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Low Cost Community Microgrids by Efficiency and Reduced Availability

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Learning Objectives

Reading this poster should teach you to:

1. Elaborate tradeoffs between microgrid versus energy efficiency costs.

2. initiate similar analyses where building energy modeling and microgrid analysis are intermixed.

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Introduction

Microgrids provide a community with the capacity to maintain electric service during power outages. Having such capacity can increase the electric resilience of a community. Unfortunately, microgrids are costly and have so far been applied to high consequence applications such as hospital life support and military command centers with availability requirements above 99.9%. **Availability is the percentage of the load energy demand served by the microgrid during power outages, not including the startup period.** In addition, current microgrids mostly consist of environmentally unfriendly solutions like diesel generators. This poster shows how the cost of a renewable energy microgrid drops by reducing availability alongside cost effects for energy efficiency (EE) measures.

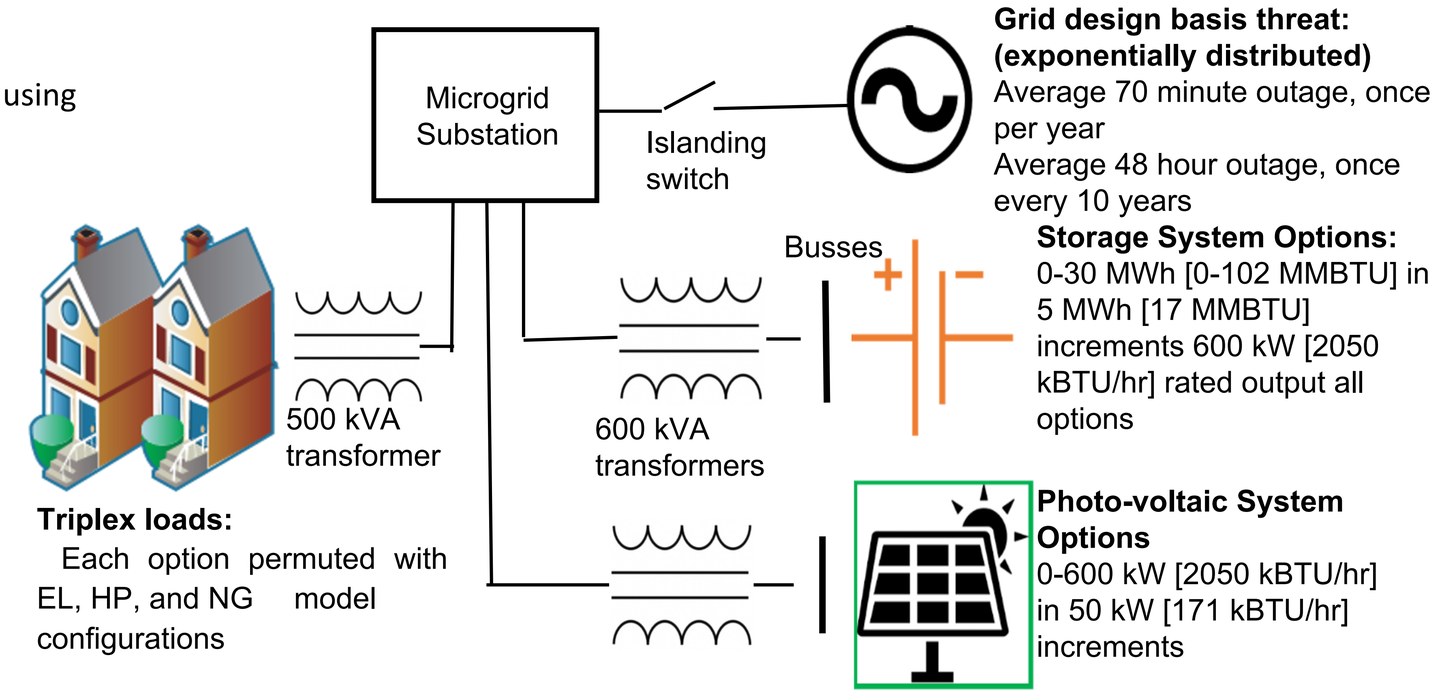
Methods

Use the microgrid design tool (MDT) to quantify cost versus availability using EnergyPlus electric loads based on different HVAC and EE measures.

