

CDEAC Scenarios: Transmission Modeling and Economic Analysis

Western Interstate Energy Board
Presented by Peter Krzykos
For SWAT Meeting
Albuquerque, New Mexico
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Outline of Presentation

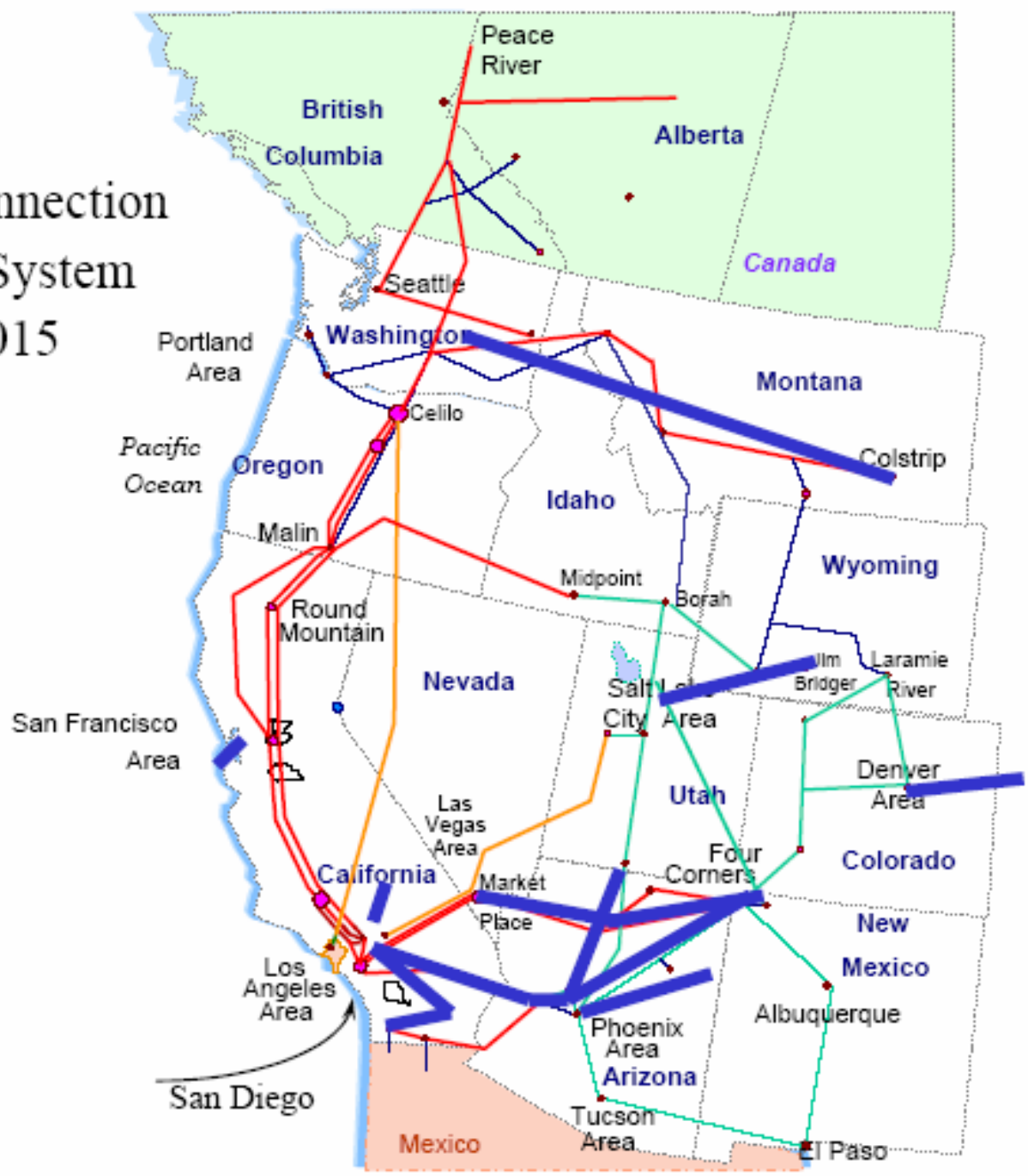
1. Update: Transmission Additions for CDEAC Scenarios
2. Economic Screening Analysis – Compare costs of CDEAC scenarios
 - Production costs
 - Generation capital costs
 - Transmission capital costs

