



Transmission System Planning With Automated ATC Tool

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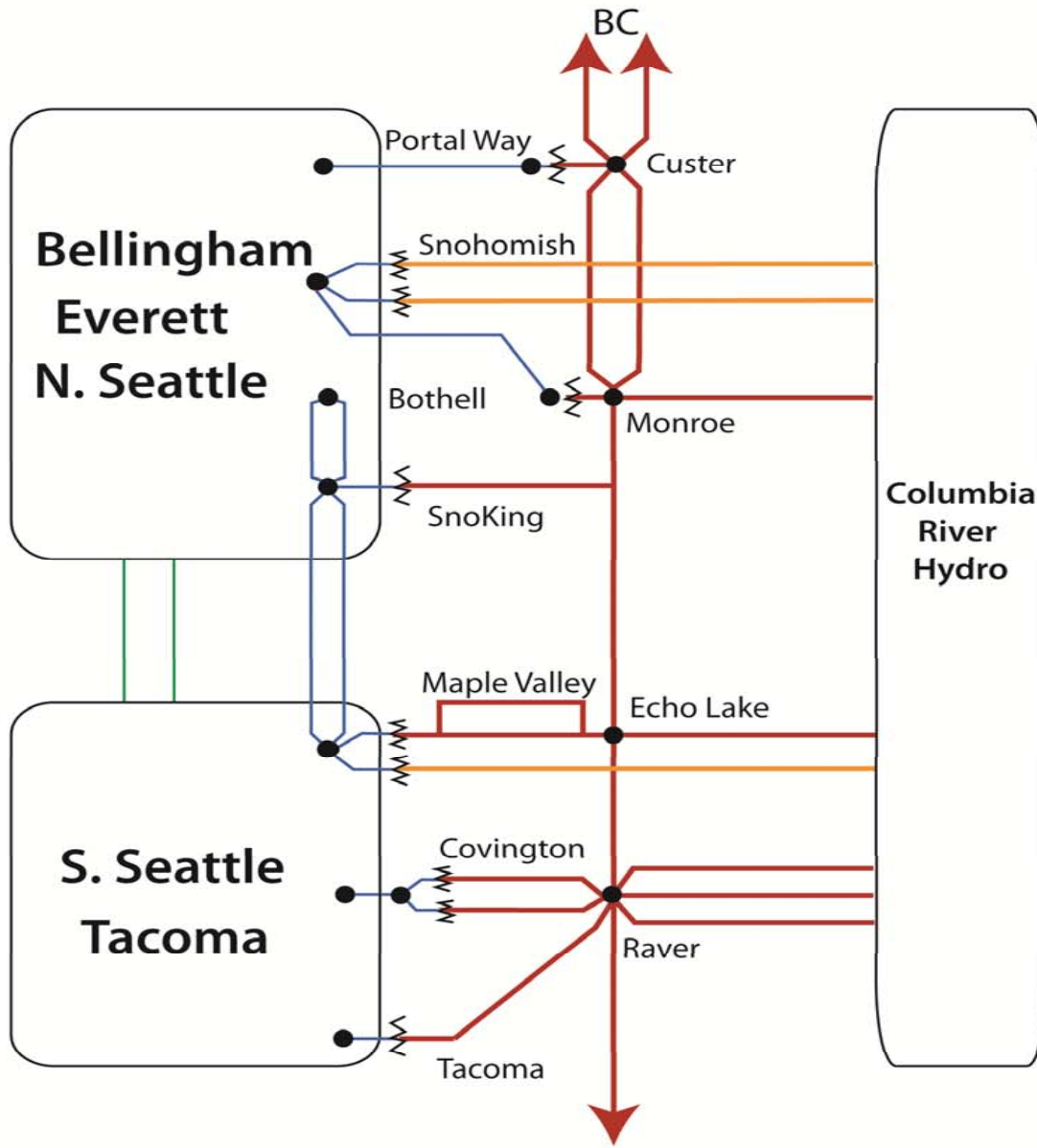
Overview

- Transfer Curtailment Concerns in the Puget Sound Area
- Puget Sound Energy Study Team's (PSAST) use of ATC Automation Tool for Transmission Study Work
- Analysis for ATC Automation Tool Output Data



Puget Sound Area Study Team

- Formed to study how load growth and planned system upgrades in the Puget Sound Area affect transfer capability on the Northern Intertie
- Currently developing an expansion plan for the area
- ATC Automation Tool has been the primary study tool for both studies



