Northern Tier Transmission Group (NTTG)

Planning Subgroup Meeting

Summary Review of Previous Studies

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March 14, 2007

NORTHERN TIER TRANSMISSION GROUP

Overview

- Why Regional Transmission Studies?
- Types of Regional Transmission Studies?
- Making the Case for Transmission Expansion?

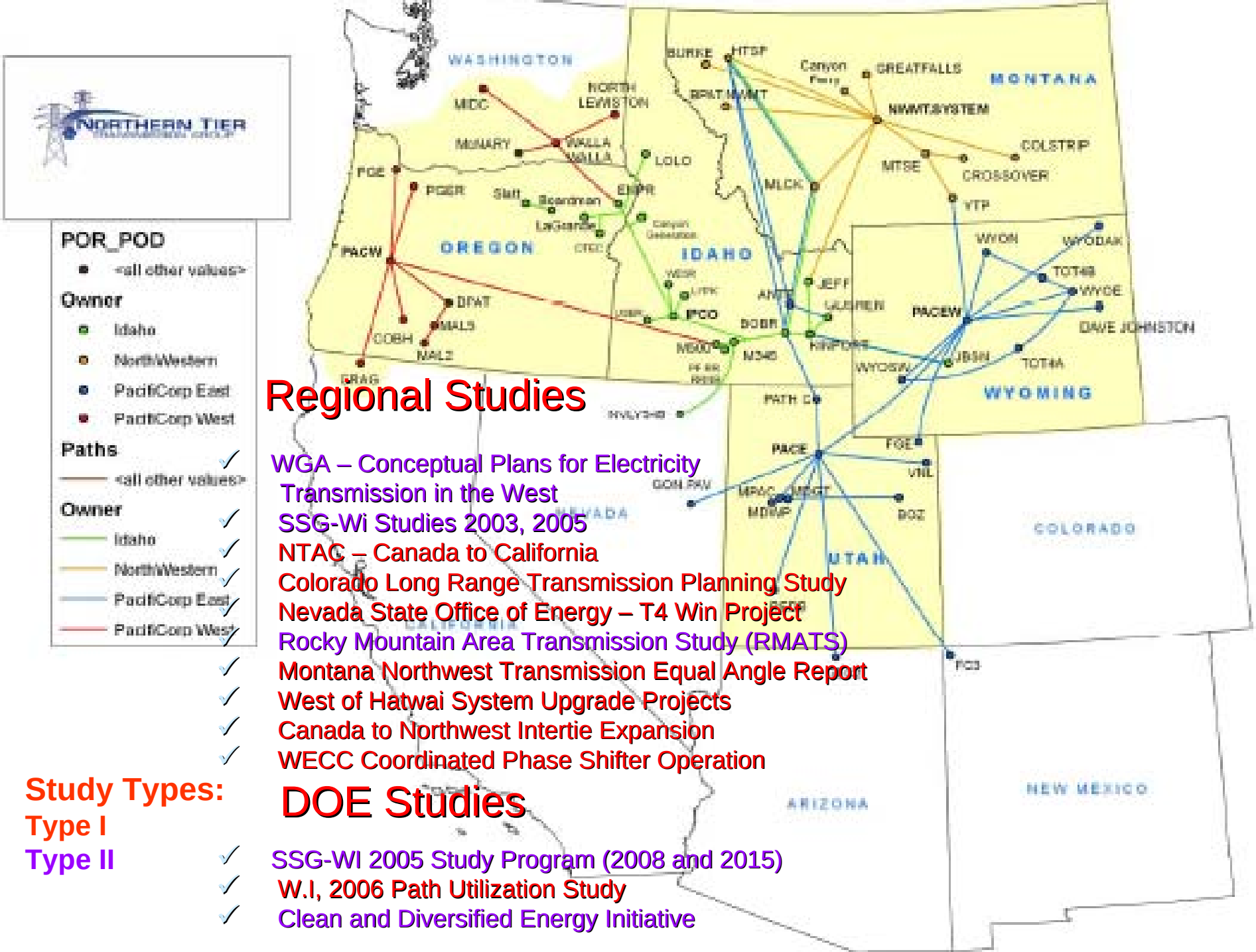
Why Regional Transmission Studies?

- Interconnected System – Western Interconnect
- Synergies (solutions that addresses inter Company, inter State congestions)
- Optimization – Economy of scale

Types of Regional Transmission Studies?

I. Technical (Powerflow, Stability – defining system operating limits)
- Integrate incremental loads & resources to meet reliability standards
- Performs transmission rating analysis (one hour test)

II. Transmission Economic Studies – uses system definition from the Technical studies and adds operating costs to give full prospective on choosing the right investment
- Multi-hour analysis (8760 system dispatch)
- Dispatches based on least cost
- Prioritizing and advocating specific economic expansion projects
- Provides economic data for basis to:
  - Develop or advocate cost allocations
  - Facilitate funding
  - Provide backstop permitting or approval authority



Regional Studies

- ✓ WGA – Conceptual Plans for Electricity Transmission in the West
- ✓ SSG-Wi Studies 2003, 2005
- ✓ NTAC – Canada to California
- ✓ Colorado Long Range Transmission Planning Study
- ✓ Nevada State Office of Energy – T4 Win Project
- ✓ Rocky Mountain Area Transmission Study (RMATS)
- ✓ Montana Northwest Transmission Equal Angle Report
- ✓ West of Hatwai System Upgrade Projects
- ✓ Canada to Northwest Intertie Expansion
- ✓ WECC Coordinated Phase Shifter Operation

Study Types:

Type I

Type II

DOE Studies

- ✓ SSG-WI 2005 Study Program (2008 and 2015)
- ✓ W.I, 2006 Path Utilization Study
- ✓ Clean and Diversified Energy Initiative

