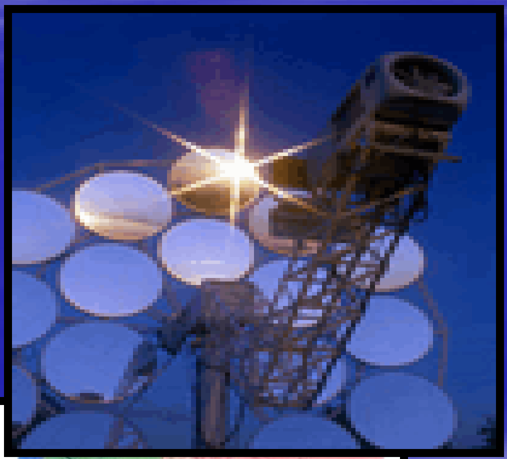
<u>“Towards 2020”</u>

Western Interconnection Regional Advisory Body

Committee on Regional Electric Power Cooperation



Michael R. Niggli
Chief Operating Officer
San Diego Gas & Electric Co.

October 29, 2008

"Towards 2020"

Load-Resource Balance (Western Interconnection)

Participants

California ISO
Your Link to Power

PacifiCorp
A MidAmerican Energy Holdings Company

Portland General Electric

SRP

PG&E

APS

NV Energy

PNM Resources

Southern California Edison
An Edison International Company

Idaho Power
An IDACORP Company

SDG&E
A Sempra Energy utility

Avista Corp.

SMUD
Sacramento Municipal Utility District

Bonneville Power Administration

LA DWP
Los Angeles Department of Water & Power

Puget Energy

“Towards 2020”

Load-Resource Balance (Western Interconnection)

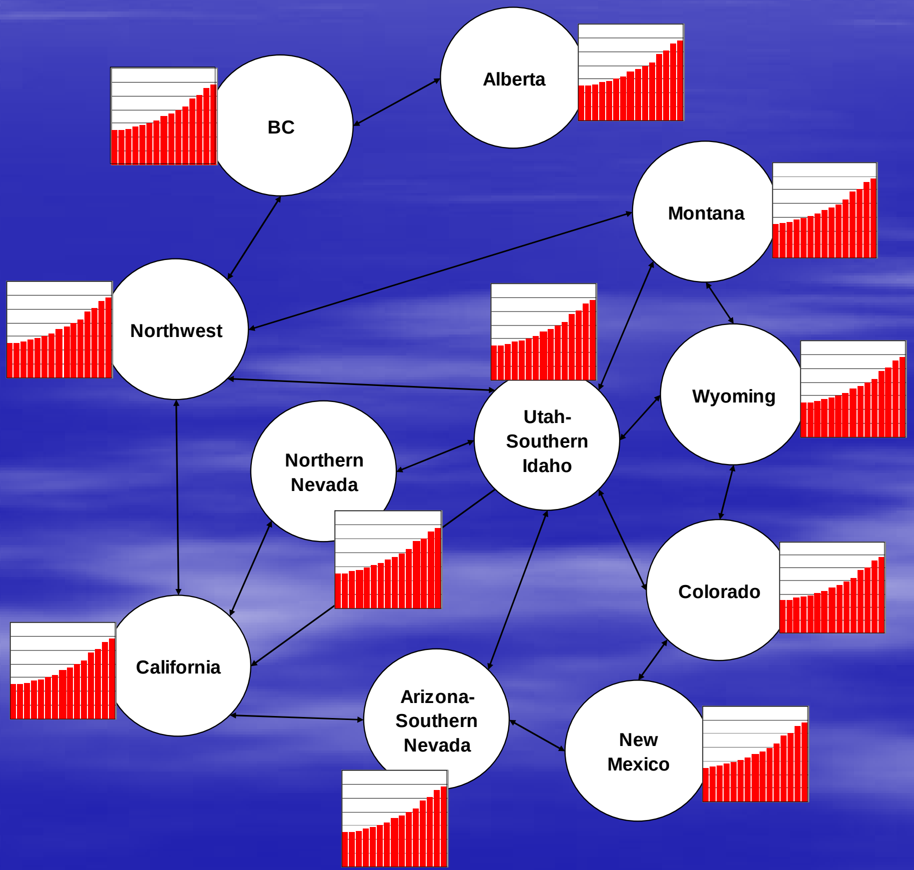
MAJOR PARAMETERS EXAMINED

- Regional Production Costs
- Resource “Firming” Costs
- Transmission “Integration” Costs
- Supply/Demand Curves
- Multi-Regional Evaluation
- Renewable Energy Credits

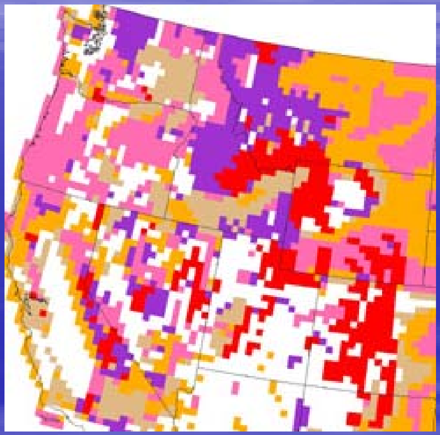
- Publicly Available Data

Step 1: Cost of Procuring Energy from Local Resources

- Divide the WECC into 11 regions
- Start with 2008 loads and resources by region
- Grow loads to 2020
- Add least-cost ***local*** resources on a MWh-for-MWh basis to meet load growth, RPS and GHG requirements

