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U.S. Coast Guard Yard Analysis of Microgrid to Reduce Onsite Generation Curtailment

Coast Guard Yard Renewable Energy Center
Photo courtesy of U.S. Coast Guard.

The Coast Guard Yard (Yard) is the Coast Guard's sole shipbuilding and major repair facility, and an essential part of the Coast Guard's core industrial base and fleet support operations. In 2007, the Coast Guard executed an energy savings performance contract (ESPC) at the Yard that installed four 1-MW reciprocating generators that ran off landfill-gas (LFG) from an adjacent landfill. At the time of award, the peak demand of the Yard was estimated to be under 4 MW and the generators were required to provide approximately 90% of the Yard's electricity requirements. The generator center was named the Renewable Energy Center, or REC for short. Due to changes at the landfill, LFG output fell below expected levels and the project underperformed because of fuel and regular production cutoffs. In 2015, the Coast Guard awarded a modification to the original ESPC to integrate natural gas into the project and boost REC output to required levels and add blackstart capabilities.

Problem Statement

The REC operation is limited by a required grid protection buffer that ensures no electricity back-feed. Current REC controls establish a grid protection buffer of about 400 kW and generators are turned on or off as loads change to maintain the buffer. Generator restart time, which can be exacerbated when the site is not staffed, causes shortfalls in REC production. To maximize performance, the Coast Guard wanted to explore possibilities of a microgrid that integrates the REC and allows the Coast Guard to reduce its dependence on utility power at the Yard.

Tasking

Building on the improvements of the 2015 ESPC modification and to increase overall energy resilience at the Yard in both normal and contingency operations, the Coast Guard tasked FEMP with investigating technical solutions and analyzing the financial efficacy of each potential solution for the ESPC. The FEMP team considered solutions to minimize trips, maximize production, and facilitate cost savings.

Potential Courses of Action (COA):

The FEMP team identified three additive technical solutions, all of which start with the installation of a 2 MW/2 MWh battery and related controls.

- Use the battery and controls to ballast changes in load and eliminate regular generator trips. This COA maximized demand savings and LFG consumption but did not expand the REC's production beyond the ESPC requirements.
- Further leverage the battery to reduce the grid protection buffer to 50 kW, increasing daily REC production. This COA enables almost islanding as normal operations but is highly dependent on the price of natural gas to be cost effective.
- Add solar adjacent to the REC to diversify the generation portfolio. This provided diversity to both the generation mix and the financial outlay of the solution. The renewable production is constrained by space and is relatively small compared to the REC, but will offset natural gas with lower cost power.

Analysis

FEMP performed several key analyses, including:

- An analysis of generator trips to highlight all causes of the outages.
- An outage analysis, that identified the length and frequency of the REC outages, then estimated the lost LFG and REC production. A summary of the outages is highlighted in Figure 1 on the next page. This analysis of the outages provided the basis for the financial analysis.
- A financial analysis of the impact of each COA, considering the existing ESPC requirements, the prevailing utility rates, and the expected REC production in ten-minute intervals.

Key Findings

- Time of day or year did not affect trips, but demand fluctuations were highest when demand was highest.
- Outages seem to be carried overnight, which lends to the importance of automatic REC restarts or the ability to run the REC when the load is consistent but low. This also explains why annual REC production is as low as it is despite maintaining high output for most of the year.
- Natural gas-fueled REC production is dependent on the natural gas costs and can be more expensive than utility purchased power, but is desired to provide energy resilience.
- The demand charges at the site are abnormally high with peak demand charged at five times the average site demand per month as shown in Figure 2. This is caused by single, high peak demand spikes occurring when generators trip off during high demand periods.
- Due to frequent, extended generator trips, the REC production was 13% below the requirements for the ESPC contract.
- Instantaneous fluctuations in demand were dramatic, but limited to less than 1 MW, which could be easily carried by a battery. These fluctuations trip the generators offline and cause shortfalls in production and increase demand charges.
- Reducing the number of generator trips without changing the utility protection buffer would solve the REC production shortfall but would generate little additional power.

