

RMATS Modeling

JOINT PLANNING GROUP MEETING

SSG-WI, WECC, CREPC, NTAC, SWAT, STEP, RMATS, CCPG



April 6, 2004

Rocky Mountain Area Transmission Study

Modeling Overview

Mike DeWolf

Modeling Team



April 6, 2004

Rocky Mountain Area Transmission Study

A three phased process

➤ **Phase 1– Economic screening**

- Assesses congestion and congestion costs under load, gas price, new resource, and transmission alternatives
- Lays groundwork for future work on siting, regulatory approvals, contracting, and financing
- Deliverable: a small number (2-5) of commercially viable alternatives
- ETA: June

➤ **Phase 2- Regulatory approvals, contracting, siting, & financing**

➤ **Phase 3- Engineering and construction**

Modeling Approach

- **Marginal costs (VOM) modeled with ABB Market Simulator**
 - Production cost model using linear program
 - West-wide in scope, with focus on Rocky Mountain states
 - Detailed transmission representation
 - Determines marginal costs at nodal/bus level (LMPs)
 - Hourly resolution

- **Test year for base case – 2008**

- **Test year for transmission alternatives - 2013**

Modeling Limitations

- **Assumes a single, seamless west-wide market**
- **No rate or loss charge pancaking**
- **Dispatch optimized on centralized, west-wide basis**
- **Not modeled:**
 - Contractual / tariff constraints
 - Transmission wheeling and loss charges
 - Must-run generation
 - Unit commitment
 - Generator forced outages
 - Actual heat rate curves- approximate only
 - Sub-hourly operations
 - Bid behavior

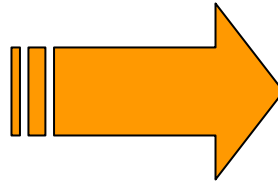
Modeling Implications

- **Tends to make fuller, more optimal use of transmission than operations currently allow**
 - Analogous to a seamless, single RTO world
- **Tends to mask the tariff and contractual constraints of today**
- **Makes wind appear more economic because fewer constraints lead to greater dispatch**
- **Fifteen percent planning margin is used - may be conservative**

Modeling Sequence

Base Case

- Assess current system (2008)
- Focus: congestion and congestion costs
- Illuminate problems and opportunities with current system
- Modeled: Fuel and other variable O&M (VOM)
- Approved in February



2013 Alternatives

- Evaluate the economics of transmission alternatives for 4 resource alternatives
- Iterative process w/ Tx Additions WG
- Focus: value of relieving congestion
- Modeled: VOM and fixed/capital costs
- Work in progress (ETA April)

See Wyoming's web page for supplemental information <http://psc.state.wy.us/htdocs/subregional/home.htm>

Resources

Ray Brush

Resource Addition Work Group (RAWG) – Co Chair



Rocky Mountain Area Transmission Study

Generation Alternatives for 2013

State	Bubble	Gen Type	Name Plate Generation Values			
2013 ALTERNATIVE CASES			1	2	3	4
Colorado	Colorado East	Coal	1250	500	1540	2500
		Gas	210	210	210	603
		Wind	800	500	800	1500
	Colorado West	Coal				
		Gas				
		Wind			250	250
Idaho	KGB	Coal				
		Gas				
		Wind	125	125	125	125
	Mid Point/Boise/Snake	Coal	575			
		Gas				
		Wind				440
Montana	Montana West	Coal			260	260
		Gas			260	260
		Wind	225	280	500	1000
	Broadview	Coal		250	500	750
		Gas				
		Wind	0		950	1000
Colstrip/Crossover	Coal		359	609	1109	
	Gas					
	Wind		50	100	200	
Utah	Bonanza	Coal				
		Gas				
		Wind				
	IPP	Coal	200		950	950
		Gas				
		Wind				
Utah North	Coal					
	Gas					
	Wind	250	100	200	320	
Utah South	Coal	575	575	575	575	
	Gas	525	140	140	140	
	Wind			120	250	
Wyoming	Big Horn Basin	Coal				
		Gas				
		Wind	250	250	250	250
	Black Hills	Coal				
		Gas				
		Wind				125
LRS	Coal					
	Gas					
	Wind		500	500	1500	
SW Wyoming	Coal					
	Gas					
	Wind	925	1150	1000	2450	
Wyoming	Coal		700	1400	2100	
	Gas	50		50	50	
	Wind				800	
WYO(IDA)	Jim Bridger	Coal		575	575	575
Gas						
Wind				160	230	
WYO(MT)	Yellowtail	Coal				
Gas						
Wind						
Total Coal			2600	2959	6149	8559
Total Gas			785	350	660	1053
Total Wind Nameplate			2575	2955	4955	10440
Total Firm Energy			3900	3900	7800	11700

✓ Alternative 1- Compilation of existing IRP's - minimal new transmission

Configured incremental resource additions in each state to meet projected load growth plus reserves in that state. (Load growth is 3900 MW from 2008 – 2013 for RM states). Major wind in CO-E and SW Wyoming close to load centers

✓ Alternative 2- “Pseudo” IRP for sub-region

Focus on Powder River coal and open range wind. Solves for same load growth as Alternative 1. Requires more transmission than Alternative 1

✓ Alternative 3- Export 1 X RM load growth

Builds off Alternative 2. Additional Powder River and Utah coal and open range wind necessitating more transmission for export