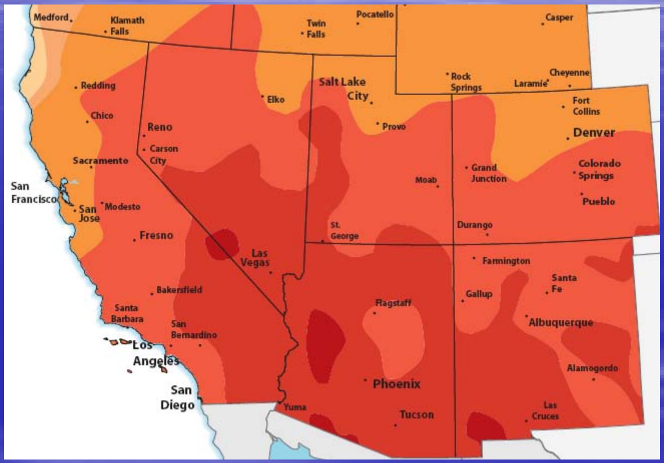


Wind Resource & Cost Data



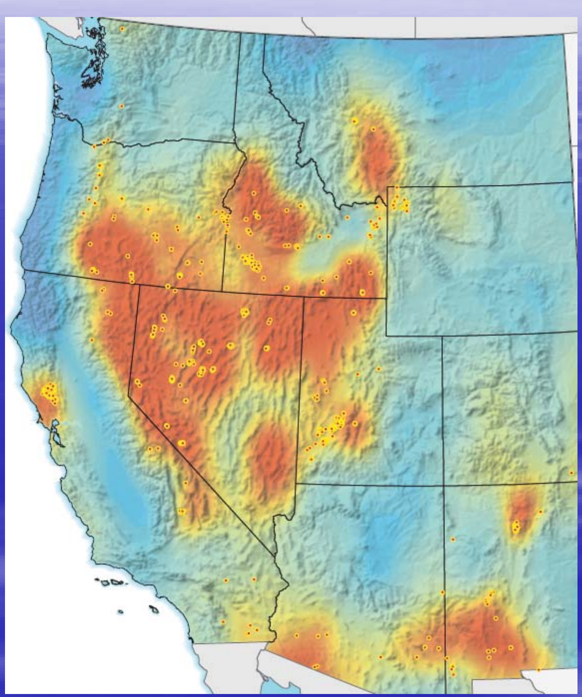
- **Resource Potential from NREL**
  - GIS input for WinDS model
  - 98 resource regions in WECC
  - Exclude cities, lakes, federal lands, >20% slopes
  - Use resource class (1-7) to calculate capacity factor
- **Generation costs (in 2008 $):**
  - Installed capital cost: **$1634/kW for base plant (AWEA Wind Vision study)**
  - Production tax credit: **1.9¢/kWh for 10 years**
  - Levelized busbar cost range for all sites in supply curve: **$65/MWh - $125/MWh**
- **Other costs:**
  - Interconnection (used NREL "assignment" method): **$1/MWh - 18/MWh**
  - Firming (assume 10% capacity on peak): **$19/MWh - $36/MWh**
  - Integration (depends on region size and wind penetration): **$2/MWh - $12/MWh**

Solar Thermal Resource & Cost Data



- **Resource Potential from NREL**
  - GIS data used for WGA CDEAC analysis
  - 31 resource regions in WECC
  - Exclude cities, lakes, federal lands, >1% slopes
  - Capacity factor based on irradiation and latitude
- **Generation costs (in 2008 $)**
  - Wide range of estimates in literature: $71 to $219/MWh
  - Parabolic trough technology, Black & Veatch (2006) costs
  - Installed capital cost: **$2,928/kW for base plant**
  - Investment tax credit: **10% in base case, 30% in high case**
  - Levelized busbar cost range for all sites in supply curve: **$123-160/MWh**
- **Other costs**
  - Interconnection (distance from center of region to 230kV+ line): **$0.15- $8/MWh**
  - Firming (assume 85% capacity on peak): **$6-8/MWh**