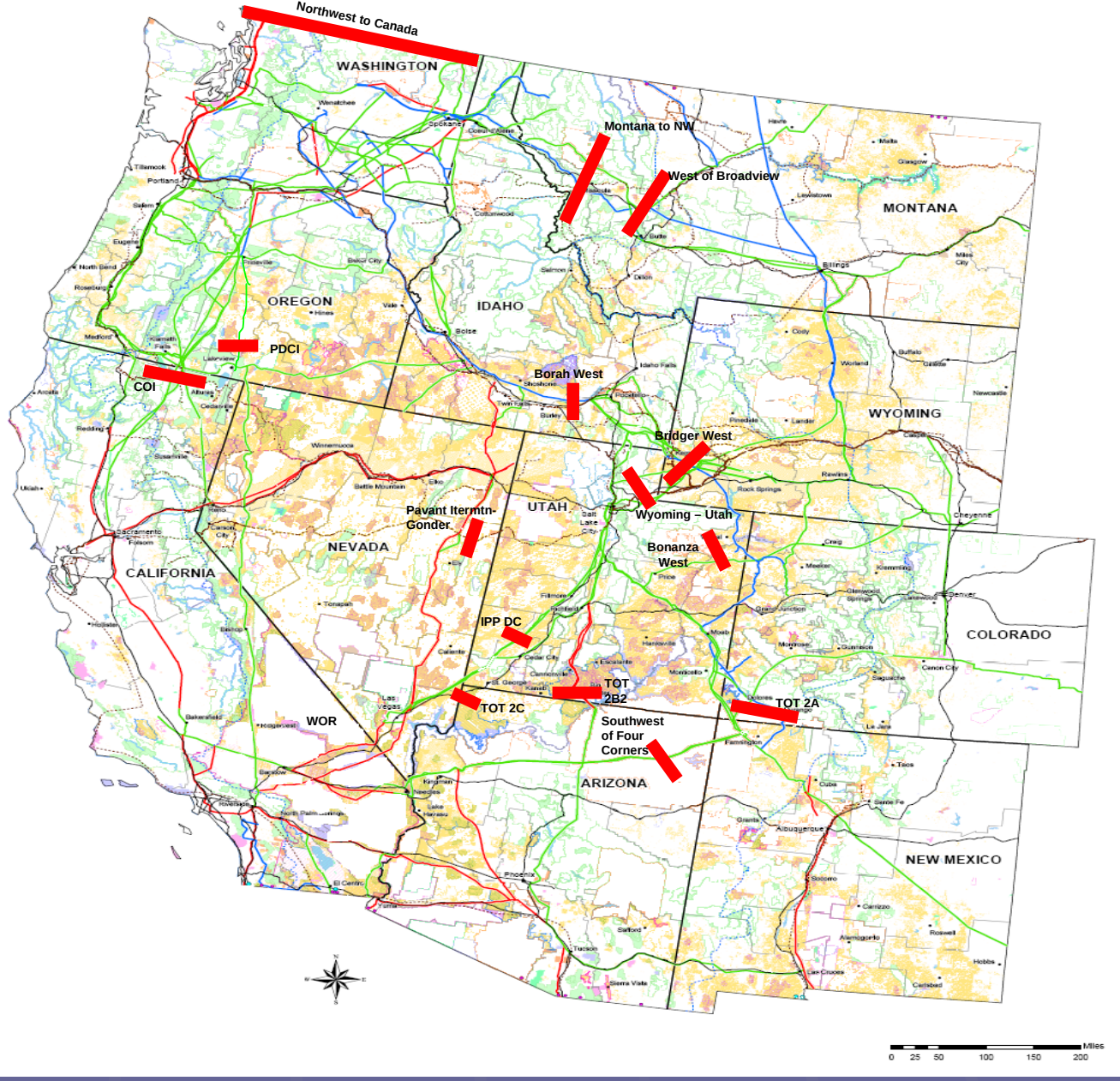
Making the Case for Transmission Expansion?

- Clarify economic interests
  - Serving loads and from where?
  - Who will have power to deliver and to from where?
- Define economic projects
  - What are the constraining elements?
  - Often need wide area perspective to identify communities of interest
- Offer usage rights in return for investment

