British Columbia Transmission
CORPORATION™

System Impact Study
For
BC Hydro Distribution
NITS 2004 – Stage 3 (Final)
Revision-1

Report # SP2005 – 06

May, 2005

System Planning and Performance Assessment

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Executive Summary

The Stage 3 report provides the following information in response to BC Hydro's NITS requests (OASIS No.'s 1349122, 1349123, 1349124 & 1349125) pursuant to the Study Agreement.

- Transmission and reactive power reinforcements for Scenario 1 and 2
- List of regional transmission reinforcements for Scenario 1
- Losses associated with deferring new transmission lines for Scenario 1

The base resource plan (Scenario 1) adds generation totaling 1700 MW in the Northern region, 2700 MW in the South Interior region, 1345 MW in the Lower Mainland region and 450 MW on Vancouver Island over the next 20 years. The probable load (one in two year probability) and losses is forecasted to increase by 2830 MW over the same period.

The major reinforcements identified for Scenario 1 include series capacitors in 5L91 (Selkirk-Ashton Creek line) & 5L96 (Selkirk-Vaseux Lake line) in the South Interior network, 5L83 (Nicola-Meridian line) and reactive power reinforcements in the Interior to Lower Mainland network, and 230 kV submarine cables to Vancouver Island. The list of regional reinforcements has also been provided for this scenario.

The first alternative resource plan (Scenario 2) adds generation totaling **3395** MW in the Northern Region, 1800 MW in the South Interior Region and 450 MW on VI over the next 20 years. However the plan reduces the Lower Mainland generation by 270 MW over the next 20 years. The high load (one in ten year probability) is forecasted to increase by 3300 MW over the same period.

The reinforcements identified for Scenario 2 include the same reinforcements identified for Scenario 1, but also include series capacitor reinforcements, line upgrades and SVCs in the Northern Region. 5L46 is also identified as a reinforcement for the Interior to Lower Mainland network.

This report also identifies the impact that coastal Reliability Must Run (RMR) has on the timing of 5L83, 5L46 (Kelly Lake – Cheekye line) and the 230 kV Arnott – VIT circuits Higher coastal RMR generation than the designated amount is required before the earliest in service dates of the lines.

Deferring 5L83 for one year from 2013 to 2014 results in an increase in line losses of approximately 268 GWh. Deferring 5L46 for five years results in increase in line losses of 553 GWh.

The appendices include detailed information on the description of the NITS 2004 Bulk Transmission upgrades, ILM nomograms, loss methodology, clarification notes for Stage 1 report and response to questions about BCTC planning criteria.

This report outlines the result of the studies and should not be considered as the planned upgrades for the BCTC transmission network.

Table of Contents

1 Introduction

The report finalizes the results of the System Impact Study (SIS), pursuant to the SIS Agreement between BCHD and BCTC. In response to BCHD's Application for 10 year NITS 2004, BCTC determined that a SIS was needed to determine the transmission requirements for meeting BCHD's 10 year load and resource forecasts between September 2004 and September 2014. On 24 January 2005, in accordance with BC Hydro's WTS Tariff Supplement # 30, BCHD and BCTC signed a SIS Agreement.

The Stage 3 report is the final report that completes the NITS 2004 SIS. Previously, the following two reports were released:

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.

In Stage 3, BCTC provides the following information:

1. A refinement of the required transmission and VAr reinforcements, including their timing, for Scenario 1 of the Stage 1 report.
2. A refinement of the required transmission and VAr reinforcements, including their timing, for Scenario 2 of the Stage 1 report.
3. A list of the regional transmission reinforcements, and their associated ISD, required in the Northern Interior (NI), Southern Interior (SI), Lower Mainland (LM), and Vancouver Island (VI) areas.
4. An approximation of the expected transmission losses associated with deferring of the new transmission lines.

This report summarized the deliverables of the Stage 3 analysis.

2 Resource Scenarios

Following the release of Stage 2 report, BCHD confirmed their choice that the "Base Resource Plan" and "Alternative 1 Resource Plan" were to be analyzed in more details. The "Base Resource Plan", shown in Table 2.1, is designated to supply the BC Hydro's October 2004 normal load forecast and 230 MW of firm export on BCTC x BPAT path in Scenario 1.

Table 2.1: "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 "Alternative 1 Resource Plan", shown in Table 2.2, is designated to supply the BC Hydro's October 2004 high load forecast and 230 MW of firm export on BCTC x BPAT path in Scenario 2.

Table 2.2: "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**

3 Required Bulk Transmission Reinforcement Projects

Report SP2005-04 reviewed eight different load / resource / export scenarios and identified the required Network Upgrades (NU) and Direct Assignment Facilities (DAF) for each scenario. NUs are upgrades for the benefit of all users of the transmission system while DAFs describe the facilities that are constructed for the sole use/benefit of a particular transmission customer.

In Stage 1 and Stage 2 reports the scope and phasing of the suggested NUs were driven by designation of minimum dependable capacity from coastal resources. For studies of Stage 3, BCHD designated higher amounts dependable generation both in LM and VI. The new levels of coastal generation impacted the scope and in-service date (ISD) of some NUs in the LM and VI. This report finalizes the required bulk transmission reinforcements for scenarios 1 and 2 of the SP2005-04. The regional transmission requirements are specified in section 7.

3.1 Bulk Transmission Reinforcements for Scenario 1

Scenario 1 is based on the following:

- BC Hydro's "Base Resource Plan" as shown in Table 2.1,
- BC Hydro's October 2004 normal load forecast,
- 230 MW firm long term point-to-point export on BCTC x BPAT path,
- 1250 MW coastal RMR generation including 636 MW VI generation after May 1st 2007.
- All prior long term firm commitments have assumed to be met except OASIS 254221(500 MW BCTC x BPAT) which has been conditionally released.

Below is a table of the bulk transmission reinforcements required for Scenario 1.

Table 3.1.1

<table>
<tr><td colspan="6">INTERIOR TO LOWER MAINLAND REINFORCEMENTS
Driver: These reinforcements are driven by the need for transferring power from the Interior resources to supply the load in the LM/VI regions.
Constraint: The existing ILM grid is limited by the thermal and voltage stability limits of the grid.
Upgrades: 5L83 will add up to 2100 MW to the ILM transfer capability.
5L83 and 5L46 will add up to 3700 MW to the ILM transfer capability.
VAr reinforcements will be required to facilitate the power flow and to provide voltage control.
Alternatives: The ILM flow will be reduced by designation of additional coastal resources.</td></tr>
<tr><td>ITEM</td><td>PROJECT DESCRIPTION</td><td>TYPE</td><td>ID & STUDY PHASE</td><td>DEFINITION PHASE</td><td>IMPLEMENTATION PHASE</td></tr>
<tr><td>1</td><td>NIC-MDN 500 kV Line (5L83)
50% series compensation, at or near AMC, 3000 A.</td><td>NU</td><td>Before Oct.'04</td><td>Oct.'04 – Aug.'08</td><td>Sep.'08 – Oct.'13</td></tr>
<tr><td>2</td><td>KLY-CKY 500 kV Line (5L46)
50% series compensation , at or near CRK, 3000 A
Note: The Stage 1 ISD is changed.</td><td>NU</td><td>Feb.'08– Sep. '08</td><td>Oct.'08– Aug.'12</td><td>Sep.'12 – Oct.'17</td></tr>
<tr><td>3</td><td>MDN 2x110 MVAr 230 kV switchable shunt capacitors.
ING 2x110 MVAr 230 kV switchable shunt capacitors.
ING one -100/+150 MVAr 230 kV SVC
Note: These items were not identified in Stage 1 report and are subject to further studies.</td><td>NU</td><td>Apr.'05 - Sep.'05
Apr.'05 - Sep.'05
Apr.'05 - Sep.'05</td><td>Oct.'05 – Mar.'06
Oct.'05 – Mar.'06
Oct.'05 – Sep.'06</td><td>Apr.'06 – Oct.'08
Apr.'06 – Oct.'08
Oct.'06 – Oct.'09</td></tr>
<tr><td colspan="6">LOWER MAINLAND TO VANCOUVER ISLAND REINFORCEMENTS
Driver: These reinforcements are mainly driven by the load growth in VI and the need for replacing the existing aging HVDC poles.
Constraint: The existing LM to VI transmission is limited by the transfer capacity of the existing ties.
Upgrades: 2L129 and 2L124 will each add 600 MW to the transfer capability from LM to VI. 2L10 and 2L57 transmission paths will be upgraded for the augmented flows. VAr compensation will be provided for voltage control.
Alternatives: The LM / VI flow will be reduced by designation of additional resources in VI.</td></tr>
<tr><td>ITEM</td><td>PROJECT DESCRIPTION</td><td>TYPE</td><td>ID & STUDY PHASE</td><td>DEFINITION PHASE</td><td>IMPLEMENTATION PHASE</td></tr>
<tr><td>4</td><td>ARN-VIT 230kV AC Cable Circuit (2L129) with a 600 MVA Phase Shifting Transformer at VIT and a 66.1 MVAr fixed shunt reactor at TBY.
Note:The stage 1 scope is changed.</td><td>NU</td><td>Before Apr.'04</td><td>Apr.'04 – Jul.'06</td><td>Dec.'05 – Oct.'08</td></tr>
<tr><td>5</td><td>SAT 230 kV, one 66.1 MVAr switchable shunt reactor,</td><td>NU</td><td>Before Apr.'04</td><td>Apr.'04 - Sep.'06</td><td>Oct.'06 - Oct.'08</td></tr>
<tr><td>6</td><td>2nd ARN-VIT 230kV AC Cable Circuit (2L124) with a 600 MVA</td><td>NU</td><td>Oct.'06 - Sep.'07</td><td>Oct.'07 – Aug.'10</td><td>Sep.'10 – Oct.'14</td></tr>
</table>

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
	Phase Shifting Transformer at VIT and a 66.1 MVAr fixed shunt reactor at TBY. Note:The stage 1 scope and ISD is changed.				
7	ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading Note: The Stage 1 ISD is changed.	NU	Oct.'06 - Sep.'07	Oct.'07 – Aug.'10	Sep.'10 – Oct.'14

SOUTH INTERIOR REINFORCEMENTS

Driver: These reinforcements are mainly driven by the need for transferring 1900 MW (peak winter), 2150 MW (peak summer), and 2470 MW (light summer) of SI east excess generation to NIC.
Constraint: The existing transmission network in SI east and SI west is limited by voltage and transient stability.
Upgrades: Series compensation of the existing 500 kV lines together with shunt compensation at ACK will increase the transfer capability on 5L91 and 5L96 from the existing 1850 MW to 2300 MW (peak winter). Addition of SEL transformer will increase the 230 kV to 500 kV transformation limit at SEL from 1650 MVA to 2700 MVA.
Alternatives: New 500 kV transmission lines between SEL and NIC are more expensive.

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
8	Series Compensation of 5L91, 5L96, and 5L98 50% compensation, 2750 A	NU	Oct.'04 – Sep.'05	Oct.'05 – Apr.'07	May '07 – Oct.'09
9	SEL Transformer Bank Addition T4 (1200 MVA)	NU	Oct.'04 – Jan.'05	Feb.'05 – Mar.'05	Apr.'05 – Nov.'06
10	SEL 500 kV, 123 MVAr shunt Reactor	NU	Oct.'04 – May.'05	Jun.'05 – Jul.'05	Aug.'05 – Jul.'06
11	ACK 250 MVAr Shunt Capacitor Note: The Stage 1 ISD is changed.	NU	Oct.'05 – Mar.'06	Apr.'06 – Jun.'07	Jul.'07 – Oct.'09
12	NIC 500 kV Station Reconfiguration	NU	Oct.'04 – Mar.'06	Apr.'06 – Mar.'07	Apr.'07 – Oct.'09
13	Series Compensation of 5L71 and 5L72, each line 40% compensation and 2750 A	DAF	Oct.'18 – Sep.'19	Oct.'19 – Apr.'21	May '21 – Oct.'23

NORTHERN REGION REINFORCEMENT

Driver: This reinforcement is required for interconnection of the designated resources.

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
14	The interconnection from KIT-SCGT (180 MW) to KIT Station	DAF	Oct.'05 - Sep.'06	Oct.'06 - Sep.'07	Oct.'07 - Oct.'09

COMMON REINFORCEMENT

Driver: The new RAS will be applicable to all regions.

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
15	Apply Remedial Action Schemes (RAS)	NU	Oct.'05 - Sep.'06	Oct.'06 - Sep.'07	Oct.'07 - Oct.'24

3.2 Bulk Transmission Reinforcements for Scenario 2

Scenario 2 is based on the following:

- BC Hydro's "Alternative 1 Resource Plan" as shown in Table 2.2,
- BC Hydro's October 2004 high load forecast,
- 230 MW firm long term point-to-point export on BCTC x BPAT path,
- 1250 MW coastal RMR generation including 636 MW VI generation after May 1st 2007.
- All prior long term firm commitments have assumed to be met except OASIS 254221(500 MW BCTC x BPAT) which has been conditionally released.

Below is a table of the bulk transmission reinforcements required for Scenario 2.

Table 3.2.1

INTERIOR TO LOWER MAINLAND REINFORCEMENTS

Driver: These reinforcements are driven by the need for transferring power from the Interior resources to supply the load in the LM/VI regions.
Constraint: The existing ILM grid is limited by the thermal and voltage stability limits of the grid.
Upgrades: 5L83 will add up to 2100 MW to the ILM transfer capability.
5L83 and 5L46 will add up to 3700 MW to the ILM transfer capability.
VAr reinforcements will be required to facilitate the power flow and to provide voltage control.
Alternatives: The ILM flow will be reduced by designation of additional coastal resources.

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
1	NIC-MDN 500 kV Line (5L83) 50% series compensation, at or near AMC, 3000 A.	NU	Before Oct.'04	Oct.'04 – Aug.'08	Sep.'08 – Oct.'13
2	KLY-CKY 500 kV Line (5L46) 50% series compensation , at or near CRK, 3000 A	NU	Feb.'05– Sep. '05	Oct.'05 – Aug.'09	Sep.'09 – Oct.'14
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. Note: These items were not identified in Stage 1 report and are subject to further studies.	NU	Apr.'05 - Sep.'05 Apr.'05 - Sep.'05 Apr.'05 - Sep.'05	Oct.'05 – Mar.'06 Oct.'05 – Mar.'06 Oct.'05 – Sep.'06	Apr.'06 – Oct.'08 Apr.'06 – Oct.'08 Oct.'06 – Oct.'09

LOWER MAINLAND TO VANCOUVER ISLAND REINFORCEMENTS

Driver: These reinforcements are mainly driven by the load growth in VI and the need for replacing the existing aging HVDC poles.
Constraint: The existing LM to VI transmission is limited by the transfer capacity of the existing ties.
Upgrades: 2L129 and 2L124 will each add 600 MW to the transfer capability from LM to VI. 2L10 and 2L57 transmission paths will be upgraded for the augmented flows. VAr compensation will be provided for voltage control.
Alternatives: The LM / VI flow will be reduced by designation of additional resources in VI.

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
4	ARN-VIT 230kV AC Cable Circuit (2L129) with a 600 MVA Phase Shifting Transformer at VIT and a 66.1 MVAr fixed shunt reactor at TBY. Note:The stage 1 scope is changed.	NU	Before Apr.'04	Apr.'04 – Jul.'06	Dec.'05 – Oct.'08
5	SAT 230 kV, one 66.1 MVAr switchable shunt reactor,	NU	Before Apr.'04	Apr.'04 - Sep.'06	Oct.'06 - Oct.'08
6	2nd ARN-VIT 230kV AC Cable Circuit (2L124) with a 600 MVA Phase Shifting Transformer at VIT	NU	Oct.'05 - Jul.'06	Jul.'06 – Jul.'08	Dec.'07 – Oct.'10

	and a 66.1 MVAr fixed shunt reactor at TBY. Note:The stage 1 scope and ISD is changed.				
7	ING-ARN 230 kV circuits (2L10 & 2L57) Upgrading Note: The Stage 1 ISD is changed.	NU	Oct.'05 - Jul.'06	Jul.'06 – Jul.'08	Dec.'07 – Oct.'10

SOUTH INTERIOR REINFORCEMENTS

Driver: These reinforcements are mainly driven by the need for transferring 1900 MW (peak winter), 2150 MW (peak summer), and 2470 MW (light summer) of SI east excess generation to NIC.
Constraint: The existing transmission network in SI east and SI west is limited by voltage and transient stability.
Upgrades: Series compensation of the existing 500 kV lines together with shunt compensation at ACK will increase the transfer capability on 5L91 and 5L96 from the existing 1850 MW to 2300 MW (peak winter). Addition of SEL transformer will increase the 230 kV to 500 kV transformation limit at SEL from 1650 MVA to 2700 MVA.
Alternatives: New 500 kV transmission lines between SEL and NIC are more expensive.

