Hybrid Storage Technology

Executive Summary

Initial assessment of the greenhouse gas reduction and economic savings from Hybrid EGT® adoption in California

July 2018

Gridwell CONSULTING

1 Executive Summary

Hybrid storage technology was pioneered by General Electric and Wellhead Power Solutions in 2016,[1] leading to the co-development of an electric gas turbine (EGT®). This technology was put into commercial use by Southern California Edison (SCE) in Q1, 2017. SCE energized two Hybrid EGT® systems, which integrated existing 50-MW combustion turbines with new 10-MW/4.3 MW-hour battery energy storage systems (BESS). SCE recently presented to the California Public Utilities Commission (CPUC), and then publicized, the lowered emissions and increased reliability that resulted from these Hybrid EGT® installations, as summarized below.[2]

- *Without* any fuel consumption—provision of 50 MWs of operating reserves[3], primary frequency response, voltage support, and the potential for black-start services.
- *With* fuel consumption—provision of instant-peaking energy for local contingencies and high-speed regulation.
- *Overall*—increased ancillary service participation (primarily spinning reserve and much higher frequency response use than before hybridizing), lower fuel gas use, lower emissions, higher capacity use, and higher market revenues.

Given these very positive initial findings, Wellhead has asked Gridwell Consulting to take the next step and independently evaluate greenhouse gas (GHG) reduction and potential economic savings to be gained from additional hybridizing of the California gas fleet. This study is intended as the first step toward understanding whether there are such benefits, before moving forward with more specialized modeling that can accommodate the unique characteristics of hybrid storage and the hybridizing option.

In general, Gridwell finds obvious benefits to hybridizing at least a subset of the existing gas fleet. These expected benefits are consistent with SCE's initial experience with the Hybrid EGT®s. This suggests that there are clearly benefits to additional hybridizing and earlier procurement of hybrid storage resources may produce additional benefits. Furthermore, we consistently verified several key findings across multiple evaluation methods:

- The optimal use for a hybrid storage resource is for spinning and regulation reserves, as well as quick response to emergency or near-emergency grid energy needs.
- Emission savings come primarily through fleet-wide re-dispatch, as hybrid storage resources take on more ancillary services and other resources can shut down or operate at their most efficient use. Secondary emission savings come from the battery responding instantaneously to unexpected, short-duration energy needs, without the resource needing to burn fuel.

[1] This report is sponsored by Wellhead.
[2] Notice of SCE of ex parte communication with the office of Commission President Michael Picker; April 13, 2018.
[3] Operating reserves refer to both spinning and non-spinning reserves.

- Early procurement of Hybrid EGT®s – in 2018, 2019, and 2020 – should reduce annual emissions even more than procurement after 2022 due to higher near-term ability to displace gas resources.
- Enabling storage hybridizing as part of the storage target leads to significant load payment savings by reducing fleet operating costs and storage build-out costs as California increases renewable energy on the grid to meet its renewable and GHG target.

Each evaluation method (described below) considers the potential benefits of hybridizing within the context of California GHG reduction and renewable resource target. California is in the process of reducing its reliance on natural gas resources in order to reduce GHG emissions and operate primarily with renewable energy and storage capacity. The movement away from natural gas limits the pool of potential gas plants to hybridize because a basic tenet of California resource planning is that natural gas plants not needed for reliability purposes should retire.

Additionally, Gridwell had to consider the fact that hybrid energy storage technology is only commercially in use to hybridize General Electric LM6000 combustion turbine engines. Currently, there are only theoretical benefits to hybridizing larger gas resources, such as combined-cycle plants. You will find a summary of the quantity of combustion turbine located in the California ISO that could benefit from hybridizing in a later section. This is a high level, total quantity that Gridwell recommends be further refined with additional analysis and modeling.

Gridwell uses three distinct methodologies to evaluate the initial potential for hybrid storage technology: (1) an analytical assessment of long-term GHG reduction and economic benefits using the capacity expansion model RESOLVE, (2) the conceptual and observed benefits of existing Hybrid EGT® resources in service, and (3) a review of previous PLEXOS modeling work done on hybrid storage resources prior to their activation.[4]

Gridwell applied the latest RESOLVE model used in the CPUC integrated resource planning (IRP) process to explore the long-term economic benefits and potential GHG reduction of installing additional Hybrid EGT®s. Gridwell modified the model to allow the Hybrid EGT®s to be considered as a resource option. Because the model would need additional, more significant optimization changes to perfectly model hybrid storage, the RESOLVE modelling results should be taken as directionally indicative, rather than an exact prediction of the future. The enhancements to the model that allow hybrid storage as a part of California's IRP yielded the following model results:

[4] Gridwell uses the following nomenclature: the technology used to combine natural gas plants and Battery Energy Storage Systems is "hybrid storage technology"; the commercialized and installed technology by SCE are the "Hybrid EGT® units" and any potential or theoretical hybrid units are "hybrid storage resources."