Top Congested Paths

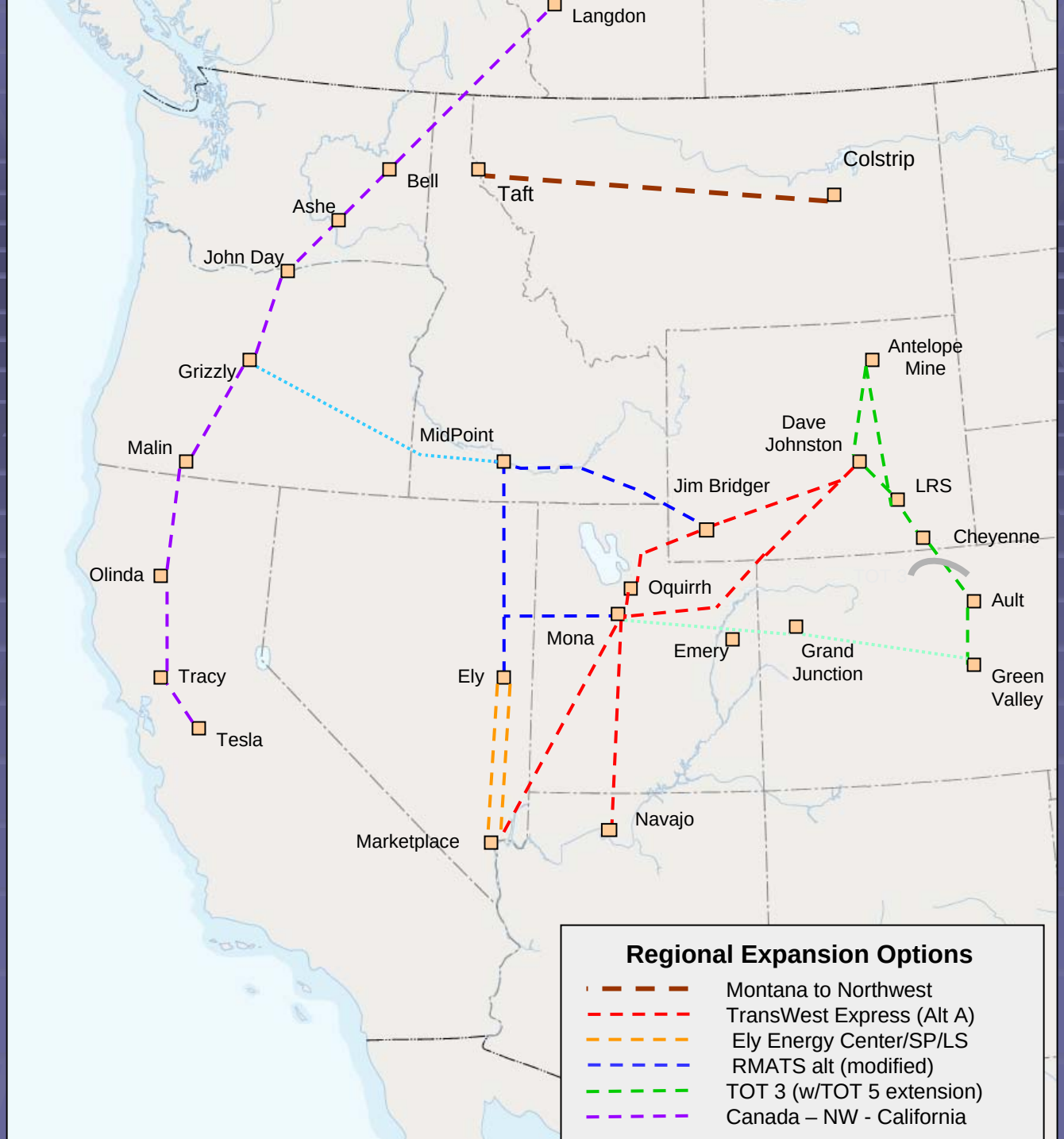
Western Interconnect

Year 2015 -- SSG-Wi Analysis



Why no top-congested paths in California?

- ISO funding mechanism (load share allocation)
- Resources were added by CEC near load growth
- Three lines added into/within S. California


Langdon
Colstrip
Bell
Taft
Ashe
John Day
Antelope Mine
Grizzly
Dave Johnston
MidPoint
Malin
Jim Bridger
LRS
Cheyenne
Olinda
Oquirrh
Ault
Mona
Emery
Grand Junction
Green Valley
Tracy
Ely
Tesla
Navajo
Marketplace
Regional Expansion Options
Montana to Northwest
TransWest Express (Alt A)
Ely Energy Center/SP/LS
RMATS alt (modified)
TOT 3 (w/TOT 5 extension)
Canada – NW - California

Rocky Mountain Area Transmission Study
(RMATS)

September 2004

Purpose

- Utah and Wyoming Governors initiated this study to promote economic development of lower cost coal and wind generation, and to quantify the value of building transmission to serve regional loads and to export generation to other parts of the Western Interconnection.

Method

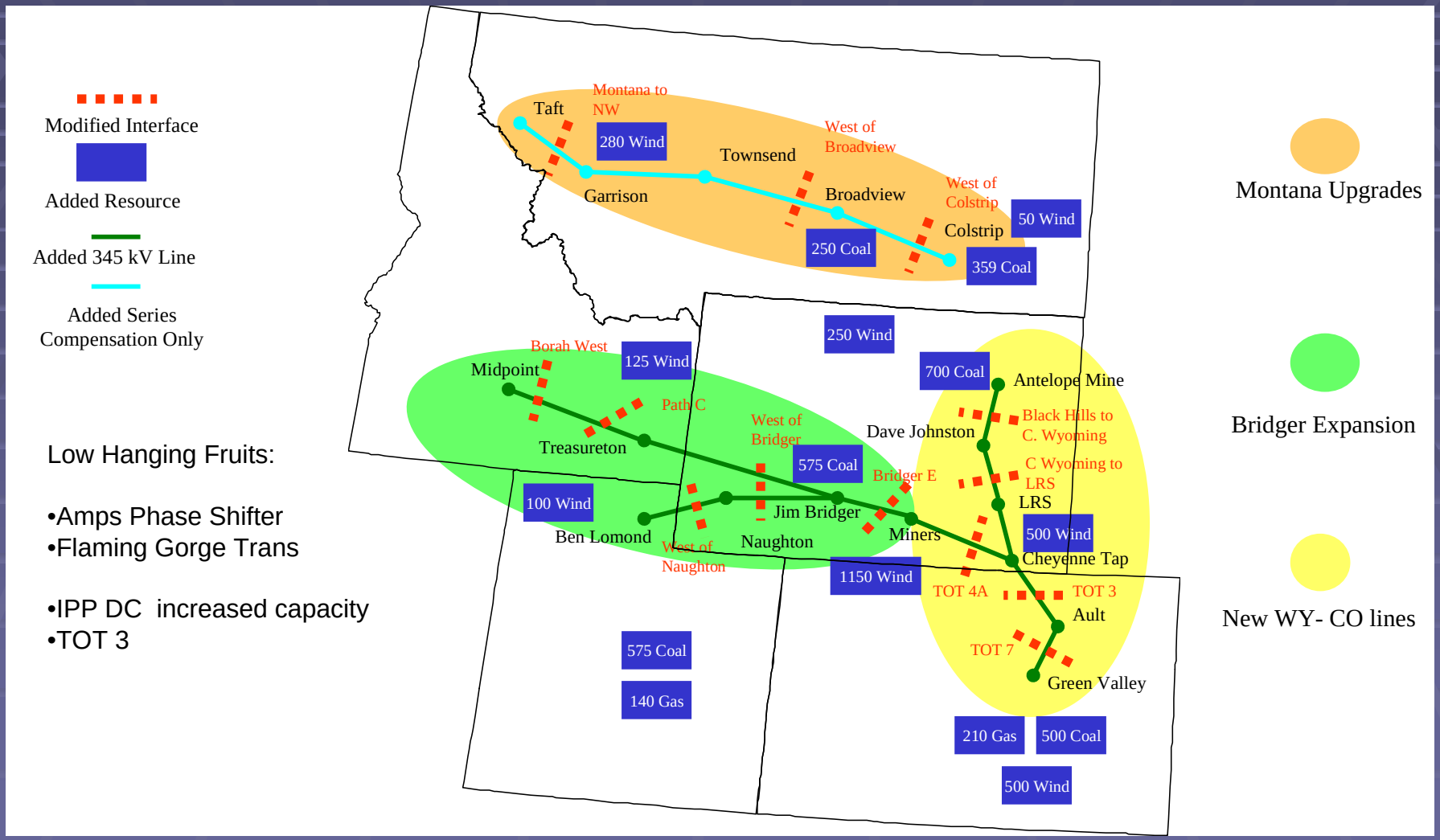
- RMATS was a Stakeholder driven study, determined the economic implications of transmission expansion alternatives for the Rocky Mountain States and for the West.
- RMATS assumed the benefits of a regionally operated system that avoids rate pancaking, consolidates control areas, and removed other institutional impediments to fuller use of the existing system.
  1. evaluated overall economics of transmission expansion under different generation scenarios.
  2. identified transmission projects that may be economic and feasible because of the savings they provide Rocky Mountain region and elsewhere in the West.