EnergyPlus Case Specifications

Case	Description	Peak Load	Annual Load
1. Baseline (BL)	Multi-unit DOE residential proto-type climate Zone 4B IECC 2018 on-slab, with one of a) electric heat and conventional air-conditioning (EL) b) heat pump (HP), c) natural gas and conventional air-conditioning (NG).	148-249 kW [505-850 kBTU/hr]	560-942 MWh [1912-3216 MMBTU]
2. Maximum Insulation (MI)	BL with 1) 100 R (17.6 RSI) insulation added to all opaque surfaces 2) All windows' U-factor changed from 0.32 to 0.053 Btu/hr·ft^{2}·^{o}F (1.82 to 0.3 W/m^{2}/K) 3) Infiltration reduced by 75%	134-177 kW [457-604 kBTU/hr];	608-883 MWh [2075-3013 MMBTU]
3. Limited HVAC and Maximum Insulation (ML)	MI with a thermo-stat range widened to -40^{o}F (-40^{o}C) to 104^{o}F (40^{o}C) to keep HVAC off most of the time. Investigation showing HVAC still operating at a couple of times for non-thermostat related control issues.	108-159 kW [369-543 kBTU/hr]	481-768 MWh [1641-2621 MMBTU]

MDT analysis specifications and layout



Grid design basis threat: (exponentially distributed)
Average 70 minute outage, once per year
Average 48 hour outage, once every 10 years

Storage System Options:
0-30 MWh [0-102 MMBTU] in 5 MWh [17 MMBTU] increments 600 kW [2050 kBTU/hr] rated output all options

Triplex loads:
Each option permuted with EL, HP, and NG model configurations

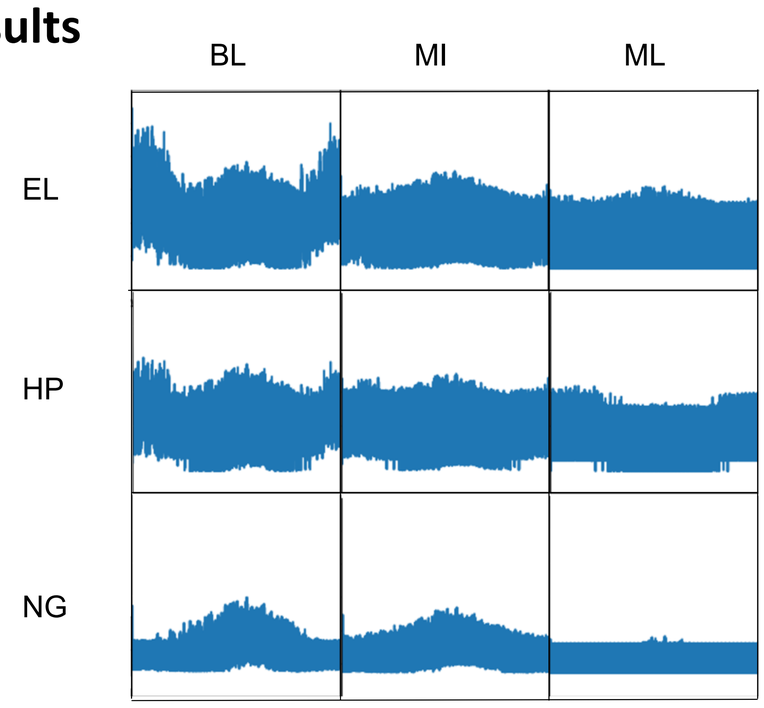
Photo-voltaic System Options
0-600 kW [2050 kBTU/hr] in 50 kW [171 kBTU/hr] increments