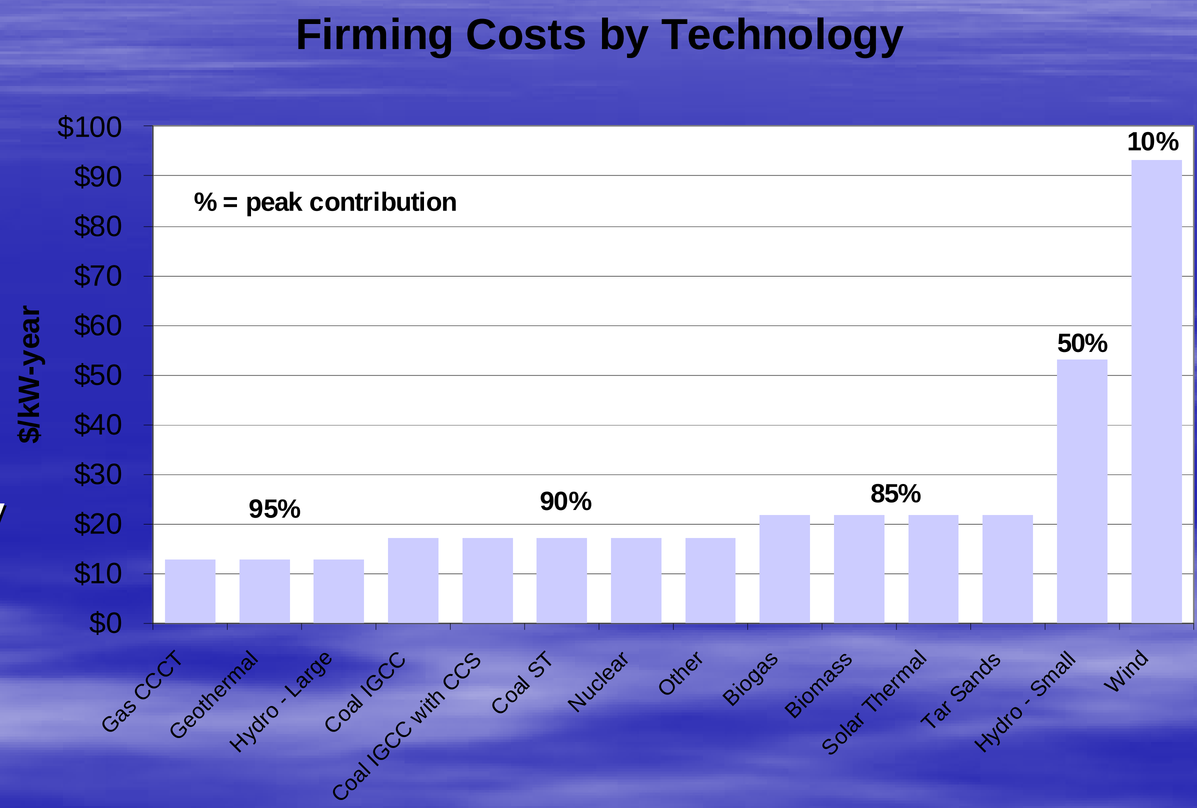
Geothermal Resource & Cost Data



- **Resource Potential**
  - Project-specific MW and cost estimates
    - Used CEC/Geothermex (2004) for CA & NV sites
    - Used WGA CDEAC (2006) for rest of WECC
  - Results after applying EIA filters:
    - CA: **3000 MW at 21 sites**
    - NV: **1300 MW at 43 sites**
    - BC: **185 MW at 2 sites**
    - Rest of WECC: **1500 MW at 24 sites**
- **Generation Costs**
  - Site-specific; varies with depth, temperature, & proven resource
  - Installed capital costs for most sites: **$2800/kW to $6700/kW**
  - Investment tax credit: **10%**
  - Levelized busbar costs for most sites: **$90/MWh - $200/MWh**
  - Interconnection Cost (distance from location to nearest 115kV line): **up to $2/MWh**

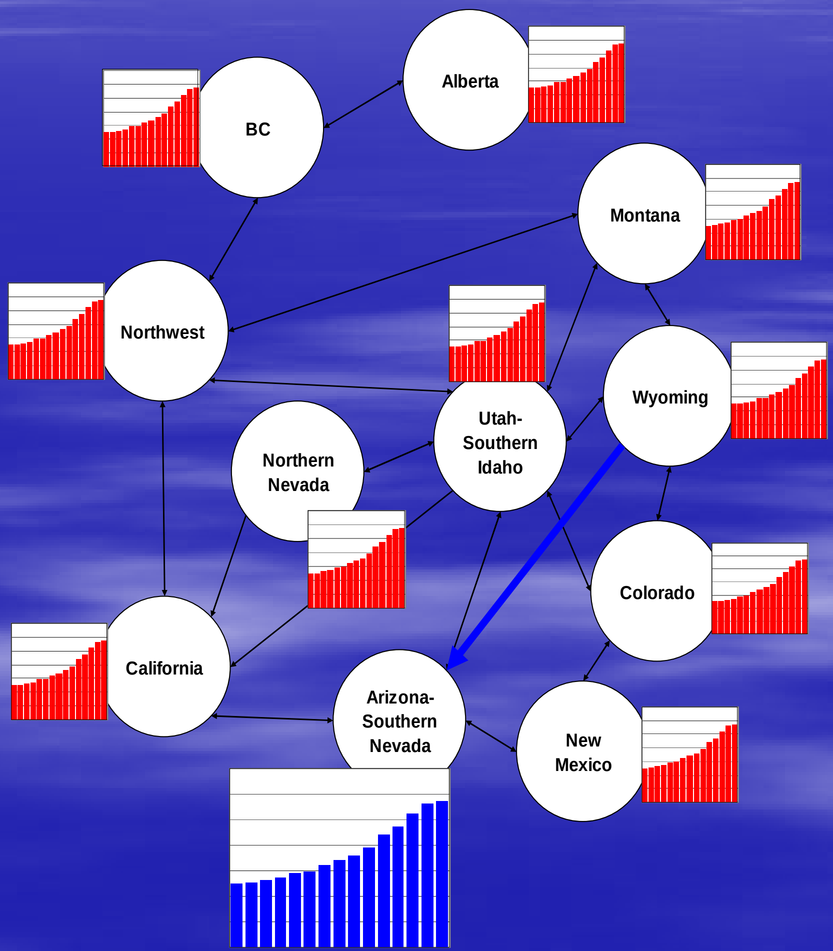
Firming Costs and Capacity Balance

- Firm all resources with CT costs to 115% of nameplate
- On-peak contribution varies by resource
- Costs represent capacity charge, not actual CT
- This approach ensures model is adding enough capacity in each region