Legend

- 500 kV Line
- 345 kV Line
- 230 kV Line
- 115 kV Line
- ⚡ Transformer

Existing System



Transfer Limitation Issues in the Puget Sound Area

- Planned & unplanned system outages have been causing operational transfer limitations on the northern intertie
- Frequency and magnitude of these limitations have been increasing (especially for south – north transfers in the winter)
- Traditional planning methods have not been addressing these system conditions



Puget Sound Area Study Team Study Plan

- Apply BPA operations ATC study process in the planning horizon
- Comprehensively identify transfer limitations in the planning horizon and develop projects to address the limitations
 - PSAST defined a transfer limitation as a system condition unable to maintain +/- 1500 MW transfer capability on the intertie without adjusting area generation dispatch



Pre-Automation ATC Study Process

- ATC Tool
 - One Power Flow Case
 - Example: Heavy Summer North - South
 - Script commands used to adjust the initial system topology (PSAST uses 70 initial system topologies)
 - Determines the ATC for multiple system scenarios
 - Generation, Temperature, etc. (PSAST: 75 total scenarios, 15 generation, 5 temperature)
 - Data stored in aux files & manually transferred to excel sheets
- Very Time Consuming for Multiple System Configurations
 - Current study has produced over 300 power flow cases with different system configurations that have been run on the tool
- Inconvenient format for further processing of output data



The ATC Calculator

- Microsoft Access Interface
 - Uses SimAuto to connect to Power World and operate ATC Tool
- Allows multiple ATC cases to be run in succession
- All results are stored in Access Database
 - Allows additional automated programs to access the data for further processing
- Saves log files, ATC result script files, pwb cases for each primary script
- The calculator has produced over 500 GB of data for the current study



The ATC Calculator Form

Study ID: **Study Name:**

Project Directory:

Study Year: **Primary Outage Aux File:**

OC/TD Scenarios

Season	Direction	Load	PowerFlow Case	ATC Settings/CTG File	Select	OC/TD Cas
Summer	NS	Heavy	HS_NS.pwb	HS_NS_ATC_DC.aux	<input checked="" type="checkbox"/>	64
*					<input type="checkbox"/>	(New)

Record: 1 of 1

Primary Outage Scenarios

Outage #	Description	Outage Script Name	Select
101	All Lines In Service		<input checked="" type="checkbox"/>
102	RAVER 500 - SCHULTZ 500 3	2	<input checked="" type="checkbox"/>
103	RAVER 500 - SCHULTZ 500 4	3	<input checked="" type="checkbox"/>
104	CUSTER W 500 - MONROE 500 2	4	<input checked="" type="checkbox"/>
105	CUSTER W 500 - MONROE 500 1	5	<input checked="" type="checkbox"/>
106	RAVER 500 - SCHULTZ 500 1	6	<input checked="" type="checkbox"/>
107	RAVER 500 - TACOMA 500 1 (SAME AS TACOMA 500/230 KV XFMR)	7	<input checked="" type="checkbox"/>

Record: 1 of 1

Retrieve all ATC Limiters

Pause Simulation after each Primary Outage:



