to the assumptions made by the RETI team. In addition to general uncertainty, there are wide variety of plausible future scenarios which may affect the modeling results and the ranking of the CREZs. An uncertainty and sensitivity assessment was carried out to identify which CREZs and resources areas might be economically viable under certain situations. In addition to a general uncertainty assessment, sensitivity studies were performed to investigate the impacts of several key issues, such as:

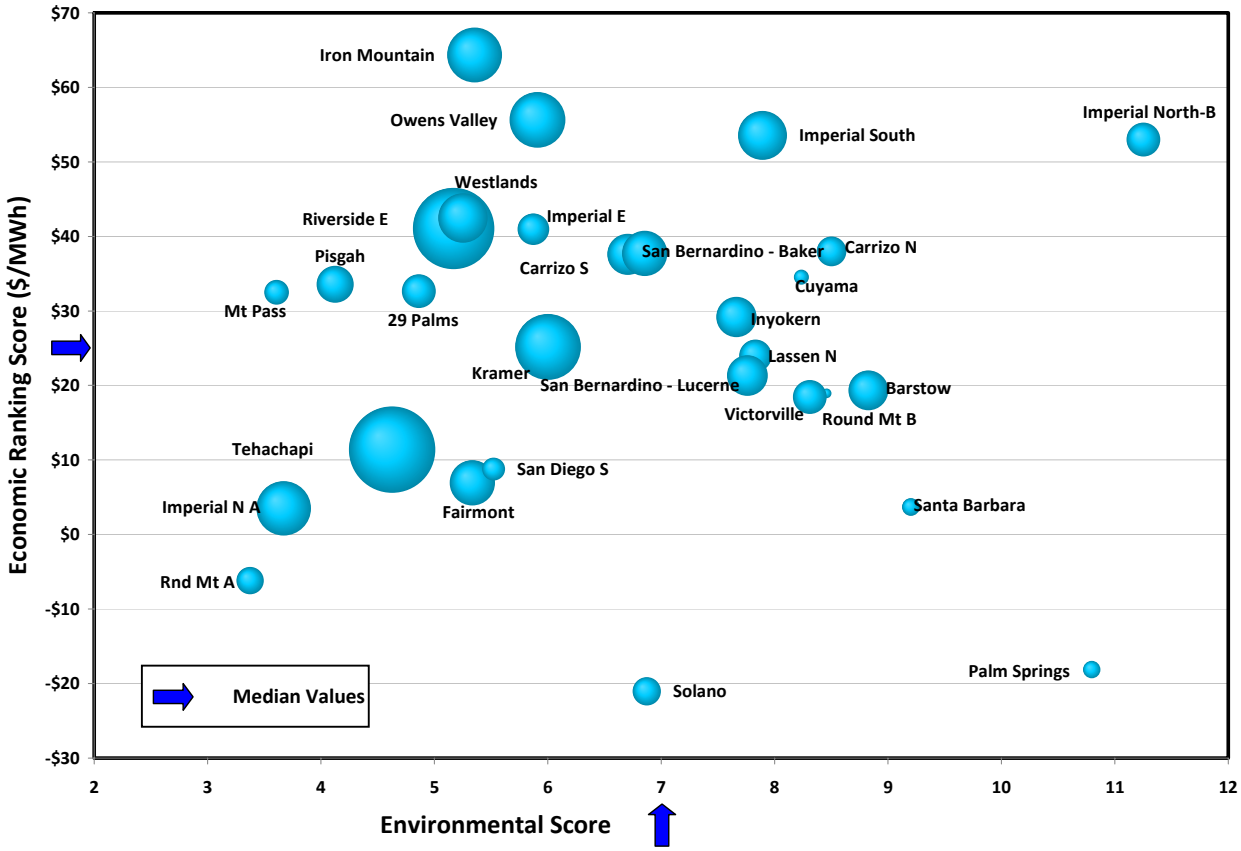
- Tax credits
- Out-of-state transmission costs
- Shaping and firming of resources (British Columbia example)
- Advanced solar thermal technologies costs
- Distributed solar photovoltaics
- Integration costs

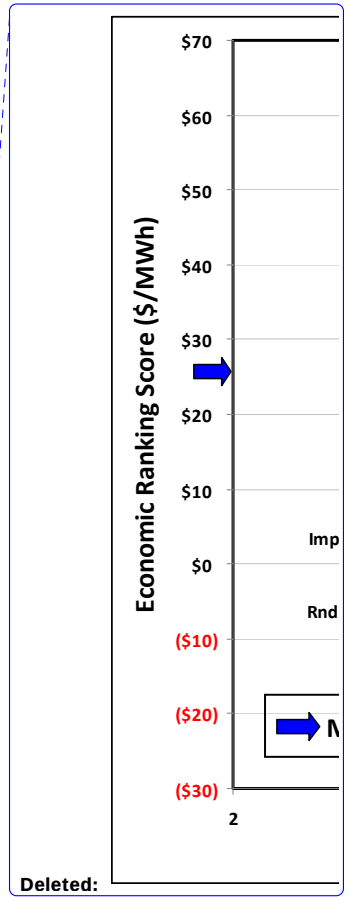
For further information on the results of these analyses, please refer to Section 7. The supply curve in Figure 1-3 is shown again with uncertainty bands in Figure 1-4.

1.4.3 Combined Environmental and Economic Ranking

Black & Veatch re-ranked the CREZ using the same process as outlined in Phase 1B of RETI. The economic scores identified in this section were used for the updated economic ranks. Based on the new CREZ descriptions, updated environmental scores were calculated employing the same process described in the Phase 1B Report. Consensus was not reached on how to treat the footprint of wind projects in environmental scores, so the wind industry has provided alternate scores based on a different formulation, which can be found in Appendix B.

The bubble chart below in Figure 1-5 shows revised CREZ assessments in terms of relative economic cost and environmental concerns per unit energy produced. As in the Phase 1B Report, CREZ to the left in this chart are expected to have fewer environmental concerns per unit energy production, and CREZ toward the bottom are expected to have lower cost/higher economic value per unit energy. Since comparable environmental data is not available, out-of-state areas are not shown on this chart.





Notes:

- Areas of the bubbles are proportional to CREZ energy.
- Lassen South CREZ is off the right side of the chart. (Economic Score = 18, Environmental Score = 19.50, Energy = 1051 GWh)
- San Diego North Central CREZ is off the right side of the chart. (Economic Score = 15, Environmental Score = 22.3, Energy = 502 GWh)
- Victorville and Round Mountain-B are coincident

Figure 1-5. CREZ Economic and Environmental Scores Phase 2B, Bubble Chart.

- "Western Renewable Energy Zones, Phase 1: QRA Identification Technical Report", October 2009, available at: http://www.nrel.gov/docs/fy10osti/46877.pdf.
- "WREZ Transmission Model", 2009, available at: http://www.westgov.org/index.php?option=com_content&view=article&catid=102%3Ainitiatives&id=221%3Awrez-generation-and-transmission-modeling&Itemid=81

The members of the Phase 2B Workgroup generously provided their time to review the assumptions, methodology and analysis that went into this report. The workgroup consists of industry representatives, developers, utilities, and other interested stakeholders. Various meeting materials and interim work products for the RETI Phase 2B Workgroup are available at:

- http://www.energy.ca.gov/reti/steering/workgroups/phase2A_update/.

2.3 Interaction with other Processes and Decisions

RETI is just one aspect of an interconnected process. There are many other initiatives underway in California to carry out more detailed studies for resource and transmission planning and advance renewables. The diverse body of stakeholders involved in RETI creates a unique forum that can provide valuable input to these processes. RETI has provided input for these in the past and will continue to interact with them in the future. Other notable initiatives and decisions underway include:

- California Transmission Planning Group (CTPG)
- California Independent System Operator's (CAISO) Renewable Energy Transmission Planning Process (RETPP)
- California Desert Renewable Energy Conservation Plan (DRECP)
- Renewable Distributed Energy Collaborative (Re-DEC)
- Tradable Renewable Energy Credits (TRECs)

The Re-DEC process and recent developments associated with TRECs are described further below.

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2.3.1 Renewable Distributed Energy Collaborative

Previous RETI work has recognized the potential for large amounts of renewable distributed generation (DG) to contribute to California's renewable energy needs. The objective of the Renewable Distributed Energy Collaborative (Re-DEC) is to identify challenges and potential solutions to high penetration of distributed generation.

Re-DEC was formed by the CPUC to explore and better understand challenges faced by developers and utilities with integrating large amounts (e.g., 15,000 MW) of renewable DG into the electricity distribution system in California. Re-DEC generally focuses on wholesale DG connected to the distribution system, on the utility side of the meter, and ranging in size from 1 to 20 MW. Since RETI is generally focused on larger scale-transmission dependent renewables, Re-DEC provides an important complementary function. For more information on Re-DEC, please refer to:

- http://www.cpuc.ca.gov/PUC/energy/Renewables/Re-DEC.htm

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2.3.2 Tradable Renewable Energy Credits

The CPUC recently passed D.10-03-021 allowing California's retail sellers to use Tradable Renewable Energy Credits (TRECs). The decision classifies which transactions will be considered bundled and which will be considered TREC transactions, and it limits the three large utilities' use of TRECs to up to 25 percent of their 2010-2011 annual RPS requirements. The 25 percent limit, as well as a REC price cap of $50/MWh, will expire on December 31, 2011 and may be re-examined based on market experience.

