WIND, GEO, AND DIESEL-OFF IN NOME, ALASKA: CONSIDERATIONS OF FREQUENCY STABILITY

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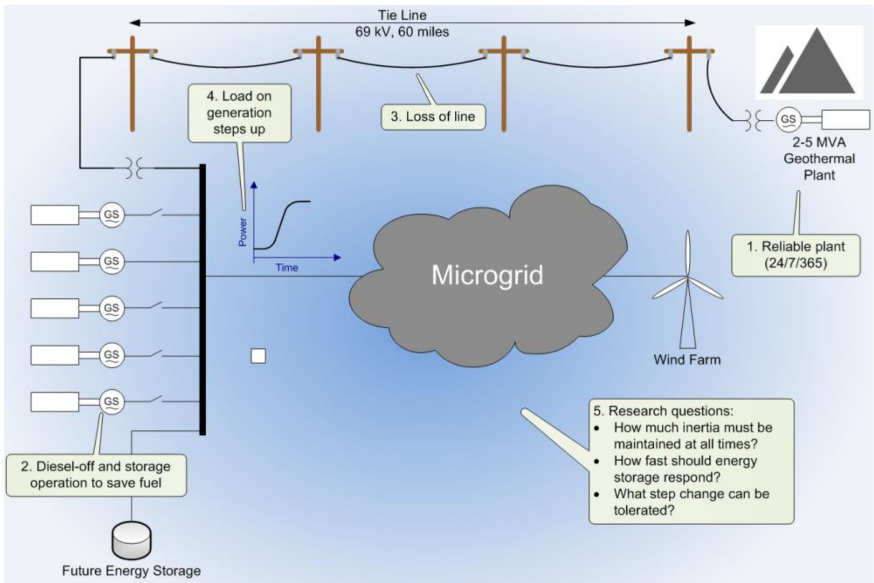
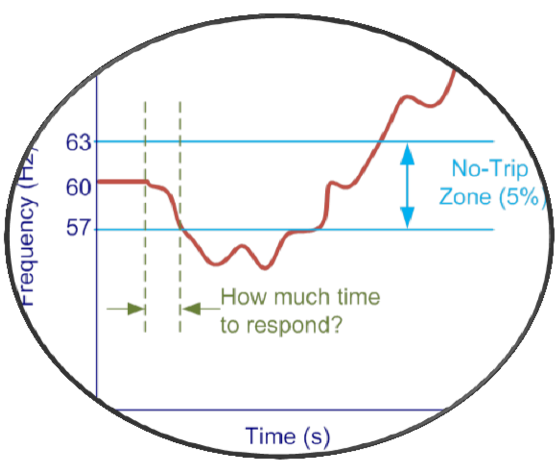


The city of Nome, Alaska, is a microgrid powered primarily by diesel generators augmented by wind power and a very small amount of solar power. It is proposed to add geothermal source (figure on right) to this mix of sources. The geothermal plant could provide 40% or more of the base load, reducing dependence on diesel fuel.

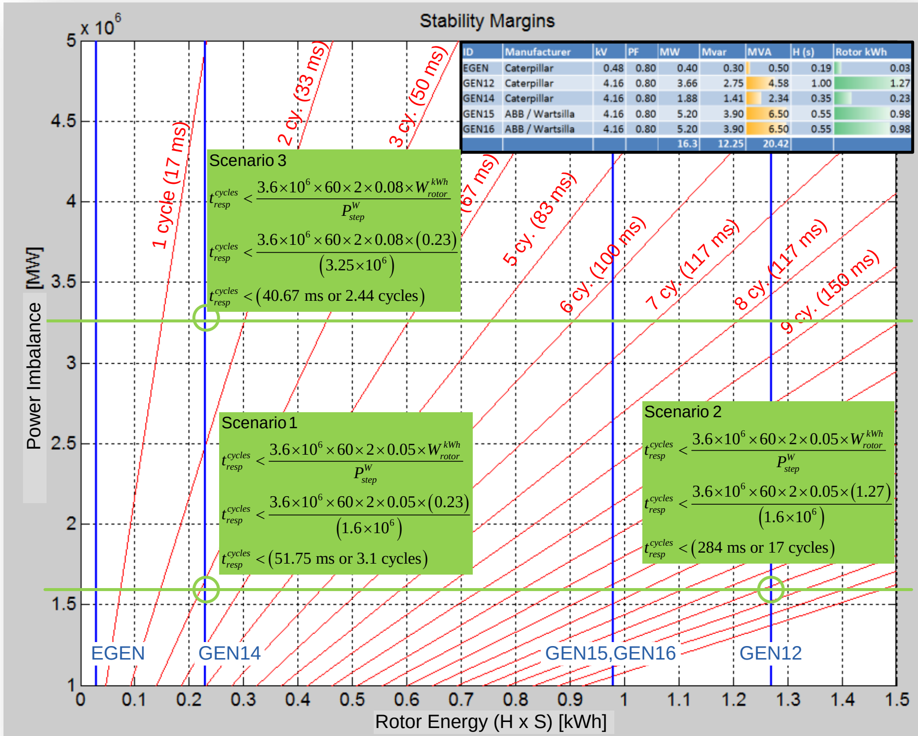
Under all conditions, the city has sufficient diesel units on standby and one in service. In the event of contingencies, the diesel units can serve the entire city and restore service in under 20 minutes. However, what is desired is to reduce the dependence on diesel and operate a single, under-sized diesel generator in parallel with the renewable resources.