The ATC Calculator Results

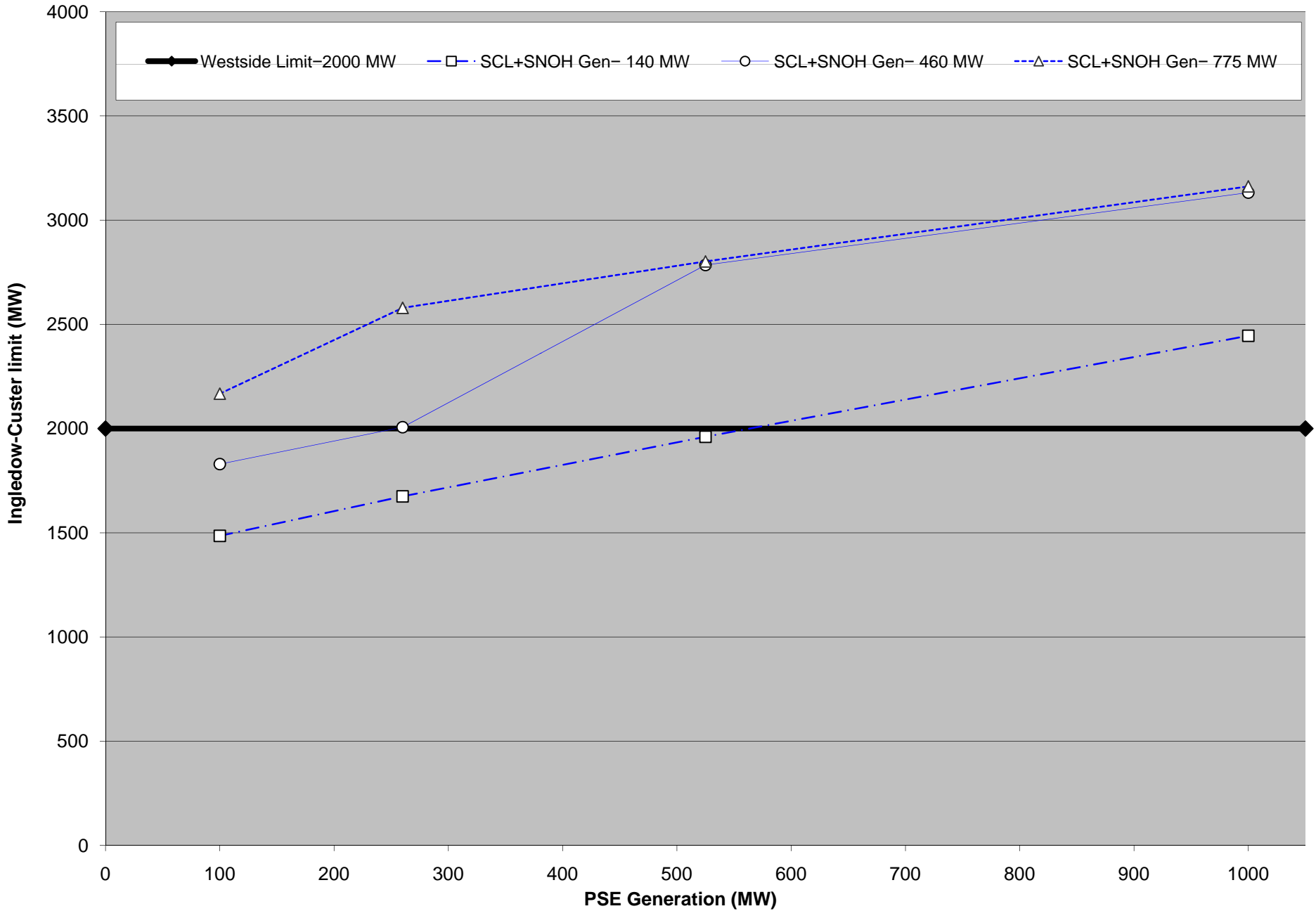
StudyID	StudyName	StudyYear	Season	Transfer	Loac	CTGI	Tempe	General	Transfer Limit (M)	Worst (Secondary) Contingency	Limiting Facility (Element)	% ODF
1	run69	2020	Summer	NS	Heavy	101	35F	G0	1,883.45	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G1	2,030.69	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G2	2,165.59	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G3	1,762.90	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G4	1,909.70	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G5	2,044.59	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G6	1,532.62	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G7	1,679.04	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G8	1,813.62	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G9	1,175.08	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G9	1,175.93	N-2: MON-SK-EL 5 & MON-SAMM2 (198)	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G9	1,282.80	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 2 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G9	1,283.62	N-2: MON-SK-EL 5 & MON-SAMM2 (198)	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 2 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G10	1,321.10	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G10	1,321.89	N-2: MON-SK-EL 5 & MON-SAMM2 (198)	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G11	1,456.14	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16
1	run69	2020	Summer	NS	Heavy	101	35F	G12	1,173.22	N-2: MON-SK-EL 5 & MON-NOV	Branch HRTAP MS (40963) TO SNOH S4 (41330) CKT 1 [230.00 - 230.00 kV]	16



Analysis of Output Data

- Two strategies for analyzing ATC data are currently being used in the PSAST
 - Nomograms: Graph showing maximum transfer capability for a given system configuration and temperature scenario
 - PSAST: 70 system configurations and 5 temperature scenarios are applied to each case ($300 \text{ cases} \times 70 \times 5 = 105,000$ nomograms)
 - Transmission Curtailment Risk Measure (TCRM): Statistical value showing the overall risk of curtailment for a specific ATC scenario
 - This statistical value was developed in order to analyze the large number of nomogram data points from BPA operational studies