Step 2: Change in Energy Cost from Adding Transmission

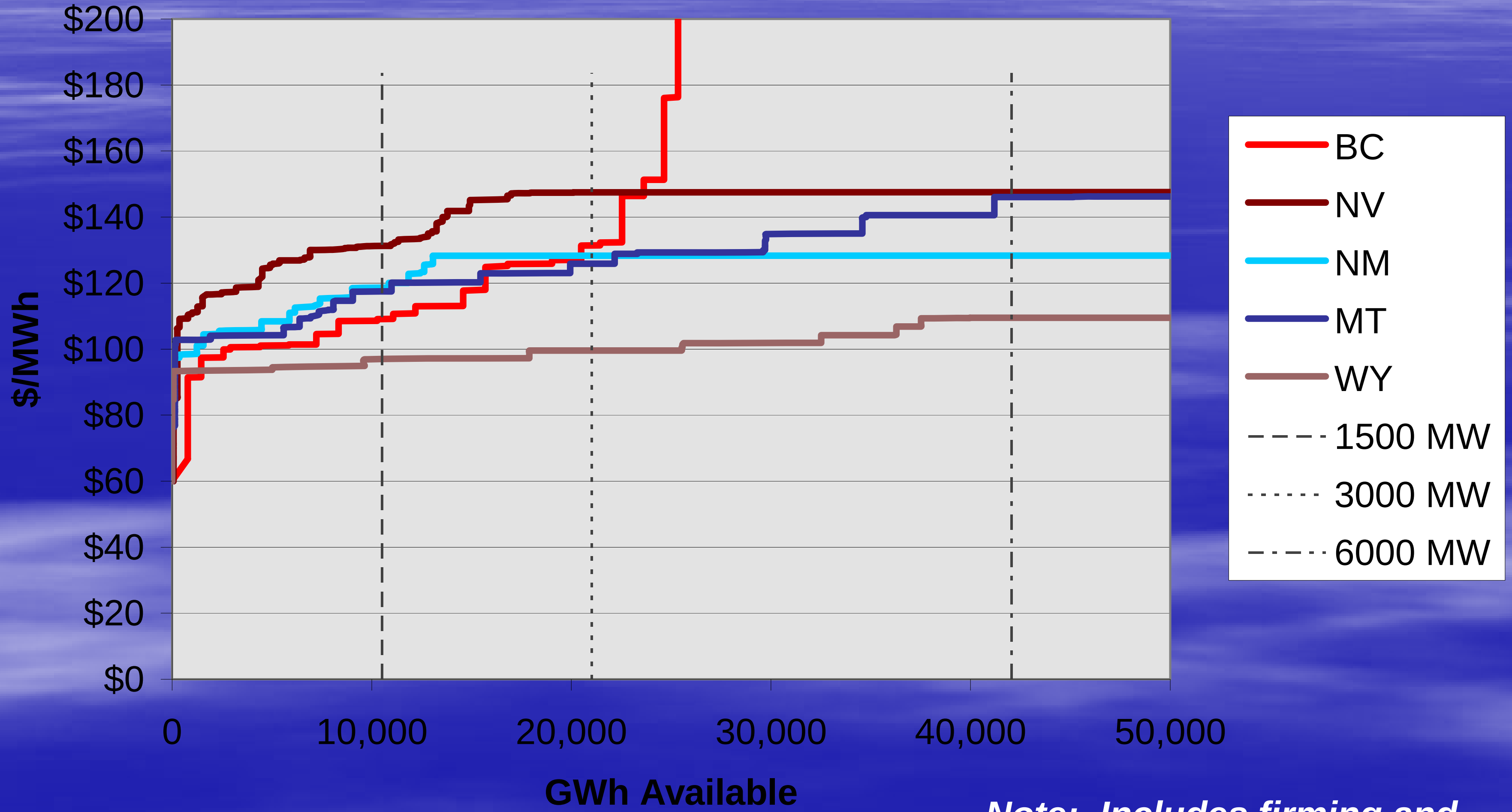
- Assume fixed-capacity DC transmission line from one region to another
- Allow resources not selected in "source" region to meet needs in "sink" region
- Calculate change in sink region energy costs
- Forward-looking only; no change in use of existing resources



What Drives the Value of New Transmission?

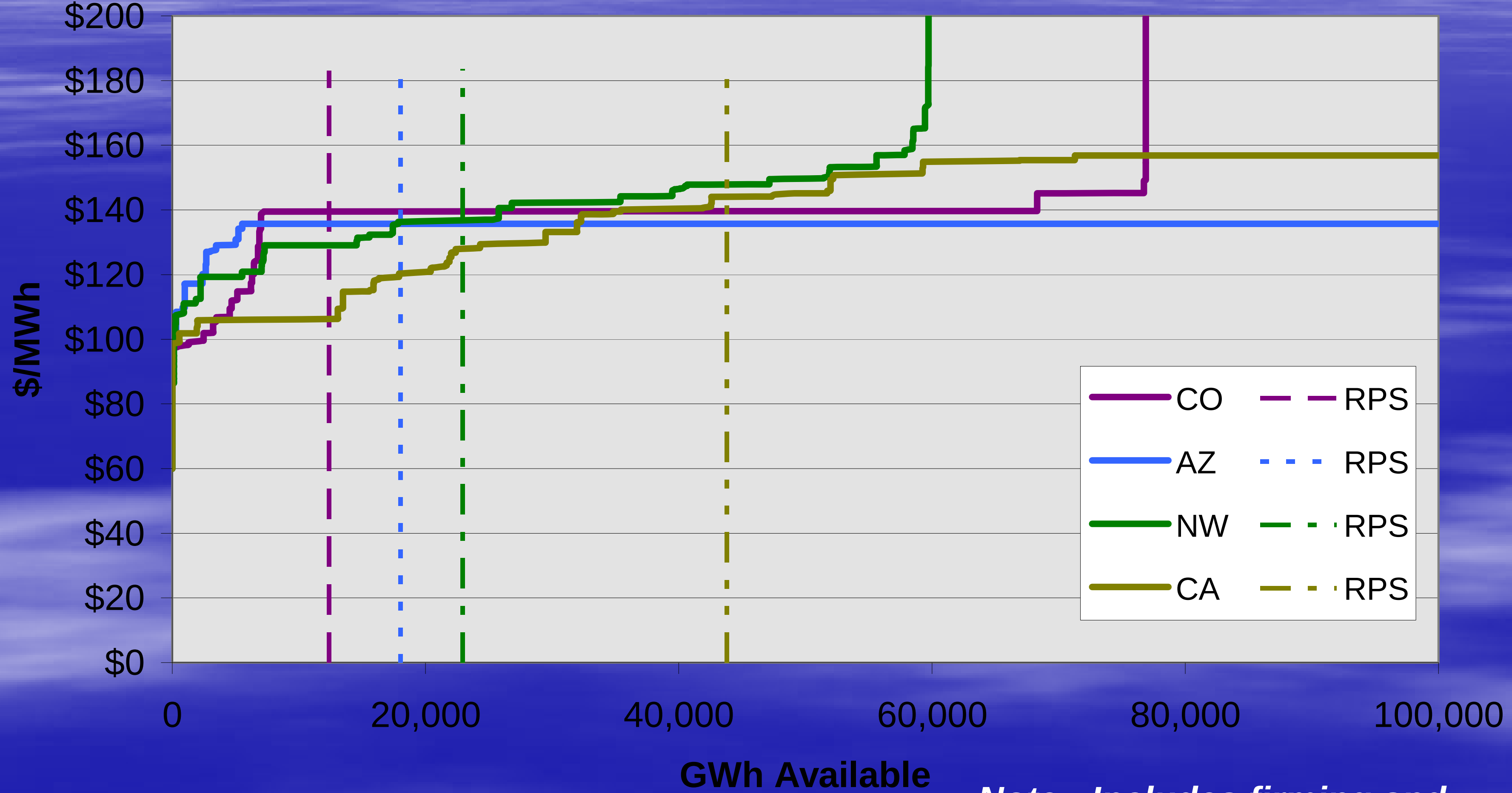
- Differences in supply curves by region
  - Lower land and labor costs in interior West
  - Superior resource endowments in supply regions
- Differences in demand by region
  - Consuming regions like California and the Northwest use up larger shares of their resource endowments to meet RPS targets
  - Producing regions like Wyoming and Montana do not require much energy to meet local load growth or RPS targets