Conclusion

- RMATS ran many alternative simulations, which evaluated additional Powder River Basin coal and open range wind generation without additional transmission in the region.

RMATS' Recommendation 1

Serving 3900 MW of Incremental Loads in Rocky Mountain Area, Year 2013



Low Hanging Fruits:

- Amps Phase Shifter
- Flaming Gorge Trans

- IPP DC increased capacity
- TOT 3

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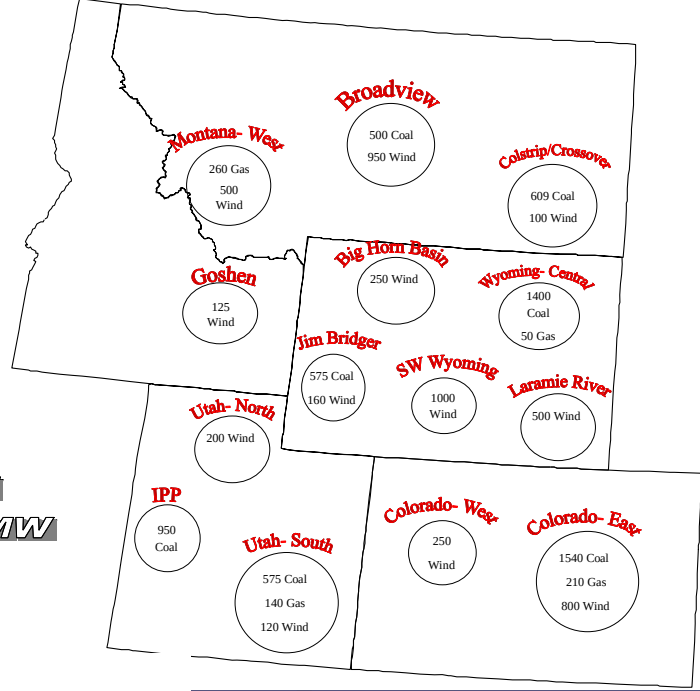
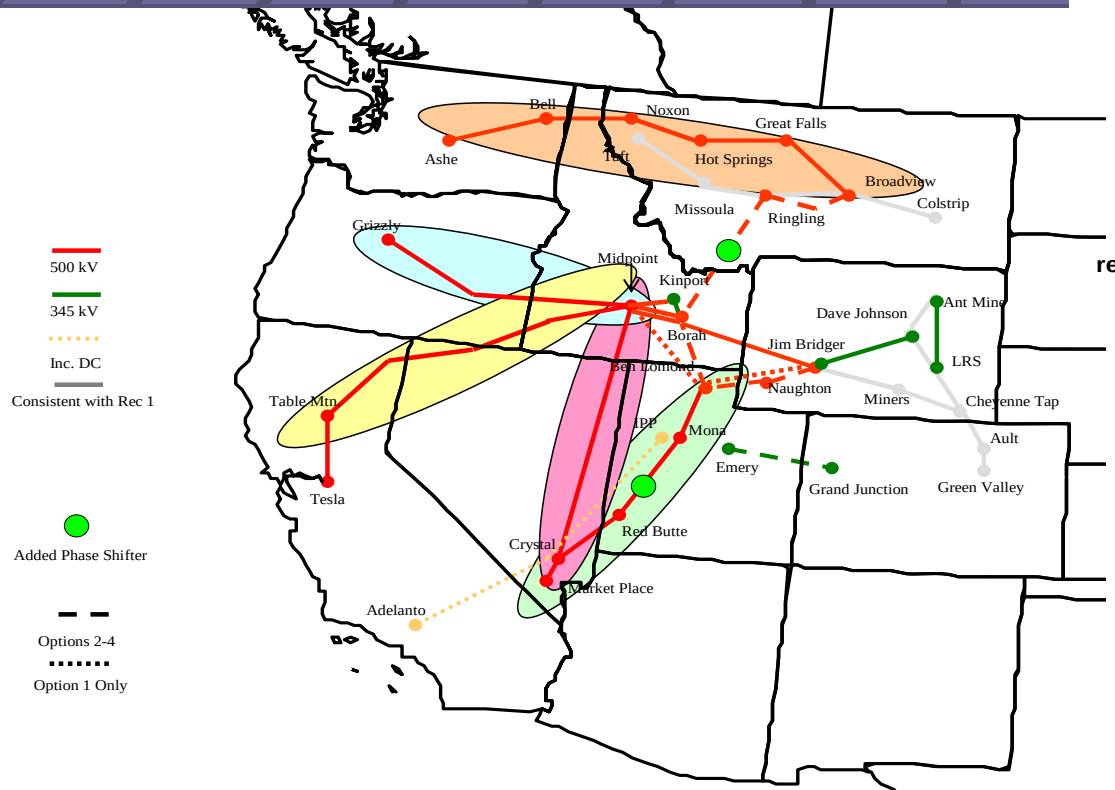
RMATS' Recommendation 2

