Facilities Study
For
BC Hydro Distribution
NITS 2004

Report # SP2005 – 26

September, 2005

System Planning and Performance Assessment

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Executive Summary

In September 2004, "BC Transmission Corporation" (BCTC) received a 10 year application from "BC Hydro Distribution" (BCHD) for Network Integrated Transmission Service. Further to the May 2005 "System Impact Study for BC Hydro Distribution NITS 2004 - Stage 3 (Final) Revision 1, Report # SP2005-06" (SIS),
http://www.bctc.com/NR/rdonlyres/7242916C-A344-434E-8C4E5B27108ADB9B/0/SIS_Stage3Revision1.pdf
this Facilities Study (FS) identifies the required modifications to BCTC Transmission System, including a planning estimate (+/-30% accuracy) of the cost and scheduled completion date for such modifications to provide the requested transmission service for Resource Scenario 1. It also provides a first cut estimate (-50% / +100% accuracy) of the additional modifications required for Scenario 2. Both resource scenarios were defined in the SIS.

The FS concludes that, to provide adequate transmission capacity for both resource scenarios, the following Network Upgrades will be required:

INTERIOR TO LOWER MAINLAND REINFORCEMENTS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST($ M)**
1	NIC-MDN 500 kV Line (5L83) 50% series compensation, at Ruby Creek Capacitor Station (RBY), 3000 A. One 500 kV 122.5 MVAr fixed line reactor at NIC.	Oct. 2013 (Scn1&2)	$307.3 M
2	KLY-CKY 500 kV Line (5L46) 50% series compensation at CRK, 3000 A. One 500 kV 122.5 MVAr fixed line reactor at KLY. One 500 kV 122.5 MVAr switchable shunt reactor at CKY.	Oct. 2017 (Scn. 1) Oct. 2014 (Scn. 2)	$350.5 M $331.2 M
3	MDN 2x110 MVAr 230 kV switchable shunt capacitors. ING 2x110 MVAr 230 kV switchable shunt capacitors. ING one -100/+150 MVAr 230 kV SVC	Oct. 2008 (Scn1&2) Oct. 2008 (Scn1&2) Oct. 2009 (Scn1&2)	$4.4 M $5.1 M $32.2 M
LOWER MAINLAND TO VANCOUVER ISLAND REINFORCEMENTS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST($ M)**
4	ARN-VIT 230kV AC Cable Circuit (2L129) with a 600 MVA 230 kV phase shifting transformer at VIT.	Oct. 2008 (Scn1&2)	$237.5 M
5	TBY 230 kV, 66.1 MVAr fixed shunt reactor SAT 230 kV, 66.1 MVAr switchable shunt reactor[1]	Oct. 2008 (Scn1&2) Oct. 2008 (Scn1&2)	$4.1 M $3.2 M
6	2nd ARN-VIT 230kV AC cable circuit (2L124), a 600 MVA 230 kV phase shifting transformer at VIT, a 66.1 MVAr 230 kV fixed shunt reactor at TBY[2]	Oct. 2014 (Scn. 1) Oct. 2010 (Scn. 2)	$220.5 M $204.9 M
7	ING-ARN upgrading 230 kV circuits 2L10 & 2L57	Oct. 2014 (Scn. 1) Oct. 2010 (Scn. 2)	$17.4 M $16.0 M
SOUTH INTERIOR REINFORCEMENTS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST($ M)**
8	Series compensation of 5L91, 5L96, and 5L98 50% compensation, 2750 A	Oct. 2009 (Scn1&2)	$71.3 M
9	SEL transformer bank addition T4 (1200 MVA)	Nov.2007 (Scn1&2)	$13.3 M
10	SEL 500 kV, 123 MVAr switchable shunt Reactor	Sep 2007 (Scn1&2)	$5.5 M
11	ACK 250 MVAr switchable shunt capacitor # 1	Oct. 2009 (Scn1&2)	$3.7 M
12	ACK 250 MVAr switchable shunt capacitor # 2	Oct. 2022 (Scn. 2)	$4.7 M
13	NIC 500 kV station reconfiguration	Oct 2011(Scn1& 2)[3]	$5.7 M

[1] In the SIS both reactors were identified in SAT.
[2] The TBY fixed shunt reactor was not identified in the SIS.
[3] In Scenario 1 of the SIS the ISD of this item was October 2009.

14	Series compensation of 5L71 and 5L72, each line 40% compensation and 2750 A[4]	Oct. 2023 (Scn. 1) Oct. 2017 (Scn. 2)	$57.2 M $51.2 M
NORTHERN REGION REINFORCEMENT			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST($ M)**
15	SKA interconnection of KIT-SCGT (180 MW)	Oct. 2009 (Scn. 1)	None
16	Upgrade KDY series capacitor station: Increase the series compensation from 50% to 65%. Increase the rated current of series capacitors from 2310 A to 2500 A.	Oct. 2014 (Scn. 2)	$41.2 M
17	Upgrade MLS series capacitor station: Increase the series compensation from 50% to 65%. Increase the rated current of series capacitors from 1950 A to 2500 A.	Oct. 2014 (Scn. 2)	$51.9 M
18	Upgrade 5L1, 5L2 and 5L3 from 2500 A to 2750 A	Oct. 2014 (Scn. 2)	$3.4 M
19	Upgrade 5L11and 5L12 from 2500 A to 2750 A	Oct. 2014 (Scn. 2)	$2.9 M
20	WSN 500 kV, +500 MVAr Dynamic Compensation	Oct. 2014 (Scn. 2)	$61.5 M
21	KLY 500 kV, +500 MVAr Dynamic Compensation	Oct. 2014 (Scn. 2)	$71.8 M
22	PCN interconnection of two 500 kV circuits from Site C (900 MW)	Oct. 2014 (Scn. 2)	$28.7 M
23	SKA interconnection of NW_Wind (700 MW)	Oct. 2014 (Scn. 2)	$19.3 M
24	Series Compensation of 5L61, 35% compensation, 1025 A	Oct. 2014 (Scn. 2)	$16.4 M
REINFORCEMENTS COMMON TO ALL REGIONS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST($ M)**
25	Apply Remedial Action Schemes (RAS)	2008-16 (Scn. 1) 2016-24 (Scn. 2)	$8.9 M $10.6 M

The FS indicates that all, but two, of the SIS reinforcements and upgrades can be completed at their required in-service dates (ISD). To achieve the transmission additions in Selkirk Substation, the ISD of SEL transformer T4 has to be deferred by one year from November 2006 to November 2007 and the ISD of SEL 500 kV shunt reactor has to change from July 2006 to September 2007.

Since completion of the NITS2004 SIS-Stage 3 report in May 2005, BC Hydro has withdrawn its designated VICFT plant at Duke Point – Vancouver Island (VI) and has committed to new generation levels in VI and the coastal region. The impact of the new resource commitment on the timing of the suggested reinforcements has been reviewed. It is concluded that without the Duke Point plant, the ISDs of items 6 and 7 above will be advanced from October 2014 to October 2013 for Scenario 1 and from October 2010 to October 2009 for Scenario 2. The ISD of 5L46 will be deferred from October 2017 to October 2021.

In this facilities study, BCTC investigated the possibility of expediting the ISD of NIC-MDN 500 kV line 5L83. It is concluded that it will be possible to advance the ISD of this project from October 2013 to October 2012. The earlier ISD will be subject to completing the definition phase of the study and acquiring all the CPCN and Environmental approvals by 31 March 2008. It also means that all the engineering and preliminary layout activities must be undertaken as a part of the project definition phase.

Based on the above estimates, the total cost of all transmission additions and reinforcements for Scenario 1 will be $1,347.6 M. The total cost for Scenario 2 will be $1,608.7 M. All costs are "Capital Direct Inflated" Dollars and include 2.58% Overhead (OH) and 4.96% Interest During Construction (IDC). The estimates do not include the cost of removing retired equipment.

[4] In the SIS this item was rated 3200 A, was only identified for Scenario 2, and had a October 2012 in-service date.

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1. Introduction

This FS report succeeds to the following three SIS reports:

1. SP2005-04 entitled “System Impact Study for BC Hydro Distribution NITS 2004 Stage 1” completed by BCTC on February 28, 2005.
2. SP2005-05 entitled “System Impact Study for BC Hydro Distribution NITS 2004 Stage 2” completed by BCTC on March 31, 2005.
3. SP2005-05 entitled “System Impact Study for BC Hydro Distribution NITS 2004 Stage 3 (Final), Revision 1” completed by BCTC on May 31, 2005.

Following the release of Stage 3 report, BCHD confirmed that the NITS2004 FS should cover the following:

- Schedule and a +/-30% cost estimate for transmission additions and upgrades required for BC Hydro’s “Base Resource Plan” (Scenario 1).
- Schedule and a -50% / +100% cost estimate for transmission additions and upgrades required for BC Hydro’s “Alternative Resource Plan” (Scenario 2).

For reference, resource additions for both scenarios, together with their associated load and firm export designations, are copied from the NITS2004 SIS reports. Removal of VICFT from both resource plans is discussed in section 4:

Table 1.1: “Base Resource Plan” - Scenario 1

Year	**Name**	Peace	Columbia	LM	VI
2003/2004	Market reserves		86	314	
2004/2005	DSBs		107	393	
By 2007/2008	IPP_EPA	119	136	270	160
2007/2008	VICFT				293
By 20010/2011	GMS Resource smart-1	246			
2009/2010	Alcan	-147			
2009/2010	KIT_SCGT	180			
2010/2011	System Generic-1	117	117	121	
By 2011/2012	Mica Resource smart		130		
2012/2013	System Generic-2	60	60	60	
2013/2014	System Generic-3	60	59	60	
2014/2015	Burrard retired			-960	
2014/2015	System Generic-4	410	410	423	
By 2018/19	GMS Resource smart-2	77			
2018/19	NWE retirement	-68			
2018/19	Rev 5		500		
By 2018/19	System Generic-5	293	293	302	
2023/24	Mica 5		450		
By 2023/2024	System Generic-6	352	352	362	
	Totals	**1699**	**2700**	**1345**	**453**

The “Base Resource Plan”, shown in Table 1.1, is designated to supply BC Hydro’s October 2004 normal load forecast and 230 MW of firm export on BCTC x BPAT path.

Table 1.2: "Alternative 1 Resource Plan" - Scenario 2

Year	Name	Peace	Columbia	LM	VI
2003/2004	Market reserves		86	314	
2004/2005	DSBs		107	393	
By 2007/2008	IPP_EPA	140	140	300	160
2007/2008	VICFT				293
By 2009/2010	GMS Resource smart	246			
By 2011/2012	Mica Resource smart		130		
2011/2012	Rev 5		500		
2013/2014	Burrard retired			-960	
2014/2015	Site-C	900			
By 2014/2015	Kelly Generic	427			
2014/2015	North West Wind	700			
By 2018/19	GMS Resource smart	77			
2017/2018	Mica 5		450		
2018/2019	NWE retirement	-68			
2022/2023	Rev 6		500		
By 2023/2024	Kelly Generic	973			
	Totals	**3395**	**1827**	**-267**	**453**

The "Alternative Resource Plan", shown in Table 1.2, is designated to supply BC Hydro's October 2004 high load forecast and 230 MW of firm export on BCTC x BPAT path.

This report summarizes the deliverables of the NITS2004 - FS. Tables showing the required transmission reinforcements and their associated costs for scenarios 1 and 2 are shown in sections 2 and 3 respectively. In Appendix 1 of this Facilities Study there is one project summary sheet for each one of the identified reinforcement projects. Each project summary sheet includes "Justification", "Alternative Solution(s)", "Project Description", and "Project In-Service Date(s)" for its respective project.

2. Transmission Reinforcements for Scenario 1

Table 2.1 is a list of all the transmission reinforcements that are required for BCHD's Base Resource Plan and normal load forecast (Scenario 1). Specifics of each project are recorded in the project summary sheets of Appendix 1. All costs are "Capital Direct Inflated" Dollars and include 2.58% OH and 4.96% IDC. The estimates do not include the cost of removing retired equipment.

Table 2.1

SCENARIO 1: ILM REINFORCEMENTS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST ($ M)**
1	NIC-MDN 500 kV Line (5L83) 50% series compensation, at RBY, 3000 A. One 500 kV 122.5 MVAr fixed line reactor at NIC.	Oct. 2013	$307.3 M
2	KLY-CKY 500 kV Line (5L46) 50% series compensation at CRK, 3000 A. One 500 kV 122.5 MVAr fixed line reactor at KLY. One 500 kV 122.5 MVAr switchable shunt reactor at CKY.	Oct. 2017	$350.5 M
3	MDN 2x110 MVAr 230 kV switchable shunt capacitors ING 2x110 MVAr 230 kV switchable shunt capacitors	Oct. 2008 Oct. 2008	$4.4 M $5.1 M

	ING one -100/+150 MVAr 230 kV SVC	Oct. 2009	$32.2 M
SCENARIO 1: LM TO VI REINFORCEMENTS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST ($ M)**
4	ARN-VIT 230kV AC cable circuit (2L129) with a 600 MVA 230 kV phase shifting transformer at VIT.	Oct. 2008	$237.5 M
5	TBY 230 kV, 66.1 MVAr fixed shunt reactor SAT 230 kV, 66.1 MVAr switchable shunt reactor	Oct. 2008 Oct. 2008	$4.1 M $3.2 M
6	2nd ARN-VIT 230kV AC cable circuit (2L124), a 600 MVA 230 kV phase shifting transformer at VIT, a 66.1 MVAr 230 kV fixed shunt reactor at TBY	Oct. 2014	$220.5 M
7	ING-ARN upgrading 230 kV circuits 2L10 & 2L57	Oct. 2014	$17.4 M
SCENARIO 1: SOUTH INTERIOR REINFORCEMENTS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST ($ M)**
8	Series compensation of 5L91, 5L96, and 5L98 50% compensation, 2750 A	Oct. 2009	$71.3 M
9	SEL transformer bank addition T4 (1200 MVA, 500/230 kV)	Nov.2007	$13.3 M
10	SEL 500 kV 123 MVAr switchable shunt reactor	Sep. 2007	$5.5 M
11	ACK 250 MVAr 500 kV switchable shunt capacitor # 1	Oct. 2009	$3.7 M
12	NIC 500 kV station reconfiguration	Oct. 2011	$5.7 M
13	Series compensation of 5L71 and 5L72, each line 40% compensation and 2750 A	Oct. 2023	$57.2 M
SCENARIO 1: NORTHERN REGION REINFORCEMENT			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST ($ M)**
14	SKA interconnection of KIT-SCGT (180 MW)	Oct. 2009	None
SCENARIO 1: REINFORCEMENTS COMMON TO ALL REGIONS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST ($ M)**
15	Apply remedial action schemes (RAS)	2008 to 2017	$8.9 M
TOTAL COST OF UPGRADES FOR SCENARIO 1			**$1,347.6 M**

The annual cash flow of each project is shown in the project's respective section in Appendix 1. The annual cash flow of costs for all projects of Scenario 1 is recorded in Table A2.1 of Appendix 2.

3. Transmission Reinforcements for Scenario 2

Table 3.1 is a list of all the transmission reinforcements that are required for BCHD's Alternative Resource Plan and high load forecast (Scenario 2). Specifics of each project are recorded in the project summary sheets of Appendix 1. All costs are "Capital Direct Inflated" Dollars and include 2.58% OH and 4.96% IDC. The estimates do not include the cost of removing retired equipment.