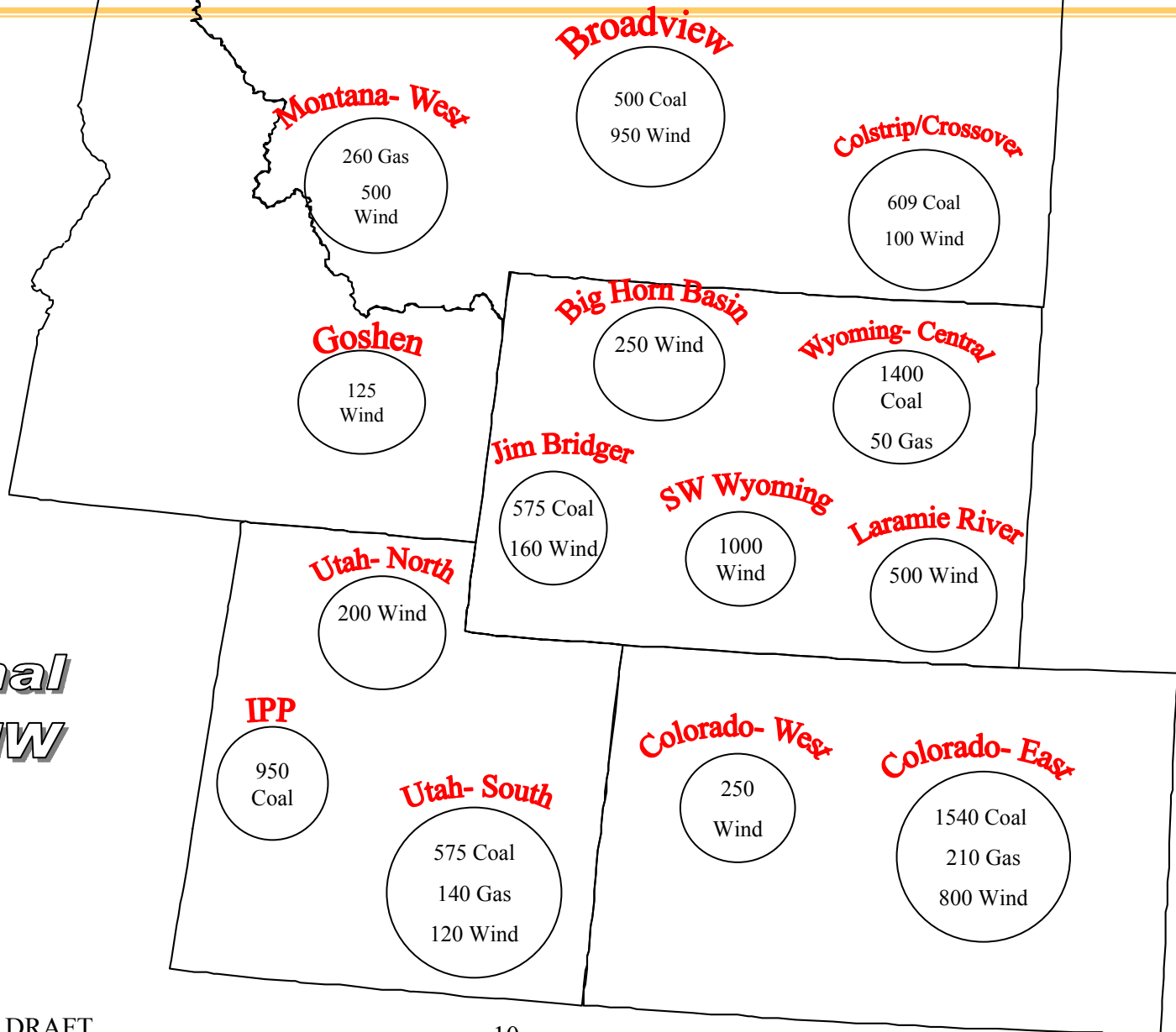
✓ Alternative 4- Export 2 X RM load growth

Still more Powder River (and Utah) coal and open range wind

20% of wind nameplate applies toward capacity

Alternative 3

Incremental Generation Additions (MW)



**Additional
7,800 MW**

Transmission

Ken Morris

Transmission Addition Work Group (TAWG) – Co Chair



Rocky Mountain Area Transmission Study

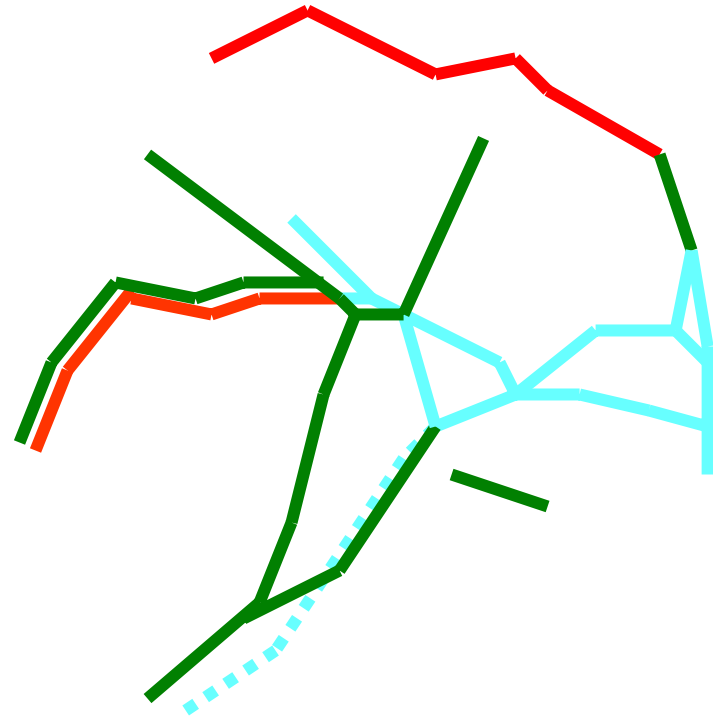
Alternative 3 Export Options

Export requires two additional
500 kV lines

Red = option 1

Green = option 2 – but several
choices are competing

Light blue is common to both options



**Map too large to e-mail;
will distribute at the meeting**

Alternative 3 – Option 1 (Montana to NW)