**Sensitivity of Ingledow-Custer limits to
PSE, SCL, and SNOH Generation**





Nomograms

- Each Nomogram:
 - Models a single transmission system configuration
 - Models a single temperature condition
 - Typically has 15 nomogram points that correspond to 15 different generation dispatches
 - Identifies the maximum Northern Intertie capability while keeping the system within limits should the next most critical contingency occur



TCRM Calculation

- Compares each limitation value from an ATC run to a threshold
 - PSAST uses 1500 MW for the study
- If the value falls below the threshold the difference is taken and added to the total TCRM value



TCRM Calculation Example

- If a project were to have only three limiters from the ATC tool of 1600, 1300, and 1200 MW. The TCRM calculation is as follows:
 - 1600 MW is omitted since it is above 1500 MW
 - $1500 - 1300 = 200$
 - $1500 - 1200 = 300$
 - $TCRM = 200 + 300 = 180$
- Note: TCRM is a unitless value and can vary greatly depending on the setup of the ATC tool. Comparing TCRM values should be done with care.
 - Additional generation patterns, temperature levels, and additional initial system conditions can greatly increase the TCRM level for any single case
 - 100 primary outages will likely produce a much larger TCRM value than 10 primary outages



Nomogram & TCRM Automation Tool

- In order to take advantage of the output ATC data in the access database Power EX developed a Nomogram and TCRM Automation Tool
- This tool accesses the data from the database, sorts the data into valid nomograms & TCRM calculations, and creates separate excel files for each nomogram & TCRM calculation
- Weighting factors are also able to be applied to each temperature and generation scenario



ATC Calculator

Master Datasheet: U:\PSASrun62\Results\NIData.mdb

Master Datasheet Path: U:\PSASrun62\Results\NIData.mdb

Export To: C:\Users\Jonathan\Desktop\PSASrun65\Results

Source Filter: All records Lowest transfer limit only

Study ID + Study Name: 1 - a

Season: Summer Winter

Initial Transfer: 1500

TTC Threshold: 1500

Transfer Direction: N-S 1 to 15 S-N 1 to 15

Primary Contingency:

Heavy Load Weighting Factor: HeavySummerNS

Summer/Winter	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
35 / 25	0	0	0	0	0	0	0	0	0.023	0	0	0	0	0	0
45 / 35	0	0.018	0	0.051	0.056	0	0.251	0.244	0.089	0	0	0	0	0	0
60 / 45	0.02	0.142	0.008	0.249	0.919	0.043	1.0	0.741	0.01	0.01	0.023	0	0	0	0
70 / 60	0	0.015	0	0.03	0.371	0.084	0.472	0.632	0.005	0.046	0.051	0	0	0	0
85 / 70	0	0	0	0	0	0	0.018	0.094	0	0.008	0.023	0	0	0	0

Light Load Weighting Factor: Template1

Summer/Winter	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
35 / 25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
45 / 35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
60 / 45	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
70 / 60	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
85 / 70	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1



TCRM Calculator

Master Datasheet:

Master Datasheet Path: U:\PSASTrun62\Results\NIData.mdb

Export To:

Summer Template (NS):

Winter Template (NS):

Summer Template (SN):

Winter Template (SN):

Summer Bi Template:

Winter Bi Template:

Study ID + Study Name:

<input checked="" type="checkbox"/> 1 - a	<input checked="" type="checkbox"/> Summer	<input checked="" type="checkbox"/> N-S	<input type="checkbox"/> HLH
	<input checked="" type="checkbox"/> Winter	<input checked="" type="checkbox"/> S-N	<input type="checkbox"/> LLH
		<input checked="" type="checkbox"/> Bi-Directional	

Primary Contingency:

Number of Nomograms: 0



Weighted TCRM Values

- Each TCRM component is weighted based on the probability of occurrence of the individual nomogram point :
 - Generation level (PSE, SCL, and SnoPUD)
 - Temperature condition
 - Intertie flow direction (north to south or south to north)
- Weightings based on historical data
 - Data used was for 2007 and 2008
 - Only used heavy load periods
 - 6:00 am to 10:00 pm Monday to Friday