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
8	Series Compensation of 5L91, 5L96, and 5L98 50% compensation, 2750 A	NU	Oct.'04 – Sep.'05	Oct.'05 – Apr.'07	May '07 – Oct.'09
9	SEL Transformer Bank Addition T4 (1200 MVA)	NU	Oct.'04 – Jan.'05	Feb.'05 – Mar.'05	Apr.'05 – Nov.'06
10	SEL 500 kV, 123 MVAr shunt Reactor	NU	Oct.'04 – May.'05	Jun.'05 – Jul.'05	Aug.'05 – Jul.'06
11	ACK 250 MVAr Shunt Capacitor Note: The Stage 1 ISD is changed.	NU	Oct.'05 – Mar.'06	Apr.'06 – Jun.'07	Jul.'07 – Oct.'09
12	ACK 250 MVAr Shunt Capacitor Note: This item was not identified in Stage 1 report.	NU	Oct.'19 – Mar.'20	Apr.'20 – Jun.'21	Jul.'21 – Oct.'22
13	NIC 500 kV Station Reconfiguration	NU	Oct.'07 – Mar.'08	Apr.'08 – Mar.'09	Apr.'09 – Oct.'11
14	Series Compensation of 5L71 and 5L72, each line 40% compensation and 2750 A Note: The Stage 1 ISD is changed.	DAF	Oct.'12 – Sep.'13	Oct.'13 – Apr.'15	May '15 – Oct.'17

NORTHERN REGION REINFORCEMENTS

Driver: The Northern region reinforcements provide interconnection facilities and transfer capability for transfer of "Site C" and "NW-Wind" resources.
Constraint: The transmission grid north of KLY will be limited by voltage and transient stability constraints.
Upgrades: Upgrading series compensation of the existing 500 kV lines between GMS and KLY together with the appropriate VAr compensation will allow the transfer of "Site C" and "NW-Wind" generation towards KLY.
Alternatives: New 500 kV transmission lines between GMS and KLY are not considered economical.

ITEM	PROJECT DESCRIPTION	TYPE	ID & STUDY PHASE	DEFINITION PHASE	IMPLEMENTATION PHASE
15	Upgrade KDY series capacitor station: Increase the series compensation from 50% to 65%. Increase the rated current of series capacitors from 2310 A to the minimum of 2500 A.	NU	Oct.'09 - Sep.'11	Oct.'11 - Sep.'12	Oct.'12 - Oct.'14
16	Upgrade MLS series capacitor station: Increase the series compensation from 50% to 65%. Increase the rated current of series capacitors from 1950 A to the minimum of 2500 A.	NU	Oct.'09 - Sep.'11	Oct.'11 - Sep.'12	Oct.'12 - Oct.'14
17	Upgrade 5L1, 5L2 and 5L3 from 2500 A to the minimum of 2750 A	NU / DAF	Oct.'09 - Sep.'11	Oct.'11 - Sep.'12	Oct.'12 - Oct.'14
18	Upgrade 5L11and 5L12 from 2500 A to the minimum of 2750 A	NU	Oct.'09 - Sep.'11	Oct.'11 - Sep.'12	Oct.'12 - Oct.'14
19	WSN 500 kV, 500 MVAr SVC or shunt Capacitor compensation	NU	Oct.09 – Mar.'11	Apr.'11 – Mar.'12	Apr.'12 – Oct.'14

20	KLY 500 kV, 500 MVAr SVC or shunt Capacitor compensation	NU	Oct.'09 – Mar.'11	Apr.'11 – Mar.'12	Apr.'12 – Oct.'14
21	Two 500 kV circuits from Site C (900 MW) to PCN switch yard	DAF	Oct.'06 - Sep.'07	Oct.'07 - Sep.'10	Oct.'10 - Oct.'14
22	The interconnection from NW_Wind (700 MW) to SKA	DAF	Oct.'06 - Sep.'07	Oct.'07 - Sep.'10	Oct.'10 - Oct.'14
23	Series Compensation of 5L61 35% compensation, 1025 A Note: This item was not identified in Stage 1 report.	NU	Oct.'06 - Sep.'07	Oct.'07 - Sep.'10	Oct.'10 - Oct.'14
COMMON REINFORCEMENT **Driver:** The new RAS will be applicable to all regions.					
ITEM	**PROJECT DESCRIPTION**	**TYPE**	**ID & STUDY PHASE**	**DEFINITION PHASE**	**IMPLEMENTATION PHASE**
24	Apply Remedial Action Schemes (RAS)	NU	Oct.'05 - Sep.'06	Oct.'06 - Sep.'07	Oct.'07 - Oct.'24

4 Impact of Coastal RMR on the Timing of New Transmission Lines

The need for new Interior to Lower Mainland (ILM) transfer capacity is significantly impacted by the amount of available coastal generation. Coastal generation resources are located near the load centers. They reduce the demand for power from the Interior and relieve the flow on the ILM network. Reduced flow patterns on the ILM network allow the grid transmission lines to operate within their respective thermal limits. As the load grows and flows on the ILM network approach their thermal limits, voltage stability becomes a constraining factor. Section 6 describes the required VAr reinforcements for the ILM network.

The Stage 1 report identified the need for a second new series compensated 500 kV line (5L46) between Kelly Lake (KLY) and Cheekye (CKY) substations by October 2014. The justification for 5L46 is based on the need to meet the LM and VI loads using interior resources and a low level of on-line coastal generation. The addition of 5L46 would enhance the Total Transfer Capability (TTC) of the ILM network and would allow simultaneous dispatch of the NITS designated resources from South Interior and Northern Interior

The need for 5L46 can be deferred if the amount of on-line coastal generation is increased after the in-service date of 5L83 in 2013. The following two tables identify the annual levels of coastal RMR required to defer this project beyond 2024. Tables 4.1 identifies the required RMR for Scenario 1 of the Stage 1 report and Table 4.2 identifies the required RMR associated with Scenario 2 of the report. The specified RMR levels will relieve the flow on the ILM transmission network to ensure that single contingency outages of the ILM lines will not overload the remaining network. This is done by relying on the coastal resources to supply part of the local load.

Each column of Tables 4.1 and 4.2 identifies the following:

a- The amount of RMR required if only one new 500 kV line is added to reinforce the existing ILM network.
b- The amount of annual RMR to defer the need for the addition of a second 500 kV ILM line.

Table 4.1

	SCENARIO 1 - RMR (MW)			
	Max. Columbia Generation ILM Reinforcement		Max. Peace Generation ILM Reinforcement	
	5L83	5L46	5L83	5L46
2005/06	1072	1072	1078	1078
2006/07	1207	1207	1195	1195
2007/08	1282	1282	1285	1285
2008/09	1427	1427	1395	1395
2009/10	1530	1530	1497	1497
2010/11	1811	1811	1641	1641
2011/12	1924	1924	1712	1712
2012/13	2069	2069	1829	1829
2013/14	1022	2213	1022	1968
2014/15	501	1768	594	997
2015/16	583	2026	849	1072
2016/17	693	2215	1036	1181
2017/18	808	2408	1261	1277
2018/19	689	3248	1424	1407
2019/20	807	3458	1621	1525
2020/21	933	3672	1825	1648
2021/22	1040	Note 1	2109	1744
2022/23	1171	Note 1	2322	1874
2023/24	1091	Note 1	2539	2005

Note 1: Maximum Columbia generation may not be achieved with any amount of coastal RMR

Table 4.2

	SCENARIO 2 - RMR (MW)			
	Max. Columbia Generation ILM Reinforcement		Max. Peace Generation ILM Reinforcement	
	5L83	5L46	5L83	5L46
2005/06	1360	1360	1360	1360
2006/07	1470	1470	1478	1478
2007/08	1552	1552	1578	1578
2008/09	1702	1702	1693	1693
2009/10	1812	1812	1865	1865
2010/11	2017	2017	2006	2006
2011/12	2517	2517	2123	2123
2012/13	2627	2627	2287	2287
2013/14	947	2732	947	2402
2014/15	914	1884	**3043**	**511**
2015/16	1059	2005	3173	652
2016/17	1208	2127	3725	670
2017/18	1139	2815	3910	802
2018/19	1292	2946	4003	965
2019/20	1450	3081	4592	992
2020/21	1614	3222	Note2	1025
2021/22	1790	3347	Note2	1061
2022/23	1712	4165	Note2	1224
2023/24	1884	4320	Note2	1390

Note 2: Maximum Peace generation may not be achieved with any amount of coastal RMR

Thermal nomograms of RMR tables for scenarios 1 and 2 are shown in Appendix 2.

Tables 4.1 and 4.2 are compared to show which reinforcement sequencing will require a smaller amount of coastal RMR. Table 4.3 indicates that if the ILM network has to be reinforced with both 5L83 and 5L46, then the preferred sequence of reinforcement will be 5L83 first and 5L46 after it.

Table 4.3

	Scenario 1		Scenario 2		Conclusion
	T-Line ISD	**Max. RMR Required Before the New Line**	**T-Line ISD**	**Max. RMR Required Before the New Line**	
Sequence 1					Sequence 1 is preferred. It requires less RMR than Sequence 2.
1st Line in	5L83 in 2013/14	2069 MW	5L83 in 2013/14	2627 MW	
2nd Line in	5L46 in 2017/18	**1036** MW	5L46 in 2014/15	**947** MW	
Sequence 2					
1st Line in	5L46 in 2014/15	2213 MW	5L46 in 2014/15	2732 MW	Sequence 2 requires more RMR than Sequence 1.
2nd Line in	5L83 in 2014/15	**2213** MW	5L83 in 2014/15	**2732** MW	

5 Computation of Transmission Losses

Transmission losses are a function of current flows on transmission lines. The line flows are affected by many factors including seasonal demand, generation pattern, daily load variations, available VAr resources, and import / export levels. In a single study, it is difficult to account for the variation of all these parameters. In order to conduct a reasonable loss analysis, many assumptions have to be made about the above parameters. Consequently, any particular loss analysis should only be viewed as an estimate of the expected results for a particular set of assumptions.

The impact of adding a new transmission line (or cable) on the transmission network losses can be significant. The peak MW and annual energy loss computations were performed for Scenario 1. For each study case, the amount of coastal RMR for maximum Peace and maximum Columbia generation dispatch were viewed and the higher of the two RMRs were modeled. The study cases are described below:

a) **Deferring 5L83:** Losses with 5L83 were computed for a level of coastal RMR corresponding to maximum Columbia generation. Similarly, losses without 5L83 were computed for a higher level of coastal RMR to meet single contingency criteria corresponding to maximum Columbia generation.
b) **Deferring 5L46:** Losses with 5L83 and 5L46 in service were computed for 1250 MW coastal generation. Similarly, losses with 5L83 in service and without 5L46 were computed for a higher level of coastal RMR to meet single contingency criteria corresponding to maximum Peace generation.

c) **5L83 or 5L46 for 2015/16:** One typical study year (2015/16) was chosen. Transmission losses with only 5L83 in service were computed for the coastal RMR corresponding to maximum Peace generation. Similarly, transmission losses with only 5L46 in service were computed for a higher level of coastal RMR to meet single contingency criteria corresponding to maximum Columbia generation.
d) **Deferring VI 230 kV Circuit-2:** VI 230kV Circuit 1 is in service, losses with VI 230 kV Circuit 2 were computed for VI generation of 425 MW. Similarly losses with VI 230kV Circuit 1 in service and without VI 230 kV Circuit 2 were computed for RMR generation in VI.

The methodology, definitions, and assumptions for the computation of transmission losses are described in Appendix-3. Results of the loss analysis are tabulated in sections 5.1 to 5.4.

5.1 Deferring 5L83

The table below summarizes the expected peak hour and annual energy losses with and without 5L83 as described in section 5. In this table, the specified generation pattern represents the regional resources at peak load. The analysis is done for 2013/14 which is the in service date of 5L83. The sensitivity analysis shows the impact of advancing or delaying the delivery of 5L83 on transmission losses.

Table 5.1.1

Transmission losses with only 5L83 in service

	Generation at Peak Load (MW)				Losses	
Year	Coastal	Peace	Columbia	Load	Peak MW	Energy GWh/yr
2011/12	999	3327	6227	9587	736.8	2,364
2013/14	1022	3586	6341	9855	787.6	2,487
2015/16	1036	3308	6887	10137	836.9	2,723

Transmission losses without any new 500 kV line

	Generation at Peak Load (MW)				Losses	
Year	Coastal	Peace	Columbia	Load	Peak MW	Energy GWh/yr
2011/12	1924	2377	6227	9587	710.9	2,614
2013/14	2213	2333	6341	9855	721.6	2,756
2015/16	2858	1421	6887	10137	758.7	3,025

5.2 Deferring 5L46

The table below summarizes the expected peak hour and annual energy losses with and without 5L46 as described in section 5. In this table, the specified generation pattern represents the regional resources at peak load.

Table 5.2.1

Transmission losses with both 5L83 and 5L46 in service

	Generation				Losses	
Year	Coastal	Peace	Columbia	Load	Peak MW	Energy GWh/yr
2017/18	1250	3957	6382	10446	832.1	2,764
2018/19	1250	3947	6569	10604	860.4	2,846
2019/20	1250	3947	6747	10765	889.2	2,927
2020/21	1250	3947	6969	10933	928.5	3,024
2021/22	1250	3947	7190	11104	975.6	3,130

Transmission losses with 5L83 in service but without 5L46

	Generation				Losses	
Year	Coastal	Peace	Columbia	Load	Peak MW	Energy GWh/yr
2017/18	1261	3957	6405	10446	864.6	2,863
2018/19	1424	3947	6421	10604	877.6	2,947
2019/20	1621	3947	6401	10765	892.2	3,037
2020/21	1825	3947	6390	10933	912.0	3,140
2021/22	2109	3947	6271	11104	913.3	3,257

5.3 5L83 or 5L46 for 2015/16

The table below summarizes the expected peak hour and annual energy losses with 5L83 or with 5L46 as described in section 5. In this table, the specified generation pattern represents the regional resources at peak load.

Table 5.3.1

2015/16 transmission losses with only 5L83 in service

	Generation				Losses	
Year	Coastal	Peace	Columbia	Load	Peak MW	Energy GWh/yr
2015/16	1036	3927	6297	10137	843.2	2,753

2015/16 transmission losses with only 5L46 in service

	Generation				Losses	
Year	Coastal	Peace	Columbia	Load	Peak MW	Energy GWh/yr
2015/16	2215	2109	6887	10137	757.1	2,951

5.4 Deferring VI 230 kV Circuit-2

The table below summarizes the expected peak hour and annual energy losses with and without VI 230 kV Circuit-2 as described in section 5.

Table 5.4.1

Transmission losses with both VI 230 kV circuit 1 and circuit 2 in service

Year	VI RMR MW	VI Load MW	Peak Losses MW	Energy Losses GWh/yr
2014/15	625	2406	91.5	302
2015/16	625	2443	95.1	313
2016/17	625	2480	98.7	325
2017/18	625	2519	103.1	340
2018/19	625	2558	111.5	368

Transmission losses with VI 230 kV circuit 1 in service and without VI 230 kV circuit 2

Year	VI RMR MW	VI Load MW	Peak Losses MW	Energy Losses GWh/yr
2014/15	639	2406	97.9	323
2015/16	677	2443	100.1	330
2016/17	717	2480	102.2	337
2017/18	757	2519	105.2	347
2018/19	798	2558	112.7	372

6 Shunt Capacitive Reinforcements for High ILM 500 kV Power Transfers

Additional shunt capacitive support in the LM area will be needed due to the high ILM power transfers in the winter peak load situation. The increasing LM and VI peak load levels and the operation of the coastal generation at the minimum acceptable RMR levels will increase the ILM loading to levels that fully use the thermal rating of the system which will require more reactive support than is available in the LM area.

The Stage 1 report anticipated the need for a SVC (-200/+300 MVAr) at Ingledow Substation with in-service date October 2010 to support the high ILM power transfers in the various scenarios. The Stage 3 reviews of the "Scenario 1" winter peak loading situation show that ILM loading at the thermal limit in the year 2009/10 will require the following reinforcements

- Two 110 MVAr switchable shunt capacitors at Meridian 230 kV Substation,
- Two 110 MVAr switchable shunt capacitors at Ingledow 230 kV Substation,
- One -100/+150 MVAr SVC at Ingledow 230 kV Substation.

These projects are required at their earliest in-service dates. Tables 3.1.1 and 3.2.1 show the expected time schedule for different phases of VAr reinforcement projects.

7 Regional Transmission Reinforcements

Table 7.1 provides a list of the planned regional transmission upgrades as submitted to British Columbia Utilities Commission (BCUC) in March 2005. The list is extracted from the growth section of BCTC's fiscal 2006 Capital Plan Application. BCTC reviews these projects on a continuous basis and once a year submits the renewed Capital Plan Application to BCUC for approval. Depending on the outcome of the ongoing regional planning studies, the scope of some of the listed items may change, other items may be eliminated, and new upgrades may be added to this list. The items listed in Table 7.1 cannot be deferred by increasing local generation.