Transmission Additions

- SSG-WI Reference Case
- CDEAC Scenarios
 - New/CDEAC Reference Case
 - High Efficiency Case
 - High Renewables Case
 - High Coal Case

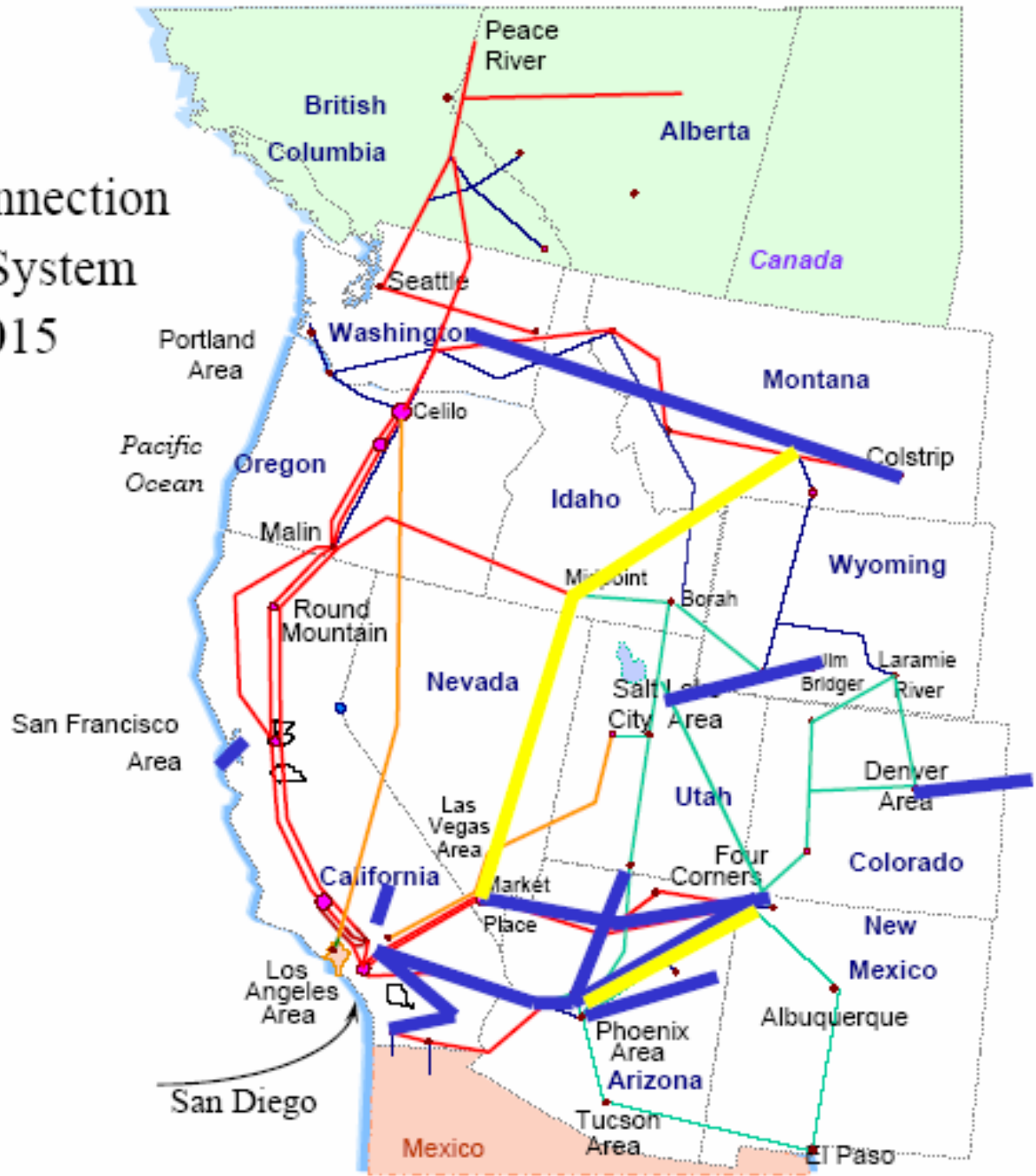
Western Interconnection Transmission System SSG-WI 2015