Winter South to North Generation Scenarios and Weighting Factors

Generation Scenarios

	G0	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14
SCL + Snoh Generation	140	460	775	140	460	775	140	460	775	140	460	775	140	460	775
PSE Generation	100	100	100	260	260	260	525	525	525	1000	1000	1000	1200	1200	1200
Combined	240	560	875	400	720	1035	665	985	1300	1140	1460	1775	1340	1660	1975

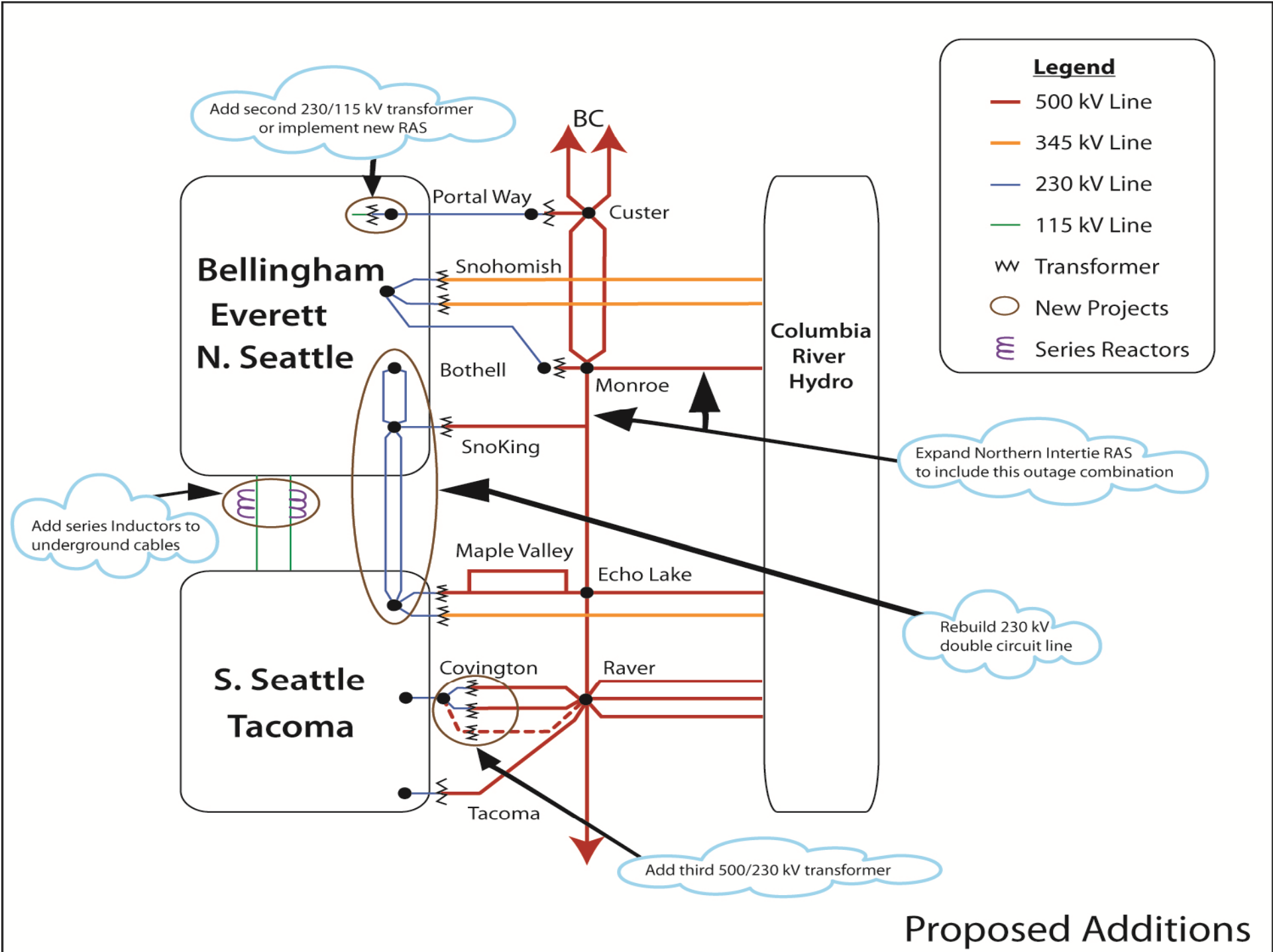
Probability of Temperature and Generation Combination