Cost and Reliability Inputs

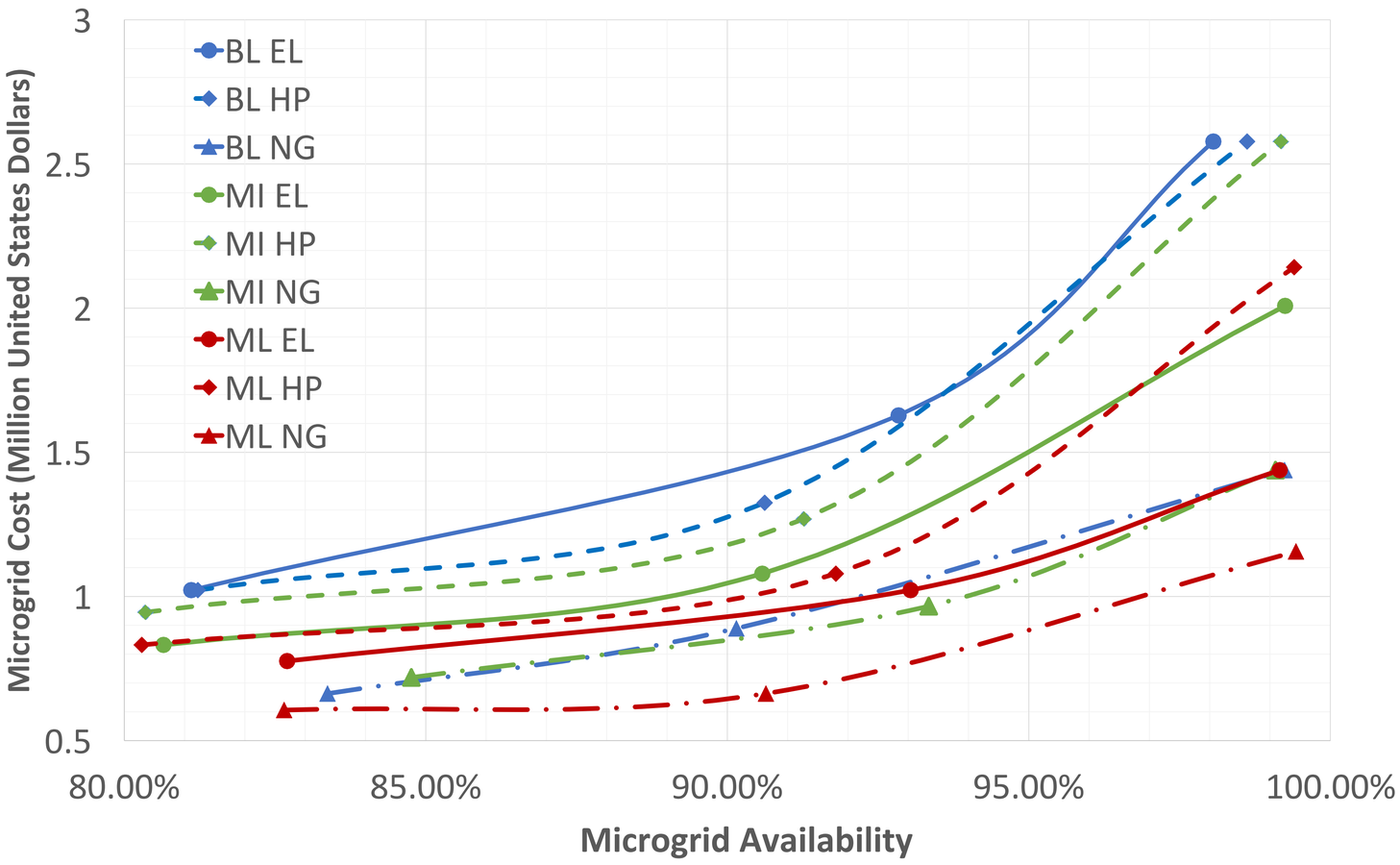
Case	MTBF(hr)	MTTR (hr)	Cost	Source
PV	8468	55	1130 $/kW [331.2 $/(kBTU/hr)]	Failure: Oozeki, 2007; Cost: NREL, 2018
BES	8468	55	380 $/kWh [111.3 $/kBTU]	Failure: Oozeki, 2007*; Cost: Cole, 2019

Acronym key: MTBF = mean time between failure, MTTR = mean time to repair, PV = photovoltaics, BES = battery energy storage. See the paper for references

Results



EnergyPlus hourly total energy for the 9 profiles. X axis ranges from hour 1 to hour 8760 of the year and the y axis ranges from 0 to 300 kWh/hr (1023 BTU/hr)



Conclusions

1) Nonlinear increase in cost with increase in availability
2) EE, microgrids, and cost have a complex relationship. For high availability EE has a higher payback. For low availability solutions microgrids give better returns
3) Low availability microgrids could help open the residential sector market