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June 1, 2011

California Energy Commission
Docket Office, MS-4
Re: Docket #11-IEP-1D Reliability
1516 Ninth Street
Sacramento, CA 95814-5512
docket@energy.state.ca.us

Re: California Energy Commission Docket No. 11-IEP-1D: Comments Related to Staff Workshop on Improving Techniques for Estimating Costs of California Generation Resources

To Whom It May Concern:

On May 16, 2011, the California Energy Commission ("Energy Commission") held a Staff Workshop on Improving Techniques for Estimating Costs of California Generation Resources (the "Workshop") in connection with the 2011 Integrated Energy Policy Report ("2011 IEPR"). Southern California Edison Company ("SCE") presented at that Workshop.

SCE found the Workshop to be very informative and appreciates the Staff efforts to organize the presentation panels and to conduct a review of how the Energy Commission evaluates generation resource costs. As indicated in its presentation, SCE is supportive of changes to the *Comparative Costs of California Central Station Electricity Generation* report ("Cost of Generation Report") that increase the Cost of Generation Report's relevance by including implicit economic costs in addition to explicit accounting costs as part of its levelized cost metric. The inclusion of implicit costs allows for the comparison of levelized costs across different types of resources and can provide users of the Cost of Generation Report with more accurate insight into the relative costs of different generation technologies.

At the Workshop, some participants suggested that including implicit costs required a system simulation. SCE does not believe that a system-wide simulation analysis is necessary to estimate the implicit costs identified in its presentation. Sufficient sources exist to provide useful estimates for these costs. For example, SCE has prepared a modified version of the Cost of Generation model that uses a market price curve based on historic data and renewable integration costs based on a

$/MWh cost metric. The revised model was included on the Energy Commission's website as a part of SCE's presentation.[1]

Further comments on the cost of generation model are attached as Appendix A hereto, including an in-depth discussion of the recommendations that SCE made at the Workshop.

Finally, SCE concurs with the presenters from Energy and Environmental Economics ("E3") and Black & Veatch that resources with widely varying capacity factors should not be compared on an all-in dollar per megawatt-hour ("$/MWh") basis. SCE recommends that the Energy Commission either use the screening curve approach outlined in SCE's presentation or simply group together resources with similar capacity factors.

As always, SCE appreciates having the opportunity to submit comments to the Workshop and to work with the Energy Commission to resolve outstanding issues. Feel free to contact me regarding any questions or concerns.

Sincerely,

/s/ Manuel Alvarez

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[1] *See* SCE Calculations for CEC Cost of Generation Report, May 16, 2011, available at: http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-16_workshop/2011-05-16_SCE_Calculations_for_CEC_Cost%20of_Generation.xlsx

Appendix A
SCE Recommendations on Improving Techniques
for Estimating Costs of California Generation Resources

Since 2003, the California Energy Commission ("the Energy Commission") has released *Comparative Costs of California Central Station Electricity Generation* ("Cost of Generation Report") as part of the bi-annual *Integrated Energy Policy Report* ("IEPR"). The report calculates the "total costs of building and operating a power plant over its economic life converted to equal annual payments, in dollars per megawatt-hour ("$/MWh") and dollars per kilowatt-year ("$/kW-year")."[2] These values are referred to as an asset's "levelized" cost.

SCE appreciates the Energy Commission's efforts to publish transparent estimates of different resource costs. From the Energy Commission staff's presentation, it is clear that a considerable amount of time and effort goes into developing reasonable and unbiased cost estimates for a significant number of different California generating technologies. Such estimates are not readily available publicly and can be valuable to industry professionals. Furthermore, they help to ensure that consistent cost assumptions are used across various regulatory forums.

Another key finding of the Workshop was that the Cost of Generation Report in its current form does not provide an accurate rank-ordering of resource levelized costs for two primary reasons. First, the Cost of Generation Report only captures explicit, accounting costs. For instance, Black & Veatch noted this issue in their presentation on the use of levelized cost as part of the Renewable Energy Transmission Initiative ("RETI"). The Cost of Generation model does not capture implicit, economic costs such as differences in economic life, capacity dependability, time of delivery flexibility, and integration requirements. Also, it compares resources with different capacity factors on a single metric. As highlighted in the presentation by Energy and Environmental Economics ("E3"), this metric varies widely depending on capacity factor assumption and may lead to inappropriate conclusions regarding cost-effectiveness when comparing resources with different capacity factors.[3] As a result of the Workshop, it is clear that the Energy Commission must decide how the next iteration of the Cost of Generation Report can be used.