Table 3.1

SCENARIO 2: ILM REINFORCEMENTS			
ITEM	**PROJECT DESCRIPTION**	**IN-SERVICE DATE**	**COST ($ M)**
1	NIC-MDN 500 kV Line (5L83) 50% series compensation, at RBY, 3000 A. One 500 kV 122.5 MVAr fixed line reactor at NIC	Oct. 2013	$307.3 M
2	KLY-CKY 500 kV Line (5L46) 50% series compensation at CRK, 3000 A. One 500 kV 122.5 MVAr fixed line reactor at KLY. One 500 kV 122.5 MVAr switchable shunt reactor at CKY.	Oct. 2014	$331.2 M
3	MDN 2x110 MVAr 230 kV switchable shunt capacitors. ING 2x110 MVAr 230 kV switchable shunt capacitors. ING one -100/+150 MVAr 230 kV SVC	Oct. 2008 Oct. 2008 Oct. 2009	$4.4 M $5.1 M $32.2 M

SCENARIO 2: LM TO VI REINFORCEMENTS			
ITEM	PROJECT DESCRIPTION	IN-SERVICE DATE	COST ($ M)
4	ARN-VIT 230kV AC cable circuit (2L129) with a 600 MVA 230 kV phase shifting transformer at VIT.	Oct. 2008	$237.5 M
5	TBY 230 kV, 66.1 MVAr fixed shunt reactor SAT 230 kV, 66.1 MVAr switchable shunt reactor	Oct. 2008 Oct. 2008	$4.1 M $3.2 M
6	2nd ARN-VIT 230kV AC cable circuit (2L124), a 600 MVA 230 kV phase shifting transformer at VIT, a 66.1 MVAr 230 kV fixed shunt reactor at TBY	Oct. 2010	$204.9 M
7	ING-ARN upgrading 230 kV circuits 2L10 & 2L57	Oct. 2010	$16.0 M
SCENARIO 2: SOUTH INTERIOR REINFORCEMENTS			
ITEM	PROJECT DESCRIPTION	IN-SERVICE DATE	COST ($ M)
8	Series compensation of 5L91, 5L96, and 5L98 50% compensation, 2750 A	Oct. 2009	$71.3 M
9	SEL transformer bank addition T4 (1200 MVA, 500/230 kV)	Nov.2007	$13.3 M
10	SEL 500 kV, 123 MVAr switchable shunt reactor	Sep. 2007	$5.5 M
11	ACK 250 MVAr 500 kV switchable shunt capacitor # 1	Oct. 2009	$3.7 M
12	ACK 250 MVAr 500 kV switchable shunt capacitor # 2	Oct. 2022	$4.7 M
13	NIC 500 kV station reconfiguration	Oct. 2011	$5.7 M
14	Series compensation of 5L71 and 5L72, each line 40% compensation and 2750 A	Oct. 2017	$51.2 M
SCENARIO 2: NORTHERN REGION REINFORCEMENT			
ITEM	PROJECT DESCRIPTION	IN-SERVICE DATE	COST ($ M)
15	Upgrading KDY Capacitor Station: Increase the series compensation from 50% to 65%. Increase the rated current of series capacitors from 2310 A to 2500 A.	Oct. 2014	$41.2 M
16	Upgrading MLS Capacitor Station: Increase the series compensation from 50% to 65%. Increase the rated current of series capacitors from 1950 A to 2500 A.	Oct. 2014	$51.9 M
17	Upgrade 5L1, 5L2 and 5L3 from 2500 A to 2750 A	Oct. 2014	$3.4 M
18	Upgrade 5L11and 5L12 from 2500 A to 2750 A	Oct. 2014	$2.9 M
19	WSN 500 kV, +500 MVAr Dynamic Compensation	Oct. 2014	$61.5 M
20	KLY 500 kV, +500 MVAr Dynamic Compensation	Oct. 2014	$71.8 M
21	PCN interconnection of two 500 kV circuits from Site C (900 MW)	Oct. 2014	$28.7 M
22	SKA interconnection of NW_Wind (700 MW)	Oct. 2014	$19.3 M
23	Series compensation of 5L61, 35% compensation, 1025 A	Oct. 2014	$16.4 M
SCENARIO 2: REINFORCEMENTS COMMON TO ALL REGIONS			
ITEM	PROJECT DESCRIPTION	IN-SERVICE DATE	COST ($ M)
24	Apply remedial action schemes (RAS)	2016 to 2024	$10.6 M
TOTAL COST OF UPGRADES FOR SCENARIO 2			**$1,608.7 M**

The annual cash flow of each project is shown in the project's respective section in Appendix 1. The annual cash flow of costs for all projects of Scenario 2 is recorded in Table A2.2 of Appendix 2.

4. Impact of Withdrawing Duke Point Plant

In August 2005, BC Hydro informed BCTC that the Vancouver Island generation commitments were reduced because BC Hydro abandoned the VICFT generation at Duke Point Plant. After withdrawing Duke Point from the designated list of resources, BC Hydro changed the "Committed On-Island Generation" from 636 MW to 562 MW in F2009 and to 584 MW in F2010 and beyond. The change of committed on-Island generation affects timing of the transmission reinforcement items 6 and 7 in the above tables 2.1 and 3.1. These items are related to the second stage of the VI transmission reinforcement.

- Item # 6: 2nd ARN-VIT 230kV AC cable circuit (2L124), a 600 MVA 230 kV phase shifting transformer at VIT, a 66.1 MVAr 230 kV fixed shunt reactor at TBY.
- Item # 7: ING-ARN upgrading 230 kV circuits 2L10 and 2L57.

Because of BC Hydro's new committed on-Island generation, the in-service dates of the above items will be advanced from October 2014 to October 2013 for Scenario 1 and from October 2010 to October 2009 for Scenario 2.

It should be noted that the in-service dates of this analysis are different from those stated in the BCTC's CPCN application for the Vancouver Island Transmission Reinforcement project. In the CPCN application, the Vancouver Island dependable generation was used, which is higher than the Vancouver Island generation commitments designated by BC Hydro in August 2005. Therefore, the in-service dates of the second 230 kV cable circuit and the related items in this section are earlier than the dates stated in the CPCN application.

5. Impact of Increasing Coastal Generation

In the SIS, BC Hydro directed BCTC to consider 1250 MW as committed coastal generation. This level of coastal generation was used in determining the ISD of ILM reinforcements. In August 2005, following the withdrawal of Duke Point Plant, BC Hydro informed BCTC about their new committed amount of coastal generation as listed in Table 5.1.

Table 5.1

	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Coastal Generation (MW)	1296.0	1320.1	1320.6	1256.6	1281.9	1335.7	1335.7	1362.6	1389.5

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Coastal Generation (MW)	1705.7	1759.5	1786.4	1813.3	1840.2	1867.0	1893.9	1947.7	1974.6

In this FS, BCTC reviewed the impact of new committed coastal generation on the ISD of ILM transmission reinforcements. It is concluded that with the new coastal generation the ISD of 5L46 will be deferred from October 2017 to October 2021 for Scenario 1. The ISD of 5L46 remains unchanged for Scenario 2.

6. Achievable In-Service Date of Selkirk Reinforcements

The Selkirk transformer T4 and the Selkirk 123 MVAr reactor projects are shown with in-service dates at their earliest possible dates which are now one year and 14 months respectively later than the dates stated in the NITS-SIS Stage 3 report.

The one year deferral of Selkirk T4 will extend compromising the normal criteria. During the deferral, generation shedding and RAS will be applied. The 14 month change to the ISD of Selkirk 123 MVAr reactor will make it necessary to continue to use more Selkirk area generators in synchronous condenser mode for voltage regulation.

7. Expediting the In-Service Date of 5L83

The SIS Stage 3 report identified the amount of Reliability Must Run (RMR) generation required in the coastal regions[5]. The required RMR levels are compared to BC Hydro's committed coastal generation levels of Table 5.1. The comparison shows that, for Scenario 1, the committed coastal generation will be exhausted by the load and losses in the LM and VI and by the firm US export in winter of 2008. For Scenario 2, the committed coastal generation will not be adequate for peak demand between 2005 and 2012. Consequently, the FS recommends the earliest ISD of 5L83 for reinforcing the ILM network.

Based on a normal schedule, the earliest ISD of 5L83 can be achieved in October 2013. However, BCTC investigated the possibility of reducing the project duration. It is concluded that it will be possible to advance the ISD of 5L83 by one year from October 2013 to October 2012. The October 2012 ISD will be subject to completing the definition phase of the project and acquiring all the CPCN[6] and environmental approvals by 31 March 2008. It also means that all the engineering and preliminary layout activities must be undertaken as a part of the project definition phase.

8. Conclusions

- Scopes of the transmission reinforcements and upgrades, that were identified in the NITS2004 SIS-Stage 3 report, are provided.
- The ISD of Selkirk transformer T4 can not be achieved sooner than November 2007.
- The ISD of Selkirk 500 kV shunt reactor can not be achieved sooner than September 2007.
- Withdrawing Duke Point Plant from VI resources together with BC Hydro's new on-island generation commitments are expected to advance the second stage of VI transmission reinforcement projects by one year.
- BC Hydro's new coastal generation commitments are expected to defer the ISD of 5L46 from October 2014 to October 2021 in Scenario 1.
- Advancing the earliest ISD of the 5L83 project from October 2013 to October 2012 will be subject to the timely acquisition of the CPCN and Environmental approvals and advancing some implementation activities to the definition phase of the project.
- The cost and cash flow of all Scenario 1 projects are estimated with +/- 30% accuracy.
- The cost and cash flow of all Scenario 2 incremental projects are estimated with - 50% / +100% accuracy. The definition phase of these projects are estimated separately with +/- 30%
- The estimated total cost of all transmission upgrades for Scenario 1 is $1,347.6 M.
- The estimated total cost of all transmission upgrades for Scenario 2 is $1,608.7 M.

[5] System Impact Study for BC Hydro Distribution NITS2004 – Stage 3 (Final) Revision 1, Page 13, tables 4.1 and 4.2.
[6] Certificate of Public Convenience and Necessity.

Appendix 1 – Project Summary Sheets

In this appendix each one of the NITS2004 transmission reinforcements / upgrades is justified, defined, and scoped in a separate "Project Summary Sheet". Each summary sheet is a brief technical reference for its associated transmission reinforcement / upgrade. Each summary sheet includes the project components that are estimated in this FS. For those reinforcements / upgrades that will be implemented, the actual scope will be finalized during the definition phase of the project. The outcome of project definition phase may not be identical to the scope of the project summary sheet.

A1.1 New Nicola - Meridian 500 kV Line 5L83

Justification:

Thermal transfer capability of the existing ILM network is up to 6300 MW. With 1250 MW coastal RMR generation, this capacity will be exhausted by the load and losses in the LM and VI and by the firm exports in 2007 (totaling 7672 MW). The shortage of ILM transfer capability can be removed by a combination of increased coastal generation and the incremental transfer capability that 5L83 provides.

- 5L83 will enhance the TTC of the ILM grid by up to 2100 MW. The increased TTC, together with the specified levels of coastal RMR, will allow dispatch of Interior generation sources to serve LM and VI load.
- 5L83 has the largest N-1-1 capability for maintenance outages of the ILM grid.
- 5L83 will significantly reduce the N-2 load and generation shedding requirements.
- 5L83 is an efficient option because it reduces the transmission losses on the grid.
- 5L83 reduces the coastal RMR.
- 5L83 increases the non-firm export capability on the BCTC x BPAT path.

Alternative Solutions:

In the SIS, the following alternatives, for removing the ILM transmission congestion, were reviewed:

- No-Line Option: Reinforcing the ILM grid by upgrading the existing transmission elements without building a new line. The No-Line option was first identified in the SIS for BC Hydro Generation Line-of-Business NITS2001 Part2, Report # NPP2002-10. Both options will provide approximately the same amount of TTC. The capital cost of No-Line option is less than the capital cost of 5L83. However, after considering the value of transmission losses over the life-time of both projects and the duration of construction outages, the net present value of costs for the No-Line option will become more than 5L83. In terms of transmission network reliability, 5L83 has higher performance indices as described above.
- 5L46: A new 500 kV series compensated line between Kelly Lake and Cheekye substations. Compared to 5L83, this option will provide less TTC for transfer of power from NIC. It will be routed through Pemberton corridor (which is considered an environmentally sensitive path), and it will require more RMR coastal generation (see section 4 of the NITS 2004 SIS Stage 3 Report).
- Increased Coastal RMR: Reinforcement of the ILM transmission network can be deferred if BCHD designates high levels of RMR coastal generation. Tables 3.2.1 and 3.2.2 of the SIS Stage 1 report identify the RMR required for deferring ILM Network Upgrades for scenarios 1 and 2 respectively.

Project Description:

The planned line 5L83 will be approximately 50% series compensated and will include one 500 kV transmission circuit between Nicola and Meridian substations, line termination at NIC, line termination at MDN, one 122.5 MVAr line reactor at NIC, and a series capacitor station. For approximately 75% of the route, 5L83 will be parallel to either 5L41 or 5L82 utilizing the existing right of way and minimizing the environmental impact of the new line. Protection of 5L83 will be equipped with Single Pole Reclose feature.

Total impedance of the series compensated line on 100 MVA base at 500 kV should be 0.01664 PU. This will make the compensated impedance of 5L83 identical to the compensated impedance of the existing Nicola-Meridian line 5L82 and will allow similar flows on both lines. The preferred location of this series capacitor station is near middle of the new Nicola-Meridian line. Final location will be determined during the definition phase of the 5L83 project. For the NITS2004 Facilities Study, it is assumed that 5L83 will be series compensated at BC Hydro owned Ruby Creek property near the junction of Talc Creek and Daioff Creek 8 km east of Harrison Lake. Scope of the estimated 5L83 project includes the following:

5L83 Transmission Circuit:
- Total Length: 249 km
- Rated Current: 3000 Amp
- Length Single Circuit Steel Tower (SCST) 500 kV: 237 km
- Length Double Circuit Steel Tower (DCST) 500 kV w/5L82: 12 km
- Delta SCST design, except high icing areas where Mk 8 design assumed
- Base Conductor: 4 B - SP926.7 45/7 ACSR

5L83 Route and Line Segments
- Nicola - Kingsvale, Length 50.0 km, SCST 500 kV Guyed, Parallel to 5L82, Easy Terrain
- Kingsvale - Uztlius, Length 19 km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain
- Uztlius - West Anderson, Length 16.5 km, SCST 500 kV Rigid, New Alignment, Rough Terrain
- West Anderson - East Anderson, Length 5.0 km, SCST 500 kV Rigid, Parallel to 5L41, Medium Terrain, 10 % Helicopter
- East Anderson - Chapmans, Length 11.0 km, SCST 500 kV Rigid, Parallel to 5L41, Medium Terrain
- Chapmans - Sawmill, Length 5.0 km, SCST 500 kV Rigid, Parallel to 5L41, Medium Terrain
- Sawmill - Yale, Length 9.3 km, SCST 500 kV Rigid, Parallel to 5L41, Med/ Rough Terrain, 20% Helicopter, 2 km DCST
- Yale - Lower Emory, Length 2.9 km, SCST 500 kV Rigid, Parallel to 5L41, Medium Terrain
- Lower Emory - American, Length 10.2 km, SCST 500 kV Rigid, Parallel to 5L81, Medium Terrain 10% Helicopter
- American - Upper Emory, Length 8.4 km, SCST 500 kV Rigid, New Alignment, Rough Terrain, 30% Helicopter
- Upper Emory - Ruby Ck , Length 11.6 km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain
- Ruby Ck - Hicks Ck, Length 4.8 km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain
- Hicks Ck - Bear Mtn, Length 5.7km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain, 50% Helicopter, 2 km DCST
- Bear Mtn - West Norrish, Length 29.5 km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain, 33% Helicopter, 2.6 km DCST
- West Norrish - Hatzic, Length 8.4 km, SCST 500 kV Rigid, New Alignment, Med/Rough Terrain, 60 % Helicopter
- Hatzic- Stave, Length 12.1km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain
- Stave - Pitt Polder, Length 22.6 km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain, 20% Helicopter
- Pitt Polder - Burke, Length 8.7 km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain,
- Burke - Meridian, Length 8.2 km, SCST 500 kV Rigid, Parallel to 5L82, Medium Terrain, 4 km DCST

Terminating 5L83 in Nicola Substation:
- 500 kV CB (5CB21, 3000 A, 40 KA, 33 ms) equipped with single and three pole trip and reclose.
- 500 kV CT (5CT21)

- 500 kV MOD (5D1CB21, 3000 A)
- 500 kV MOD (5D2CB21, 3000 A)
- 500 kV CVT (5CVT21)
- 500 kV Surge Arrester (5SAB21)
- 500 kV Line Reactor (5RX7, 122.5 MVAr)
- 500 kV Surge Arrester (5SA47)
- 500 kV DS (5D47, 4000 A)
- 500 kV Neutral Reactor (5NR7, 1000 Ohm at 60 Hz, 20 A)
- 500 kV Surge Arrester (5SANR7)
- 500 kV Line DS (5D27, 4000 A)
- 500 kV Ground DS (5GD27)
- Associated P&C additions.
- Associated Telecommunications and SCADA additions.

