicable Taxes	CFAT	PV of CF	Discount Factor	CNPV
2015	-	-	-	(102,501.8)	-	-	(102,501.8)	-	(102,501.8)	(102,501.8)	1.00	(102,501.8)
2016	141,455.4	-	-	(2,547,813.2)	102,031.8	2,577,962.9	(2,406,357.8)	(12,221.3)	(2,418,579.2)	(2,279,313.1)	0.94	(2,381,815.0)
2017	3,394,930.0	-	-	(255,079.4)	216,307.4	2,595,164.1	3,139,850.6	(985,373.0)	2,154,477.5	1,913,503.9	0.89	(468,311.1)
2018	3,394,930.0	-	-	-	199,002.8	2,376,316.2	3,394,930.0	(990,737.4)	2,404,192.6	2,012,335.1	0.84	1,544,024.0
2019	3,394,930.0	-	-	-	183,082.6	2,174,976.1	3,394,930.0	(995,672.7)	2,399,257.3	1,892,568.3	0.79	3,436,592.3
2020	3,394,930.0	-	-	-	168,435.9	1,989,743.2	3,394,930.0	(1,000,213.2)	2,394,716.8	1,780,215.6	0.74	5,216,807.9
2021	3,394,930.0	-	-	-	154,961.1	1,819,328.9	3,394,930.0	(1,004,390.4)	2,390,539.6	1,674,781.1	0.70	6,891,589.0
2022	3,394,930.0	-	-	-	142,564.2	1,662,547.8	3,394,930.0	(1,008,233.4)	2,386,696.6	1,575,807.0	0.66	8,467,396.0
2023	3,394,930.0	-	-	-	131,159.1	1,518,309.2	3,394,930.0	(1,011,769.0)	2,383,161.0	1,482,869.3	0.62	9,950,265.3
2024	3,394,930.0	-	-	-	120,666.3	1,385,609.6	3,394,930.0	(1,015,021.7)	2,379,908.3	1,395,575.7	0.59	11,345,840.9
2025	3,394,930.0	-	-	-	111,013.0	1,263,526.1	3,394,930.0	(1,018,014.3)	2,376,915.7	1,313,562.2	0.55	12,659,403.1
2026	3,394,930.0	-	-	-	102,132.0	1,151,209.2	3,394,930.0	(1,020,767.4)	2,374,162.6	1,236,491.1	0.52	13,895,894.2
2027	3,394,930.0	-	-	-	93,961.4	1,047,877.6	3,394,930.0	(1,023,300.3)	2,371,629.7	1,164,048.6	0.49	15,059,942.8
2028	3,394,930.0	-	-	-	86,444.5	952,812.6	3,394,930.0	(1,025,630.5)	2,369,299.5	1,095,942.8	0.46	16,155,885.6
2029	3,394,930.0	-	-	-	79,528.9	865,352.8	3,394,930.0	(1,027,774.3)	2,367,155.7	1,031,901.9	0.44	17,187,787.5
2030	3,394,930.0	-	-	-	73,166.6	784,889.8	3,394,930.0	(1,029,746.6)	2,365,183.4	971,672.9	0.41	18,159,460.4
2031	3,394,930.0	-	-	-	67,313.3	710,863.8	3,394,930.0	(1,031,561.2)	2,363,368.8	915,019.8	0.39	19,074,480.2
2032	-	-	-	-	61,928.2	642,759.9	-	19,197.8	19,197.8	7,004.8	0.36	19,081,484.9
2033	-	-	-	-	56,974.0	580,104.3	-	17,661.9	17,661.9	6,073.3	0.34	19,087,558.2
2034	-	-	-	-	52,416.1	522,461.1	-	16,249.0	16,249.0	5,265.7	0.32	19,092,823.9
2035	-	-	-	-	48,222.8	469,429.4	-	14,949.1	14,949.1	4,565.5	0.31	19,097,389.4
2036	-	-	-	-	44,365.0	420,640.3	-	13,753.1	13,753.1	3,958.4	0.29	19,101,347.8
2037	-	-	-	-	40,815.8	375,754.2	-	12,652.9	12,652.9	3,432.0	0.27	19,104,779.9
2038	-	-	-	-	37,550.5	334,459.1	-	11,640.7	11,640.7	2,975.7	0.26	19,107,755.5
2039	-	-	-	-	34,546.5	296,467.6	-	10,709.4	10,709.4	2,580.0	0.24	19,110,335.5
2040	-	-	-	-	31,782.7	261,515.3	-	9,852.6	9,852.6	2,236.9	0.23	19,112,572.4
2041	-	-	-	-	29,240.1	229,359.3	-	9,064.4	9,064.4	1,939.4	0.21	19,114,511.8
2042	-	-	-	-	26,900.9	199,775.8	-	8,339.3	8,339.3	1,681.5	0.20	19,116,193.4
2043	-	-	-	-	24,748.8	172,558.9	-	7,672.1	7,672.1	1,457.9	0.19	19,117,651.3
2044	-	-	-	-	22,768.9	147,519.4	-	7,058.4	7,058.4	1,264.1	0.18	19,118,915.4
2045	-	-	-	-	20,947.4	124,483.0	-	6,493.7	6,493.7	1,096.0	0.17	19,120,011.3
2046	-	-	-	-	19,271.6	103,289.6	-	5,974.2	5,974.2	950.2	0.16	19,120,961.6
2047	-	-	-	-	17,729.9	83,791.6	-	5,496.3	5,496.3	823.9	0.15	19,121,785.5
2048	-	-	-	-	16,311.5	65,853.5	-	5,056.6	5,056.6	714.3	0.14	19,122,499.8
2049	-	-	-	-	15,006.6	49,350.4	-	4,652.0	4,652.0	619.3	0.13	19,123,119.1
2050	-	-	-	-	13,806.1	34,167.5	-	4,279.9	4,279.9	537.0	0.13	19,123,656.1
2051	-	-	-	-	12,701.6	20,199.3	-	3,937.5	3,937.5	465.6	0.12	19,124,121.7
2052	-	-	-	-	11,685.4	7,348.6	-	3,622.5	3,622.5	403.7	0.11	19,124,525.4
2053	-	-	-	-	10,750.6	(4,474.1)	-	3,332.7	3,332.7	350.0	0.11	19,124,875.4
2054	-	-	-	-	9,890.6	(15,351.0)	-	3,066.1	3,066.1	303.4	0.10	19,125,178.8
2055	-	-	-	-	9,099.3	(25,357.7)	-	2,820.8	2,820.8	263.1	0.09	19,125,441.9
Total	51,065,405.4	-	-	(2,905,394.5)	2,701,231.7		48,160,010.9	(14,992,893.9)	33,167,117.0	19,125,441.9		