If the Energy Commission wants to provide comparable estimates of levelized cost for different resources, the analysis must include implicit economic costs in addition to explicit accounting costs, and it must remove the all-in $/MWh comparison of resources with differing capacity assumptions. Though some of these costs are sometimes estimated using system-wide simulation using production cost software and a system perspective, it is possible to estimate these costs using historical data or research studies.[4] To incorporate these implicit costs, SCE makes the following recommendations.

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[2] http://www.energy.ca.gov/2010publications/CEC-200-2010-002/index.html
[3] http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-16_workshop/presentations/Michele_Chait_E3_Cost_of_Generation.pdf (page 23)
[4] Appendix A provides a detailed example of the calculations that SCE presented during the Workshop.

First, compare levelized cost on a real basis. Calculating levelized cost on a nominal basis (i.e. equal values for all years in nominal dollars) will distort reported cost when comparing resources with different asset lives. To illustrate this, consider two resources (see Figure 1) with the same levelized real cost[5] but differing economic lives. Resource 1 will have a lower levelized nominal value despite providing the same value from year to year as Resource 2. If comparing resources on a levelized nominal basis only, a decision maker will mistakenly believe that Resource 1 is a better value when in fact he or she should be indifferent between the two assets because he or she will have to build a new Resource 1 in year 20. The fundamental issue with levelized nominal values is that they do not consider replacement energy and capacity costs. Two possible solutions are to assume generic replacement energy and capacity cost and evaluate all resources on an equal to time frame or to assume that resources will be replaced with the same resource (see Figure 2). The analysis presented by SCE at the Workshop assumed the latter by calculating a levelized real value (i.e. equal values for all years in constant dollars). Using this metric, resources with differing economic lives can be accurately compared.

Second, compare resources on an equal capacity value basis. Comparing resources on a $/kW-year basis, where kW-year is equal to nameplate capacity, makes the implicit assumption that each resource's nameplate capacity is approximately equal to what can be provided to the system at any given moment throughout the year. In other words, a kW of one resource is equivalent to a kW of another resource in terms of value to system reliability. This assumption may not be reasonable in the case of intermittent resources. When comparing two resources with differing capacity value, an unadjusted $/kW-year metric will overvalue the resource with a lower capacity value because it is not responsible for providing the same value as the alternative resource (see Figure 3). Hence, a decision maker will incur an additional capacity cost by choosing Resource 1 that is not reflected in the fixed costs of this resource. To accurately compare Resource 1 to Resource 2, the levelized cost of Resource 1 should reflect the cost of the additional capacity necessary to provide the same reliability to the system.

Third, the levelized cost of intermittent, must-take resources should consider the interaction between their expected generation profiles and associated market prices. The differential between the prices an intermittent resource would optimally choose to dispatch against and its actual generation profile are an opportunity cost associated with owning and operating that resource (see Figure 5). Currently, the Cost of Generation report does not consider this cost when comparing the levelized costs of intermittent resources to those of dispatchable resources. As Paul Joskow noted in his paper presented at a Berkeley Energy Institute Electricity Policy Conference, comparing traditional levelized cost "is seriously flawed because it effectively treats all MWhs supplied as a homogeneous product governed by the law of one price."[6] In the analysis presented at the

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[5] This is also known as a real economic carry charge.

[6] Joskow, Paul. 2010. "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies." Massachusetts Institute of Technology, Center for Energy and Environmental Policy Research Working Paper 1013. http://tisiphone.mit.edu/RePEc/mee/wpaper/2010-013.pdf

Workshop, SCE used an historical market heat rate curve for Southern California Edison's Default Load Aggregation Point ("DLAP") and the CEC's levelized gas price from the Cost of Generation Model to create a forecasted market price curve. Then using historical generation profiles, SCE calculated the differential between the average price a wind and solar resource would face to the optimal price for a given capacity factor. This differential is then added to the levelized cost of the intermittent resource.

Fourth, the levelized cost of intermittent resources should consider integration costs. Intermittent resources require additional ancillary services in order to ensure that load and generation are always in balance. Figure 6 is an example of how variable wind generation can be throughout a month. This variability requires the procurement of additional regulation, ramping, and following resources for integration. Estimates for these additional costs are very rough and are contingent upon technology, location, and the amount of intermittent resources already on the system. There are a number of public sources for wind integration costs that can be relied upon by the Energy Commission, however. For instance, an evaluation of a Pacific Gas & Electric ("PG&E") renewable integration model conducted by Lawrence Berkeley National Laboratory found scenarios in which the model produced results from $13 to $46/MWh. In contrast, the study authors noted outside-of-California analyses generally below $10/MWh.[7] SCE's presentation assumed $15/MWh as an interim value, with the expectation that more refined values will be available in the future.