Terminating 5L83 in Meridian Substation:

- 500 kV CB (5CB5, 3000 A, 40 KA, staggered phase controllers SPC, POWC, single - and - three - pole trip and reclose).
- 500 kV CT (5CT5)
- 500 kV MOD (5D1CB5, 3000A)
- 500 kV MOD (5D2CB5, 3000A)
- 500 kV CB (5CB6, 3000 A, 40 KA, staggered phase controllers SPC, single - and - three - pole trip and reclose)
- 500 kV CT (5CT6)
- 500 kV MOD (5D1CB6, 3000A)
- 500 kV MOD (5D2CB6, 3000A)
- 500 kV CVT (5CVT3),
- 500 kV Surge Arrester (5SA83)
- 500 kV Line DS (5D23, 4000 A)
- 500 kV Ground DS (5GD23)
- Associated P&C additions
- Associated Telecommunications and SCADA additions

Ruby Creek Series Capacitor Station:

- Capacitor Bank (896 MVAR, 3000 A) to be placed in two platforms, actual components CTs, MOVs, etc. to be specified by manufacturer.
- 500 kV Bypassing CB (5CB1, 3000 A, 40 kA, 50ms) c/w CTs
- 500 kV MOD DS (5D1, 3000 A)
- 500 kV MOD DS (5D2, 3000 A)
- 500 kV MOD DS (5BP1, 3000 A)
- 500 kV Ground DS (5GD1, 3000 A)
- 500 kV Ground DS (5GD2, 3000 A)
- Associated P&C
- Associated Telecommunication

Project In-Service Date:

In both scenarios 1 and 2, 5L83 will be required at its earliest in-service date. The estimated earliest in-service date for 5L83 is October 2013 as per the following cash flow (all costs are in $000s):

Project description	Prior years	F2006	F2007	F2008	F2009	F2010	F2011	F2012	F2013	F2014	F2015	Total
NIC-MDN 500 kV Line (5L83)definition	169.90	2,003.10	3482	4,312.80	1,814.50	751.60	799.60	850.60	904.80	554.20		15,643.10
NIC-MDN 500 kV Line (5L83) Implementation						5,357.70	16,338.80	86,039.40	103,253.10	37,367.80	2,223.40	250,580.20
50% series compensation, at RYC, 3000 A.								1009.4	6462.5	19201.9		26,673.80
NIC Station work								351.70	2,197.90	5,746.20		8,295.80
MDN Station work								313.10	1,937.70	3,837.60		6,088.40

A1.2 New Kelly Lake - Cheekye 500 kV Line 5L46

Justification:
Even with the commissioning of 5L83 in October 2013, the ILM network will be unable to transfer the NITS2004 designated dispatch capacity of all Interior resources. In the NITS2004 SIS Stage 3 report, scenarios 1 and 2 require dispatch of both Northern and South interior resources and 1250 MW of coastal resources. Under these conditions, the post 5L83 ILM transmission network will be thermally constrained during winter peak single contingencies. Construction of 5L46 is one option for removing the ILM transmission congestion. 5L46 will relieve the network customer from designating new coastal resources, allowing them to retire their existing coastal resources, and giving them the full flexibility to dispatch maximum interior generation at all times.

Alternative Solutions:
Coastal generation would eliminate or defer the need for this project. Section 4 of the NITS2004 SIS-Stage 3 report identifies the coastal RMR levels that are required to defer 5L46.

Project Description:
5L46 will include one 500 kV transmission circuit between Kelly Lake and Cheekye substations with approximately 55% series compensation. The circuit will have line terminations at KLY and CKY, one 122.5 MVAr line reactor at KLY, one 122.5 MVAr switchable line reactor at CKY, and a series capacitor station preferably at CRK or near the middle of the line.

Total impedance of the series compensated line on 100 MVA base at 500 kV should be 0.01202 PU. This will make the compensated impedance of 5L46 identical to the compensated impedance of the existing Kelly Lake-Cheekye line 5L42 and will allow similar flows on both lines. The preferred location of this series capacitor station is near middle of the new Kelly Lake-Cheekye line. Final location will be determined during the definition phase of the 5L83 project. For the NITS2004 Facilities Study, it is assumed that 5L46 will be series compensated at the existing Creekside Capacitor Station. Scope of the estimated 5L46 project includes the following:

5L46 Transmission Circuit:
- Total Length: 203 km
- Length of Single Circuit Steel Tower (SCST) 500 kV: 129 km
- Length of Double Circuit Steel Tower (DCST) 500/230 kV w/ 2L2: 73 km
- Delta SCST design, except high icing areas where Mk 8 design assumed
- Base Conductor: 4 B - SP926.7 45/7 ACSR

Terminating 5L46 in Cheekye Substation:
- 500 kV CB (5CB11, 4000A, 40KA, 33ms, SPR) c/w 5CT11,
- 500 kV MOD DS (5D1CB11)
- 500 kV CVT (5CVT1)
- 500 kV Surge Arrester (5SA1)
- 500 kV Line DS 5D21
- Add SPR, SPC, and POWC on 5CB21
- 500 kV Shunt Reactor (5RX2, 135 MVAr)
- 500 kV CB (5CBRX2, 4000A, 40kA, 33ms)
- 500 kV MOD (D1)
- 500 kV Surge Arrester (5SARX2)
- Add segregated phase controller (SPC) and point-on-wave controller (POWC) to existing 5CB21.
- Associated telecom and SCADA additions.

Terminating 5L46 in Kelly Lake Substation:

- 500 kV CB (5CB6, 4000A, 40KA, SPC, SPR) c/w 5CT6
- 500 kV MOD DS (5D1CB6)
- 500 kV MOD DS (5D2CB6)
- 500 kV CB(5CB16, 4000A, 40KA, SPC, POWC, SPR) c/w 5CT16
- 500 kV MOD DS (5D1CB16)
- 500 kV MOD DS (5D2CB16)
- 500 kV Surge Arrester (5SA1B6)
- 500 kV CVT (5CVT6)
- 500 kV Surge Arrester (5SA41)
- 500 kV Line MOD DS 5D26
- 500 kV Wave Trap (5WT6)
- Remove existing connection between 5B7 and future 5B6
- 500KV CB (5CB37, 4000A, 40KA, 33ms, SPC, POWO, SPR) c/w 5CT37
- 500KV MOD DS (5D37)
- 500KV Surge Arrester (5SA37)
- 500KV Shunt Reactor (5RX7, 525KV, 3-phase, 135MVAR)

Compensating 5L46 in Creekside Capacitor Station:

- Capacitor Bank (770 MVAR, 3000 A) to be placed in two platforms, actual components CTs, MOVs, etc. to be specified by manufacturer.
- 500 KV Bypassing CB (5CB1CX2, 3000 A, 40 KA, 50ms)
- MODs: 500 KV DS (5D1, 3000 A), 500 KV DS (5D2, 3000 A), 500 KV DS (5BP2, 3000 A)
- 500 KV Ground DS (5GD1, 3000 A), 500 KV Ground DS (5GD2, 3000 A)
- Associated P&C

Project In-Service Date:

In Scenario 1 the expected in-service date of 5L46 is October 2017 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 1	F2011	F2012	F2013	F2014	F2015	F2016	F2017	F2018	F2019	Total
KLY-CKY 500 kV Line (5L46) definition Scenario 1	3,613.80	4,342.90	3,773.00	748.30	796.00	846.80	900.80	551.80		15,573.40
KLY-CKY 500 kV Line (5L46) Implementation Scenario 1				7,491.90	22,746.10	88,980.90	115,378.30	50,266.20	2,362.40	287,225.80
KLY Station work Scenario 1						352.60	2,746.70	8,223.80		11,323.10
CKY Station Work Scenario 1						316.30	2,222.00	6,847.00		9,385.30
50% Series Compensation of 5L46-at CRK Scenario 1						1,017.70	6,490.40	19,458.70		26,966.80

In Scenario 2 the expected in-service date of 5L46 is October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2008	F2009	F2010	F2011	F2012	F2013	F2014	F2015	F2016	Total
KLY-CKY 500 kV Line (5L46) definition	3,375.20	4,099.80	3,563.00	704.10	749.10	796.80	847.70	519.20		14,654.90
KLY-CKY 500 kV Line (5L46) Implementation				7,080.70	21,499.70	84,094.30	109,044.40	47,506.90	2,232.70	271,458.70
KLY Station work						333.30	2,595.90	7,772.30		10,701.50
CKY Station Work						298.90	2,100.00	6,471.10		8,870.00
50% Series Compensation of 5L46-at CRK						961.80	6,134.00	18,390.30		25,486.10

A1.3 Shunt Capacitors at Meridian and Ingledow, and SVC at Ingledow

Justification:
To accommodate the expected winter peak loadings, the ILM 500 kV transmission system will require additional voltage support in the receiving area (LM and VI region) both for the system normal and the single contingency situations. The addition of 2 x 110 MVAr mechanically switched shunt capacitors (MSC) at the Meridian 230 kV bus and another 2 x 110 MVAr at the Ingledow 230 kV bus will allow the dynamic voltage support from the four on-line Burrard units to be kept in reserve for the possible forced outage of a ILM 500 kV line.

Only half of this new shunt capacitive support would need to be on-line during the system normal situation, and the other half would be available for fast switch-in when the 500 kV line outage occurs. To meet the performance criteria for voltage stability after "N-1" forced outages, an addition of approximately 150 MVAr of voltage support is needed. This additional shunt capacitive support should be an SVC rated -100/+150 MVAr and located at the Ingledow 230 kV bus.

Due to the low coastal RMR values in the years before 2009/10 as given in SIS Stage 1 report (Table 2.1.2 for Scenario 1 and Table 2.2.2 for Scenario 2), the ILM loading at the thermal limit would be just as high before 2009/10 as in winter of 2009/10. Therefore the shunt capacitive reinforcement is needed as soon as possible to remove the need to have extra RMR generation.

The definition phase of the VAr reinforcement project will finalize the location, size, and type of VAr compensation. Mid term dynamic studies will determine the mix of MSC and SVC.

Alternative Solutions:
Increasing the coastal RMR by about 250 MW, from the RMR generations of tables 2.1.2 and 2.2.2 in the NITS 2004 SIS Stage 1 report, will be necessary in the winter peak load situations until the new shunt capacitive support can be added.

An alternative to the additional shunt compensation would be to adopt increased coastal RMR levels in the peak load situations in the winters leading up to 2009/10 and also until 2012/13 just before 5L83 is expected to be added to the ILM system. The increase of 250 MW coastal generation would be adequate for 2009/10 but higher amounts would be needed in the following years.

Project Description:

Meridian 230 kV, 2 x 110 MVAr shunt capacitors
Each shunt capacitor is switched by a circuit breaker, so these new capacitors will be part of the Meridian auto-VAr control scheme that provides fast switching of shunts when needed.

- 230 kV CB (2CB13, 3000 A, 50 KA, 50 ms)
- 230 kV CVT (2CVT5)
- 230 kV CVT (2CVTCX5)
- 230 kV Surge Arrester (2SACX5)
- 230 kV Capacitors (2CCX5) and (2CX5)
- 230 kV Series Reactor (2RXCX5)
- 230 kV CB (2CB31, 3000 A, 50 KA, 50 ms)
- 230 kV MOD DS (2DCB31, 600 A)
- 230 kV CVT (2CVTCX6)
- 230 kV Surge Arrester (2SACX6)
- 230 kV Capacitors (2CCX6) and (2CX6)
- 230 kV Series Reactor (2RXCX6)

- 230 kV CB (2CB32, 3000 A, 50 KA, 50 ms)
- 230 kV MOD DS (2DCB32, 600 A)
- Associated P&C, and CTs

Ingledow 230 kV, 2 x 110 MVAr shunt capacitors

Each shunt capacitor is switched by a circuit breaker, so these new capacitors will be part of the Ingledow auto-VAr control scheme that provides fast switching of shunts when needed.

- 230 kV CB (2CB25, 3000 A, 50 KV, 50 ms)
- 230 kV CB (2CB26, 3000 A, 50 KV, 50 ms)
- 230 kV CVT (2CVTCX12)
- 230 kV Surge Arrester (2SACX12)
- 230 kV Capacitors (2CCX12) and (2CX12)
- 230 kV Series Reactor (2RXCX12)
- 230 kV CB (2CB28, 3000 A, 50 KV, 50 ms)
- 230 kV CVT (2CVTCX41)
- 230 kV Surge Arrester (2SACX41)
- 230 kV Capacitors (2CCX41) and (2CX41)
- 230 kV Series Reactor (2RXCX41)
- 230 kV CB (2CB35, 3000 A, 50 KV, 50 ms)
- 230 kV MOD DS (2D48, 600 A)
- 230 kV CVT (2CVT36)
- Move Reactor 2RX21
- 230 kV MOD DS (2D46, 600A)
- 230 kV MOD DS (2D47, 600A)
- Associated P&C, CTs

Ingledow 230 kV, -100 / +150 MVAr SVC

- 230 kV CB (2CB35, 3000 A, 50 KA, 50 ms)
- 230 kV DS (2D1CB35, 3000 A)
- 230 kV DS (2D2CB35, 3000 A)
- 230 kV SVC -100/+150 MVAR with all the associated equipment and controls:
    - Main transformer (T1, 150 MVA), Stand by transformer (T2, 150 MVA)
    - Two thyristor switched reactors (2x50 MVAR)
    - One thyristor switched capacitor (150 MVAR)
    - 230 kV MOD (2D43, 3000 A)
- 230 kV Bus (2B34)
- 230 kV DS (2D2CB34, 3000 A)
- Associated P&C

Project In-Service Date:

In both scenarios 1 and 2, the ILM VAr reinforcement projects will be required at their earliest in-service date. The estimated earliest in-service date of the ILM VAr reinforcements will be as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 1	F2007	F2008	F2009	F2010	Total
ING one-100/+150 MVAr 230 kV SVC- Revised	606.70	1,779.40	4,893.00	24,929.20	32,208.30
ING 2X110 MVAr 230 kV switchable Shunt Cap- New	359.5	1499.9	3202.4		5,061.80
MDN 2X110 MVAr 230 kV switchable Shunt Cap- New	332.4	1314.5	2732.4		4,379.30

A1.4 Arnott – Vancouver Island Terminal 230 kV Cable Circuit 2L129

Justification:
In the NITS2004 SIS Stage 3, the designated VI generation for scenarios 1 and 2 is 636 MW. This level of on-island generation and the existing transfer of power from the LM to VI will not be sufficient to balance the VI demand. To adequately supply the Vancouver Island load, one 230 kV / 600 MW cable circuit is required at its earliest in-service date.

Alternative Solutions:
The new 230 kV cable from LM to VI can be delayed beyond the scope of this NITS application by designating RMR generation in VI. Tables 4.1 and 4.2 of Stage 2 report identifies the required on-island RMR levels between 2004/05 and 2024/25.