The use of TRECs could have a significant effect on the need for transmission. As an indication of the potential role that TRECs may play, a recent study by LBNL about the transmission expansion needs and costs for the Western Electricity Coordinating Council (WECC) included a scenario that allowed the use of TRECs.[2] The study found that the use of TRECs reduced the needs for transmission expansion and the overall costs. However, those study results are not necessarily directly applicable to California's situation. In particular, the CPUC's TREC program has unique limitations that would affect results. Given the current time constraints and the uncertainty on the actual use, scope and effectiveness of TRECs, RETI has made no attempt to include them in this analysis. It is recommended that the impacts of TRECs be analyzed for future phases of RETI.

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2.4 Report Organization

Following this Introduction, this report is organized into the following sections:

- **Section 3 – Economic Model Updates:** Several modifications have been made to the Cost of Generation Calculator in order to improve its accuracy and flexibility. In addition, the American Recovery and Reinvestment Act of 2009 has changed the incentives available for renewables in the U.S. This section describes the changes that have been made to accommodate this new

[2] See Exploration of Resource and Transmission Expansion Decisions in the Western Renewable Energy Zone Initiative, Lawrence Berkeley National Laboratory, February 2010. http://eetd.lbl.gov/EA/EMP

costs have been incorporated into the rank costs at this time. A sensitivity analysis on integration costs was performed and is discussed in section 7.4.7

3.2 Cost of Generation Calculator Improvements

Following is a list of changes that have been made to the Cost of Generation calculation, which is shown in Figure 3-1.

- All technologies in the U.S. are now considered eligible for the 30 percent investment tax credit (ITC) or equivalent grant.
- The ITC is now modeled as a capital cost reduction, not a year 1 windfall. This more appropriately reflects the ARRA "ITC Grant".
- The model now allows for a mix of depreciation schedules. This better reflects tax code and better mimics foreign depreciation rules.
- Includes additional revenue streams which allows for more flexibility in modeling incentives.
- The model now allows for a direct input for performance degradation over time. This mostly affects solar PV projects.

The model was reviewed with the Phase 2B Workgroup and is available on the RETI web page. While improvements have been made to the model, it is still important to note that it is a screening model intended primarily for use as part of the RETI process. There are many simplifications in the model which constrain its use. Those interested in using the model should refer to the original documentation, available at:

- http://www.energy.ca.gov/reti/steering/2008-06-18_meeting/2008-06-18_B+V_Cost_of_Geneneration_information.pdf

3.3 Incentives Assumptions

In February 2009, the American Recovery and Reinvestment Act of 2009 (ARRA) was signed into law. This act includes several provisions specifically designed to encourage the development of renewable energy such as including improvements to tax incentives that lower the cost of renewables. Most importantly, ARRA allows for biomass, geothermal, and wind projects to now take advantage of the 30 percent investment tax credit (ITC) or equivalent grant. Previously these technologies were only eligible for the production tax credit (PTC). The cost of generation model evaluates each resource under various incentive assumptions and picks the lowest cost.

The future of financial incentives is a source of uncertainly in the analysis. The extension of both the PTC and ITC as part of the ARRA now has the PTC expiring at the end of 2012-2013 and the 30 percent ITC/grant program expiring at the end of 2012, 2013, or 2016, depending on the technology. Table 3-1 shows the current PTC and ITC expiration years by technology.

Table 3-1. PTC and ITC Expiration Years.

	PTC Amount/Year	PTC Expiration Year	30% ITC Expiration Year
Solar PV	-	-	2016
Solar Thermal Electric	-	-	2016
Wind	$21	2012	2012
Geothermal	$21	2013	2013*
Closed-Loop Biomass	$10	2013	2013
Qualified Hydro	$10	2013	2013

*10% by 2016 also available

There is little basis on which to forecast future incentives. However, it appears to be widely accepted that incentives will, in general and in some form, be available to renewable energy projects for the foreseeable future. As with RETI Phase 1B, it has been assumed that these subsidies are available throughout the study term (until 2020). Because project scheduling information has not been associated with RETI projects, it is not possible to perform an analysis incorporating the actual sunset dates of these provisions. However, a sensitivity analysis, which can be found in section 7.4.2 has been performed showing the results when tax credits have been eliminated, which can be used as a bounding scenario.

6.5 Transmission Costs

A new approach to determining transmission costs also needed to be developed for out-of-state resources. Transmission costs were split between an in-state component and an out-of-state component. The in-state costs were calculated using the shift factors developed for California resources for RETI Phase 2A. The shift factor approach was not readily adaptable outside the state, so a new approach was developed and new estimates were made. This section describes the assumptions adopted for both in-state and out-of-state transmission, including a detailed explanation of transmission line utilization.

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6.5.1 In-state Transmission

California transmission costs were assigned to both California CREZ and out of state areas exporting renewable energy into California. Out-of-state resources imported to California were assumed to enter California through one of five "gateway" CREZs/substations which are described in section 6.5.3. Transmission from that entry point was assumed to have the same cost as energy from the CREZ at the entry point.

Transmission cost estimates for each CREZ, including in-state transmission costs for imported renewable energy, were based on the generic cost estimates for all of the line segments identified in the Phase 2A report. The costs from Phase 2A were annualized with 10 percent fixed charge rate and spread over the energy deliveries on a per MWh basis. It was assumed that one-half of the cost of new delivery and foundation lines would be allocated to renewable generation. This was arbitrarily chosen since it is recognized that not all of the costs for these lines are due to new renewables development. The full cost of collector lines was allocated to renewables. California transmission losses were estimated at 5 percent for all projects regardless of location.

The allocation of the cost of the new transmission lines to each CREZ was based on the shift factors developed in the Phase 2A report as follows:

1. The costs of delivery and foundation line segments were reduced by 50 percent.
2. The shift factor matrix was weighted by the estimated total capacity (MW) for each CREZ. For out of state areas, the shift factor for the CREZ at the entry point was used.
3. The resulting cost of each line segment was allocated to each CREZ proportional to the weighted shift factor for that segment and CREZ compared to the sum of all weighted shift factors for the segment.
4. For each CREZ, total cost was found by summing the CREZ share for all line segments.

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<#>Assign OOS resources to a California "gateway" CREZ/substation¶
<#>Include all costs for 2A Collector Lines; allocation based on 2A shift factors¶
<#>Include 50 percent of the 2A Foundation and Delivery Line costs; allocation based on the 2A shift factors. 50 percent was arbitrarily chosen since it is recognized that not all of the costs for these lines are due to new renewables development. ¶
<#>Use costs from Phase 2A, annualized with 10 percent fixed charge rate and spread over the energy deliveries on a per MWh basis¶
<#>California transmission losses were estimated at 5 percent for all projects regardless of location¶
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5. The in-state transmission cost for each CREZ was reported as $/MWh by dividing the cost allocated in step #4 by the total energy potential for the CREZ.

Note that as a result of step #5, CREZs with large amount of energy per megawatt of capacity (such as geothermal) were assigned a lower cost per megawatt hour, reflecting the higher line utilization rate. For this reason, CREZs with nearly identical locations (Round Mountain A/B, and Imperial North A/B) can have substantially different costs per megawatt hour.

Table 6-1 lists the in-state transmission costs determined for each CREZ. The in-state transmission costs do not represent actual costs from the California ISO or reflect the results that would be found in more specific studies. The transmission costs used are for overall transmission planning and the assumptions have been simplified. The ultimate actual design will be quite different, and these costs should only be used relative to each other.

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Table 6-1. California In-state Transmission Costs.

CREZ Name	California pro rata Transmission Cost ($Million)	California pro rata Transmission Cost Adder ($/MWh)
Barstow	11.97	$11.08
Carrizo North	7.40	$12.04
Carrizo South	13.88	$11.83
Cuyama	1.85	$11.46
Fairmont	10.42	$7.39
Imperial East	14.01	$20.36
Imperial North-A	18.50	$9.10
Imperial North-B	24.71	$30.93
Imperial South	50.64	$30.66
Inyokern	19.98	$17.75
Iron Mountain	85.96	$41.47
Kramer	33.66	$11.30
Lassen North	16.12	$22.26
Lassen South	4.51	$21.30
Mountain Pass	6.55	$15.39
Owens Valley	73.29	$34.16
Palm Springs	2.58	$12.21
Pisgah	13.19	$13.91
Riverside East	86.93	$19.16
Round Mountain-A	4.06	$7.88
Round Mountain-B	1.45	$21.23
San Bernardino - Baker	24.65	$17.32
San Bernardino - Lucerne	12.66	$11.11
San Diego North Central	1.86	$18.44
San Diego South	7.89	$21.41
Santa Barbara	2.00	$8.87
Solano	6.08	$11.09
Tehachapi	63.57	$12.41
Twentynine Palms	10.24	$12.84
Victorville	6.85	$8.72
Westlands	23.14	$13.81

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The map in Figure 6-4 shows the in-state transmission costs. The bubble sizes are relative to the total capacity (MW) of each CREZ.

