Analysis of the Integration of Energy Storage with Diesel Generation in the Village of Levelock, Alaska

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Abstract: The Village of Levelock is located by the Kvichak River in Alaska, with a population of 49. The village’s electric power is supplied exclusively by diesel generators, which have proved unreliable and costly. The tribe wanted to investigate how battery energy storage systems (BESS) could improve the performance of the Village’s electric power system. Sandia has provided technical and economic independent evaluation of the performance of Levelock's new electric system. With data recorded from the tribe’s system and forecasts of diesel prices, we investigate the benefits a BESS could bring to the overall system life, fuel costs, and reliability of the power supply. The variable efficiency of the generators, impact of start-up/shutdown process, and low-load operation concerns are considered.

Village of Levelock

- Tribal community of 49 inhabitants
- Located by the Kvichak river, in Lake and Peninsula Borough, Alaska
- Main economic activities are commercial fishing, sports fishing and tourism
- Diesel generators are old, inefficient and unreliable
  - Diesel costs higher than national average: $3.658 per gallon
  - The village experiences an average of 3 to 4 power interruptions per month

Levelock Electric Power System

- The Village's electric system is isolated and depends exclusively on diesel generators (DGs)
- The existing system has 3 generators rated at 100 kW (1 unit) and 67 kW (2 units)
- The load has strong seasonal variations, with a peak in winter
- Fuel usage by generators
  - Diesel generator sets' life is larger than 20 years
  - Operation in varying loads or low loading accelerate degradation of diesel generators
  - Continuous operation close to rated power also must be limited to avoid excessive wear
  - Planned maintenance of generators is a function of runtime (hours of operation)
- Reliability improvements
  - The electric system is restarted manually, with estimated restoration time of 15 minutes
  - Automation could reduce this restoration time to zero

Benefits of Battery Energy Storage Systems

- Reduction in fuel usage by generators
  - Operating generators at most efficient point of operation can save fuel
  - Charge BESS to shift the point of operation of generators to close to full load
  - Shut down generators and discharge BESS to supply loads
- Extending diesel generator set's life and reducing O&M costs
  - Levelock's generators operate in prime rated power (PRP) regime, as described in the standard ISO 8528-1
  - Operation in varying loads or low loading accelerate degradation of diesel generators
  - Continuous operation close to rated power also must be limited to avoid excessive wear
  - Planned maintenance of generators is a function of runtime (hours of operation)
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Case Study

- Based on Energy Information Administration’s (EIA) 2020 Annual Energy Outlook (AEO), three forecasted diesel price trajectories were considered (Fig. 3):
  - AEO 2020 reference
  - High oil price
  - Low oil price
- Key assumptions:
  - Load will not change
  - Prices of fuel will change proportionally to estimates by EIA’s 2020 AEO;
  - BESS energy capacity was oversized in 20% to compensate for capacity fade over time
  - To avoid wet stacking, the generator cannot operate under 30% of its rated power
- Optimization aimed at minimizing costs of replacing generators, fuel usage, Operation and Maintenance Costs, and capital costs of BESS over 10 years
- Objective function is present value of proposed system with BESS and 2 generators (100 kW + 67 kW) compared to a new system with 3 generators (100 kW + 2x 67 kW)

Table 1. Summary of reliability indices for Levelock, AK, the state of Alaska and the United States.

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<tbody>
<tr>
<td>Levelock, historical est.</td>
<td>42</td>
<td>10.50 h (630 min)</td>
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<tr>
<td>Levelock est. (2020)</td>
<td>67.23</td>
<td>17.76 h (1065.59 min)</td>
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<tr>
<td>Levelock, improved</td>
<td>17.93</td>
<td>10.87 h (652.13 min)</td>
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<tr>
<td>Alaska (2019)2</td>
<td>3.28</td>
<td>4.95 h (297.27 min)</td>
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<tr>
<td>U.S. (2019)2</td>
<td>1.44</td>
<td>4.45 h (267.13 min)</td>
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</tbody>
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Case Study

- Optimal point of power interruptions
- Forecasted average diesel prices
- Present value of 2 DG, 50 kW/25kWh system versus 3 DG system, no solar
- Present value of 2 DG, 50 kW/25kWh system versus 3 DG system, 50 kW solar

References