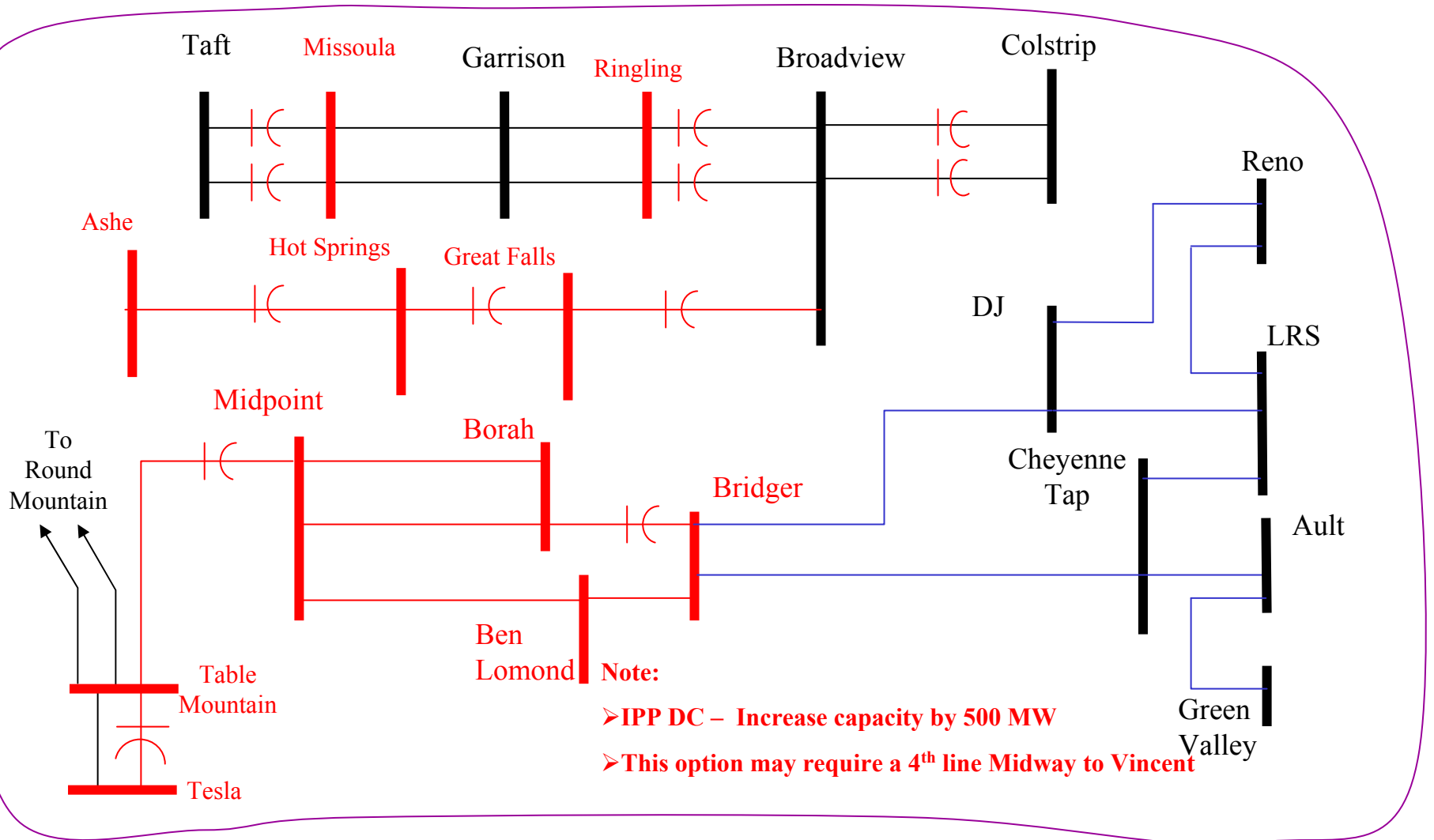
7800 MW Plan

Existing

— “New” 500 kV

— “New” 345 kV

Run 1



Alternative 3 – Option 1 – Run 1 includes all solutions

Transmission Configuration	Definition	Incremental Increase (MW)
Solutions from Alt 1&2	Amps Line – Add a Phase Shifter 230 kV Midpoint to Boise Flaming Gorge Transformers	100
	Upgrade IPP DC	500
West of Colstrip	Colstrip Transformer 500/230 kV Colstrip to Broadview – Increase Series Compensation	500
	500 kV Broadview to Garrison tap 500 kV Broadview to Ringling – Increase Series Compensation (Replaces Broadview-Townsend lines) Series Comp @Ringling Series Comp @ Missoula 500	500
Montana to Northwest	500 kV Broadview to Gt Falls; with 50 % Series Compensation Great Falls 500/230 Transformer, duplicate one of the transformers at Broadview 500 kV Gt Falls to Hot Springs; with 50% Series Compensation 500 kV Hot Springs to Ashe; with 50% Series Compensation	1000
	500 kV Chief Jo to Monroe (not modeled; no expansion value, no binding limit)	1500

Alternative 3 – Option 1 Run 1 includes all solutions

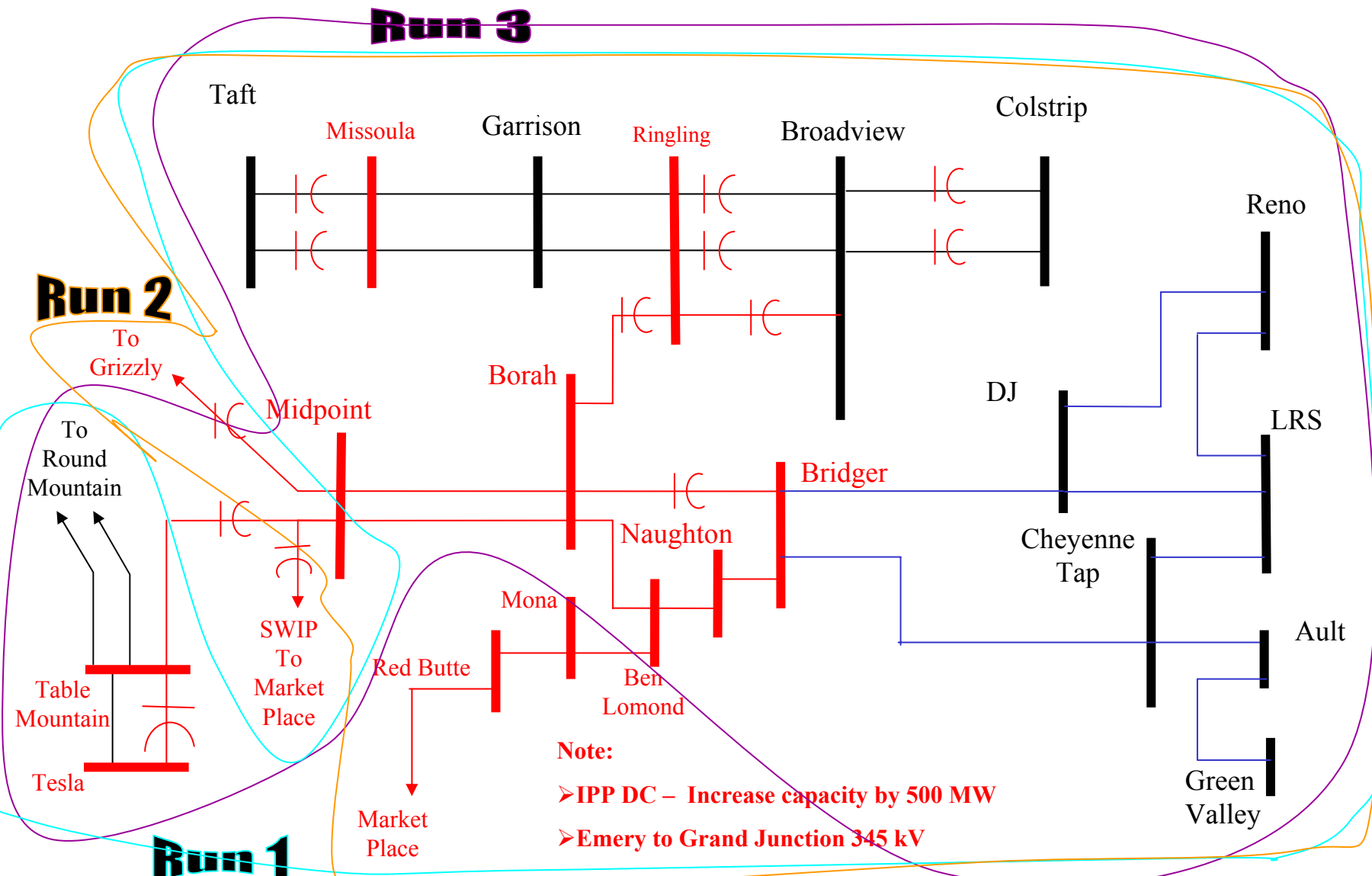
(Continued)

Transmission Configuration	Definition	Incremental Increase (MW)
Bridger West	500 kV Bridger to Borah; w/ 30% Series Compensation Convert Kinport-Midpoint 345 kV to 500 kV 345 kV Kinport-Borah (new) Add Borah 500/345 kV Transformer 2- 500 kV Borah-Midpoint	1000
	500 kV Bridger to Ben Lomond; w/30% Series Compensaion 500 kV Ben Lomond to Midpoint	1000
Idaho to California	500 kV Midpoint to Table Mountain to Tesla; w/50 % Series Compensaion	1500
TOT 3	345 kV Reno to DJ to LRS to Cheyenne Tap to Ault to Green Valley 345 kV Reno to LRS	500
TOT 4A	345 kV Bridger to Miners to Cheyenne 345 kV DJ to Bridger	500

Alternative 3 – Option 2 (Montana S & W)

7800 MW Plan

Existing █
 “New” 500 kV █
 “New” 345 kV █



Alternative 3 – Option 2 - Run 1 (UT – LV & ID – CA)