Finally, the Energy Commission should compare resources on a $/kW-year basis and using a screening curve that controls for the impact of capacity factor levelized cost. Figure 6 and 7 show the results of the analysis presented by SCE at the workshop and are consistent with each other. Figure 6 shows the $/MWh impact of each of the four implicit costs noted above as well as an estimate of greenhouse gas emissions compliance costs. Figure 7 shows the same analysis using SCE's recommended screening curve approach. Levelized $/kW-year is displayed on the y-axis and capacity factor is displayed on the x-axis. Dispatchable resources are represented by a line from zero to one hundred percent capacity factor. Non-dispatchable resources are represented by a single point. This approach more clearly reflects the underlying economics of resource planning. For instance, it is now clear why CTs are often constructed when a resource is only needed to run a few hours out of the year. The cheapest conventional resources create a "screening curve" by which all other resources are benchmarked. Both solar and wind resources should be benchmarked to a CCGT with an equivalent capacity factor according to the screening curve, and both resource technologies are slightly more expensive than a CCGT.

If the Energy Commission decides to keep the scope of the Cost of Generation Report narrow, then the Energy Commission should reconsider the purpose of the report as "comparative." For instance, the current title of report claims to provide comparative costs and the report's abstract states that

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[7] See Andrew Mills, Erik Ela, Bri-Mathia Hode, Brendan Kirby and Michael Milligan, "DRAFT: Review of PG&E Renewable Integration Model and CAISO 33% RPS Analysis," December 21, 2010. Available at http://docs.cpuc.ca.gov/efile/Rulings/128790.pdf

"levelized costs provide a basis for comparing the total costs of one power plant against another."[8] Making changes to the Cost of Generation Report's scope will help to prevent some of the common misconceptions surrounding the appropriate uses for levelized costs that SCE often encounters. The Cost of Generation report will continue to be a useful document, but it is important for users of the report to understand that the levelized costs presented in the Cost of Generation report do not reflect all of the underlying economics that drive resource choices.

Regardless of scope, SCE makes the following recommendations.

- Modify summary tables to isolate the impact of capacity factor on levelized cost. This would address concerns raised by E3, Black and Veatch, and SCE.
- For technologies that have a variety of nameplate capacities, consider multiple categories to account for economies of scale.
- For technologies incorporating energy storage in the design (e.g., solar thermal, pumped storage hydroelectric), identify a process for excluding these capital and O&M costs from the generation technology costs, or provide separate categories for technologies that include energy storage.
- Consider issuing interim partial updates to the report for technologies with the potential for significant changes in any of the cost components (e.g., solar and wind).
- Consider including a section in the report that provides emerging data for new technologies, such as new generation nuclear and fuel cells.

[8] Ibid.

Finally, SCE thanks the Energy Commission for engaging stakeholders in a thoughtful process aimed at gaining a deeper understanding of what information the Cost of Generation Report currently does and does not provide. SCE encourages the Energy Commission to think carefully about how the next iteration of the Cost of Generation will be conducted and looks forward to commenting on the draft report.

Example Calculation: On-Shore Wind Class 3/4

Economic Life Adjustment

A)	Total Levelized Revenue Requirement ($/kW)	$2,469.2	
B)	Nominal Discount Rate	7.70%	
C)	Economic Life (years)	30.0	
D)	Levelized Nominal Cost ($/kW-yr)	$213.07	=-PMT(C, B, A)
E)	Real Discount Rate	6.04%	
F)	Levelized Real Cost ($/kW-yr)	$180.1	
G)	Economic Life Adjustment ($/kW-yr)	($32.9)	=-PMT(C, E, A)

Capacity Adjustment

I)	Levelized Real Capacity Cost ($/kW-yr)	$192.1	
	CEC Levelized Fixed Costs of Combustion Turbine - 49.9 MW		
H)	Net Qualifying Capacity	11.40%	
J)	Capacity Adjustment ($/kW-yr)	$170.2	= I * (1 - H)

Intermittent Opportunity Cost

K)	Capacity Factor	37%	
L)	Average $/MWh above 37th Percentile	$82.5	
M)	Average $/MWh below 37th Percentile	$58.3	
	Based on SCE Day-Ahead DLAP Market Heat Rate and CEC Levelized Gas Forecast		
N)	Percent Production above 37th Percentile	38%	
O)	Percent Production below 37th Percentile	62%	
P)	Weighted Average Price ($/MWh)	$67.4	
Q)	Opportunity Cost ($/MWh)	$15.1	= L - P