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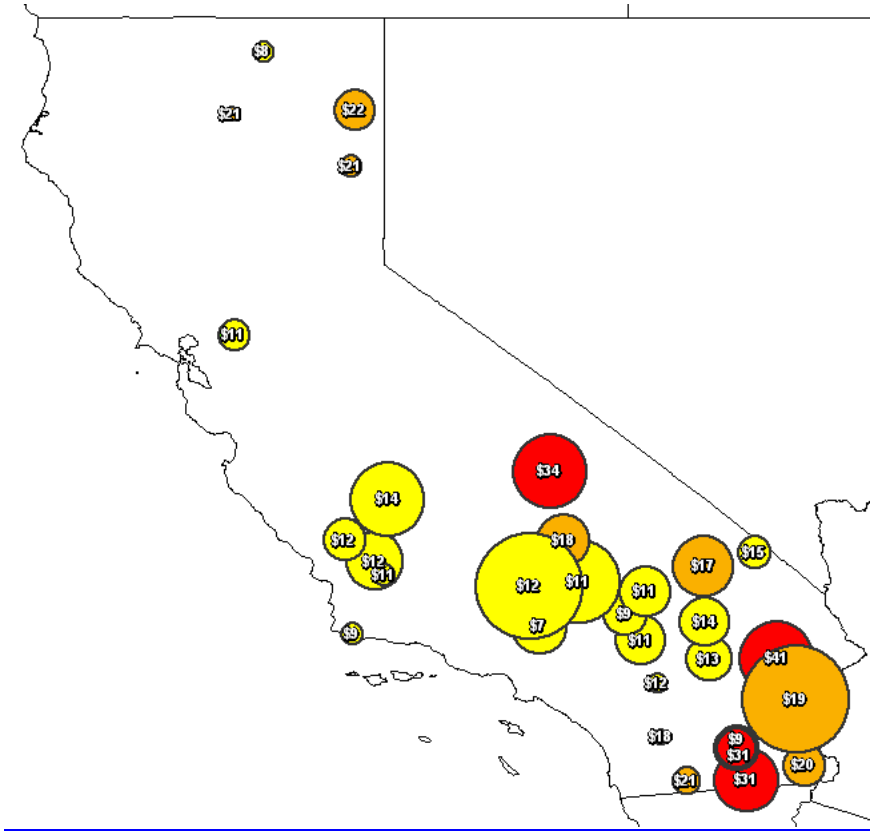

Figure 6-4. Map of In-state Transmission Costs ($/MWh). Circle Size Proportional to CREZ

6.5.2 Out-of-state Transmission Assumptions

For out-of-state transmission, RETI used assumptions developed for the WREZ project. As part of the stakeholder process for WREZ, the WREZ Transmission Characteristics Working Group agreed on adopting the following basis for transmission cost assumptions:

- All incremental transmission (no existing transmission capacity is used)[10]
- 500 kV single circuit ac lines were used (see Table 6-2)
- For most projects import path was determined based on lowest cost or shortest path by region as determined by the WREZ Transmission model (see Figure

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[10] There is some existing transmission capacity available; however, it is difficult to estimate exactly how much and at what cost for this type of study. In addition, there are currently limits to the amount of variable generation that can be scheduled across interites (e.g., transfer of intermittent wind from BPA to CAISO). These may be resolved in the future.

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6-5). For resources in Baja and wind resources in Southern Nevada, pathways and generation tie-line costs were calculated for individual projects.

- The lines would be financed with a mix of federal and private financing (see Table 6-3)
- Resources would be delivered to California through "gateway CREZs" (e.g., Mountain Pass) (see section 6.4.3)
- Line utilization for different clusters of resources varied, and was determined by region-specific factors (see section 6.4.4)
- Transmission losses were determined by line distance from the source zone to the California gateway CREZ

Table 6-2. Assumptions Used for a 500 kV Single Circuit Line.

Nominal Capacity (MW)	1,500
Capital Cost ($/mile)	1,800,000
Substation Costs ($)	50,000,000 each
ROW Width (ft)	175
ROW costs per acre ($)	10,700

Table 6-3. Transmission Economic Assumptions, 50:50 Federal/Private.

Economic Life	40 years
Debt Percentage	50%
Debt Term	30 years
Interest Rate	6%
Equity Cost	13%
Tax Life	15%
Discount Rate	7.625%
Tax Rate	40
Allowance for Funds Used During Construction	7.5% of capital cost
Annual Operation and Maintenance Costs	3% of initial cost

This approach represents a "default" set of assumptions for new transmission development. These assumptions were agreed to by the Phase 2B Workgroup for the sake of consistency, even though it is recognized that there may be opportunities to deliver renewable energy to California at lower cost. For example, section 2.3.2 discusses how TRECs could potentially reduce out-of-state transmission costs. Shaping

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and firming resources are included as a sensitivity in section 7.4.4. The use of existing transmission would be another good opportunity, especially considering the potential reduction of fossil fuel imports caused by new restrictions. Pseudo ties and/or dynamic scheduling could also be important to reducing out-of-state transmission costs[12], as well as better financing and the use of more cost effective technologies, such as HVDC. The sensitivity of the results to the out-of-state transmission cost assumptions is explored in Section 7.

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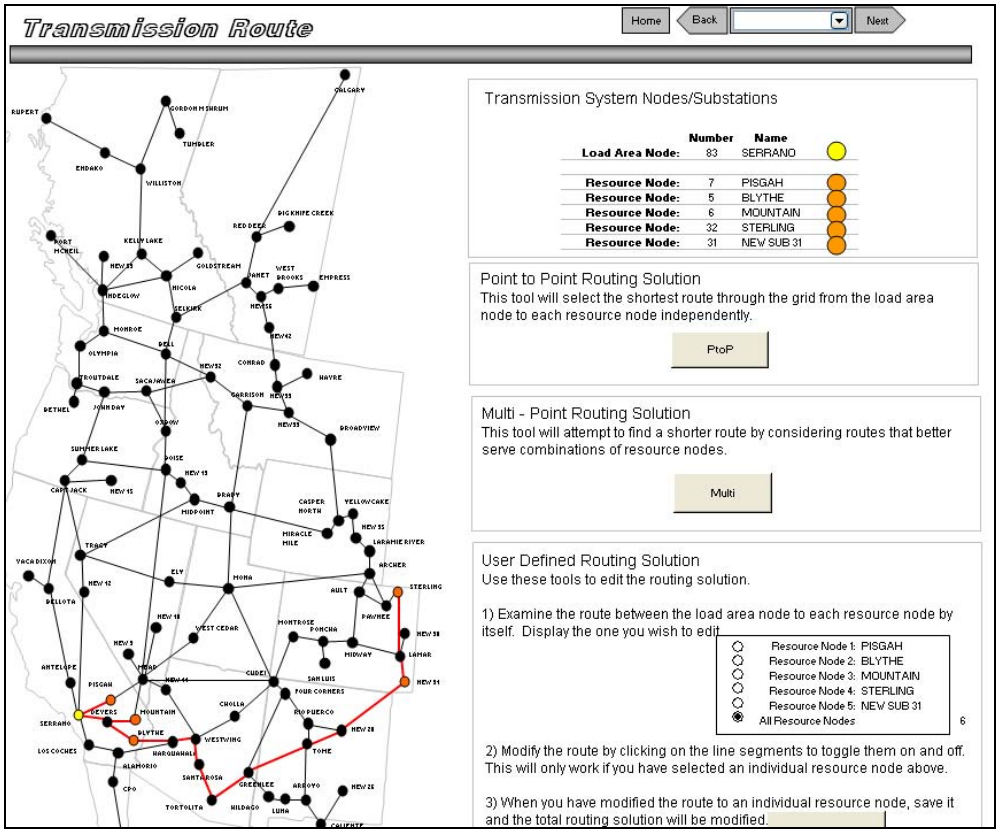

Figure 6-5. Screenshot from WREZ Transmission Model.

6.5.3 California Delivery Gateway Substations

The cost of transmission for out of state resources did not include the cost of transmission within California. The transmission line distances were therefore based on

[12] Interchange scheduling is fundamental to the implementation of dynamic transfers across inter-ties. See the CAISO's Dynamic Transfer Straw Proposal at http://www.caiso.com/2755/2755e7b852d20.pdf.