Renewable Energy Supply Curves for Major Potential Supply Regions Compared with Potential Transmission Line Capacity



Note: Includes firming and interconnection costs

Renewable Energy Supply Curves for Major Consuming Regions, Compared with Base Case RPS Targets



Note: Includes firming and interconnection costs

Benefit-Cost Ratios for 1500 MW Line Under Base Case RPS

- Add up state-by-state RPS requirements:
  - 15% of energy in the WECC renewable by 2020
  - 14,000 aMW of new resources WECC-wide
- WY-CO most cost-effective path
- Several other interesting possibilities

Benefit-Cost Ratio for 1500 MW Line, Base Case RPS

		Consuming Region			
		AZ	**CA**	**CO**	**NW**
Producing Region	**MT**	0.7	**0.9**	0.7	**1.2**
	NM	**1.1**	**0.9**	**0.7**	0.4
	NV	0.3	0.6	0.2	0.3
	WY	**1.3**	**1.3**	**3.2**	**1.1**

Key:	**>1.0**	**0.7-1.0**	<0.7

Benefit-Cost Ratios for 1500 MW Line Under High RPS

- High RPS Case, 30% RPS in CA, 25% elsewhere
  - 27% of energy in the WECC renewable by 2020
  - 28,000 aMW of new resources WECC-wide
- Lines into CA and NW gain value
- Lines into CO lose value due to wind integration

Benefit-Cost Ratio for 1500 MW Line, High RPS

		Consuming Region			
		AZ	CA	CO	NW
Producing Region	MT	0.6	**1.0**	0.6	**1.6**
	NM	**0.9**	**1.0**	0.5	0.6
	NV	0.3	**1.3**	0.2	**1.0**
	WY	**1.3**	**1.3**	**2.9**	**1.3**

Key:	>1.0	0.7-1.0	<0.7

Benefit-Cost Ratios for 1500 MW Line Under CO2 Reduction Case

- Reduce CO2 by 30% from 2008 levels
  - 43,000 aMW of new low-carbon resources in WECC by 2020
  - Allow nuclear and IGCC with carbon capture as low-carbon resources
- WY still big supplier if IGCC pans out
- NW and CA still big buyers

Benefit-Cost Ratio for 3000 MW Line, CO2 Reduction Case

		Consuming Region			
		AZ	CA	CO	NW
Producing Region	MT	0.3	0.9	(0.1)	1.5
	NM	0.5	1.2	0.0	0.8
	NV	0.0	0.9	-	0.8
	WY	1.3	1.7	2.5	1.7