Serving Area Loads + 3900 MW for Export



Total 7,800 MW



This recommendation requires two 500 kV lines for export

Option 1 +

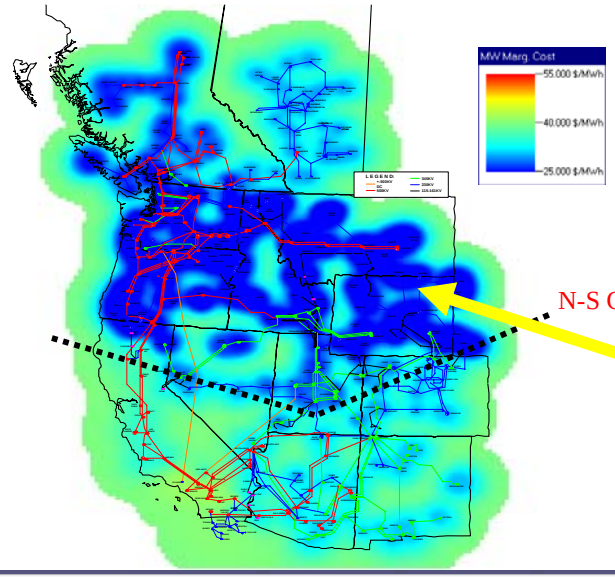
Option 2 +

Option 3 +

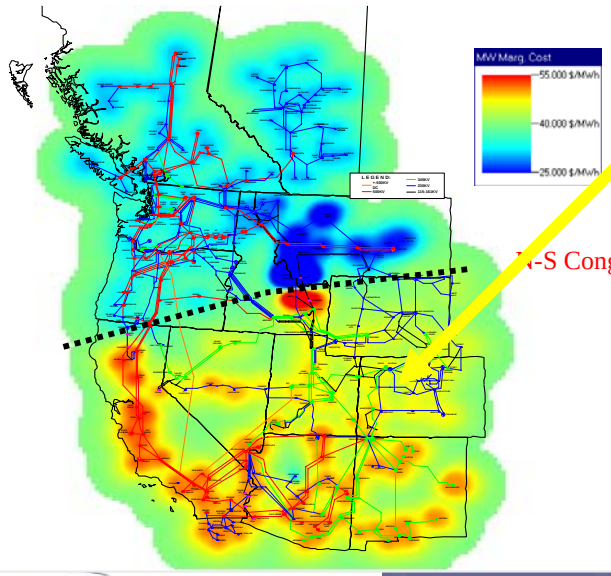
Option 4 +

(RMATS)