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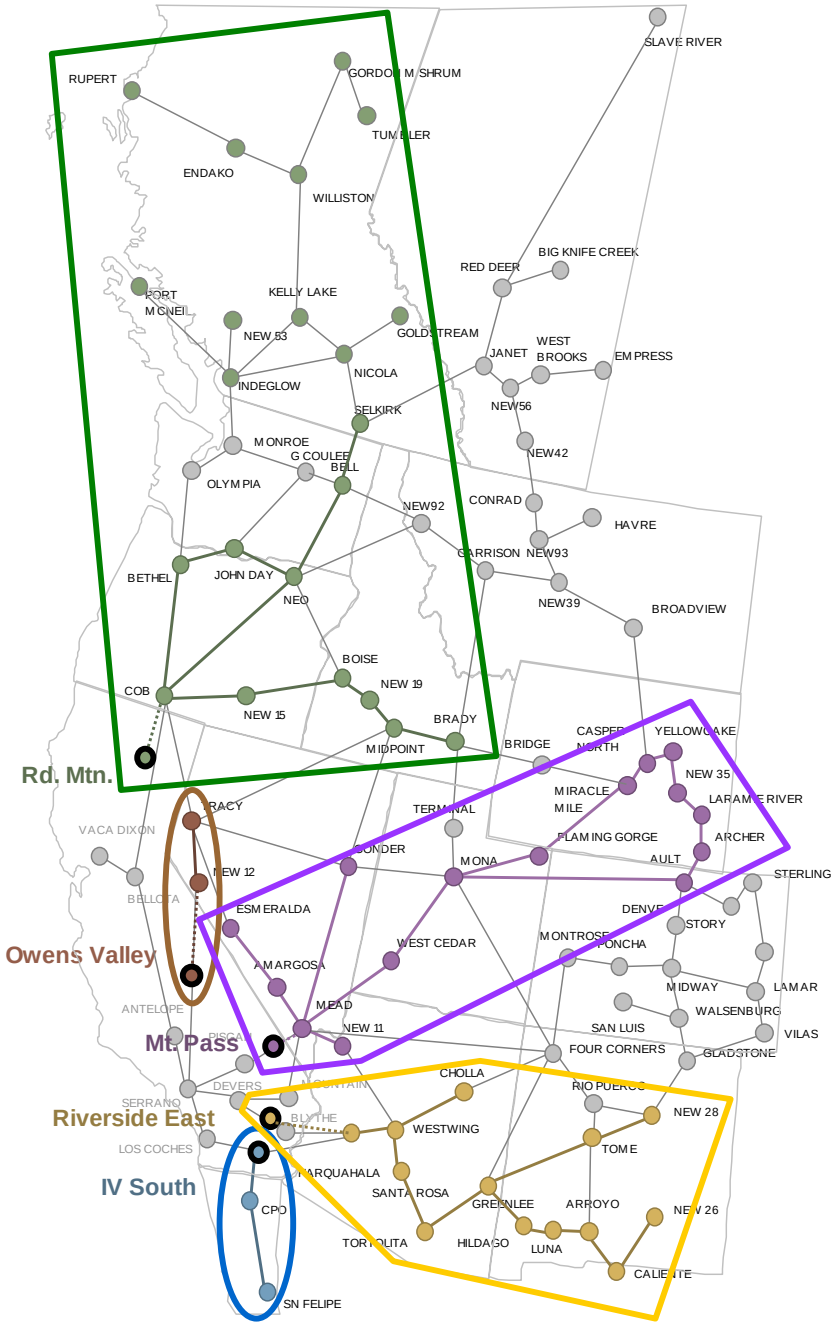

Figure 6-6. Out-of-state Resource Regions and Corresponding Delivery Gateway CREZs.

Note: Gateway CREZs designated for economic calculations only and do not represent a preferred delivery path or delivery point of out-of-state resources.

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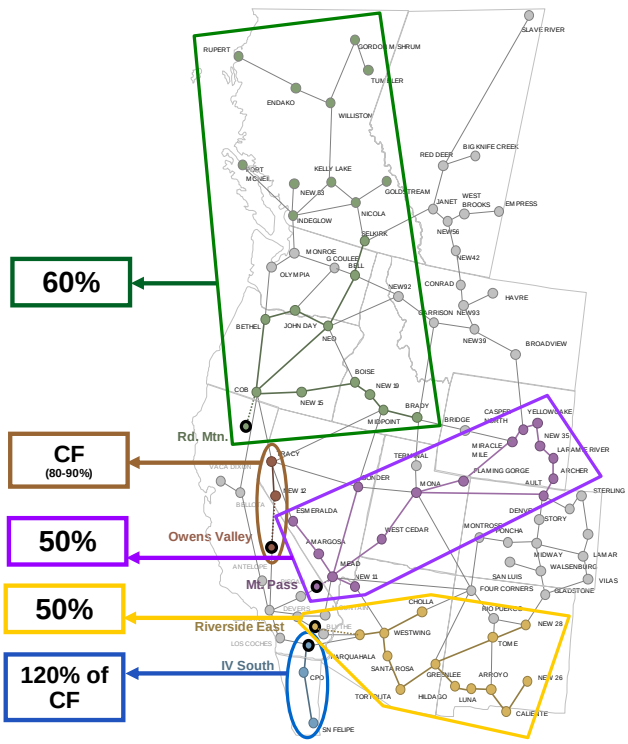
6.5.4 Transmission Line Utilization

Transmission line utilization has a large bearing on the delivered cost of renewable energy. The higher the line utilization, the more energy that high transmission capital costs are spread over, and the lower the cost per MWh. For renewables, line utilization is largely determined by the resource mix of generation projects using that line. The different regions added to the RETI out-of-state resources have distinctly different resource mixes. Figure 6-7 explains the different resource mixes and shows the selected line utilizations for each region. The appropriate factors for transmission utilization were the subject of much discussion within the Phase 2A Working Group. However, the working group ultimately came to agree to use the numbers shown in Figure 6-7 as one possible scenario, while noting that actual line utilization will depend on which resources will ultimately be connected and where they will connect.

- **Pacific Northwest** has lots of existing transfer, blend of resources (including hydro, biomass, geothermal, wind) → use 60%
- **N. Nevada** is largely geothermal → use resource CF (80-90%)
- **WY/UT/S. NV** – additional study has shown overbuild is economic, use 50%
- **AZ/NM** – Mixed wind and solar; additional study has shown overbuild is economic, use 50%
- **Baja** is all wind → use + 120% of resource CF to account for overbuild and dynamic line ratings*



*Average Baja CF = 36%, average utilization = 43%
Note: Actual line utilization depends on which resources will ultimately be connected and where they will connect

Figure 6-7. Selected Line Utilization by Region.

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The utilization assumptions were relatively straightforward for the Pacific Northwest, Nevada geothermal, and Baja wind. The Wyoming/Utah and Arizona/New Mexico regions represent a mix of resources and required more analysis. Due to the variable nature of wind and solar resources, overbuilding generation to increase transmission line utilization was found to be economic. Therefore, the line utilizations used for the Wyoming/Utah and Arizona/New Mexico regions are based on a study of the economic optimum of overbuild in those areas, as described in this further in this section.

It should be noted that there are considerable economic and technical barriers to actually overbuilding generation on a transmission line in order to increase line utilization. In particular, a different method of allocating costs and transmission rights would be required due to the necessity to curtail generation. Also, generation development would likely take place over a relatively long period of time. However, to date no one has built very long-distance transmission lines solely for intermittent resources. Building one would certainly require adjustments to the current system and involve consideration of how to make it the more economically efficient. Therefore, agreement was made to further study the effects of different mixes and overbuilding on line utilization.

Line utilization is not only based on what kind of resources are on a line, but also on where resources connect to the line. It should be noted that in the Arizona/New Mexico region, the resources in Arizona are much closer to California than the resources in New Mexico. Therefore, the actual resource mix on the line will not be as modeled over the entire distance of the transmission line.

Approach

In order to determine the appropriate line utilizations for the Wyoming/Utah and Arizona/New Mexico regions, Black & Veatch performed an optimization study. The basic steps for this study are as follows:

1. Obtain hourly generation data for the resources of interest
2. Combine the generation data for projects within a region in order to create a representative "combined" resource profile
3. Create generation duration curves in order to observe the maximum line utilization for the combined resources
4. Determine the economically optimal amount of overbuild
5. Determine the line utilization at the economically optimal overbuild

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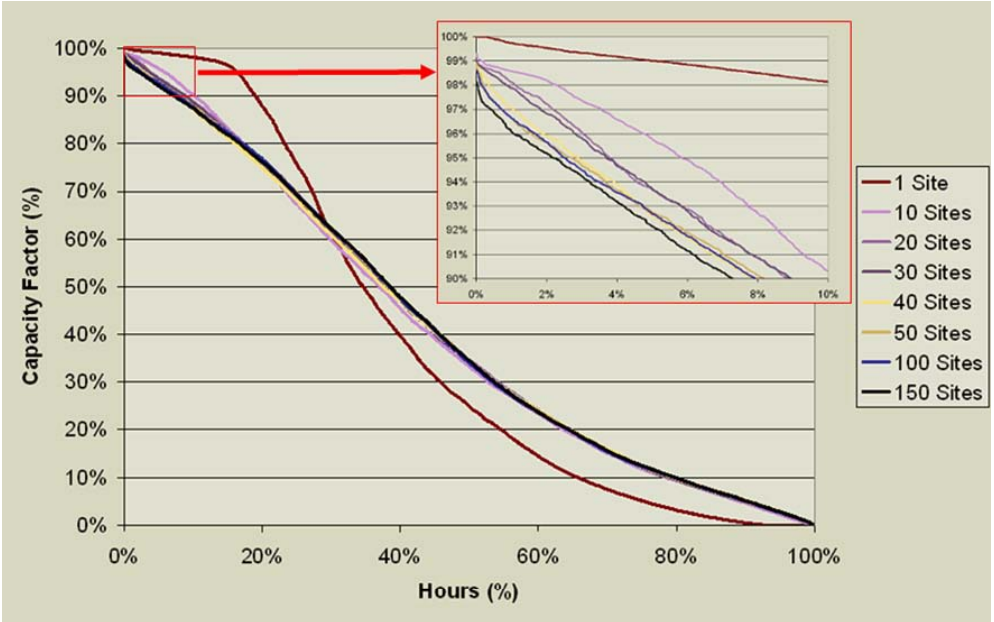

Figure 6-8. Generation Duration Curves for Various Numbers of Wind Sites in Wyoming.

When there is no overbuild, this curve would be equivalent to the load duration curve on a transmission line. In this case (Figure 6-8), using the curve for 50 sites, the transmission line utilization would be using above 90 percent of its capacity about 8 percent of the time. Figure 6-9 and Figure 6-10 show the combined duration curves representing the resource mixes in the two regions.