25 degrees F	0.00%	0.00%	0.00%	0.00%	0.20%	0.08%	0.00%	0.20%	0.28%	0.00%	0.28%	0.06%	0.00%	0.00%	0.00%
35 degrees F	0.11%	0.92%	0.03%	0.11%	5.19%	0.75%	0.03%	5.77%	1.76%	0.00%	0.03%	0.11%	0.00%	0.00%	0.00%
45 degrees F	4.04%	6.78%	0.28%	2.04%	12.44%	1.70%	0.08%	3.60%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
60 degrees F	1.37%	1.53%	0.00%	1.12%	2.71%	0.06%	0.03%	0.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
70 degrees F	0.00%	0.14%	0.00%	0.00%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%



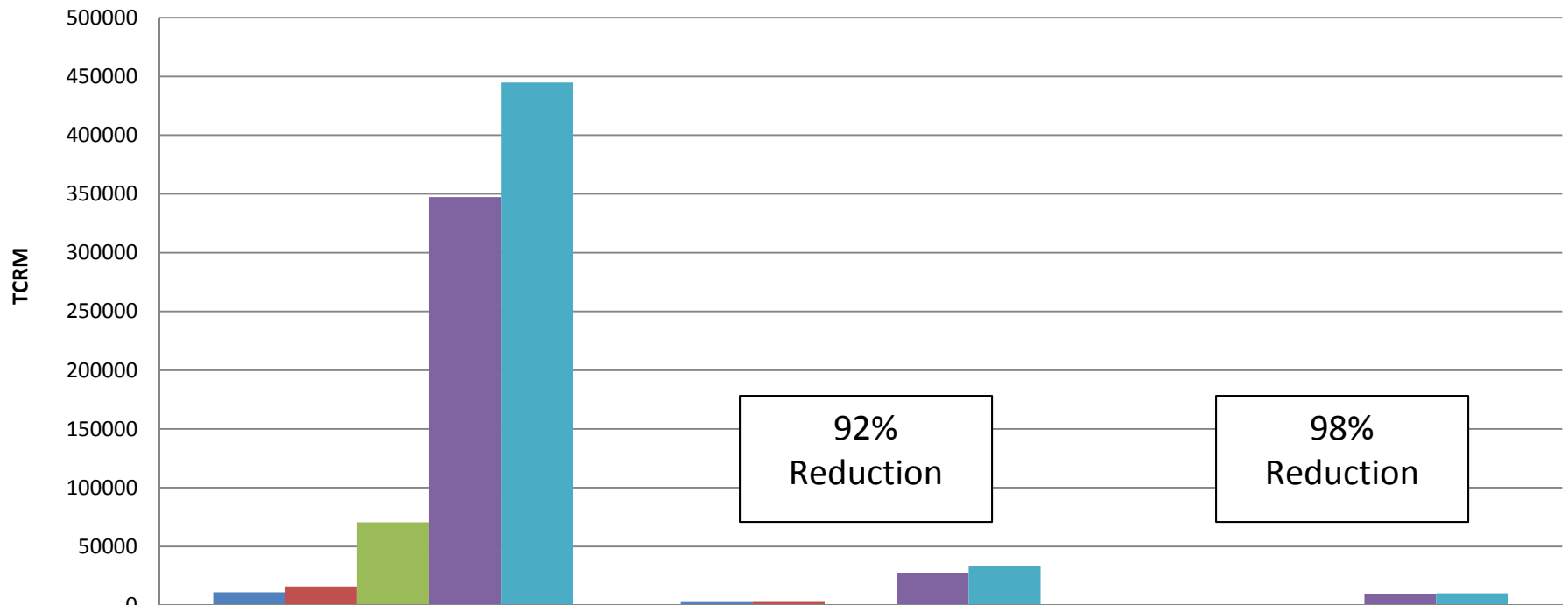
Initial Results

- **Major Projects**
 - Five projects were found to be very effective at reducing curtailment risk
 - Most require new construction to complete
- **Additional Projects**
 - Fifteen line upgrade projects that would reduce the curtailment risk to minimal levels
 - The majority of the benefit seen from these upgrades occur after the major projects are constructed