Added Transmission-
SSG-WI Reference Case



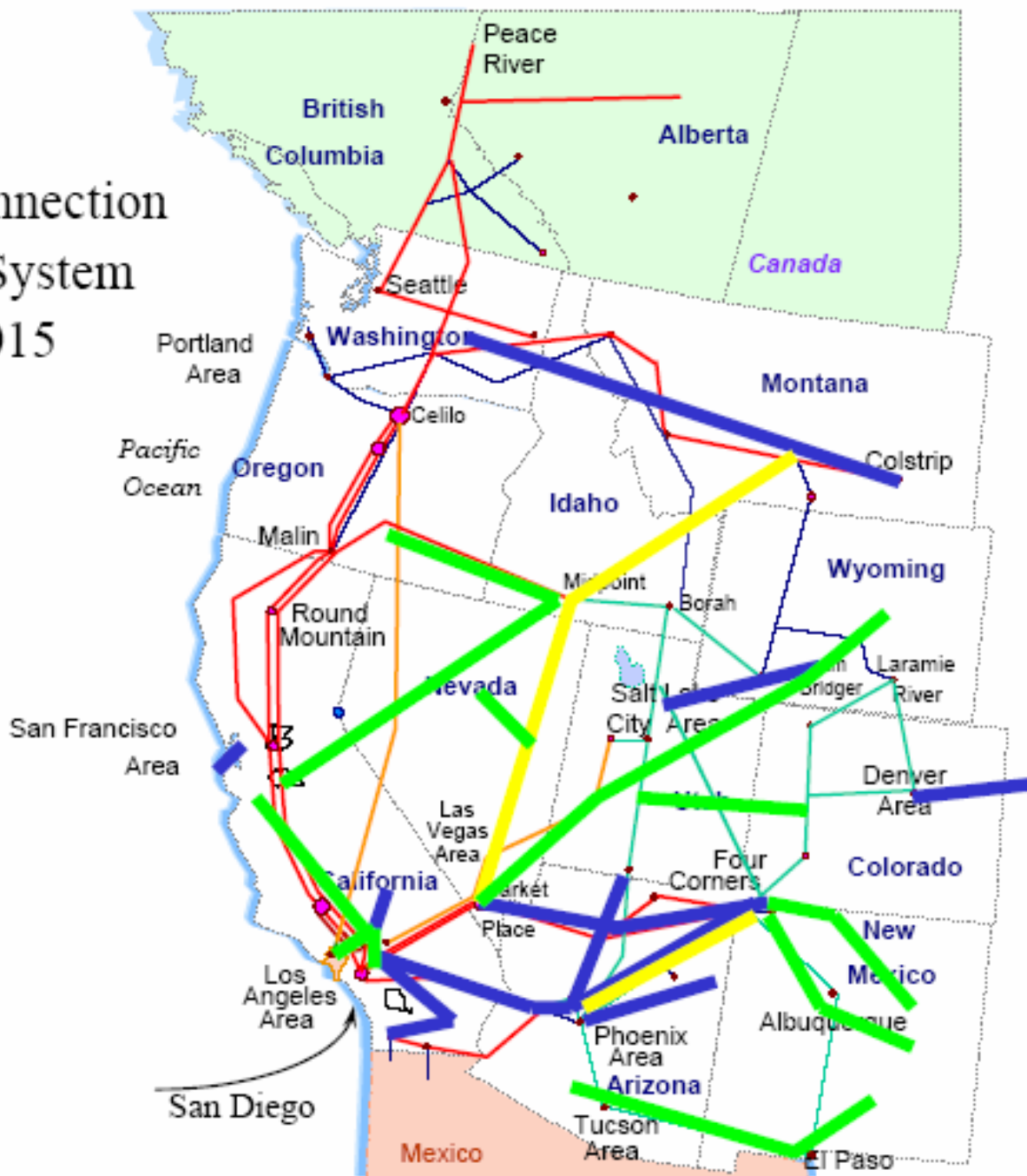
Western Interconnection Transmission System CDEAC 2015