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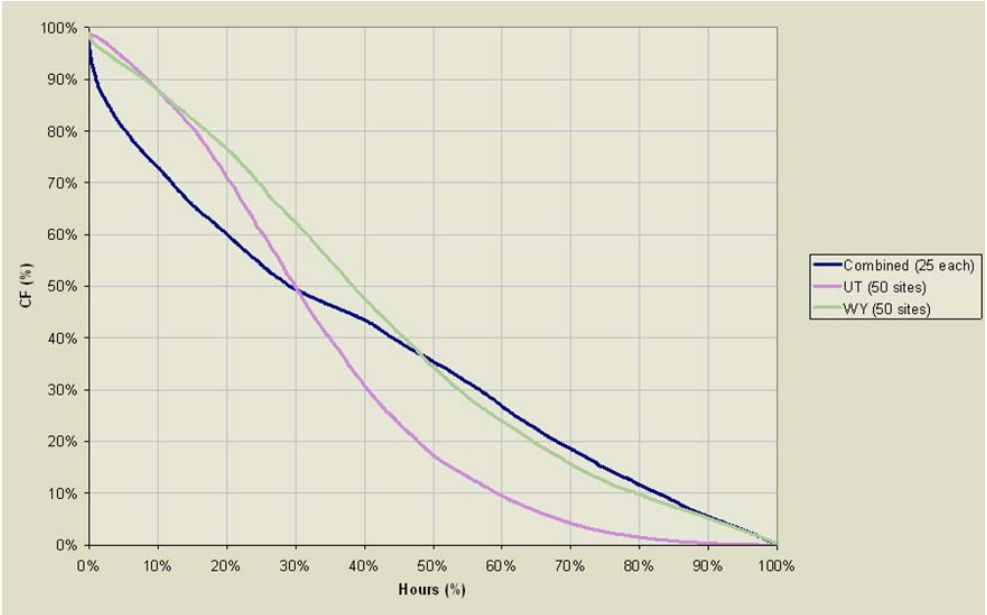

Figure 6-9. Combined Generation Duration Curve for Wyoming and Utah Wind.

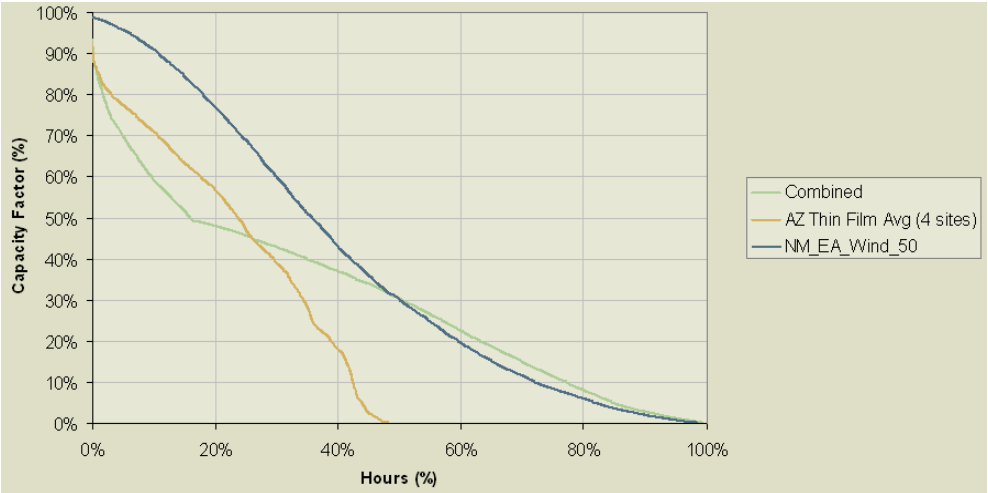

Figure 6-10. Combined Generation Duration Curve for Arizona Solar and New Mexico Wind.

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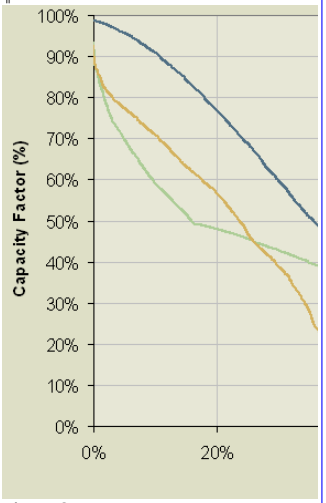

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Table 6-5. Out-of-state Transmission Costs, Delivered to Gateway CREZ.

Out-of-state Area	Transmission Capital Cost ($Million)	Transmission Cost Adder ($/MWh)
Arizona - Northeast	747	$19.81
Arizona - Northwest	285	$7.56
Arizona - South	728	$19.31
Arizona - West	241	$6.38
Baja – North*	226	$7.07
Baja – South*	511	16.18
British Columbia - Central	2,608	$57.64
British Columbia - East	1,699	$37.55
British Columbia - Northeast	2,911	$64.35
British Columbia - North	2,712	$59.95
British Columbia - Northwest	3,110	$68.76
British Columbia - Southeast	1,699	$37.55
British Columbia - Shaped	1,698	$28.77
British Columbia - South	1,885	$41.68
British Columbia - Southwest	1,899	$41.98
British Columbia - West/Central	1,818	$40.19
British Columbia - West	2,096	$46.33
Idaho - East	1,440	$31.83
Idaho – Southwest	1,052	$23.25
New Mexico - East	1,641	$43.54
New Mexico - Southeast	1,956	$51.90
Nevada - East	719	$19.07
Nevada – North	546	$8.52
Nevada – Southwest**	411	$10.91
Nevada - West	713	$18.92
Oregon - Northeast	1,009	$22.31
Oregon - South	236	$5.23
Oregon - West	790	$17.47
Utah - West	559	$14.83
Washington - South	1,065	$23.55
Wyoming - East	2,248	$59.63
Wyoming - East/Central	1,693	$44.92
Wyoming - North	1,977	$52.45
Wyoming - South	1,980	$52.51

* Costs were calculated for individual projects rather than the region. These numbers represent an average of projects in the region
** Costs for wind resources in Southwestern Nevada that can directly interconnect to the CAISO were calculated separately and had an out-of-state cost of $4.01.

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The map in Figure 6-15 shows the transmission costs for each resource area by location. Grey circles represent resources that were not included in the out-of-state analysis as described earlier in this section.

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Major drivers in cost differences between transmission lines include the length of the transmission line, the number of substations required for the pathway taken, and the line utilization. The line utilization that was used depended on the resource mix on the line, which is discussed in detail in section 6.5.4. Therefore, two regions that are located in close geographic proximity to each other may have noticeably different transmission costs because distance is not the only major driver. For example, the transmission cost result for Nevada West was about twice as much as that for Nevada North, even though the transmission pathway is only about 50 miles longer. This is because the Nevada North region is on a transmission route dominated by geothermal resources as opposed to wind and solar for the line used by Nevada West resources. Therefore, Nevada North used a higher line utilization. Also, the pathway taken for Nevada West requires one more substation which adds a significant cost.

Details on the underlying assumptions for out-of-state transmission costs are provided in Appendix B, which was derived from the WREZ Transmission Model

6.6 Out-of-state Results

The following figures summarize the out-of-state resource capacity included in the RETI model based on the updates described above. The economics for the resources are presented in the next section.

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Figure 7-3 is useful in communicating the overall level of uncertainty that can be ascribed to the analysis. There is significant overlap in the uncertainty bands, which indicates considerable uncertainty in identifying a discrete set of clear CREZ priorities. The uncertainty results indicate that many CREZs may be competitive with the most economic CREZs once uncertainty is considered. Assuming all projects are successfully developed, the RETI net short could theoretically be satisfied at a rank cost of about $20/MWh. If costs are at the low end of the uncertainty range, there are many other resources that could be competitive with this range. These additional resources are those shown in Figure 7-3 whose lower uncertainty band drops below the $20/MWh range.

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7.4.2 Sensitivity Analysis – Elimination of Tax Credits

A sensitivity run was made to evaluate the effect that tax credits have on the CREZ rank results. To perform this assessment, the following steps were taken:

- The ability to claim the production tax credit was removed for wind, biomass, and geothermal
- The ability to claim the 30 percent grant / investment tax credit was eliminated for solar, wind, biomass, and geothermal
- As noted in section 3.3 no tax credits were modeled for Mexico and Canada. No changes were made for accelerated deprecation assumptions for any projects, therefore the Mexico and Canadian projects experienced no change during this sensitivity run.

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Figure 7-5 shows the original supply curve from Figure 7-1 (green) with an alternate supply curve removing U.S. tax credits. The alternate supply curve is shown in red. The red supply curve is simply the original curve less the effects of the tax credits. The difference between the two is the impact of the tax credits on the average rank cost for each resource. From this chart it is clear that Mexican and Canadian resources benefit from the higher costs of U.S. projects. However, Canadian resources are still relatively high rank cost. While the economics of all U.S. resources are hurt by elimination of the tax credit, costs for solar are more severely impacted such that the resource loses competitiveness.

The results are summarized in Table 7-5. These can be compared to Table 7-3, which shows the base case results. Additional CREZs that enter the top 100,000 GWh/yr of supply are highlighted in Table 7-5 in yellow.