Transmission Configuration	Definition	Incremental Increase (MW)
Solutions from Alt 1&2	Amps Line – Add a Phase Shifter 230 kV Midpoint to Boise	
IPP DC	Upgrade IPP DC	500
Montana to Wyoming	Colstrip Transformer 345/230 kV Colstrip to Broadview – Increase Series Compensation	500
West of Colstrip	500 kV Broadview to Garrison tap 500 kV Broadview to Ringling – Increase Series Compensation	500
	500 kV Ringling to Broadview 500 kV Ringling to Borah	1000
Bridger West	500 kV Bridger to Borah; w/ 30% Series Compensation Convert Kinport-Midpoint 345 kV to 500 kV 345 kV Kinport-Borah (new) Add Borah 500/345 kV Transformer 2- 500 kV Borah-Midpoint 500 kV Bridger to Naughton to Ben Lomond ; w/30% Series Compensation 500 kV Ben Lomond to Borah; w/30% Series Compensation	1000
TOT 3	345 kV Reno to DJ to LRS to Cheyenne Tap to Ault to Green Valley 345 kV Reno to LRS	500
TOT 4A	345 kV Bridger to Miners to Cheyenne 345 kV DJ to Bridger	500
Tot 1A	Emery to Grand Junction	500
Utah to Market Place	500 kV Ben Lomond to Mona to Red Butte to Market Place; w/Phase Shifter	1200
Idaho to California	500 kV Midpoint to Table Mountain to Tesla; w/50% Series Compensation	1500

Alternative 3 – Option 2 - Run 2 (UT – LV & ID – NW)

Transmission Configuration	Definition	Incremental Increase (MW)
Solutions from Alt 1&2	Amps Line – Add a Phase Shifter 230 kV Midpoint to Boise	
IPP DC	Upgrade IPP DC	500
Montana to Wyoming	Colstrip Transformer 345/230 kV Colstrip to Broadview – Increase Series Compensation	500
West of Colstrip	500 kV Broadview to Garrison tap 500 kV Broadview to Ringling – Increase Series Compensation	500
	500 kV Ringling to Broadview 500 kV Ringling to Borah	1000
Bridger West	500 kV Bridger to Borah; w/ 30% Series Compensation Convert Kinport-Midpoint 345 kV to 500 kV 345 kV Kinport-Borah (new) Add Borah 500/345 kV Transformer 2- 500 kV Borah-Midpoint 500 kV Bridger to Naughton to Ben Lomond ; w/30% Series Compensation 500 kV Ben Lomond to Borah; w/30% Series Compensation	1000
TOT 3	345 kV Reno to DJ to LRS to Cheyenne Tap to Ault to Green Valley 345 kV Reno to LRS	500
TOT 4A	345 kV Bridger to Miners to Cheyenne 345 kV DJ to Bridger	500
Tot 1A	Emery to Grand Junction	500
Utah to Market Place	500 kV Ben Lomond to Mona to Red Butte to Market Place; w/Phase Shifter	1200
Idaho to Northwest	500 kV Midpoint to Grizzly; w/50% Series Compensation	1000

Alternative 3 – Option 2 - Run 3 (ID – LV & ID – CA)

Transmission Configuration	Definition	Incremental Increase (MW)
Solutions from Alt 1&2	Amps Line – Add a Phase Shifter 230 kV Midpoint to Boise	
IPP DC	Upgrade IPP DC	500
Montana to Wyoming	Colstrip Transformer 345/230 kV Colstrip to Broadview – Increase Series Compensation	500
West of Colstrip	500 kV Broadview to Garrison tap 500 kV Broadview to Ringling – Increase Series Compensation	500
	500 kV Ringling to Broadview 500 kV Ringling to Borah	1000
Bridger West	500 kV Bridger to Borah; w/ 30% Series Compensation Convert Kinport-Midpoint 345 kV to 500 kV 345 kV Kinport-Borah (new) Add Borah 500/345 kV Transformer 2- 500 kV Borah-Midpoint 500 kV Bridger to Naughton to Ben Lomond ; w/30% Series Compensation 500 kV Ben Lomond to Borah; w/30% Series Compensation	1000
TOT 3	345 kV Reno to DJ to LRS to Cheyenne Tap to Ault to Green Valley 345 kV Reno to LRS	500
TOT 4A	345 kV Bridger to Miners to Cheyenne 345 kV DJ to Bridger	500
Tot 1A	Emery to Grand Junction	500
Idaho to California	500 kV Midpoint to Table Mountain to Tesla; w/50% Series Compensation	1500
Rocky Mountain to California	SWIP to STEP; with 70% Series Compensation	1200

Results

Jamie Austin – Modeling Team



Rocky Mountain Area Transmission Study

Alternative 3 is the focus

- ✓ Integrates power to serve Rocky Mountain area load
- ✓ Also includes 2 options for export to California & NW
- ✓ Intent is to reduce down to a single option

Option 1-

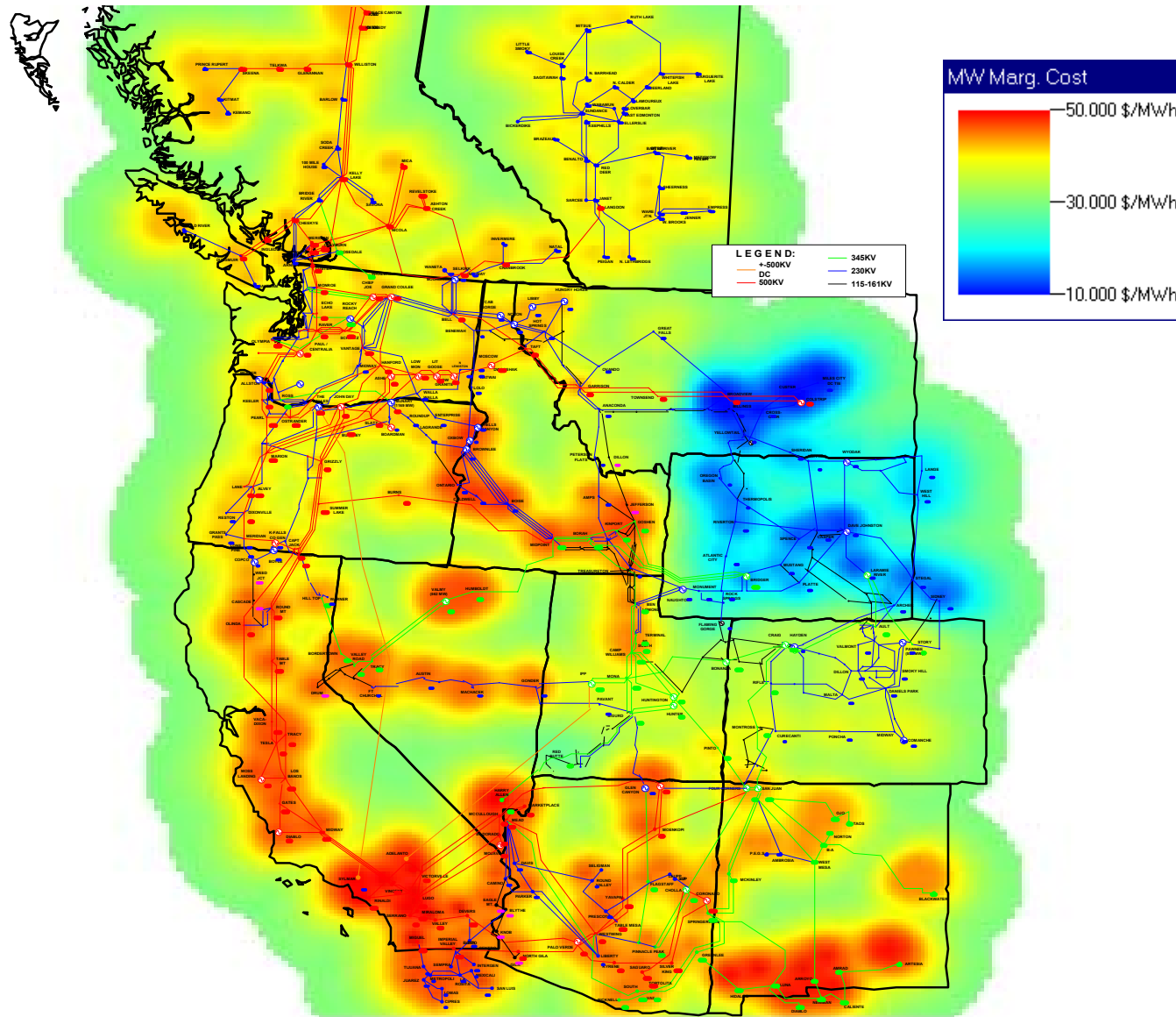
- a. *Broadview, Montana → Eastern Washington, via Ashe*
- b. *Midpoint, Idaho → Bay Area, California via Table Mtn & Tesla*