- Added Transmission-
SSGWI Reference
- Added Transmission-
CDEAC Reference



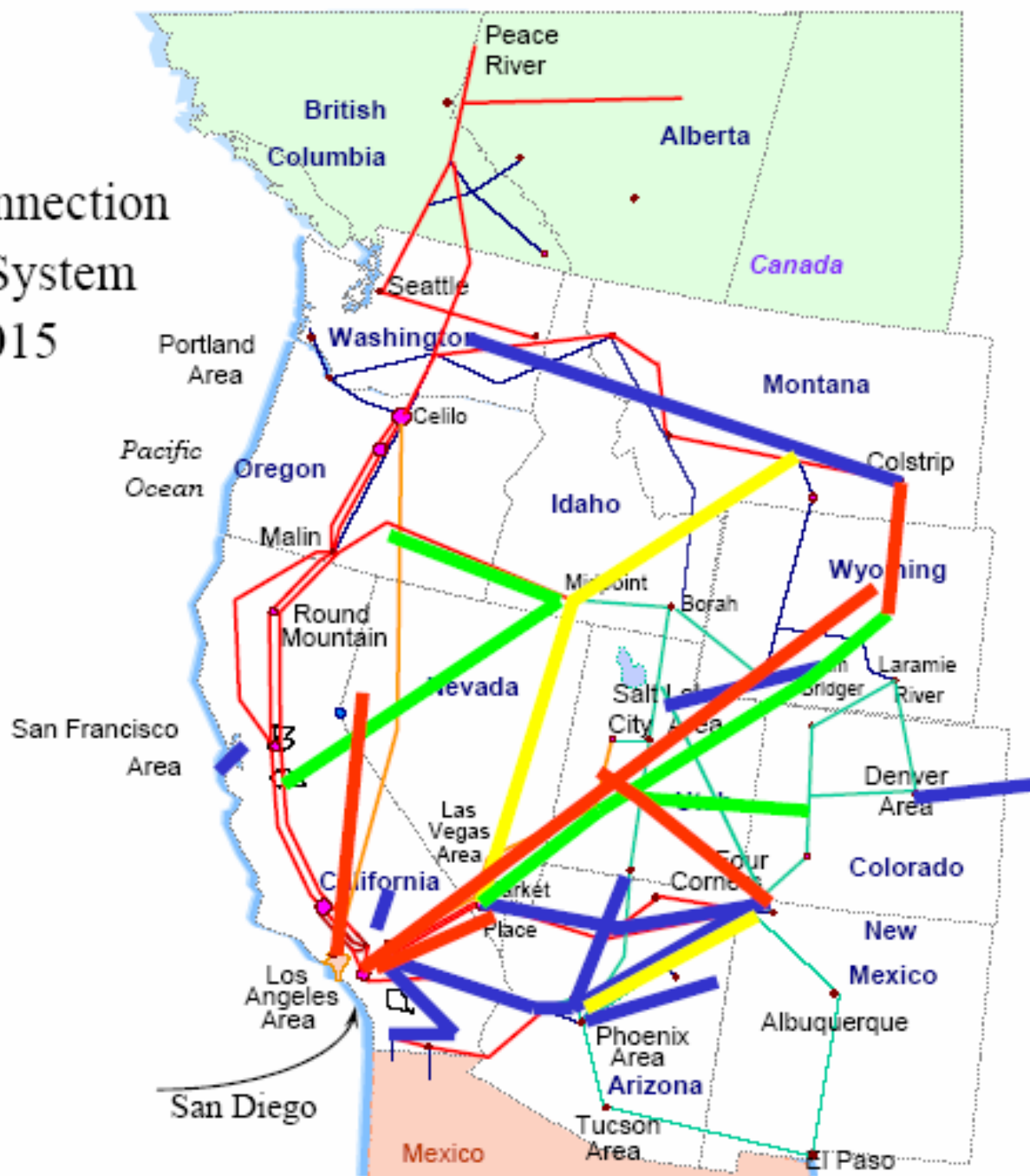
Western Interconnection Transmission System CDEAC 2015

- Added Transmission-
SSGWI Reference
- Added Transmission-
CDEAC Reference
- Added Transmission-
CDEAC High
Renewable