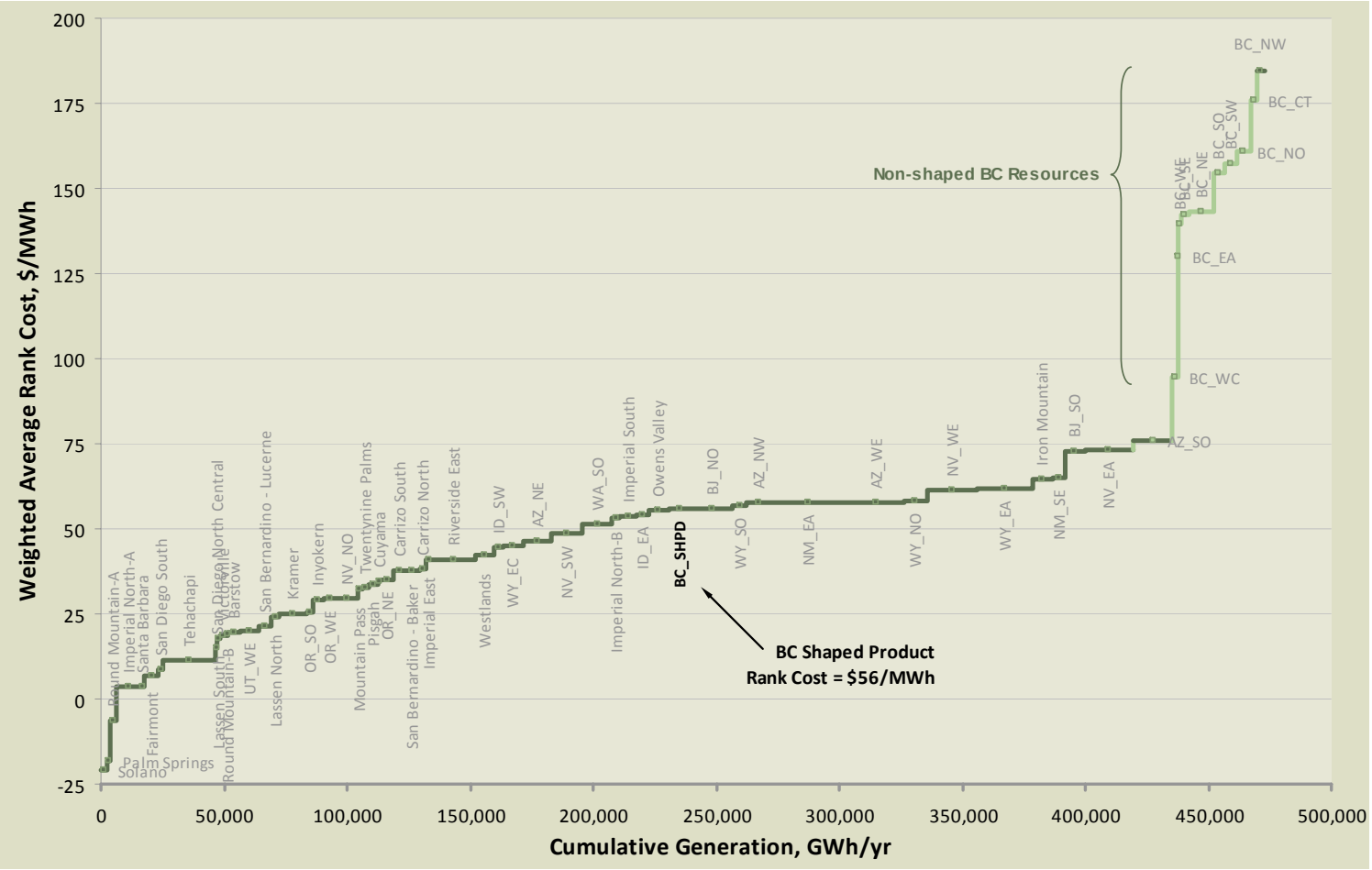

Figure 7-7. BC Shaped Resource Compared to Reference Case Assumptions.

Note: The BC firmed and shaped resource represents a single resource, and therefore is not a weighted average like the other resources

The intent of this exercise is not to specifically promote BC resources as more compelling than other resources. Other regions, including OR, WA, and ID, can likely offer similar shaped products. Rather, the purpose is to show the potential benefits that firming and shaping may provide. From this analysis it appears that these services may reduce the cost of out-of-state resources and provide additional benefits.

It should be noted that the characteristics for firming and shaping BC resources would not necessarily be appropriate for other regions and should not be applied across the board. A large fraction of the electricity in BC comes from hydro, whereas in other regions where fossil fuel resources are used, it may be more likely to provide firming and shaping with the flexible fossil-fueled resources. This is not to say that renewable resources should be excluded in other regions. Methods for dealing with the intermittent management of resources are only recently starting to be developed. For example, although in the past biomass typically has served as a baseload resource, it could transition to being used for firming services when necessary due to its dispatchable nature. Another issue is that resources chosen for firming may have higher incremental costs than the resources selected for the BC analysis. In general, more needs to be understood about the costs and interactions with different resources mixes in order to extend this analysis to other areas. Black & Veatch recommends that such products be further considered in future phases of RETI work.

7.4.5 Sensitivity Analysis – Advanced Solar Thermal Technologies

Solar comprises the largest share of renewable energy potential in California. Technology developers continue to innovate and advance technologies; evidence of this is the recent substantial declines in the cost of solar photovoltaics.[20] RETI assumed dry-cooled parabolic trough technology without storage as the proxy technology for characterizing solar thermal resources. There are numerous advanced solar thermal technologies that could improve on the economic and environmental characteristics of parabolic trough technology. However, to date, costs declines for solar thermal technologies have not been modeled by RETI. In Phase 1 of RETI, stakeholders agreed to not predict changes in technology cost over time. However, several other studies, including work by Black & Veatch, have forecast improvements in solar thermal technology that could lead to lower costs. This sensitivity study explores how reduction in costs for solar thermal could impact the RETI results.

[20] The RETI Phase 1B report had relatively high costs ($7,000/kW) for tracking crystalline photovoltaics; these have since been reduced to around $4,500/kW for this report. RETI Phase 1 also only considered thin film technology as a sensitivity case. Thin film has since been adopted by RETI as a commercial technology, with a base cost of around $3,800/kW. Thus RETI has already recognized a large drop in solar PV costs, but has not considered potential declines for solar thermal.

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RETI Phase 1 identified 1375 potential 20 MW solar PV sites (27,500 MW). Figure 7-12 shows a rank-ordered list of these sites applying the assumptions listed above.[24] The lowest cost sites generally have a rank cost between $10/MWh and $20/MWh under the "best case" assumptions. This range can be compared to Table 7-3, which shows the base case results for the best CREZs up to $30/MWh. This indicates that there is potential for distributed solar to compete with the larger CREZ resources. However, the key question is how much is available under the "best case" assumptions. As discussed earlier, this potential should be better assessed through the Re-DEC project or the CPUC's LTPP proceeding.

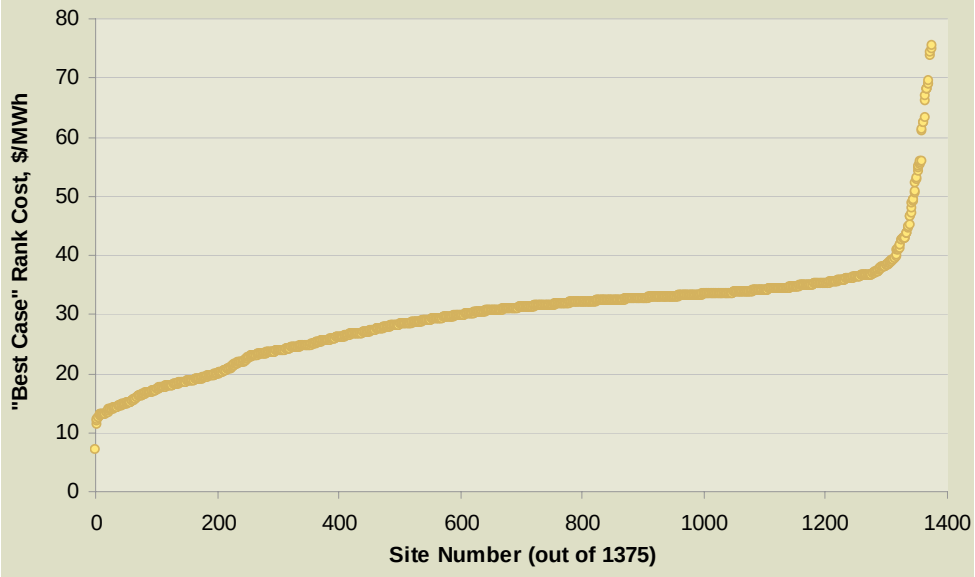

Figure 7-12. Ranked List of Distributed Solar PV Sites.

7.4.7 Sensitivity Analysis – Integration Costs

Due to lack of data and reliable information on integration costs, it has not been included in the rank costs to date for RETI. For this sensitivity analysis, the effect of including a wide range of integration costs was studied to see how it would affect the final results. An integration cost starting at $1.00 was added to all wind and solar

[24] Note that the potential supply in MW or GWh/yr is not shown on the chart because it is not appropriate to assume that all of the sites could be fully developed to accommodate 20 MW while still assuming negligible interconnection and transmission cost. Further analysis is needed to assess the quantity available at various cost points. *If* every site could be developed at a full 20 MW, then the x-axis would go to 27,500 MW.