Transmission Curtailment Risk Measure Results

Weighted TCRM Values

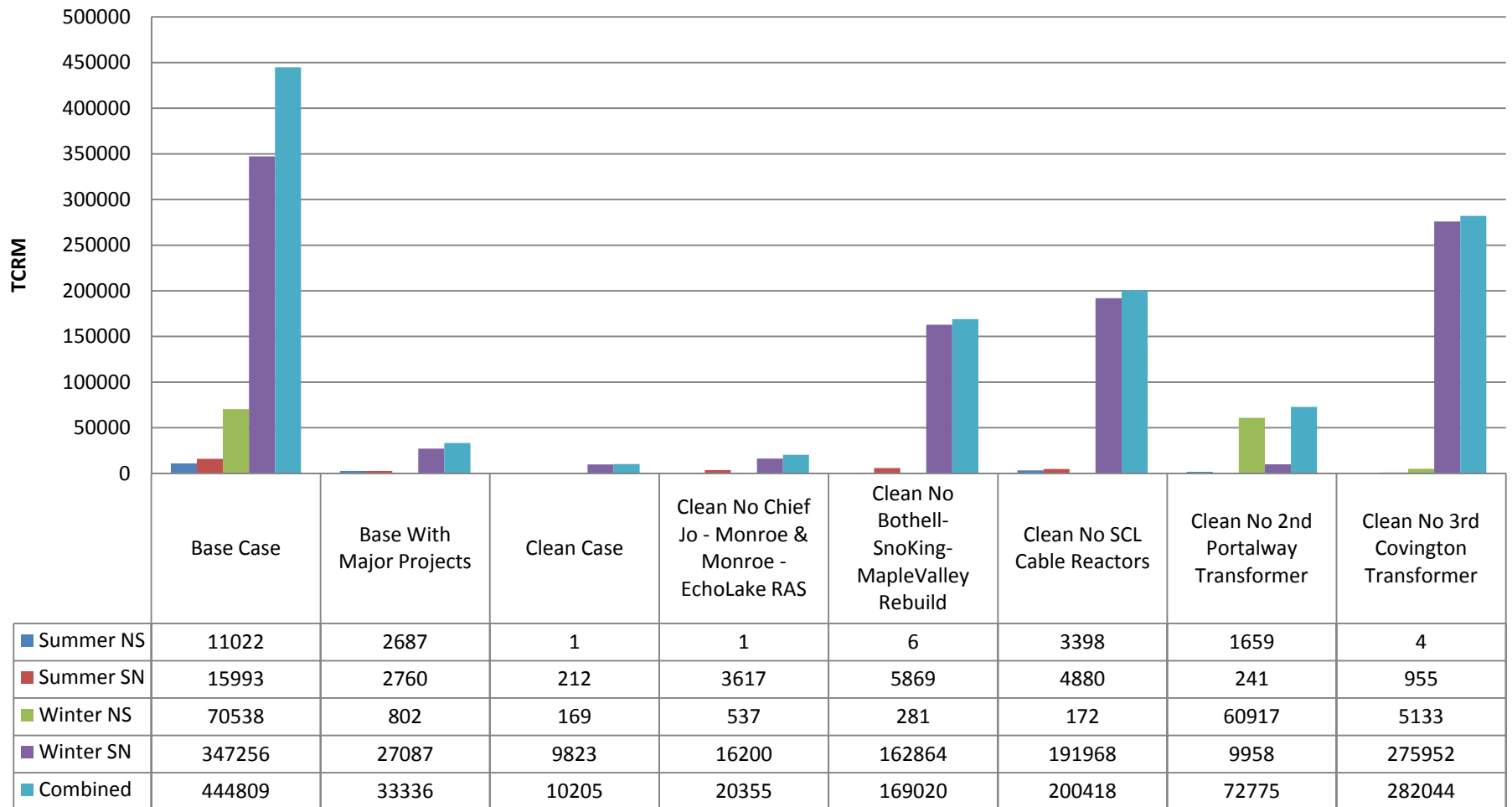


	Base Case	Base With Major Projects	Clean Case
■ Summer NS	11022	2687	1
■ Summer SN	15993	2760	212
■ Winter NS	70538	802	169
■ Winter SN	347256	27087	9823
■ Combined	444809	33336	10205

TCRM Results

(TCRM – Transmission Curtailment Risk Measure)

Weighted TCRM Values





Study Status

- Draft 4 of the report has recently been posted on the ColumbiaGrid web site
- Completing ATC analysis on possible alternatives to major projects
- Completing traditional study work
 - It was requested that traditional study work was done to supplement the ATC work and verify the results
- Refining cost estimates for the major projects and some of the more valid alternatives



Questions?