Project Description:
The double 230 kV circuits, each with 600 MW capacity, are planned to utilize the existing 138 kV corridors (1L17 &1L18) between Arnott Substation (ARN) and Vancouver Island Terminal (VIT) in two stages. In the first stage, the double overhead lines and the 230 kV submarine cables for one circuit (2L129) will be built, and a 600 MVA phase shifting transformer at VIT will be installed. The transformer will control the power flow. The second 230 kV overhead line together with the existing 138 kV cables will operate at 138 kV to supply South Gulf Islands.

Terminating 2L129 in Arnott Substation:
- Replace 2CB6 with a 230 KV CB (2CB6, 3000 A, 50 KA, 50 ms) equipped with independent pole operators (IPO) and SPR operation.
- Replace 2CB7 with a 230 KV CB (2CB7, 3000 A, 50 KA, 50 ms, IPO, SPR)
- 230 kV CVT (2VT6),
- 230 kV Surge Arrester (2SA26)
- 230 kV MOD DS (2D6, 2000 A)
- Transfer converter transformer T6
- Associated P&C, Telecommunications, and SCADA

Re-terminate 1L18 on 1L17 Position at Arnott and VIT
- Physical re-termination occurs at both Arnott and VIT and reconnection at Galiano and Saltspring
- Scrap 138 kV CB (1CB2), 1CT2, D1 and D2 at Arnott
- Scrap 138 kV CB (1CB3), 1CT3, D1 and D2 at Arnott
- Scrap 138 kV VT (1PT2) at Arnott
- Scrap 138 kV DSs (1D21, 1D22, 1D23, 1D24, 1D25, 1D26, 1D30, 1D31, 1D32) at Arnott
- Scrap 138 kV Ground Switches (1GD24, 1GD25, 1GD26, 1GD30) at Anrott
- Scrap 138 kV CB (1CB10) at VIT
- Scrap 138 kV VT (1PT17) at VIT
- Scrap 138 kV DSs (1D41, 1D42, 1D43, 1D47, 1D48, 1D49, 1D50, 1D51, 1D52) at VIT
- Scrap 138 kV Ground Switches (1GD41, 1GD42, 1GD43, 1GD50) at VIT

Tsawwassen Substation
- Establish cable potheads for 2L129

Saltspring Substation:
- Remove existing 1L17, 1L18 changeover scheme.
- Associate P&C

VIT 230 KV Line Termination and Phase Shifter

- 230 kV CB (2CB31, 2000 A, 40 KA, 50 ms)
- 230 kV DS (D1, 2000 A)
- 230 kV DS (D2, 2000 A)
- 230 kV CB (2CB32, 2000 A, 40 KA, 50 ms)
- 230 kV DS (D1, 2000 A)
- 230 kV DS (D2, 2000 A)
- 230 kV CT(2CT31)
- Transfer converter transformer T1
- 230 kV Phase Shifter (PST1, 630 MVA, +/- 20 Degree at no load)
- 230 kV Surge Arrester (2SA1PST1),
- 230 kV Surge Arrester (2SA2PST1),
- 230 kV Surge Arrester (2SA31)
- 230 kV CVT (2CVT1PST),
- 230 kV CVT (2CVT2PST),
- 230 kV VT (2VT31)
- 230 kV MODs (2D11), (2D12), (2D21), (2D31)
- 230 kV DS (2D1CB33, 2000 A)
- 230 kV DS (2D1CB34, 2000 A)
- 230 kV DS (2D2CB33, 2000 A)
- 230 kV DS (2D2CB34, 2000 A)
- Associated P&C
- Scrap CB (1CB10)

2L129 Transmission Circuit:
Lengths of the 5 segments are as follows:

Location	Description	Length
Delta (Lower Mainland)	ARN to EBT (Overhead)	12.0 km
Straight of Georgia	EBT to TBY (Cable)	25.5 km
Galiano and Parker Islands	TBY to MTG (Overhead)	5.2 km
Trincomali Channel	MTG to MBO (Cable)	4.5 km
Salt Spring and Vancouver Islands	MBO to VIT (Overhead)	21.8 km

Project In-Service Date:
In both scenarios 1 and 2, 2L129 will be required at its earliest in-service date. The estimated earliest in-service date for 2L129 is October 2008 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenarios 1 & 2	Prior years	F2006	F2007	F2008	F2009	F2010	Total
Vancouver Island 230Kv Submarine cable. Definition	2,646.10	6,333.80	1,194.30	644.70	396.70		11,215.60
Vancouver Island 230Kv Submarine cable. Stage 1		313.80	19,888.20	49,941.70	78,857.80		149,001.50
Vancouver Island 230KV Arnott Substation Line Termination		27.00	169.80	312.70	1,235.90		1,745.40
Vancouver Island 230KV VIT Line termination , Phase shifter		125.10	526.60	1,641.30	12,803.60		15,096.60
VITR - Overhead Line		220.20	1,345.40	24,851.20	17,084.30	236.80	43,737.90
Vancouver Island 230Kv Undeground Cable in TWWSN		127.50	949.70	12,286.20	3,357.90		16,721.30

A1.5 Sahtlam and Taylor Bay 230 kV Shunt Reactors

Justification:
The charging current of the proposed new cable circuit 2L129 will produce significant capacitive power. While this reactive power is useful for supporting transmission voltages during heavy power transfers, it can cause voltage control difficulties under light load conditions. The risk of having over voltages increases when one cable circuit needs to be energized from VIT (normally these cables will be energized from ARN). One switchable shunt reactor at SAT, and one fixed shunt reactor on the circuit at Taylor Bay Cable Terminal in Galiano Island (TBY), will provide sufficient capability and flexibility for system voltage control.

Alternative Solution:
Reactive shunt compensation can be located in the middle of the circuit such as one of the cable terminals on South Gulf Islands.

Project Description:
Sahtlam

- 230 kV Shunt Reactor (2RX1, 66.1 MVAR)
- 230 kV CB (2CB31, 2000 A, 40 KA, 50 ms)
- 230 kV Surge Arrester (2SA31)
- 230 kV Surge Arrester (2SAB5)
- 230 kV MOD (2D31, 2000 A)
- 230 kV MOD (2D32, 2000 A)
- Relocate 2CVT5
- Associated P&C

Taylor Bay Cable Terminal Adjacent to Galiano Substation

- 230 kV Shunt Reactor (2RX1, 66.1 MVAr)
- 230 kV Neutral Shunt Reactor (2NRX1, 200 ohms)
- 230 kV Surge Arrester (2SA1)
- 230 kV Surge Arrester (2SA129)
- Surge Arrester (1SA18)
- 230 kV MOD (2D1, 1200 A)
- Associated P&C

Project In-Service Date:
In both scenarios 1 and 2 the in-service date of SAT reactor has to coincide with the in-service date of 2L129 (October 2008) as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenarios 1 & 2	F2006	F2007	F2008	F2009	Total	
SAT 230 kV, 66.1 MVAr switchable shunt reactor, One unit	90.10	525.30	1,034.00	1,553.60	3,203.00	
TBY 230 kV, 66.1 MVAr fixed shunt reactor, one unit	44.9	199.6	1476.1	2377.2	4,097.80	

A1.6 Arnott – Vancouver Island Terminal 230 kV Cable Circuit 2L124

Justification:
Based on the designated on-island generation of 636 MW, after the first cable circuit 2L129 is commissioned, the second cable circuit 2L124 will be required to meet VI load growth.

Alternative Solutions:
The second 230 kV cable from LM to VI can be delayed beyond 2024/25 by designating RMR generation in VI. Tables 4.1 and 4.2 of the NITS2004 SIS Stage 2 report identify the required on-island RMR levels between 2004/05 and 2024/25.

Project Description:
The overhead line sections of 2L124 are planned to be built with 2L129 during stage 1. Stage 2 of VI cables project includes building of the second 230 kV submarine cable sections and installation of a 600 MVA phase shifting transformer at VIT and a 66.1 MVAr fixed shunt reactor at Taylor Bay Terminal (TBY). When both circuits 2L124 and 2L129 become operational to supply VI at 230 kV, they will also supply the South Gulf Islands load through a converted 230 kV substation on Salt Spring Island.

2L124 Transmission Circuit:
Lengths of the 5 segments are as follows:

Location	Description	Length
Delta (Lower Mainland)	ARN to EBT (Overhead)	12.0 km
Straight of Georgia	EBT to TBY (Cable)	25.5 km
Galiano and Parker Islands	TBY to MTG (Overhead)	5.2 km
Trincomali Channel	MTG to MBO (Cable)	4.5 km
Salt Spring and Vancouver Islands	MBO to VIT (Overhead)	21.8 km

Terminating 2L124 in Arnott Substation:
- Replace 2CB9 with a 230 kV CB (2CB9, 3000 A, 50 KA, 50 ms) equipped with Independent Pole Operators (IPO) and Single Pole Reclosing (SPR) on the new line.
- Replace 2CB10 with a 230 KV CB (2CB10, 3000 A, 50 KA, 50 ms, IPO, SPR)
- Replace 230 kV MODs (2D21), (2D25), (2D34)
- 230 kV Surge Arrester (25SA29)
- 230 kV Surge Arrester (2SA30)
- 230 kV VT (2VT8)
- Transfer converter transformer T5 and add external CT.
- Remove associated equipment with the remaining 132 KV line including T1, T2 & T3.
- Associated P&C and Telecommunications

Tsawwassen Substation
- Add potheads
- 230 kV Surge Arrester (2SA129)
- 230 kV Surge Arrester (2SA124)

Taylor Bay Terminal/ Galiano Substation:
- 230 KV 3-phase Shunt Reactor (2RX2, 75 MVAR)
- 230 KV MOD (2D2)
- Station Service Transformer, SS2

- Dismantle the existing Galiano substation and replace the function with new feeder circuits from Saltspring substation.
- Associated P&C and removal of protection equipment at Galiano substation.

Saltspring Substation:

- 2 x 230/25 kV, 50 MVA Transformers
- 2 x 230 kV, 2000 A dead tank CBs
- 2 x 230 kV MODs
- 4 set of 230 kV Surge Arresters
- 2 x 230 kV CVTs
- 230 kV single phase wave trap and coupling capacitor
- 2 x 25 kV Feeders including 25 kV CBs, 25 kV DSs, 25 kV (400 A) Shunt Reactors
- Associated bus work
- Associated P&C

Terminating 2L124 in Vancouver Island Terminal:

- 230 kV Phase Shifter (PST1, 630 MVA, +/- 20 Degree at no load)
- 230 kV CB (2CB31) with IPO
- 230 kV CB (2CB32) with IPO
- 230 kV MODs (2D21, 2D22, 2D25, 2D33)
- 230 kV DSs (2D1CB31, 2D2CB31, 2D1CB32, 2D2CB32)
- 230 kV CVTs (2CVT1, 2CVT2)
- 230 kV VT (2VT32)
- 230 kV Surge Arresters (2SA32, 2SA1PST2, 2SA2PST2)
- Remove the temporary shifter bypass bus installed in the first stage
- Remove the 138 KV Line 1L18 termination
- Associated P&C and Telecommunications

Project In-Service Date:

In Scenario 1 the required in-service date of 2L124 is October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 1	F2011	F2012	F2013	F2014	F2015	Total
ARN-VIT 230 kV AC Cable Circuits (2L124) Stage 2	25.2	3,109.50	26,151.20	76,726.90	114,481.70	220,494.50

In Scenario 2 the required in-service date of 2L124 is October 2010 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2006	F2007	F2008	F2009	F2010	F2011	Total
ARN-VIT 230 kV AC Cable Circuits (2L124) Stage 2	15.9	1364.2	2944.6	22953.9	71342.3	106333.6	204,954.50

A1.7 Ingledow – Arnott 230 kV Circuits 2L10 and 2L57

Justification:
ARN is supplied from ING by four 230 kV circuits 2L6, 2L10, 2L57 and 2L63. After commissioning of both 2L124 and 2L129, the additional flow from ING to ARN will increase and will cause overload of 2L10 and 2L57. Both 2L10 and 2L57 have to be upgraded in conjunction with the 2L124 project. The upgrade will match the ratings of 2L10 and 2L57 with the ratings of 2L6 and 2L63.

Alternative Solutions:
Upgrading 2L10 and 2L57 is directly related to the building of 2L124. By designating RMR generation in VI, both projects can be delayed beyond 2024/25. Tables 4.1 and 4.2 of the NITS 2004 SIS Stage 2 report identify the required on-island RMR levels between 2004/05 and 2024/25.

Project Description:

Transmission Lines:
- Total Length of 2L10: 16.8 km
- Summer rating of 2L10: 2000 A
- Total Length of 2L57: 16.8 km
- Summer rating of 2L57: 2000 A
- Replace in separate stages the existing "Drake" conductor with 2 bundle "crane" conductor
- Structural study determined that 15 of 33 Type A, AG, AX towers can be reinforced to remain in-service. The reinforcement includes reinforcement of the legs and tower on the four outer corners. Main splice bolts also need to be changed.
- Assume 13 remaining towers require replacement. Estimate assumes use of self-supporting steel poles w/ caisson foundations.
- Assumes all insulators and hardware is replaced. Suspension hardware w/ armour rods and conductor w/ spacer dampers.

Ingledow Substation:
- 230 kV CB (2CB8, 3000 A, 50 KA, 50 ms)
- 230 kV CB (2CB9, 3000 A, 50 KA, 50 ms)
- 230 kV DS (2D1CB8, 3000 A)
- 230 kV DS (2D1CB9, 3000 A)
- 230 kV DS (2D2CB8, 3000 A)
- 230 kV DS (2D2CB9, 3000 A)
- 230 kV MOD (2D27, 3000 A)
- 230 kV MOD (2D29, 3000 A)
- Associated P&C

Arnott Substation:
ARN requirements are included in the scope of ARN-VIT 230 KV AC Cable Circuits (2L124) Stage 2 and are repeated here:
- Replace 230 KV CB (2CB9) and (2CB10) with CB with independent pole operators (IPO), equipped with SPR operation.
- Replace 230 KV MODs (2D21), (2D25), (2D34)
- 230 kV Surge Arrester (25SA29)
- 230 kV Surge Arrester (2SA30)
- 230 kV VT (2VT8)
- Transfer converter transformer T5 and add external CT.

- Remove associated equipment with the remaining 132 KV line including T1, T2 & T3.
- Associated P&C and Telecommunications

Project In-Service Date:
In Scenario 1 the required in-service date of 2L10 / 2L57 uprating is October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 1	F2013	F2014	F2015	F2016	Total
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Definition					0.00
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Implementation	433.7	9290.7	5580.7	84.9	15,390.00
ING-ARN 230 kV circuits (2L10 & 2L57) Station Work (ING only)	27.70	1,404.50	567.80		2,000.00

In Scenario 2 the required in-service date of 2L10 / 2L57 uprating is October 2010 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2009	F2010	F2011	F2012	Total
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Definition					0.00
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Implementation	402.2	8617	5176	78.8	14,274.00
ING-ARN 230 kV circuits (2L10 & 2L57) Station Work	24.6	1246	503.8		1,774.40

A1.8 Series Compensation of 5L91 / 5L96 / 5L98

Justification:
After commissioning of Vaseux Lake (VAS) 500 kV substation in November 2005, the total transfer capability on the 5L91 (SEL-ACK) - 5L96 (SEL-VAS) - 5L98 (VAS-NIC) cut-plane will be limited to about 1850 MW. The limit is imposed to prevent voltage instability for loss of 5L96. Based on the base resource plan and the firm import from Alberta (NITS2004 SIS Stage 1 report, section 1.4) and also based on the designated return of Down Stream Benefits on 2L 112 (NITS2004 SIS Stage 1 report, section 1.7), the approximate load requirements on the cut-plane would be:

- In 2007: 1900 MW at winter peak load hours and 2130 MW at summer peak load hours;
- In 2010: 1900 MW at winter peak load hours and 2150 MW at summer peak load hours;
- In 2015: 1870 MW at winter peak load hours and 2130 MW at summer peak load hours.