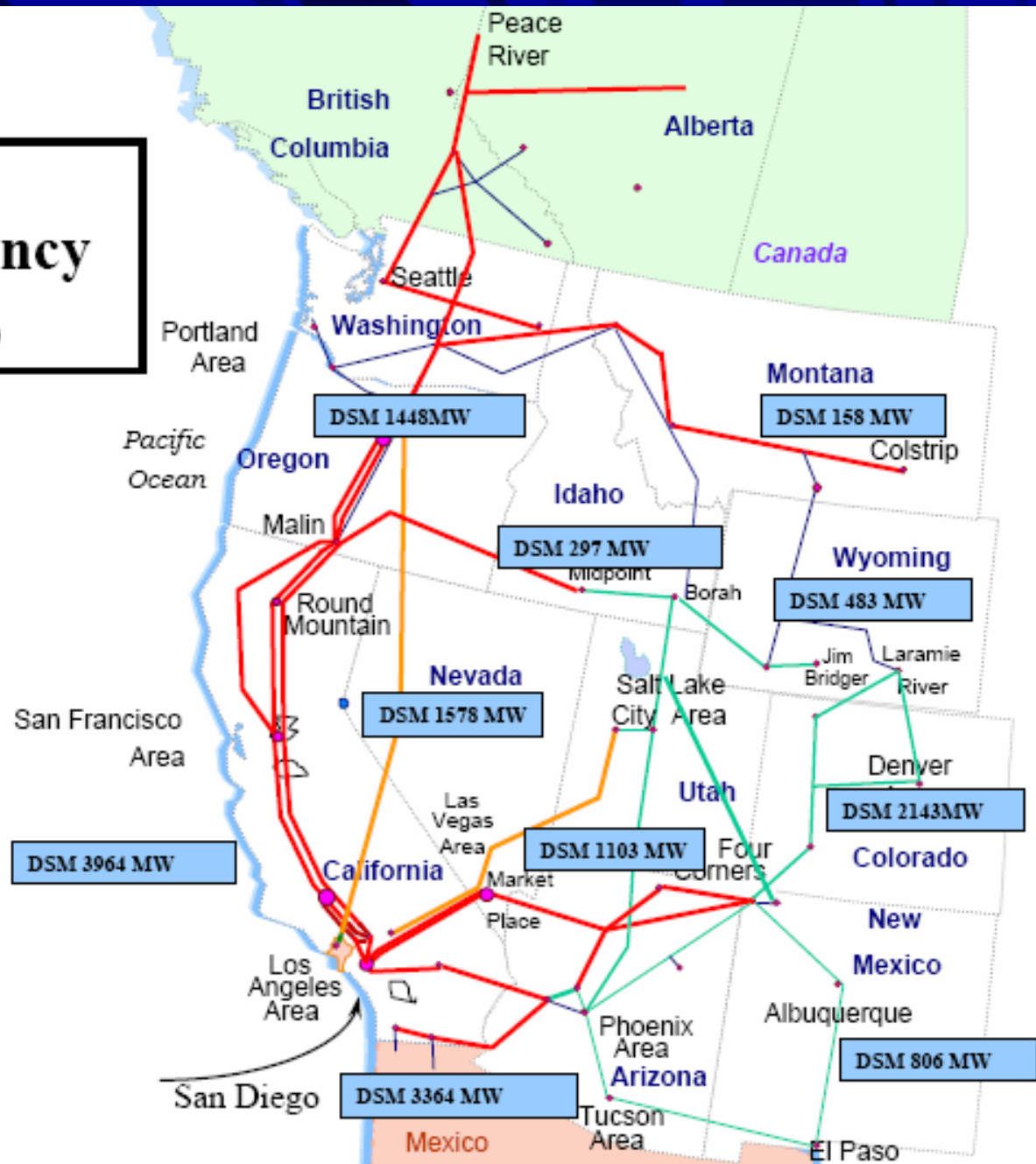
Western Interconnection Transmission System CDEAC 2015

- Added Transmission-SSGWI Reference
- Added Transmission-CDEAC Reference
- Added Transmission-CDEAC High Renewable
- Added Transmission-CDEAC High Fossil



CDEAC High Efficiency Scenario

State Incremental
Peak Load Reduction
from DSM/LR (MW)



