IRES[1] Network Document Review

Subject: Simulating the Value of Concentrating Solar Power with Thermal Energy Storage in a Production Cost Model[2]

Relevance to IRESN[3]: IRESN's predecessor organization, Cal-IRES, organized a public advisory process for a study to determine the value to the California electric system of concentrating solar power (CSP) plants that include thermal energy storage (TES) capacity. The study was initiated by the National Renewable Energy Laboratory in the second quarter of 2011 in order to evaluate the economic benefits of thermal energy storage coupled to concentrating solar (thermal) power (CSP) plant in California. An interim result is now available, which exercises relevant methodologies using a test case involving an assumed CSP plant deployed in Colorado.

Resource Integration Context: To the extent that the California grid includes flexible centralized generation resources, it will be able to accommodate higher levels of cost-effective renewable building and community based electricity supply. Foreseeable and cost-effective sources of flexibility are load following hydroelectric and natural gas fueled thermal plants and CSP plants that include TES. Load following hydroelectric capacity is unlikely to increase, and reduced reliance on natural gas-based generation may become important for economic or policy reasons. So, it is important to know how the capital cost of a TES-enabled CSP power plant fleet compares to the present value of avoided costs of the fleet's operation over its economic life.[4]

Report Content: The report describes the simulation of grid operations in a test system of two balancing areas located primarily in Colorado that include hypothetical percentages of CSP, solar PV and Wind. Projected generation characteristics and fuel prices in 2020 were assumed for two Renewable Energy (RE) cases—a low RE scenario where wind and solar provide 13% of the annual generation and a high RE scenario where wind and solar provide 34% of generation, including 8% from PV. Total value of equal 1.4% energy contributions to 2020 supply from PV, CSP/TES, CSP w/o TES and a generic base-loaded plant was computed as the sum of operational value and capacity value. Special cases explore the sensitivity of avoided energy cost results to storage "hours" and natural gas price in 2020.

Report Conclusions: Under 2020 assumptions the operational value of TES is about $6.6/MWh over a plant without TES (at low RE penetration). In the high RE Colorado test system the operational value is about $16.7/MWh over a plant without TES. These figures are consistent with Figure ES-2 from the report (page 3), which compute a total value by including estimated "capacity costs" that are theoretically avoided as a result of plant operation.

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[1] Integrated Resources Enabling Sustainability (IRES)
[2] Paul Denholm and Marissa Hummon, November, 2012. http://www.nrel.gov/docs/fy13osti/56731.pdf
[3] The IRES Network
[4] For a comprehensive overview of CSP power plants, projects, industry status and benefits, see "The A-B-Cs of CSP", Frank Wilkins, June, 2012:
http://iresn.org/Resources/Documents/the-a-b-cs-of-CSP-6-2012.pdf

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Significance: The report will be of special interest to transmission system operators and project developers in Colorado, because it demonstrates a methodology that uses off-the-shelf commercial software to quantify CSP-related operational and capacity values for a specific utility balancing area or ISO jurisdiction. It also provides insight into the impact of foreseeable percentages of variable renewable resources on grid operations, evolutionary directions for generation mixes that include variable resources, and relative values of various costs avoided by operation of variable resources with and without energy storage. The project is significant in providing validation and experience with the modeling software that may be used in the future to evaluate operational CSP economics in larger systems where substantial CSP deployment is already committed, e.g. California.

IRESN Perspective: The current generation of CSP plants being deployed in California are marginally cost-effective on an avoided energy production basis. Further deployment of CSP beyond the currently active projects is not a given. The next generation of CSP plants could incorporate TES, because it is a commercially demonstrated option. Such plants would have the flexibility to deliver electricity reliably during peak periods when avoided generation costs are high. TES has a minor or neutral effect on levelized CSP energy production costs but a significant benefit to overall grid operational economics. The economic benefit would be enhanced by the operational flexibility to accommodate a higher percentage of variable renewable sources in California's generation mix. Policies to capture this benefit will have to be justified in quantitative economic terms. Therefore, analyses to quantify the economic benefits of CSP/TES in a California grid context are timely and important.