List of Figures

Figure 1

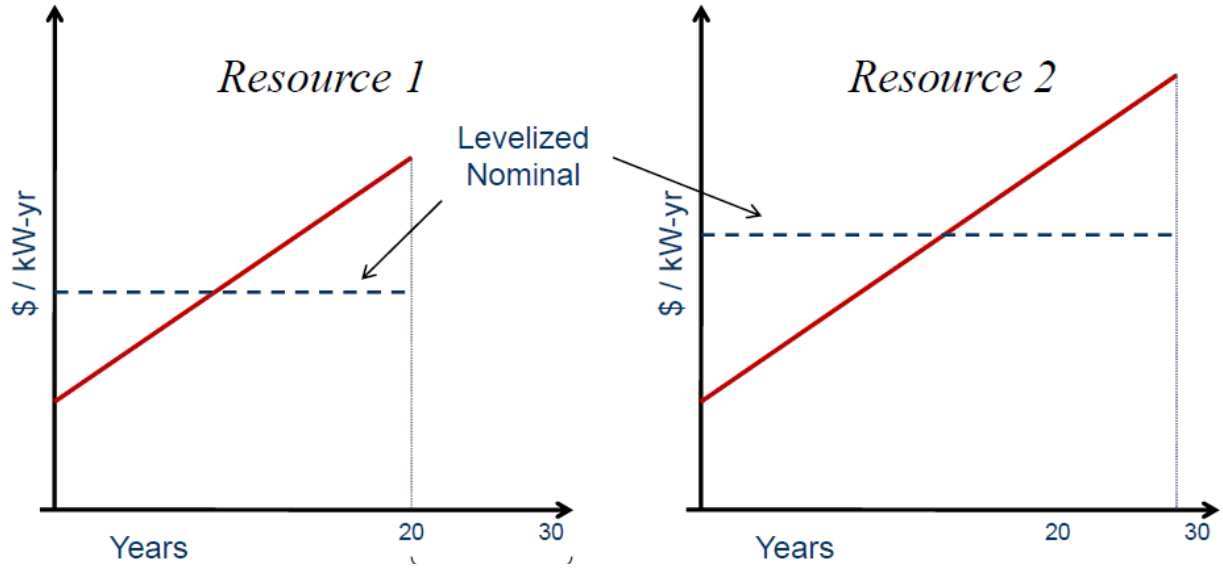


Figure 2

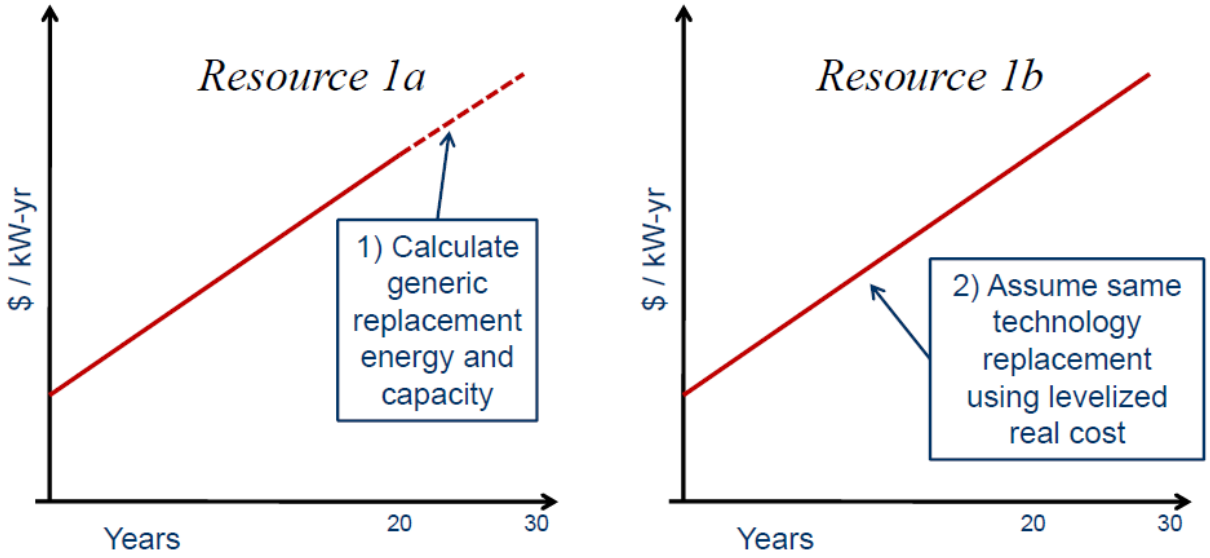


Figure 3

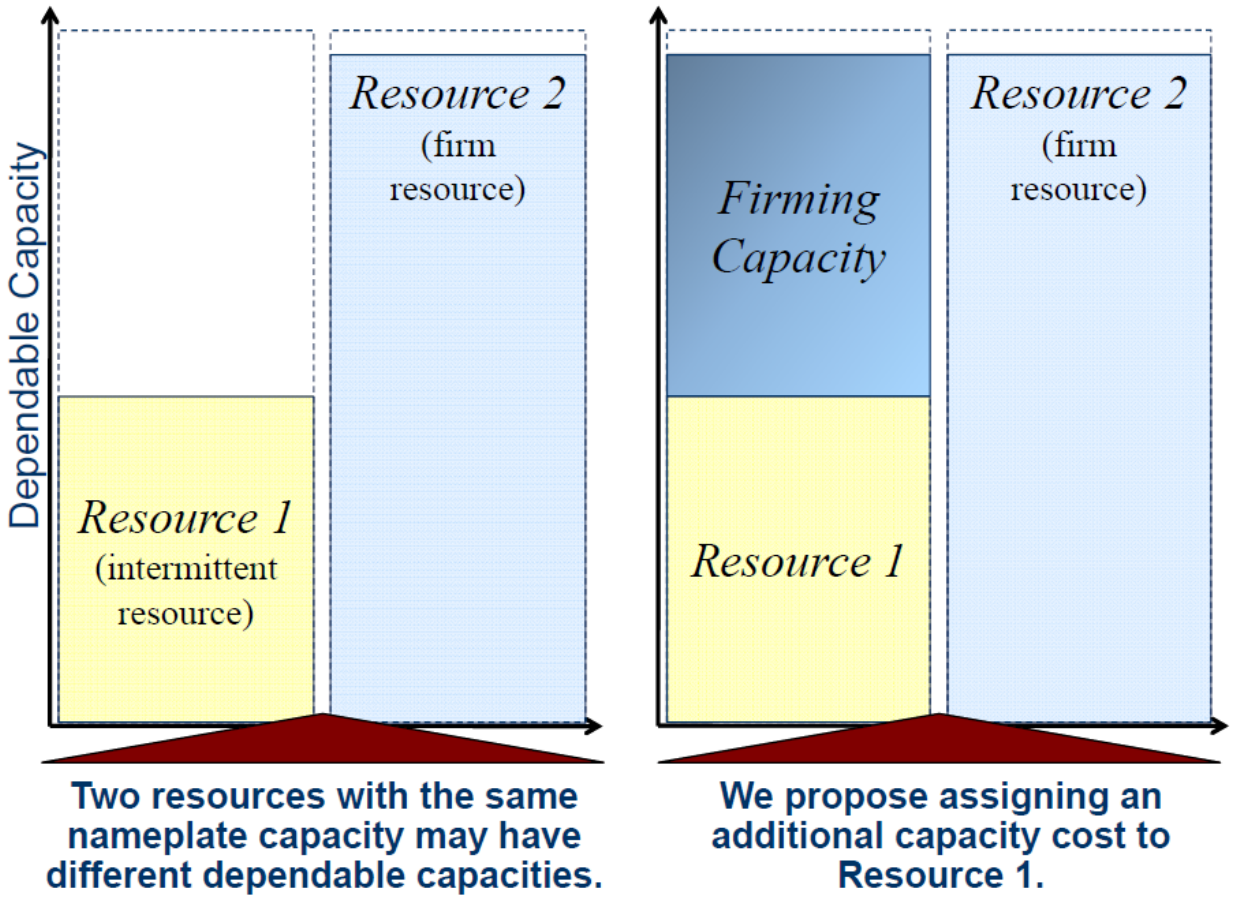

Dependable Capacity
Resource 2
(firm
resource)
Resource 1
(intermittent
resource)
Two resources with the same nameplate capacity may have different dependable capacities.
Firming Capacity
Resource 2
(firm
resource)
Resource 1
We propose assigning an additional capacity cost to Resource 1.