June 12, 2008 6:00am
$4 Gas



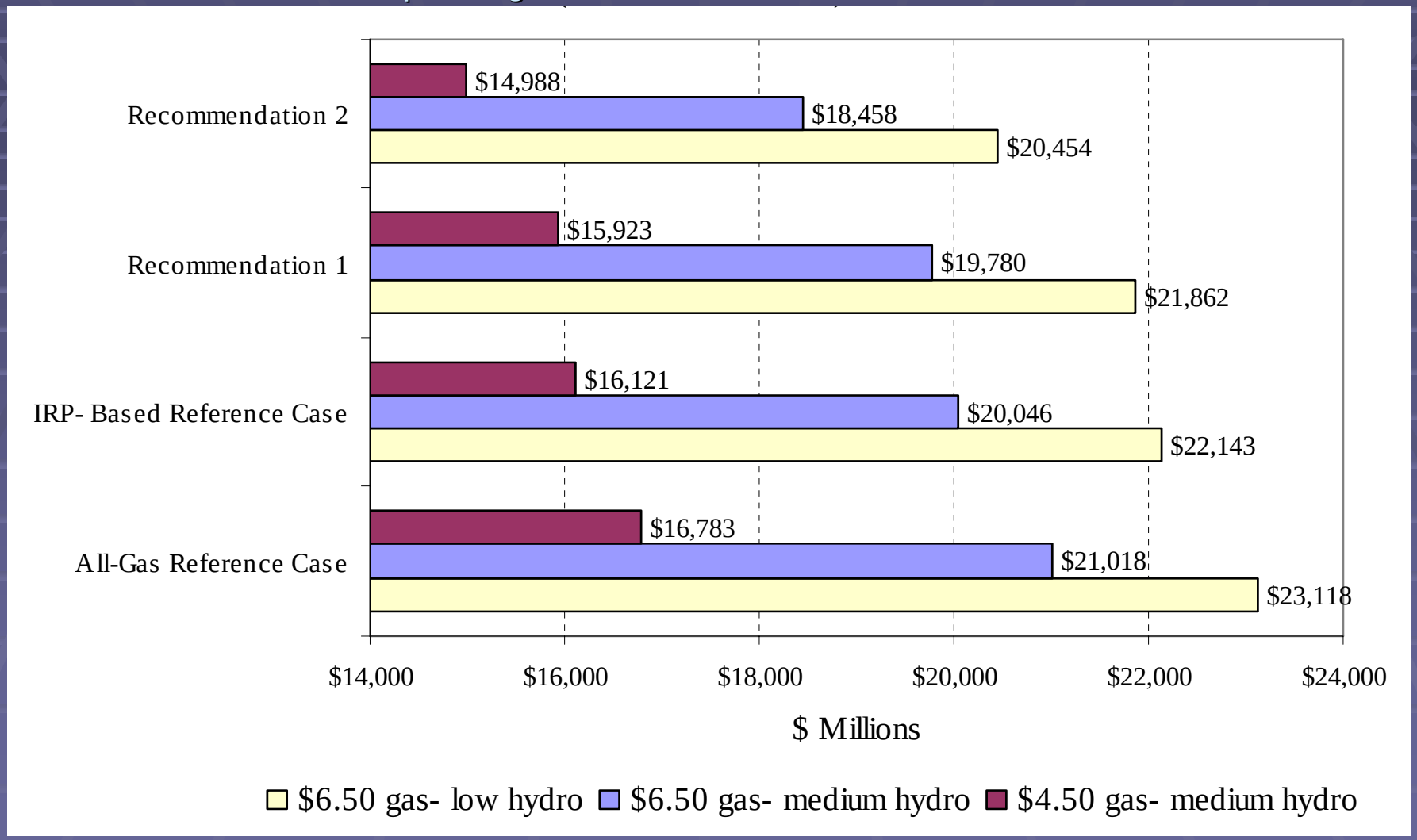
June 12, 2008 3:00pm
$4 Gas



LMPs increase as loads pick up during the day - increasing congestion. This in turn causes gas generation to become the marginal unit in peak hours

Western Interconnection Production Costs

Variable Operating and Maintenance cost in millions of dollars



NORTHERN TIER TRANSMISSION GROUP

Reference
Summary of Studies

WGA

Conceptual Plans for Electricity Transmission in the West
August 2001

Purpose

- Western Governors requested a study to address the need for transmission enhancements in the Western Interconnection.
- The focus of the study was on transmission to support alternative generation futures. *(This effort was the first pro-active, stakeholder-driven study of interconnection-wide transmission needs.)*

Method

- The study used a production cost model (ABB) to evaluate the demand for new transmission under two basic scenarios –
  1. gas-fired generation near load centers
  2. "other-than-gas" scenario that assumed new coal, wind, hydro and geothermal generation located in remote areas
- Transmission was added in each scenario to equalize LMPs.
- The capital cost of transmission additions and interconnection-wide operating costs were estimated for the scenarios.

Conclusion

- The results illustrated bookends of potential transmission needs in the Western Interconnection under widely different generation scenarios.
- The gas-fired generation scenario did not require significant new transmission. At $5.40/mmBTu gas, scenario 2 yielded $5.4 billion (2010$) annual savings
- The study suggested improvements in future modeling analysis.

SSG-WI 2003 Studies

Framework for Expansion of the WI Transmission System

Purpose

- To provides transmission owners, users of the transmission system and state entities, insight into potential areas of transmission congestion, based upon a one-utility least cost use of the regions resources.

Method

- Because of the uncertainty in resource development, the 2013 studies modeled three resource development scenarios, each stressing development of a particular resource type; namely: 1) gas, 2) coal and 3) renewables.
- Studies were run with transmission paths modeled both with and without transfer capability limits to determine how much power would flow on the path if path flow was not limited by path capacity.
- Transmission shadow prices were calculated to give one indication of the west-wide economic benefit of increasing path capacity.
- LMPs were calculated to identify the cost impact on generators and loads of transmission constraints resulting in localized areas of resource surplus and deficit.

Conclusion

- The areas of observed congestion in 2008 were: TOT3, Arizona to California, Alberta to British Columbia, southern New Mexico area and Southern California to Mexico
- In the 2013 case, transmission was added to relieve congestion in all three scenarios between Alberta to BC to the Northwest, between Arizona and California, into San Diego area, into Puget Sound area and between Colorado and Utah.
- Additional integrating transmission was required for both the coal and renewable scenarios. The coal scenario required the most transmission additions, followed by the renewable scenario and then the gas scenario.

NTAC Studies

Canada to California

2006

Purpose

- To provide high-level information on the feasibility of potential transmission projects to transfer a variety of new resources out of Canada into the Northwest and California. *(The study was intended to be modular in nature, i.e. additional options could be developed from the information provided.)* 20 transmission options were studied.

Method

- Proposed AC transmission options were tested at an incremental 1500 MW capacity and verified by powerflow analysis along with estimated construction costs.
- DC options up to 3000 MW were evaluated economically.
- The analysis included proposing routes, verifying transfer capability and developing cost estimates for each option.
- All options were compared using delivered cost of energy.

Conclusion

- There are many congested paths in the West. This study group used its judgment to identify congested paths and upgrades to relieve that congestion so that new remote resources could get to the load.

Colorado Long Range Transmission Planning Study

April 27, 2004

Purpose

- To identify transmission needs for a 10-year horizon (2004 through 2014) integrating resources identified from the PSCo Least Cost Resource Plan Request for Proposals and other queued resource requests for the sub-regional utilities in the Wyoming/Colorado area.

Method

- Studies were reliability-based analysis (powerflow and stability). Modeled three separate resource scenarios and associated transmission additions and tested against the load projections of 2700 MW by 2014. Resource scenarios included:
  1. Heavy additions in NE Colorado
  2. Heavy additions in SE Colorado
  3. Balanced additions between NE and SE Colorado

Conclusion

- Transmission additions for scenarios 1 and 2 included:
  1. New transmission between Ft. Morgan, Colorado and Ft. Lupton/NE Denver metro area
  2. New transmission between Lamar, Colorado and Limon/Colorado Spring/SE Denver metro area

Nevada State Office of Energy

May 10, 2005

Purpose

- Study objective was to complete an integrated assessment of the wind energy potential in Nevada and southern Idaho.
- Evaluate transmission alternatives to support wind energy development in Nevada, Idaho and neighboring states.