Table 7.1

AREA REINFORCEMENTS	**IS Date**
Projects in Progress	
60L350 - Williston to Canreed 3rd 69 kV Line	2007/10
Highland - 138/69 kV Transformer Replacement	2006/10
Mt Pleasant Area Supply	2006/10
Proposed Projects	
60L300 (Soda Creek to Mount Polley) Line Upgrade	2005/06
Fort St. John - Fox Creek Substation	2006/10
Langley Area System Reinforcement - Harvie Road substn	2006/10
Maple Ridge Area - Haney substation	2006/11
Metro 230 kV Supply - Sperling to Cathedral Square (CPCN)	2007/10
Mission and Matsqui Area Supply	2007/10
Salmon Arm Substation - 230/138 kV Transformer Addition	2007/10
Whistler Village Reinforcement - Function Junction Substn	2006/11
3L3 (Wahleach to Rosedale) - 230 kV Conversion	2008/10
60L101 (McLellan to Nikomekl) - New 69 kV Trans Line	2007/10
60L43/44 (Richmond) - Undergrounding	2007/10
Goward Substation - 230/138 kV Transformer Addition	2008/10
Rainbow Substation - 2L2 Loop-in	2007/10
East Kootenay 230 kV Reinforcement	2011/10
60L359 - Tachick to Fort St. James 2nd 69 kV Line	2015/10
Valleyview - 230/138 kV Transformer Addition	2014/10
Valleyview - 230/138 kV Transformer RAS	2009/10
STATION EXPANSIONS & MODIFICATIONS	**IS Date**
Projects in Progress	
Douglas Street - 138/25 kV Transformer	2005/08
Pender Harbour - 138/25 kV Transformer	2005/10
PFMS Transformer Data Book	2006/03
Proposed Projects	

Annacis Island Substation - 69/12 kV Transformer Addition	2006/05
Cambie Substation - 230/25 kV Transformer Addition	2006/10
Cathedral Square - 230/12 kV Transformer Addition	2007/03
Como Lake - 25 kV Feeder Section Addition	2006/10
Cheekye - 60/25 kV Transformer and Feeder Position	2006/08
Fort St. James - Mobile transformer connection	2006/09
Horne Payne - 230/12 kV Transformer (Definition Phase)	2007/09
Lougheed Substation - 12 kV Circuit Breaker Replacements	2005/11
Mainwaring - 230/12 kV Transformer (T2) replacement	2005/11
Metro Van Supply / Mainwaring - T1 replacement (CPCN)	2006/11
Mission Substation - Equipment Upgrade	2005/10
Mission Substation - Monitoring Equipment	2005/10
Seventy Mile House - 69/25 kV Transformer Replacement	2006/10
Squamish - 69/25 kV Transformer Addition	2006/10
Winsor - 69/12 kV Transformer Replacement	2006/10
Ashcroft - 69/25 kV Transformer	2009/05
Cheakamus GS - 230/12 kV Transformer	2010/09
Colwood - 138/25 kV Transformer	2011/11
Harewood - 138/25 kV Transformer	2012/10
Keating - 230/25 kV Transformer	2012/10
McLellan - 230/25 kV Transformer	2010/10
Mt Lehman - Upgrade to 200 MVA	2015/10
Nakusp - 69/12 kV Transformer	2010/10
Steveston - 230/25 kV Transformer	2010/10
Williston - 230/69 kV Transformer	2009/06
Notes	
1. Projects that contain only transmission facilities, or both transmission and System Distribution Assets components, have been included.	
2. IS Date = In Service Date (Year/Month)	

8 Conclusions

Scenarios 1 and 2 of the “System Impact Study for BC Hydro Distribution NITS 2004 Stage 1” are analyzed in detail. Results of the analysis include the following:

- The required transmission and VAr reinforcements for both scenarios are finalized.
- The expected transmission losses associated with deferring 5L83 are estimated.
- The expected transmission losses associated with deferring 5L46 are estimated.
- The expected transmission losses associated with deferring the second VI 230 kV cable are estimated.
- For both scenarios the required RMR levels associated with 5L83 are specified.
- For both scenarios the required RMR levels associated with 5L46 are specified.
- A list of the expected regional transmission reinforcements are provided.

This report outlines the result of the studies and should not be considered as the planned upgrades for the BCTC transmission network.

Appendix 1: Description of the NITS 2004 Bulk Transmission Upgrades

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

Justification:
The transfer capability of the existing ILM network is up to 6300 MW. With 1250 MW coastal RMR, 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:
For this study, 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 this 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 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 50% series compensated and will include approximately 246 km of 500 kV transmission circuit between NIC and MDN 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. Location of the series capacitor station is to be determined and is preferred to be near the middle of the line. The thermal rating of the line will be limited by the 3.0 kA continuous rating of the series capacitor bank.

Project In-Service Date:
The NITS 2004 SIS Stage 1 Report indicated that for dispatch of the Interior resources designated in scenarios 1 and 2, the ILM transmission network will be constrained in 2007. Completion of the 5L83 project is expected to last eight years. During this time, any peak hour congestion of the ILM transmission network has to be addressed by other means (such as increased coastal RMR

generation). This situation has made the earliest ISD of 5L83 desirable. Currently, the ISD of 5L83 is targeted for October 2013 but advancing the ISD by up to two years may be feasible. Shortening the project duration by one or two years will result in lower amounts of coastal RMR generation during those years. A more detailed project schedule and the risks associated with the fast track project delivery can be estimated in the Facilities Study stage.

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 requested dispatch capacity of all Interior resources. In this 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. This report identifies the coastal RMR levels that are required to defer 5L46 in section 4.

Project Description:
5L46 would be a 197 km 500 kV transmission circuit between KLY and CKY substations with approximately 55% series compensation. The circuit would 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 likely at CRK or near the middle of the line. The thermal rating of the line will be limited by the 3.0 kA continuous rating of the series capacitor bank.

Project In-Service Date:
To provide the requested generation dispatch flexibility, 5L46 will be needed in October 2017 for Scenario 1 and in October 2014 for Scenario 2.

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 Stage 1 report (thermal capacity limited), 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 thermal limit-based values, 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:

- At Meridian station: 2 x 110 MVAr shunt capacitors at the 230 kV bus, each shunt capacitor 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.
- At Ingledow station: 2 x 110 MVAr shunt capacitors at the 230 kV bus, each shunt capacitor switched by a circuit breaker (auto-VAr scheme).
- At Ingledow station: a -100/+150 MVAr SVC (static VAr compensator) connected at the 230 kV bus.

Project In-Service Date:
The ILM system will be constrained to below its thermal capability until these projects are added. When coastal generation is at or just above the low RMR values the constraint will be evident. Targeted in-service dates for the shunt capacitors should be October 2008 or sooner if possible, and for the SVC October 2009 or sooner if possible.

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

Justification:
In 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 and a 66.1 MVAr shunt

reactor at Taylor Bay Cable Terminal (TBY) will be installed. The transformer will control the circuit power flow and the fix-connected reactor will absorb a portion of charging power from the circuit. The second 230 kV overhead line together with the existing 138 kV cables will operate at 138 kV to supply South Gulf Islands.

Project In-Service Date:
The project earliest in-service date is October 2008.

A1.5 Sahtlam 230 kV Shunt Reactor

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 reactors at SAT, besides one reactor fix-connected on the circuit at 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:
One 66.1 MVAr switchable shunt reactor will be built at SAT in conjunction with the first 230 kV cable circuit (2L129) between ARN and VIT.

Project In-Service Date:
The project in-service date is October 2008.

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 Solution:
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 Stage 2 report identifies 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 (see A1.4). 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.

Project In-Service Date:

Scenario 1: October 2014
Scenario 2: October 2010.

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

Justification:
Currently, 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 overload 2L10 and 2L57. Both 2L10 and 2L57 need to be upgraded in conjunction with the 2L124 project.

Alternative Solution:
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 Stage 2 report identifies the required on-island RMR levels between 2004/05 and 2024/25.

Project Description:
2L10 and 2L57 will be upgraded to have the same thermal ratings as 2L6 and 2L63.

Project In-Service Date:
Scenario 1: October 2014
Scenario 2: October 2010.

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

Justification:
With Vaseux Lake (VAS) 500 kV substation in service, 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 (Stage 1 report, section 1.4) and also based on the designated return of Down Stream Benefits (Stage 1 report, section 1.7) on 2L112, the approximate load requirements on the cut-plane would be:

- 1900 MW at winter peak load and 2130 MW at summer peak load in 2007;
- 1900 MW at winter peak load and 2150 MW at summer peak load in 2010, and
- 1870 MW at winter peak load and 2130 MW at summer peak load in 2015.

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. These reinforcements can be deferred by reducing the SI East resource dispatch.

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.

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.

Project In-Service Date:
The earliest expected in service date is 2009.

A1.9 Selkirk Transformer Bank Addition T4

Justification:
The total surplus generation in Selkirk area plus import from FortisBC, and US through the 230kV Nelway – Boundary connection are transferred out of the area to the BCTC 500kV system through the Selkirk 230/500kV transformers. The loss of Selkirk transformer T1 will result in limiting the total transfer to 1650MVA to prevent thermal overload of remaining 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. The addition of a new 1200 MVA unit T4 will raise the firm capacity 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:
Installation of a new SEL 500 kV / 1200 MVA transformer T4 and joining the existing two 672 MVA units T2 & T3 into one transformer zone will provide additional transfer capability from SEL 230 to 500 kV system.

Project In-Service Date:
November, 2006

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) to regulate 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.

Project In-Service Date:

July, 2006

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 In-Service Dates:

ACK 5CX1: 2009 (Scenarios 1 & 2)
ACK 5CX2: 2022 (Scenario 2)

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 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.

Project In-Service Date:
October 2009.

A1.13 Series Compensation of Mica – Nicola Lines 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 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 thermal limits 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 end of 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 3300 A for each line.

Project In-Service Date:
Scenario 1: October 2023.
Scenario 2: October 2017.

A1.14 Upgrade of Kennedy Series Capacitor Station

Justification:
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

Discussion of Alternatives:
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 longer construction time and would require reviewing the Right-of-Way issues. Increasing series compensation of MLS and KDY capacitor stations and upgrading the existing 500 kV lines and adding some shunt compensation at WSN and/or KLY are a preferred solution because of the much less cost, least environment impact and short construction period.

Project Description:

This project includes:

- Increase series compensation from 50% to 65%
- Increase the continuous current rating from 2310 A to 2500 A

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

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Project In-Service Date:
In order to accommodate the interconnection of 900 MW from Site C and 700 MW from NW-Wind plants, upgrade of Kennedy Series Capacitor Station has to be completed by 2014.

A1.15 Upgrade of McLeese Series Capacitor Station

Justification:

See A1.14

Discussion of Alternatives:

See A1.14

Project Description:

This project includes:

- Increase series compensation from 50% to 65%
- Increase the continuous current rating from 1950 A to 2500 A

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

Project In-Service Date:

In order to accommodate the interconnection of 900 MW from Site C and 700 MW from NW-Wind plants, upgrade of McLeese Series Capacitor Station has to be completed by 2014.

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

Justification:

See A1.14

Discussion of Alternatives:

See A1.14

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.

Project In-Service Date:
In order to accommodate the interconnection of 900 MW from Site C and 700 MW from NW-Wind plants, upgrade of 5L1, 5L2, and 5L3 has to be completed by 2014.

A1.17 Thermal Upgrade of 500 kV Lines 5L11 and 5L12

Justification:

See A1.14

Discussion of Alternatives:

See A1.14

Project Description:
This project will upgrade the overload capabilities of 5L11and 5L12 from the existing 2500 A (at 30 C) to a minimum of 2750 A

Project In-Service Date:
In order to accommodate the interconnection of 900 MW from Site C and 700 MW from NW-Wind plants, upgrade of 5L11 and 5L12 has to be completed by 2014.

A1.18 Williston 500 kV SVC

Justification:

See A1.14

Discussion of Alternatives:

See A1.14

Project Description:
This project is to install one 500 kV SVC with +450 to +500 MVAr (capacitive) at WSN Substation. The definition phase of the SVC 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.

Project In-Service Date:
In order to accommodate the interconnection of 900 MW from Site C and 700 MW from NW-Wind plants, installation of WSN SVC has to be completed by 2014.

A1.19 Kelly Lake 500 kV SVC

Justification:

See A1.14

Discussion of Alternatives:

See A1.14

Project Description:
This project is to install one 500 kV SVC with +450 to +500 MVAr (capacitive) at KLY Substation. The definition phase of the SVC 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.

Project In-Service Date:
In order to accommodate the interconnection of 900 MW from Site C and 700 MW from NW-Wind plants, installation of KLY SVC has to be completed by 2014.

A1.20 Two 500 kV Ties from Site C to Peace Canyon

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.

Project In-Service Date:
In order to accommodate the interconnection of 900 MW from Site C, the two 500 kV ties to Site C have to be completed by 2014.

A1.21 The Interconnection from NW-Wind to Skeena Substation (SKA)

NW_Wind generation plants with the maximum output of 700 MW are designated for 2014 in service date. The SKA 287 kV bus is assumed as the point of interconnection for the plants. Based on the data contained in the NITS 2004 Application, the interconnection facilities for this project can not be defined at this time.

Project In-Service Date:
Interconnection of the 700 MW NW-Wind plant to the transmission grid is suggested for 2014 in service date.

A1.22 The Interconnection from Kitimat SCGT to Kitimat Substation

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.

Project In-Service Date:

October 2009.

A1.23 The Series Compensation of WSN – GLN Line 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.

Discussion of Alternatives:
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.

Project In-Service Date:
In order to accommodate the interconnection of 700 MW from NW-Wind plants, series compensation of 5L61 has to be completed by 2014.

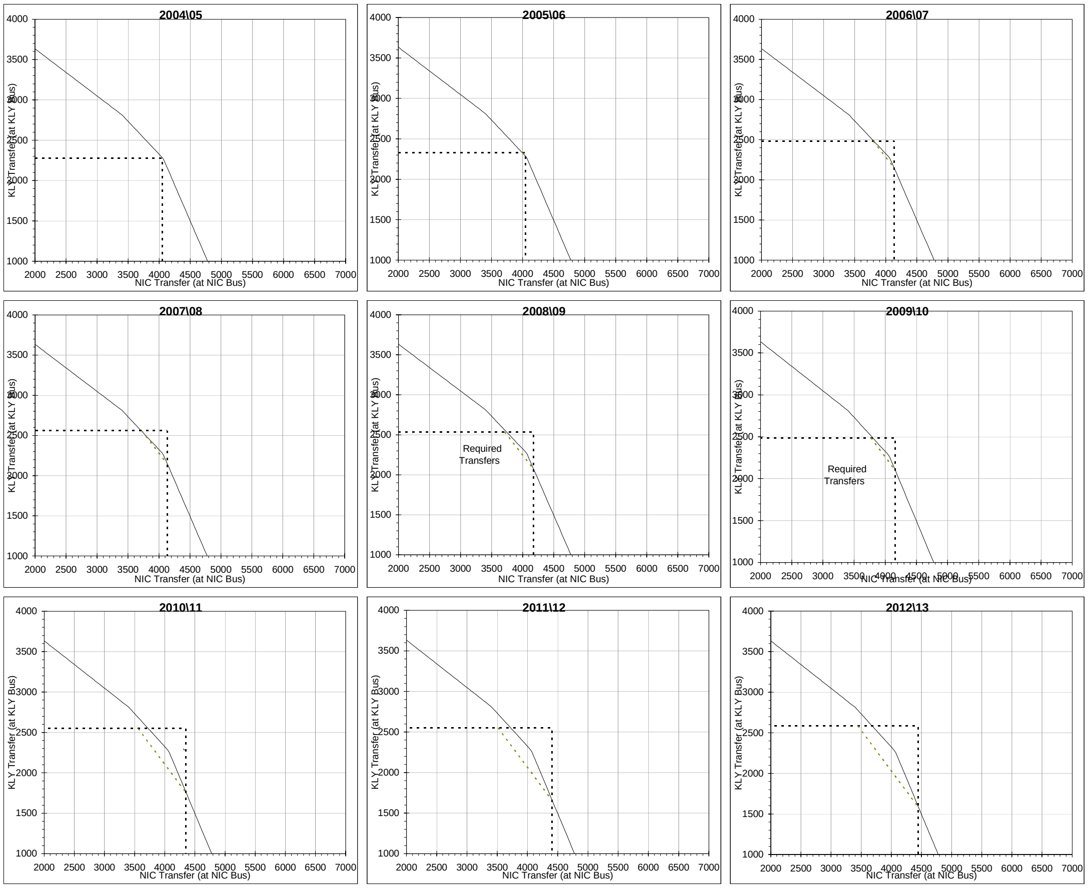
A1.24 Application of Remedial Action Schemes - RAS

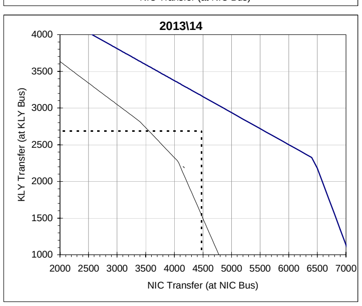
The Remedial Action Schemes for the NITS 2004 Application include, but are not limited to, the upgrade / modification of Undervoltage Load Shedding, Direct Transfer Trips, Generation Shedding, Underfrequency Load Shedding, and Overload Protection. New RAS will be required for secure operation of the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

Appendix 2: The Interior to Lower Mainland N-1 Nomograms

This appendix summarizes details of the Stage 3 N-1 nomogram analysis for scenarios 1 and 2.