Figure 4

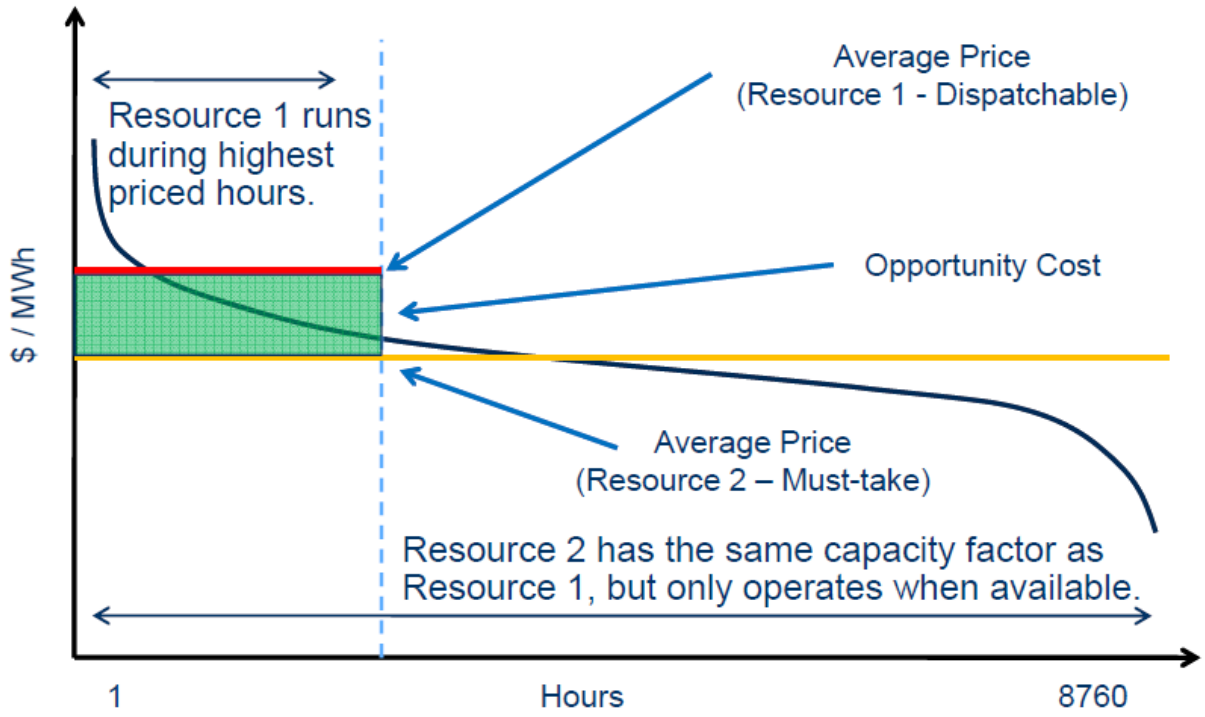


Figure 5

Example

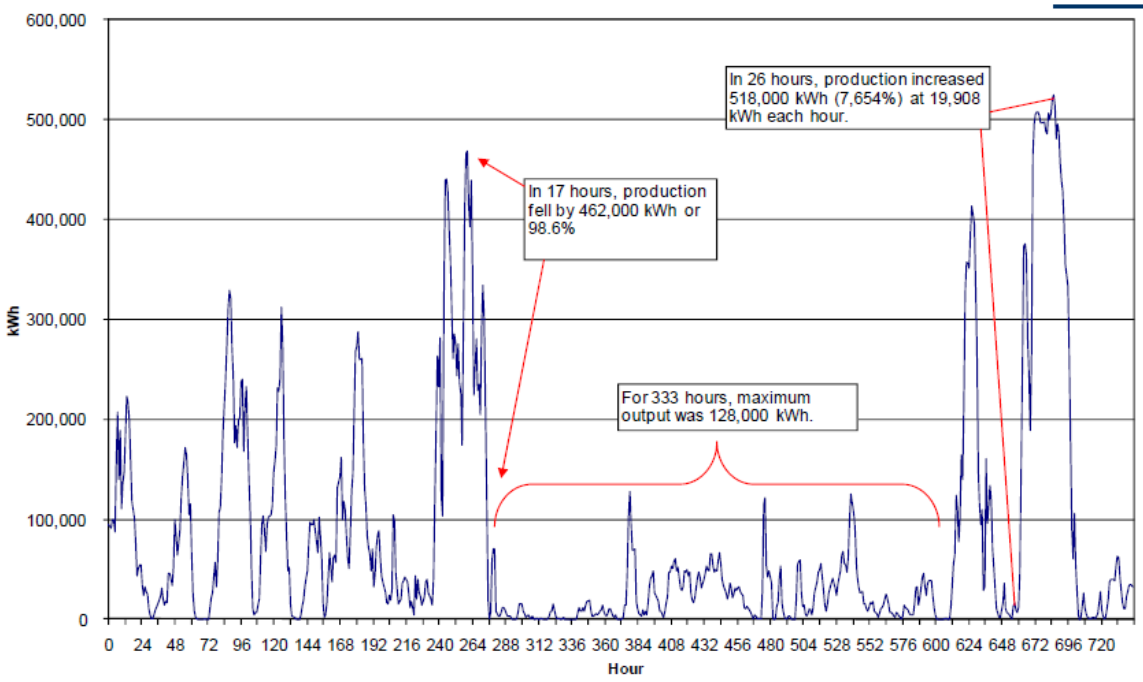

Tehachapi Hourly Generation January 2005
600,000
500,000
400,000
300,000
200,000
100,000
0
kWh
0 24 48 72 96 120 144 168 192 216 240 264 288 312 336 360 384 408 432 456 480 504 528 552 576 600 624 648 672 696 720
Hour
In 26 hours, production increased 518,000 kWh (7,654%) at 19,908 kWh each hour.
In 17 hours, production fell by 462,000 kWh or 98.6%
For 333 hours, maximum output was 128,000 kWh.