Method

- Transmission planners from SPPC and NPC studied the interconnection of wind generation from proposed sites assuming specific upgrades to the system. This analysis included load flow contingency analysis, stability studies, and fault duty analyses.
- The assessment of Nevada wind resources was based on DOE/NREL Wind Power map of Nevada and collaboration with the Desert Research Institute.
- Idaho wind resources were analyzed by the Idaho Energy Division using the True Wind/Northwest Sustainable Energy for Economic Development (NWSEED) wind map.

Conclusion

- Congestion is implicit in the analysis since wind energy generation could not be delivered by the current electrical system.

Montana - Northwest Transmission Equal Angle Study

October 12, 2005

Purpose

- The purpose of the study was to determine infrastructure upgrades and associated costs for an approximate increase of 750 MW firm capacity between eastern Montana and western Washington/Oregon.
- The study was initiated under the Northwest Transmission Assessment Committee for the purpose of providing potential resource developers and buyers with initial capacity gains and expected costing information for an upgrade of the transmission system capacity.

Method

- The method used in the study to measure the effect of the system additions was to keep the existing power angle the same after the addition of new generation.

Conclusion

- The firm capacity between Montana and the Pacific Northwest is essentially already committed to firm contract rights holders. If new resources are to receive firm transmission, additional capacity will be needed.
- Increase transfer capacity between Montana and the Pacific Northwest coast, net 750 MW capacity across West of Broadview, West of Garrison, West of Hatwai, North Cross Cascades and South Cross Cascades paths.
- The new facilities are primarily series capacitor upgrades and some new 230 kV and 500 kV line work in Washington and Oregon.

West of Hatwai System Upgrade Study

February 28, 2005

Purpose

- The purpose of the study was to evaluate transmission constraints and justify upgrades to allow for increased flow from Eastern British Columbia, and Eastern Washington
- Increased capacity is also needed to allow for additional load service to Eastern Washington.

  In 2001 several major industrial loads shut down creating a net loss of approximately 1000 MW of net firm transfer capacity across the West of Hatwai cutplane under some operating conditions.
- The Bonneville Power Administration and Avista Utilities initiated the study at the request of affected regional wholesale customers .

Method

- Load flow, Reactive Margin, and Stability Studies were used to assess the capacity increase under the NERC and WECC reliability criteria.

Conclusion

- Insufficient firm transfer capacity due to multiple limiting outages under varying operating conditions. The limiting performance criteria would be system instability and thermal overloads.
- Solution - increase the West of Hatwai east to west transfer limit to 4277 MW from 2800 MW .

Northwest Intertie Expansion Study

(in progress)

Purpose

- BC Transmission has initiated this study to estimate the trade and economic impacts of a range of transmission expansion levels and transmission paths.
- To determine, among three possible routing options, the most suitable, economic and strategic transmission corridor for capacity expansion between British Columbia and Washington State to facilitate electricity trade and resource sharing throughout the Pacific Northwest region.

Method

- Transmission usage levels are forecast on each critical transmission path within BC Transmission's service region and a variety of future regional resource and load forecast scenarios have been modeled.
- The magnitude of the problem will be measured by the economic cost of restricted electricity trade flows that impact upon BCTC's service region.
- Economic electricity trade flows will be modeled according to present trade strategies using high-load-hour and low-low-hour price differentials and seasonal price differentials at the Mid-Columbia and California-Oregon Border trading hubs.
- Congestion will be measured by the difference between "ideal" and actual economic trade flows.

Conclusion

- Pending.

WECC Coordinated Phase Shifter Operation Study

2001 to 2005

Purpose

- Purpose of the study was to review and summarize operating experience with the coordinated phase shifter operation under the Unscheduled Flow (USF) program, for use in identifying constraints areas within the Western Interconnection.

The USF program for coordinated operation of phase shifters was initiated 11 years ago as a means to control unscheduled flow within the western interconnected system.

Method

- Analyze Hours for which coordinated operation of phase shifters was called upon to relieve overloads due to unscheduled flow.
- Report the number of hours when schedule curtailments were required to relieve overloads because phase shifters were no longer effective in reducing path flows below path limits.

Conclusion

- Paths must qualify to participate in the program, based upon the number of curtailment hours experienced. Those paths that are currently qualified are:
  - Path 15 - Midway - Los Banos (California)
  - Path 20 - Path C (Idaho to Utah)
  - Path 21 - AZ to California
  - Path 22 - SW of 4 Corners (NE Arizona)
  - Path 23 - 4 Corners Transformer (NE Arizona)
  - Path 30 - TOT 1A (Colorado to Utah)
  - Path 31 - TOT 2A (Colorado to New Mexico)
  - Path 36 - TOT 3 (Wyoming to Colorado)
  - Path 66 - COI (NW to California) .

SSG-WI 2005 Studies

February, 2006

Purpose

- The planning program was intended to accomplish two goals:
  1. To update and expand a Western Interconnection-wide generating resource, transmission, load and fuel price database, using public ally available information.
  2. To establish a reference case to be used as a basis for comparing the economics of scenarios.

Method

- The study program updated the database using the ABB GridView production cost model that measures the level and cost of projected congestion, indicated by hourly LMPs, line loadings, and shadow prices *(the reduction in production cost associated with relaxing a constraint by 1 MW).*
- Developed the 2015 IRP-RPS Reference case which was designed to be a benchmark study, it also took into account the capital carrying cost associated with the new generation resources and new transmission facilities forecasted to be put in service between the 2008 Base Case year and the 2015 study year.