Key:	>1.0	0.7-1.0	<0.7

Benefit-Cost Ratios for 1500 MW Line Under Low Solar Cost Case

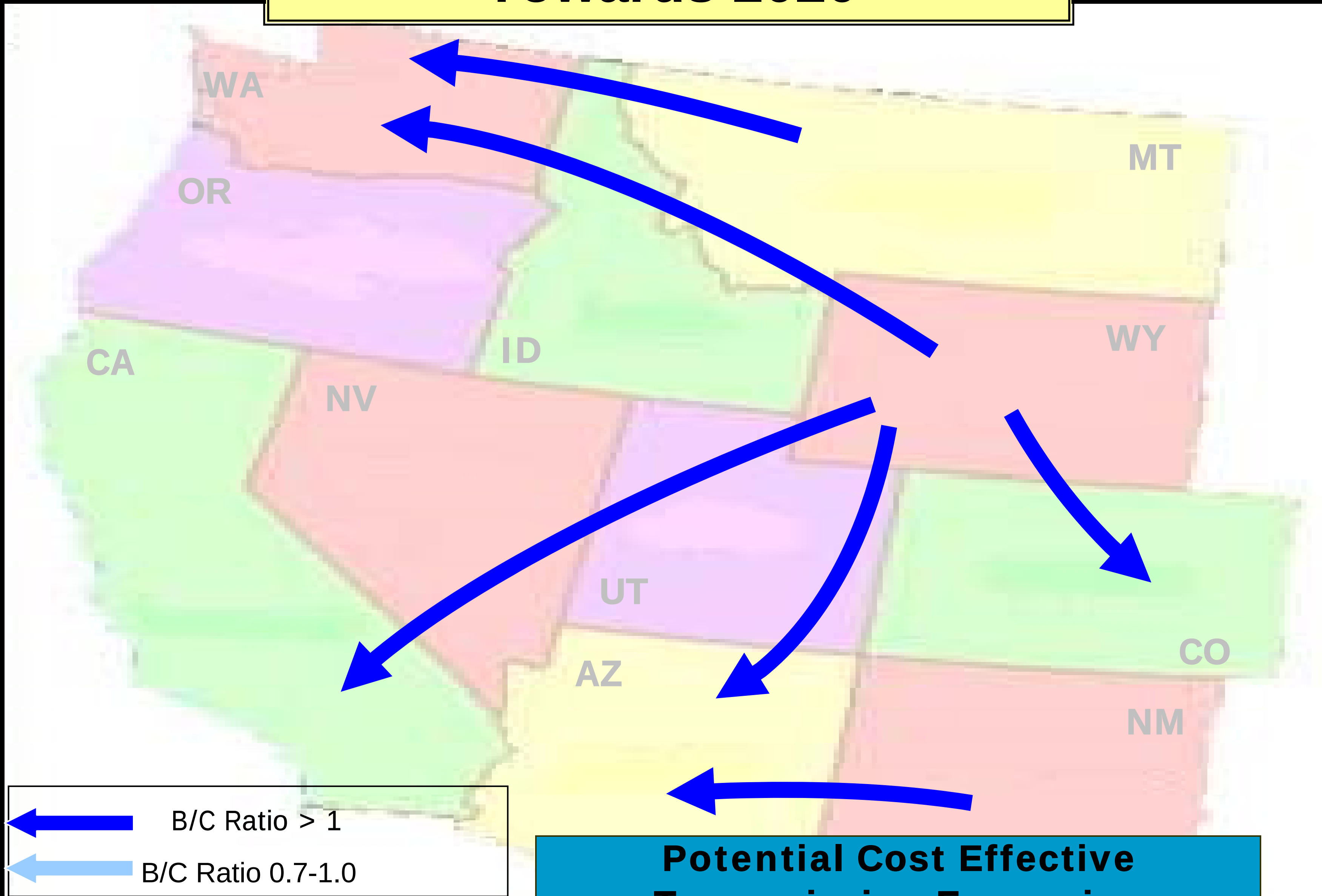
- Reduce cost of solar thermal by 20%
- Base case RPS
- Model selects 10,500 MW of solar thermal in AZ, CA and CO
- Lines into CA, CO and AZ lose value
- NW values unaffected

Benefit-Cost Ratio for 3000 MW Line, Low Solar Cost Case

		Consuming Region			
		AZ	CA	CO	NW
Producing Region	MT	0.3	**0.7**	0.1	**1.2**
	NM	0.4	**0.8**	0.3	0.5
	NV	-	0.4	(0.1)	0.4
	WY	**0.9**	**1.1**	**1.7**	**1.1**