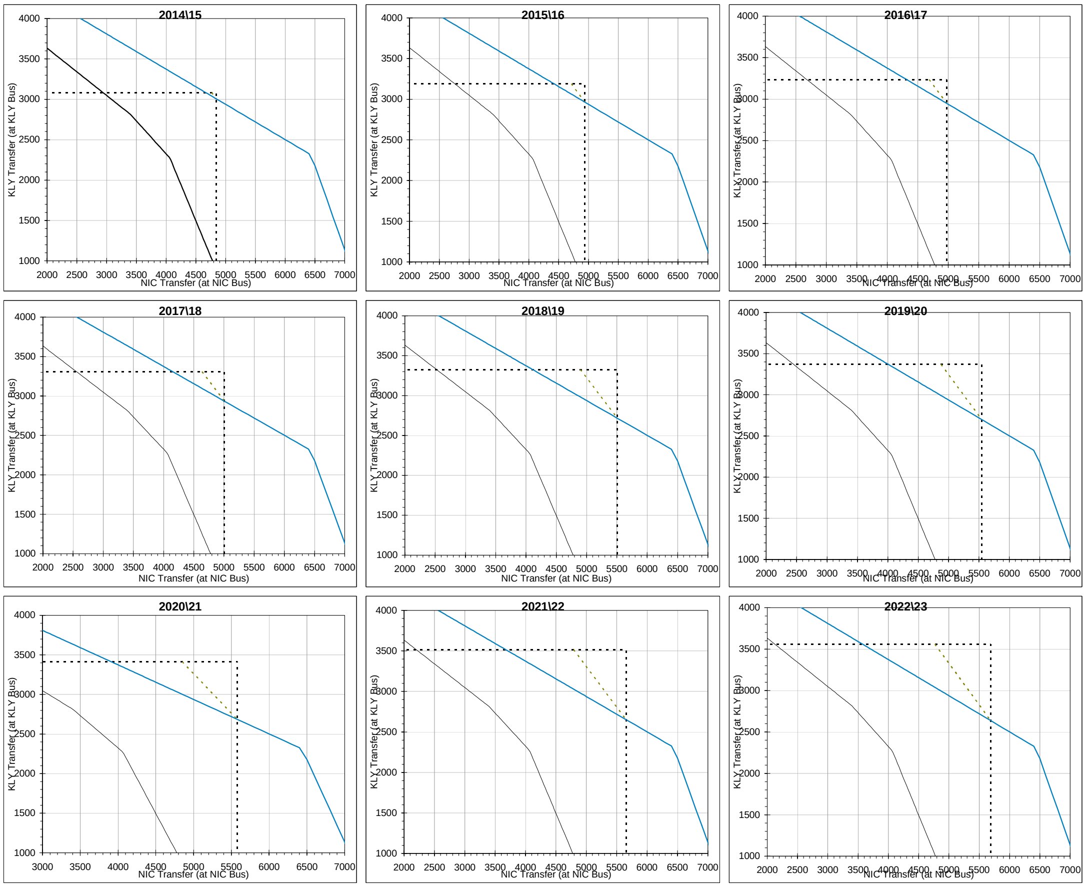
Scenario 1: 5L83 only coastal RMR maximum Columbia generation (MW)

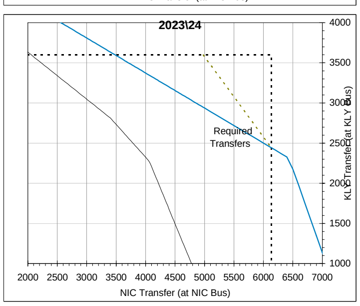




Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1016	1072	1207	1282	1427	1530	1811	1924	2069	1022
Installed Cap (Adjuste	1016	1072	1207	1282	1427	1530	1811	1924	2069	1022
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Installed Cap (Adjuste	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Installed Cap (Adjuste	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2279	2331	2480	2558	2537	2488	2547	2552	2586	2689
Max NIC Transfer	4045	4047	4133	4133	4173	4162	4351	4404	4446	4476
Req Trans @ KLY/NIC	6322	6331	6280	6280	6247	6257	6105	6063	6030	7164
Req Trans @ LM	6101	6110	6061	6061	6031	6040	5896	5856	5824	6960
Export @ ING	280	280	280	280	280	280	280	280	280	280

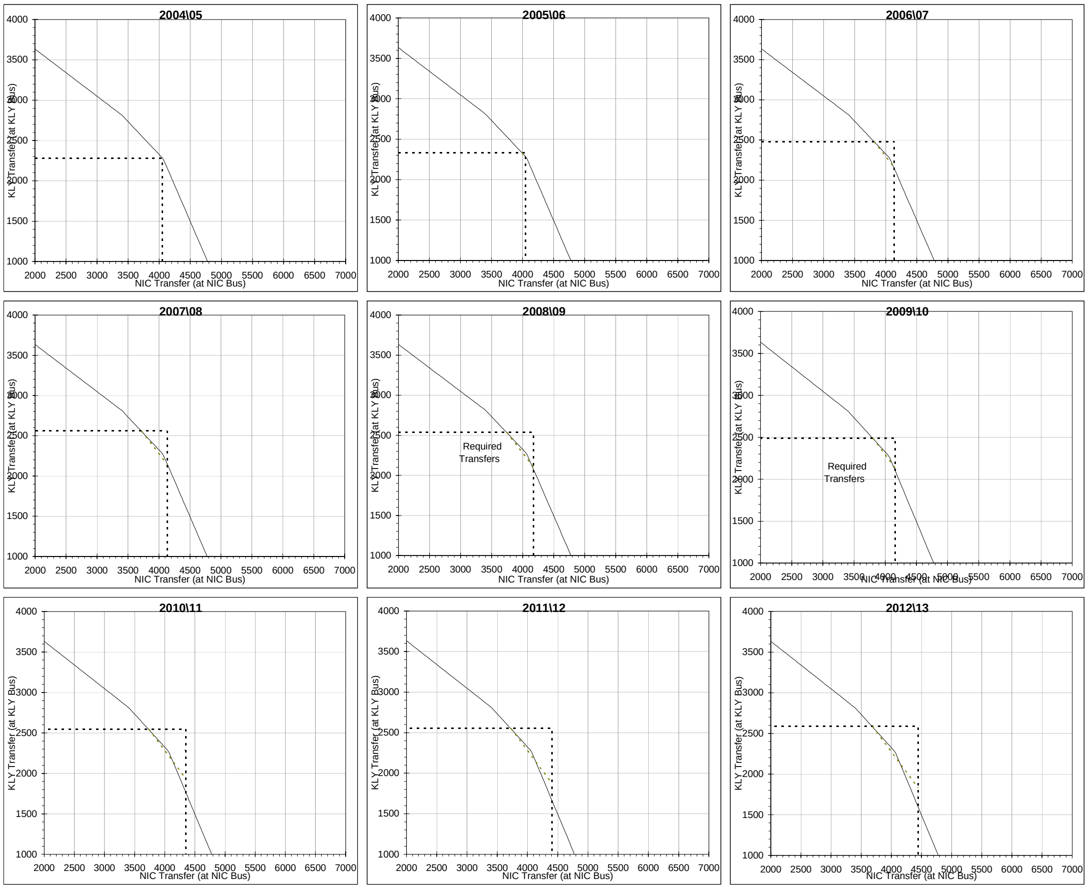


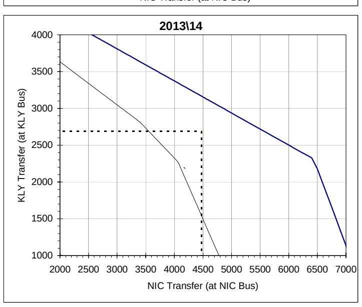


Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	501	583	693	808	689	807	933	1040	1171	1091
Installed Cap (Adjuste	501	583	693	808	689	807	933	1040	1171	1091
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Installed Cap (Adjuste	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Installed Cap (Adjuste	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	3085	3189	3235	3308	3327	3371	3414	3515	3559	3602
Max NIC Transfer	4842	4935	4972	5010	5507	5543	5578	5654	5689	6134
Req Trans @ KLY/NIC	7849	7901	7923	7943	8223	8244	8263	8306	8326	8576
Req Trans @ LM	7605	7654	7674	7693	7955	7975	7992	8032	8050	8283
Export @ ING	280	280	280	280	280	280	280	280	280	280

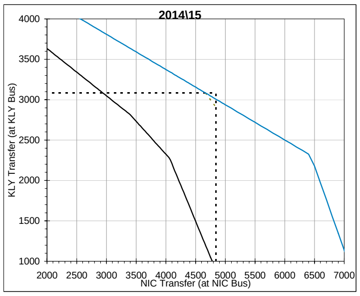
Scenario 1: 5L83 only coastal RMR maximum Peace generation (MW)

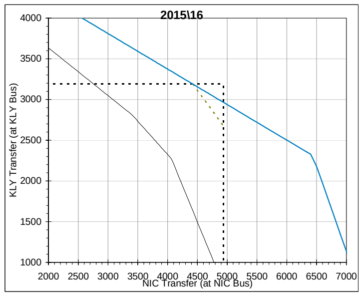


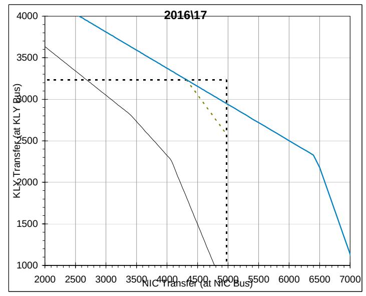


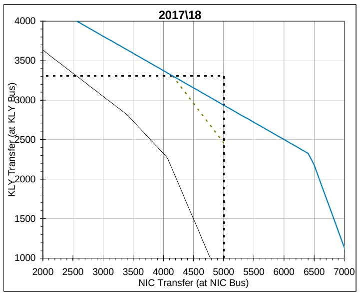
Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

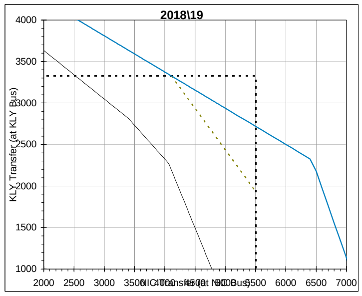
Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1016	1078	1195	1285	1395	1497	1641	1712	1829	1022
Installed Cap (Adjuste	1016	1078	1195	1285	1395	1497	1641	1712	1829	1022
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Installed Cap (Adjuste	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Installed Cap (Adjuste	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2279	2331	2480	2558	2537	2488	2547	2552	2586	2689
Max NIC Transfer	4045	4047	4133	4133	4173	4162	4351	4404	4446	4476
Req Trans @ KLY/NIC	6322	6325	6293	6276	6282	6291	6281	6281	6274	7164
Req Trans @ LM	6101	6104	6073	6058	6063	6072	6061	6060	6053	6960
Export @ ING	280	280	280	280	280	280	280	280	280	280

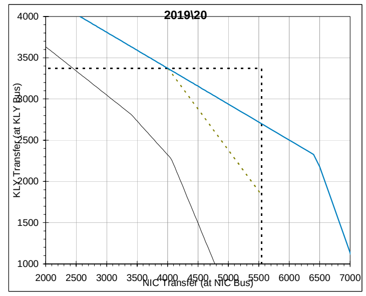


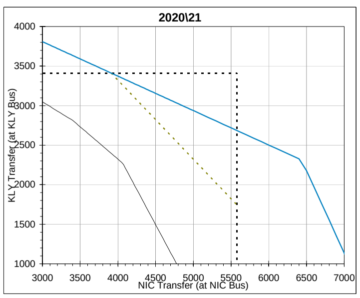


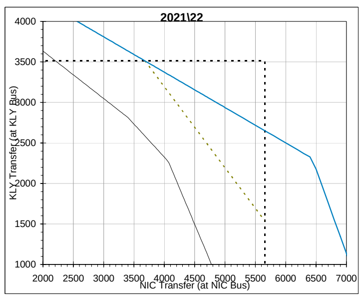


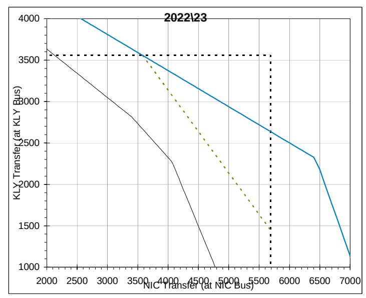


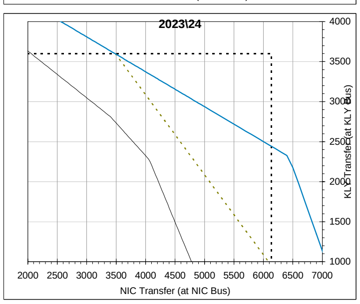








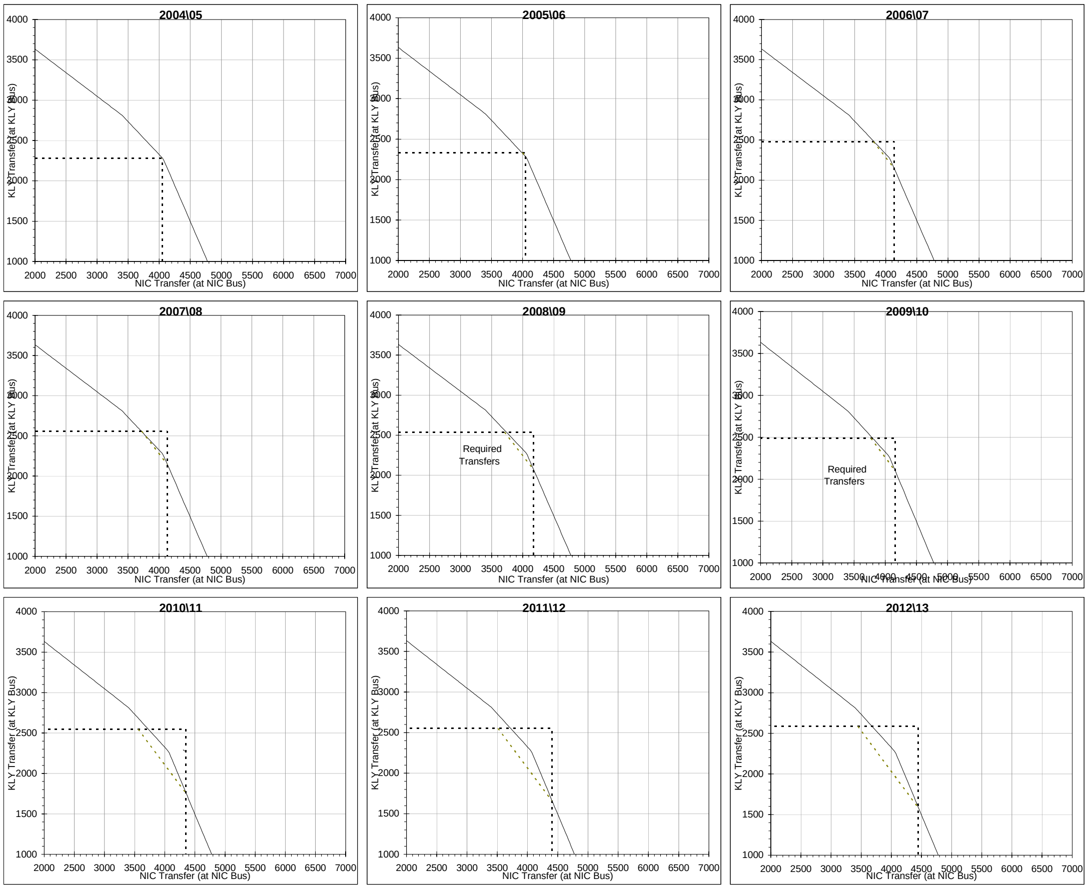


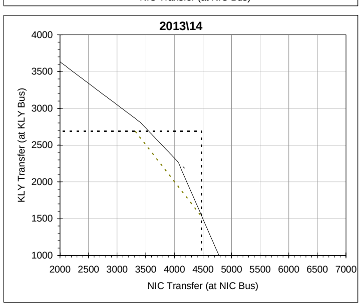


Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	594	849	1036	1261	1424	1621	1825	2109	2322	2539
Installed Cap (Adjust	594	849	1036	1261	1424	1621	1825	2109	2322	2539
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Installed Cap (Adjust	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Installed Cap (Adjust	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	3085	3189	3235	3308	3327	3371	3414	3515	3559	3602
Max NIC Transfer	4842	4935	4972	5010	5507	5543	5578	5654	5689	6134
Req Trans @ KLY/NIC	7747	7611	7553	7458	7436	7379	7323	7192	7136	7085
Req Trans @ LM	7509	7381	7325	7235	7212	7158	7104	6978	6924	6871
Export @ ING	280	280	280	280	280	280	280	280	280	280

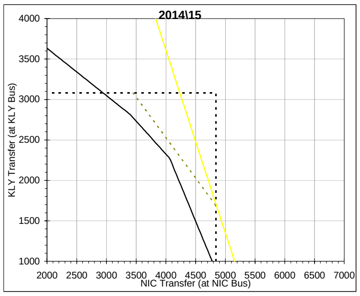
Scenario 1: 5L46 only coastal RMR maximum Columbia generation (MW)