Conclusion

- No specific projects were identified in the SSG-WI 2005 study program.
- The database and cases were developed to be used:
  1. As baseline to study future scenarios at the regional and sub-regional levels
  2. To evaluate specific project proposals

SSG-WI 2005 Studies

Congestion

- The study viewed congestion in two ways:
  1. Physically-identified congestion, which was revealed by observing path flow results in the study as compared to historical path flows,
  2. Congestion costs. Participants decided to use two methods for determining congestion cost in order to isolate the most congested paths in the West. The group tested the sensitivity of congestion cost rankings to changes in natural gas prices.

- **Method I:** Method I ranks the paths based on congestion cost. The congestion cost for each congested path is defined as the hourly shadow price for each congested hour multiplied by the flow on the path for that hour, with the results summed for the year. The shadow price is the production cost decrease if 1 MW limit of the constraint is relaxed.
- **Method II:** Method II ranks the paths based on the Annual Average Shadow Price alone.

SSG-WI 2005 Studies

- **Method I:** Method I ranks the paths based on congestion cost. The congestion cost for each congested path is defined as the hourly shadow price for each congested hour multiplied by the flow on the path for that hour, with the results summed for the year. The shadow price is the production cost decrease if 1 MW limit of the constraint is relaxed.
- **Method II:** Method II ranks the paths based on the Annual Average Shadow Price alone.

Interface Name	Method I (Shadow Price X MW Flow) ($000)			Rank			Method II Shadow Price ($/MW) (Annual Average)			Rank		
	$5G	$7G	$9G	$5G	$7G	$9G	$5G	$7G	$9G	$5G	$7G	$9G
ALBERTA - BRITISH COLUMBIA	34 199	52,048	39,270	10	11	10	5.57	8.49	11.29	7	7	7
BONANZA WEST	128 592	193,862	250,621	3	3	3	18.93	28.19	37.90	1	1	1
BORAH WEST	32 490	53,503	79,154	11	10	8	1.43	2.39	3.53	18	16	14
BRIDGER WEST	36 955	55,449	73,984	9	9	9	1.93	2.93	3.84	16	12	12
BROWNLEE EAST	847	950	1,041	29	30	29	0.05	0.06	0.06	30	30	29
COI	90 005	77,532	30,446	5	0	11	2.25	1.00	1.66	12	19	21
HA-Red Butte PS	5 030	5,865	9,252	19	20	20	2.04	2.61	3.52	13	14	15
Hassayampa - N. Gila	4 988	3,371	812	20	25	30	0.45	0.20	0.05	25	28	30
IDAHO - SIERRA	1 976	4,049	6,136	25	23	22	0.62	1.28	1.95	22	21	19
IPP DC LINE	117 109	172,445	227,726	4	4	4	6.86	10.25	13.54	5	6	6
MONTANA - NORTHWEST	209 839	334,400	491,453	2	2	2	8.22	12.94	19.02	4	4	4
NORTHWEST - CANADA	1 060	1,525	2,224	28	29	28	0.06	0.09	0.13	29	29	28
NW to Canada Cost 60	7 110	9,461	12,600	17	17	19	1.90	2.69	3.59	15	10	10
PACIFIC DC INTERTIE (PDCI)	86 728	103,170	117,582	6	6	3	3.47	4.21	4.79	10	10	11
PACIFICORP PG&E 115 KV INTERCOB.	2 016	1,867	1,788	24	27	28	2.68	2.53	2.44	11	15	18
Path 45	3 914	5,725	5,905	23	22	23	0.78	0.82	0.86	21	23	24
PATH C	4 610	5,365	8,802	22	21	21	0.61	0.86	1.19	23	22	23
PINNACLE MT HOLLY - GARFIELD 230 KV	14 015	23,201	31,702	13	12	13	6.76	11.27	15.40	6	5	5
SOUTHERN NEW MEXICO (NM)	9 462	13,665	28,457	16	15	14	1.02	2.03	3.10	19	18	17
SOUTHWEST OF FOUR CORNERS	717 200	1,117,571	1,501,641	1	1	1	15.60	23.08	32.26	2	2	2
TOT 1A	6 846	9,158	12,985	18	18	17	0.96	1.31	1.85	20	20	20
TOT 2A	76 727	129,341	177,936	7	5	5	12.25	21.40	29.44	3	3	3
Tot 2a 2b 2c Homingum	1 357	3,414	4,815	27	24	24	0.09	0.25	0.35	28	27	26
TOT 2B2	4 929	9,095	12,684	21	19	13	2.01	3.92	5.46	14	11	10
TOT 2C	13 531	23,724	27,313	14	14	15	4.99	7.89	10.39	8	8	8
TOT 4A	10 252	15,543	24,952	15	16	16	1.57	2.19	3.52	17	17	16
TOT 4B	667	1,647	2,066	30	29	27	0.10	0.26	0.36	27	26	27
TOT 7	1 902	3,070	3,752	26	26	25	0.20	0.39	0.48	26	25	25
WEST OF BROADVIEW	14 280	21,085	39,050	12	13	12	0.52	0.72	1.34	24	24	22
WYOMING TO UTAH	57 250	81,758	107,017	8	7	7	3.87	5.49	7.19	9	9	9

Clean and Diversified Energy Initiative

April 30, 2006

Purpose

- The Western Governors adopted the goals of adding 30,00 MW of clean and diversified energy and attaining 20% energy efficiency in the 18 state region of the Western Governors' Association (WGA). The Clean and Diversified Energy Advisory Committee (CDEAC) and numerous task forces were created to develop recommendations to attain the Governors' goals.

Method

- This study sought to analyze the transmission to support three bookend generation scenarios for 2015, using economic screening analysis that compares costs of the three scenarios relative to the SSG-WI 2015 Reference Case. Scenarios:
  1. High Efficiency
  2. High Renewables
  3. High Coal

Conclusion

- The High Efficiency Case postulated reduced loads and enabled the system to operate without adding new transmission lines beyond the SSG-WI 2015 Reference Case.