Key:	>1.0	0.7-1.0	<0.7

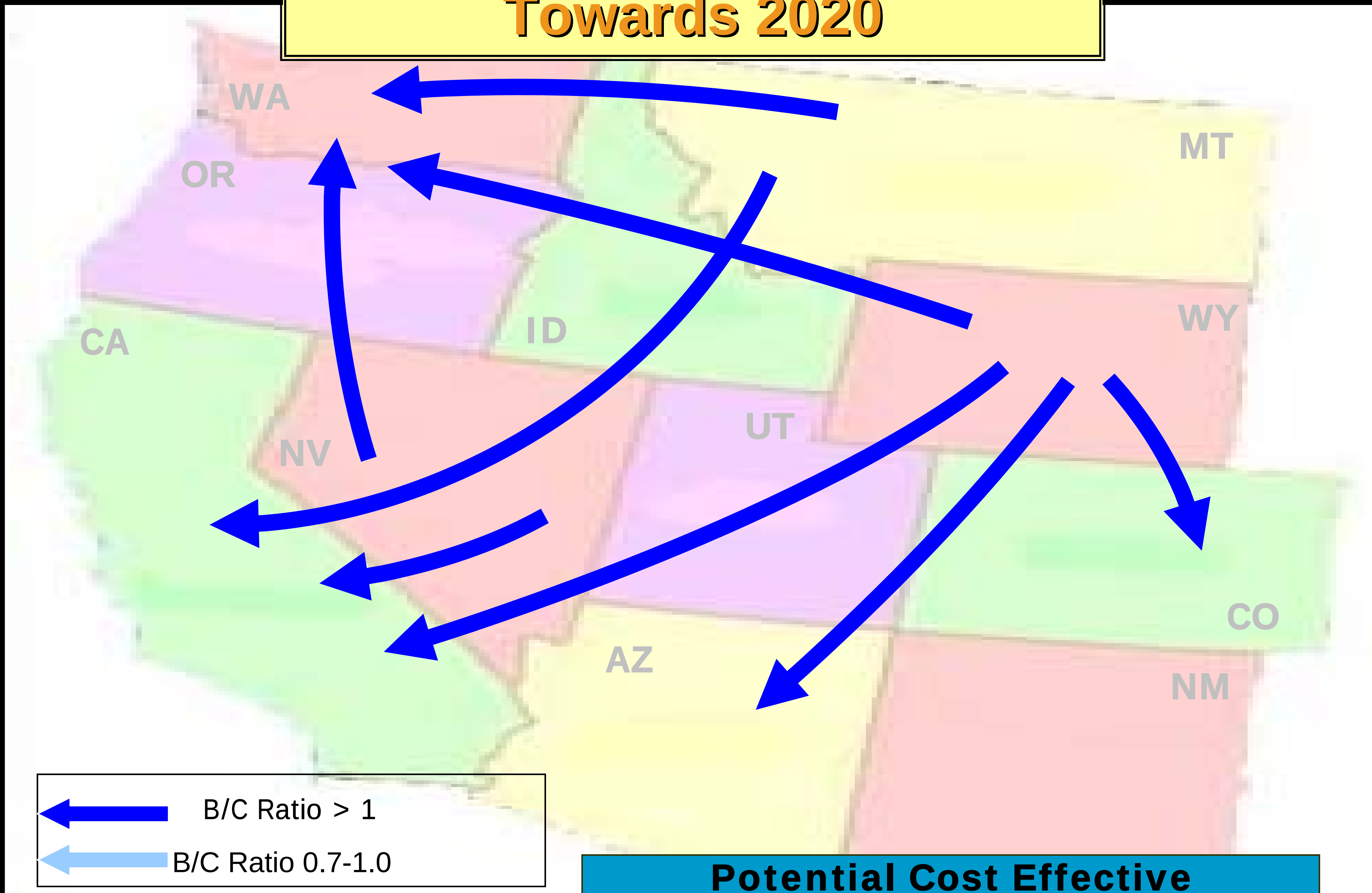
Towards 2020



Potential Cost Effective Transmission Expansion

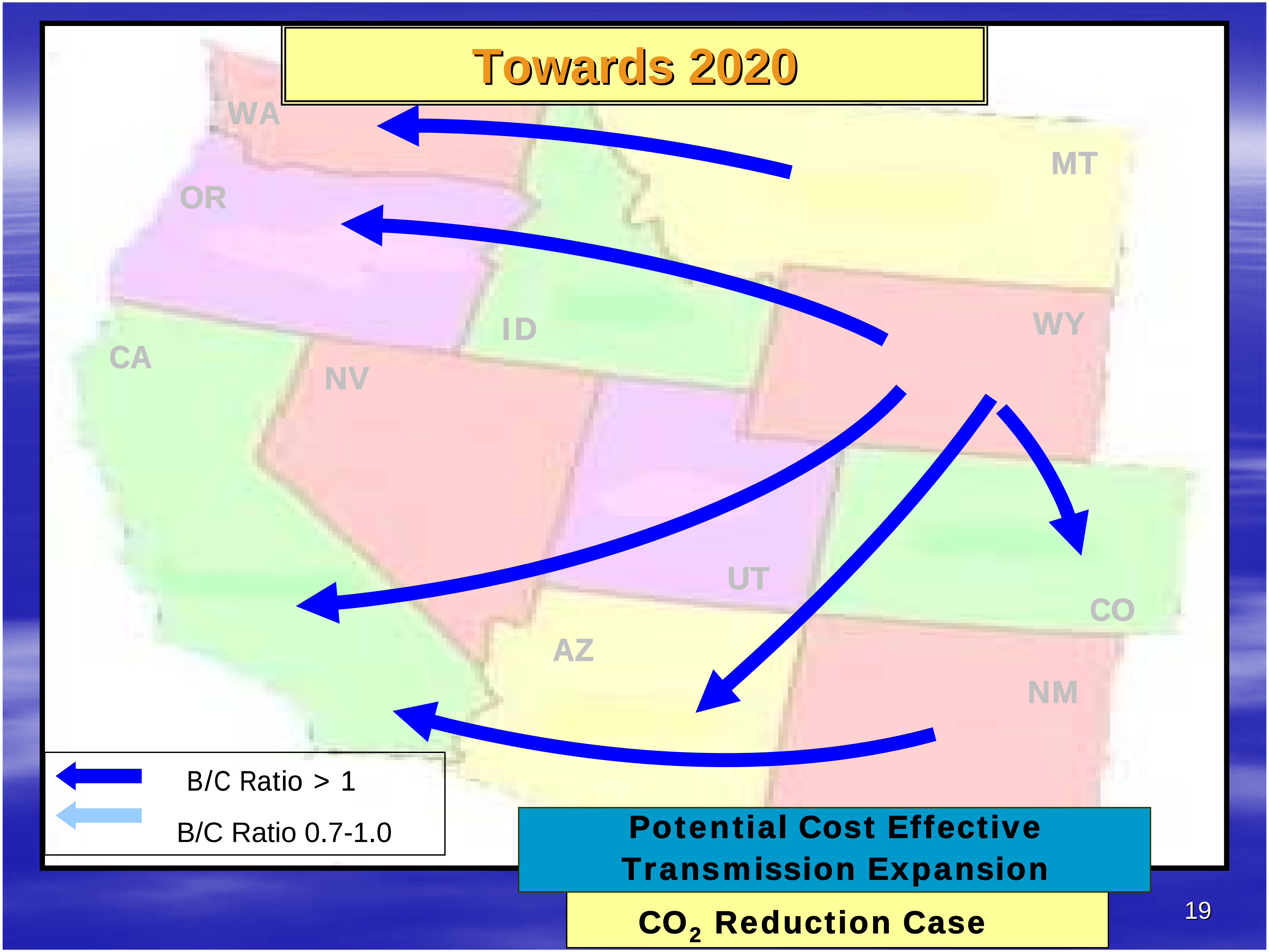
Base Case RPS

Towards 2020

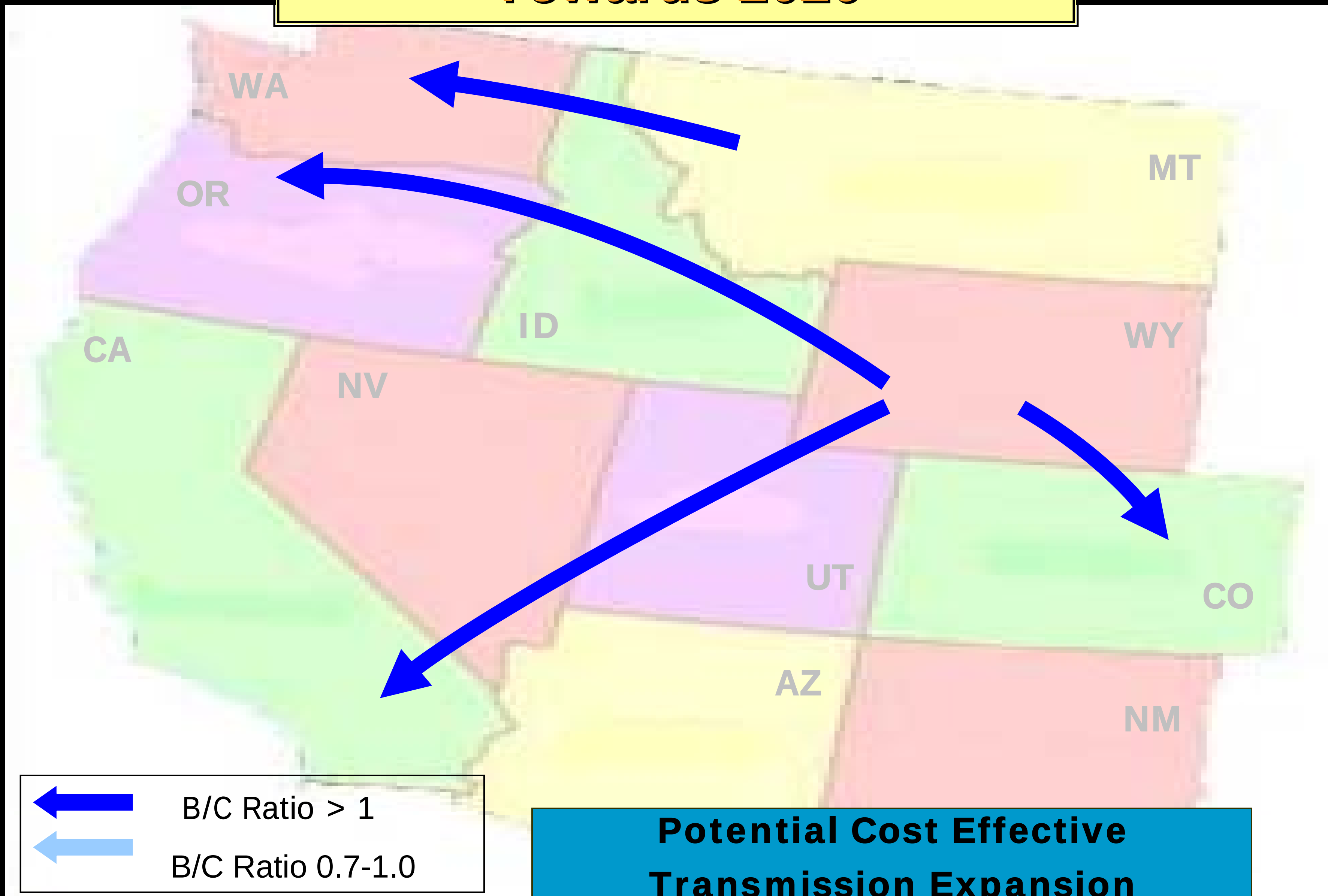


Potential Cost Effective Transmission Expansion

High RPS


Towards 2020
WA
OR
MT
ID
WY
CA
NV
UT
CO
AZ
NM
B/C Ratio > 1
B/C Ratio 0.7-1.0
Potential Cost Effective
Transmission Expansion
CO2 Reduction Case

Towards 2020



Potential Cost Effective Transmission Expansion

Low Solar Cost Case

Results of Tradable REC Analysis

Renewables subtracted:

- California wind: 3,581 MW
- Colorado solar: 1,238 MW
- Northwest biomass: 757 MW
- California other: 214 MW

Renewables added:

- Wind (all regions): 4,291 MW
- Solar (NM, AZ): 1,364 MW
- Hydro (BC, UT, WY): 278 MW
- Biomass (all regions): 231 MW
- Geothermal (UT): 200 MW

Conventional:

- Subtract 3,307 MW in AB, AZ, BC, MT, NM, NV, UT, WY
- Add 2,931 MW in CA, CO and NW

Total annual value of REC trading in 2020: $351 million

Transmission Siting

(Gas & Electric)

- Since January 1, 2000, the FERC has certificated 10, 253 miles of natural gas transmission pipeline that physically crossed state lines.
- Since January 1, 2000, 18 interstate electric transmission lines have been built totaling 917 miles that physically crossed state lines.

What Can We Do?

- Recognize the interdependency of our networks.
- Recognize the benefits of this interdependency.
- "Electric transmission is a key element in unlocking substantial environmental value."
  – Renewable energy enablement
  – Electrifying transportation
- Establish a common vision among disparate groups.

What Can We Do?

- Finalize Renewable Energy Zones
- Establish Transport Corridors that are
  - reliable
  - effective
  - economic
- Develop Common Siting Principles, such as
  - Garamendi Principles
    - Follow existing corridors
    - Focus on previously disturbed areas
    - Provide objective approach
- Minimize Subsequent Project-Specific Environmental Reviews
  - Focus on impacts not previously analyzed in corridor designation process
- Establish a REC Trading Market