Transmission Additions & Upgrades for SGG-WI Reference Case

		(million \$)			
	Facility	Line	Line	Equip.	Total
		Miles	Costs	Costs	Cap.Costs
	<u>SSG-WI Reference Case</u>				
	AZ-HM				
R-1	Four Corners-Pinnacle #1 (Phoenix) 500 kV	289	577.0		577.0
R-2	Navajo/Desert Rock; Four Corners-Moenkopi	220	560.0		560.0
R-3	Moenkopi to Market Place	218	436.0		436.0
R-4	Coronado to Silver King line including series comp			20.0	20.0
R-5	Pinal Project	60	204.6	52.6	257.2
R-6	Capacity upgrade at N. Gila			5.2	5.2
	CA				
R-7	Trans Bay Area Project	55	300.0		300.0
R-8	Palo Verde-Devers #2	230			628.0
R-9	Tehachapi Wind transmission -- 2 lines	72			94.0
R-10	West of Devers upgrade				101.0
R-11	San Diego Sunrise Link & Imperial Valley Central 500/230 kV	120			1,400.0
R-12	Imperial Valley Upgrade 500/230 kV	280	249.3	9.9	259.2
R-13	Otay Mesa	70			209.0
	CO				
R-14	Kansas-Colorado added lines to integrate 2-700 MW coal plants	830	747.0	11.5	758.5
	MT-IW				
R-15	Colstrip to Spokane Upgrade (series compensation)				142.0
	WY-UT				
R-16	Bridger-- Wasatch Front TX 345/230 kV	363	409.0		409.0
R-17	Path C Upgrade		65.0		65.0
R-18	Amps Phase Shifter (Mill Creek Phase Shifter)			10.0	10.0
	Total	2,807	3,548.0	109.2	6,231.1

Transmission Additions for CDEAC Scenarios

							(million \$)		
Facility	Ref	High	High	High	Line	Line	Equip.	Total	
	Case	Effic.	Ren	Fossil	Miles	Costs	Costs	Cap.Costs	
<u>New/CDEAC Reference Case</u>									
1 SWP (Midpoint-Rocky Pk-Robinson-Crystal)	X		X	X	462	739.2	73.9	813.1	
2 Broadview-Midpoint 500 kV (Broadview-Towns-Midpoint)	X		X	X	399	638.9	63.9	702.8	
3 Four Corners-Pinnacle #2 500 kV	X		X	X	289	577.0	57.7	634.7	
Subtotal					1,150	1,955.1	195.5	2,150.6	
<u>CDEAC Scenarios</u>									
4 Dave Johnston-Bridger-Mona 500 kV			X	X	462	739.2	73.9	813.1	
5 Mona-Crystal (Marketplace) 500 kV			X	X	319	510.4	51.0	561.4	
6 Midpoint-Grizzly 500 kV			X	X	539	862.4	86.2	948.6	
7 Midpoint-Tesla 500 kV			X	X	550	880.0	88.0	968.0	
8 Grand Junction-Emery 345 kV			X	X	151	242.0	24.2	266.2	
9 Upgrade thermal limits on 5 lines: Shasta-Flanagan; Silver Park-Silver PS; Ft. Chur-Ft. Ch.PS; Cal.Sub-Cal. S. PS; Flanigan-Keswich			X		20	13.0	40.0	53.0	
10 Falcon to Robinson 345 kV added			X		133	213.0	21.3	234.3	
11* NM Wind Export Plan: 4 x 500 kv in NM			X*			1,441.0	300.0	1,741.0	
1 x 500 kV Route 1: ENM-Las Vegas-Taos-Ojo-San Juan-Four Corners					352	352.0			
2 x 500 kV Route 2: ENM-West Mesa-Four Corners					308	616.0			
1 x 500 kV Route 3: ENM-Amrad-Newman-Luna-Hildago-Saguro					473	473.0			
12* Tehachapi Wind -- To Phase 4 of Tehachapi Collaborative Study Group			X*					2,182.0	
Phase 1: Antelope-Pardee, Antelope-Vincent, Antelope-Tehachapi					69				
Phase 2: Antelope-Mesa					60				
Phase 3: Tehachapi-Vincent, SCE & PG&E network upgrades					45				
Phase 4: Tehachapi-PG&E					250				