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projects. This was systematically increased to determine at what point the top-ranked economic and environmental CREZs would change (that is, those in the lower left hand quadrant of Figure 7-13). Even at very high integration cost adders (>$30/MWh) the list of CREZs in the top quadrant does not change. This is because the best environmental CREZs that would rank relatively better with high integration costs were already ranked well economically. The other top environmental CREZs experienced the same effect from integration costs relative to each other. Therefore, although integration costs are certainly important, the current results are robust in their absence.

7.5 CREZ Environmental Rankings

The current environmental scores are shown in Table 7-6 below.

A couple of changes have been made to the environmental rankings. In Solano, the Delta Smelt critical habitat was taken out of the analysis because it was having a significant impact on Solano's environmental score even though the species lives in water which would not be affected by the development of renewables. The Cuyama CREZ was deleted at one point due to economics and lack of commercial interest. This caused issues which prevented it from receiving a new environmental ranking at the same time as other CREZs. This report includes the updated score for Cuyama.

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Table 7-6. California CREZ Environmental Scores.

CREZ	Environmental Score
Barstow	8.8
Carrizo North	8.5
Carrizo South	6.7
Cuyama*	8.2
Fairmont	5.3
Imperial East	5.9
Imperial North-A	3.7
Imperial North-B	11.3
Imperial South	7.9
Inyokern	7.7
Iron Mountain	5.4
Kramer	6.0
Lassen North	7.8
Lassen South	19.5
Mountain Pass	3.6
Owens Valley	5.9
Palm Springs	10.8
Pisgah	4.1
Riverside East	5.2
Round Mountain-A	3.4
Round Mountain-B	8.5
San Bernardino - Baker	6.9
San Bernardino - Lucerne	7.8
San Diego North Central	22.3
San Diego South	5.5
Santa Barbara	9.2
Solano*	6.9
Tehachapi	4.6
Twentynine Palms	4.9
Victorville	8.3
Westlands	5.3
* Unofficial estimates	

Decisions were made by consensus within the Environmental Working Group to the extent possible. However, consensus could not be reached with the wind industry on how the project footprint for wind projects should be defined and applied. The industry concerns are described in previous reports, and their proposed alternate environmental scores are included in Appendix B.

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Deleted: 3.4
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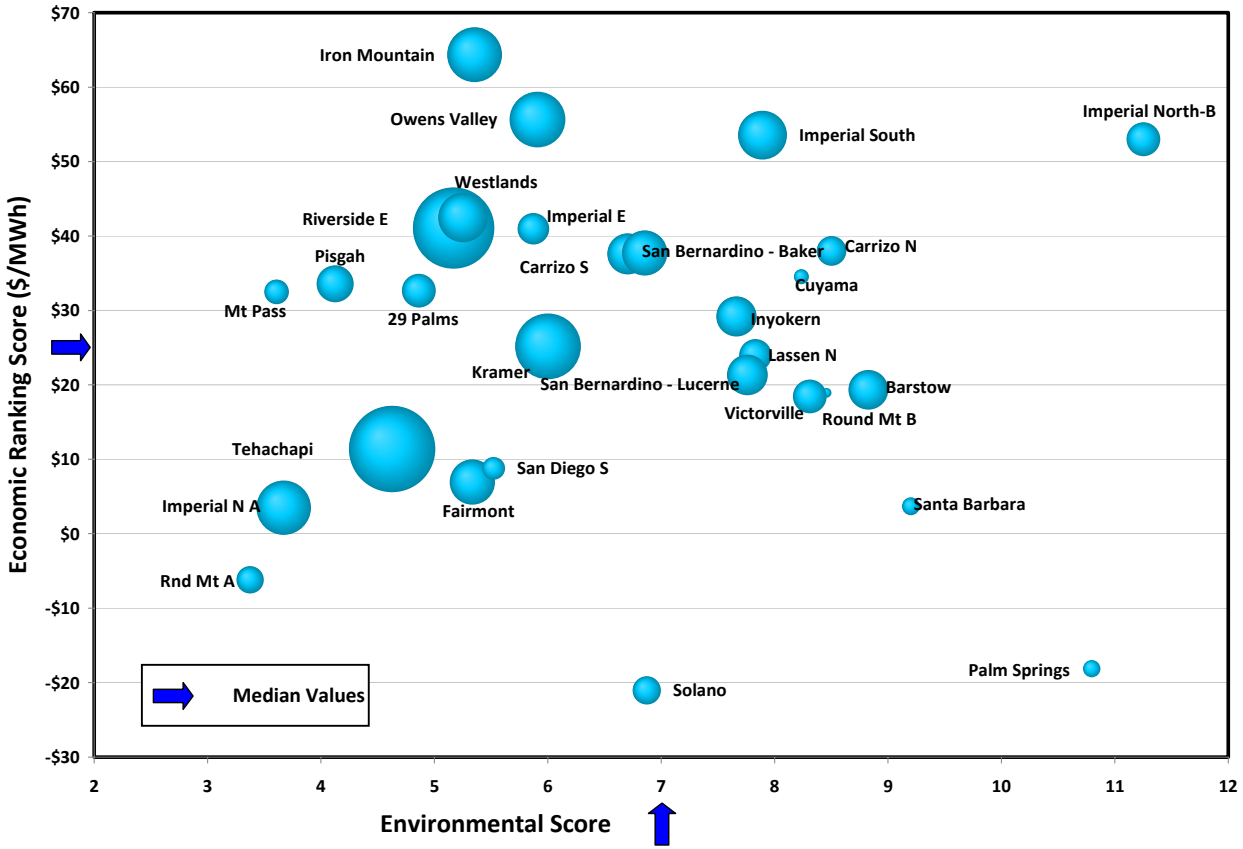

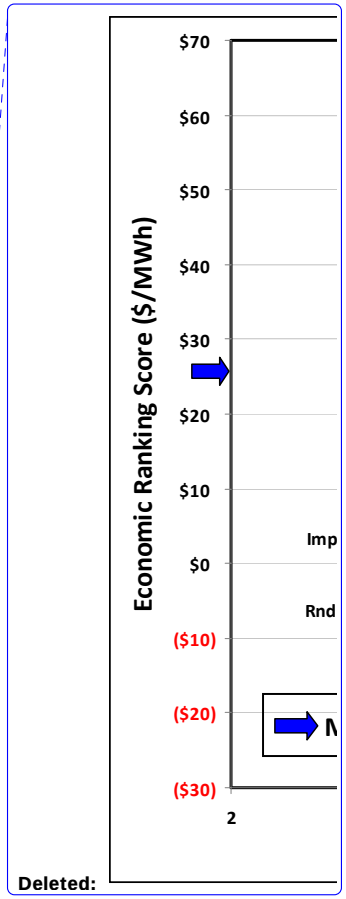

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Notes:

- Areas of the bubbles are proportional to CREZ energy.
- Lassen South CREZ is off the right side of the chart. (Economic Score = 18, Environmental Score = 19.50, Energy = 1051 GWh)
- San Diego North Central CREZ is off the right side of the chart. (Economic Score = 15, Environmental Score = 22.3, Energy = 502 GWh)
- Victorville and Round Mountain-B are coincident

Figure 7-13. CREZ Economic and Environmental Scores Phase 2B, Bubble Chart.

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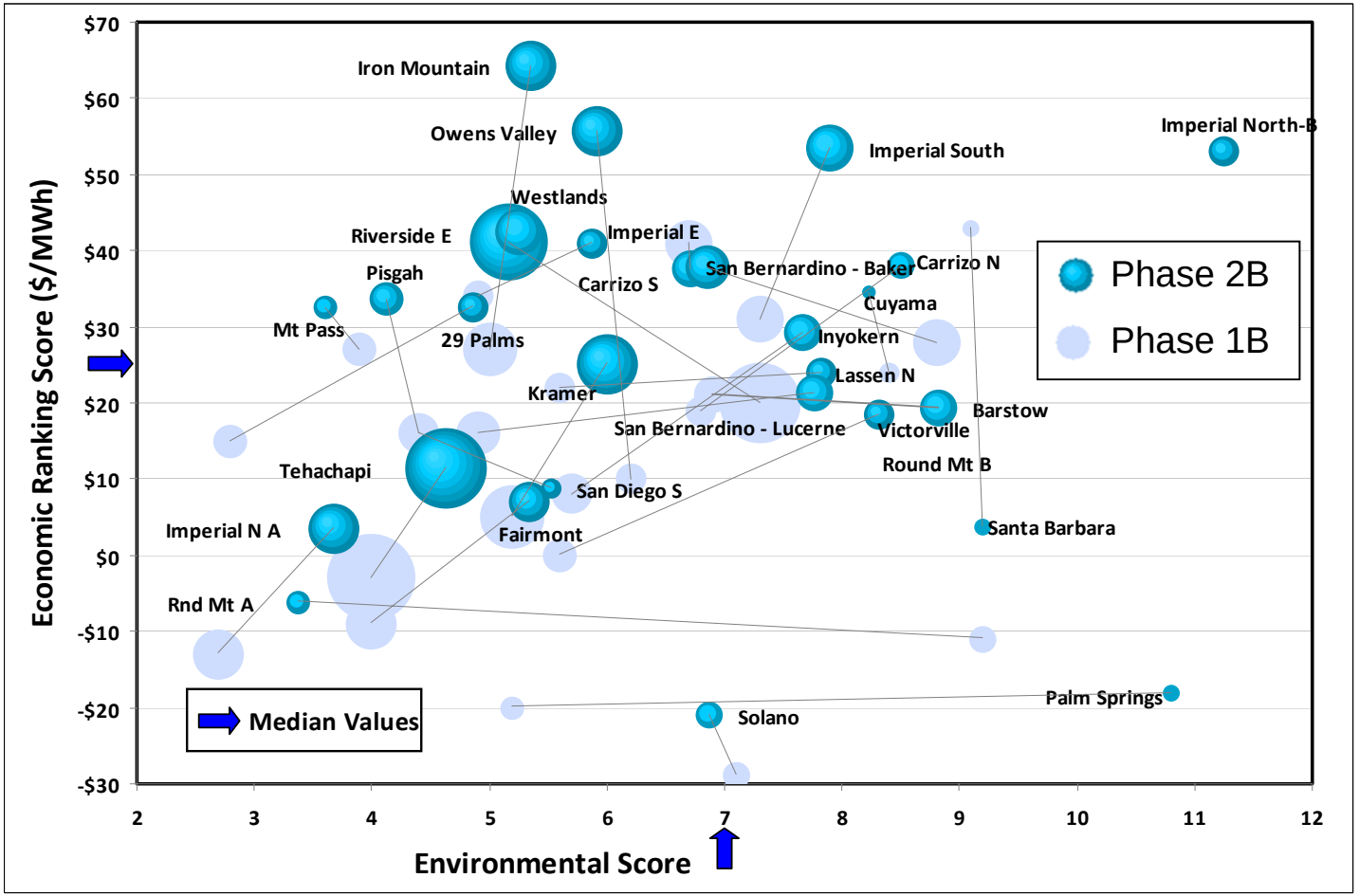