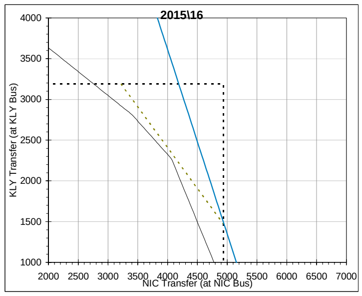


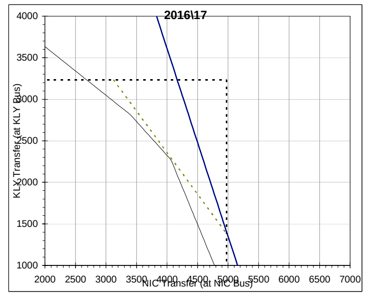


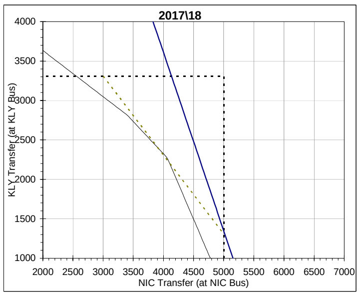
Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

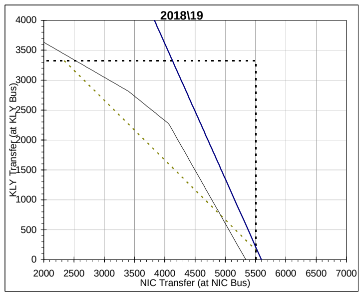
Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1016	1072	1207	1282	1427	1530	1811	1924	2069	2213
Installed Cap (Adjuste	1016	1072	1207	1282	1427	1530	1811	1924	2069	2213
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Installed Cap (Adjuste	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Installed Cap (Adjuste	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2279	2331	2480	2558	2537	2488	2547	2552	2586	2689
Max NIC Transfer	4045	4047	4133	4133	4173	4162	4351	4404	4446	4476
Req Trans @ KLY/NIC	6322	6331	6280	6280	6247	6257	6105	6063	6030	6005
Req Trans @ LM	6101	6110	6061	6061	6031	6040	5896	5856	5824	5800
Export @ ING	280	280	280	280	280	280	280	280	280	280

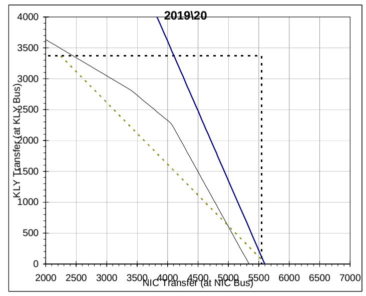


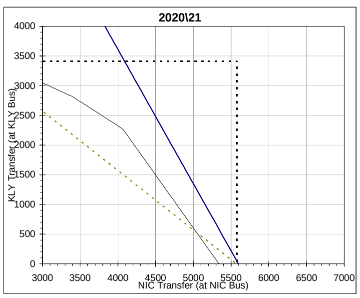


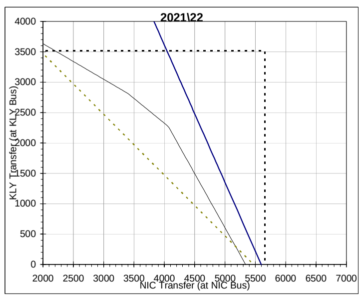


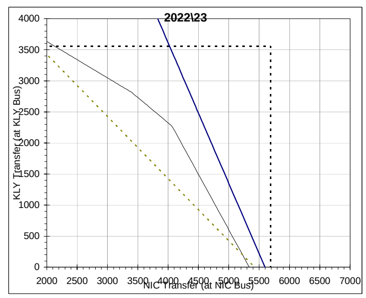


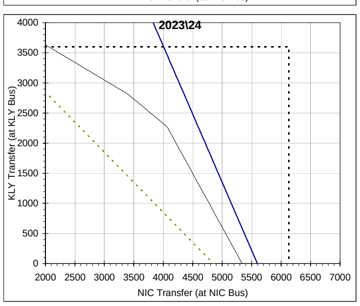








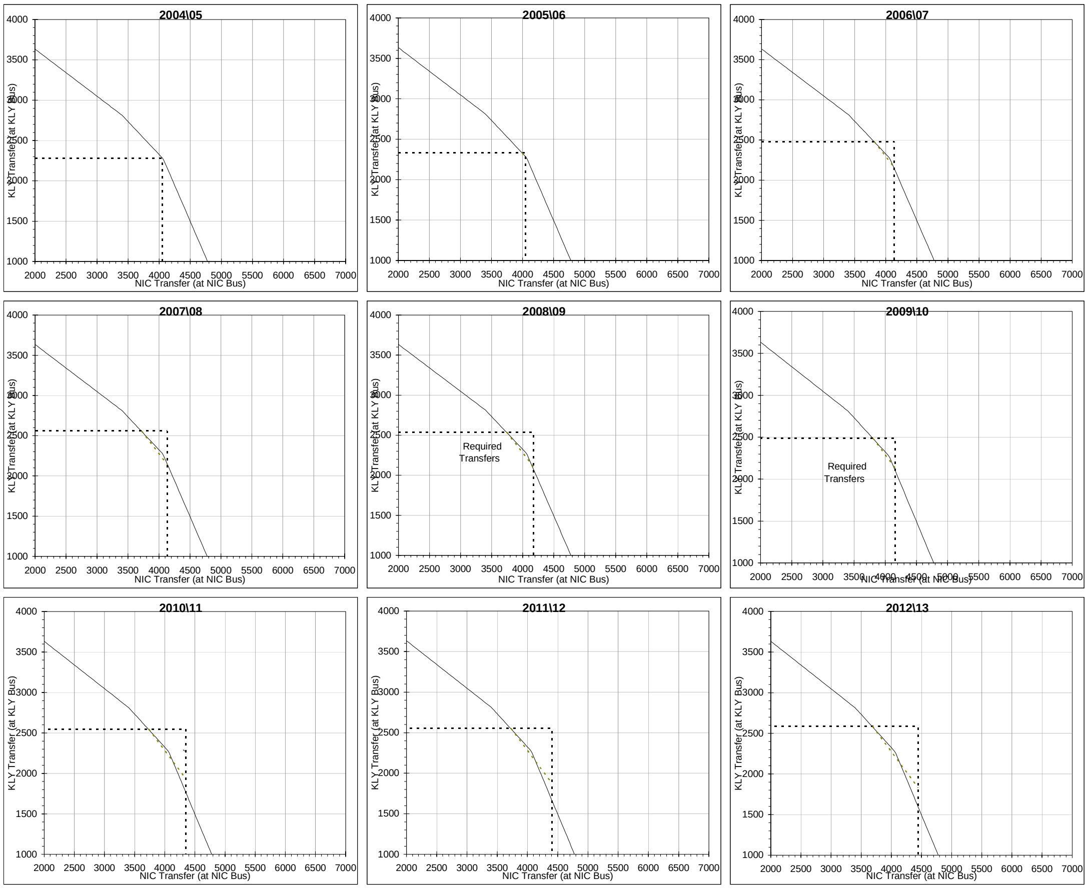


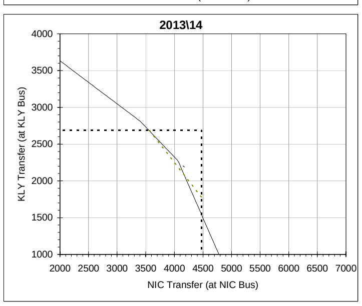


Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	1768	2026	2215	2408	3248	3458	3672	3954	4179	5057
Installed Cap (Adjust	1768	2026	2215	2408	3248	3458	3672	3954	4179	5057
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Installed Cap (Adjust	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Installed Cap (Adjust	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	3085	3189	3235	3308	3327	3371	3414	3515	3559	3602
Max NIC Transfer	4842	4935	4972	5010	5507	5543	5578	5654	5689	6134
Req Trans @ KLY/NIC	6527	6406	6358	6309	5664	5616	5571	5471	5427	4848
Req Trans @ LM	6336	6220	6173	6126	5496	5449	5404	5306	5262	4689
Export @ ING	280	280	280	280	280	280	280	280	280	280

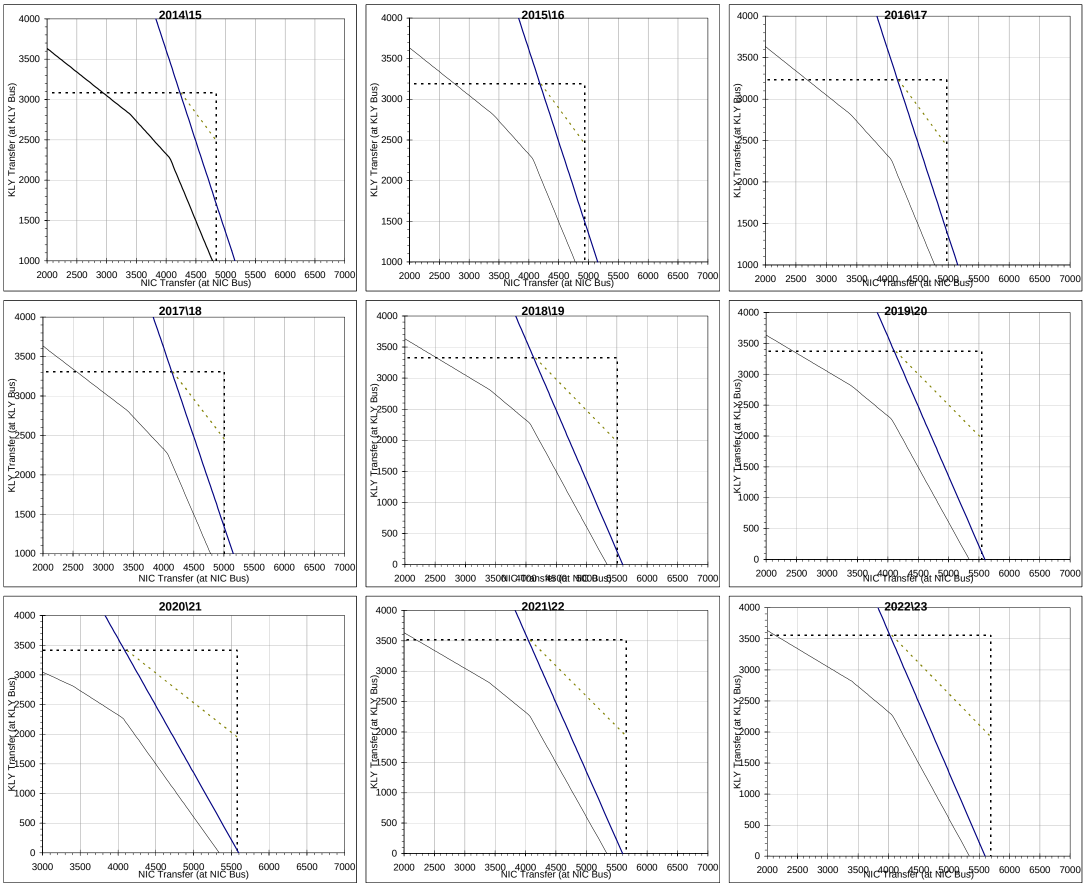
Scenario 1: 5L46 only coastal RMR maximum Peace generation (MW)

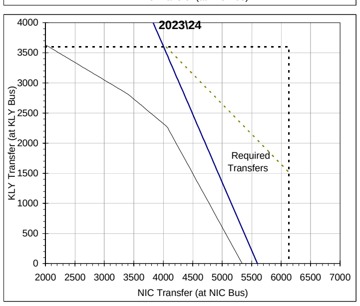




Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1016	1078	1195	1285	1395	1497	1641	1712	1829	1968
Installed Cap (Adjust	1016	1078	1195	1285	1395	1497	1641	1712	1829	1968
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Installed Cap (Adjust	3820	3828	3978	4055	4101	4005	4109	4109	4168	4285
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Installed Cap (Adjust	5599	5599	5695	5695	5701	5701	5883	5948	6007	6054
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2279	2331	2480	2558	2537	2488	2547	2552	2586	2689
Max NIC Transfer	4045	4047	4133	4133	4173	4162	4351	4404	4446	4476
Req Trans @ KLY/NIC	6322	6325	6293	6276	6282	6291	6281	6281	6274	6252
Req Trans @ LM	6101	6104	6073	6058	6063	6072	6061	6060	6053	6032
Export @ ING	280	280	280	280	280	280	280	280	280	280

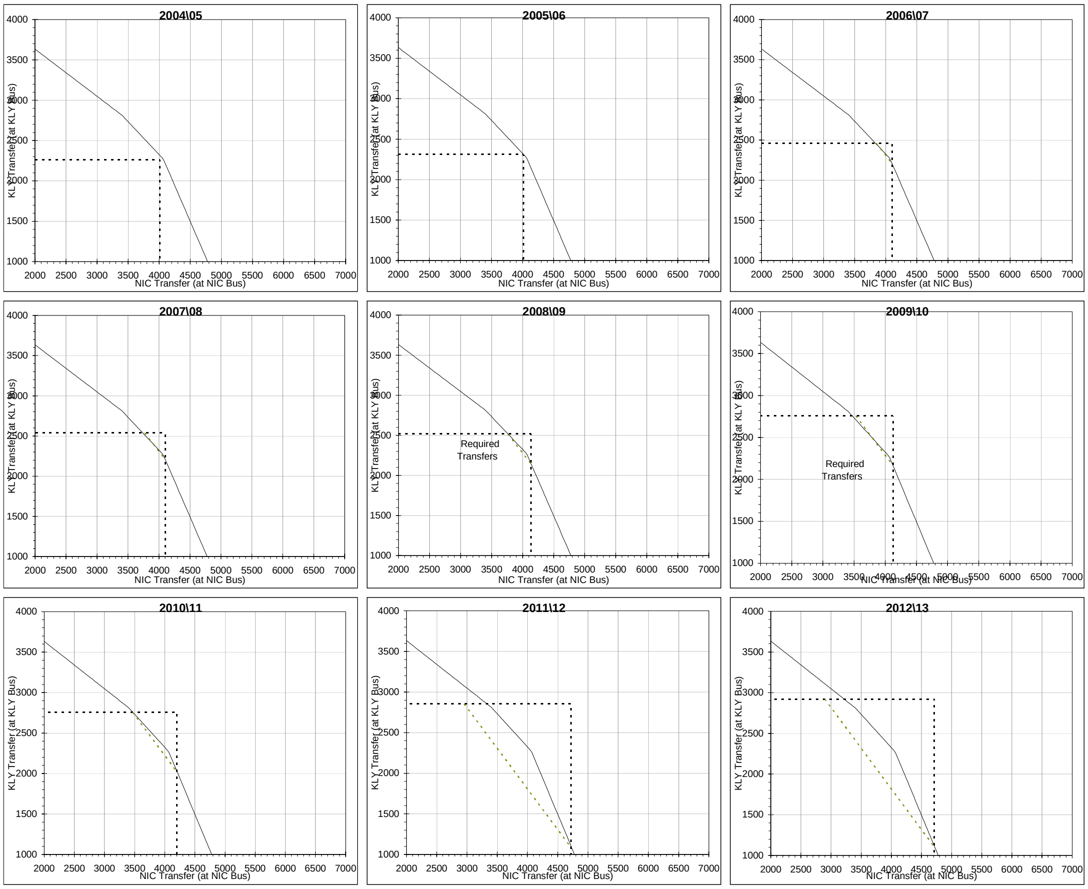


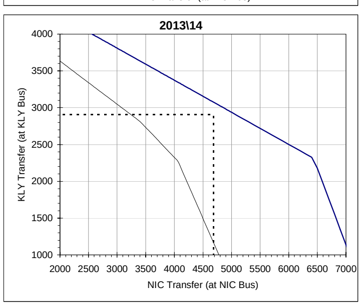


Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: System Generic
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	997	1072	1181	1277	1407	1525	1648	1744	1874	2005
Installed Cap (Adjuste	997	1072	1181	1277	1407	1525	1648	1744	1874	2005
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Installed Cap (Adjuste	4695	4812	4871	4961	4997	5056	5114	5232	5290	5349
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Installed Cap (Adjuste	6464	6581	6640	6699	7257	7316	7374	7478	7536	8045
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	3085	3189	3235	3308	3327	3371	3414	3515	3559	3602
Max NIC Transfer	4842	4935	4972	5010	5507	5543	5578	5654	5689	6134
Req Trans @ KLY/NIC	7330	7391	7417	7459	7479	7505	7530	7589	7613	7649
Req Trans @ LM	7098	7155	7179	7219	7229	7253	7276	7331	7354	7378
Export @ ING	280	280	280	280	280	280	280	280	280	280