- Hybrid storage resources are part of the optimal resource mix under all planning scenarios considered, providing a significant proportion of required spinning reserves.
- Hybrid storage resources provide additional cost savings and GHG reductions if the model is forced to procure hybrid resources in the near-term.
    a. Hybrid Storage resources enable California to reach its GHG target at a lower cost, *ceteris paribus*. **Based on the model results, each hybrid storage resource can reduce GHG emissions by almost 30,000 tons of CO_2 per year.**
    b. Hybrid storage resources significantly reduce revenue requirements over the long-run. The model results show that under the existing storage target, **each hybrid resource has the potential to reduce ratepayer costs by a net present value of over $26.4 million through 2030.**

The figure below summarizes the highlights of the resulting benefits of hybrid storage resources selected by RESOLVE from a California capacity expansion perspective based on modeling by Gridwell to date.

Figure 1: Resolve Modeling Results Summary

Energy Storage Target Assumed in RESOLVE (MW)	Hybrid Storage (MW)	Battery Component (MW)	Annual Average GHG Savings Per Hybrid Resource (Metric Tons CO2)	Total Average Annual CAISO GHG Savings (Metric Tons CO2)	Net Present Value Rev Req't Savings Thru 2030 (Millions)	Net Present Value Rev Req't Savings Per Hybrid Resource (Millions)
1,325	704 (700 by 2022)	140	29,928	418,998	$369	$26.4
1,825	2,500	500	17,643	882,147	$589	$11.8

Under the 1,325 MW case above, Gridwell evaluated the potential savings of procuring at least 700 MWs of Hybrid EGT resources by 2022, representing an "early procurement" case. The 1,825 MW case evaluates if 500 MWs of the 1,825 MW energy storage target was met by Hybrid EGTs.

Gridwell also conceptually explored the benefits of hybrid storage technology, both to reduce emissions and provide additional grid services. Gridwell finds that:

- There are significant potential emission savings from adding battery storage to a gas turbine engine. If Hybrid EGT®s provide spinning reserves, emissions are significantly reduced across the entire fleet, as compared to spinning reserves being provided by

combined-cycle or combustion turbines.[5] The GHG reduction value of hybridizing is to make gas plants needed for reliability as low-emission as possible, while concurrently enhancing their reliability and flexibility benefits to the grid.

- Hybrid EGT®s are a low-cost, high-benefit option for load-serving entities to meet their storage target. [6] Hybridizing the existing LM6000 peaking facilities in local areas will have a positive benefit-cost ratio, and higher net present value than BESS alone, will be extremely cost-competitive, and could help disadvantaged communities reduce emissions while maintaining local jobs and the property tax base.
- Additional analysis is needed to determine the optimal adoption rate and quantity. This is more fully explored in a later section.

Finally, Gridwell reviewed previous PLEXOS® modeling on the predicted benefits done prior to Hybrid EGT® energization to determine if the predicted benefits aligned with Gridwell's independent findings. All studies were aligned with conceptual and observed benefits and the RESOLVE modeling using actual operating characteristics. The PLEXOS® modeling, using expected characteristics, showed extremely similar results.

- The PLEXOS® production cost modeling efforts show the primary use of hybrid storage resources is to provide a significant portion of spinning reserves.
- Hybrid storage resources provide energy and spinning reserves at a lower heat rate than alternatives, thus reducing overall GHG emissions and cost.
- The modeled market realized significant cost savings due to the hybrid storage resources displacing higher-cost resources.

Overall, Gridwell finds positive indications that adopting hybrid storage technology in California will lower emissions (including GHG) and costs to load as well as provide significant reliability benefits. As noted above, additional study is needed to estimate more precise cost and GHG reduction savings, as well as optimal adoption timing and amounts. Furthermore, Gridwell focused exclusively on proven technology applicable only to hybridizing LM6000 turbines. Therefore, Gridwell believes that further theoretical and modeling work would be beneficial to explore the benefits on other technology types, particularly combined-cycle resources.[7]

[5] In 2017, approximately 34% of spinning reserves were provided by gas resources. http://www.caiso.com/Documents/2017AnnualReportonMarketIssuesandPerformance.pdf, page 146.
[6] Target as authorize by CPUC Resolution E-4791 and consistent with D.13-10-040.
[7] Initial modeling of combined-cycle hybridizing is very promising but requires additional RESOLVE model enhancements for more conclusive results.