These transfer requirements are above the current voltage stability limit of the cut-plane. With the addition of 50% series compensation on 5L91, 5L96 and 5L98 and with 250 MVAr shunt capacitor compensation at ACK, the transfer capability limit will be increased to about 2300 MW meeting the voltage stability requirements.
Under light load conditions, the maximum transfer on the cut-plane would be between 2300 MW and 2470 MW for the base resource plan and the 2005-2015 normal load forecast. To meet these transfer requirements, the continuous rating of the series capacitor banks has to be 2750 A.
SI East dispatch will have to be curtailed until this series compensation is in service in 2009. Generation shedding could also be considered as a short-term solution.

Alternative Solutions:
For this study, the following solutions, for increasing the transfer capability on the cut-plane of 5L91 and 5L96 (5L98), were reviewed:

- A new 500 kV line from SEL to VAS to NIC;
- A new 500 kV line from SEL to ACK;

Although a new 500 kV line would increase the transfer capability to met the NITS requirement, it is a costly solution and requires a long construction period. The addition of series compensation on 5L91, 5L96 and 5L98 plus 250 MVAr shunt compensation at ACK has been identified as the preferred solution based on its lower cost and shorter construction time. These reinforcements can be deferred by reducing resource dispatch from South Interior East.

Project Description:
The series capacitor stations will be located in the middle of 5L91, 5L96, and 5L98. The degree of series compensation for each line is 50% and the continuous current rating of each series capacitor is 2.75 kA.

5L91 Series Capacitors:

- Series Compensation: 50%
- Series Reactance: 36.65 Ohm
- Nameplate Current Rating: 2750 Amp
- Continuous Overload Rating: 3000 Amp (8 hr in 12 hr)
- Reactive Rating: 831 MVAr
- Bank Configuration: MOV plus trigger gap
- Nominal Operating Voltage: 500 kV
- Max. Continuous Voltage: 550 kV
- 500 kV CB (5CB1, 3000 A, 40 KA, 50 ms)
- 500 kV MOD (5D1, 3000 A)
- 500 kV MOD (5D2, 3000 A)

- 500 kV MOD (5BP1, 3000 A)
- 500 kV Ground DS (5D1GD1, 3000 A)
- 500 kV Ground DS (5D2GD2, 3000 A)
- Associated P&C and Telecommunications

5L96 Series Capacitors:

- Series Compensation: 50%
- Series Reactance: 27.1 Ohm
- Nameplate Current Rating: 2750 Amp
- Continuous Overload Rating: 3000 Amp (8 hr in 12 hr)
- Reactive Rating: 615 MVAr
- Bank Configuration: MOV plus trigger gap
- Nominal Operating Voltage: 500 kV
- Max. Continuous Voltage: 550 kV
- 500 kV CB (5CB1, 3000 A, 40 KA, 50 ms)
- 500 kV MOD (5D1, 3000 A)
- 500 kV MOD (5D2, 3000 A)
- 500 kV MOD (5BP1, 3000 A)
- 500 kV Ground DS (5D1GD1, 3000 A)
- 500 kV Ground DS (5D2GD2, 3000 A)
- Associated P&C and Telecommunications

5L98 Series Capacitors:

- Series Compensation: 50%
- Series Reactance: 22.8 Ohm
- Nameplate Current Rating: 2750 Amp
- Continuous Overload Rating: 3000 Amp (8 hr in 12 hr)
- Reactive Rating: 517 MVAr
- Bank Configuration: MOV plus trigger gap
- Nominal Operating Voltage: 500 kV
- Max. Continuous Voltage: 550 kV
- 500 kV CB (5CB1, 3000 A, 40 KA, 50 ms)
- 500 kV MOD (5D1, 3000 A)
- 500 kV MOD (5D2, 3000 A)
- 500 kV MOD (5BP1, 3000 A)
- 500 kV Ground DS (5D1GD1, 3000 A)
- 500 kV Ground DS (5D2GD2, 3000 A)
- Associated P&C and Telecommunications

Project In-Service Date:

In both scenarios 1 and 2, series compensation of 5L91, 5L96, and 5L98 will be required at their earliest in-service date. The estimated earliest in-service date for these projects is October 2009 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenarios 1 & 2	F2007	F2008	F2009	F2010	Total
Series Compensation of 5L91 (50% compensation, 2750 A)	163.10	1,460.40	5,785.10	17,325.00	24,733.60
Series Compensation of 5L96 (50% compensation, 2750 A)	163.10	1,508.80	6,115.90	16,107.20	23,895.00
Series Compensation of 5L98 (50% compensation, 2750 A)	163.10	1,452.70	5,732.50	15,325.30	22,673.60

A1.9 Selkirk Transformer Bank Addition T4

Justification:
The total surplus generation in Selkirk area plus import from FortisBC, and import from US on 2L112 are transferred out of the area to the BCTC 500kV system through the Selkirk 230/500kV transformers. The loss of the existing Selkirk transformer T1 will limit the total transfer to 1650MVA to prevent thermal overload of the remaining Selkirk transformers. Because of significant resource increase in the area (such as Brilliant expansion) the total transfer out of SEL may reach 2300-2440 MW during daily light load in summer 2007. This level will be significantly higher than the firm capacity of the station. Addition of a new 1200 MVA unit T4 and joining the existing two 672 MVA units T2 & T3 into one transformer zone will raise the firm 230 kV to 500 kV transformation capacity of Selkirk Substation to 2700 MVA, alleviating the overload problem.

Alternative Solutions:
The alternative solution is to replace the existing 672 MVA transformers T2 and T3 with two 1200 MVA units. The cost of this alternative would be approximately double the cost of adding T4.

Project Description:
- 500-230 kV, 1200 MVA Transformer T4 equipped with NLTC +/- 2x2.5%
- 500 kV Surge Arrester (5SA4)
- 500 kV MOD (5D4, 3000 A)
- 230 kV Surge Arrester (2SA4)
- 230 kV MOD (2D4)
- 12 kV Voltage Transformer 12VT4
- Associated P&C

Project In-Service Date:
In both scenarios 1 and 2, Selkirk transformer T4 will be needed at its earliest possible date, which is November 2007, as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenarios 1 & 2	F2006	F2007	F2008	Total
SEL Transformer Bank Addition T4 (1200 MVA)	40.30	711.60	12,595.20	13,347.10

A1.10 Selkirk 500 kV Shunt Reactor

Justification:
During low transfers on the 500 kV lines in the BC South Interior East region, the SEL area generators (SEV, KCL, ALH, etc) are required to be on line to be operated at low output or as synchronous condensers to regulate SEL area voltages. Operating these units as synchronous condensers will increase power losses.
Installing a 500 kV shunt reactor at 500 kV SEL substation would reduce the reliance on SEL area generators (particularly SEV units) and will result in regulating voltages, reducing the losses, and lowering operating costs.
In addition, this shunt reactor will provide the opportunity to add a new neutral reactor which will become a backup for the existing ACK 5RX4 neutral reactor. The addition would increase the successful rate of 5L91 single pole reclosing and would improve system reliability.

Alternative Solutions:
Doing nothing will result in significant losses from operating SEV units as synchronous condensers during low transfers on the 500 kV lines in the BC South Interior east region. Installing a SVC at SEL will be a more costly option.

Project Description:
Add a new 500 kV / 123 MVAr shunt reactor at SEL to meet system voltage regulation requirements and to reduce operation cost caused by operating SEV generators at low output or as synchronous condensers.

- 500 KV CB (5CB43, 4000 A, 40 kA)
- 500 KV Shunt Reactor (5RX3, 123 MVAR)
- 500 KV Neutral Shunt Reactor (5RXN3, 1000 Ohm @ 60 Hz, 20 A)
- 500 KV Surge Arrester (5SA43),
- 500 KV Surge Arrester (5SARXN3)
- 500 KV CTs (5RXN3CT1), (5RXN3CT2), (5RXN3CT3)
- 500 KV MOD (5D43, 2000 A)
- 500 KV Single Pole MOD (5GDRXN3, 600 A)
- Associated P&C

Project In-Service Date:
In both scenarios 1 and 2, Selkirk 123 MVAr reactor will be needed at its earliest possible date, which is September 2007, as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenarios 1 & 2	F2006	F2007	F2008	Total
SEL 500 kV, 123 MVAr shunt Reactor	22.10	1,620.50	3,871.40	5,514.00

A1.11 Ashton Creek 500 kV Shunt Capacitors

Justification:
Increased generation capacity at REV or higher SEL transfers associated with series compensation of 5L91/96/98 will cause higher flow through ACK. Shunt capacitors at ACK are required to securely support these higher transfers by maintaining adequate voltages.
A single 500 kV / 250 MVAr shunt capacitor will be adequate when both REV G5 and the 5L91/5L96/5L98 series capacitors are built. Once REV G6 is built, a second similar sized capacitor will be required to ensure sufficient reactive margin during contingencies.

Alternative Solutions:
Series compensation of 5L76 and 5L79 would also meet the required performance. However, the cost of series compensation is much higher than the cost of shunt capacitors.

Project Description:

Ashton Creek Shunt Capacitor # 1:
- 500 kV CB (5CB49, 4000A, 40 kA)
- 500 kV Capacitor (5CX1, 250 MVAr)
- 500 kV Capacitor (5CX11, 0.125 micro Farad)
- 500 kV Series Reactor (5RX11, 3 mH)
- 500 kV MOD (5D49)
- 500 kV Surge Arrester (5SA11)
- Associated P&C

Ashton Creek Shunt Capacitor # 2:
- 500 kV CB (5CB50, 4000 A, 40 kA)
- 500 kV Capacitor (5CX2, 250 MVAr)
- 500 kV Capacitor (5CX12, 0.125 micro Farad)
- 500 kV Series Reactor (5RX12, 3 mH)
- 500 kV MOD (5D50)
- 500 kV Surge Arrester (5SA12)
- Associated P&C

Project In-Service Dates:
In both scenarios 1 and 2, the first ACK 250 MVAr shunt capacitor will be required in October 2009 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenarios 1 & 2	F2008	F2009	F2010	Total
ACK 250 MVAr Shunt Capacitor #1	5.60	284.10	3,388.60	3,678.30

The second ACK 250 MVAr shunt capacitor will be required only in Scenario 2 for the October 2022 in-service date as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2021	F2022	F2023	Total
ACK 250 MVAr Shunt Capacitor # 2	8.8	363.40	4,326.10	4,698.30

A1.12 Nicola 500 kV Station Reconfiguration

Justification:
Nicola Substation terminates seven 500 kV transmission lines now and eight with the addition of 5L83. More than 50% of BC Hydro's peak load flows through NIC. When BC Hydro adds new generators at Mica, Revelstoke, or Selkirk area, it will become necessary to reconfigure NIC to minimize the risk of losing the entire substation. Loss of this substation would have very serious reliability implications for the Province and the WECC integrated system.

Alternative Solutions:
Building a new substation to enhance the transmission reliability would be costly and is not considered a practical option. Application of load shedding RAS is not an acceptable solution.

Project Description:
The reconfiguration includes the addition of bus sectionalizing circuit breakers and possible re-termination of transmission lines. The scope of this project will be finalized at the definition phase. The existing project scope includes:

- 500 kV CB (5CB19, 4000 A, 40 KA)
- 500 kV MOD (5D219)
- 500 kV CT (5CT19)
- 500 kV CB (5CB24, 4000 A, 40 KA)
- 500 kV MOD (5D124)
- 500 kV CT (5CT24)
- 500 kV CVT (5CVT24)
- 500 kV CB (5CB32, 4000 A, 40 KA)
- 500 kV MOD (5D32)
- 500 kV CT (5CT20)
- Associated P&C
- Scrap 500 kV CB (5CB18), MODs (5D1CB18, 5D2CB18), CT (5CT18)
- Scrap 500 kV CB (5CB28), MODs (5D1CB28, 5D2CB28), CT (5CT28)
- Scrap 500 kV Bus (5B18), MOD (5D1CB8)
- Scrap 500 kV Bus (5B28)

Project In-Service Date:
In both Scenarios 1 and 2, the reconfiguration of Nicola Substation will be required in October 2011 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2010	F2011	F2012	Total
NIC 500 kV Station Reconfiguration	249.3	1555.9	3940.6	5,745.80

A1.13 Skeena Interconnection of Kitimat SCGT

Justification:
SKA 287 kV switchyard is suggested as the point of interconnection for Kitimat Singe-Cycle-Gas-Turbine SCGT (180 MW). Based on the data contained in the NITS 2004 Application, the interconnection facilities for this project can not be defined at this time. Separate projects will cover the facilities at KIT SCGT and the transmission line from Kitimat to Skeena Substation. The NITS2004 studies will move this power from Skeena Substation to the loads through the 500kV grid. This report estimates the impact of KIT SCGT interconnection on SKA switchyard.

Alternative Solutions:
As long as KIT SCGT remains a designated BC Hydro resource connected to SKA 287 kV bus, its impact on SKA must be evaluated.

Project Description:
To integrate KIT SCGT into BC Hydro's grid, no additional work at SKA Substation will be required.

Project In-Service Date:
Interconnection of KIT-SCGT to SKA is only identified in Scenario 1. It will be required in October 2009.

A1.14 Application of Remedial Action Schemes - RAS

Justification:
The Remedial Action Schemes for the NITS 2004 Application include, but are not limited to, the upgrade / modification of Undervoltage Load Shedding, Direct Transfer Trips, Generation Shedding, Under Frequency Load Shedding, and Overload Protection. New RAS will be required for secure operation of the transmission network under N-1-1 and N-2 conditions. Future Operational Planning studies will identify the full scope of the required RAS.

Alternative Solutions:
Any alternative to a RAS solution will be identified at the time of studying the RAS.

Project Description:
Details of RAS requirements associated with the NITS2004 reinforcement items will be developed during the course of the NITS2004 coverage.

Project In-Service Date:

In Scenario 1, capital money is allocated for the RAS applications during the course of NITS 2004 agreement as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 1	F2008	F2009	F2010	F2011	F2012	F2013	F2014	F2015	F2016	Total
Apply Remedial Action Schemes (RAS)	146.90	836.10	1,065.40	544.70	1,730.50	1,068.70	1,168.00	1,666.00	683.90	8,910.20

In Scenario 2, capital money is allocated for the RAS applications during the course of NITS 2004 agreement as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2016	F2017	F2018	F2019	F2020	F2021	F2022	F2023	F2024	Total
Apply Remedial Action Schemes (RAS)	174.70	988.30	1,265.20	648.70	2,047.70	1,266.10	1,379.90	1,977.30	810.30	10,558.20

A1.15 Series Compensation of 5L71 and 5L72

Justification:
Series compensation of 5L71 and 5L72 (Mica – Nicola lines) is required to securely transfer increases in Mica generation. These capacitors are required when the output of Mica is greater than 2000 MW.

It is acceptable to continue the practice of shedding at most one Mica unit for loss of 5L71 (or 5L72) due to a 3-phase fault. Detailed studies indicate that, after uprating the existing Mica units, the transfer limit with shedding of one 500 MW unit will be 2000 MW. This assumes the power factor of the MCA plant is maintained at 0.95 or lower.

With the series capacitors installed, at least 2500 MW can be securely transferred from Mica without the need for generation shedding.

Alternative Solutions:
The only other viable solution is building a third MCA – NIC line. The high cost of the new line is not justifiable.

A 300 MVAr 500 kV SVC at NIC increases the MCA-NIC transfer limit by less than 50 MW and is not considered a viable option.

Project Description:
The series capacitors are to compensate 5L71 and 5L72 by 40% and are to have continuous rating of 2750A each. The location, within the lines, will be decided with the definition phase of the project. It is preferred to be in either the middle of the lines or towards the NIC end.

The addition of a sixth MCA generator is a possibility in the period after the NITS study time range. The series capacitor station should be designed to accommodate a possible future upgrading to 50% compensation and a continuous rating of 3300A for each line.