The subject report quantifies the operational economics of possible future variable renewable deployment in Colorado. It validates the intuitive assumption that a single CSP plant with TES would deliver more economic benefits in 2020 than alternative base-loaded or otherwise non-dispatchable plants delivering the same amount of annual electricity in at least one state where CSP deployment might occur. Additional sensitivities[5] should be explored if funding is available for further work, including:

- How the value of a storage-coupled CSP plant located in California would vary over its economic life under different generation mix assumptions, and what would be the present value of the plant's avoided cost stream over its years of expected operation.
- How the value would change if an entire fleet of CSP plants were deployed and constitute a significant share of a regional generation mix
- How the plant's or fleet's annual economic value would change over the its economic lifetime and what would be the present value of capacity and operational values calculated for each year of the relevant investment amortization period
- The extent to which the economic value of the variable portion of a generation mix is limited at renewable penetrations > 33% targeted (and likely to be met) in California within 10 years

[5] LBNL addresses some of these sensitivities in a California context in a recent report. Full report: http://eetd.lbl.gov/ea/ems/reports/lbnl-5445e.pdf. PowerPoint summary: http://eetd.lbl.gov/ea/ems/reports/lbnl-5445e-ppt.pdf

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- Likewise the extent to which deployment of CSP with TES would make such higher penetrations economically feasible or desirable[6]
- The effects on value of alternative, preferably expert, assumptions regarding long term natural gas price escalation

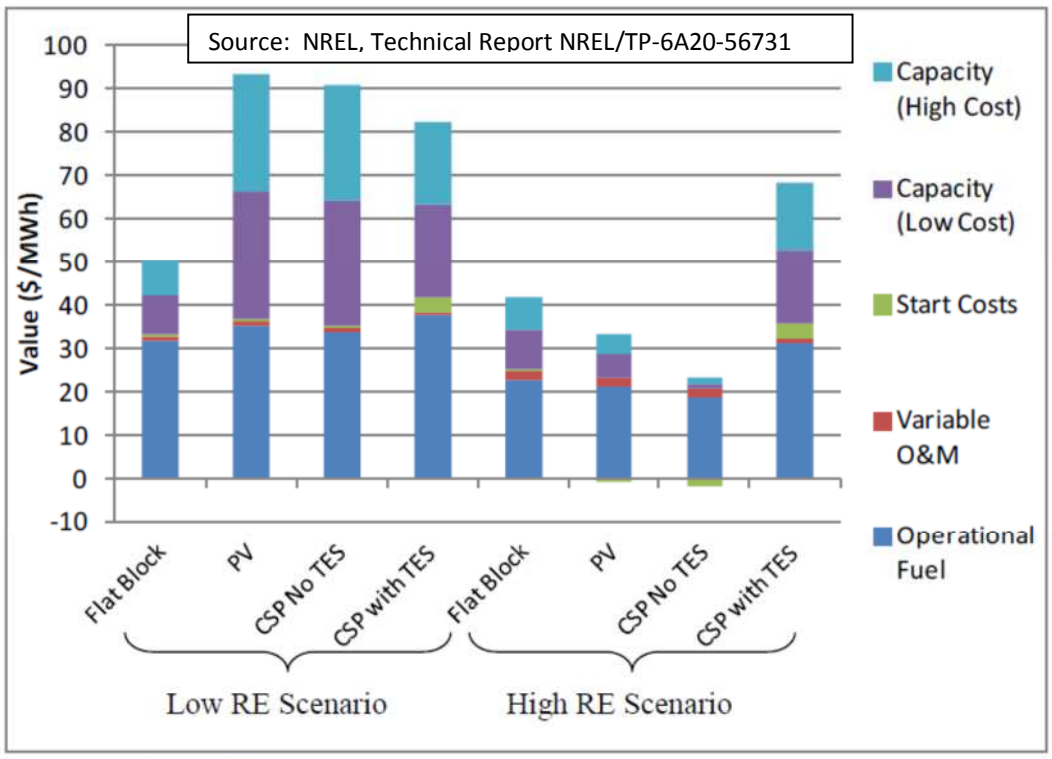

Figure ES-2. Total value of generation sources in the test system

[6] See http://www.nrel.gov/docs/fy12osti/52978.pdf for a preliminary analysis of using dispatchable CSP plants to avoid PV curtailments at high solar penetration levels. Economic benefits are not evaluated.