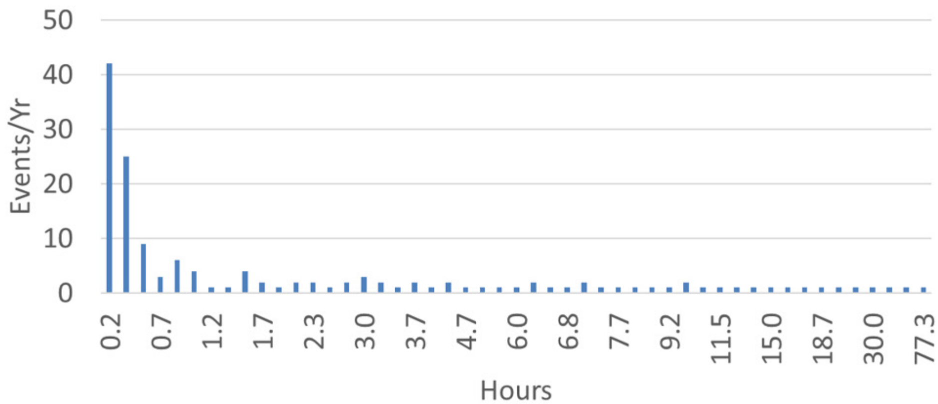

Figure 1. Frequency and Length of REC Outage

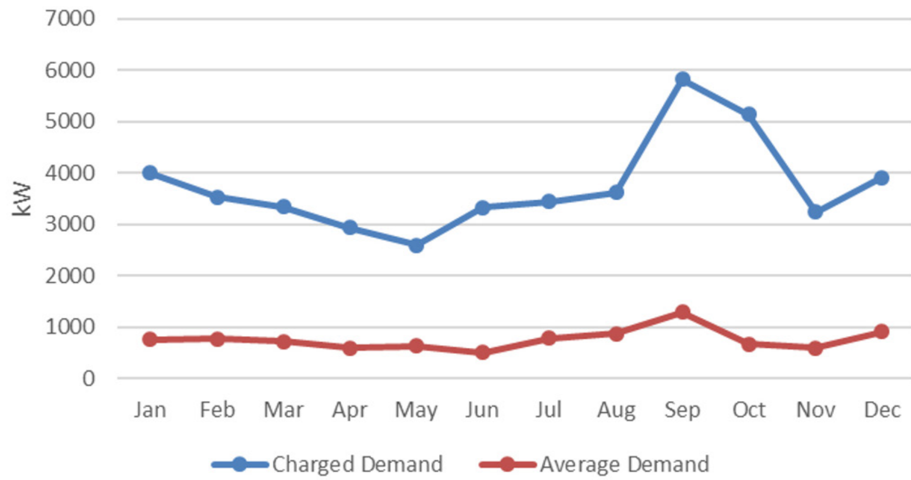

Figure 2. Maximum Versus Average Demand

Recommendation and Path Forward

The FEMP team recommended the addition of battery storage, related controls, reducing the grid protection buffer to 50 kW, and adding solar photovoltaics. This solution should minimize the need to purchase power from the utility during normal operations and allow for operation as a microgrid in contingency operations. With this information, FEMP recommended that the Coast Guard pursue this complete solution and evaluate the best acquisition strategy and timing to implement this solution.

Lessons Learned

- Industrial equipment requirements and operational fluctuation must be considered when pursuing distributed energy resources. The unpredictable fluctuations in demand need to be accounted for during system design. This study found that the speed at which the demand changed had a greater impact on generator trips than the magnitude of the change.
- Distributed energy resources require controls that align with their operating requirements and the load they are serving to maximize operational effectiveness.
- To identify the root cause of the problem and potential solutions, analysis of the highest level of detail data was required. For this analysis both 10-min and 1-min interval data was required to identify the characteristics of outages and understand the financial implications of them due to the highly variable industrial operations.
- Due to the generator trips, overall demand charges were higher than expected but can be controlled with addition of the energy storage (by eliminating REC outages).

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