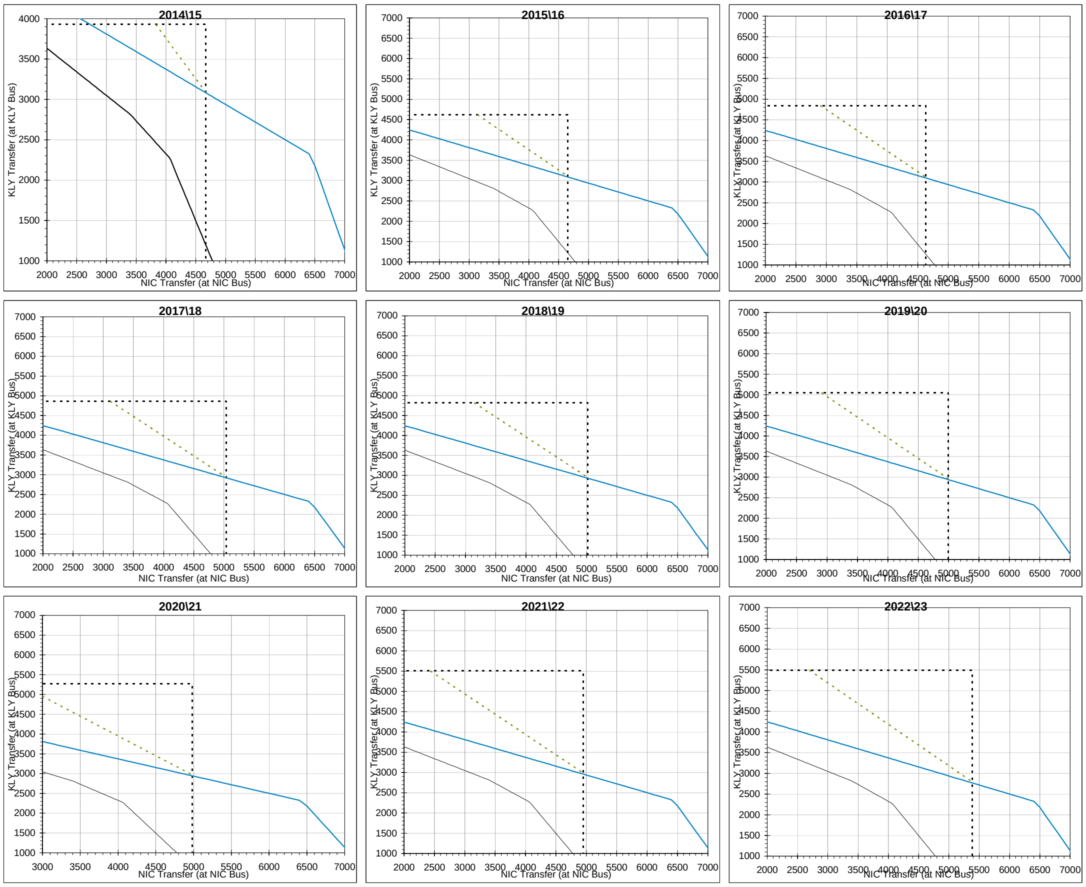
Scenario 2: 5L83 only coastal RMR maximum Columbia generation (MW)

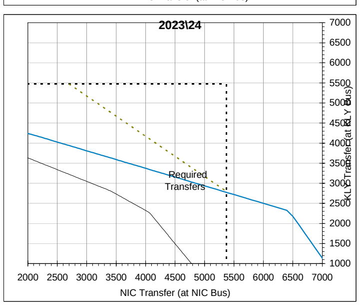




Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1342	1360	1470	1552	1702	1812	2017	2517	2627	947
Installed Cap (Adjust	1342	1360	1470	1552	1702	1812	2017	2517	2627	947
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Installed Cap (Adjust	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Installed Cap (Adjust	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2259	2312	2461	2538	2517	2758	2758	2854	2921	2907
Max NIC Transfer	4011	4013	4099	4098	4137	4125	4205	4723	4710	4685
Req Trans @ KLY/NIC	6269	6324	6306	6307	6277	6286	6221	5806	5815	7591
Req Trans @ LM	6051	6103	6086	6087	6059	6068	6007	5610	5618	7362
Export @ ING	280	280	280	280	280	280	280	280	280	280

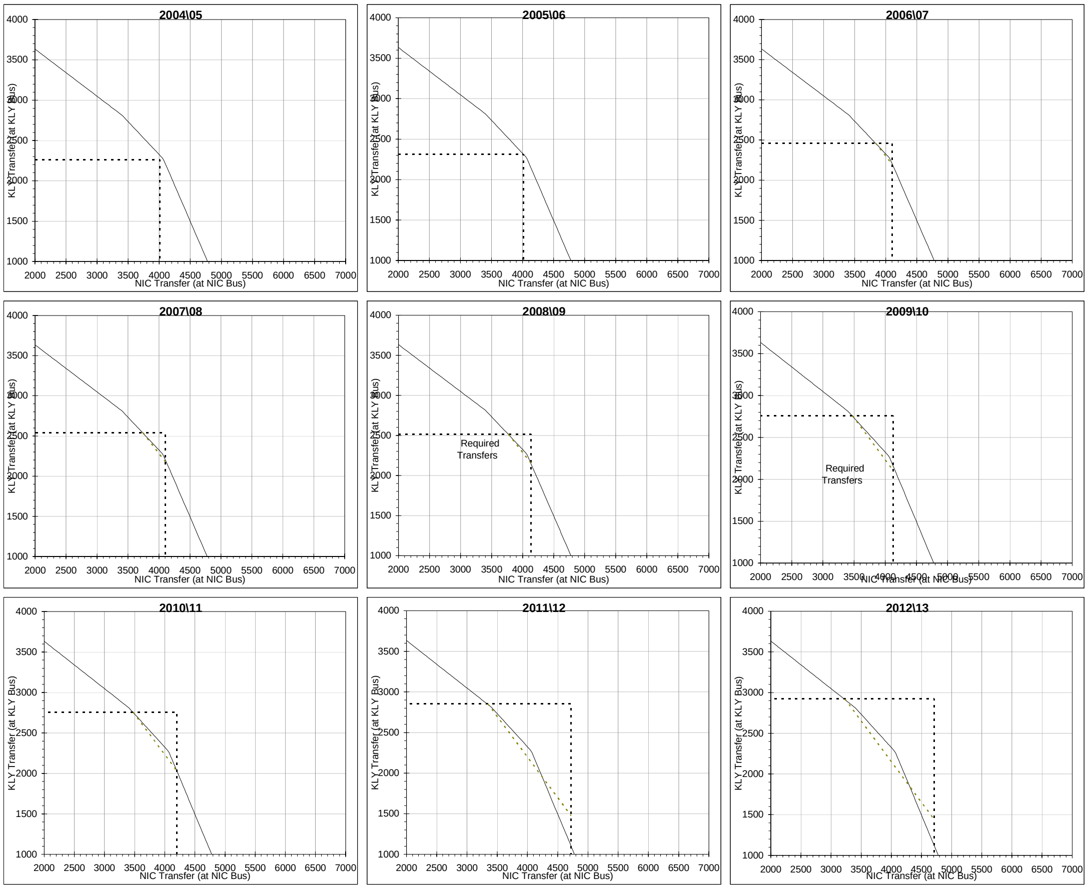


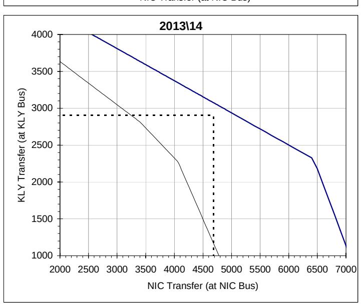


Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	914	1059	1208	1139	1292	1450	1614	1790	1712	1884
Installed Cap (Adjust	914	1059	1208	1139	1292	1450	1614	1790	1712	1884
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	5700	6400	6643	6674	6652	6895	7138	7382	7382	7382
Installed Cap (Adjust	5700	6400	6643	6674	6652	6895	7138	7382	7382	7382
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Installed Cap (Adjust	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	3931	4618	4848	4861	4820	5049	5276	5503	5488	5472
Max NIC Transfer	4670	4652	4635	5035	5016	4998	4980	4947	5388	5369
Req Trans @ KLY/NIC	7756	7755	7747	7973	7962	7955	7949	7935	8181	8170
Req Trans @ LM	7513	7504	7494	7707	7697	7687	7678	7660	7892	7882
Export @ ING	280	280	280	280	280	280	280	280	280	280

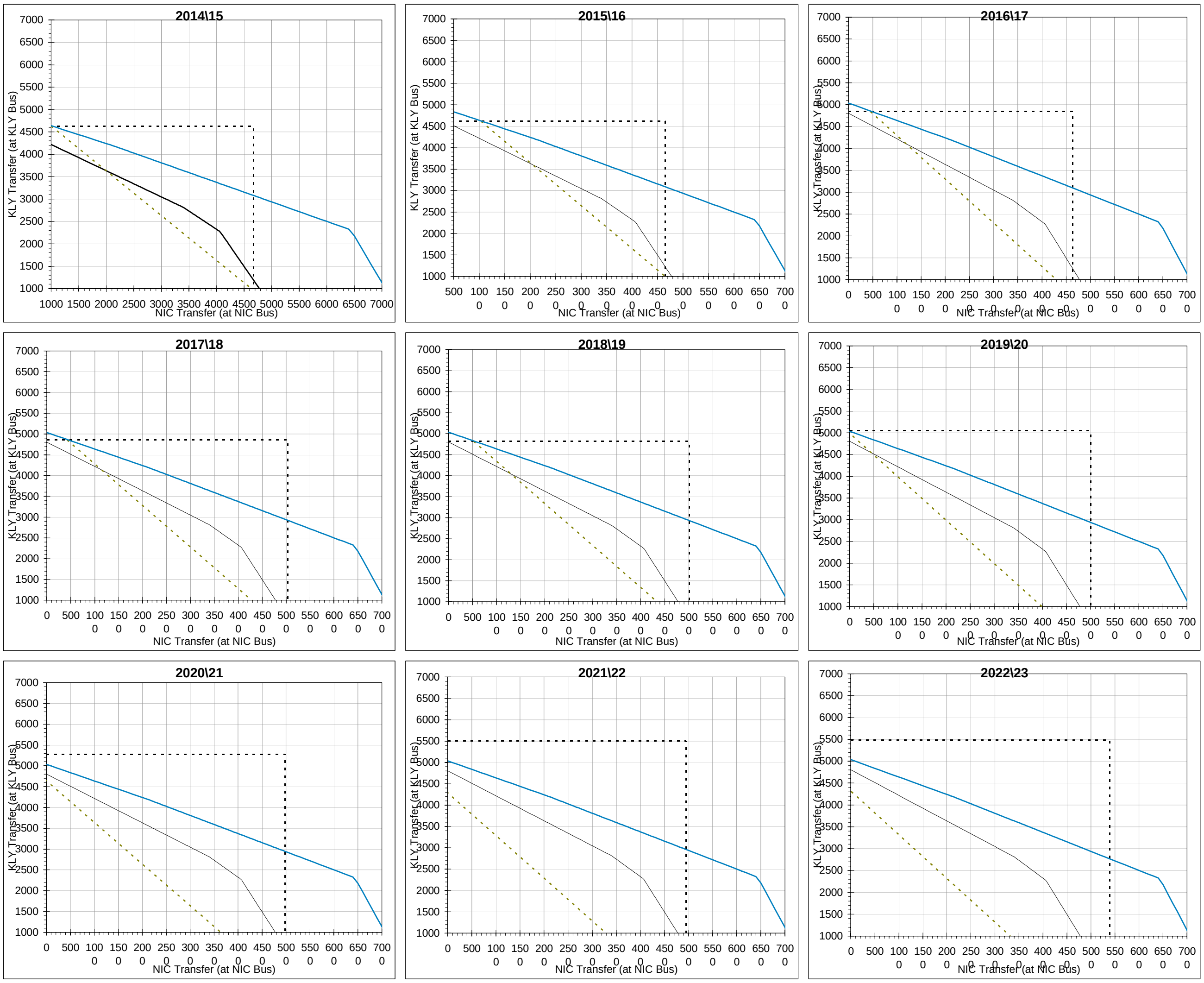
Scenario 2: 5L83 only coastal RMR maximum Peace generation (MW)

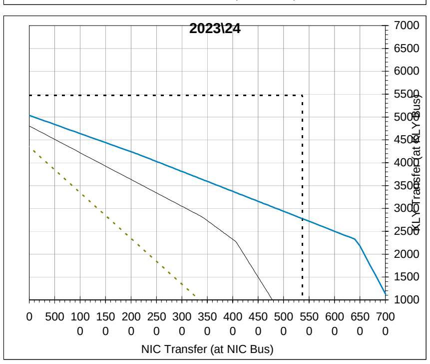




Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1342	1360	1478	1578	1693	1865	2006	2123	2287	947
Installed Cap (Adjuste	1342	1360	1478	1578	1693	1865	2006	2123	2287	947
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Installed Cap (Adjuste	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Installed Cap (Adjuste	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2259	2312	2461	2538	2517	2758	2758	2854	2921	2907
Max NIC Transfer	4011	4013	4099	4098	4137	4125	4205	4723	4710	4685
Req Trans @ KLY/NIC	6269	6324	6297	6279	6287	6232	6233	6197	6150	7591
Req Trans @ LM	6051	6103	6078	6061	6068	6017	6018	5979	5934	7362
Export @ ING	280	280	280	280	280	280	280	280	280	280

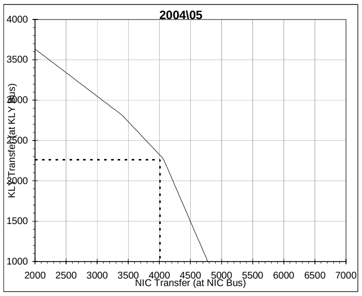


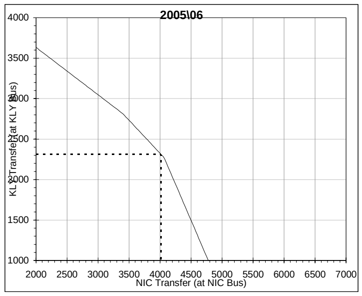


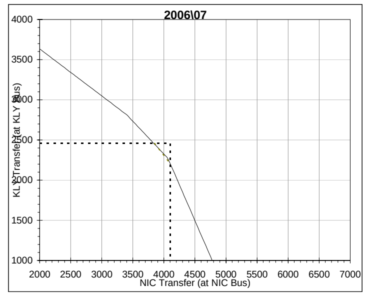
Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

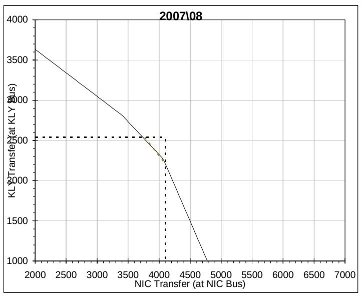
Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	3043	3173	3725	3910	4003	4592	5209	5860	6029	6202
Installed Cap (Adjust	3043	3173	3725	3910	4003	4592	5209	5860	6029	6202
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	6400	6400	6643	6674	6652	6895	7138	7382	7382	7382
Installed Cap (Adjust	6400	6400	6643	6674	6652	6895	7138	7382	7382	7382
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Installed Cap (Adjust	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	4631	4618	4848	4861	4820	5049	5276	5503	5488	5472
Max NIC Transfer	4670	4652	4635	5035	5016	4998	4980	4947	5388	5369
Req Trans @ KLY/NIC	5629	5649	5295	5279	5342	4989	4639	4287	4318	4342
Req Trans @ LM	5472	5491	5143	5124	5185	4837	4489	4136	4160	4184
Export @ ING	280	280	280	280	280	280	280	280	280	280

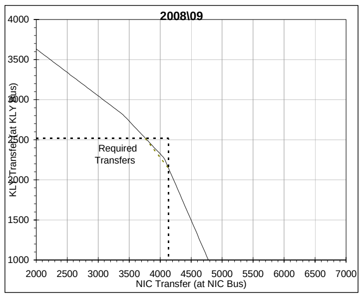
Scenario 2: 5L46 only coastal RMR maximum Columbia generation (MW)