Option 2- Best 2 performing lines

- a. *Midpoint, Idaho → Grizzly, Oregon*
- b. *Ben Lomond, Utah → LA, California via Mona & Market Place*
- c. *Midpoint, Idaho → Bay Area, California via Table Mtn & Tesla*
- d. *Midpoint, Idaho → LA, California via SWIP*

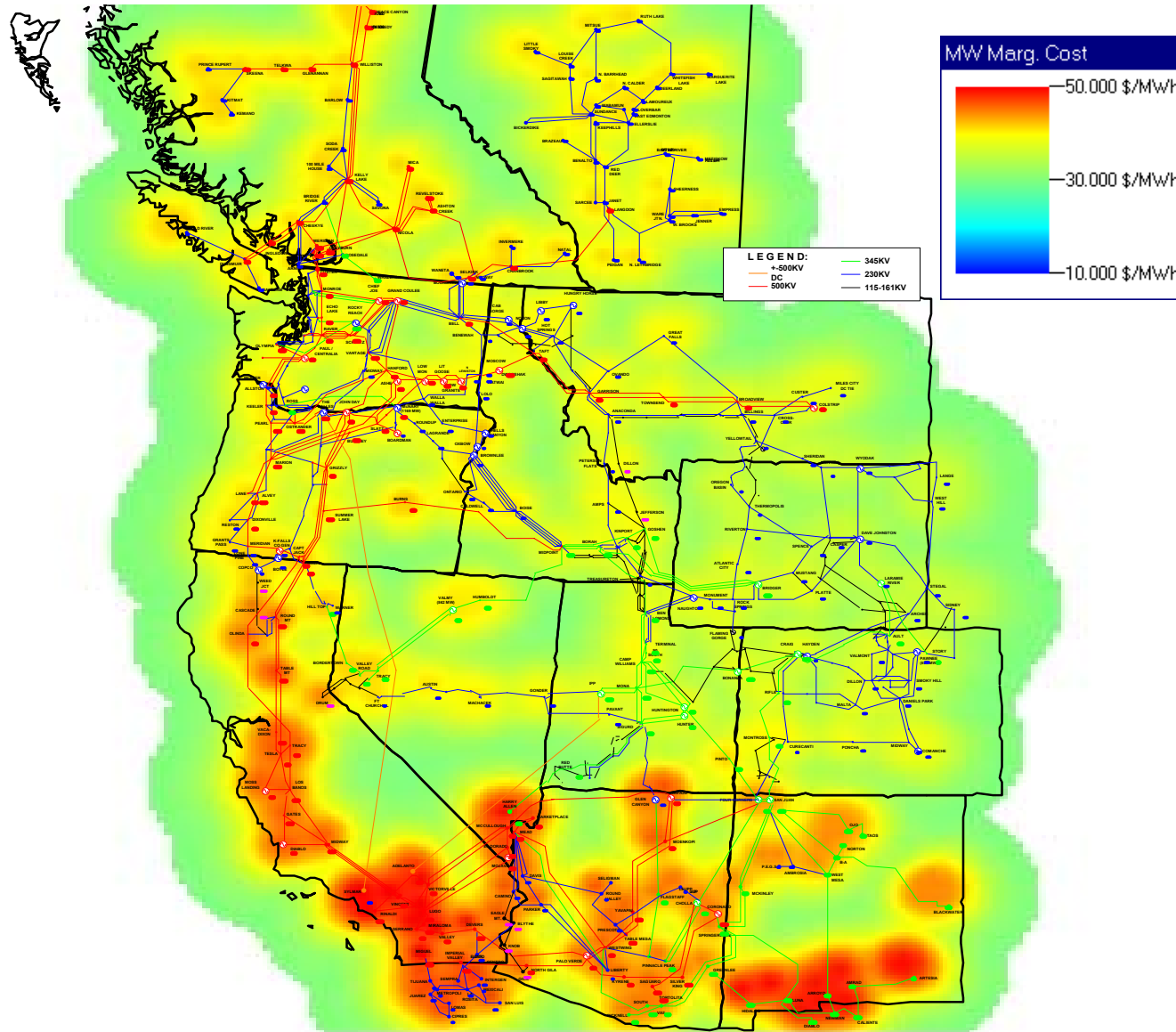
Average Monthly LMP- July 2013

Alternative 3 – Existing Transmission (Run 0)