Figure 7-14. Comparison of Combined Economic and Environmental Ranking between Phase 2B and 1B.

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Appendix A. Out-of-state Transmission Information

Table 1. Out-of-state Transmission Costs, Delivered to Gateway CREZ.

Out-of-state Area	Distance (miles)	Number of Substations	Line Utilization
Arizona - Northeast	294	3	50%
Arizona - Northwest	91	2	50%
Arizona - South	260	4	50%
Arizona - West	94	1	50%
Baja – North	62*	2	42%*
Baja – South	178*	3	42%*
British Columbia - Central	1089	8	60%
British Columbia - East	739	4	60%
British Columbia - Northeast	1214	9	60%
British Columbia - North	1140	8	60%
British Columbia - Northwest	1312	9	60%
British Columbia - Southeast	739	4	60%
British Columbia - Shaped	739	4	78.3%
British Columbia - South	782	6	60%
British Columbia - Southwest	789	6	60%
British Columbia - West/Central	749	6	60%
British Columbia - West	886	6	60%
Idaho - East	562	6	60%
Idaho – Southwest	420	4	60%
New Mexico - East	662	6	50%
New Mexico - Southeast	718	10	50%
Nevada - East	305	2	50%
Nevada – North*	220	2	80%
Nevada - Southwest	154	2	50%
Nevada - West	278	3	50%
Oregon - Northeast	448	2	60%
Oregon - South	92	1	60%
Oregon - West	341	2	60%
Utah - West	226	2	50%
Washington - South	452	3	60%
Wyoming - East	887	9	50%
Wyoming - East/Central	712	5	50%
Wyoming - North	803	7	50%
Wyoming - South	853	5	50%

* Transmission characteristics were analyzed for individual projects, these numbers are regional averages

Appendix B. CREZ Environmental Ranking Results Using Wind Industry Formulas

As noted in the RETI Phase 1B Report and explained in Section 2.4 of the RETI Phase 2A Report, there was no consensus regarding how project footprint for wind projects should be defined and applied in assessing potential environmental concern. EWG formulas should not be considered to establish a precedent for evaluating wind project impacts. This is first instance in which the environmental effect of wind projects has been characterized as proportional to the entire project lease area, and the wind industry takes strong exception to such formulas, pointing to the lack of data and systematic study of such impacts. The U.S. Department of Energy 20% Wind Vision report (May 2008) found that wind projects in the U.S. directly disturb on average 2.5%-5% of total project lease area for turbine foundations, access roads and substations.

The following CREZ rankings are based on calculations based on a wind project footprint of 3.5% of the lease area for Criterion #1 (Project Area), Criterion #3 (Sensitive Areas in CREZ), Criterion #4 (Sensitive Buffer Areas) and Criterion #6 (wildlife corridors). The EWG formulas used 3.5% of project lease area for Criterion #1.

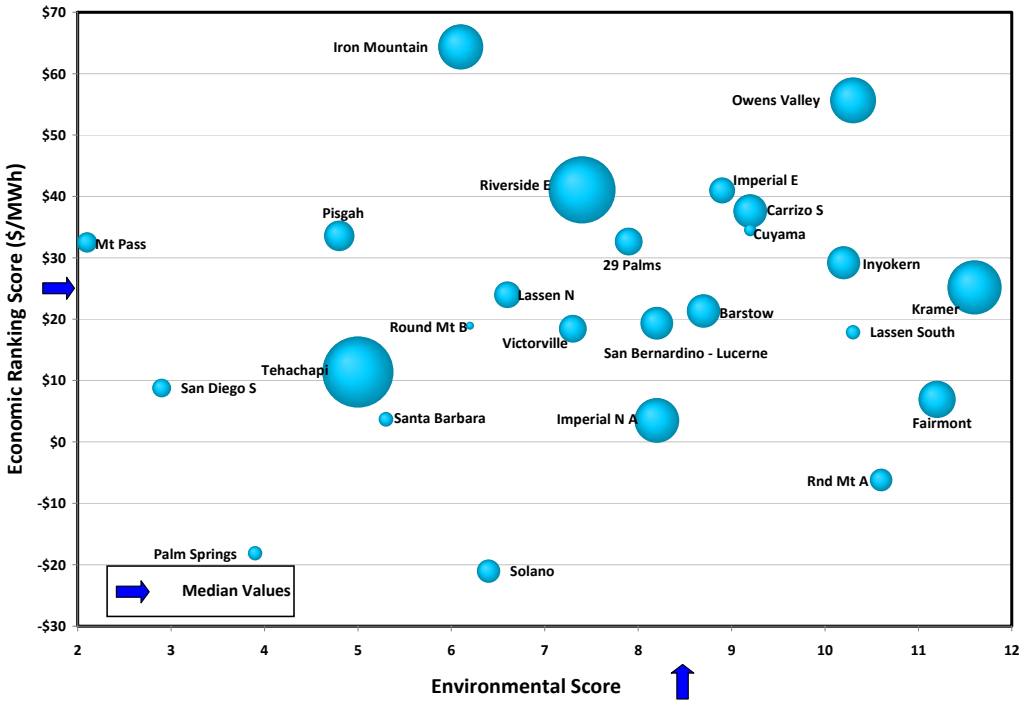
Table 1 compares the CREZ environmental rankings using the wind industry formulas with the EWG formulas.

Figure 1 charts the CREZ environmental rankings using the wind industry formulas with the CREZ economic rankings.

All of the calculations and results reported here have been made independently by the wind industry.

Table 1. CREZ Environmental Ranking Results Using Wind Industry Formulas.

CREZ Name	Annual Energy (GWh/yr)	Score Using Wind Formulas	Score Using EWG Formulas
Barstow	5,362	8.2	8.8
Carrizo North	3,053	13	8.5
Carrizo South	5,823	9.2	6.7
Cuyama	801	9.2	8.2
Fairmont	7,000	11.2	5.3
Imperial East	3,416	8.9	5.9
Imperial North-A	10,095	8.2	3.7
Imperial North-B	3,965	20.7	11.3
Imperial South	8,197	13.1	7.9
Inyokern	5,589	10.2	7.7
Iron Mountain	10,288	6.1	5.4
Kramer	14,784	11.6	6.0
Lassen North	3,595	6.6	7.8
Lassen South	1,051	10.3	19.5
Mountain Pass	2,111	2.1	3.6
Owens Valley	10,651	10.3	5.9
Palm Springs	1,047	3.9	10.8
Pisgah	4,706	4.8	4.1
Riverside East	22,525	7.4	5.2
Round Mountain-A	2,557	10.6	3.4
Round Mountain-B	339	6.2	8.5
San Bernardino - Baker	7,064	15.6	6.9
San Bernardino - Lucerne	5,656	8.7	7.8
San Diego North Central	502	13.2	22.3
San Diego South	1,829	2.9	5.5
Santa Barbara	1,121	5.3	9.2
Solano	2,721	6.4	6.9
Tehachapi	25,432	5	4.6
Twentynine Palms	3,959	7.9	4.9
Victorville	3,899	7.3	8.3
Westlands	8,317	-	5.3



Notes:

- Areas of the bubbles are proportional to CREZ energy
- Imperial South is off to the right side of the chart. (Economic Score = 54, Environmental Score =13.1 , Energy = 8197)
- Imperial North - B is off to the right side of the chart. (Economic Score = 53, Environmental Score = 20.7, Energy = 3965)
- Carrizo North is off to the right side of the chart. (Economic Score = 38, Environmental Score = 13, Energy = 3053)
- San Bernardino - Baker is off to the right side of the chart. (Economic Score = 38, Environmental Score = 15.6, Energy = 7064)

Figure 1. California CREZ Economic and Environmental Scores Phase 2B, Bubble Chart, Using Wind Industry Environmental Formulas.