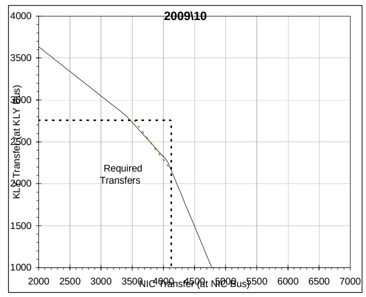


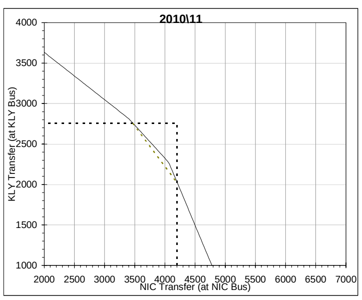


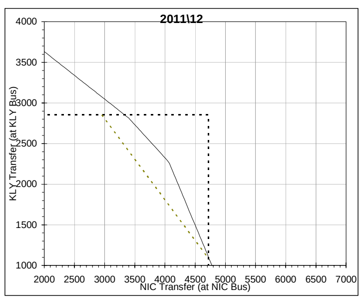


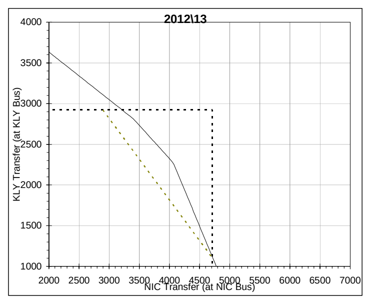


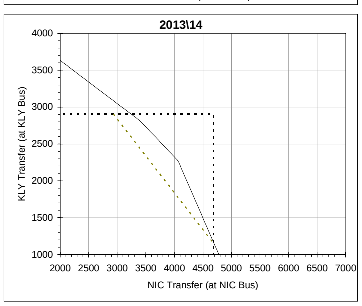






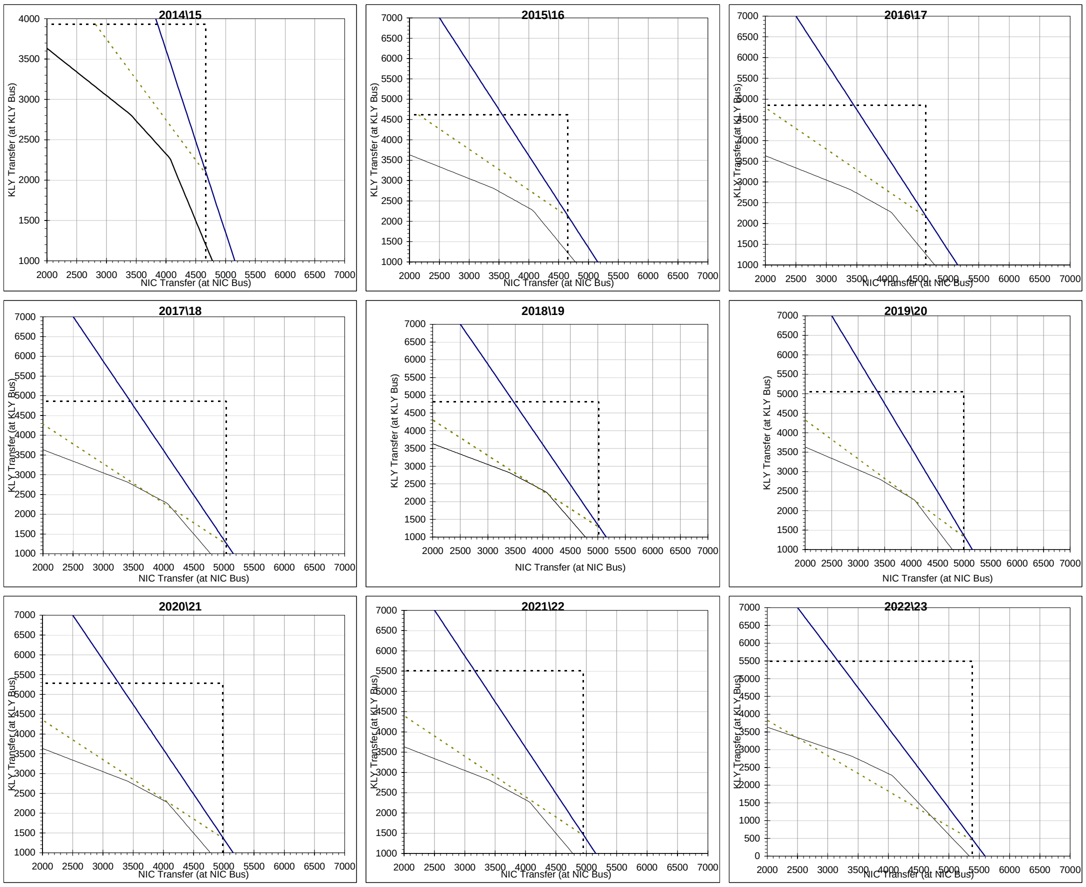


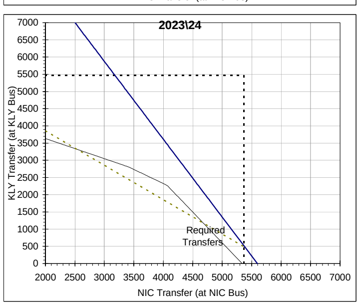




Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1342	1360	1470	1552	1702	1812	2017	2517	2627	2732
Installed Cap (Adjuste	1342	1360	1470	1552	1702	1812	2017	2517	2627	2732
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Installed Cap (Adjuste	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Installed Cap (Adjuste	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2259	2312	2461	2538	2517	2758	2758	2854	2921	2907
Max NIC Transfer	4011	4013	4099	4098	4137	4125	4205	4723	4710	4685
Req Trans @ KLY/NIC	6269	6324	6306	6307	6277	6286	6221	5806	5815	5837
Req Trans @ LM	6051	6103	6086	6087	6059	6068	6007	5610	5618	5639
Export @ ING	280	280	280	280	280	280	280	280	280	280

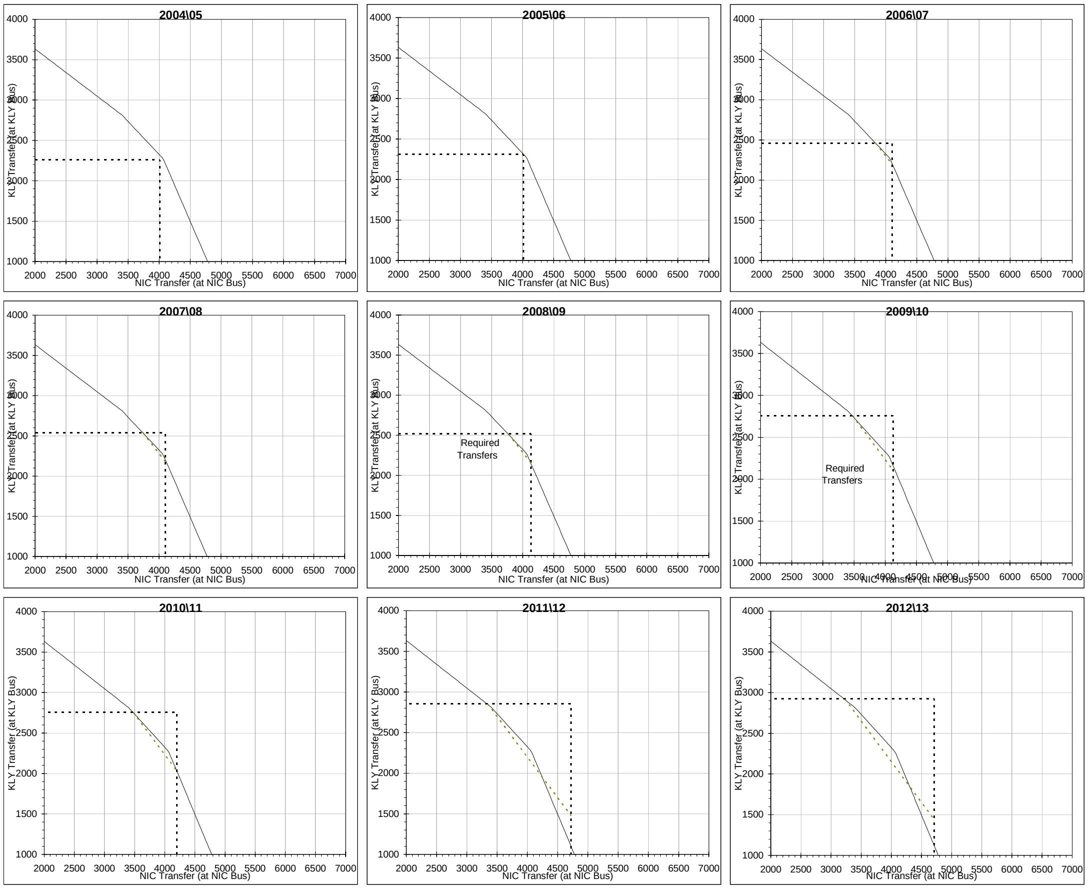


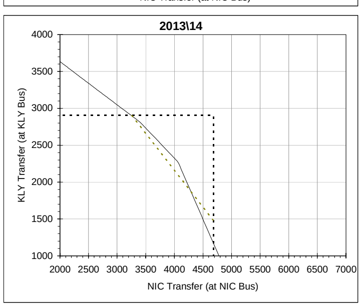


Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	1884	2005	2127	2815	2946	3081	3222	3347	4165	4320
Installed Cap (Adjust	1884	2005	2127	2815	2946	3081	3222	3347	4165	4320
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	5700	6400	6643	6674	6652	6895	7138	7382	7382	7382
Installed Cap (Adjust	5700	6400	6643	6674	6652	6895	7138	7382	7382	7382
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Installed Cap (Adjust	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	3931	4618	4848	4861	4820	5049	5276	5503	5488	5472
Max NIC Transfer	4670	4652	4635	5035	5016	4998	4980	4947	5388	5369
Req Trans @ KLY/NIC	6746	6767	6791	6276	6300	6325	6351	6396	5828	5852
Req Trans @ LM	6552	6573	6595	6094	6117	6140	6164	6205	5646	5670
Export @ ING	280	280	280	280	280	280	280	280	280	280

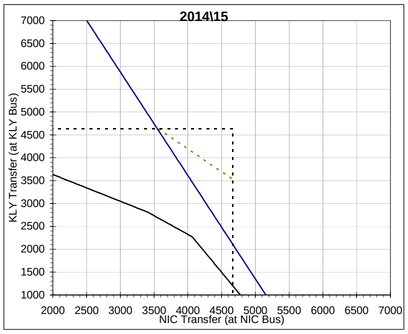
Scenario 2: 5L46 only coastal RMR maximum Peace generation (MW)

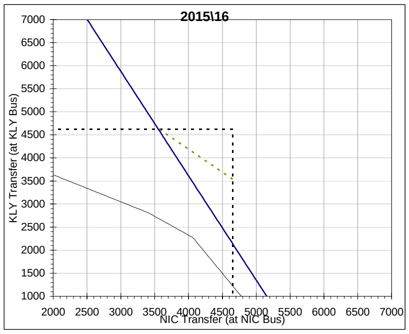


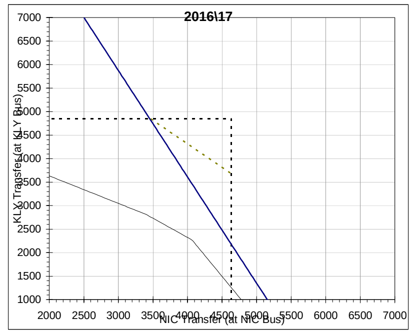


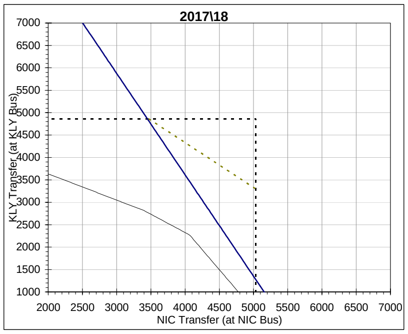
Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

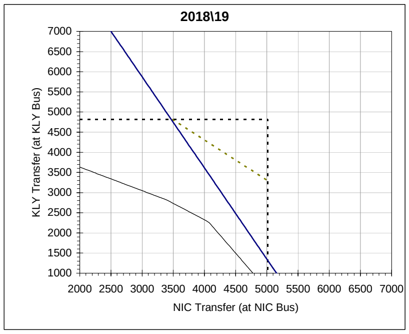
Year	2004\05	2005\06	2006\07	2007\08	2008\09	2009\10	2010\11	2011\12	2012\13	2013\14
LM/VI Generation	1342	1360	1478	1578	1693	1865	2006	2123	2287	2402
Installed Cap (Adjuste	1342	1360	1478	1578	1693	1865	2006	2123	2287	2402
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Installed Cap (Adjuste	3820	3828	3978	4055	4101	4327	4373	4465	4557	4557
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Installed Cap (Adjuste	5599	5599	5695	5695	5701	5701	5766	6331	6331	6320
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	2259	2312	2461	2538	2517	2758	2758	2854	2921	2907
Max NIC Transfer	4011	4013	4099	4098	4137	4125	4205	4723	4710	4685
Req Trans @ KLY/NIC	6269	6324	6297	6279	6287	6232	6233	6197	6150	6160
Req Trans @ LM	6051	6103	6078	6061	6068	6017	6018	5979	5934	5944
Export @ ING	280	280	280	280	280	280	280	280	280	280

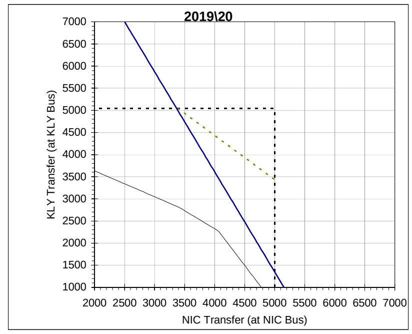


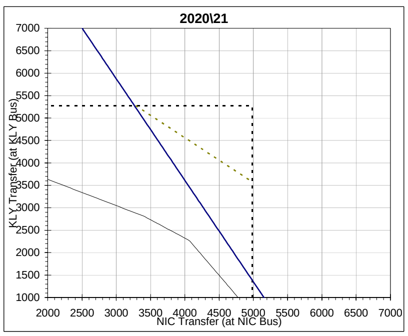


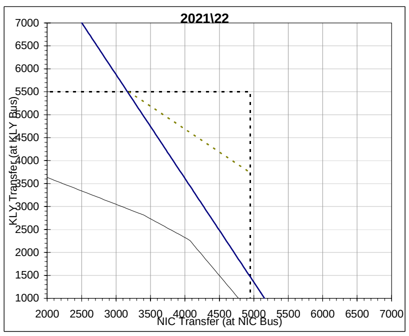


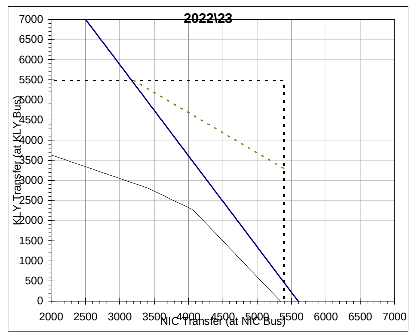


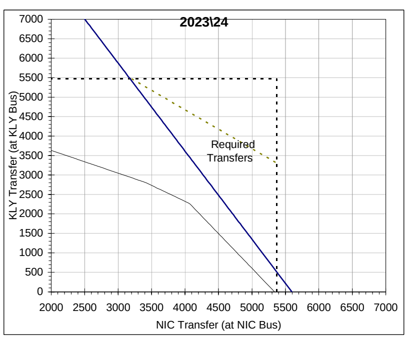












Sequence: SPPA System Plan for RM Portfolios
Generation: Maximum NI & SI generation (Minimums for LM & VI) provided in the NITS Application for SL
Resource Plan: Site-C
Load Forecast: October 2004 Forecast - Heavy Winter

Year	2014\15	2015\16	2016\17	2017\18	2018\19	2019\20	2020\21	2021\22	2022\23	2023\24
LM/VI Generation	511	652	670	802	965	992	1025	1061	1224	1390
Installed Cap (Adjust	511	652	670	802	965	992	1025	1061	1224	1390
Redispatch	0	0	0	0	0	0	0	0	0	0
Peace Generation	6400	6400	6643	6674	6652	6895	7138	7382	7382	7382
Installed Cap (Adjust	6400	6400	6643	6674	6652	6895	7138	7382	7382	7382
Redispatch	0	0	0	0	0	0	0	0	0	0
Columbia Generation	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Installed Cap (Adjust	6320	6320	6320	6770	6770	6770	6770	6756	7256	7256
Redispatch	0	0	0	0	0	0	0	0	0	0
Max KLY Transfer	4631	4618	4848	4861	4820	5049	5276	5503	5488	5472
Max NIC Transfer	4670	4652	4635	5035	5016	4998	4980	4947	5388	5369
Req Trans @ KLY/NIC	8193	8186	8314	8327	8305	8432	8558	8684	8682	8673
Req Trans @ LM	7927	7920	8042	8049	8027	8148	8268	8387	8378	8370
Export @ ING	280	280	280	280	280	280	280	280	280	280

Appendix 3: Methodology & Assumptions for Computation of Transmission Losses

Definitions

Peak Losses: MW losses in the transmission network at peak load hour.
Average Losses: MW losses in the transmission network at average load hour.
Loss Factor (LF): Ratio of "Average Losses" to "Peak Losses".
Energy Losses: Average energy losses in the transmission network throughout the year.

Assumptions

In this report, for the computation of transmission losses, the following assumptions are made:

1. In study cases of sections 5.1, 5.2, and 5.3; BC Hydro's recorded hourly load curve from 01 April 2004 until 31 March 2005 is utilized. This load curve is used for shaping BC Hydro's hourly load in all study years.
2. In study case of section 5.4, Vancouver Island's recorded hourly load curve from 01 April 2004 until 31 March 2005 is utilized. This load curve is used for shaping VI's hourly load in all study years.
3. In all study cases of sections 5.1, 5.2, 5.3, and 5.4; appropriate levels of capacitive VAr support are added to load flow cases beyond 2014.
4. The annual load growth is modelled by uniform scaling of all regional loads at fixed power factor.