Average Monthly LMP- July 2013

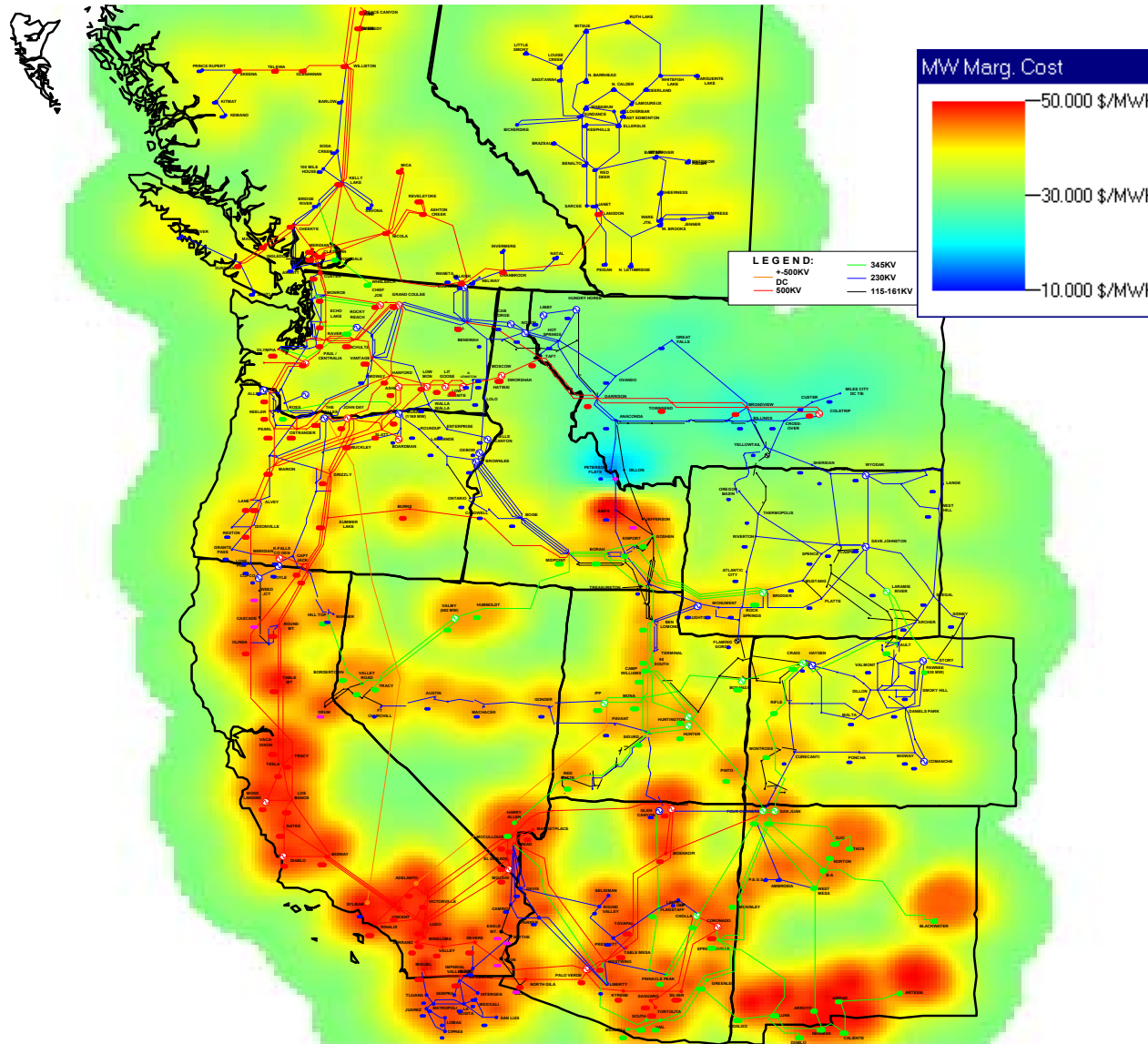
Alternative 3 – Option 1



Includes 500kV from Montana to NW
500kV from Midpoint to Tesla

Average Monthly LMP- July 2013

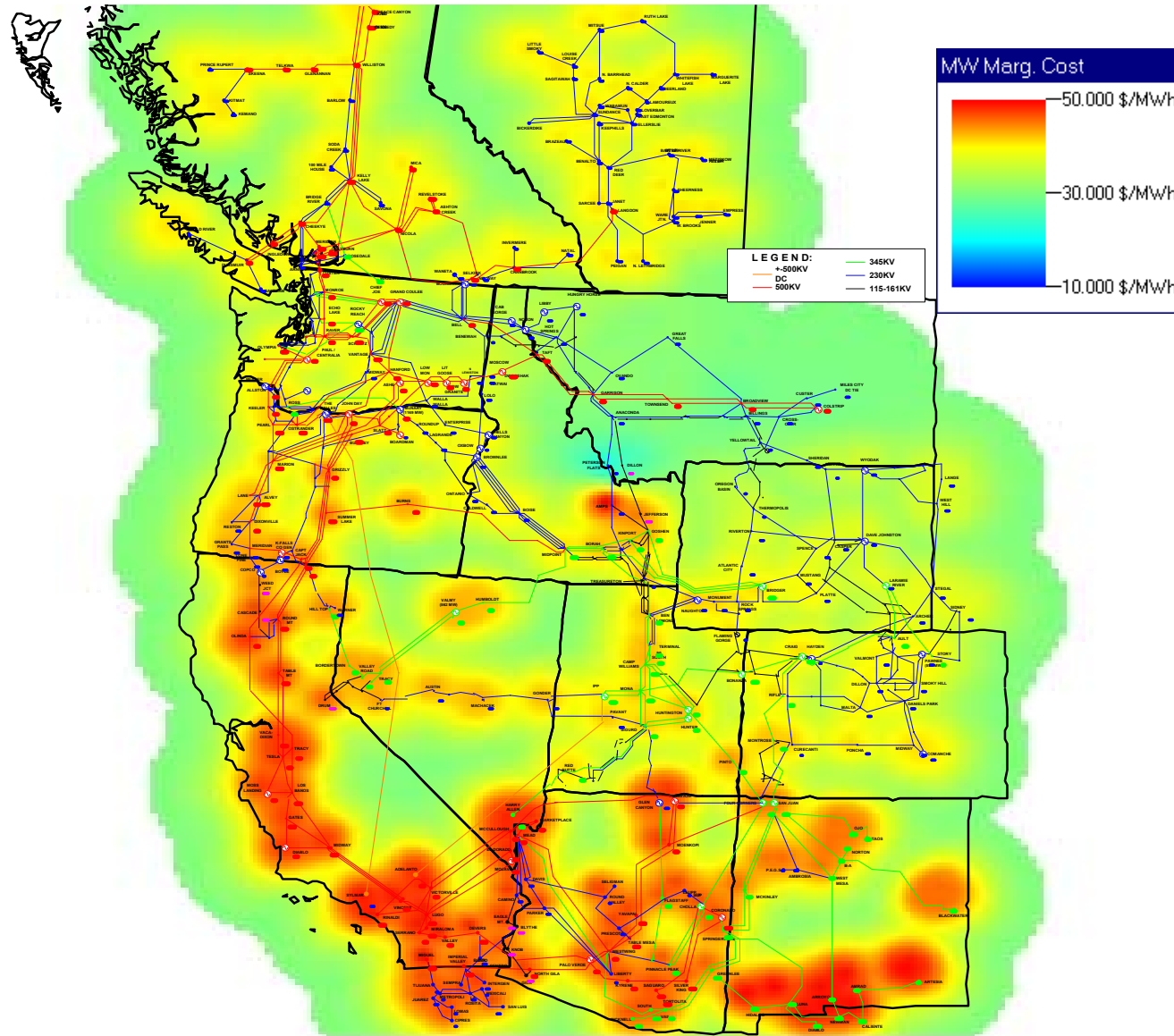
Alternative 3 – Option 2, run 1



Includes 500kV from Utah to LA
500kV from Midpoint to Tesla

Average Monthly LMP- July 2013

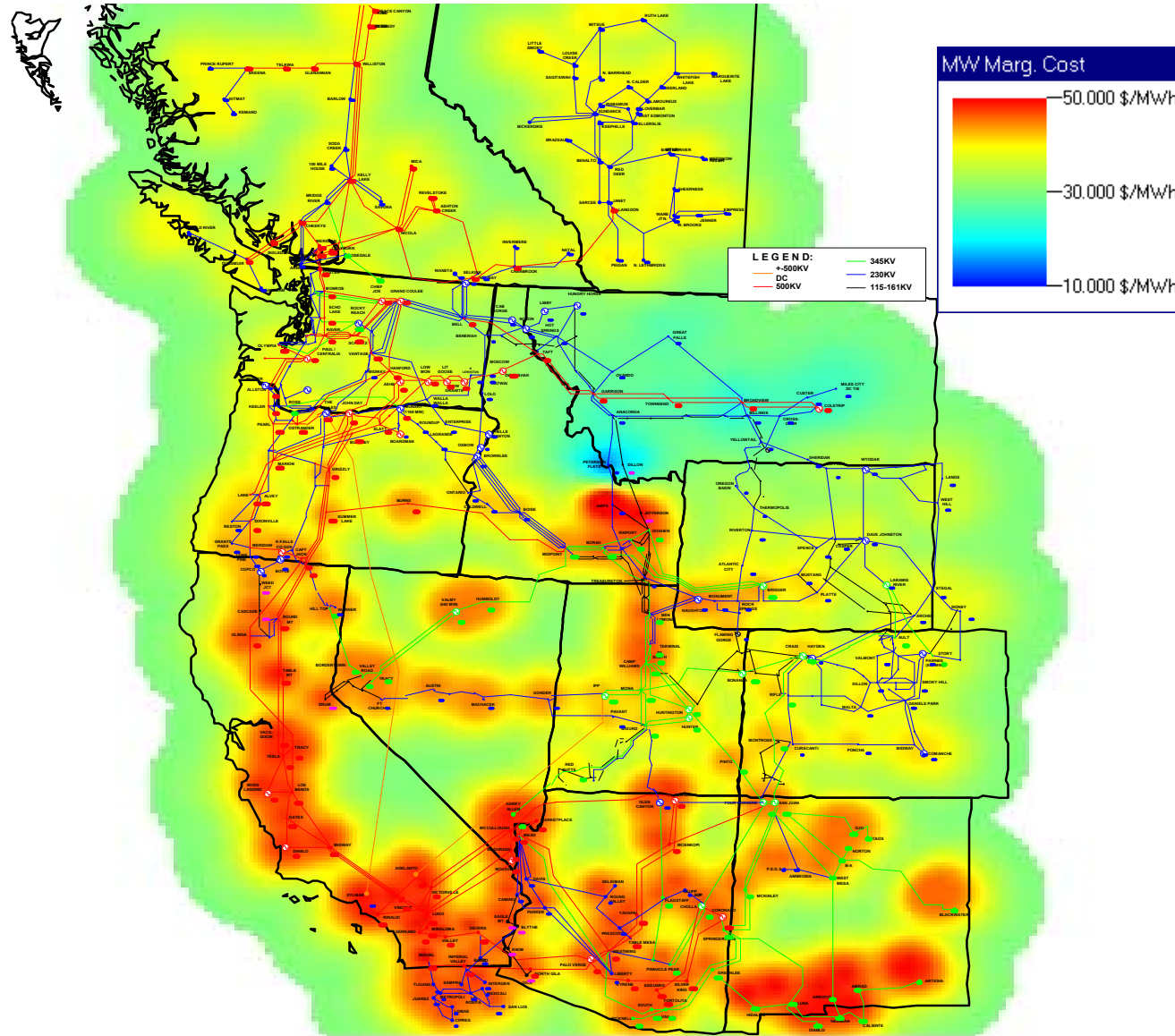
Alternative 3 – Option 2, run 2



Includes 500kV from Utah to LA
500kV from Midpoint to Grizzly

Average Monthly LMP- July 2013

Alternative 3 – Option 2, run 3



Includes 500kV from Idaho to LA (SWIP)
500kV from Midpoint to Tesla

Alternative 3 – Thermal VOM by Area (\$000)

Row	Area Name	Run 0 (no added Tx)	Run 0 (No Constraints)	Option 1 (Mont & Telsa)	Option 2 (Ut & Tesla)	Option 2 (Ut & Grizzly)	Option 2 (SWIP & Telsa)
1	NEW MEXI	418,361	449,740	429,150	434,902	433,064	434,836
2	ARIZONA	3,343,013	4,099,897	3,339,797	3,448,842	3,442,690	3,449,932
3	NEVADA	1,324,414	1,071,774	1,144,405	1,169,709	1,253,220	1,238,720
4	WAPA L.C	408,675	472,637	413,720	456,942	460,269	460,022
5	MEXICO-C	867,287	877,234	869,909	859,765	858,486	863,810
6	IMPERIAL	18,564	12,015	15,217	14,397	14,467	14,525
7	SANDIEGO	706,677	555,051	693,202	623,908	611,296	626,787
8	SOCALIF	1,663,429	844,070	1,496,304	1,251,285	1,230,032	1,219,093
9	LADWP	298,932	152,714	293,961	262,801	252,646	260,177