	Facility	Ref	High	High	High	Line	Line	Equip.	Total
		Case	Effic.	Ren	Fossil	Miles	Costs	Costs	Cap.Costs
13	Dave Johnston-Mira Loma 3000 MW DC line				X	968	1,548.8	154.9	1,703.7
14	Colstrip-Dave Johnston 500 kV				X	218	348.5	34.8	383.3
15	Mona-Huntington-Four Corners 500 kV				X	297	475.2	47.5	522.7
16	Mohave-Lugo upgrade 500 kV				X			12.0	12.0
17	Eldorado-Lugo upgrade 500 kV				X			12.0	12.0
18	Reno to Sylmar 500 kV (Limit PDCI + fossil gen.added at Sylmar to 4330 MW total)				X	399	718.7	71.9	790.6
Totals									
	New/CDEAC Reference Case					3,956	5,503.0	304.7	8,381.7
	CDEAC-High Efficiency					2,807	3,548.0	109.2	6,231.1
	CDEAC-High Renewables + New Reference Case 2015					7,264			16,149.4
	CDEAC-High Coal + New Reference Case 2015					7,860			15,363.4
Changes from the New/CDDEAC Reference Case									
	CDEAC-High Efficiency					-1,150			-2,150.6
	CDEAC-High Renewables					3,307			7,767.7
	CDEAC-High Coal					3,903			6,981.7

2. Economic Screening Analysis – Preliminary Findings

- Three parts to economic analysis:
 1. Production Operating Costs
 2. Incremental Generation Capital Costs
 3. Incremental Transmission Capital Costs
- Sum all 3 parts on annualized basis for comparison of scenarios

Production Costs

	(Billion 2005\$)	
	Total	Diff Ref. Case
Reference Case	14.5	
High Efficiency	12.2	-2.2
High Renew ables	11.6	-2.9
High Coal	12.5	-2.0

Generation Capital Costs

	(Billion 2005\$)			
	Total	Diff Ref. Case	Gen. Added	Gen. Removed
Reference Case	64.0			
High Efficiency	62.3	-1.7	12.1	13.8
High Renew ables	135.7	71.6	92.2	20.5
High Coal	80.9	16.9	21.2	4.3

Transmission Capital Costs

	(Billion 2005\$)	
	Total	Diff. Ref. Case
Reference Case	8.4	
High Efficiency	6.2	-2.2
High Renewables	16.1	7.8
High Coal	15.4	7.0

CDEAC Scenarios: Comparing Costs To Reference Case

(Annualized, Billion 2005\$)				
	Ref. Case	Difference to Ref. Case		
		High Effic.	High Ren.	High Coal
Production Costs	14.5	-2.2	-2.9	-2.0
Generation FC	7.8	-1.6	7.7	0.9
Transmission FC	1.0	-0.3	0.9	0.8
Total	23.3	-4.0	5.7	-0.2

Appendix

- Detailed Tables
 - All Fixed and Variable Costs
 - Generation Capital Costs

Fixed Costs are incremental to 2008 Base Case

2015

Dollars in Millions (2005)		CDEAC Reference Case		High Efficiency Case		High Renewables Case		High Coal Case	
		Initial Investment	Annual Costs	Initial Investment	Annual Costs	Initial Investment	Annual Costs	Initial Investment	Annual Costs
1	Production Costs (Fuel & Other VOM)		14,456		12,243		11,606		12,496
2	Change from Reference Case		-		(2,213)		(2,850)		(1,960)
3									
4	Incremental Resource Costs:								
5	Reference Case Resource Additions¹								
6	Wind	17,602		17,602		17,602		17,602	
7	Gas	13,080		13,080		13,080		13,080	
8	Coal	21,789		21,789		21,789		21,789	
9	Other (Solar, Biomass, etc)	11,575		11,575		11,575		11,575	
9a	Subtotal Reference Case	64,047		64,047		64,047		64,047	
9b									
9c	Scenario Resource Additions¹								
9d	Demand Side Management			12,088					
9e	Biomass					16,771			
9f	Geothermal					9,128			
9g	Solar CSP					13,008			
9h	Solar PV					26,799			
9i	Wind					30,747			
9j	Coal							21,184	
9k	Subtotal Additions			12,088		96,453		21,184	
9l									
9m	Resources Removed from Reference Case								
9n	Coal			9,638		12,193			
9o	Gas			4,186		8,335		4,317	
9p	Subtotal Removals			13,824		20,529		4,317	
9q									
10	Resource Net Investment Total	64,047		62,311		139,971		80,914	
11									
12	Annualized Fixed Cost of Resource Additions								
13	Incremental Capital Charge @ 10%		6,405		6,231		13,997		8,091
14	Incremental Fixed O&M ²		1,393		-		1,929		608
15	Subtotal Annualized Fixed Cost Resource Additions		7,798		6,231		15,926		8,699
16									
17	Incremental Fixed Gas Transportation Costs³		176		176		176		176
18									
19	Incremental Transmission Costs:								
20	Transmission Additions Investment								
21	Line Investment								
22	Customized Equipment Investment								
23	Transmission Investment Sub Total	8,382		6,231		16,149		15,363	
24									
25	Annualized Fixed Cost of Transmission Additions								
26	Incremental Fixed O&M		168		125		323		307
27	Incremental Capital Charge @ 10%		838		623		1,615		1,536
28	Subtotal Fixed Annualized Cost of Transmission Additions		1,006		748		1,938		1,844
29									
30	Total Annualized Fixed Costs (Line 15 + Line 17 + Line 28)		8,979		7,155		18,039		10,718
31	Change from Reference Case				(1,825)		9,060		1,739
32									
33	Total Incremental Investment (Line 10 + Line 23)	72,428		68,542		156,121		96,277	
34									
35	Annual Net (Savings)/Cost from Reference Case (Line 2 + Line 30)				(4,038)		6,211		(221)