Methodology

1. For study cases of sections 5.1, 5.2, and 5.4; the losses are evaluated for up to 5 years. For these study cases the first year is defined as the year in which the new transmission line is required. For each study case, the loss evaluation stopped when the required coastal RMR generation exceeded the designated dependable capacity of the available coastal resources. Based on this approach, loss evaluation of section 5.1 (deferring 5L83) covers one year, loss evaluation of section 5.2 (deferring 5L46) covers five years, and loss evaluation of section 5.4 (deferring VI circuit 2) covers five years.
2. To enhance the accuracy of loss evaluation, in a study case with and without a transmission line addition, fictitious synchronous condensers are added to the appropriate busses. This technique maintains voltages at major transmission buses and mitigates the impact of voltage variation on calculation of transmission losses.
3. The Loss Factors are computed using the PLOSS program Version 1.0. This program estimates the transmission losses for each hour of the year and drives the hourly flows utilizing a user provided load duration curve.
4. BC Hydro's annual energy losses in sections 5.1, 5.2 and 5.3 are computed for two separate time periods. Tables 5.1.1, 5.2.1, and 5.3.1 show the summation of annual energy losses for these two time periods.
   The first time period is 110 hours long and is consisted of the hours of the year that BC Hydro's load is greater than 90 % of its peak hour load. During this 110 hours the coastal generation is the same as the coastal RMR specified in tables 5.1.1, 5.2.1, and 5.3.1. The assumed Loss Factor for this time period is 1.00.
   The second time period, is consisted of the remaining 8650 hours of the year. During these 8650 hours, the system load is less than 90 % of the peak hour load and the modeled coastal generation can be less than the coastal RMR. In this study, the coastal generation of the second time period is 1250 MW.
5. BC Hydro's Annual Energy Losses (sections 5.1, 5.2 and 5.3) =
   110 x 1.00 x Peak MW loss for BCH transmission network +

8650 x LF x MW loss at 90% of Peak load for BC Hydro transmission network

6. VI's Annual Energy Losses (sections 5.4) =
   8760 x LF x Peak MW loss for VI transmission network.

Appendix 4: Clarification Notes on NITS2004 SIS-Stage 1 Report SP2005-04

Following the release of "System Impact Study for BC Hydro Distribution NITS 2004 Stage 1 Report # SP2005-04" on 28 February 2005, BCHD submitted a request for clarification of specific items in the report. This appendix provides the requested clarifications. All references are made to the tables and pages in SP2005-04.

1- **Table 1.1 (Page 5 of 104) :** The correct in-service year for Rev. G5 is 2018/19.
2- **Table 1.1 (Page 5 of 104) :** The correct in-service year for Mica G5 is 2023/24.
3- **Section (Page 8 of 104):** "fiscal" should be changed to "calendar" since the changes take place on 2010-Jan-1.
4- **Section 1.6 (Page 8 of 104):** The FBC import and export levels shown in tables 1.6.1 and 1.6.2 are extracted from BCHD's Application for NITS2004 System Impact Study. The Application also specifies FBC load forecast and generation dispatch. Unless advised otherwise, BCTC considers this information valid. In the NITS 2004 System Impact Study, the MW injection from FBC into the SI east 230 kV system is based on the FBC generation dispatch level minus FBC's forecasted load.
5- **Bullet 4 from the top (Page 9 of 104):** "…cannot be achieved with any amount of coastal RMR" should be changed to "…may not be achieved with any amount of coastal RMR".
6- **Bullet 5 from the top (Page 9 of 104):** Stressing the SI transmission between SEL and NIC by 3/14th of the DSBr on BDY-NLY means the following: For importing the DSBr on the BPAT x BCTC path, it is assumed that 3/14th of the imported MW will flow from BDY to NLY on 2L112. This power will flow from NLY to SEL and NIC. The remaining 11/14th of the imported MW will flow from CUS to ING on 5L51 and 5L52. For example, if the designated level of the DSBr is 1400 MW, then 300 MW will flow into NLY and 1100 MW will flow into ING.
7- **Bullet 1 from the top (Page 12 of 104):** This bullet suggests that 147 MW of coastal generation is not adequate for providing the load and resource balance between 2005/06 and 2022/23. To count for the amount of coastal generation deficiency, 147 MW should be deducted from the RMR numbers in Table 2.1.2. For instance, the coastal generation deficiency for Maximum Peace Generation Without NU in 2022/23 is 3792 MW (3939 MW – 147 MW).
8- **Timing of 5L46:** The earliest in-service date of the new KLY-CKY 500 kV line 5L46 is October 2014. With this in-service date, the new line will be available to remove the peak load hour stress from the ILM network in January and February 2015.
9- **Coastal RMR Tables:** The specified levels of coastal RMR provide an indication of the required coastal generation for balancing the designated demand and supply. They are not intended to specify which resources make up the coastal RMR. It will be up to the transmission customer to insure that adequate coastal resources are secured to provide the required levels of RMR.
10 – **Designation of DSBr as a Coastal Resource:** Designation of the DSBr as a coastal resource should be treated with caution. The 11/14th of the DSBr which flows into BC on 5L51 and 5L52 can be as high as 1100 MW..During heavy import time, outage of 5L81 and 5L82 will require generation shedding in the SI region. The reduced SI generation will be picked up by the governor action in the US adding to the existing flow on 5L51 and 5L52. This can cause overloading of 5L51 and 5L52 and would lead to additional LM and VI load shedding.

Appendix 5: Response to Questions about BCTC's Planning Criteria

This Appendix is the response by BCTC to the Criteria questions put by BC Hydro at the NITS SIS Stage 1 Report meeting on Wednesday, Mar 2, 2005.

Question 1:

Does the basic planning criteria assume that, under the most onerous normal system conditions (no major system elements on forced outage, N-0), the system would survive, without shedding of load or generation and without operator action, (a) any three phase fault followed by an unsuccessful reclose and (b) any single line-to-ground fault with a breaker failure (stuck breaker)?

Response to Q1:

We understand this to be a question regarding BCTC's planning criteria for acceptable performance of the transmission system when subjected to a specific fault disturbance under any extreme generation and load system stress condition with all existing and planned transmission facilities in service.. The BCTC system planning criteria in this regard is aligned with the NERC/WECC Planning Standards (Revised April 10, 2003). The desired system performance, as tested by computer simulation studies, for the two specific disturbances (a) and (b) is as follows:

a) **A three-phase fault with unsuccessful breaker reclose.** Here the faulted line is first tripped, clearing the fault on the system, momentarily. The breakers then reclose automatically (in less than a second). In this case, the line is reclosed on to the fault and is tripped permanently, clearing the fault. The automatic fast line reclosing feature is applied where a parallel circuit or a parallel transmission system is in place and in service. This initiating event results in a single contingency (N-1) line outage condition. This is a "Category B" event and the system response requirements are as defined in Table I of the NERC/WECC Planning Standards. The system is required to maintain stability with no loss of load (or firm exports), without exceeding the applicable line and equipment thermal ratings and without exceeding the applicable voltage level limits. BCTC's practice is to plan the transmission system to survive single contingencies without generation shedding. However, exceptions to this practice do exist as described in the BCTC Planning Standards included in the NITS report # SP2005-04. In other words, the system is planned to survive a type (a) system disturbance without application of any automatic remedial action scheme (RAS) such as load shedding or generation shedding, or without any immediate operator action.

b) **A single line-to-ground (SLG) fault with breaker failure.** Here the fault is cleared by tripping the element or elements connected adjacent to the failed breaker. This initiating event results in the loss of two or more elements, a double (N-2) or multiple contingency. This is a "Category C" event and allows for controlled load shedding, as defined in Table I of the NERC/WECC Planning Standards. BCTC's practice is to plan the transmission system to survive double contingencies with load shedding and generation shedding RAS permitted. In practice, and to the extent possible, BCTC configures its stations to avoid generation shedding, although the Planning Standards do permit this.

Question 2:

Please confirm that planning criteria are met if, after a contingency, the loading on a series capacitor bank is below its one-hour rating.

Response to Q2:

This is a question regarding the applicable thermal rating for BC Hydro's 500 kV Series Capacitor bank equipment loading under system contingency conditions for system planning purposes by BCTC. Where the thermal rating of a 500 kV transmission circuit is limited by the thermal rating of its series capacitor bank, and not by that of the other components of the circuit such as the line terminal circuit breakers or overhead line sections, the one-hour overload rating of the series capacitor bank is considered for system planning. Allowing operator action for generation redispatch within one hour conforms to the NERC/WECC Planning Standards.

Question 3:

(a) On what basis is the one-hour rating of series capacitor banks considered sufficient for contingencies and how is this consistent with the "no operator action" rule (if it still exists)? (b) For example, is this based on the assumption that the load will have diminished sufficiently by that time to bring the loading on the capacitor bank down to its continuous rating? (c) Was the system load shape considered in this criteria? (d) If generation redispatch is required to bring the capacitor bank loading down to its continuous rating within one hour, what limits are placed on this redispatch (eg, is redispatch limited to a specific amount like 500MW?)?

Response to Q3:

This question is about the rationale used by BCTC for adopting the one-hour thermal rating of the 500 kV series capacitor banks for system planning. BCTC implements this practice to reduce the cost of transmission reinforcements without compromising the system security. The responses to the specific parts are as follows:

a) The one-hour overload rating of the series capacitors adopted by BCTC is primarily a planning (and not an operating) criterion. This is based on a 1 hr in 24 hrs loading thermal limit which is in the order of 15% to 35% above the continuous nameplate rating. The one-hour rating is considered to be a prudent choice between continuous and other short-time ratings (eg. 30 minutes in 6 hrs, to 8 hr in 12 hrs) for planning purposes. It takes into account that this provides adequate time for operator action to redispatch generation. The general rule for minimum time for operator action is 30 minutes.
b) The assumption that the loading on the line with series capacitors would have diminished to the continuous rating within an hour was not used since system load or line loadings can remain high (above 95% peak) for over 2 to 3 hours.
c) In keeping with (b) above, the system load shape was not a consideration in the selection of the one-hour rating.
d) There are no specific restrictions placed on amount of generation redispatch we can rely upon to relieve system overloads within one hour, since these would depend on the specific system operating conditions. In general terms,it may amount to reduction of capacity equivalent to the output of one or two generation units (250 -500 MW) at either the remote Columbia River or Peace River regions that is offset by increased generation in the other region and/or in the Lower Mainland and Vancouver Island region.

Question 4:

What is the criteria for determining when shedding on first contingency is permissible when it is needed, not for the stability of the bulk system, but only to maintain the stability of a radial extension to a generation-rich region like MCA? In the case of MCA, would the limit be the shedding of a single unit? That is, is the limit the point when sufficient additional generating capacity is added at MCA (either through upgrading of the existing units or by adding more units), such that a three-phase fault on 5L71 or 5L72 requires more than one MCA unit to be shed?

Response to Q4:

This question is answered under "BCTC Internal Standards" in Appendix 13 of the "SIS for BCHD NITS2004-Stage 1- Preliminary Results, Report # SP2005-4". For ready reference, the response is quoted here: "Generation shedding for a single, first contingency shall not exceed the capacity of the largest unit in the BCTC system." This criterion has been guided by WECC Minimum Operating Reliability Criteria (MORC), which defines operating reserves requirements.

Question 5:

What is the rule for the maximum size of plant that can be connected to the system by a single line? Is it dependent on the length of the connecting line?

Response to Q5:

We understand that this question is about BCTC's planning considerations of factors, such as plant size and length of interconnection, that dictate the need of two lines instead of a single line for redundancy. As a general rule, the maximum MW size of a hydro generation plant (aggregate capacity of all units at the one plant) that can be connected by a relatively short line is around 450 MW which is the normal capacity of the largest hydro generating unit on the system, a Revelstoke or Mica unit. The rationale used here is that a single contingency outage of the line and hence of the whole generation plant would have a similar forced outage rate and the same impact on the system as, that due to an outage of either of the existing 4 units at Revelstoke and 4 units at Mica. Other factors may need to be considered for thermal plants such as desired high capacity factor operation and the relatively long time for restarting the thermal units after tripping and upon restoration of the single line connection. There may also be a requirement to minimize load rejection shocks on the thermal units. Other factors that would need to be considered for the interconnection are the expected line performance based on the line length, terrain and exposure to environmental hazards.

Question 6:

In cases where equipment overloading is the limiting phenomenon, is generator run-back a permissible option to generator shedding? What are the criteria and factors considered when deciding between generator run-back and generator shedding? Clearly, transient (first-swing) electromechanical stability would invariably require generator shedding, but what about voltage stability? Would there be situations where, considering the expected speed of voltage decline, generator run-back would be suitable if the generator run-back speed were sufficiently fast? Would the advantages to the system arising from the fact that run-back keeps units on line providing voltage control and inertia be enough to make generator run-back preferable to shedding in cases were equipment overload were the limiting factor, considering also the benefit to generator windings resulting from the reduction in the frequency of the mechanical shock torques associated with shedding?

Response to Q6:

This question refers to use of generator turbine runback (to reduce unit power output) as a technically feasible option to generation shedding to relieve thermal overloads in the system. Generator turbine run-back may be acceptable in certain situations where the response time is judged to be adequate. The impact on voltage stability and transient stability of the system would need to be assessed for technical feasibility. A combination of generator shedding and generator turbine runback may also be considered. This could be applied in some situations where control logic could be used to effect generator shedding (tripping) instead of runback where faster response is required above certain threshold system or line loading (eg. as applied at BPA's Boundary generation plant connected to the BCH/Fortis system at Nelway and Waneta).

Appendix 6: Revision-1 modifications.

1. The corrections are based on further close scrutiny of the report based on discussions both internal and with BCH.

2. The tables 2.1 and 2.2 were based on data provided by BCH. Alcan generation is not an additional generation but continuation beyond 2009. For the purpose of consistency in data presented, Alcan generation was deleted from Table 2.2. This affected the totaling of generations presented in the Peace region for scenario 2. This resulted in correction in the executive summary also. The in service year of North West Wind was corrected as 2014/15.

3. The requirement and location of shunt reactors associated with ARN-VIT 230kV AC Cable Circuits were reviewed.

4. The requirement and rating of 5L71/72 series capacitors were reviewed.

5. The Coastal Reliability Must Run (RMR) generation numbers in Table 4.3 are made consistent to the description of the heading.

6. BCH requested for two more years of 5L83 loss impacts, 2011/12 and F2015/16 to facilitate RMR vs 5L83 trade-off analysis.

7. Corrections in the body of report are indicated in red color other than table 2.2 and Nomogram graphs

NITS 2004_Stage3 Report	NITS 2004_Stage3 Revised Report	Location
3540	3395	Page 3 after bullets third paragraph line 1
Tables 2.2	New table 2.2	Page 6 “Alternative 1 Resource Plan” - Scenario 2
	and a 66.1 MVAr shunt reactor at TBY.	Page 8 Table 3.1.1 item 4 project description
2 x 66.1 MVAr shunt reactors	one 66.1 MVAr shunt reactor,	Page 8 Table 3.1.1 item 5 project description
	and a 66.1 MVAr shunt reactor at TBY.	Page 9 Table 3.1.1 item 6 project description
None	Series Compensation of 5L71 and 5L72, each line 40% compensation and 2750 A Note: The Stage 1 ISD is changed.	Page 9 Table 3.1.1 Added Item 13 Project description
None	DAF	Page 9 Table 3.1.1 item 13 colum 3

None	Oct.'18 – Sep.'19	Page 9 Table 3.1.1 item 13 colum 4
None	Oct.'19 – Apr.'21	Page 9 Table 3.1.1 item 13 colum 5
None	May '21 – Oct.'23	Page 9 Table 3.1.1 item 13 colum 6
13	14	Page 9 Table 3.1.1 item 14 column 1
14	15	Page 9 Table 3.1.1 item 15 column 1
	and a 66.1 MVAr shunt reactor at TBY.	Page 10 Table 3.2.1 item 4 project description
2 x 66.1 MVAr shunt reactors	one 66.1 MVAr shunt reactor,	Page 10 Table 3.2.1item 5 project description
	and a 66.1 MVAr shunt reactor at TBY.	Page 10 Table 3.2.1 item 6 project description
3300	2750	Page 11 Table 3.2.1 item 14 project description
Oct.'07 – Sep.'08	Oct.'12 – Sep.'13	Page 11 Table 3.2.1 item 14 column 4
Oct.'08 – Apr.'10	Oct.'13 – Apr.'15	Page 11 Table 3.2.1 item 14 column 5
May '10 – Oct.'12	May '15 – Oct.'17	Page 11 Table 3.2.1 item 14 column 6
1981	3043	Page 13 Table 4.2
873	511	Page 13 Table 4.2
1261	1036	Page 14 Table 4.3
1981	947	Page 14 Table 4.3
1768	2213	Page 14 Table 4.3
1884	2732	Page 14 Table 4.3
None	A sensitivity analysis was conducted to investigate the impact of advancing or delaying the delivery of 5L83.	Page 15 section 5.1 last line
Table 5.1.1	Table replaced. Additional data for 2011/12 and 2015/16 provided	Page 15 Table 5.1.1
A1.4 Project description contents	Replaced with modified description	Page 23 A1.4 Project description
A1.5 Justification contents	Replaced with modified contents	Page 24 A1.5 Justification
A 1.5 Project description contents	Replaced with modified description	Page 24 A1.5 Project description

A 1.6 Project description contents	Replaced with modified description	Page 24 A1.6 Project description
A 1.13 Paragraph 3	deleted	Page 28 A1.13 Justification
3300	2750	Page 29 project description second line
Second Paragraph	Replaced with modified contents	Page 29 Project description Second Paragraph
Nor Required	October 2023.	Page 29 Project In-Service Date, Scenario-1:
2012	2017	Page 29 Project In-Service Date, Scenario-2:
Nomograms	New Nomograms with X-Y scale readjusted and modified for wind farm year of service.	Page 47 Nomogram
Nomograms	New Nomogram with X-Y scale readjusted and modified for wind farm year of service.	Page 51 Nomogram