This work addresses frequency stability, which is the ability to sustain frequency despite contingencies such as a loss of renewable source or a fault. The figure on the left shows common ± 5% limits where frequency should remain at all times. A system operating at 60 Hz should remain bounded to 57-63 Hz despite contingencies. Falling outside these boundaries would trip the frequency-protection and cause a total system blackout (i.e., an unstable condition).

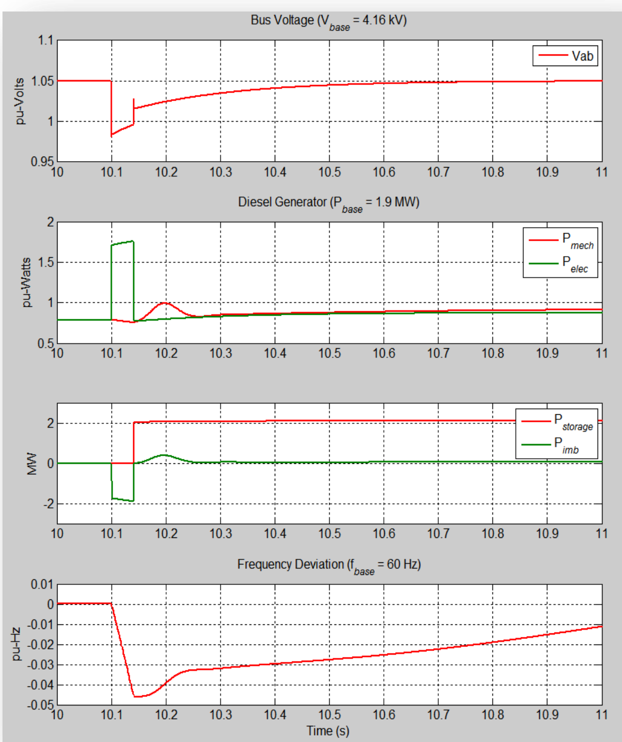


While a geothermal plant can provide reliable power for Nome year-round, the uncertainty lies in the tie line—particularly, in the terrain birding Nome and Pilgrim Hot Springs (60 miles).

Under a loss-of-geothermal import power, the load exerted on a single diesel unit can cause the frequency to fall out of bounds--more so rapidly when operating a diesel generator with low inertia.



The authors derived stability margins (figure on right) to predict response times requirements for an eneryg storage unit to sustain bounded frequency. The horizontal axis represents the rotor kinetic energy of a single diesel unit. The vertical axis represents the step-change of power under an assumed contingency. The vertical blue lines correspond to the diesel machine (various units available at Nome). The red lines represent the response time margins. The circles (cross-hairs) show the requirements determined for the city of Nome.



Several case studies validated the response margins predicted above. The traces on the left show (from top to bottom) the system voltage, mechanical and electrical power exerted on the single diesel generator, the power imbalance, the energy storage output power in response to a contingency, and the system frequency in per unit. For the contingencies studied, system frequency was maintained with an energy storage unit. **The predictions were validated with simulations showing that 3.1 cycles after the contingency, the system frequency reduces nearly 5 % and is on the verge of system instability.**