5L71 Series Capacitors:
- Compensation: 40%
- Series Compensation Reactance: 37.51 Ohm
- Nameplate Current Rating: 2750 A
- Reactive Rating: 851 MVAr
- Nominal Operating Voltage: 500 kV
- Max Continuous voltage: 550 kV
- 500 kV CB (5CB1, 3000 A, 40 KA, 50 ms)
- 500 kV MOD (5D1, 4000 A)
- 500 kV MOD (5D2, 4000 A)
- 500 kV MOD (5BP1, 4000 A)
- 500 kV Ground DS (5D1GD1, 4000 A)
- 500 kV Ground DS (5D2GD2, 4000 A)

5L72 Series Capacitors:
- Compensation: 40%
- Series Compensation Reactance: 37.43 Ohm
- Nameplate Current Rating: 2750 A

- Reactive Rating: 849
- Nominal Voltage: 500 kV
- Max Continuous Voltage: 550 kV
- 500 kV CB (5CB1, 3000 A, 40 KA, 50 ms)
- 500 kV MOD (5D1, 4000 A)
- 500 kV MOD (5D2, 4000 A)
- 500 kV MOD (5BP1, 4000 A)
- 500 kV Ground DS (5D1GD1, 4000 A)
- 500 kV Ground DS (5D2GD2, 4000 A)

Project In-Service Date:

Scenario 1: October 2023 as per the following cash flow (all costs are in $000s).

Annual Cashflow - Scenario 1	F2021	F2022	F2023	F2024	Total
Series compensation of 5L71&5L72, Implementation Phase		1424.6	9617.4	45295.9	56,337.90
Series compensation of 5L71 & 5L72, Definition Phase	298.80	560.40			859.20

Scenario 2: October 2017 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2015	F2016	F2017	F2018	Total
Series compensation of 5L71 & 5L72, Implementation Phase		1271.8	8586.2	40438.8	50,296.80
Series compensation of 5L71 & 5L72, Definition Phase	266.9	520.6	50.2	30.8	868.50

A1.16 Upgrade of Kennedy Series Capacitor Station

Justification:
The NITS2004 Alternative 1 resource plan identifies major new generation in the Peace River system from 2005 to 2015. The new generation resources include the addition of:

a. Site C hydro plant with the maximum output of 900 MW scheduled in service in 2014; and
b. NW_Wind generation plant with the maximum output of 700 MW scheduled in service in 2014.

At winter peak load and with Maximum Peace generation, the transfer requirement on the North to South transmission system will exceed the voltage and transient stability limits of the system. In 2014, the expected transfer requirement on the north of WSN cut-plane (5L1, 5L2 and 5L3) will be about 4340 MW and the transfer on the north of KLY cut-plane (5L11, 5L12, 5L13, and 2L96) will be about 4045 MW. The current transfer limits are about 3650 and 2920 MW for the north of WSN and north of KLY cut-planes respectively. Furthermore, the transfer on the north of KLY cut-plane will be above the thermal limit (3700 MW) of MLS series capacitor station. The MLS current ratings have to be improved. Series compensation at KDY and MLS will need to be increased and additional shunt capacitor banks at WSN and/or KLY may also be required to increase both transient and voltage stability limits.

At 55% of the winter peak load (which may also reflect summer season operating conditions), the 2014 transfer on the north of WSN cut-plane will be about 4500 MW and the 2014 transfer on the north of KLY cut-plane will be about 4800 MW. These transfers exceed the transient stability and thermal limit of the lines and series capacitor banks at KDY and MLS capacitor stations. One of the limiting factors of the Peace transmission lines (5L1, 5L2, 5L3, 5L11, 5L12, 5L13, etc) is low line clearance. The thermal overload problems could be removed by upgrading these lines and by increasing the current ratings of MLS and KDY banks. At the same time, the level of the series compensation in MLS and KDY should be increased to increase Peace system transient stability limits.

Based on the power flow and transient stability required to accommodate the addition of new NW_Wind (700 MW) and Site C (900 MW) generation, the following Peace system major transmission reinforcements are suggested to meet WECC reliability standard.

- Upgrade KDY and MLS series capacitor stations. Increase series compensation and continuous current rating of capacitors
- Upgrade the overload capabilities of 5L1, 5L2 and 5L3
- Upgrade the overload capabilities of 5L11and 5L12
- Add shunt capacitor compensation at WSN, KLY stations

Alternative Solutions:
The addition of a fourth 500 kV series compensated circuit from PCN to WSN to KLY would also meet the increased transfer capacity requirements to incorporate new generation from Site C and NW-wind. However, the new transmission line would be a significantly higher cost alternative, would have a longer construction time, and would require a review of the Right-of-Way issues. Increasing series compensation of MLS and KDY capacitor stations and upgrading the existing 500 kV lines and adding shunt compensation at WSN and/or KLY are a preferred solution because of the lower cost, least environment impact and short construction period.

Project Description:

Upgrade of Kennedy Capacitor Station includes:

- Addition of 384MVA capacitance to 5CX1
- Addition of 384MVA capacitance to 5CX2
- Addition of 387MVA capacitance to 5CX3
- Modification of platform to suit new capacitor cans including racks, insulators, steel support and deck, bus for 2500A continuous rating.
- Associated P&C additions
- Associated Telecommunications and SCADA additions

The definition phase of this project will finalize the size and details of the series compensation.

Project In-Service Date:
This project is not required in Scenario 1. In Scenario 2, upgrade of Kennedy Capacitor Station will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	**F2012**	**F2013**	**F2014**	**F2015**	**Total**
Upgrade KDY series capacitor station, Implementation Phase		60.10	6,863.80	33,875.30	40,799.20
Upgrade KDY series capacitor station, Definition Phase	204.80	141.20	22.10	13.50	381.60

A1.17 Upgrade of McLeese Series Capacitor Station

Justification:

The NITS2004 Alternative 1 resource plan identifies major new generation in the Peace River system from 2005 to 2015. The new generation resources include the addition of:

a. Site C hydro plant with the maximum output of 900 MW scheduled in service in 2014; and
b. NW_Wind generation plant with the maximum output of 700 MW scheduled in service in 2014.

At winter peak load and with Maximum Peace generation, the transfer requirement on the North to South transmission system will exceed the voltage and transient stability limits of the system. In 2014, the expected transfer requirement on the north of WSN cut-plane (5L1, 5L2 and 5L3) will be about 4340 MW and the transfer on the north of KLY cut-plane (5L11, 5L12, 5L13, and 2L96) will be about 4045 MW. The current transfer limits are about 3650 and 2920 MW for the north of WSN and north of KLY cut-planes respectively. Furthermore, the transfer on the north of KLY cut-plane will be above the thermal limit (3700 MW) of MLS series capacitor station. The MLS current ratings have to be improved. Series compensation at KDY and MLS will need to be increased and additional shunt capacitor banks at WSN and/or KLY may also be required to increase both transient and voltage stability limits.

At 55% of the winter peak load (which may also reflect summer season operating conditions), the 2014 transfer on the north of WSN cut-plane will be about 4500 MW and the 2014 transfer on the north of KLY cut-plane will be about 4800 MW. These transfers exceed the transient stability and thermal limit of the lines and series capacitor banks at KDY and MLS capacitor stations. One of the limiting factors of the Peace transmission lines (5L1, 5L2, 5L3, 5L11, 5L12, 5L13, etc) is low line clearance. The thermal overload problems could be removed by upgrading these lines and by increasing the current ratings of MLS and KDY banks. At the same time, the level of the series compensation in MLS and KDY should be increased to increase Peace system transient stability limits.

Based on the power flow and transient stability required to accommodate the addition of new NW_Wind (700 MW) and Site C (900 MW) generation, the following Peace system major transmission reinforcements are suggested to meet WECC reliability standard.

- Upgrade KDY and MLS series capacitor stations. Increase series compensation and continuous current rating of capacitors
- Upgrade the overload capabilities of 5L1, 5L2 and 5L3
- Upgrade the overload capabilities of 5L11and 5L12
- Add shunt capacitor compensation at WSN, KLY stations

Alternative Solutions:

The addition of a fourth 500 kV series compensated circuit from PCN to WSN to KLY would also meet the increased transfer capacity requirements to incorporate new generation from Site C and NW-wind. However, the new transmission line would be a significantly higher cost alternative, would have a longer construction time, and would require a review of the Right-of-Way issues. Increasing series compensation of MLS and KDY capacitor stations and upgrading the existing 500 kV lines and adding shunt compensation at WSN and/or KLY are a preferred solution because of the lower cost, least environment impact and short construction period.

Project Description:

Upgrade of McLeese Capacitor Station includes:

- Addition of 700MVA capacitance to 5CX1
- Addition of 700MVA capacitance to 5CX2
- Addition of 687MVA capacitance to 5CX3
- Modification of platform to suit new capacitor cans including racks, insulators, steel support and deck, bus for 2500A continuous rating.
- Replacement of MOV with higher rating
- Associated P&C additions
- Associated Telecommunications and SCADA additions

The definition phase of this project will finalize the size and details of the series compensation.

Project In-Service Date:
This project is not required in Scenario 1. In Scenario 2, upgrade of McLeese Capacitor Station will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2012	F2013	F2014	F2015	Total
Upgrade MLS series capacitor station, Implementation Phase		53.10	8,508.00	42,931.10	51,492.20
Upgrade MLS series capacitor station, Definition Phase	204.80	141.20	22.10	13.50	381.60

A1.18 Thermal Upgrade of 500 kV Lines 5L1, 5L2, and 5L3

Justification:

The NITS2004 Alternative 1 resource plan identifies major new generation in the Peace River system from 2005 to 2015. The new generation resources include the addition of:

a. Site C hydro plant with the maximum output of 900 MW scheduled in service in 2014; and

b. NW_Wind generation plant with the maximum output of 700 MW scheduled in service in 2014.

At winter peak load and with Maximum Peace generation, the transfer requirement on the North to South transmission system will exceed the voltage and transient stability limits of the system. In 2014, the expected transfer requirement on the north of WSN cut-plane (5L1, 5L2 and 5L3) will be about 4340 MW and the transfer on the north of KLY cut-plane (5L11, 5L12, 5L13, and 2L96) will be about 4045 MW. The current transfer limits are about 3650 and 2920 MW for the north of WSN and north of KLY cut-planes respectively. Furthermore, the transfer on the north of KLY cut-plane will be above the thermal limit (3700 MW) of MLS series capacitor station. The MLS current ratings have to be improved. Series compensation at KDY and MLS will need to be increased and additional shunt capacitor banks at WSN and/or KLY may also be required to increase both transient and voltage stability limits.

At 55% of the winter peak load (which may also reflect summer season operating conditions), the 2014 transfer on the north of WSN cut-plane will be about 4500 MW and the 2014 transfer on the north of KLY cut-plane will be about 4800 MW. These transfers exceed the transient stability and thermal limit of the lines and series capacitor banks at KDY and MLS capacitor stations. One of the limiting factors of the Peace transmission lines (5L1, 5L2, 5L3, 5L11, 5L12, 5L13, etc) is low line clearance. The thermal overload problems could be removed by upgrading these lines and by increasing the current ratings of MLS and KDY banks. At the same time, the level of the series compensation in MLS and KDY should be increased to increase Peace system transient stability limits.

Based on the power flow and transient stability required to accommodate the addition of new NW_Wind (700 MW) and Site C (900 MW) generation, the following Peace system major transmission reinforcements are suggested to meet WECC reliability standard.

- Upgrade KDY and MLS series capacitor stations. Increase series compensation and continuous current rating of capacitors
- Upgrade the overload capabilities of 5L1, 5L2 and 5L3
- Upgrade the overload capabilities of 5L11and 5L12
- Add shunt capacitor compensation at WSN, KLY stations

Alternative Solutions:

The addition of a fourth 500 kV series compensated circuit from PCN to WSN to KLY would also meet the increased transfer capacity requirements to incorporate new generation from Site C and NW-wind. However, the new transmission line would be a significantly higher cost alternative, would have a longer construction time, and would require a review of the Right-of-Way issues. Increasing series compensation of MLS and KDY capacitor stations and upgrading the existing 500 kV lines and adding shunt compensation at WSN and/or KLY are a preferred solution because of the lower cost, least environment impact and short construction period.

Project Description:

This project will increase the overload capabilities of 5L1, 5L2, and 5L3 from 2500 A (at 30 C) to a minimum of 2750 A. The estimates are based on the following data and assumptions:

- Existing early 1990s photogrammetry of ground and tower data.
- Conductor tensions are based on ruling span tension rather than individual span tensions.
- Highway conductor to road clearance of 15.0 m.
- Ground data does not include re-contour work completed in the 90's and assumes the work was completed as requested.
- Re-contour costs are based on generic earth sites.
- Future ground, tower and conductor data is LIDAR data.

New circuit data is collected via LIDAR. Circuits are modeled using PLS-CADD and ground deficiencies determined and confirmed through a field investigation.
The definition phase of this project will finalize the upgrade requirements for 5L11 and 5L12.

Project In-Service Date:
This project is not required in Scenario 1. In Scenario 2, thermal upgrade of 5L1, 5L2, and 5L3 will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2012	F2013	F2014	F2015	Total
Upgrade 5L1, 5L2 and 5L3, Implementation Phase		196.40	1,319.40	1,103.90	2,619.70
Upgrade 5L1, 5L2 and 5L3, Definition Phase	319.30	222.50	34.60	21.20	597.60

A1.19 Thermal Upgrade of 500 kV Lines 5L11 and 5L12

Justification:

The NITS2004 Alternative 1 resource plan identifies major new generation in the Peace River system from 2005 to 2015. The new generation resources include the addition of:

a. Site C hydro plant with the maximum output of 900 MW scheduled in service in 2014; and

b. NW_Wind generation plant with the maximum output of 700 MW scheduled in service in 2014.

At winter peak load and with Maximum Peace generation, the transfer requirement on the North to South transmission system will exceed the voltage and transient stability limits of the system. In 2014, the expected transfer requirement on the north of WSN cut-plane (5L1, 5L2 and 5L3) will be about 4340 MW and the transfer on the north of KLY cut-plane (5L11, 5L12, 5L13, and 2L96) will be about 4045 MW. The current transfer limits are about 3650 and 2920 MW for the north of WSN and north of KLY cut-planes respectively. Furthermore, the transfer on the north of KLY cut-plane will be above the thermal limit (3700 MW) of MLS series capacitor station. The MLS current ratings have to be improved. Series compensation at KDY and MLS will need to be increased and additional shunt capacitor banks at WSN and/or KLY may also be required to increase both transient and voltage stability limits.

At 55% of the winter peak load (which may also reflect summer season operating conditions), the 2014 transfer on the north of WSN cut-plane will be about 4500 MW and the 2014 transfer on the north of KLY cut-plane will be about 4800 MW. These transfers exceed the transient stability and thermal limit of the lines and series capacitor banks at KDY and MLS capacitor stations. One of the limiting factors of the Peace transmission lines (5L1, 5L2, 5L3, 5L11, 5L12, 5L13, etc) is low line clearance. The thermal overload problems could be removed by upgrading these lines and by increasing the current ratings of MLS and KDY banks. At the same time, the level of the series compensation in MLS and KDY should be increased to increase Peace system transient stability limits.

Based on the power flow and transient stability required to accommodate the addition of new NW_Wind (700 MW) and Site C (900 MW) generation, the following Peace system major transmission reinforcements are suggested to meet WECC reliability standard.

- Upgrade KDY and MLS series capacitor stations. Increase series compensation and continuous current rating of capacitors
- Upgrade the overload capabilities of 5L1, 5L2 and 5L3
- Upgrade the overload capabilities of 5L11and 5L12
- Add shunt capacitor compensation at WSN, KLY stations

Alternative Solutions:

The addition of a fourth 500 kV series compensated circuit from PCN to WSN to KLY would also meet the increased transfer capacity requirements to incorporate new generation from Site C and NW-wind. However, the new transmission line would be a significantly higher cost alternative, would have a longer construction time, and would require a review of the Right-of-Way issues. Increasing series compensation of MLS and KDY capacitor stations and upgrading the existing 500 kV lines and adding shunt compensation at WSN and/or KLY are a preferred solution because of the lower cost, least environment impact and short construction period.