Investments for Incremental Resources in CDEAC Scenarios

Scenario	Resource Type	Capacity (MW)	Bucket	Initial Investment			
				\$/kw	Total \$	AFUDC*	Total Investment
HIGH EFFICIENCY Additions							
	DSM	15,344			11,300,000,000	788,367,100	12,088,367,100
Removals							
	Coal	6,050	19	1373	8,306,650,000	1,331,398,169	9,638,048,169
	Gas						
	CCCT+DF	1,486	10	580	861,880,000	136,086,543	997,966,543
	CCCT- Frame F	600	10	580	348,000,000	54,947,460	402,947,460
	CCCT- Frame G	2,663	26	580	1,544,540,000	141,050,482	1,685,590,482
	SCCT	1,550	25	663	1,027,650,000	71,696,058	1,099,346,058
	Total Gas	6,299					4,185,850,542
		12,349					13,823,898,711
HIGH RENEWABLES Additions							
	Biomass	7,139	20	2196	15,677,244,000	1,093,754,282	16,770,998,282
	Geothermal	4,222	21	2021	8,532,662,000	595,298,230	9,127,960,230
	Solar CSP	4,000	27	3040	12,160,000,000	848,366,720	13,008,366,720
	Solar PV	3,240	28	7732	25,051,680,000	1,747,780,559	26,799,460,559
	Wind	25,524	33	1116	28,484,784,000	2,261,748,819	30,746,532,819
		44,125					96,453,318,610
Removals							
	Coal	7,654	19	1373	10,508,942,000	1,684,383,733	12,193,325,733
	Gas						
	CCCT+DF	2,681	10	580	1,554,980,000	245,523,567	1,800,503,567
	CCCT- Frame F	1,114	10	580	646,120,000	102,019,117	748,139,117
	CCCT- Frame G	3,971	26	580	2,303,180,000	210,331,004	2,513,511,004
	SCCT	4,615	25	663	3,059,745,000	213,469,229	3,273,214,229
	Total Gas	12,381					8,335,367,918
		20,035					20,528,693,651

Scenario	Resource Type	Capacity (MW)	Bucket	\$/kw	Total \$	AFUDC*	Total Investment
HIGH COAL Additions							
	Coal -- 15 New Plants	11,300	N/A	N/A	16,935,300,000	2,714,406,819	19,649,706,819
	Coal --Conversions			Differential			
	Desert Rock Power Plant (1	750		947	710,250,000	113,839,580	824,089,580
	Conv.Xcel/Cornerpoint	600		0	-	0	-
	White Pine Project	550		0	-	0	-
	Jim Bridger 5	550		441	242,550,000	38,876,157	281,426,157
	MT Lignite Circle-Colstrip	550		672	369,600,000	59,239,858	428,839,858
						21,184,062,414	
Removals	Gas						
	CCCT+DF	1,330	10	580	771,400,000	121,800,203	893,200,203
	CCCT- Frame F	514	10	580	298,120,000	47,071,657	345,191,657
	CCCT- Frame G	2,561	26	580	1,485,380,000	135,647,872	1,621,027,872
	SCCT	2,055	25	663	1,362,465,000	95,055,096	1,457,520,096
	Total Gas	6,460					4,316,939,828