10	IPP	339,073	341,407	335,472	340,338	336,545	340,352
11	PG AND E	3,507,169	2,290,859	3,242,563	3,412,510	3,259,691	3,276,106
12	NORTHWES	2,185,105	1,969,638	1,829,071	1,906,939	1,965,726	1,948,564
13	B.C.HYDR	552,300	516,578	488,367	463,404	478,381	466,372
14	AQUILA	31,307	33,758	28,994	25,578	27,553	26,265
15	ALBERTA	1,435,783	1,706,559	1,395,736	1,362,184	1,386,106	1,367,620
16	IDAHO	1,577	43	770	86	260	96
18	MPC	42,868	95,824	73,320	42,481	47,476	50,509
19	SIERRA	199,948	234,523	197,037	199,330	204,355	210,972
20	WYO	72,486	120,471	112,282	111,239	112,137	112,340
22	BONZ	65,943	68,644	66,424	63,079	61,519	64,554
23	UT N	122,667	159,945	134,668	142,237	140,751	147,082
24	UT S	354,754	460,559	397,900	397,358	396,933	401,569
25	COL E	574,337	876,624	636,812	635,895	652,272	643,191
26	COL W	193,368	200,404	196,457	200,139	199,771	200,360
28	B HILL	54,891	59,683	52,250	53,121	52,887	52,852
29	LRS	79,220	82,520	82,520	82,520	82,520	82,520
30	JB	233,717	307,200	300,850	304,855	306,444	303,345
32	BDVW	43,887	48,515	47,692	44,559	44,943	44,344
33	CRSOVRCO	118,806	189,264	187,280	183,184	184,086	183,026
	Total	19,258,557	18,298,151	18,502,131	18,493,588	18,496,527	18,489,941

Delta From Run 0	(960,406)	(756,426)	(764,970)	(762,030)	(768,616)
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Alternative 3 – Thermal VOM by Area

Delta from Run 0 (\$000)