Project Description:

This project will increase the overload capabilities of 5L11 and 5L12 from 2500 A (at 30 C) to a minimum of 2750 A. The estimates are based on the following data and assumptions:

- Existing early 1990s photogrammetry of ground and tower data.
- Conductor tensions are based on ruling span tension rather than individual span tensions.
- Highway conductor to road clearance of 15.0 m.
- Ground data does not include re-contour work completed in the 90's and assumes the work was completed as requested.
- Re-contour costs are based on generic earth sites.
- Future ground, tower and conductor data is LIDAR data.

New circuit data is collected via LIDAR. Circuits are modeled using PLS-CADD and ground deficiencies determined and confirmed through a field investigation.
The definition phase of this project will finalize the upgrade requirements for 5L11 and 5L12.

Project In-Service Date:
This project is not required in Scenario 1. In Scenario 2, thermal upgrade of 5L11 and 5L12 will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2012	F2013	F2014	F2015	Total
Upgrade 5L11and 5L12, Impementation Phase		181.70	1,221.20	1,021.80	2,424.70
Upgrade 5L11and 5L12, Definition Phase	308.20	121.60	27.40	16.80	474.00

A1.20 Kelly Lake 500 kV Dynamic Compensation

Justification:
The NITS2004 Alternative 1 resource plan identifies major new generation in the Peace River system from 2005 to 2015. The new generation resources include the addition of:

a. Site C hydro plant with the maximum output of 900 MW scheduled in service in 2014; and

b. NW_Wind generation plant with the maximum output of 700 MW scheduled in service in 2014.

At winter peak load and with Maximum Peace generation, the transfer requirement on the North to South transmission system will exceed the voltage and transient stability limits of the system. In 2014, the expected transfer requirement on the north of WSN cut-plane (5L1, 5L2 and 5L3) will be about 4340 MW and the transfer on the north of KLY cut-plane (5L11, 5L12, 5L13, and 2L96) will be about 4045 MW. The current transfer limits are about 3650 and 2920 MW for the north of WSN and north of KLY cut-planes respectively. Furthermore, the transfer on the north of KLY cut-plane will be above the thermal limit (3700 MW) of MLS series capacitor station. The MLS current ratings have to be improved. Series compensation at KDY and MLS will need to be increased and additional shunt capacitor banks at WSN and/or KLY may also be required to increase both transient and voltage stability limits.

At 55% of the winter peak load (which may also reflect summer season operating conditions), the 2014 transfer on the north of WSN cut-plane will be about 4500 MW and the 2014 transfer on the north of KLY cut-plane will be about 4800 MW. These transfers exceed the transient stability and thermal limit of the lines and series capacitor banks at KDY and MLS capacitor stations. One of the limiting factors of the Peace transmission lines (5L1, 5L2, 5L3, 5L11, 5L12, 5L13, etc) is low line clearance. The thermal overload problems could be removed by upgrading these lines and by increasing the current ratings of MLS and KDY banks. At the same time, the level of the series compensation in MLS and KDY should be increased to increase Peace system transient stability limits.

Based on the power flow and transient stability required to accommodate the addition of new NW_Wind (700 MW) and Site C (900 MW) generation, the following Peace system major transmission reinforcements are suggested to meet WECC reliability standard.

- Upgrade KDY and MLS series capacitor stations. Increase series compensation and continuous current rating of capacitors
- Upgrade the overload capabilities of 5L1, 5L2 and 5L3
- Upgrade the overload capabilities of 5L11and 5L12
- Add shunt capacitor compensation at WSN, KLY stations

Alternative Solutions:
The addition of a fourth 500 kV series compensated circuit from PCN to WSN to KLY would also meet the increased transfer capacity requirements to incorporate new generation from Site C and NW-wind. However, the new transmission line would be a significantly higher cost alternative, would have a longer construction time, and would require a review of the Right-of-Way issues. Increasing series compensation of MLS and KDY capacitor stations and upgrading the existing 500 kV lines and adding shunt compensation at WSN and/or KLY are a preferred solution because of the lower cost, least environment impact and short construction period.

Project Description:

This project is to install one +450 to +500 MVAr (capacitive) dynamic compensation system at KLY 500 kV Substation. The definition phase of the project will finalize the size and details of the project. Mid term dynamic studies will determine if a mix of MSC and SVC is going to be feasible. Included in this FS estimate are:

- Establish +500 MVAR dynamic compensation system at Kelly Lake
- 500 kV CB (5CB9, 4000 A, 40 kV)
- 500 kV CB (5CB19, 4000 A, 40 kV)
- Replace DS (5D32) with new 500 kV CB (5CB32, 4000 A, 40 kA)
- Replace DS (5D34) with new 500 kV (5CB34, 4000 A, 40 kA)
- Add a SVC with thyristor switched capacitors in a geomertric sequence of 40/80/160 MVAR.
- Associated P&C additions

Project In-Service Date:
This project is not required in Scenario 1. In Scenario 2, the Kelly Lake 500 kV dynamic compensation will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2012	F2013	F2014	F2015	Total
KLY 500 kV, 500 MVAr SVC, Imlementation Phase		1128.1	7616	61,732.50	70,476.60
KLY 500 kV, 500 MVAr SVC, Definition Phase	368.80	717.50	69.30	42.40	1,198.00

A1.21 Williston 500 kV Dynamic Compensation

Justification:
The NITS2004 Alternative 1 resource plan identifies major new generation in the Peace River system from 2005 to 2015. The new generation resources include the addition of:

a. Site C hydro plant with the maximum output of 900 MW scheduled in service in 2014; and

b. NW_Wind generation plant with the maximum output of 700 MW scheduled in service in 2014.

At winter peak load and with Maximum Peace generation, the transfer requirement on the North to South transmission system will exceed the voltage and transient stability limits of the system. In 2014, the expected transfer requirement on the north of WSN cut-plane (5L1, 5L2 and 5L3) will be about 4340 MW and the transfer on the north of KLY cut-plane (5L11, 5L12, 5L13, and 2L96) will be about 4045 MW. The current transfer limits are about 3650 and 2920 MW for the north of WSN and north of KLY cut-planes respectively. Furthermore, the transfer on the north of KLY cut-plane will be above the thermal limit (3700 MW) of MLS series capacitor station. The MLS current ratings have to be improved. Series compensation at KDY and MLS will need to be increased and additional shunt capacitor banks at WSN and/or KLY may also be required to increase both transient and voltage stability limits.

At 55% of the winter peak load (which may also reflect summer season operating conditions), the 2014 transfer on the north of WSN cut-plane will be about 4500 MW and the 2014 transfer on the north of KLY cut-plane will be about 4800 MW. These transfers exceed the transient stability and thermal limit of the lines and series capacitor banks at KDY and MLS capacitor stations. One of the limiting factors of the Peace transmission lines (5L1, 5L2, 5L3, 5L11, 5L12, 5L13, etc) is low line clearance. The thermal overload problems could be removed by upgrading these lines and by increasing the current ratings of MLS and KDY banks. At the same time, the level of the series compensation in MLS and KDY should be increased to increase Peace system transient stability limits.

Based on the power flow and transient stability required to accommodate the addition of new NW_Wind (700 MW) and Site C (900 MW) generation, the following Peace system major transmission reinforcements are suggested to meet WECC reliability standard.

- Upgrade KDY and MLS series capacitor stations. Increase series compensation and continuous current rating of capacitors
- Upgrade the overload capabilities of 5L1, 5L2 and 5L3
- Upgrade the overload capabilities of 5L11and 5L12
- Add shunt capacitor compensation at WSN, KLY stations

Alternative Solutions:
The addition of a fourth 500 kV series compensated circuit from PCN to WSN to KLY would also meet the increased transfer capacity requirements to incorporate new generation from Site C and NW-wind. However, the new transmission line would be a significantly higher cost alternative, would have a longer construction time, and would require a review of the Right-of-Way issues. Increasing series compensation of MLS and KDY capacitor stations and upgrading the existing 500 kV lines and adding shunt compensation at WSN and/or KLY are a preferred solution because of the lower cost, least environment impact and short construction period.

Project Description:

This project is to install one +450 to +500 MVAr (capacitive) dynamic compensation system at WSN 500 kV Substation. The definition phase of the project will finalize the size and details of the project. Mid term dynamic studies will determine if a mix of MSC and SVC is going to be feasible. Included in this FS estimate are:

- Establish +500 MVAR dynamic compensation system at Williston
- 500 kV CB (5CB21, 4000 A, 40 kA)
- Replace DS (5D31) with new 500 kV CB (5CB31, 4000 A, 40 kA)
- Replace DS (5D33) with new 500 kV CB (5CB33, 4000 A, 40 kA)
- Add a SVC with thyristor switched capacitors in a geomertric sequence of 40/80/160 MVAR.
- Expand the station site to the east to accommodate the SVC.
- Associated P&C additions

Project In-Service Date:
This project is not required in Scenario 1. In Scenario 2, the Williston 500 kV dynamic compensation will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2012	F2013	F2014	F2015	Total
WSN 500 kV, 500 MVAr SVC, Imlementation Phase		744.7	5027.2	54,577.50	60,349.40
WSN 500 kV, 500 MVAr SVC, Definition Phase	347.6	676.3	65.3	40.00	1,129.20

A1.22 Peace Canyon Interconnection of Site C

Justification:
Peace Canyon 500 kV switchyard is suggested as the point of interconnection for Site C. The Peace River Site C would be located about 7 km southwest of Fort St. John. The powerhouse would contain six units with total rated capacity of 900 MW. The suggested transmission interconnection includes two new 500 kV lines from the plant to the existing Peace Canyon switchyard. Each line would be 70 km long. This report estimates the impact of Site C interconnection on PCN switchyard.

Alternative Solutions:
As long as Site C remains a designated BC Hydro resource connected to PCN 500 kV bus, its impact on PCN must be evaluated.

Project Description:

To integrate Site C into BC Hydro's grid, the following additions will be required at PCN 500 kV switchyard:

- 500 kV CB (5CB4, 3000 A, 40 KA, 50 ms)
- 500 kV MOD DS (5D1CB4, 3000 A)
- 500 kV MOD DS (5D2CB4, 3000 A)
- 500 kV Ground DS (5GD1CB4)
- 500 kV Ground DS (5GD2CB4)
- 500 kV CB (5CB6, 3000 A, 40 KA, 50 ms)
- 500 kV MOD DS (5D1CB6, 3000 A)
- 500 kV MOD DS (5D2CB6, 3000 A)
- 500 kV Ground DS (5GD1CB6)
- 500 kV Ground DS (5GD2CB6)
- 500 kV VT (5VT3)
- 500 kV Surge Arrester (5SA23)
- 500 kV CT (5CT3)
- 500 kV MOD (5D23, 3000 A)
- 500 kV Ground DS (5GD23, 40KA, 3 SEC)
- 500 kV Ground DS (5GDB3, 40KA, 3 SEC)
- 500 kV VT (5VT4)
- 500 kV Surge Arrester (5SA24)
- 500 kV CT (5CT4)
- 500 kV MOD (5D24, 3000 A)
- 500 kV Ground DS (5GD24, 40KA, 3 SEC)
- 500 kV Ground DS (5GDB4, 40KA, 3 SEC)
- Associated P&C additions
- Associated Telecommunication requirements

Project In-Service Date:
Interconnection of Site C to PCN is only identified in Scenario 2. It will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2010	F2011	F2012	F2013	F2014	F2015	Total
Two 500 kV circuits in PCN switch yard, Implementation Phase			298.70	2,045.30	3,587.40	22,579.00	28,510.40
Two 500 kV circuits in PCN switch yard, Definition Phase	14.10	95.30	33.70	9.10	9.70	5.90	167.80

A1.23 Skeena Interconnection of NW-Wind

Justification:
SKA 287 kV switchyard is suggested as the point of interconnection for NW-Wind generation plants (maximum output 700 MW). Based on the data contained in the NITS 2004 Application, the interconnection facilities for this project can not be defined at this time. This report estimates the impact of NW-Wind interconnection on SKA switchyard.

Alternative Solutions:
As long as NW-Wind remains a designated BC Hydro resource connected to SKA 287 kV bus, its impact on SKA must be evaluated.

Project Description:

To integrate NW-Wind generation into BC Hydro's grid, the following additions will be required at SKA Substation:

- 500/287 kV Transformer T3, 672 MVA (3 x 224 MVA single phase)
- 396 kV Surge Arrester (5SA3, 3x single phase)
- 240 kV Surge Arrester (2SA3, 3x single phase)
- 15 kV Surge Arrester (12SA3, 3x single phase)
- 14.4 kV Voltage Transformer (12VT3)
- 500 kV MOD DS (5D3, 4000 A)
- 287 kV MOD DS (2D3, 3000 A)
- 500 kV Circuit Breaker (5CB3, 4000 A, 40 kA)
- 500 kV MOD DS 5D1CB3
- 500 kV MOD DS 5D2CB3
- 500 kV circuit Breaker (5CB23, 4000 A, 40 kA)
- 500 kV MOD DS 5D1CB23
- 500 kV MOD DS 5D2CB23
- 287 kV Circuit Breaker (2CB9, 3000 A, 40 kA)
- 287 kV DS (2D1CB1, 3000 A)
- 287 kV DS (2D2CB9, 3000 A)
- 287 kV Circuit Breaker (2CB11, 3000 A, 40 kA)
- 287 kV DS (2D1CB11, 3000 A)
- 287 kV DS (2D2CB11, 3000 A)
- 287 kV Circuit Breaker (2CB12, 3000 A, 40 kA)
- 287 kV DS (2D1CB12, 3000 A)
- 287 kV DS (2D2CB12, 3000 A)
- 287 kV DS (2D2CB10, 3000 A)
- Reconnect line position 2L101 to the bus between 2CB11 and 2CB12
- Remove temporary bus and reuse connection point between 2CB5 and 2CB6 to connect to the new line for North West Wind IPP with associated CVT (2CVT3), single phase wave trap (2WT3) , motor operated disconnect (2D23), coupling capacitor (2CC3) and surge arrester (2SA23)
- Associated P&C

Note: The 2CB7 and 2D2CB7 will be installed under Forrest Kerr IPP Project in 2006 or 2007 if the project goes ahead.

Project In-Service Date:

Interconnection of NW-Wind to SKA is only identified in Scenario 2. It will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2011	F2012	F2013	F2014	F2015	Total
The interconnection form NW_WIND at SKA station, Imp. Phase		1,708.10	3,294.30	6,775.10	7,164.70	18,942.20
The interconnection form NW_WIND at SKA station, Def. Phase	286.3	61.3	22.2	23.6	14.40	407.80

A1.24 Series Compensation of 5L61

Justification:
Scenario 2 designates a new 700 MW wind generation plant (NW_Wind) in North Coast area in 2014. SKA 287 kV bus is assumed as the point of interconnection. Preliminary transient studies show that a fault on 5L61 near WSN bus, during high GMS / PCN / Site C and NW_Wind generation output, can cause slipping of the Kemano (KMO) units. Such a fault will result in the tripping of the KMO units by the slip relay of the tie line 2L103. Series compensation of 5L61 by 35% would allow the slip relay not to trigger. Consequently, KMO units would stay in sync with the rest of the system and 2L103 will remain in service for the first contingencies.

Alternative Solutions:
Series compensation of 5L61 reduces the impedance between WSN and SKA, increases transient stability of KMO units, and allows the transfer of NW-Wind generation. Alternatively, the same can be achieved by building new 500 kV line(s) from WSN to GLN or from GLN to TKW or from TKW to SKA. It is concluded that although building new 500 kV line(s) would have the additional advantage of reducing transmission losses, their high cost, long construction time, and environmental impact are not justifiable.

Project Description:
The preferred location for the new series capacitor station is middle of 5L61. The degree of series compensation is 35% and the continuous current rating of the capacitor bank is 1025 A.
Note that the suggested series compensation of 5L61 is based on the preliminary study results. These studies were conducted using the available information and modeling of the NW_Wind generators. These study results may change after the system interconnection impact study of the NW_Wind generation is conducted.