Figure 6

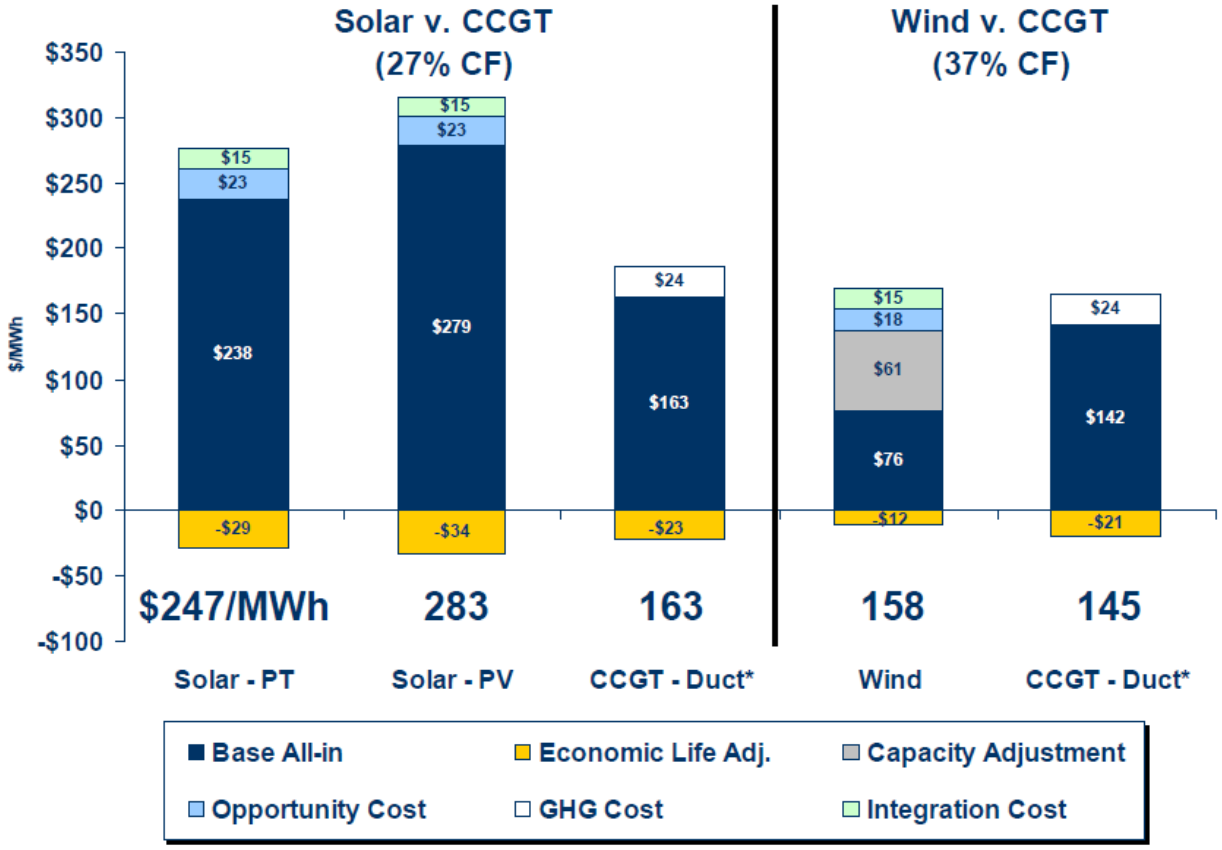
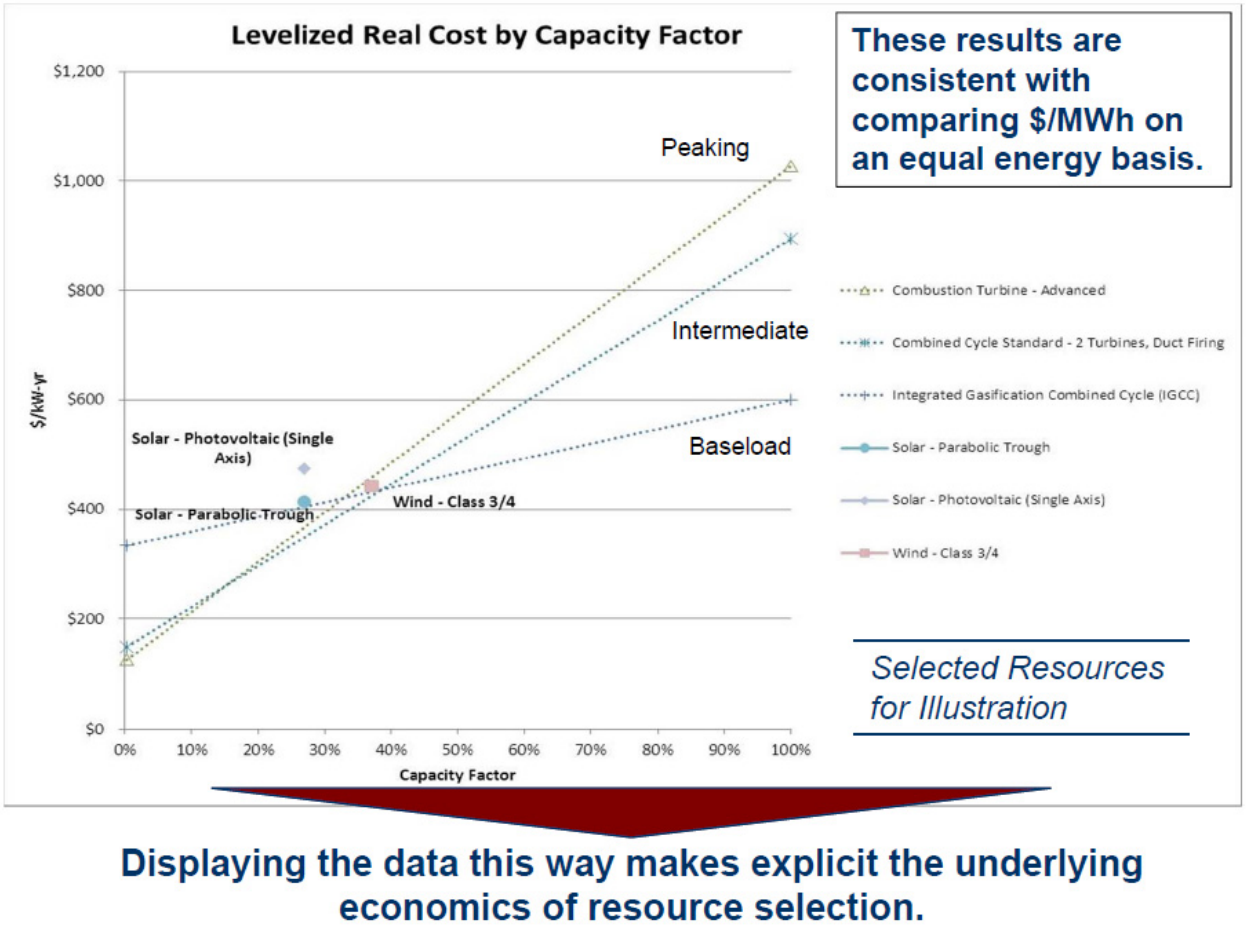