Row	Area Name	Run 0 (No Constraints)	Option 1 (Mont & Telsa)	Option 2 (Ut & Tesla)	Option 2 (Ut & Grizzly)	Option 2 (SWIP & Telsa)
1	NEW MEXI	31,380	10,790	16,542	14,704	16,476
2	ARIZONA	756,883	(3,216)	105,828	99,677	106,919
3	NEVADA	(252,640)	(180,009)	(154,705)	(71,194)	(85,694)
4	WAPA L.C	63,962	5,045	48,267	51,595	51,347
5	MEXICO-C	9,947	2,622	(7,522)	(8,801)	(3,477)
6	IMPERIAL	(6,549)	(3,347)	(4,167)	(4,098)	(4,039)
7	SANDIEGO	(151,625)	(13,475)	(82,769)	(95,381)	(79,890)
8	SOCALIF	(819,359)	(167,125)	(412,144)	(433,397)	(444,336)
9	LADWP	(146,218)	(4,971)	(36,131)	(46,286)	(38,755)
10	IPP	2,334	(3,601)	1,266	(2,528)	1,280
11	PG AND E	(1,216,310)	(264,606)	(94,660)	(247,478)	(231,063)
12	NORTHWES	(215,467)	(356,034)	(278,167)	(219,379)	(236,541)
13	B.C.HYDR	(35,722)	(63,933)	(88,896)	(73,919)	(85,929)
14	AQUILA	2,451	(2,313)	(5,729)	(3,754)	(5,042)
15	ALBERTA	270,777	(40,047)	(73,598)	(49,677)	(68,162)
16	IDAHO	(1,534)	(807)	(1,491)	(1,317)	(1,481)
18	MPC	52,956	30,452	(388)	4,608	7,640
19	SIERRA	34,575	(2,911)	(617)	4,408	11,025
20	WYO	47,985	39,796	38,753	39,651	39,854
22	BONZ	2,701	481	(2,864)	(4,424)	(1,388)
23	UT N	37,278	12,001	19,569	18,084	24,414
24	UT S	105,805	43,146	42,603	42,178	46,814
25	COL E	302,287	62,474	61,558	77,935	68,854
26	COL W	7,036	3,089	6,771	6,403	6,992
28	B HILL	4,792	(2,641)	(1,769)	(2,004)	(2,039)
29	LRS	3,301	3,301	3,301	3,301	3,301
30	JB	73,484	67,133	71,139	72,727	69,628
32	BDVW	4,628	3,805	672	1,056	457
33	CRSOVRCO	70,458	68,474	64,378	65,280	64,220
	Total	(960,406)	(756,426)	(764,970)	(762,030)	(768,616)

Alternative 3 – Top Binding Interfaces

“yellow” highlights indicate a change was made to the interface from run 0

Row	Interface	Opp. Cost (\$) % Binding		Mont & Tesla		Ut & Telsa		Ut & Grizzly		SWIP & Telsa	
		Run 0		Option 1		Option 2- Run 1		Option 2- Run 2		Option 2- Run 3	
1	Black Hills to C Wyoming	285,045	100%	-	0%	-	0%	-	0%	-	0%
2	BRIDGER WEST	242,204	82%	38,040	21%	5,504	5%	2,548	3%	12,527	10%
3	WEST OF BROADVIEW	191,239	61%	32,177	12%	33,506	14%	27,566	12%	38,265	15%
4	TOT 2C	169,697	48%	83,275	39%	17,382	11%	35,205	22%	34,740	17%
5	MONTANA - NORTHWEST	156,383	70%	16,293	14%	59,654	43%	89,600	44%	59,778	37%
6	TOT 3	143,238	52%	5,293	5%	4,031	5%	5,712	6%	2,790	4%
7	IPP DC LINE	73,415	90%	29,858	68%	31,831	71%	38,159	71%	32,918	70%
8	WOR - PV to Devers	72,028	39%	44,017	40%	30,120	20%	33,353	22%	27,104	20%
9	ALBERTA - BRITISH COLUMBIA	56,387	68%	38,501	60%	42,309	69%	45,815	66%	43,816	70%
10	BONANZA WEST	51,911	32%	37,502	21%	24,555	14%	26,237	14%	4,698	3%
11	North of Miguel	50,580	56%	42,428	61%	32,918	54%	33,527	54%	33,273	53%
12	WOR -n- El Dor to Lugo	48,561	55%	32,741	45%	730	4%	1,625	7%	804	6%
13	TOT 2B2	32,770	24%	19,267	14%	13,694	9%	19,752	13%	14,283	11%
14	SOUTHERN NEW MEXICO (NM1)	28,580	43%	28,793	38%	23,321	33%	23,870	34%	23,536	33%
15	West of Naughton (E-S&W)	28,326	11%	-	0%	41	0%	489	0%	-	0%
16	TOT 1A	22,764	19%	26,661	18%	2,209	3%	2,830	4%	387	1%
17	PAVANT, INTRMTN - GONDER 230 KV	18,122	9%	796	1%	144	0%	78	0%	3,620	3%
18	SOUTHWEST OF FOUR CORNERS	16,525	7%	6,873	4%	12,236	5%	13,884	6%	13,985	6%
19	COI	14,398	59%	5,023	21%	13	0%	13,918	57%	86	1%
20	NW to Canada, East BC	13,368	8%	8,811	9%	8,943	7%	14,032	9%	9,478	7%
21	SW Wyoming to N Utah	13,141	2%	-	0%	-	0%	-	0%	-	0%
22	Combined PACI & PDCI	12,931	19%	8,414	10%	124	0%	14,651	21%	324	0%
23	TOT 2A	10,150	8%	7,898	18%	5,108	3%	5,602	4%	5,195	3%
24	PATH C	9,481	7%	5,213	5%	228	1%	4,094	6%	2,459	2%
25	IDAHO - MONTANA	6,464	2%	1,626	1%	117,830	29%	58,650	18%	127,709	35%
26	N to S Utah	6,337	3%	889	2%	-	0%	-	0%	4,511	5%
27	Southern CA Imports	6,167	39%	10,828	77%	4,644	48%	3,364	40%	3,864	43%
28	TOT 7	5,302	4%	-	0%	-	0%	-	0%	12	0%
29	Montana - Southeast	4,659	9%	13,272	11%	1,385	1%	1,653	1%	1,376	1%
30	IDAHO - NORTHWEST	4,483	2%	3,950	3%	-	0%	-	0%	-	0%
31	PACIFIC DC INTERTIE (PDCI)	4,266	18%	3,768	14%	15,796	36%	5,755	18%	16,014	8%
32	Combined 4a, 4b	4,196	6%	864	0%	-	0%	-	0%	-	0%
33	NORTHERN - SOUTHERN CALIFORN	4,022	22%	4,342	16%	1,902	14%	1,371	8%	507	5%
34	Idaho to California	N/A	N/A	77,939	56%	150,775	67%	N/A	N/A	107,514	61%
35	Idaho to LV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	31,927	26%
36	Colstrip South	N/A	N/A	N/A	N/A	1,858	2%	2,400	2%	2,655	2%

Deliverable: 3-5 commercially viable alternatives

- **Pull together commercial parties**
- **Technically feasible**
- **Maintain or increase reliability/security and price stability**
- **Add flexibility and robustness to network to facilitate competitive wholesale markets**
- **Cost-effective; benefits are commensurate with risks**
- **High probability of cost recovery; investment community is likely to look favorably upon**
- **Likely to pass muster with state regulatory bodies**
- **Likely to pass muster with FERC**

Next Steps- Phase 1 (RMATS)