- Rating of Capacitor banks: 21.3 MVAr / Phase
- 500 kV Circuit Breaker (5CB1, 4000 A, 40 kA)
- 500 kV MOD DS (5D1, 4000 A)
- 500 kV MOD DS (5D2, 4000 A)
- 500 kV MOD DS (5BP1, 4000 A)
- 500 kV CT (3 x single phase)

Project In-Service Date:
This project is not required in Scenario 1. In Scenario 2, to accommodate the interconnection of 700 MW from NW-Wind plants, series compensation of 5L61 will be required in October 2014 as per the following cash flow (all costs are in $000s):

Annual Cashflow - Scenario 2	F2012	F2013	F2014	F2015	Total
Series compensation of 5L61, Implementation Phase		711.40	4,802.30	10,375.40	15,889.10
Series compensation of 5L61, Definition Phase	147.40	286.70	27.70	17.00	478.80

Appendix 2 – Annual Cash Flow of the Projects

Table A2.1

Annual cash flow of all the Scenario 1 projects.

All costs are capital direct inflated Dollars and include 2.58% OH and 4.96% IDC.

The estimates do not include cost of removing retired equipment.

Annual Cashflow - Scenario 1	Prj Short Name	Prior years	F2006 $K	F2007 $K	F2008 $K	F2009 $K	F2010 $K	F2011 $K	F2012 $K	F2013 $K	F2014 $K	F2015 $K	F2016 $K	F2017 $K	F2018 $K	F2019 $K	F2020 $K	F2021 $K	F2022 $K	F2023 $K	F2024 $K	Total $K
Project description																						
NIC-MDN 500 kV Line (5L83)definition	5L83DER3	169.90	2,003.10	3482	4,312.80	1,814.50	751.60	799.60	850.60	904.80	554.20											15,643.10
NIC-MDN 500 kV Line (5L83) Implementation	N45L83						5,357.70	16,338.80	86,039.40	103,253.10	37,367.80	2,223.40										250,580.20
50% series compensation, at or near AMC, 3000 A.	N4L83CAP		0	0	0	0	0	0	1009.4	6462.5	19201.9											26,673.80
NIC Station work	N4NICL83								351.70	2,197.90	5,746.20											8,295.80
MDN Station work	N4MDNL83								313.10	1,937.70	3,837.60											6,088.40
																						0.00
KLY-CKY 500 kV Line (5L46) definition Scenario 1	N45L46D1							3,613.80	4,342.90	3,773.00	748.30	796.00	846.80	900.80	551.80							15,573.40
KLY-CKY 500 kV Line (5L46) Implementation Scenario 1	N45L46I1										7,491.90	22,746.10	88,980.90	115,378.30	50,266.20	2,362.40						287,225.80
KLY Station work Scenario 1	N4KLYL46												352.60	2,746.70	8,223.80							11,323.10
CKY Station Work Scenario 1	N4CKYL46												316.30	2,222.00	6,847.00							9,385.30
50% Series Compensation of 5L46-at CRK Scenario 1	N4L46CAP												1,017.70	6,490.40	19,458.70							26,966.80
ING one-100/+150 MVAr 230 kV SVC- Revised	N4INGSVC			606.70	1,779.40	4,893.00	24,929.20															32,208.30
ING 2X110 MVAr 230 kV switchable Shunt Cap- New	N4INGCX			359.5	1499.9	3202.4																5,061.80
MDN 2X110 MVAr 230 kV switchable Shunt Cap- New	N4MDNCX			332.4	1314.5	2732.4																4,379.30
																						0.00
Vancouver Island 230Kv Submarine cable. Definition	VI230DEF	2,646.10	6,333.80	1,194.30	644.70	396.70																11,215.60
Vancouver Island 230Kv Submarine cable. Stage 1	N4Vi230C		313.80	19,888.20	49,941.70	78,857.80																149,001.50
Vancouver Island 230KV Arnott Substation Line Termination	N4Vi230A		27.00	169.80	312.70	1,235.90																1,745.40
SAT 230 kV, 66.1 MVAr shunt reactors, One unit	N4VI230S		90.10	525.30	1,034.00	1,553.60																3,203.00
Vancouver Island 230KV VIT Line termination , Phase shifter	N4VI230V		125.10	526.60	1,641.30	12,803.60																15,096.60
VITR - Overhead Line	N4VI23OH		220.20	1,345.40	24,851.20	17,084.30	236.80															43,737.90
Vancouver Island 230Kv Undeground Cable in TWWSN	N4VI230U		127.50	949.70	12,286.20	3,357.90																16,721.30
Vancouver Island 230KV Taylor Bay Terminal-one 66.1 MVAR Reactor	N4VI230T		44.9	199.6	1476.1	2377.2																4,097.80
ARN-VIT 230 kV AC Cable Circuits (2L124) Stage 2	VIP4							25.2	3,109.50	26,151.20	76,726.90	114,481.70	0.00									220,494.50
(Scenario 1 ISD: Oct 2014, Scenario 2 ISD: Oct 2010)																						0.00
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Definition																						0.00
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Implementation	N4L10i2									433.7	9290.7	5580.7	84.9									15,390.00
ING-ARN 230 kV circuits (2L10 & 2L57) Station Work (ING only)	N4INGAR2									27.70	1,404.50	567.80										2,000.00
Series Compensation of 5L91 (50% compensation, 2750 A)	N4L91CX			163.10	1,460.40	5,785.10	17,325.00															24,733.60
Series Compensation of 5L96 (50% compensation, 2750 A)	N4L96CX			163.10	1,508.80	6,115.90	16,107.20															23,895.00
Series Compensation of 5L98 (50% compensation, 2750 A)	N4L98CX			163.10	1,452.70	5,732.50	15,325.30															22,673.60
SEL Transformer Bank Addition T4 (1200 MVA)	N4SELT4		40.30	711.60	12,595.20																	13,347.10
SEL 500 kV, 123 MVAr shunt Reactor	N4SELRX		22.10	1,620.50	3,871.40																	5,514.00
NIC 500 kV Station Reconfiguration	N4NICREC				237.20	1,498.10	3,794.90															5,530.20
ACK 250 MVAr Shunt Capacitor - ISD Oct 2009	N4ACKCXA				5.60	284.10	3,388.60															3,678.30
ACK 250 MVAr Shunt Capacitor-ISD Oct 2022																						0.00
The interconnection from KIT_SCGT(180 MW) at SKA station	N4KITIC																					0.00
Apply Remedial Action Schemes (RAS) Scenario 1	N4RAS2				146.90	836.10	1,065.40	544.70	1,730.50	1,068.70	1,168.00	1,666.00	683.90									8,910.20
																						1,290,390.70
Series compensation of 5L71 and 5L72 (each line 40% comp., 2750 Amp)	N4L72CAP																		1424.6	9617.4	45295.9	56,337.90
Series compensation of 5L71 and 5L72 DEF	N4L72DEF																	298.80	560.40			859.20
Total Scenario 1		**2,816.00**	**9,347.90**	**32,400.90**	**122,372.70**	**150,561.10**	**88,281.70**	**21,322.10**	**97,747.10**	**146,210.30**	**163,538.00**	**148,061.70**	**92,283.10**	**127,738.20**	**85,347.50**	**2,362.40**	**0.00**	**298.80**	**1,985.00**	**9,617.40**	**45,295.90**	**1,347,587.80**

Table A2.2

Annual cash flow of all the Scenario 2 projects.

All costs are capital direct inflated Dollars and include 2.58% OH and 4.96% IDC.

The estimates do not include cost of removing retired equipment.

Annual Cashflow - Scenario 2	Prj Short Name	Prior Years	F2006 $K	F2007 $K	F2008 $K	F2009 $K	F2010 $K	F2011 $K	F2012 $K	F2013 $K	F2014 $K	F2015 $K	F2016 $K	F2017 $K	F2018 $K	F2019 $K	F2020 $K	F2021 $K	F2022 $K	F2023 $K	F2024 $K	Total $K
Project description																						
NIC-MDN 500 kV Line (5L83)definition	5L83DER3	169.90	2,003.10	3482	4,312.80	1,814.50	751.60	799.60	850.60	904.80	554.20											15,643.10
NIC-MDN 500 kV Line (5L83) Implementation	N45L83						5,357.70	16,338.80	86,039.40	103,253.10	37,367.80	2,223.40										250,580.20
50% series compensation, at or near AMC, 3000 A.	N4L83CAP		0	0	0	0	0	0	1009.4	6462.5	19201.9											26,673.80
NIC Station work	N4NICL83								351.70	2,197.90	5,746.20											8,295.80
MDN Station work	N4MDNL83								313.10	1,937.70	3,837.60											6,088.40
																						0.00
KLY-CKY 500 kV Line (5L46) definition	N45L46D2				3,375.20	4,099.80	3,563.00	704.10	749.10	796.80	847.70	519.20										14,654.90
KLY-CKY 500 kV Line (5L46) Implementation	N45L46I2							7,080.70	21,499.70	84,094.30	109,044.40	47,506.90	2,232.70									271,458.70
KLY Station work	N4KLY462									333.30	2,595.90	7,772.30										10,701.50
CKY Station Work	N4CKY462									298.90	2,100.00	6,471.10										8,870.00
50% Series Compensation of 5L46-at CRK	N4L46CP2									961.80	6,134.00	18,390.30										25,486.10
ING one-100/+150 MVAr 230 kV SVC- Revised	N4INGSVC			606.70	1,779.40	4,893.00	24,929.20															32,208.30
ING 2X110 MVAr 230 kV switchable Shunt Cap- New	N4INGCX			359.5	1499.9	3202.4																5,061.80
MDN 2X110 MVAr 230 kV switchable Shunt Cap- New	N4MDNCX			332.4	1314.5	2732.4																4,379.30
																						0.00
Vancouver Island 230Kv Submarine cable. Definition	Vi230DEF	2,646.10	6,333.80	1,194.30	644.70	396.70																11,215.60
Vancouver Island 230Kv Submarine cable. Stage 1	N4Vi230C		313.80	19,888.20	49,941.70	78,857.80																149,001.50
Vancouver Island 230KV Arnott Substation Line Termination	N4Vi230A		27.00	169.80	312.70	1,235.90																1,745.40
SAT 230 kV, 66.1 MVAr shunt reactors, One unit	N4VI230S		90.10	525.30	1,034.00	1,553.60																3,203.00
Vancouver Island 230KV VIT Line termination , Phase shifter	N4VI230V		125.10	526.60	1,641.30	12,803.60																15,096.60
VITR - Overhead Line	N4VI23OH		220.20	1,345.40	24,851.20	17,084.30	236.80															43,737.90
Vancouver Island 230Kv Undeground Cable in Tsawwaasen	N4VI230U		127.50	949.70	12,286.20	3,357.90																16,721.30
Vancouver Island 230KV Taylor Bay Terminal-one 66.1 MVAR Reactor	N4VI230T		44.9	199.6	1476.1	2377.2																4,097.80
ARN-VIT 230 kV AC Cable Circuits (2L124) Stage 2	VIP5		15.9	1364.2	2944.6	22953.9	71342.3	106333.6														204,954.50
(Scenario 1 ISD: Oct 2010, Scenario 2 ISD: Oct 2014)																						0.00
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Definition																						0.00
ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading- stage 2 Implementation	N4L10i1					402.2	8617	5176	78.8													14,274.00
ING-ARN 230 kV circuits (2L10 & 2L57) Station Work	N4INGAR2					24.6	1246	503.8														1,774.40
Series Compensation of 5L91 (50% compensation, 2750 A)	N4L91CX			163.10	1,460.40	5,785.10	17,325.00															24,733.60
Series Compensation of 5L96 (50% compensation, 2750 A)	N4L96CX			163.10	1,508.80	6,115.90	16,107.20															23,895.00
Series Compensation of 5L98 (50% compensation, 2750 A)	N4L98CX			163.10	1,452.70	5,732.50	15,325.30															22,673.60
SEL Transformer Bank Addition T4 (1200 MVA)	N4SELT4		40.30	711.60	12,595.20																	13,347.10
SEL 500 kV, 123 MVAr shunt Reactor	N4SELRX		22.10	1,620.50	3,871.40																	5,514.00
NIC 500 kV Station Reconfiguration	N4NICRC2						249.3	1555.9	3940.6													5,745.80
ACK 250 MVAr Shunt Capacitor - ISD Oct 2009	N4ACKCXA				5.60	284.10	3,388.60															3,678.30
ACK 250 MVAr Shunt Capacitor-ISD Oct 2022	N4ACKCXB																	8.8	363.40	4,326.10		4,698.30
The interconnection from KIT_SCGT(180 MW) at SKA station	N4KITIC																					0.00
																						0.00
Series compensation of 5L71 and 5L72 (each line 40% comp., 2750 Amp)	N4L72CP2												1271.8	8586.2	40438.8							50,296.80
	N4L72DF2											266.9	520.6	50.2	30.8							868.50
Upgrade KDY series capacitor station:	N4KDYUR									60.10	6,863.80	33,875.30										40,799.20
Increase the series compensation from 50% to 65%	N4KDYURD								204.80	141.20	22.10	13.50										381.60
Increase the rated current from 2310 A to the minimum of 2500 A																						0.00
Upgrade MLS series capacitor station:	N4MLSUR									53.10	8,508.00	42,931.10										51,492.20
Increase the degree of series compensation from 50% to 65%	N4MLSURD								204.80	141.20	22.10	13.50										381.60
Increase the rated current from 1950 A to the minimum of 2500 A																						0.00
Upgrade 5L1, 5L2 and 5L3 from 2500 A to the minimum of 2750 A	N4L1L2L3									196.40	1,319.40	1,103.90										2,619.70
	N4L1L2LD								319.30	222.50	34.60	21.20										597.60
Upgrade 5L11and 5L12 from 2500 A to the minimum of 2750 A	N4L11L12									181.70	1,221.20	1,021.80										2,424.70
	N4L11L1D								308.20	121.60	27.40	16.80										474.00
WSN 500 kV, 500 MVAr Auto SVC or	N4WSNSVC									744.7	5027.2	54,577.50										60,349.40
	N4WSNSDE								347.6	676.3	65.3	40.00										1,129.20
KLY 500 kV, 500 MVAr Auto SVC or	N4KLYSVC									1128.1	7616	61,732.50										70,476.60
shunt Capacitor compensation	N4KLYSDE								368.80	717.50	69.30	42.40										1,198.00
Two 500 kV circuits (900 MW) PCN switch yard	N4PCN5L								298.70	2,045.30	3,587.40	22,579.00										28,510.40
	N4PCN5LD						14.10	95.30	33.70	9.10	9.70	5.90										167.80
Deleted- Not Required																						0.00
Deleted- Not Required																						0.00
																						0.00
The interconnection form NW_WIND (700MW) at SKA station	N4NWWIC								1,708.10	3,294.30	6,775.10	7,164.70										18,942.20
	N4NWWICD							286.3	61.3	22.2	23.6	14.40										407.80
Series compensation of 5L61 (35% compensation , 1025 A)	N4L61CAP									711.40	4,802.30	10,375.40										15,889.10
	N4L61DEF								147.40	286.70	27.70	17.00										478.80
Apply Remedial Action Schemes (RAS)	N4RAS1												174.70	988.30	1,265.20	648.70	2,047.70	1,266.10	1,379.90	1,977.30	810.30	10,558.20
																						0.00
Total Scenario 2		**2,816.00**	**9,363.80**	**33,765.10**	**128,308.40**	**175,707.40**	**168,453.10**	**138,874.10**	**118,835.10**	**211,994.50**	**233,451.90**	**318,696.00**	**4,199.80**	**9,624.70**	**41,734.80**	**648.70**	**2,047.70**	**1,274.90**	**1,743.30**	**6,303.40**	**810.30**	**1,608,653.00**