Solar v. CCGT
(27% CF)
Wind v. CCGT
(37% CF)
$350
$300
$250
$200
$150
$100
$50
$0
-$50
-$100
$/MWh
$15
$23
$238
-$29
$15
$23
$279
-$34
$24
$163
-$23
$15
$18
$61
$76
-$12
$24
$142
-$21
$247/MWh
283
163
158
145
Solar - PT
Solar - PV
CCGT - Duct*
Wind
CCGT - Duct*
Base All-in
Economic Life Adj.
Capacity Adjustment
Opportunity Cost
GHG Cost
Integration Cost

Figure 7


Levelized Real Cost by Capacity Factor
These results are consistent with comparing $/MWh on an equal energy basis.
$1,200
$1,000
$800
$600
$400
$200
$0
$/kW-yr
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Capacity Factor
Peaking
Intermediate
Baseload
Solar - Photovoltaic (Single Axis)
Solar - Parabolic Trough
Wind - Class 3/4
Combustion Turbine - Advanced
Combined Cycle Standard - 2 Turbines, Duct Firing
Integrated Gasification Combined Cycle (IGCC)
Solar - Parabolic Trough
Solar - Photovoltaic (Single Axis)
Wind - Class 3/4
Selected Resources for Illustration
Displaying the data this way makes explicit the underlying economics of resource selection.