What is the right investment in renewable energy for on-site generation?

A portfolio optimization approach

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Investment in on-site power systems for buildings and small campuses requires trade-offs analyses and decisions on the right size of liquid fueled and renewable energy power sources. The main driving factors for investing in on-site generation are (1) grid-connected benefits and (2) reducing the risk of power outages. On-site generation based fully on renewable energy (RE) systems substantially reduce the electricity bill, but comes with the uncertainty of meeting critical loads when operated in islanded mode. During normal grid-connected operations, the uncertainty of RE generation is generally of little concern. However, for some customers, power outages can cause large economic losses, thus there is an interest in back-up or on-site generation to maintain reliable power supply.

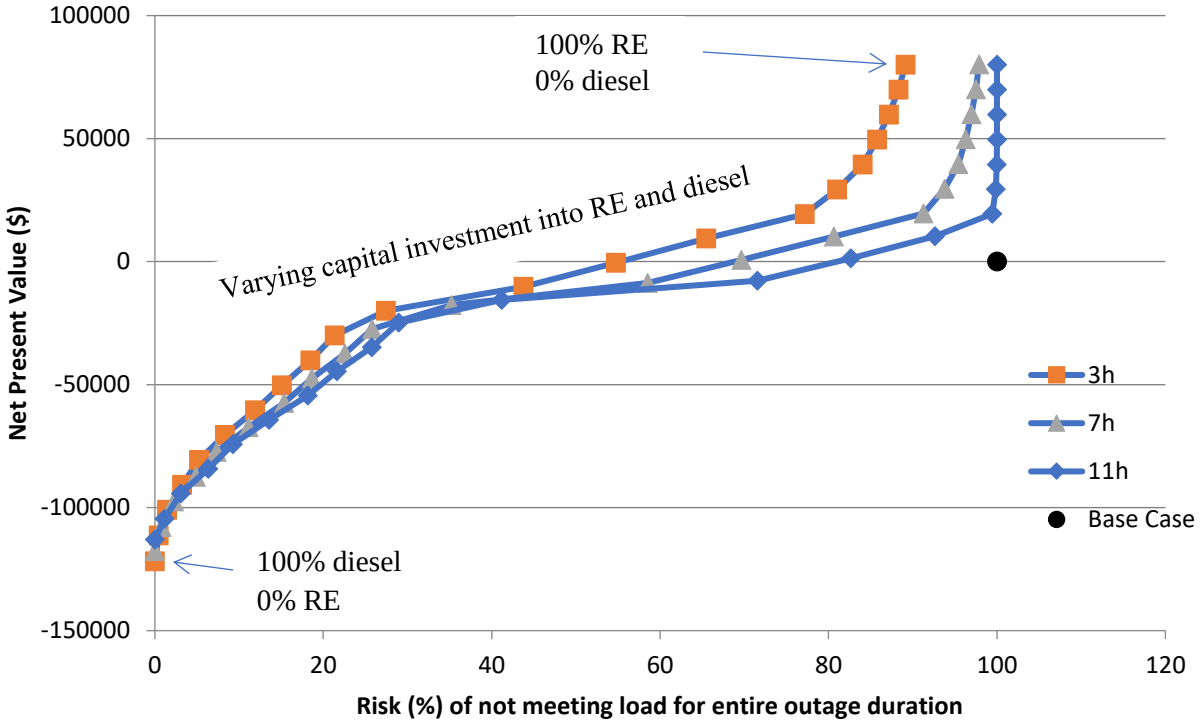
Another option for on-site power generation is a conventional diesel power generator which is sized to meet all or certain critical loads during grid-power outages. While dispatchable, diesel generators are limited in their ability to off-set electricity costs because of their relatively low efficiency. Furthermore, they may be limited in their use due to emission constraints.

To make prudent investments in selecting the right combinations and sizes of generators (RE versus conventional diesel) for micro-grid applications it is imperative that the potential risks and rewards options and trade-offs of different power systems are well understood prior to making an investment. Our work focuses on creating a techno-economic model with which we explored the option space of different power system combinations given a fixed capital investment amount. We search for the optimal portfolio choice of generator mixes based on an investor's acceptance level of risk.

To seek the portfolio optimal set of different sized RE-diesel generator mixes, we maximize the 25-year net present value (NPV of benefits minus cost) of a set of RE-diesel systems with the same initial capital cost using the National Renewable Energy Laboratory's REopt model. Each system combination was analyzed for its probability of not meeting critical load conditions during a grid outage of a randomly assigned length. The outcome of this analysis is a functional relation (frontier curve) of NPV to risk of not meeting critical load during a grid outage (as seen in the figure below).

Two insights were gained from these results: (1) for the selected U.S. location given a fixed capital cost, one can invest in a renewable energy only (100% RE) generator, that offers a significantly large increase in NPV, with a high risk of not meeting loads during grid outages. In contrast, investments aimed at lower risks of not

meeting loads (say lower than 20% risk) will all have a significantly negative NPV due to the high investment cost of the diesel generator relative to the cost of power outages and the inability of the conventional diesel generator to reduce the electricity bill. (2) generator mixes in the medium and medium-high RE range indicate high sensitivity in the risk dimension with little change in NPV.



The results of this research indicate to building and campus owners and operators how a preference in dispatchable diesel generator versus variable generator renewable resources impacts the cost and benefits on NPV basis and the risk or not meeting loads during an outage. Such results can be used by owners and operators to make informed choices given their risk-acceptance of power outages and desire to reap financial rewards by lower electricity bills. Future work in this subject area would focus on evaluating risk and reward of different systems at a location with high cost of outages such as at a datacenter or hospital.